

Proceedings of the 11th Annual

***GREAT LAKES DAIRY SHEEP
SYMPOSIUM***

November 3 – 5, 2005

Sheraton Hotel & Conference Center
Burlington, Vermont, USA

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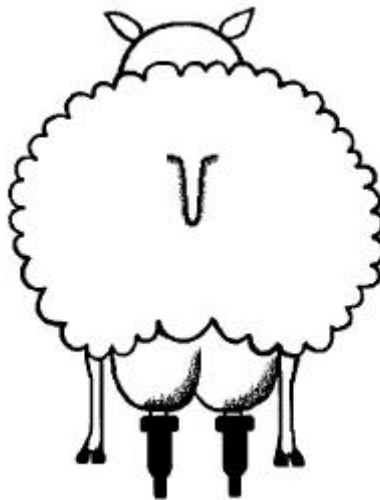
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Center for Sustainable Agriculture, Burlington,
Vermont, USA

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Presented by:

Dairy Sheep Association of North America, Rock
Hill, South Carolina, USA

(<http://www.dsana.org/index.php>)



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Clockwise from top left:

Dairy ewes on pasture at Major Farm, Putney, Vermont
Milking ewes at Bonnieview Farm, Craftsbury Common, Vermont
Artisan cheesemaking workshop, Burlington, Vermont
Milk cans and freshly made sheep and goat milk cheeses, Burlington, Vermont

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Program of Events

Thursday, November 3, 2005

- 7:45 – 9:00 a.m. **Registration**, Sheraton Hotel, Burlington, Vermont
- 9:00 a.m. – noon **Sensory Evaluation of Cheese Workshop** (optional - separate fee)
Dr. Montserrat Almena-Aliste, Vermont Institute of Artisan Cheese,
University of Vermont, Burlington, Vermont, USA
- 9:00 a.m. **“You Want to Milk What?” Important Figures and Considerations
to Ponder Before Starting a Sheep Dairy**
Mike Ghia, Ewetopia Farm, Saxton’s River, Vermont, USA
- 10:00 a.m. **Factors Contributing to Milk Production – The Spooner Example**
Yves Berger, Spooner Agricultural Research Station, University of
Wisconsin-Madison, Spooner, Wisconsin, USA
- 10:45 a.m. **Starting a Milk Processing Facility: Costs and Considerations**
Peter Dixon, Dairy Foods Consultant, Putney, Vermont, USA
- 11:30 a.m. **Lunch**
- 1:15 p.m. **Lamb Rearing Strategies: Farmer Panel**
Beth Slotter, Old Chatham Shepherding Company, Old Chatham,
New York, USA
Neil Urie, Bonnieview Farm, Craftsbury, Vermont, USA
Karen Weinberg, 3-Corner Field Farm, Shushan, New York, USA
- 2:15 p.m. **Profitability of Small Ruminant Farmstead Cheese Operations**
Bob Parsons, University of Vermont Extension, Burlington, Vermont,
USA
- 3:00 p.m. **Vendor Fair**
- 4:00 p.m. **Tour, Vermont Institute of Artisan Cheese**

Friday, November 4, 2005

- 7:30 – 8:30 a.m. **Registration**, Sheraton Hotel, Burlington, Vermont
- 8:30 a.m. **Non-Nutritional Strategies to Improve Lactation Persistency in
Dairy Ewes**
Giuseppe Pulina, University of Sassari, Sassari, Sardinia, Italy
- 9:15 a.m. **Milk Fat Synthesis and Its Regulation in Sheep**
Adam Lock, Cornell University, Ithaca, New York, USA

Program of Events (cont.)

Friday, November 4, 2005

- 10:00 a.m. **Break**
- 10:15 a.m. **Managing Your Own Retail Shop: Marketing and Self-Distribution of Farmstead Cheese**
Alastair MacKenzie, La Moutonnière, Sainte-Hélène-de-Chester,
Québec, Canada
- 11:15 a.m. **Lunch**
- 1:30 p.m. **How to Graze and Supplement Dairy Sheep for High Production**
Giuseppe Pulina, University of Sassari, Sassari, Sardinia, Italy
- 2:30 p.m. **Grazing Techniques to Maximize Pasture and Production**
David Major, Major Farm, Putney, Vermont, USA
- 3:00 p.m. **An Integrated Approach to Raw Milk Cheese Safety**
Paul Kindstedt, Department of Nutrition and Food Sciences, University
of Vermont, Burlington, Vermont, USA
- 3:45 p.m. **Farmer Panel on Labor – How to Attract and Train Your Labor
Force, Year After Year: Successful Methods and Challenges**
Mark Fischer, Woodcock Farm, Weston, Vermont, USA
David Major, Major Farm, Putney, Vermont, USA
Bob Works, Peaked Mountain Farm, Townshend, Vermont, USA
- 4:30 p.m. **Annual Meeting of the Dairy Sheep Association of North America**
- 7:00 p.m. **Symposium Banquet** (separate ticket)

Saturday, November 5, 2005

- 7:30 a.m. – **Farm Tours**
6:00 p.m. Three Owls Farm, Granville, Vermont, USA – Dan Hewitt
Bonnieview Farm, Craftsbury Common, Vermont, USA – Neil Urie
Up A Creek Cheese Company, Irasburg, Vermont, USA – Frankie
and Marybeth Whitten

Sunday, November 6, 2005

- Times to be **Optional Open Farms**
announced 3-Corner Field Farm, Shushan, New York, USA – Karen Weinberg
Old Chatham Shepherding Company, Old Chatham, New York,
USA – Tom and Nancy Clark

Speakers

at the symposium site in Burlington, Vermont and at the farm tours and open farms in Vermont and New York

Almena-Aliste, Montserrat – Research Associate, Vermont Institute of Artisan Cheese, University of Vermont, Burlington, Vermont, USA

Berger, Yves – Superintendent and Sheep Researcher, Spooner Agricultural Research Station, University of Wisconsin-Madison, Spooner, Wisconsin, USA

Clark, Tom and Nancy – Dairy Sheep Producers and Sheep Milk Processors, Old Chatham Shepherding Company, Old Chatham, New York, USA

Dixon, Peter – Dairy Foods Consultant, Putney, Vermont, USA

Fischer, Mark – Dairy Sheep Producer and Cheesemaker, Woodcock Farm, Weston, Vermont, USA

Ghia, Mike – Producer, Ewetopia Farm, Saxton's River, Vermont, USA

Hewitt, Dan – Dairy Sheep Producer and Cheesemaker, Three Owls Farm, Granville, Vermont, USA

Lock, Adam – Research Associate, Cornell University, Cornell, New York, USA

Kindstedt, Paul – Professor, Department of Nutrition and Food Sciences, University of Vermont, Burlington, Vermont, USA

MacKenzie, Alastair – Dairy Sheep Producer and Cheesemaker, La Moutonnière, Sainte-Hélène-de-Chester, Québec, Canada

Major, David – Dairy Sheep Producer and Cheesemaker, Major Farm and Vermont Shepherd, Putney, Vermont, USA

Parsons, Robert – Farm Management Specialist, University of Vermont Extension, Burlington, Vermont, USA

Pulina, Giuseppe – Professor, Dipartimento di Scienze Zootecniche, Università di Sassari, Sassari, Sardinia, Italy

Slotter, Beth - Flock Manager, Old Chatham Shepherding Company, Old Chatham, New York, USA

Urie, Neil – Dairy Sheep Producer and Cheesemaker, Bonnieview Farm, Craftsbury Common, Vermont, USA

Weinburg, Karen – Dairy Sheep Producer and Cheesemaker, 3-Corner Field Farm, Shushan, New York, USA

Speakers (cont.)

Whitten, Frankie and Marybeth – Cheesemakers, Up A Creek Cheese Company, Irasburg,
Vermont, USA

Works, Bob – Dairy Sheep Producer and Cheesemaker, Peaked Mountain Farm, Townshend,
Vermont, USA

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Small Ruminant Dairy Project, University of Vermont Center for Sustainable Agriculture, Burlington, Vermont, USA; <http://www.uvm.edu/sustainableagriculture/smallrumi.html>

Silver:

University of Vermont Extension, Burlington, Vermont, USA; <http://www.uvm.edu/extension/>

Wisconsin Sheep Dairy Cooperative, Strum, Wisconsin, USA; <http://www.sheepmilk.biz/>

Bronze:

Eriel Sales Associates, Inc. (BOVIDR Laboratories, Inc.; H. W. Naylor Co.), Ballston Lake, New York, USA; <http://www.erielsales.com/>

Fromagex, Rimouski, Québec, Canada; <http://www.fromagex.com/>

Grober Nutrition, Cambridge, Ontario, Canada; New York Mills, New York, USA; <http://www.grobernutrition.com/>

JayBee Precision, Inc., Bristol, New Hampshire, USA; <http://www.jaybeeprecision.com/>

Merrick's, Inc., Middleton, Wisconsin, USA; <http://www.merricks.com/>

Old Chatham Shepherding Company, Old Chatham, New York, USA; <http://www.blacksheepcheese.com/>

Premier Dairy Services, LLC (DeLaval), Argyle, New York; Middlebury, Vermont; St. Albans, Vermont; USA; <http://www.premierdairy.com/>

Vermont Agency of Agriculture, Food and Markets, Montpelier, Vermont, USA; <http://www.vermontagriculture.com/>

Vermont Cheese Council, Richmond, Vermont, USA; <http://www.vtcheese.com/>

Vermont Sheep and Goat Association, Richmond, Vermont, USA; <http://www.vermontsheep.org/>

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<http://www.glengarrycheesemaking.on.ca/>

Hoegger Supply Company, Inc., Fayetteville, Georgia, USA;

<http://www.hoeggergoatsupply.com/>

Land O'Lakes, St. Paul, Minnesota, USA; <http://www.landolakesinc.com/>

Natural Resources Conservation Service, Vermont Office, U.S. Department of Agriculture,

Colchester, Vermont, USA; <http://www.vt.nrcs.usda.gov/>

The Shepherd Magazine, New Washington, Ohio; Cardington, Ohio; USA;

shepmag@bright.net

University of Vermont, Department of Animal Science, Burlington, Vermont, USA;

<http://asci.uvm.edu/>

Wooldrift Farm, Chris Buschbeck and Axel Meister, Markdale, Ontario, Canada;

wooldrift@bmts.com

“YOU WANT TO MILK WHAT?” IMPORTANT CONSIDERATIONS TO PONDER BEFORE STARTING A SHEEP DAIRY

**Michael Ghia
Ewetopia Farm
Saxtons River, Vermont, USA**

Introduction

As my wife and I prepared to start our sheep dairy in 1997, I took a course from the Extension Service called the Vermont-New Hampshire Agribusiness Management Course. One of the guest speakers was a loan officer from the Vermont Economic Development Authority (VEDA) who had also worked in the same capacity for the USDA Farm Service Agency (FSA). After the class, I spoke with him about what we wanted to do, and asked him for advice about approaching VEDA or FSA about a loan to get started. At that time, the Major Farm was the only established sheep dairy in Vermont, and the loan officer told me not to be surprised if the FSA officer asked me, “You want to milk what?!” and then chuckled into the phone. “If its not black and white, weighs 1200 lbs. and gives 20,000 lbs. of milk, they won’t know what to do with you”, he added.

Sheep dairying is more widely known these days. Nonetheless, the point that he was trying to make still holds true. If you are going to get into sheep dairying, you need to know your business better than the loan officers and the other technical service providers. Even (or perhaps especially) if you are setting up a sheep dairy with your own money, it is important to understand what you are getting yourself into before taking the plunge. It has been my experience in conducting workshops, and doing consulting over the years, that there are a great many myths and unmet expectations around sheep dairying and around value-added products. There is an expectation that sheep dairying offers a greater chance at success and profitability than other forms of dairying (cow, goat, etc.) or other types of farming. Further, there is an expectation that value-added products are both necessary for and a guarantee of farm profitability. The realities, of course, are much different. Sheep dairying is like any other form of farming, and the keys to success lie in hard work, long days, thorough research, careful financial planning, thorough management, good record keeping, financial monitoring, and some luck. Additionally, anyone getting into sheep dairying or doing value-added products needs to know from experience that they are suited to work and the lifestyle that will be required of them.

Over the course of the conference, other presenters will get into greater detail on specific management and financial considerations than I can offer during this talk. Also, everyone comes to the table here with many different backgrounds and financial resources. So, instead of providing too many specifics here, my intention is present to you some general principals and some questions that, in my opinion, anyone getting into sheep dairying should consider before committing themselves to this venture.

Principle One: There is no absolute economic advantage to milking sheep over milking goats or cows, etc.

While it is true that sheep milk is worth more than either cow or goat milk, in general, these animals can make up for the price difference by generating more milk per animal, per unit feed, or per hour of labor. Especially, if you are comparing the economics of sheep dairying to organic cow dairying or to other dairies with value-added products, the net returns can be comparable. The main reason to choose to milk sheep instead of (or addition to) other dairy animals is because you like sheep; you have the disposition to handle sheep; you like sheep milk and other sheep milk products; or you are trying to figure out how to make your existing sheep operation more profitable.

Principle Two: A sheep dairy is a sheep farm first, with a dairy component.

As mentioned in principal one, if someone wants to concentrate solely on milk or dairy product production, they probably will find it easier to milk cows or goats because the volume of milk that those animals are able to produce makes up for the fact that their milk and finished products are worth less per pound (push the pencil for awhile). But, additionally, a sheep dairy will put a fair amount of money and work into lambs and wool, which have the potential for significant returns, and should not be ignored. Karl and Jane North in New York as well as Karen Weinberg also of New York are two examples of people who made this approach successful.

Further, if you can't run your lamb/wool operation at least at break-even, then you are necessitating that the sale of milk will cover the losses of this aspect of your operation as well as the extra capital, operating, and labor expenses of milking, cooling, and transporting milk. This cuts into overall profitability, and makes profitability more elusive, especially if milk production levels are low. Further, if you decide to value-add your product and your farm is losing money at the lamb/wool and milking enterprises, then you are requiring the cheese (or yogurt, etc.) to be your sole profit center and carry the losses of the other two aspects of the sheep business as well as the additional costs of processing, curing, storing, marketing, and distribution. If that is the case, the question I ask is, "Why not forget about the livestock operation"? Just set up a dairy plant, and buy milk from farmers who focus on milk production.

Principle Three: It takes 3-4 years or more to establish a sheep dairy.

Creating a sheep dairy from scratch/nothing is extremely difficult and very costly. Sheep farms, which are already established and have good markets for their meat, wool, and pelts, are in the best position to convert to successful sheep dairies since they already have most of the facilities, expertise, markets, and perhaps animals to get started. This reduces their upfront costs, their learning curve, and the energy and effort needed to address the meat and wool part of the business. A sheep farm that is already somewhat profitable in this area will have the best chance at success.

The upfront costs and time commitment of investing in milking equipment, and a milk parlor, let alone processing equipment, curing facilities, and transportation systems is usually greater than anyone expects. This will produce personal, physical, and cash-flow stress, unless there is an outside capital source subsidizing the business. This is where established cow and goat producers can have a significant edge over sheep dairies when deciding to value-add. They

already have their milking facilities and systems, and a market for their milk. As long as their milk contracts don't preclude them from doing so, the cow dairy can continue to ship milk while they are building their facilities, and while they are experimenting with products and equipment and markets. Even if the goal of the farmer is to sell a value-added sheep milk product, starting out by simply selling milk to another processor will make it easier to get started.

Rushing to get started, and expecting quick profitability is a recipe for failure. Most sheep dairies will need off-farm income or other farm income in order to carry the business during its start-up phase (I don't know of any in the US that have not started this way). Depending on where someone is starting from, I would say that it will take at least 3-4 years to get a sheep dairy full up and running:

Year 1: Planning and interning. You need to do the work, before you know that you are ready to commit. You also need to do your financial business planning and need to start facilities research and planning.

Year 2&3: Set up sheep facilities, and go through 1-2 lambings. If you are not already sheep farming, you need this experience and need to get the bugs worked out of your feeding, cropping, grazing, lambing, overwintering systems, etc. You should also use this time to figure out how you are going to care for lambs, and your markets for lambs and fiber. It will be important to watch udder health during this year, since high producing dairy sheep will be more susceptible to mastitis.

Year 3&4: Set up your milking and cooling systems and get them functional. This is often more complicated than people realize. Make sure that you consult with the milk inspectors during the planning process. Even if you ultimately plan to value-add your milk, you are arguably better off finding another milk market initially so that you can focus on your milking system, your milk metering/record keeping system, and udder and animal health in that first year. This is especially true if your animals have never been milked before, since most of them will take a while to get used to it. Expect longer milkings during the start-up year.

Year 4 &5: If desired, build your processing facility. Practice/test making your target product, and start marketing. If you do this instead of trying to make your product the first year that you milk, you will probably throw away less product, since milk quality and cheese quality will probably be better, and you will have more time to establish markets.

Principle 4: Milk production records are more important than breed or % dairy breed.

When you buy your breeding stock, it is important to not let the fact that the sheep are part or pure East Friesian or Lacaune distract you from your selection criteria, despite the fact that these are considered the "Holstein's" of the sheep world. For instance, the sheep still should have milk records to back up the value of their lines. Just as in dairy cows, there is variation within every breed, and just because an animal is East Friesian, or Lacaune, or a percentage, does not guarantee milk production. Thus, it is important to scrutinize the lineage (milk production of the mother and both grandmothers if possible) of any rams or ewe lambs that you might buy, and both the lineage and the milk records of any experienced, mature ewe that you are considering

for purchase. There is little that can be concluded exclusively from the percentage of East Friesian or Lacaune in a given crossbred ewe.

Further, when you do your business plan, make sure that you are using a reasonable milk production level, including lowering your expectations in the initial years. There will be a big difference in the economics if you are only producing 250 lbs. of milk versus 500 lbs. of milk.

Principle 5: Size does matter.

Like with most types of farming operations, small sheep dairies (<60-100 ewes) are likely to only be successful if they value-add some or all of their products (milk, meat, wool, etc.), and market as directly to the consumer as possible, while keeping labor and expenses down. The advantage of these operations is that they can be set up with minimal capital.

When it comes to value-adding on a small farm, so little milk will likely go through a cheese facility that small farms will need a very high return per pound of milk in order to pay for even an inexpensive facility and to make a living wage. Further, many small sheep dairies who value-add the dairy products find that they need to diversify into cow milk cheeses or blended cheeses or need to rent out their cheese facility in order to have enough volume of milk going through their cheese plant in order to pay for the facility.

Large sheep dairies (>250-500 ewes) will have more of an economy of scale advantage, and perhaps can tolerate a smaller margin per head because they are dealing in volume. However, they still will need to pay attention to their products and markets since the quantity of milk will still be relatively small. They may be most efficient if they milk most or all of the year. Sheep dairies in the middle population range will probably struggle the most, since they will not have the advantages that either of the other two sizes of operations will have.

In all size farms, thorough record keeping, financial monitoring, and budgeting are important to financial success. One mistake that people often make in preparing their budgets is that they don't sufficiently budget for losses or potential losses. For instance, what will be your lamb mortality? How many runts will you have? What will be your ewe cull rate? How much bad cheese will you throw away?, etc.

Principle 6: There is no money in value-adding, but there is money in selling value-added products.

Unless you doing custom processing for another farmer, you are not guaranteed an economic return just because you made a value-added product...But, you are guaranteed the extra expense. The money is made when you sell a quality value-added product at a profitable price. It is important to not take for granted the costs of producing value-adding products, especially dairy products. This includes your labor. The price for the farmer's value-added product needs to be sufficient to cover the market price of the milk (\$.70-\$.85/lb for sheep), the costs of the facility, production, marketing, and distribution, as well as an appropriate wage for all of this extra labor. If a farmer is not selling the product for a price that pays for all of these costs, then the farmer needs to consider changing the price of their product or becoming more

efficient or just selling milk (or getting into another venture altogether). Otherwise, the farmer will burn out quickly.

Another option is to pay someone else to do the value-adding if possible, and then the farmer spends their time on marketing and distribution and accounts receivable. This is generally an expected practice when it comes to processing meat, or pelts, or fiber, but has not generally been done for dairy products. However, at least in Vermont, there are some opportunities to do this. In the future, I expect that these opportunities may increase.

Another consideration for those wanting to sell value-added products is that the farmstead dairy product market is currently growing very rapidly relative to demand. Competition is becoming greater in this area. Like any agricultural product, there is a risk of market saturation. There will likely be a downward pressure on price over the next few years, especially if the economy declines. The farmers that will make out the best in this situation will be those that are producing the highest quality products; those that are efficient enough or well enough established to compete on price; those with special niches such as organic producers; and those that have the most direct relationships with the consumers, where the buyers feel a loyalty to support these farmers.

Principle 7: Know your goals and your motivations. Plan based on “quality of life”.

One of the biggest mistakes that I see people make is that they get into sheep dairying for the wrong reasons. For instance, there are people who jump in because they “really like the cheese.” But, if they aren’t committed to farming, they would be better off setting up a cheese-making facility, and buying the milk from, or custom processing for, someone who wants to farm.

Most people underestimate the time commitment of sheep dairying, and farming in general. This can lead to family stress and a diminished quality of life. A few years ago, Mary Falk, a Wisconsin sheep dairy farmer, wrote up a very thorough list of questions that people should ask themselves before jumping into sheep dairying. Among them were, “Who is going to do the laundry?” and “Who is going to watch and care for the children?”

It is important for people to come to this venture with their eyes wide open and to structure their business and farm with a set of family goals (financial, personal, spiritual) placed out in front.

EVOLUTION OF THE MILK PRODUCTION AT THE SPOONER AGRICULTURAL RESEARCH STATION BETWEEN 1996 AND 2004

Yves M. Berger

**Spooner Agricultural Research Station, University of Wisconsin-Madison
Spooner, Wisconsin, USA**

The year 1996 was the first year of milking sheep at the Spooner Agricultural Research Station. The total production for this first year was a modest 24,000 pounds of milk from 136 ewes put at milking. In 2004 the total amount of milk produced at the station was 186,000 lbs with 292 ewes put at milking with an average production per ewe of 755 pounds (331 liters) for adults and 492 pounds (216 liters) for young ewes in first lactation. This level of production is becoming very satisfying and rewarding. The tremendous increase of milk, as shown in Figure 1, has been constant year after year. The greater number of ewes milked, also shown in the same graph, cannot, by itself, explain this increase. Certainly, many factors contribute to a better production, all of them with a cumulative effect. Some of the factors can be quantified such as the amount of dairy breeding, the length of lactation, the weaning systems, but others, such as feedstuff quality, overall management, and acquisition of a “know-how” are much more difficult, if not impossible, to measure.

Genetic Composition of the Flock

As shown in Figure 2, the breeding composition of the flock changed drastically from 1996 to 2004. Originally, the starter flock was composed of Dorset-type ewes mixed with some Romanov or Finnsheep, therefore many ewes that were milked during the first few years had no or little dairy breeding. The percentage of dairy breeding increased regularly. During the first 3-4 years most of the ewes had less than 50% dairy breeding. The number of ewes with 50% dairy breeding reached a peak in 2001. These ewes were replaced by ewes with 75% dairy breeding, which in turn, are now being replaced by ewes with more than 75% dairy breeding.

The East Friesian breed was the first breed used for upgrading using live rams purchased in the United States and Canada, and frozen semen of Dutch and New Zealand origins. In 1998 the Lacaune was introduced in the United States by purchasing live rams from a Canadian producer and by purchasing frozen semen from 3 different rams in England. At this time, no Lacaune could be purchased directly from France. Dorset ewes were crossed with either East Friesian or Lacaune and all female progenies were kept as replacement. Ewe lambs sired by Lacaune were bred by East Friesian rams, and ewe lambs sired by East Friesian were bred by Lacaune rams. The same breeding principle was used every year. In 2004, 85% of the ewes were crossbreds East Friesian x Lacaune in various percentages with a small percentage of Dorset.

One could expect that most of the increase in the overall amount of milk produced, would, therefore, be due to the flock being more and more “dairy”. Surprisingly however, although it certainly contributes, it does not seem to be the most important factor.

Dorset type ewes with no dairy breeding produce the least amount of milk, which is well illustrated in Figure 3. When crossed with a dairy breed (East Friesian or Lacaune), the milk

production doubles. However, there is not a big difference in the milk production of ewes with different percentage of dairy genetics. In 1999 ewes with less than 50% dairy breeding produced almost as much milk as ewes with 75% dairy breeding. In the following years, there was little or no difference between 50%, 75% and more than 75% dairy breeding ewes. Yet almost each year the milk production of each genotype kept increasing. In the early years, the overall production of 1/2 East Friesian – 1/2 Dorset ewes was around 300-350 pounds but was near 700 pounds in 2004.

Perhaps the particular breed composition is more important to the overall production than the percentage of dairy breeding. Figure 5 shows that for an equal dairy percentage of 75%, East Friesian-Lacaune crossbred ewes produce more milk than the 75% East Friesian or the 75% Lacaune. The percentage of EF-Lacaune crossbred ewes grew rapidly from 6.8% of the milking flock in 2001 to 55.8% in 2004.

The average percentage of fat and protein in the milk (all genotypes, age of ewes and type of management confounded), have also improved throughout the years (Figure 4). The increase of the fat percentage is in part related to a higher proportion of Lacaune breeding. The Lacaune breed is known for a higher fat content than the East Friesian.

Dairy “Value” of the Rams Used

It is possible to have an idea of the “value” of the rams used over time by comparing the average production of their daughters. Figure 6 shows that none of the rams (not all rams are shown) used at the Spooner Research Station are of outstanding value. The biggest difference was between the two 50% EF rams used in 1994 and 1995 to start the dairy flock. All other rams, East Friesian from Canada, New Zealand or of Dutch origin are all more or less equal. The same hold true for Lacaune rams of Canadian (Switzerland) or of British origin. Therefore, the increase in total milk production does not come from the use of better rams.

Length of the Milking Period

From 1996 to 2004, the average length of the milking period per ewe went from a little over 100 days to 190 days as shown in Figure 7. The evolution curve of the length of the milking period follows exactly the curve of the evolution of the total milk production. It looks like the lengthening of the milking period is a very important, maybe the most important, contributor to the increase of the total milk production. When, for some reasons, the average length of the milking period was shortened in 2001, the total milk production was also decreased.

The lengthening of the milking period per ewe was achieved with 2 management practices: 1. Lambing and milking earlier in the year: January instead of April. 2. Raising more and more lambs on milk replacer and milking more ewes 24 hours after lambing.

Lambing Earlier in the Year

It seems that there is a strong correlation between the length of the milking period and the photoperiod. Ewes lambing during short days have a longer lactation because more of their

lactation occurs during a lengthening of the days. At the Spooner Research Station ewes are removed from the milking line when their production drops below 1 pound per day. Figure 8 shows that more ewes stay in lactation longer when lambing occurs early in January-February (growing days). Ewes that lambed later with a lactation starting closer to the longest day have altogether shorter lactations therefore more ewes were removed from the milking stand earlier. The persistency of lactation is certainly one of the most important contributors to the overall milk production.

Milking Starting 24 Hours After Lambing

For the first 2 years of milking, practically all ewes raised their lambs for the first 30 days after which lambs were weaned and the ewes put at milking twice a day. The system works well and does not require more labor or expenses than an ordinary lambing. However it does not favor a maximum commercial (measurable and saleable) milk production for 2 main reasons: 1) because of the stress due to lamb separation at the time of the strongest bond of ewe-to-lamb, the milk production of the ewes drops by 30% at the time of weaning. 2) about 25-30% of the total milk production occurs during the first 30 days of lactation. At this stage of lactation there is often more milk produced than even twin lambs can use. Therefore in 1999, two other types of lamb management were introduced. The MIX system (lambs are raised by their dams but the ewes are milked once a day) and the DY1 system in which all lambs are separated from their mother at 24 hours of age and artificially raised, and the ewes are milked twice a day. Although much more expensive and more labor intensive than the other two systems, the DY1 system works well favoring milk production without hindering lamb survivability or growth. The percentage of ewes put in each system each year is shown in Figure 9. When in 2001, because of a trial constraint, more ewes were put in the DY30 and MIX management systems, the overall milk production of the flock was significantly reduced.

Conclusion

The increase in milk production over the years is not due to a single factor but rather to a cumulative effect of several. The inclusion of “dairy” breeds such as the East Friesian or Lacaune is indispensable to reach a decent level of milk production, but the amount of East Friesian or Lacaune over 50% does not appear to be as important. The composition of the genotype (such as both East Friesian and Lacaune included in the cross) however, might be more important. Management improvements (or changes) certainly contributed more to the overall increase in milk production than genetic improvement. The lengthening of the milking period through earlier lambing and milking the ewes a few days after parturition is very important for the overall milk production. One has to keep in mind, however, that with this system, the overall cost of production also increases and in some cases might not be economical. The resources available to the producer in terms of feed, labor, space, desires and objectives have to be examined before adopting a management system.

Figure 1. Evolution of the total production and number of ewes milked at the Spooner Research Station

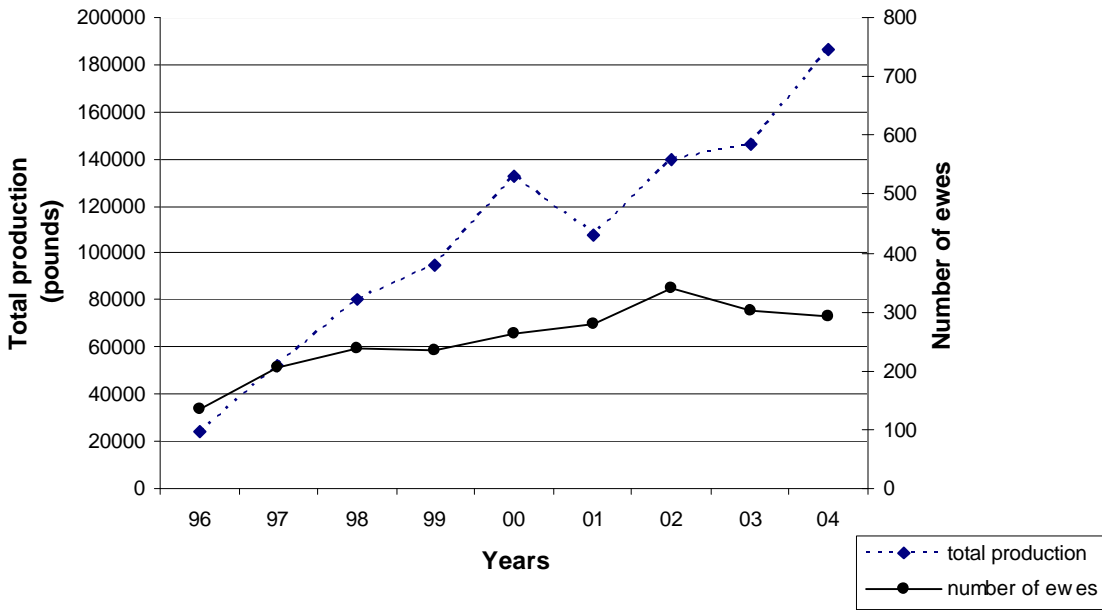


Figure 2. Dairy composition of the flock

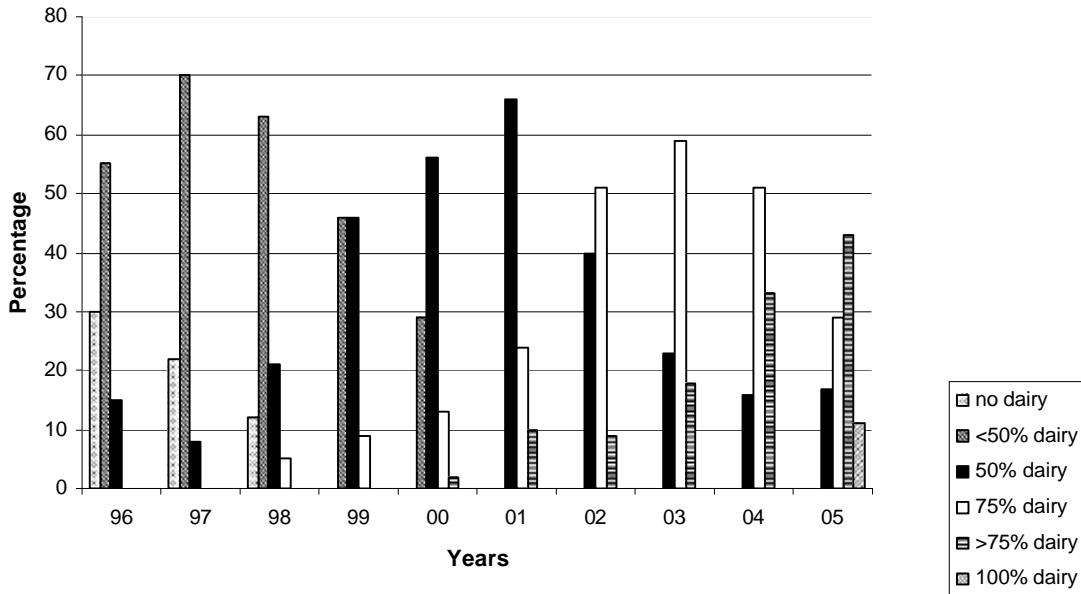


Figure 3. Milk production per ewe according to dairy percentage

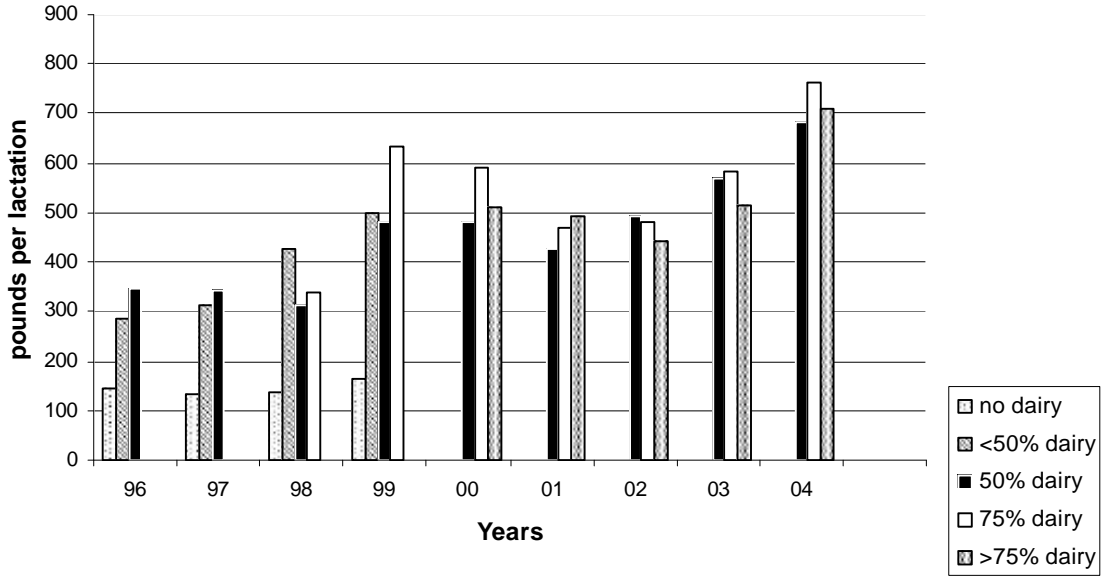


Figure 4. Evolution of the fat and protein percentage through the years

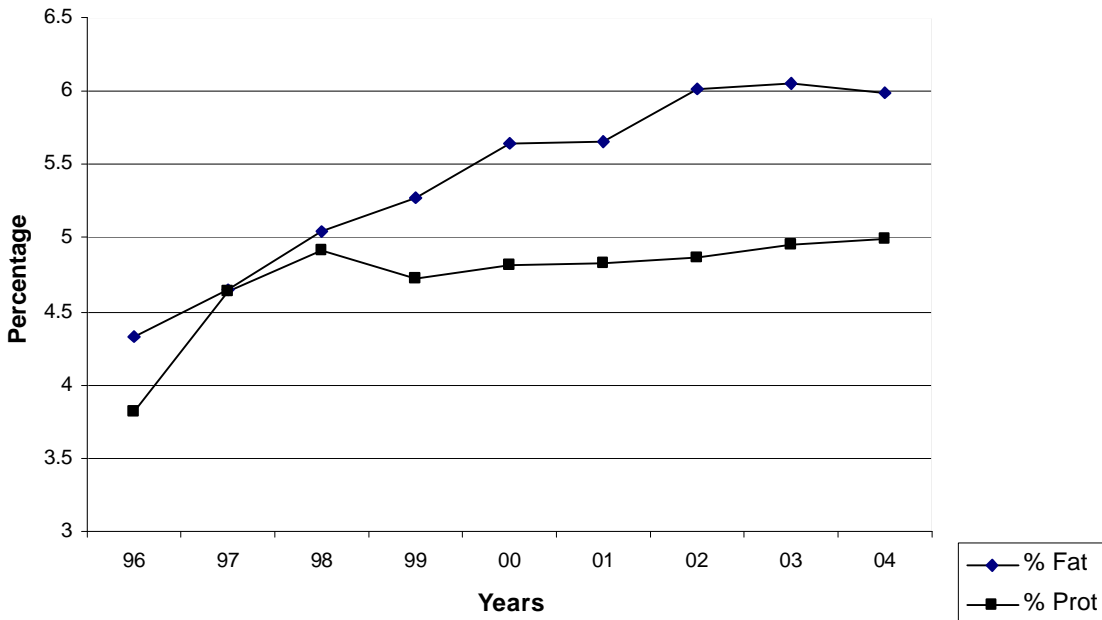


Figure 5. Effect of genotype on the milk production of adult ewes

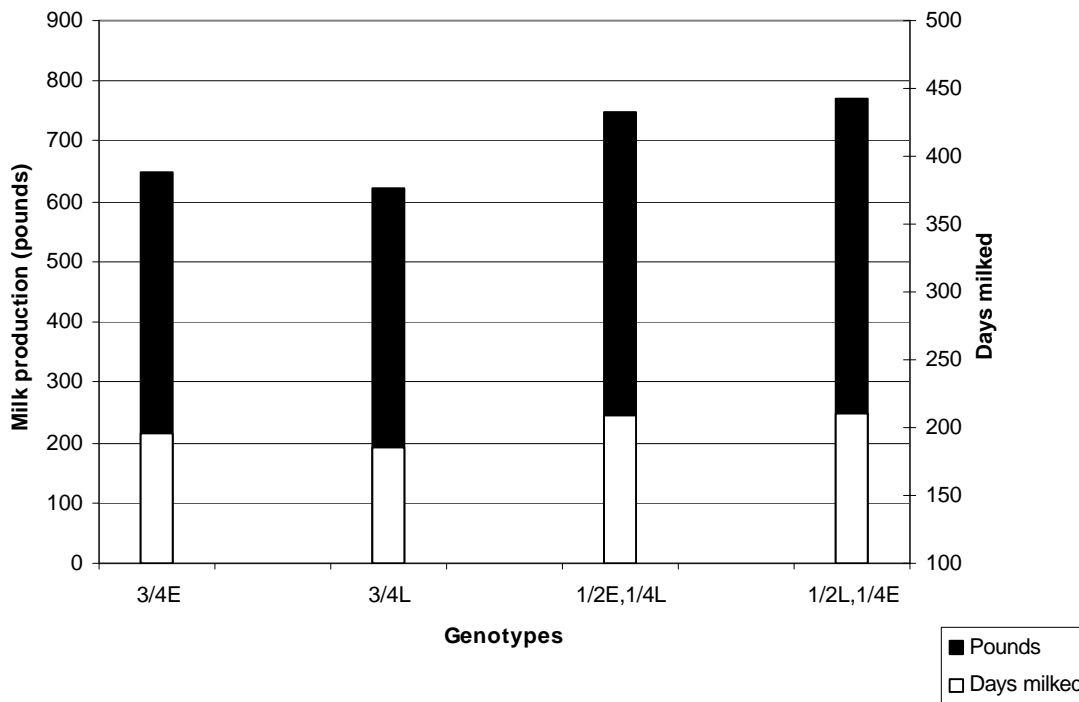
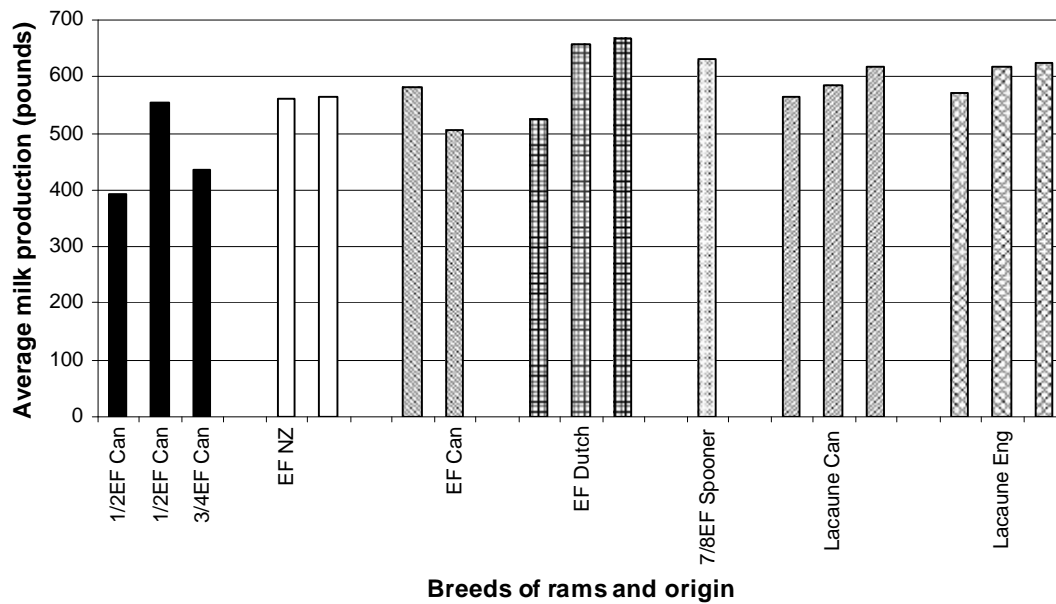


Figure 6. Average milk production of adult daughters of some of the rams used.



**Figure 7. Evolution of the length of the milking period
(Includes all ewes)**

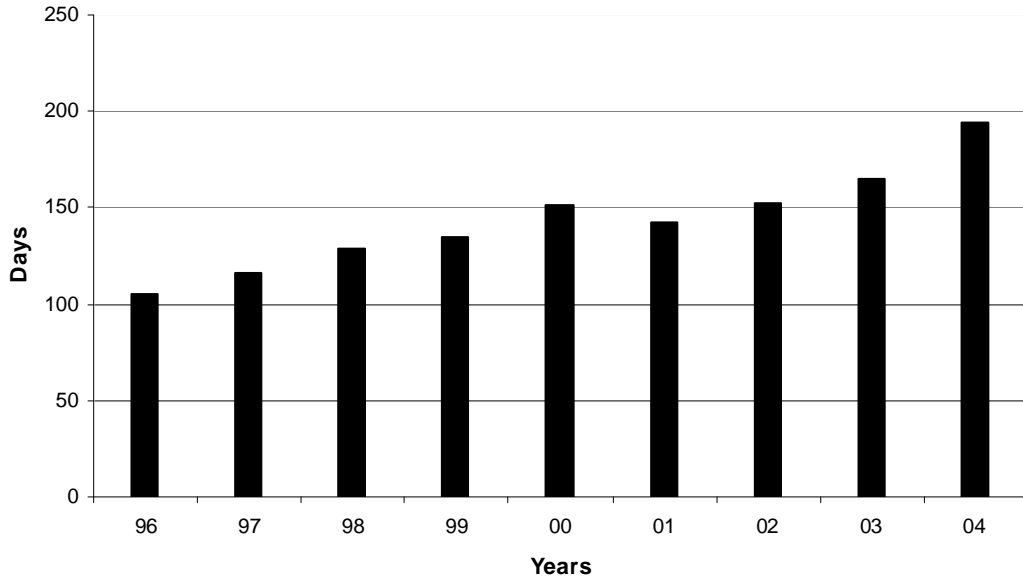
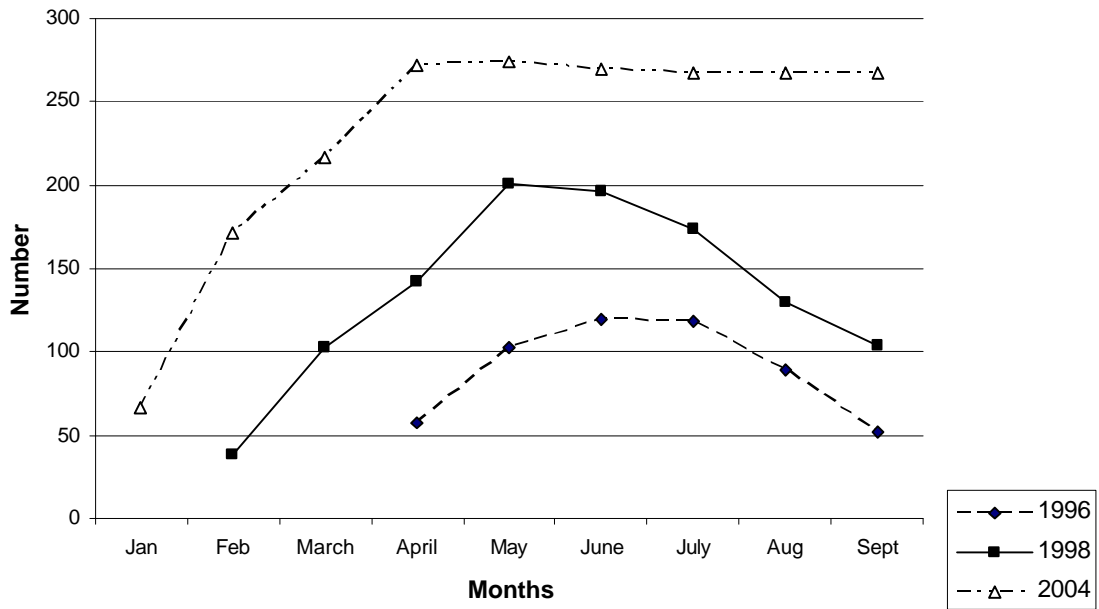
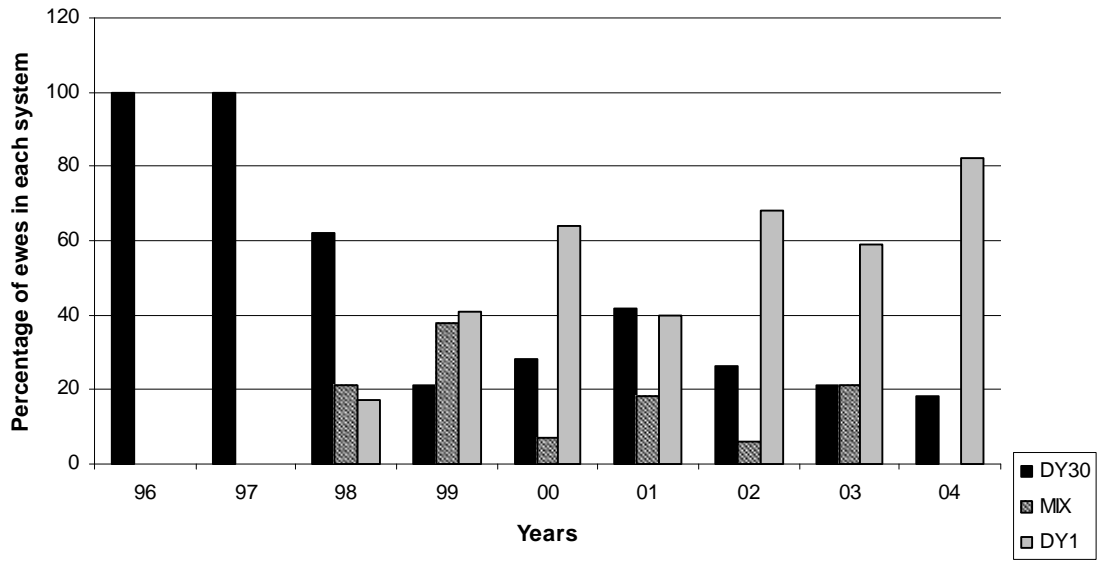


Figure 8. Number of ewes at milking per month



**Figure 9. Evolution of the type of lamb management
(weaning systems)**



STARTING A NEW MILK PROCESSING FACILITY: CONSIDERATIONS AND COSTS

Peter Dixon
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Facilities

These are the basic requirements for different types of dairy products. Some of the different functions in the processes of making dairy products for commercial sale must be done in separate rooms to prevent cross contamination of pasteurized milk with raw milk and finished products with packaging materials. The different rooms needed for making a variety of dairy products are outlined below.

1. Raw Milk Cheeses - aged more than 60 days:
 - production room
 - mechanical room
 - aging and brining room(s)
 - packaging/shipping room

2. Soft-ripened Cheeses from pasteurized milk, e.g., Camembert, Brie, Muenster, Brick, and Limburger:
 - raw milk receiving/storage room
 - pasteurization/production room
 - mechanical room
 - salting/drying room: 80% relative humidity (RH), 60-65 °F
 - aging room: minimum 95% RH, 45-55 °F
 - finished product cooler: ambient RH, 34-40 °F
 - packaging/shipping room

3. Fresh Cheeses from pasteurized milk, e.g., Chevre, Cottage, and Ricotta:
 - raw milk receiving/storage room
 - pasteurization/production room
 - climate controlled draining room; refrigerated for Ricotta
 - mechanical room
 - finished product cooler: ambient RH, 34-40 °F
 - packaging/shipping room

4. Fluid and Cultured Milk Products:
 - raw milk receiving/storage room
 - pasteurization/production room
 - mechanical room
 - finished product cooler: ambient RH, 34-40 °F
 - packaging/shipping room

5. Ice Cream and Butter:

- raw milk receiving/storage room
- pasteurization/production room
- mechanical room
- finished product cooler: ambient RH, 34-40 °F for ice cream mix and butter storage
- packaging/shipping room
- freezer/hardening room for ice cream

Other Considerations:

An entry room to the processing room is an excellent idea. It helps to keep the production room clean. The entry room can have many functions, such as a worker changing area, a visitor viewing area, and a store. It should be sized according to the specific needs of the business. A footbath can be placed in the doorway on the production room side. Visitors should not be allowed to come into the processing room unless they put on clean boots or shoe covers.

The mechanical room should be large enough to contain the furnace or boiler, circulator pumps, hot water heater, the electrical panel, an air compressor (if needed), and space for tools and spare parts. If an ice water chiller is being used, there should also be a space for it outside of the processing room, although the boiler room may not be the best choice.

Construction: Key Points (often overlooked):

- concrete knee walls in all rooms for storing milk, processing milk, and aging rinded cheese so that there is no wood below two feet above the floor
- floors sloped correctly to drains to prevent puddles
- sloped window sills with epoxy paint or marine varnish
- as little wood as possible in the processing room
- metal doors
- sealed concrete, epoxy-coated, aggregate, acrylic or tiled floors
- fiberglass paneled interior walls
- covered light fixtures
- separate washing room and kiln for washing and drying wooden shelving adjacent to cheese aging room
- cheese cellars and caves are more energy efficient and have higher natural humidity than above-ground cheese aging rooms
- ventilation fans are needed in the milk processing and storage rooms
- ventilation in cheese aging rooms should be sufficient to prevent build up of ammonia; for soft-ripened cheeses 98 feet per minute air speed is required

Equipment

The following list has some options depending on which products are made. For example, a cream separator is not needed unless some products are made from low or high fat milk, and a curd mill is used for Cheddar and other English-style cheeses. If the milk processing room is attached to the barn, the milk can be pumped directly to the vat or pasteurizer. A clean-in-place

(CIP) stainless steel pipe loop is needed to clean out the delivery line unless the piping can be taken apart and washed by hand. If the processing facility is by itself, the milk can be hauled in cans or in a stainless steel or food grade plastic tank.

1. Raw Milk Cheeses - aged more than 60 days:

- furnace or steam boiler
- milk pump and hauling tank or milk cans
- stainless steel piping and/or milk hose
- vat
- cream separator
- drain table and/or press table
- hoops and followers for forming wheels and blocks of cheese
- cheesecloth
- drain matting
- milk stirrer and other tools, e.g., curd fork, shovel, squeegee
- curd harps
- curd scoop and/or pail
- curd mill
- vacuum sealing machine and/or waxing system if rindless cheese is made
- weights for direct pressing, e.g. water jugs, gym weights
- cheese press: compressed air or hydraulic or lever-action
- wooden boards and drying kiln or metal shelving with plastic matting
- whey removal system: pump, hose, and stock tank or bulk tank
- hot water kettle for “pasta filata” cheeses

2. Soft-ripened Cheeses made from pasteurized milk:

- furnace or steam boiler
- milk pump and hauling tank or milk cans
- stainless steel piping and/or milk hose
- vat or tubs or basins
- vat or HTST pasteurizer
- air compressor if using HTST
- cooling water system. e.g. ice water chiller
- cream separator
- drain table
- Single forms or block forms for forming the wheels and other shapes
- cheesecloth
- drain matting
- milk stirrer
- curd harps and/or ladles
- curd scoops
- whey removal system: pump, hose, and stock tank or bulk tank
- hot water kettle for “pasta filata” cheeses

3. Fresh Cheeses made from pasteurized milk:
 - furnace or steam boiler
 - milk pump and hauling tank or milk cans
 - stainless steel piping and/or milk hose
 - vat or tubs or basins
 - vat or HTST pasteurizer
 - air compressor if using HTST
 - cooling water system, e.g. ice water chiller
 - cream separator
 - drain table
 - hoops
 - drain bags or cheesecloth
 - drain matting
 - milk stirrer
 - curd harps and/or ladles
 - curd scoops
 - whey removal system: pump, hose, and stock tank or bulk tank
 - filling/sealing machine or filling machine and hand sealer or vacuum sealer and hot water dip
 - hot water kettle for “pasta filata” cheeses and ricotta

4. Fluid and Cultured Milk Products:
 - furnace or steam boiler
 - milk pump and hauling tank or milk cans
 - stainless steel piping and/or milk hose
 - vat or HTST pasteurizer
 - air compressor if using HTST
 - cooling water system, e.g. ice water chiller
 - cream separator
 - homogenizer
 - plate cooler
 - surge tank
 - batch tanks for flavors and standardizing
 - Milk bottling machine and capper
 - filling/sealing machine or filling machine and hand sealer for cultured products
 - bottle washer for glass bottles
 - incubation chamber for cup-style yogurt

5. Ice Cream and Butter:
 - furnace or steam boiler
 - milk pump and hauling tank or milk cans
 - stainless steel piping and/or milk hose
 - vat or HTST pasteurizer
 - air compressor if using HTST
 - cooling water system, e.g. ice water chiller
 - cream separator

- homogenizer
- plate cooler
- batch tanks for aging, flavoring and standardizing
- butter churn
- ice cream freezer
- fruit feeder
- filling machines
- freezer for finished products

Other possibilities:

These pieces of equipment may or may not be necessary:

- insulated storage tank
- refrigerated storage tank (farm bulk tank)
- ice water chiller (also know as an ice builder)
- centrifugal pump for pumping raw milk and/or whey
- positive pressure pump for pumping curd and/or soft cheeses and cultured products
- refrigerated delivery truck
- freezer delivery truck
- jet-recirculation parts washer

Regulations

The “Grade ‘A’ Pasteurized Milk Ordinance” (PMO) is the FDA’s regulation book for the dairy industry, which sets down rules for the production of milk on farms, quality/safety standards for raw milk and milk products, and rules for the processing of milk and for construction of facilities.

Each state has a regulation book that is taken from the PMO. The Vermont Agency of Agriculture, Food and Markets has published a Vermont dairy regulation handbook, which is a simplified version of the PMO. If you are considering starting a milk processing business, it is a very good idea to contact the Dairy Division inspector in your state who will be inspecting you, invite him out and go over your plans together. This way, you will have a very clear idea of the regulations from the beginning.

The Federal Code of Regulations (CFR) contains legal definitions of all dairy products. If a certain product is not listed, there is no legal criteria for how it is made or Federal standards for its composition. For example, there are Federal composition standards for chocolate milk, low fat yogurt, and Cheddar and Cottage cheeses but there are none for Chevre, Brie, and Leicester cheeses. The CFR also sets down “Good Manufacturing Practices” (GMP’s) for food production, which are used as guidelines for personal hygiene and safe food production. These are worth reading to find out where the inspectors are coming from and what they are looking for in terms of a sanitary operation.

The Vermont Cheese Council (www.vtcheese.com) has published a “Code of Best Practice,” which sets down GMP’s used in making, aging, and selling cheese. There is also a section on creating a Hazard Analysis and Critical Control Point (HACCP) program for a cheese business. The same concepts are adaptable to businesses making other processed milk products. It is wise to become familiar with HACCP because this is the direction that the milk industry is moving in to produce safer dairy products.

The Dairy Practices Council (www.dairypc.org) publishes “guidelines” concerning issues such as animal housing, parlor construction, vacuum pump installation, waste management, cleaning and sanitation, milk quality, and HACCP systems for the dairy industry.

The interpretation of the PMO varies from state to state. Vermont has a relatively relaxed regulatory climate compared to other states. The days of legal retail sales of bottled raw milk are gone, but the inspectors will work with small-scale milk processors to find solutions to burdensome regulations, e.g., innovative vat pasteurizer designs and using wooden shelving for aging cheese. Listed below are some of the important aspects of the regulations that must be considered for the farmstead milk processor:

1. Construction of milking parlor and milk storage room
 - smooth, impermeable materials
 - easily cleaned
 - covered floor drains
 - well ventilated
 - separate hand washing sink and towels
 - screens to keep out flies and rodents
 - mandatory monthly milk testing for antibiotics, total bacteria, fat, and somatic cells; results must be posted in the milk room

2. Construction of production, storage and aging facilities
 - smooth, impermeable materials
 - easily cleaned
 - covered floor drains
 - well ventilated
 - separate hand washing sink in production room and towel dispenser
 - bathroom in the production facility if there are employees other than immediate family members working in the business
 - physically separated raw storage and receiving area if making pasteurized dairy products
 - protocol for board sanitation if using wooden shelving for aging cheese
 - product contact surfaces must be stainless steel or food-grade plastic
 - welds on all milk/product contact surfaces must be “3A”, which means highly polished (expensive to make)
 - coolers and cheese aging rooms do not need drains but the floors must be sloped to the doorways so that they can be cleaned and dried
 - storage tanks that are cleaned in place must have chart temperature recorders to show time/temp of milk storage and cleaning cycle

- each batch of milk must be tested for antibiotics using a rapid analysis (Penzyme, Snap, Charm) before it is processed; results are posted in plant for official review
- potable water supply; inspected every six months
- State inspection of facilities every three months
- plan for whey disposal

For the processor who is purchasing milk from other farms:

3. Additional requirements to those listed above
 - must be bonded or have guaranteed letter of credit
 - must give farmer 90 days notice prior to terminating milk purchases
 - is responsible for carrying out mandatory milk testing
 - in the case of transporting milk in a mobile tank, there must be a separate enclosed washing facility with a floor drain and hot and cold water
 - for transporting milk in cans, a separate washing bay is not required
 - milk handler’s license is required for all people in the business who are involved in transporting milk and receiving milk (if farmers deliver their own)

Start Up Costs

The costs of starting a milk processing business vary widely depending on the choice of products, the scale of operations, and design and materials used for construction. A reasonable budget includes the costs of constructing the facility, purchasing equipment and installation, and marketing operations. The facility is either built into an existing building, added onto the existing milk storage room of the barn, or a new building is constructed. A facility producing 20,000 lb. of cheese, which includes all of the necessary rooms, will be 1,000 to 2,000 square feet. In very general terms, the interior work for a milk processing facility of this size will cost around \$50,000. The choice of flooring is the largest single factor in the total cost; acid-resistant brick flooring is around \$17 per square foot. A specialized cheese aging room, such as a concrete cave, will add another \$50,000 to the cost.

Equipment costs have the widest variation. Sometimes used equipment bargains can be found and it may only take \$10,000 to get set up to process milk. On the other hand, the cost of new equipment for making fresh dairy products may be \$100,000. A moderate budget for raw milk cheese making is \$25,000. In budgeting, installation costs are often overlooked. Estimates are needed for boiler hook ups and stainless steel pipe welding jobs. The list below includes some of the common costs for milk processing equipment for a farm producing 400-600 liter of milk per day. These can be used to develop a budget.

| | |
|--|----------|
| 1 x 1,200 liter Cheese Vat w/ agitator and curd knives (new) | \$15,000 |
| 1 x 50 gallon Vat Pasteurizer (used)..... | 5,500 |
| Pasteurization controls and Steam filter..... | 3,500 |
| 1 x 7.5 HP (60,000 BTU/hr.) Steam Boiler (new)..... | 8,000 |
| Boiler Condensate return system..... | 3,000 |

| | |
|--|--------|
| 1 x Brine Tank (10' long x 3 ft. wide, used) | 1,500 |
| 2 x Work tables (6' long, used) - \$250 ea. | 500 |
| 1 x Cheese Press and Drain Table (used)..... | 2,000 |
| 1 x Centrifugal Milk pump and dump station (new) | 800 |
| 25 x 10 lb. Cheese Hoops (\$215 ea., new)..... | 5,375 |
| 20 x Camembert cheese Block-forms (\$335 ea., new)..... | 6,700 |
| 240 x Cheese Aging racks (stainless steel wire, \$25 ea., new) | 6,000 |
| 50 x 5 lb. Cheese Hoops (\$50 ea., new)..... | 2,500 |
| 10 x 20 lb. Cheese Hoops (\$150 ea., new)..... | 1,500 |
| Ice cream Freezer (10 gallon batch, new) | 20,000 |
| Cream Separator (100 gallon/hour, open bowl, used) | 800 |
| Cream Separator (200 gal. cold, 400 gal. hot/hour, closed bowl, used) | 9,500 |
| Homogenizer (400 gal. per hour)..... | 12,500 |
| Ice water chiller (3 HP)..... | 6,000 |
| Walk-in Cooler (6 ft. x 6 ft., with refrigeration, new) | 6,000 |
| Walk-in Freezer (6 ft. x 6 ft., with refrigeration, new) | 6,000 |
| Refrigeration and Fresh Air Recovery ventilation system (in a room for aging 20,000 lb. cheese per year)..... | 14,000 |
| Cheese Aging boards and posts..... | 4,000 |
| Vacuum sealer and hot water dip tank | 9,000 |

A budget for marketing operations is needed to ensure that there are funds for labels, packaging and shipping materials, sales, service, product samples, promotion, web site development, etc. These costs typically are estimated at 15-20% of anticipated gross sales during the early years of the business; they may decrease to 8-10% once the business has established a solid reputation.

A few additional considerations will help in developing start up budgets. These include:

- shrinkage/waste of product, which is made but not of sufficient quality to sell: count on 20% during first year, 5% is the normal operating amount and is an achievable goal within 5 years of start up
- set your prices based on what you need to carry the operation; there should be a 40% profit margin above the production cost, which is what it costs you to get the product ready for sale before sales and distribution costs are factored
- make high-priced products in limited quantities thereby increasing demand

SAMPLE OPERATING CASH FLOW ANALYSIS

| | Year one | Year two | Year three | Year four | Year five |
|--|------------------|------------------|------------------|------------------|------------------|
| Lb. Milk used | 61,600 | 100,000 | 180,600 | 240,800 | 301,000 |
| Lb. Cheese made | 12,320 | 20,000 | 36,120 | 48,160 | 60,200 |
| Yield (Lb. milk/lb. cheese) | 5 | 5 | 5 | 5 | 5 |
| SALES: | | | | | |
| Cheese: (20% retail @ \$20/lb. + 80% wholesale @ \$12/lb.) | 167,552 | 272,000 | 491,232 | 654,976 | 818,720 |
| | | | | | |
| EXPENSES: | | | | | |
| Licenses, Permits and Fees | 1,200 | 1200 | 1,200 | 1,200 | 1,200 |
| Cheese Ingredients: (\$2.50/cwt for rennet, salt & cultures) | 1,540 | 2,500 | 4,515 | 6,020 | 7,525 |
| Milk (\$100/cwt) | 61,600 | 100,000 | 180,600 | 240,800 | 301,000 |
| Energy: (oil, electric, & wood) | 2,500 | 4,000 | 6,000 | 7,980 | 10,613 |
| Insurance (liability) | 2,500 | 2500 | 2,500 | 2,500 | 2,500 |
| Loan (\$60,000@5%x7 years) | 5,300 | 10600 | 10,600 | 10,600 | 10,600 |
| Outside Labor (\$12/hr.) | 12,480 | 16,598 | 22,076 | 29,361 | 40,000 |
| Marketing (20% Of Sales): (sales, packaging, shipping distribution, & service) | 33,510 | 54,400 | 98,246 | 130,995 | 163,744 |
| Cheese Room Supplies: (incl. cleaning supplies) | 500 | 600 | 800 | 1,000 | 1,200 |
| Office Supplies | 300 | 400 | 600 | 900 | 1,200 |
| TOTAL EXPENSES | \$121,430 | \$192,798 | \$327,137 | \$431,356 | \$539,582 |
| Total Cost/lb. | \$9.86 | \$9.64 | \$9.06 | \$8.96 | \$8.96 |
| RETURN TO Owner's Labor | \$46,122 | \$79,202 | \$164,095 | \$223,620 | \$279,138 |
| PROFIT MARGIN before distribution | 38% | 39% | 43% | 44% | 44% |
| Cheese Production Cost/lb. before distribution | 7.14 | 6.92 | 6.34 | 6.24 | 6.24 |

LAMB REARING STRATEGIES: FARMER PANEL EXPERIENCED FARMERS DISCUSS PROS AND CONS OF DIFFERENT WEANING SYSTEMS

**Beth Slotter
Old Chatham Shepherding Company
Old Chatham, New York, USA**

The lamb rearing strategy used at the Old Chatham Shepherding Company (OCSC) is designed to maximize milk production for cheese making. Therefore, all lambs are raised separately from the ewes.

Bred ewes are checked approximately 60 days after breeding to determine if the ewe is actually pregnant. All pregnant ewes are on pasture until one month prior to lambing, when they are brought into the lambing barn. During the last month of pregnancy, the ewes are fed a custom total mixed ration to raise the quality of their nutrition, preparing them for lambing and lactation. The ewes lamb in a common pen and, after birthing, they are placed in a jug with the lambs for 1 – 4 days.

Shortly after birth, lambs are tagged if they are to be kept as replacements. Replacement lambs are chosen based on their mother's milk production history or an estimated breeding value that is used to predict a ewe's potential milk production. Any lambs not being kept for replacements are sold to farms in the area that raise them for meat. Space limitations dictate this practice.

After about four days, replacement lambs are moved to a greenhouse barn, where they are initially bottle fed with milk replacer. The milk replacer is custom mixed and contains 30% protein and 25% fat to encourage a faster rate of gain. After 2-3 days on bottles, the lambs are trained to eat from automatic Lak-Tec machines. Lambs have access to the machines 24 hours a day. A week later, the lambs are also provided with a free choice custom mixed creep ration that contains 25% protein and grass hay. The automatic milk machines have eliminated lamb deaths due to bloat and the machines save a great deal of labor.

The greenhouse barn has a blacktop floor, which is easy to clean. The barn is thoroughly cleaned on a weekly basis. A stall-drying product is added to bedding during humid weather to absorb ammonia fumes and to keep the bedding drier, thus minimizing disease. The greenhouse barn is well ventilated with an open ridge vent, and sides roll up. Fans are in the corners, and large aisle fans are used in the summer to improve ventilation.

Lambs are weaned off the milk replacer shortly after they reach one month of age. They are kept in the greenhouse until two months of age, so they can become adjusted to their new diet. At two months they are moved to another building, which is three sided and well ventilated. They are fed a custom milled grower grain that contains 18% protein and high quality hay that typically is mostly grass with some alfalfa. Depending on the weather, the lambs are moved to pasture at 4-6 months of age. The last inside feeding step has improved growth rates significantly and allows breeding at less than one year of age.

The above strategy, while labor intensive, allows for careful treatment of both ewes and lambs, resulting in significant numbers of healthy replacement lambs being raised throughout each year.

BONNIEVIEW FARM'S LAMB REARING STRATEGIES

**Neil Urie
Bonnieview Farm
Craftsbury Common, Vermont, USA**

We started milking sheep in 1999, and for the first four seasons, we left the lambs on the ewes for at least one month, and then started milking as the lambs were weaned. In 2003 we constructed a greenhouse barn for the lambs. We took the lambs off their mothers at one day old, and put them into group pens in the greenhouse where they were fed from nipple buckets with their mothers' milk as well as milk replacer. In the last three seasons, the systems have been modified slightly to better meet our and the lamb's needs.

In 2005 the lambing season started on April 10. In the morning, we took any lambs off their mother who were healthy, nursing well, and at least 12 hours old. The lambs were moved down to the greenhouse barn where 280 pens were set up, each roughly 5'X12'. Most mornings there were between 12-30 lambs to be moved to the greenhouse. The greenhouse has a dirt floor and a generous amount of straw on top.

For lambs less than a week old, the population per pen was between 10-15 lambs, and the only furniture in the pen was a four gallon bucket with ten nipples. Training them to the nipples would take place in the early afternoon after they had gotten hungry. As the lambs were taken, ewes were milked twice a day, and all of this milk was fed back to the lambs until a majority of the lambs were weaned.

At two weeks old, the lamb population per pen is reduced to ten lambs per pen or one lamb per nipple. Grain was offered free choice at nose level, and good second cut hay was available in hay racks. They were given their mother's milk in the morning and evening immediately after milking, and in the middle of the day, they were given milk replacer as needed so the buckets were rarely empty.

At three weeks and older, the pens were opened up, and four pens would become one big pen with four buckets. Each bucket in the pen would receive at least 4 gallons of milk in the morning and evening, and then in the middle of the day they would be given 4-6 gallons of milk replacer. They would become hungry in between feedings and consume more grain and hay. They would also have access to a paddock outside the greenhouse where they were introduced to grass and electric fence. As the lambs reach 32-40 lbs each, they were sold to customers who came to the farm to pick them up or they were moved to our pastures.

The problems this year that I would like to address for next year would be bloat among the older lambs and bucket maintenance. As the pens were opened up, there would be a feeding frenzy on the first bucket in the pen filled and the swarm of lambs wouldn't move to the next bucket until that one was empty. I feel that this rapid consumption of milk on top of grain would cause more cases of bloat than might naturally occur. When there was less than one hundred lambs we cleaned the buckets regularly but when the numbers went into the three hundreds, the

cleanings per week went way down. Other problems we would like to address would be lambs taking straws out of the buckets, rendering the nipples useless, and lambs nursing each other.

REARING LAMBS AT 3-CORNER FIELD FARM

**Karen Weinberg
3-Corner Field Farm
Shushan, New York, USA**

- I. Preparation of Ewes (prior to lambing)**
 - A. Free-choice selenium/vitamin E/salt
 - B. C,D&T booster
 - C. Coccidiostat

- II. At Lambing**
 - A. Open area for lambing (with access to outdoors)
 - B. Traditional jugs (for ensuring colostrum intake)
 - C. Grafting (goal of 2 lambs/ewe)

- III. 24-Hours Post Lambing**
 - A. BO-SE
 - B. Dock
 - C. Tag
 - D. Lambing order ID with dam

- IV. Lamb Creep in Barn (within 2 weeks of lambing)**
 - A. Day – pasture with Dams
Night – access to inside creep area with food & water
 - B. Quality hay
 - C. Lamb pellets with transition to whole corn & soybeans
 - D. Water with coccidiostat

- V. Weaning**
 - A. Weaning strategies: 30-Day
 Milk once-a-day
 45-Day
 - B. Worm, vaccinate, coccidiostat
 - C. Back on pasture as soon as possible
 - D. Supplement with whole, dry corn on pasture

- VI. Post-Weaning Strategies**
 - A. Ram lambs and ewe lambs separated at 3 months of age
 - B. Worm only as needed
 - C. 1/2 pound whole, dry corn on pasture
 - D. Intensively grazed – moved every other day (125-150/group)

VII. General Strategies for Lamb Health, Replacement Ewes and Meat Quality

- A. Replacement ewe lambs are handled and treated as all other lambs.
- B. Reduce stress as much as possible (i.e., consistent feeding schedule, gentle handling and moving, etc.)
- C. Minimize medications (e.g., wormer) by targeting individuals

PROFITABILITY OF SMALL RUMINANT FARMSTEAD DAIRY PROCESSING OPERATIONS

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Problem Statement

To paraphrase Mark Twain a bit out of context, “Everyone talks about value-added dairy operations but no one does anything about it.” There is a huge void of data on the profitability of farmstead dairy processing operations available for farmers, extension specialists, and lenders. There is even a greater lack of information when done with small ruminants. Extension specialists from across the country report getting increasingly more calls from farmers interested in doing their own processing. But the only information available comes from spot and second hand reports.

To help bridge this gap, Cornell University Program on Dairy Markets and Policy, in cooperation with University of Vermont Extension researchers and the Wisconsin Department of Agriculture, Trade & Consumer Protection, developed a study in 2004 to examine the profitability of farmstead dairy processing operations. The study included cow, sheep, and goat operations with production of fluid milk, cheese, yogurt, and ice cream.

The purpose of the study was to examine the financial performance of small-scale dairy processing businesses for profitability, investment, and markets. The results of the study would provide information to individual processing businesses on their financial performance as compared to others in a similar business. In addition, the study would provide educators, animal industry groups, and policymakers updated information on the financial status of these enterprises. So Mr. Twain, someone decided to do something about obtaining information on value-added farmstead cheese operations.

Study Methodology

The targets of this study were farmsteads attempting to capture additional profits from performing value-added processing and marketing of their own dairy products. The researchers’ initial criteria for farms to participate in the study were farms that produced and processed their own milk. An additional requirement was that the farms had to have been involved in processing milk for more than one year so to eliminate immediate start-up operations.

Initial producer identification was obtained from the respective state agencies for dairy product licensing and inspection. Then all farmers were contacted by mail inviting them to participate in the study. The letter informed the farmer we would need all sales and production

data for 2003. Each producer was offered a stipend for his or her time and efforts. Farmers were then contacted by phone and appointments were then set up for a researcher to visit the farm to gather the financial data. Farmers were then paid for their participation.

The data that was collected included farm receipts and expenses, processed product receipts and expenses, crop production, milk production, quantities of product produced, inventoried, and sold, markets where sold, and prices. Balance sheets were also compiled to measure changes in accounts payable, accounts receivable, inventories of feed, animals, and product, and value of farm and processing assets and liabilities. Distinctions were made on the expenses and receipts as to what was considered farm production and what was considered part of the processing sector. Farm debts were applied on a percentage of assets assigned to the farm for processing. For example if 10% of building use was for processing, product storage, and sales, then 10% of long term debt was assigned to the processing sector. Collecting data in this manner permitted the researchers to examine the financial performance of farm and processing sectors individually to provide a fair comparison.

The data was analyzed at Cornell University by Pro-Dairy with the use of software used to analyze and produce the Cornell University Dairy Farm Summary each year. A few modifications were incorporated to account for the enterprise accounting approach. All milk used in processing was “sold” by the farming enterprise to the “processing” enterprise at market prices. The enterprise analysis approach enabled us to ask which business was most profitable and, furthermore, is the farm better off from specialization.

In all, 27 farms were involved in the study from Wisconsin, New York, and Vermont. Of these farms, 10 farms were small ruminant, with 7 goat producers and 3 sheep producers. There are two problems with the data presented below. For one, 10 farms is not a very large sample and it becomes difficult to draw any major conclusions. For two, the sample is not random, with only farms willing to participate in the study involved.

Farm Descriptions

The study results presented in Table 1 are from 7 goat and 3 sheep farms. Farmers reported “farming” for an average of 10 years and “processing” for an average of 6 years. One farmer had been involved in processing for 16 years. The average farm had 31 acres of pasture and 26 acres of crops. One farm had a minimum of 3 acres. The farms averaged 87 producing animals with a maximum of 300. The average was influenced by 2 farms with more than 200 head. Milk production ranged from 163 to 2300 lbs per animal with the higher production going to the goats.

Milk production ranged from 12,000 lbs. to more than 332,000 lbs., averaging a bit more than 66,000; quite a range of farm production. Of this milk, not all was processed. Some was sold to other farmers, markets, or on-farm milk sales. Cheese was the most popular product, with 8 farms averaging 5867 lb. of cheese. One farm produced fluid milk and 1 farm produced yogurt.

Table I. General Farm Description

Location of Participating Farms

| | |
|-----------|---|
| Vermont | 6 |
| New York | 3 |
| Wisconsin | 1 |

| | <u>Average</u> | <u>Minimum</u> | <u>Maximum</u> |
|-------------------------------------|----------------|----------------|----------------|
| Years in Farming | 10 | 1 | 20 |
| Years in Processing | 6 | 1 | 16 |
| Farm Size | | | |
| Owned and Rented Tillable Acres | 46 | 0 | 130 |
| Acres Crops for Dairy Herd | 26 | 0 | 120 |
| Acres Pasture | 31 | 3 | 110 |
| Number of Mature Animals | 87 | 24 | 300 |
| Milk Production | | | |
| Total Milk Production (lbs) | 66,743 | 12,242 | 332,000 |
| Milk Lbs Per Animal | 892 | 163 | 2,300 |
| Farm Milk Used in Processing (lbs) | 56,973 | 2,242 | 246,000 |
| Total Milk Used in Processing (lbs) | 57,710 | 4,242 | 246,000 |
| Dairy Processing Product | | | |
| Lbs Cheese Production (8 farms) | 6,371 | 0 | 24,203 |
| Lbs Cheese Sold | 5,867 | 0 | 21,657 |
| Gallons Fluid Production (1 farm) | 3,020 | 0 | 30,202 |
| Gallons Fluid Product Sold | 3,020 | 0 | 30,202 |
| Gallons Yogurt Production (1 farm) | 22 | 0 | 215 |
| Gallons Yogurt Sold | 22 | 0 | 215 |

Marketing

The farms in the study utilized different types of markets. Not all farms used every type of market, but most farms used at least 2 marketing channels (Table 2). The reported results are weighted by quantity of product sold. Wholesalers were the top outlet and provided a safety outlet for surplus product. The next most popular market outlets were farmers markets and traditional retailers as grocery stores. Prices are not reported in this report, but highest prices were generally received at farmers markets.

Reasons for Entering Processing

The farmers were asked about their reason for starting dairy processing. The reasons were evenly split between economic and lifestyle (Table 3). Economic reasons included making best use of resources and finding processing the best way to add extra income. These people saw processing as a definite plus for additional income. Just as important were the lifestyle reasons.

Many see cheese making as an attractive lifestyle that they find desirable. Although we did not collect data by sex, a number of the smaller operations were started and operated by women who saw it more likely as an extra enterprise. The bigger operations that were full time often involved both spouses. So from this evidence, one could infer that the lifestyle reason was related to smaller operations.

Table 2. Market Outlets for Dairy Products (As % of Weight)

| | <u>Average</u> | <u>Minimum</u> | <u>Maximum</u> |
|----------------------|----------------|----------------|----------------|
| Farm Stand | 2 | 0 | 10 |
| Farmer's Market | 23 | 0 | 80 |
| Traditional Retailer | 20 | 0 | 90 |
| Other Retailer | 12 | 0 | 63 |
| Wholesaler | 38 | 0 | 98 |
| Other | 4 | 0 | 13 |

Table 3. Reasons for Trying Dairy Processing

Economic

- Better use of labor and other farm resources (2)
- Farm cannot survive at small-scale production. Cheese brings additional business.
- Always wanted to farm. Value added with goats seemed like only viable way.
- Increased income compared to farming or other occupation

Lifestyle

- Allows for an attractive life style (2)
- Interested in making cheese
- Was told wouldn't be able to do it - retired so took the challenge.
- Always intrigued by cheese making and living independently

Balance Sheet

The business balance sheets are reported on Table 4 and separated by farm and processing enterprises. The farms averaged an asset distribution ratio of 4:1 of farm to processing assets. The three farms with the highest farming assets had the highest value in processing facilities. Several of the farm values were influenced by high real estate prices. One aspect of this study was the wide range of variation between the farms. Some farms were just a bit larger than a backyard operation with little invested in the farming operation, buying most of their feed, and processing with mostly used equipment. Other farms, however, were much more heavily invested but could justify the operation with larger product volumes.

Table 4. Business Balance Sheet

| Assets | <u>Average</u> | <u>Minimum</u> | <u>Maximum</u> |
|--|-----------------------|-----------------------|-----------------------|
| Cash | 1,701 | -2,500 | 6,681 |
| Accounts Receivable | 7,574 | 0 | 45,756 |
| Farm Feed and Supplies | 5,386 | 602 | 19,450 |
| Processing Prepaid Expenses | 645 | 0 | 3,000 |
| Processing Supplies | 11,978 | 0 | 77,835 |
| Total Current Assets | \$27,285 | \$1,250 | \$139,973 |
| Livestock | 24,981 | 7,050 | 77,700 |
| Farm Machinery and Equipment | 43,955 | 2,350 | 215,000 |
| Processing Machinery and Equipment | 16,816 | 3,500 | 38,000 |
| Total Intermediate Assets | \$85,752 | \$31,650 | \$330,700 |
| Farm Land and Buildings | 162,950 | 40,000 | 330,000 |
| Processing Land and Building | 25,675 | 0 | 80,000 |
| Total Long Term Assets | \$188,625 | \$50,000 | \$350,000 |
| | | | |
| Farm Assets | 238,623 | 57,800 | 642,101 |
| Processing Assets | 63,038 | 9,050 | 187,591 |
| Total Assets | \$301,661 | \$82,900 | \$715,105 |
| | | | |
| Liabilities | | | |
| Farm Short-term Debt | 2,013 | 0 | 12,000 |
| Processing Short-term Debt | 102 | 0 | 1,022 |
| Farm Accounts Payable | 636 | 0 | 6,363 |
| Processing Accounts Payable | 1,844 | 0 | 18,437 |
| Farm Current Portion of Debt | 6,635 | 0 | 23,213 |
| Processing Current Portion of Debt | 2,363 | 0 | 9,237 |
| Total Current Debt | \$13,592 | \$0 | \$47,400 |
| Farm Intermediate Debt | 28,426 | 0 | 137,950 |
| Processing Intermediate Debt | 12,825 | 0 | 48,000 |
| Total Intermediate Debt | \$41,251 | \$0 | \$155,000 |
| Farm Long-term Debt | 42,227 | 0 | 196,972 |
| Processing Long-term Debt | 11,610 | 0 | 78,134 |
| Total Long-term Debt | \$53,837 | \$0 | \$248,834 |
| Farm Liabilities | 79,936 | 0 | 358,135 |
| Processing Liabilities | 28,743 | 0 | 100,125 |
| Total Liabilities | \$108,680 | \$0 | \$408,736 |
| Farm Net Worth | 158,687 | 48,632 | 283,966 |
| Processing Net Worth | 34,295 | -21,977 | 87,466 |
| Total Business Net Worth | \$192,982 | \$53,540 | \$340,800 |
| Farm Debt-to-Asset Ratio, % | 25 | 0 | 64 |
| Processing Debt-to-Asset Ratio, % | 66 | 0 | 343 |
| Total Business Debt-to-Asset Ratio, % | 30 | 0 | 67 |

Several items were particularly striking. Accounts receivable ranged as high as \$45,756. One farm, the yogurt producer, did not have any milk at the end of the year and thus did not have any inventory or accounts receivable. Processing supplies ranged from \$0 to \$77,000. Processing land and buildings averaged only \$25,000 as compared to farm assets of \$162,000, indicating the lower investment in fixed structures needed for processing. Processing equipment ran from \$3500 to \$38,000.

Debt was more variable than assets for this study. Three farms did not have any debt, making financial decisions a bit less risky than for the farm with debt. Farms averaged a total of \$108,000 debt that was split closely in relation to the investment in processing and farm assets. More striking was the range of debt, with 2 farms with more than \$300,000 in debt.

The debt/asset ratio provided a size neutral assessment of debt for the farms in the study. Generally lenders consider a D/A ratio greater than 0.5 as high and 0.7 as dangerous. The farms averaged a 30% D/A ratio, ranging from 0 to 0.67. What is more striking is the D/A ratio of the processing sector. This ranged from 0 to 3.43, meaning a debt at 3.43 times the value of the assets. How does this happen? You have to consider the type of asset. For the farm assets, land does not depreciate and usually escalates in value, providing equity and collateral for the owner. Also, farm equipment and animals usually maintain reasonable market value.

Processing assets, however, are expensive, new, and drop in value quickly. Depreciation is especially high for installation costs, which cannot be sold. Thus, for some farms, the value of equipment and accessories can be discounted significantly while any debt related to the items only goes down as fast as the payment schedule. On the other extreme, some farmers who are small operators have done an excellent job finding low value and used equipment that limits their depreciation and also their debt levels.

Income Statement

The accrual adjusted income from the 10 farms would not induce one to head out right away and jump into the processing business. Four of the 10 farms ended with negative net business income (Table 5). How does this happen? A lot of farms do not calculate income according to accounting standards. For this study, we first examined farm and processing income separately, then together, and then charging for depreciation. In addition, milk was sold at a going wholesale price from the farm to the processing sector.

On average, farming operations broke even, with expenses equaling costs. On the processing side, the average farm made just under \$20,000 after paying for expenses. It shows that the demands of the processing sector required much more time and emphasis that generally did not permit operating the farm to maximum production. In most cases, farming was done as a method to supply their own milk. What may be interesting is that a number of the farms would be better off buying their milk from a farm that concentrated on producing milk and did not concentrate on processing. But then, a sales point for most farms is that they produce and process their own milk.

Table 5. Income Statement

| Income | <u>Average</u> | <u>Minimum</u> | <u>Maximum</u> |
|---|-----------------------|-----------------------|-----------------------|
| Raw milk sales | 4,732 | 0 | 40,811 |
| Transfer Value to Processing | 27,126 | 1,281 | 116,738 |
| Livestock Sales | 3,468 | 0 | 16,257 |
| Crop Sales | 591 | 0 | 5,831 |
| Government and Other Farm Receipts | 2,371 | 0 | 8,534 |
| Total Farm Receipts | \$38,288 | \$10,502 | \$176,675 |
| Dairy Product Sales | 82,260 | 4,497 | 244,483 |
| Other Processing Receipts | 1,494 | 0 | 13,944 |
| Total Processing Receipts | \$83,755 | \$4,497 | \$258,427 |
| Total Farm and Processing Receipts | \$122,043 | \$17,327 | \$409,627 |
| Expenses | | | |
| Farm Hired Labor | 8,583 | 0 | 40,012 |
| Purchased Feed | 11,243 | 2,854 | 33,467 |
| Farm Machinery & Equipment | 2,963 | 0 | 13,871 |
| Livestock Supplies | 6,305 | 916 | 38,471 |
| Crop Supplies | 998 | 0 | 6,964 |
| Farm Real Estate and Building Repairs | 2,477 | 870 | 4,862 |
| Farm Utilities | 1,596 | 214 | 5,973 |
| Farm Interest | 2,625 | 0 | 9,208 |
| Farm Miscellaneous | 2,173 | 0 | 8,978 |
| Total Farm Operating Expenses | \$38,963 | \$12,988 | \$161,806 |
| Processing Hired Labor | 9,064 | 0 | 62,082 |
| Processing Materials and Supplies | 15,592 | 1,344 | 77,641 |
| Processing Machinery and Equipment Repairs | 1,039 | 0 | 7,006 |
| Processing Real Estate and Building Repairs | 418 | 0 | 1,000 |
| Processing Utilities | 2,789 | 250 | 6,224 |
| Processing Interest | 862 | 0 | 3,029 |
| Marketing Expenses | 4,899 | 0 | 18,501 |
| Processing Miscellaneous Expenses | 2,350 | 283 | 7,765 |
| Transfer Value to Processing | 27,126 | 1,281 | 116,738 |
| Total Processing Operating Expenses | \$64,137 | \$9,471 | \$228,873 |
| Total Farm & Processing Operating Expenses | \$103,100 | \$22,459 | \$349,197 |
| Farm Depreciation Expense | 12,280 | 464 | 57,029 |
| Processing Depreciation Expense | 4,650 | 867 | 14,257 |
| Total Depreciation Expense | \$16,930 | \$1,921 | \$71,286 |
| Farm Net Income | -13,109 | -42,160 | -2,116 |
| Processing Net Income | 14,968 | -5,841 | 35,689 |
| Net Accrual Farm and Processing Income | \$1,860 | -\$23,448 | \$31,850 |

While the average farm makes money on the processing side, now the economist comes along and dampens the situation. On an accrual income basis, a charge is made for depreciation of equipment and buildings. Total depreciation was \$12,280 for the farm sector and \$4630 for the processing sector. When depreciation is added, average net income drops to \$1860. The range is -\$23,446 to \$31,850. With depreciation added, 4 farms had negative income.

Value of Equity, Operator Management, and Operator Labor

This is where the economists get thrown off the farm. From an economic perspective, there has to be a charge for the value of owner equity, operator labor, and operator management skills (Table 6). The owners' equity represents a rental of assets to the business operation. There should be a charge for the operator's labor. This labor is not free and would require a cash charge if someone was to be hired for the tasks. And management - How much is management worth? For this study, we asked what the owner/operator would require as a wage if someone were to pay them to do what they are doing.

The results in Table 6 make the farms less profitable with the inclusion of a charge for interest on owner equity. The average saw net business income drop from \$1860 to -\$8168. The maximum income dropped to \$20,231. Then the charge for owner labor and management puts the farm in the red. The stated value of operator labor and management averaged \$67,348 and ranged from \$20,400 to \$150,000. It must be noted that owners put in different hours, and for some operations, the time of both spouses is included. It should also be noted that most folks were doing this in hope of building a business and would never pay anyone to put in the hours they did to make the business a success. But with a full economic analysis with charges for owners' labor and management, interest on equity, and depreciation, none of the farms in this study showed a positive net income for either farming or processing.

Conclusions

This study is not a conclusive analysis of a sizeable number of randomly selected farms to make a representative sample. Instead, it is an in-depth analysis of a limited number of diverse farms that all conduct milk production from small ruminants and process their own dairy products. This study does allow us a few conclusions.

First, value-added dairy operations are quite diverse. In this study, we had 10 of 27 farms with small ruminants instead of cows. In addition, the size of operation, processed products, and marketing techniques varied significantly across farms. Then there is the financial performance. With depreciation included, none of the farms made any profit on the farm operation. Two reasons drive this finding. First, high land values make it difficult to make profits in agriculture. Second, most farms were in business to market their own products. Yet many would be better off to buy their milk and just do processing. When charges on equity and operator labor and management are included, the conclusion is that on farm processors "ain't gettin' rich."

Lifestyle is a definite reason for involvement in on-farm processing. People are attracted to this field with the hope of developing successful businesses. It takes this faith to build a successful business. But the income is not adequate for supporting a family.

Where can we go from this study? First, we need an analysis from more farms to draw any conclusions. We need more research on reasons for entering the processing business and how people got started. There is much need for studying the markets for small farms and pricing strategies for small farmers. In addition, there needs to be some understanding of the learning curve for processing dairy products. One does not just start making high quality artisan cheese.

Farmers definitely need some assistance on information that leads them through the learning process. A full business plan that examines all areas of risk would be helpful. Farmers likely need to do an apprenticeship or internship somewhere to learn the ropes of processing. Then there is the selection of the proper product and pricing. Cheese is not just cheese. What type should you try to make, where will you market the cheese, and how will you price it. This study provides some initial information for farmstead dairy processors, but hopefully this is only the beginning of research articles on this topic. Mark Twain may not think anyone does anything about examining value added processing but at least we made a step to change this assessment.

Table 6. Impact of the Value of Equity and Family Labor

| Income Adjustments | <u>Average</u> | <u>Minimum</u> | <u>Maximum</u> |
|--|-----------------------|-----------------------|-----------------------|
| Farm Net Income | -13,109 | -42,160 | -2,116 |
| Farm Unpaid Family Labor | -86 | 0 | -770 |
| Farm Interest on Equity | -7,935 | -2,432 | -14,198 |
| Farm Labor & Management Income | -\$21,129 | -\$56,358 | -\$6,070 |
| | | | |
| Processing Net Income | 14,968 | -5,841 | 35,689 |
| Processing Unpaid Family Labor | -183 | 0 | -1,826 |
| Processing Interest on Equity | -1,825 | 0 | -4,373 |
| Processing Labor & Management Income | \$12,961 | -\$5,841 | \$34,520 |
| | | | |
| Net Business Labor & Management Income | -\$8,168 | -\$36,832 | \$20,231 |
| | | | |
| Farm Value of Operator's Labor | 35,134 | 13,813 | 112,492 |
| Processing Value of Operator's Labor | 32,214 | 6,587 | 79,988 |
| Total Value of Operator's Labor | \$67,348 | \$20,400 | \$150,000 |
| | | | |
| Return on Farm Assets w/Equity, Operator and Family Labor | | | |
| Farm ROA (%) | -24 | -65 | -8 |
| Processing ROA (%) | -44 | -127 | 8 |
| Total ROA (%) | -27 | -59 | -9 |

NON-NUTRITIONAL STRATEGIES TO IMPROVE LACTATION PERSISTENCY IN DAIRY EWES

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Introduction

Milk production is largely dependent on the shape of the lactation curve. Important elements in the lactation pattern are the peak yield, which is the maximum milk yield during lactation, and lactation persistency, which is the ability of animals to maintain a reasonably constant milk yield after the lactation peak. “Persistent” animals are those with flatter lactation curves.

Domesticated animals have lactation curves with high peaks and persistency, and thus higher milk yield than their wild ancestors. Dairy breeds, when compared to meat and wool breeds, have greater persistency rather than high peaks (Figure 1).

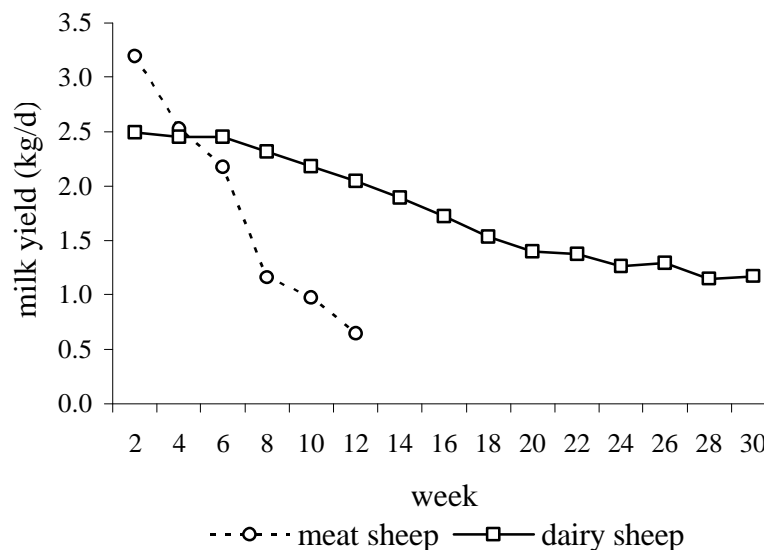


Figure 1 - Lactation curves of dairy (data from Cappio-Borlino et al., 1997b) and meat-wool sheep (data from Snowder and Glimp, 1991).

In dairy sheep, genetic selection has caused deep morphological changes in the udder and physiological changes in the whole body of the animal. The former are seen in the higher mammary cistern volume and the latter in neuro-hormonal changes that allow the alveoli to have a longer life-span and maintain a metabolic status that favors the switch of energy and nutrients to the mammary gland instead of body reserves. In practice, the ideal lactation curve has a reasonably high peak and a flat trend after the peak. More persistent lactation is desirable due to the relationships between this trait and health status and feed costs (Dekkers et al., 1998;

Grossman et al., 1999). Animals with very high peak yields are not able to consume adequate amounts of nutrients in the first part of lactation. This causes a negative energy balance, reduced reproductive efficiency and increased susceptibility to diseases (Jakobsen et al., 2002; Swalve, 2000). By contrast, animals with flat curves are less subject to metabolic stress in early lactation and have a more constant pattern of energy requirements throughout lactation. This means that cheaper feeds can be used (Sölkner and Fuchs, 1987; Dekkers et al., 1998).

In most cases the milk of the first month of lactation is suckled by the lamb. This means that there is less milk yield data available on the ascending phase of lactation, which consequently has been little studied.

The Economic Impact of Lactation Persistency

The lactation curves of sheep have certain peculiarities. These are due to biological and, above all, management factors. In Mediterranean countries the reproductive and productive cycles are strictly seasonal and are synchronized with the availability of natural pasture: the two periods of grass growth are autumn and spring. Feed supplements are given only in some periods of the year: hay from late summer to autumn and concentrates from late autumn to winter. This means that milk production is strongly influenced by environmental factors (Macciotta et al., 1999). As a result, different types of lactation curves can be observed in the same area within the same breed. For instance, one can often observe curves which are smooth in the first part of lactation (with no lactation peak) due to adverse environmental conditions (such as low temperatures and scarce feed availability) and curves that present a “false” lactation peak in the second half of lactation due both to favorable climatic conditions in spring and, more importantly, the greater availability of pasture (Cappio-Borlino et al., 1997a). Pulina et al. (2001) developed a static and deterministic bio-economic model for these types of breeding systems. This model included many biological and economic factors and was used to calculate the economic values of milk production and feed intake in dairy sheep farms. The model was implemented in the OVISOFT2® software (Boe and Pulina, 2005) which was tested in several dairy sheep farms in Italy with good results in various combinations of management conditions. OVISOFT2® simulates the daily milk yield by using the Wood’s lactation curve $y = at^b \exp^{-ct}$ (Wood, 1967) where the parameter a is related to initial milk production, b represents the slope of the curve in the ascendant phase and c indicates the slope of the curve in the descending phase. Dairy ewes may differ in total milk yield because of differences in persistency but have the same peak yield or, contrariwise, have different peak yields but similar lactation persistency. Two simulations were carried out using Ovisoft® in a standard flock of 100 Sarda ewes (average BW 45 kg and total milk yield (TMY) 280 kg per ewe lambing in Nov), in order to evaluate the economic impact of changes in lactation persistency. It was assumed that the total milk yield and lactation length was the same in the two simulations. In other words, the values for parameters a and c in Wood’s lactation curve equation varied (Table 1). All other inputs (biological, technical and economic variables) remained constant in both simulations.

Table 1 – Values of parameters *a*, *b* and *c* for the simulations of low (L-pers) and high (H-pers) persistency of lactation.

| | | Month of lambing | | | | | | |
|--------|---|------------------|---------|---------|---------|---------|---------|---------|
| | | Nov | Dec | Jan | Feb | Mar | Apr | May |
| L-pers | a | 1232.23 | 1232.23 | 1232.23 | 1232.23 | 1232.23 | 1232.23 | 1232.23 |
| | b | 0.23 | 0.23 | 0.20 | 0.18 | 0.27 | 0.29 | 0.23 |
| | c | -0.045 | -0.045 | -0.05 | -0.055 | -0.062 | -0.065 | -0.045 |
| H-pers | a | 990.52 | 990.52 | 990.52 | 990.52 | 990.52 | 990.52 | 990.52 |
| | b | 0.23 | 0.23 | 0.20 | 0.18 | 0.27 | 0.29 | 0.23 |
| | c | -0.0315 | -0.0315 | -0.035 | -0.0385 | -0.0434 | -0.0455 | -0.0315 |

Under these conditions the economic impact of an increase in lactation persistency (H-persistency), simulated by reducing the absolute value of *c* parameter by 30% compared to the low persistency curve (L-persistency), was evaluated. The curve of each flock is the mean of the lactation curves of animals with delivery distributed in different months of the year (Figure 2).

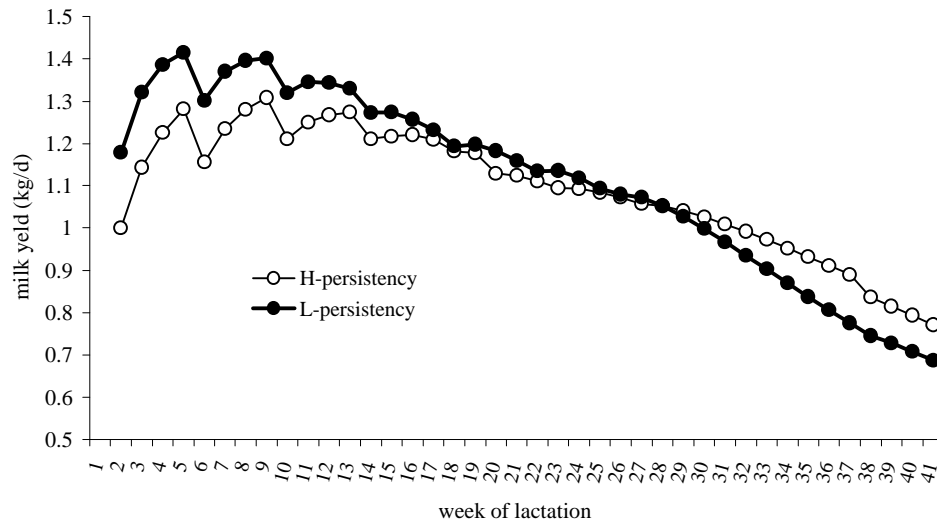


Figure 2 - Lactation curves of ewe flocks using an Ovisoft® software (Boe and Pulina, 2005) simulation. The values for parameters *a* and *c* of Wood’s equation varied while all the remaining inputs, including lactation length and total milk yield, remained fixed. The curve for each flock is the mean of the lactation curves of animals with delivery distributed over different months of the year.

Analysis of the economic output of the simulation showed that an increase in lactation persistency reduced farm operating costs by 2% and gave an annual added value per animal of \$1.00. The outputs of these simulations showed that dairy sheep farms are more profitable if the flock’s lactation persistency can be increased, even when there is no increase in milk production

Physiological Factors Affecting Lactation Persistency

The pattern of the lactation curve is influenced by the number of secretory cells in the mammary gland and by the synthetic activity of each secretory cell. Growth and differentiation of the glandular epithelium during puberty and pregnancy are important determinants of the total area of secretory epithelium and consequently of milk yield. After parturition, the maintenance of the secretory epithelium is the key factor in determining lactation persistency and total milk yield. Knowledge of the physiological and environmental factors that influence the number and the activity of mammary secretory cells is needed in order to develop a proper strategy for maintaining lactation. Maintenance of milk synthesis and secretion is controlled by a combination of both systemic and local regulatory factors.

Systemic factors

Hormones such as prolactin (PRL) and growth hormone (GH) are systemic factors involved in maintaining lactation in lactating sheep (Hooley et al. 1978). Oxytocin (OT) may also be involved in mammary cell maintenance and metabolism, as well as causing myoepithelial cell contraction and milk letdown (Zamiri et al., 2001).

During lactation, GH (Akers, 2002) and PRL (McMurtry et al., 1975) levels decrease. This reduces milk synthesis. GH receptors are not present in the mammary gland. It exerts its positive effects on milk yield indirectly by stimulating the synthesis and secretion of insulin-like growth factor-I (IGF-I). IGF-I is mainly synthesized by the liver, but it is produced and acts in other tissues also, such as, for example, the mammary parenchyma. IGF-I receptors have been identified in the mammary glands of sheep (Akers, 2002). GH administration increases IGF-I in serum, which means that GH may help the mammary epithelial cells to survive. IGF-I is, indeed, a stimulatory protein in DNA synthesis and in mammary proliferation, in casein gene expression, and in glucose transport. Secretion of IGF-I is regulated by the nutritional status of animals. For example, plasma IGF-I concentration increases when high-energy and high-protein diets are used (McGuire et al., 1992). Increasing the frequency of feeding with concentrates from one to three times a day, or improving the quality of forage, increases IGF-I plasma concentrations in ewes in late pregnancy (Chestnutt and Wylie, 1995). GH treatments may be a useful way of increasing milk yield as discussed later.

The role of PRL in milk synthesis is probably related to the fact that it inhibits mammary apoptosis by suppressing the actions of IGFBP-5 (IGF binding protein), which antagonizes the effects of IGF-I on the survival of mammary epithelial cells (Tonner et al., 2000). A reduction in serum PRL concentration reduces the milk yield and results in a 20-25% loss in the number of secretory cells within 48 h (Flint and Knight, 1997). In sheep if bromocriptine, an alkaloid that inhibits the release of PRL, is administered 10 days after parturition, there is a 60-70% reduction in milk production (Burvenich et al., 1991).

Local factors

Local control of milk secretion is directly linked to the physical removal of the milk. The impact of these factors on the mammary function in dairy animals is evident from the known positive effects of frequency of milk removal on milk yield and the negative effects of milk stasis in the mammary cistern. The accumulation of milk in the mammary gland accelerates the involution process and reduces lactation persistency.

Local factors involved in the control of milk secretion were demonstrated in half udder experiments carried out in cows (Stelwagen and Knight, 1997), goats (Wilde and Knight, 1990) and sheep (Nudda et al., 2002a) in which unilateral alteration of the frequency of milking affected only the treated gland. Increasing milking frequency from 1 to 2 times per day in one udder increased milk yield without effecting the milk yield of the other udder, which continued to be milked twice a day (Figure 3).

Wilde et al. (1987) identified the local factor involved in the reduction of milk secretion as a peptide, which they called feedback inhibitor of lactation (FIL). It is synthesized by the mammary epithelial cells and secreted with the milk in the alveoli. As time from last milking increases, milk accumulates in the alveoli, as does this peptide. This causes a progressive reduction in milk synthesis and secretion. Thus, frequent removal of milk (and consequently of the FIL) from the mammary gland reduces local inhibitory effects.

Further evidence of the existence of local factors in the mammary gland was obtained in one of our experiments where one udder half was dried while the other continued to be milked twice a day. The milk yield of the milked udder half was 50% lower than the milk yield obtained from ewes in which both udder halves were milked twice a day (618 vs. 1221 g/d) (Cannas et al., 2002).

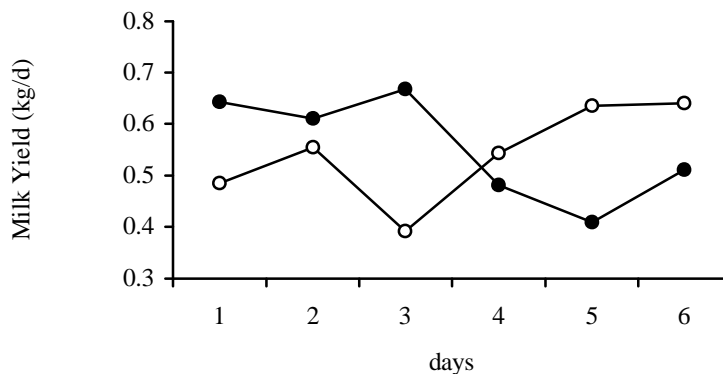


Figure 3 - Milk production (g/d) of right (●) and left (○) udder halves milked once or twice a day. The right udder halves were milked twice a day (2X) for the first period of the experiment and once a day (1X) in the second period. The left udder halves were milked once a day in the first period and twice a day in the second period (Nudda et al., 2002a).

Recently, it has been hypothesized that there is a proteolytic casein fragment in the mammary gland which inhibits milk synthesis (Silanikove et al., 2000). This peptide, which is made up of residues 1-28 of β -casein produced by the proteolytic activity of plasmin, reduces milk secretion in cows and goats. In goats, injection of casein hydrolyzates into the udder caused a local inflammation and a loss of the integrity of the tight junction (TJ), followed by a rapid drying off of the gland (Shamay et al., 2002). This finding was supported by our experiment simulating once a day milking (1X) in the same half-udder (Pulina et al., 2005). In this experiment the injection of casein hydrolyzates into the mammary gland of goats caused a reduction in milk yield, and an increase in somatic cell count (SCC), plasmin, and Na in milk.

Other factors: the role of the plasmin-plasminogen system

Plasmin is the predominant protease in milk and is mainly associated with casein micelles, which are its substrate of action. Plasmin is responsible for the hydrolysis of α and β casein in milk. Plasmin and its precursor, plasminogen (PG), are present simultaneously in milk. The plasminogen is converted into active plasmin by the action of the plasminogen-activator (PA), whose activity is reduced by PA inhibitors (PAI) (Politis, 1996). The plasmin-plasminogen system seems to be involved in the events that occur during the gradual involution of the mammary gland (Politis, 1996). Indeed, the activity of plasminogen and plasmin increases in milk as lactation progresses.

The plasma insulin-like growth factor (IGF-I), which acts as a mediator of the growth hormone (GH), and the nutritional status of the animals also help to decrease PA, probably through the stimulation of PAI (Padayatty et al., 1993). It is well known that administration of exogenous GH in sheep (Baldi et al., 1997; Baldi, 1999; Chiofalo et al., 1999), cows (Politis et al., 1990), and goats (Baldi et al., 2002) increases milk yield and lactation persistency and reduces plasmin activity, probably through its mediator IGF-I.

Disruption of tight junctions integrity

The involution of mammary secretory cells is triggered by the disruption of the tight junctions (TJ) between adjacent cells. The TJ are structures which encircle the cells and fuse adjacent cell membranes, thus forming a barrier between blood and milk. The TJ are connected with the cytoskeleton, a network of micro-filaments that is probably involved in the secretion of the neo-synthesized milk components from the secretory cells into the alveolar lumen. During lactation, or in conditions in which the integrity of TJ is maintained, milk precursors reach the alveolar lumen by passing through the secretory cells (the transcellular route). During involution (but also in other conditions such as pregnancy, mastitis, and extended milking intervals) the TJ become leaky and permit the passage between cells of blood precursors that reach the alveolar lumen (the paracellular route). As a consequence, TJ leakiness affects cytoskeleton activity, reducing its dynamic properties in the transfer of neo-synthesized milk components towards the apical membrane of the mammary secretory cells (Mephram, 1987). The reduced secretion of milk components inhibits further synthesis and makes the involution of secretory cells more likely (see review of Cannas et al., 2002).

The impairment of TJ, which causes the activation of the paracellular pathway, allows the passage of substances between epithelial cells, causing an increase of Na in milk and the passage of lactose into the blood (Stelwagen et al., 1994). A high Na/K ratio in milk has been associated with the mechanisms that reduce milk yield in cases where the permeability of mammary TJ is increased (Allen, 1990).

Tight junctions can be damaged by: the increased activity of plasmin, as lactation progresses, in the case of mastitis or prolonged milking intervals; the massive migration of somatic cells (leukocytes or white blood cells) from blood to mammary gland to defend the tissue from pathogens in case of inflammations (mastitis); and the stretching caused by excessive accumulation of milk (Mepham, 1987) with long milking intervals (Stelwagen et al., 1994).

It appears, then, that mammary involution is controlled by local and systemic factors with highly integrated mechanisms of control.

Non-Nutritional Factors Affecting Lactation Persistency

A proper definition of strategies to improve lactation persistency requires knowledge of the several factors that affect lactation persistency. There include genetics, hormonal status, seasonal effects, management techniques, animal health (e.g. mastitis) and stress.

The influence of feeding on lactation persistency in dairy ewes was reviewed previously (Cannas et al., 2002), while factors other than nutrition are discussed more deeply in this paper.

Genetics

The genetic modification of the shape of the lactation curve in an economically desirable direction is an interesting challenge for scientists and technicians in the dairy industry (Rekaya et al., 2001). Several studies have been carried out in dairy cattle on the relationships between fundamental traits of lactation curve shape such as persistency and peak yield, and productive and functional traits. The favorable relationships which exist between persistency and feeding costs, metabolic status, and disease resistance have been highlighted in dairy cows (Dekkers et al., 1998; Sölkner and Fuchs, 1987; Pryce et al., 1997). However, the strategies to genetically improve this trait are less defined and clear. At present, the main constraint is the lack of consensus on the most suitable measure of persistency. Several approaches have been proposed in the literature (Gengler, 1996; Grossman et al., 1999; Jamrozik et al., 1998; Sölkner and Fuchs, 1987; Togashi and Lin, 2003). These have been based on: i) ratios between cumulated yields of different stages of lactation; ii) variability of test day yields; iii) parameters of mathematical models of lactation curves; and iv) days in which a constant level of production is maintained. One result of this variety of approaches is the wide range of estimated values for genetic parameters of lactation persistency that are found in the literature, depending on the measure used to define this trait. To take just one example, heritability goes from a value of around zero to values higher than 0.30. The relationship between persistency and total lactation yield is another issue. Some measures of persistency show a high correlation with accumulated milk yield, even though some authors state that a robust measure should be independent of total yield (real persistency) (Gengler, 1996) or that the total lactation yield should be included as a

(co)variate in the genetic model used to estimate genetic parameters and breeding values for lactation persistency (Swalve, 1995). In any case, most scientists agree that persistency possesses a certain degree of genetic variation, with moderate heritability (0.15-0.20), and that selection for this trait is feasible.

Genetic aspects of lactation curve shape have been little investigated in dairy sheep. At present in this species, the main breeding goal is cumulated lactation yield, while in only a few breeds are milk composition traits considered (Barillet, 1997; Macciotta et al., 2004). Selection based on lactation curve traits is also limited by the reduced number of TD records available. In the typical dairy sheep farming system of Mediterranean countries where most of dairy sheep flocks are located, the milk of the first month of lactation is suckled by the lamb and thus data for this period (which is when the lactation peak occurs) are not available. However when one considers that the dairy sheep farming system has a low level of inputs (feed, technology, equipments), genetic improvement of traits that affect the economic efficiency of the animal by reducing costs rather than increasing production (Groen et al., 1997), such as, for example, lactation curve shape traits, could be of great value.

The genetic variation of features of lactation curve shape in sheep has been investigated by Chang et al. (2001, 2002), using a quadratic function and the Wood's model. Heritability ranges were 0.23-0.35, 0.15-0.35 and 0.17-0.27, respectively, for parameters a , b and c of the Wood's model (the third parameter controls the descending rate of the curve after the lactation peak, i.e. lactation persistency). This indicates that the lactation curve shape in sheep can be altered by selecting on the basis of parameters of lactation curve functions.

A multivariate measure of lactation persistency has been proposed for dairy sheep (Macciotta et al., 2003). In this approach, TD milk yields recorded at different time distances from parturition are considered different traits and are analysed with the multivariate Factor Analysis technique.

In the Factor approach, the correlation matrix of original variables (\mathbf{S}) is decomposed as

$$\mathbf{S} = \mathbf{B}\mathbf{B}' + \mathbf{Y}$$

where \mathbf{B} is the matrix of the factor coefficients, i.e. of the correlations between the new latent variables and the original variables, and \mathbf{Y} is a residual correlation matrix. Factor analysis is able to extract from original data new latent variables (Factors) that are able to reconstruct a relevant quota of the variability of original variables. By contrast with all the previously reported measurements, this multivariate approach does not require an *a priori* definition of what persistency is, because the new factors are objectively derived from the correlation matrix among the original variables.

The \mathbf{B} matrix obtained by applying Factor Analysis on milk test day (TD) records of 380 Sarda breed dairy ewes is shown in Table 2. Each ewe had 5 TD records, and these were considered to be different traits.

Table 2 - Correlations between original variables and common factors.

| Variable | Milk Yield | |
|--------------------|------------|----------|
| | Factor 1 | Factor 2 |
| TD1 | 0.20 | 0.85 |
| TD2 | 0.44 | 0.82 |
| TD3 | 0.65 | 0.53 |
| TD4 | 0.84 | 0.30 |
| TD5 | 0.70 | 0.19 |
| Variance explained | 0.37 | 0.36 |

Two common factors were able to explain about 73% of the original variance. Factor 1 is associated with the TD of the last part of lactation and can be considered to be an indicator of lactation persistency, whereas Factor 2 is correlated with the tests of the first part, and can be considered to be an indicator of production levels in early lactation. The relationships between Factor 1 scores and lactation curve shape can be inferred from Figure 4 where the average lactation patterns of five different classes of animals, grouped according to Factor 1 scores, are shown. One can see that as the value of Factor 1 increases, the persistency of lactation tends to increase. A mixed model analysis of the Factor 1 scores gave a repeatability value of 0.32, which agrees with previous results reported for dairy cattle (Gengler, 1996). Factor 1 scores were affected by parity and year of lambing, i.e. sources of variability that are known to affect lactation persistency.

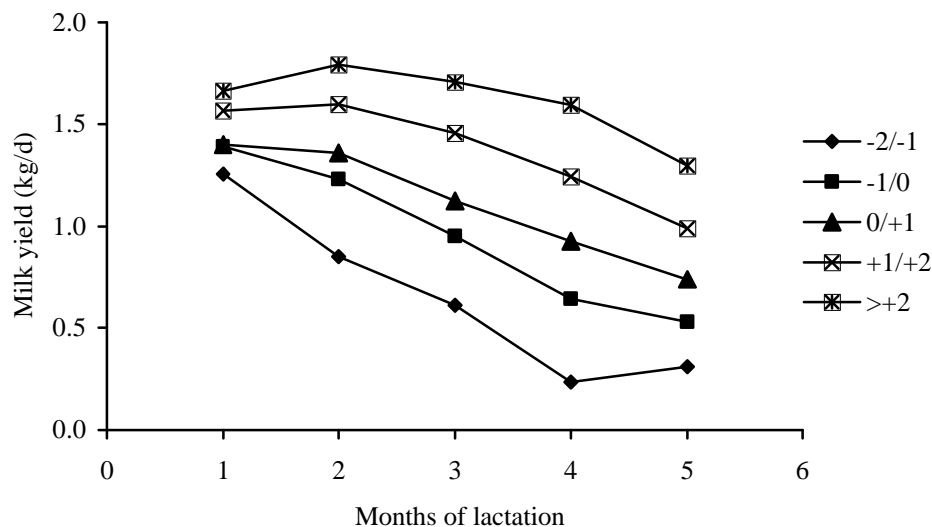


Figure 4 - Lactation curves for the milk yield of animals with different classes of factor 1.

Use of hormones

It is well established that exogenous somatotropin (ST) increases milk production in cows and in other dairy ruminants. ST increases the concentration of somatomedins (IGF) in the blood. These are involved in the mechanism by which exogenous ST treatments increase milk production in middle and late lactation. In general ST administration studies on dairy ruminants

show that milk production increases in the short term (the immediate post-injection period) and that there is also a medium to long term positive effect on lactation persistency (Baldi 1999). The administration of 320 mg of ST to Comisana ewes increased the milk yield significantly (Figure 5) (D'Urso et al., 1998).

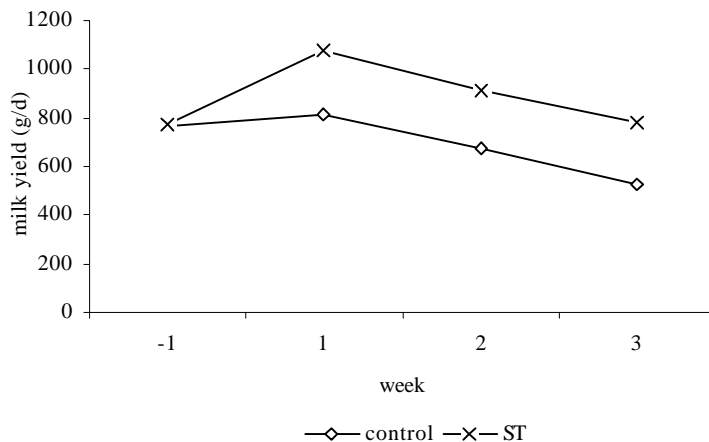


Figure 5 - Milk yield in Comisana ewes treated with exogenous somatotropin (ST) and control in the 3 weeks post-injection (data from D'Urso et al., 1998).

Several studies indicate that ST administration increases milk yield by 10-40% in cows (Flint et al., 2005) and by 14–29% in dairy goats (Baldi, 1999).

Baldi (1999) reported an increased milk yield in dairy ewes treated with ST, without any negative effects on the composition or coagulating properties of the milk, except in late lactation. In that period ST reduced the percentages of fat and protein in milk, although the coagulation time was lower in treated animals.

In other trials, dairy ewes treated with ST during pregnancy, in early-mid lactation (Table 4) and in late lactation (Table 5), had milk yields from 20% to 56% higher than controls. Fernandez et al. (1997) observed that increasing ST from 160 to 240 mg/head did not increase the milk yield of Manchega dairy ewes. A biological explanation could be that there was a plateau phase caused by the saturation of the effect of the hormone or by the saturation of the mammary storage site between milkings, which leads to an autocrine inhibition of lactation. Fernandez et al. (1997) showed that the first part of lactation needs a higher dose of ST than the second if a maximum increase in milk yield is to be achieved. The number of lactations did not improve milk production, but primiparous ewes responded better than multiparous ones to ST treatment. An interaction between body condition score and ST was observed only in the first part of lactation. This was when the highest response to ST was obtained from ewes with average body condition score 3 that received a dose of 200 mg of ST released throughout 14 d. However the body condition score had no effect on milk yield during the second part of lactation.

Table 4 - Response of dairy ewes to somatotropin (ST) administration in early-mid lactation.

| Breed | Lactation stage | ST dose | Milk Yield increase (%) | Reference |
|--------------|------------------------|---------------------------------|--------------------------------|------------------------|
| Assaf | after peak | 0.1 mg/kg BW | +55.5 | Leibovich et al., 2001 |
| Manchega | weeks 3-8 | 80 mg/14d | +20.2 | Fernandez et al., 1995 |
| | | 160/14d | +34.1 | |
| | | 240/14d | +30.2 | |
| Comisana | 62 days | High starch and 320 mg bST/head | +20.6 | Dell'Orto et al., 1996 |
| | | Low starch and 320mg bST/head | +35.8 | |
| Arcott | pregnancy | 0.1 mg/kg BW | +41.9 | Stelwagen et al., 1993 |

Table 5 - Response of dairy ewes to somatotropin (ST) administration in late lactation.

| Breed | Lactation stage | ST dose | Milk Yield increase (%) | Reference |
|--------------|------------------------|------------------|--------------------------------|------------------------|
| Manchega | weeks 11-23 | 80 mg/14d | +41.3 | Fernandez et al., 1995 |
| | | 160/14d | +53.2 | |
| Comisana | week 14 | LSR + 320mg/head | +34.0 | D'Urso et al., 1998 |
| | | HSR + 320mg/head | +42.4 | |
| Comisana | 200 days | 120 mg/21 days | +21.9 | Chiofalo et al., 1999 |

The role of ST in sheep has also been recently investigated by the production of ST transgenic sheep with doubled levels of ST plasma. The gains in productivity were counterbalanced by a decrease in reproductive efficiency and an increase in several disease problems, which became more evident as the animals aged (Adams and Brigel, 2005).

The daily injection of oxytocin (2 IU) in Mehraban ewes from 15 days postpartum increased the lactation length by 30 days compared to the control group (Zamiri et al., 2001). The amount of milk recorded during the entire lactation was 55% greater for the oxytocin treated group than for the control group (Figure 6). In this study the parameters of the lactation curve were not estimated. However in a similar experiment in dairy cows (Nostrand et al., 1991), it was observed that the oxytocin group produced 849 kg more milk during lactation than the control group, with a significant difference occurring after peak milk yield and greater persistency of lactation.

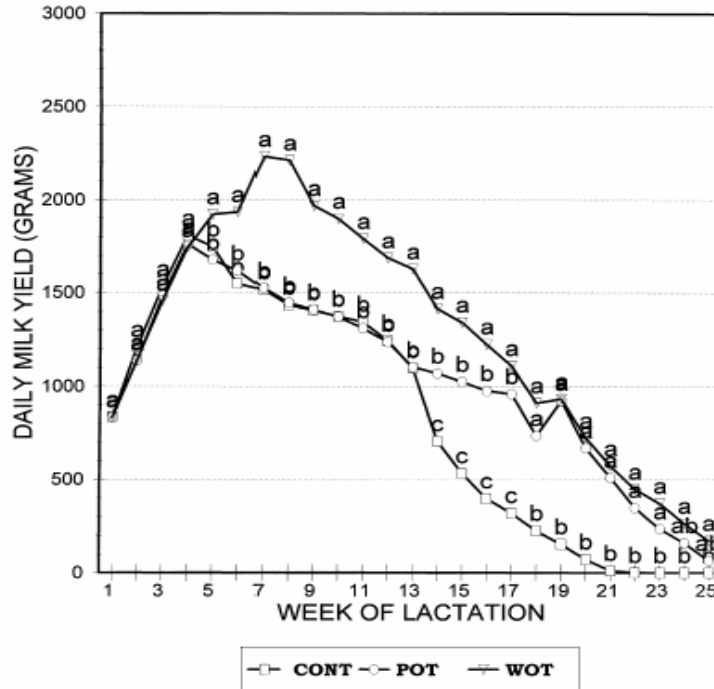


Figure 6 - Lactation curves of ewes given daily oxytocin injection over the whole lactation (WOT) or during the post-weaning period (POT) compared to saline treated control ewes (CONT) (Zamiri et al., 2001).

Lambing season

The effects of the lambing season on persistency of lactation have been mainly attributed to seasonal differences in the availability and quality of pasture (Cappio-Borlino et al., 1997b). The ewes that lambed when the maximum amount of forage was available had a higher milk yield, perhaps because of a positive effect on the differentiation of udder secretory cells and on the accumulation of body reserves.

The influence of the lambing season on milk yield may also be related to the photoperiod. In Mediterranean areas, lactation occurs during the period when the days are lengthening. As has also been observed in dairy cows, the increase in the hours of light seems to improve milk production and feed intake (Bocquier et al., 1997). This effect was evident when the treatment lasted more than 30 days and may be explained by the fact that the animals feed more when there is more light. Indeed, sheep which were submitted, for a short period, to sharp changes in day length produced less milk (Pulina et al., 2002).

Lactation number

Analysis of the evolution of the shape of the lactation curve according to the number of lambings showed that Laxta (Gabina et al., 1993), Lacaune (Barillet, 1985), Sarda (Carta et al., 1995) and Valle del Belice (Cappio-Borlino et al., 1997b) dairy ewes produced more milk after the third or subsequent parities. By contrast, the peak yield took place quite late in 1st lactation sheep and lactation is more persistent in almost all dairy breeds. Stanton et al. (1992) observed

the same effect in dairy cows and suggested that this pattern could be due to the fact that the body and mammary gland of young animals are still developing during the first part of lactation. In sheep, the effect of the fact that the animal is still maturing is evident only in the first part of lactation (70-120 days in milking (DIM)), after which it gradually becomes less pronounced and the rest of the 1st lactation curve becomes similar to that of pluriparous ewes (Cappio-Borlino et al., 1997a; Ruiz et al., 2000). Portolano et al. (1996) observed that there was an interaction between the effects of the lambing season and the lactation number on the shape of the lactation curve in Comisana dairy ewes. Ewes which lambed in autumn showed greater persistence, smaller peak production and reached this peak later than the same parity ewes which lambed in winter. This phenomenon may be due to the environmental and nutritional effects of different lambing seasons on grazing management conditions. In fact, the peak milk production for ewes lambing in autumn is depressed by the effects of winter, and they can only take advantage of more and better quality pasture after the lactation peak.

Type of lambing

Several studies have reported higher milk yields for ewes with multiple births, in both non-dairy (Figure 7) (Wohlt et al., 1984) and dairy sheep (Figure 8) (Pulina et al., 1993). This can be explained by the fact that ewes rearing multiple fetuses or with a heavier single fetus have higher placental weight and higher serum progesterone and more placental lactogen hormones during pregnancy (Butler et al., 1981; Schoknecht et al., 1991). The higher average serum progesterone levels during pregnancy means that mammary glands are better developed at parturition as can be seen from the greater number of mammary cells and the increased synthetic activity (Manalu et al., 1998; 2000). In addition, because the mammary glands are suckled more frequently by twins than by one lamb, the local inhibitors to milk secretion, such as the FIL, are removed.

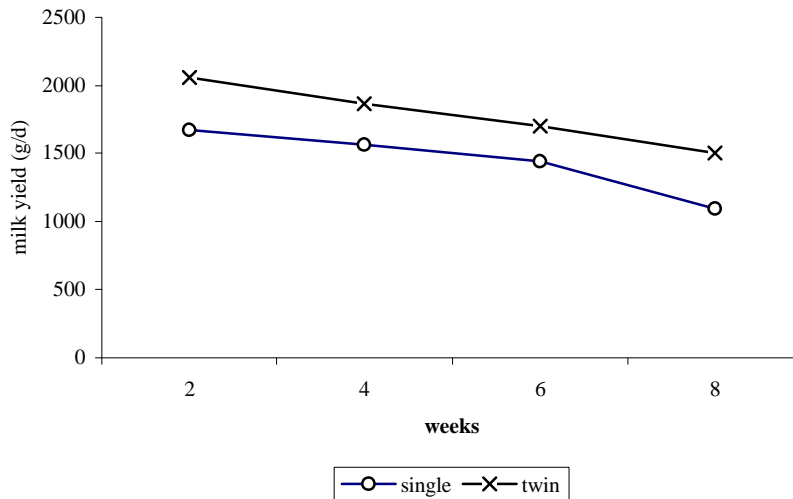


Figure 7 - Lactation curves in Dorset ewes with different types of lambing (Wohlt et al., 1984).

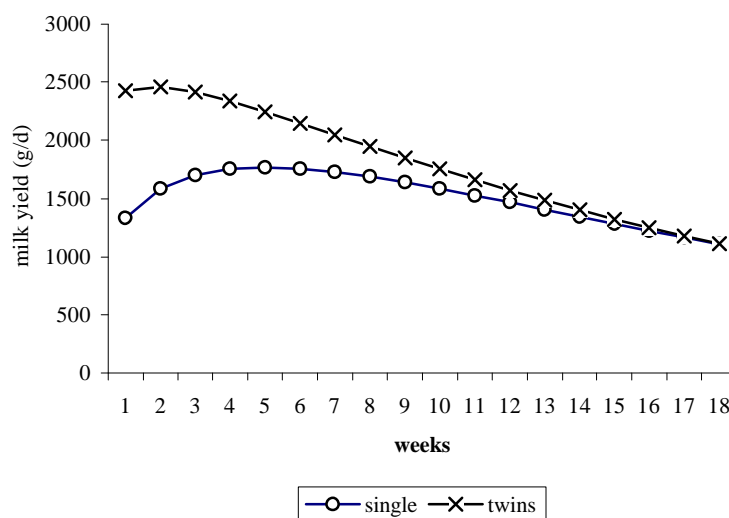


Figure 8 - Lactation curves in dairy ewes with different types of lambing (Pulina et al., 1993).

Ewes superovulated with Pregnant mare serum gonadotropin (PMSG), were found to have 31% better developed mammary glands at parturition and 55% greater milk production during the first 12 weeks of lactation (Frimawaty and Manalu, 1999). This is because superovulation prior to mating increases the numbers of corpora lutea and mean serum progesterone concentrations during pregnancy (Manalu et al., 1998). However, Frimawaty and Manalu (1999) did not observe differences in milk yield between ewes rearing single or twin lambs. Analysis of the mammary glands at the end of lactation indicated that superovulated ewes had 79% higher total DNA and 56% higher total RNA than non-superovulated ewes (Manalu et al., 2000). This indicates that there were more secretory cells and higher synthetic activity per cell.

Weaning system

Reduction of the suckling period during lactation is a widespread practice in dairy animals. This is done to increase the length of the milking period and the amount of saleable milk. However particular attention has to be paid to the weaning technique used, because it could reduce milk yield after weaning.

Studies on different weaning systems were carried out during the first 30 days of lactation. In these studies, ewes were either: milked twice daily after weaning at 24 hours post partum (D1), suckled lambs for 30 days and were then machine milked twice a day after weaning (D30), or suckled for part of the day and then separated from their lambs during the night to allow the ewes to be machine milked once daily the following morning (MIX) (McKusick et al., 1999; 2001). Total commercial milk production in the MIX ewes was only 10% lower than D1 (236 vs. 261 kg) and 37% higher than the D30 ewes (172 kg). Average lactation length (suckling + milking period) was similar in the various weaning systems. McKusick et al. (2002) compared the MIX and D1 weaning systems in East Friesian crossbreed ewes and found a higher milk yield in MIX ewes in weeks 2 and 4 postpartum. This was probably due to more frequent and

complete udder evacuation by the suckling lambs than by machine milking, as the latter reduces local concentrations of a feedback inhibitor of lactation.

In another study on East Friesian ewes, Thomas et al. (2001) observed that raising lambs on milk replacer and starting the milking of ewes 24–36 hours after parturition increased milk production by 61% when compared to starting machine milking after the lambs were weaned at 30 days of age.

Milking frequency

The reduction of milking frequency or the extension of milking intervals can accelerate the involution process and reduce lactation persistency through a mechanism that involves systemic and local factors, as described previously in this paper.

In dairy sheep, once per day milking (1X) reduced milk yield when compared to twice daily milking (2X) with similar intensity in dairy and non-dairy sheep breeds (Table 6) (Pulina and Nudda, 1996).

Table 6 - Influence of milking frequency on milk yield (MY) in dairy and non-dairy sheep

| Breed | Milk yield, Kg/d | MY variation in % compared to 2X | | Reference |
|------------------|---------------------|-------------------------------------|-------|-------------------------------|
| | | 1X | 3X | |
| Chios | 0.891 | -21.6 | - | Papachristoforou et al., 1982 |
| Churra | 0.803 | -47.0 | - | Purroy Unanua and Diaz, 1983 |
| Comisana | 0.387 | -26.4 | - | Battaglini et al., 1979 |
| Comisana | 0.440 | -21.3 | - | De Maria et al., 1982 |
| Lacaune | 0.933 | -41.0 | - | Labussière et al., 1983 |
| Meat sheep breed | 1.430 | -20.0 | +0.8 | Morag, 1968 |
| Poll Dorset | 0.494 | -7.3 | - | Knight and Gosling, 1995 |
| Prealpes du Sud | 1.008 | -51.3 | +14.7 | Labussière et al., 1974 |
| Sarda | 1.177 | -8.8 | - | Enne et al., 1972 |
| Sarda | 1.568 | -37.0 | +2.0 | Cannas et al., 1991 |
| Tsigai | - | - | +22.6 | Gaal, 1958 |
| Tsigai | 0.562 | -65.0 | - | Mykus and Masar, 1989 |

When, however, the ewes are milked more than twice per day, then the effect on non-dairy ewes is greater than in dairy ewes (Bencini, 1993). For example, increasing milking frequency from twice to three times per day only increased milk yield for the whole lactation period by 3% in Sarda ewes (Cannas et al 1991), while in Merino ewes it increased milk yield by about 21% (Bencini, 1993). The difference is probably due to the smaller udder storage capacity of Merino ewes compared to Sarda ewes. If the udder capacity is low then the milk must be removed more frequently. In an experiment with East Friesian crossbreed ewes, the responses to an increase in milking frequency in the first 30 days of lactation was related to the genetic potential of the animals (de Bie et al., 2000). In this trial, 25% of the animals did not show any response to a third milking, 50% of ewes produced 13% more milk, and 37.5% of the animals produced 36% more milk during the first 30 days of lactation. Probably, 37.5% of the ewes had

a genetic potential to produce more milk but had limited udder storage capacity. If this is the case then the more often the udder is milked, the more milk the ewe can produce. It is worth pointing out that when the third milking was removed, the milk yield dropped immediately to the level of twice a day milking (De Bie et al., 2000). Thus, the third milking at the beginning of lactation created a higher lactation peak, but the positive effect was not maintained during the rest of lactation.

A reduction in milk yield has also been reported when one evening milking per week was removed. The reduction varied with the breed, from 7.0% in Poll Dorset (Knight and Gosling; 1995) to 8.5% in Manchega (Huidobro, 1989), 14% in Sardinian (Casu and Boyazoglu, 1974) and 25.6% in Prealpes du Sud (Labussière et al., 1974). The magnitude of the effect of missing an evening milking may also be related to the production level and the cistern size of the animals. Castillo et al. (2005) evaluated the effects of 1X versus 2X on milk yield in Manchega (medium yielding) and Lacaune (high yielding) dairy ewes in two different stages of lactation: early-mid and mid-late lactation. The reduction in milk yield when one milking per day was omitted in early-mid lactation was higher in the Manchega breed (-33%) than in the Lacaune breed (-10%). The authors attributed the result to the lower cistern storage capacity of Manchega ewes (63%) compared to Lacaune ewes (77%), and the way that this can increase the negative effects of local factors on milk secretion.

Udder morphology and cistern dimension

As the alveoli are the site of action of the inhibitor peptides (Henderson and Peaker, 1984), the local inhibitory factors (i.e. the FIL) affect the rate of secretion when the milk is stored in the secretory tissue, whereas they are inactive in the milk stored in the cistern. As a consequence, the action of the FIL should be less in animals with larger cisterns, because a large proportion of the milk is stored in the mammary cistern and so the time during which the milk is in contact with the alveoli is reduced. Some studies have shown that milk production is positively influenced by mammary gland size (Bencini, 1993; Labussière et al., 1981) and cistern dimension (Nudda et al., 2000; Rovai et al., 2002). The use of ultrasound techniques to measure cistern size found that there was a strong positive relationship between cistern dimension and milk yield in Sarda ($r = 0.74$; $P < 0.001$; Nudda et al., 2002b) and Manchega ewes ($r = 0.76$; $P < 0.01$; Rovai et al., 2002). The hypothesis that the action of the FIL should be less in animals with larger cisterns was tested in an experiment in which dairy and non-dairy breeds were compared (Nudda et al., 2002a). We observed that two breeds, which were highly selected for milk production (Sarda and Awassi), responded to the reduction in the frequency of milking from twice to once a day by producing 18% to 24% less milk. Similar results were seen in Merino ewes, a wool breed not selected for milk production (Nudda et al., 2002a). This result is probably due to the fact that while the cisterns of the Merinos were smaller so was their average yield, and so the ratios between milk volume and milk cistern storage capacity were similar in dairy and non-dairy breeds. In the same trial it was also observed that the reduction of milk yield with once per day milking increased in proportion with the production level of the Sarda ewes, while in Merino ewes the reduction was independent of the production level. This was probably because the latter produced very little milk.

Stress

Reducing the emotional or physical stress of dairy animals will help to increase their productivity and maintain their health status. The effects of human contact (Rushen et al., 2001), a gentle or rough handler during milking (Munksgaard et al., 2001), and the use of the preferred side of the milking parlour (Paranhos da Costa and Broom, 2001) on milk yield have been analyzed in dairy cows. Dimitrov-Ivanov and Djorbineva (2002) found that machine-milked calm ewes produced more milk than nervous ones (Table 7). Agitation and excitement in the milking parlour is probably influenced by both genetic factors and the previous handling experience of the animals. In cattle it has been observed that animals with previous experience of quiet handling will be calmer and easier to handle in the future. In dairy cows the presence of a rough handler did not modify the total milk yield per milking but increased the residual milk by 70% (Rushen et al., 1999), which affected the milking length.

Breuer et al. (2000) carried out a survey on 31 farms and observed that several variables related to rough stockperson behaviour were negatively correlated with cow productivity. To be precise, they found that the behaviour used when forcing cows into position in the milking shed and/or when moving cows out of the shed were significantly correlated with milk yield ($r = -0.40$ and -0.39 , respectively, $P < 0.05$). They also found negative correlations between the number of loud or harsh sounds used by the stockperson and milk yield, and protein and fat content.

Table 7 -Effects of ewes' temperament during machine milking on milk production traits (Dimitrov-Ivanov and Djorbineva, 2002)

| Functional parameters | | Calm n = 106 | Nervous n = 54 | P |
|---------------------------|--------|-----------------|-------------------|-----|
| <i>Total morning milk</i> | ml | 592 | 477 | ** |
| Machine milk | ml | 421 | 336 | * |
| Machine steaming milk | ml | 38.3 | 34.8 | NS |
| <i>Hand steaming milk</i> | ml | 137.1 | 107.4 | * |
| Machine Milking Time | sec | 31.4 | 27.4 | * |
| Milk flow rate | ml/sec | 15.6 | 13.6 | * |
| Milk ejection latency | sec | 1.9 | 5.3 | *** |

The speed of movement of the stockperson when moving the cows from pasture to the milking shed over the last 50 m was also negatively correlated with milk yield. Thus it seems that fear of humans may have practical implications for the productivity of commercial dairy animals, including sheep. Our preliminary results showed that primiparous ewes that started to enter the milking parlor 2 weeks before weaning the lambs were calmer than ewes that entered the milking parlor after weaning. There was also higher milk yield and lower milk SCC at the beginning of lactation (Rassu et al., unpublished data).

Others physical stress such as water deprivation (Senn et al., 1996) or high temperatures, can negatively influence milk production. Restricting water consumption to 50% of the voluntary water intake for four days decreased the milk yield in cows by 74%

when compared with the control group. In addition, the restricted cows behaved very aggressively around their water trough and spent more time in its vicinity (Little et al., 1980). Whether the animals return to their normal productive capacity after the stress depends on the lactation stage, and in fact decreases as lactation progresses. Two main mechanisms may be involved in the response of animal productivity to stress: a local mechanism, proposed by Silanikove et al. (2000) which connects the plasminogen-plasmin system to the autocrine inhibition of lactation; a systemic mechanism which takes into account the role of the hypothalamic-pituitary-adrenal (HPA) axis in determining the rate of milk secretion (Matteri et al., 2000).

Silanikove et al. (2000) showed that stress activates the HPA axis that liberates cortisol into blood plasma. This in turn induces the liberation of the plasmin activator (PA) from the mammary epithelial cells into the mammary cistern where it activates the plasmin system that degrades β -casein and produces the residue 1-28 β -casein. This is also called proteoso-peptone channel blocking (PPCB). PPCB inhibits the ion channels in mammary epithelia apical membranes and, thus also inhibits lactose and monovalent ion secretion. This results in a decrease in milk volume (Figure 9). When injecting the 1-28 β -casein fraction into the udder lumen of goats, the authors observed a transient reduction in milk production, which was not associated with the disruption of the integrity of the mammary cell junctions.

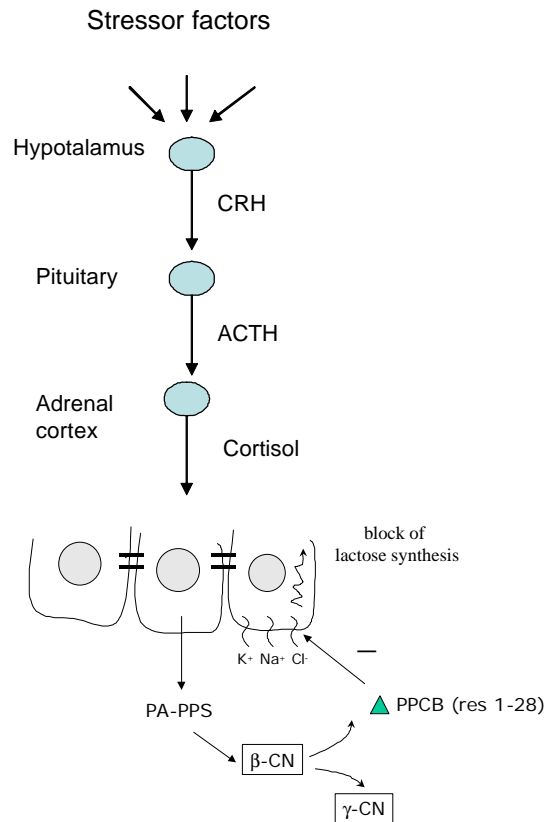


Figure 9 - A schematic and simplified representation of the local mechanisms of fraction 1-28 peptide (PPCB) derived from plasmin activity on β -casein into the mammary gland.

In the systemic mechanism, stress activates the HPA axis: the response to different stress factors provokes firstly the release of the hypothalamic factor vasopressin and corticotropin releasing hormones, which stimulate the secretion of Adrenocorticotrophic hormone (ACTH) by the pituitary gland. The ACTH stimulates the synthesis and release of glucocorticoids (cortisol and corticosterone) from the adrenal cortex. The main function of cortisol, which is secreted within a few minutes after exposure to stress, is to mobilize energy reserves to promote hyperglycemia and reduce cellular glucose uptake (Borski, 2000). In dairy animals, cortisol shows itself in a decrease of milk synthesis, by blocking the uptake of glucose by the mammary gland (Davis and Collier, 1985). Simulation of stress using ACTH treatment in dairy cows resulted in the cortisol concentrations being substantially higher and a reduction of mammary tight junction leakiness (Stelwagen et al., 1998), which showed itself in involution of the mammary gland (see paragraph 2). A secondary effect of stress is the inhibition of prolactin synthesis by the pituitary gland, due to the hypothalamic release of dopamine. Both cases lead the lactating ewe to a transient metabolic energy unbalance, due to the reduction in the energy output by the milk and an increase in mobilization of stored energy. This is caused by a sharp increase in glucocorticoids, followed by an increase in insulin and adipose tissue uptake capacity. If the stress level remains, it may have a negative effect on lactation persistency, especially in the second half of lactation, due to the leptin hormone secreted by adipose tissue inhibiting the IGF-I action on mammary parenchyma (Silva et al., 2002). In fact, Cannas et al. (unpublished data) found a negative relationship between leptin concentration in the blood and milk yield in ewes with different DM intake levels (Table 8).

Table 8 - Relationship between leptin, milk yield and DM intake in Sardinian breed ewes (Cannas et al., unpublished data).

| Leptin class ng/ml | Leptin ng/ml | Milk yield kg | Fat % | FCM ^a kg | DM Intake |
|-----------------------|-----------------|------------------|----------|------------------------|-----------|
| <2.30 | 1.95 | 1.983 | 6.90 | 2.044 | 2.79 |
| >2.30 | 2.70 | 1.434 | 7.28 | 1.531 | 2.22 |
| P | 0.000 | 0.039 | 0.490 | 0.034 | 0.088 |

^aFCM = Fat corrected milk

Udder health status

Although clinical cases of mastitis are a source of milk loss, subclinical mastitis is more important economically because it occurs more frequently (Ruiu and Pulina, 1992). It is associated with a decrease in milk production, milk quality and coagulation properties (Nudda et al., 2001). The coagulase negative staphylococci (CNS) are the most prevalent pathogens in the mammary gland of sheep (Gonzalo et al., 2002; McDougall et al., 2002). Bacterial infection of the mammary gland is associated with a higher somatic cell count (SSC) in milk (Figure 10) (Pulina et al., unpublished data).

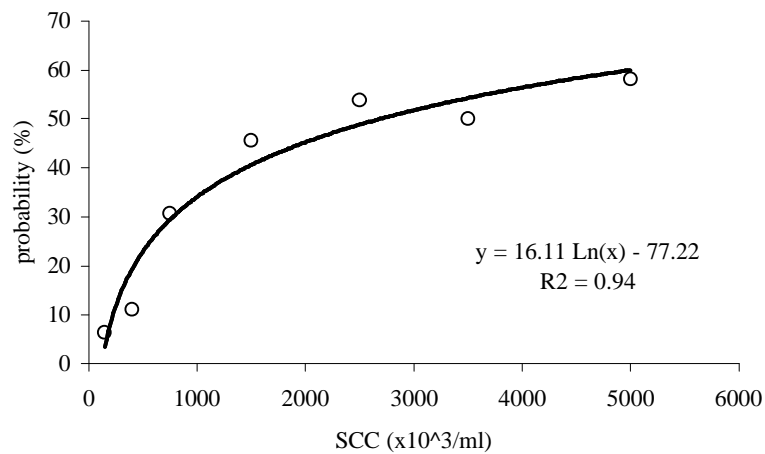


Figure 10 – Relationship between the probability of isolating microorganisms and somatic cell count (SCC) in half udders of dairy sheep (Pulina et al., unpublished data).

Losses of milk yield through intramammary infection (IMI) in sheep varies with the type of pathogen. High SCC, corresponding to major pathogens, causes larger milk yield losses (Table 9) (Gonzalo et al., 2002).

Table 9 - Least square means of somatic cell count (SCC) and milk yield losses (1322 Churra ewes; 9592 milk samples) (Gonzalo et al., 2002).

| Infection status | SCC (x10 ³ /ml) | Milk losses (%) |
|---|-------------------------------|--------------------|
| Uninfected | 82 | - |
| Infection by minor pathogens | 120 | 2.6 |
| Unilateral inf. by NSCNS ^a | 597 | 5.1 |
| Unilateral infection by major pathogens | 1317 | 8.8 |
| Bilateral infection by NSCNS | 1547 | 3.6 |
| Bilateral infection by major pathogens | 2351 | 10.1 |

^aNSCNS = Novobiocin sensitive coagulase-negative staphylococci

Sarda breed ewes with mammary glands, which were positive on bacteriological analysis, suffered a reduction in milk yield of about 24% in overall lactation when compared to negative animals (Figure 11). The pattern showed that intramammary infections (IMI) before the peak caused a reduction in peak yield, and the milk yield loss is maintained during lactation with a consequent lower persistency (Pulina et al., 1993).

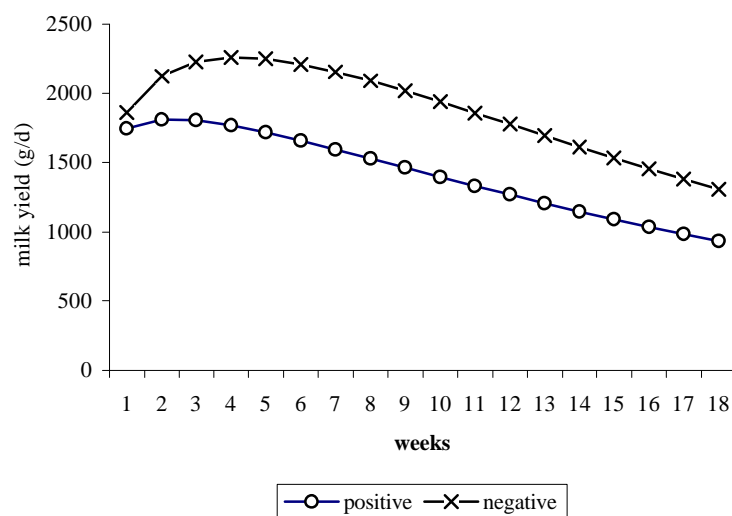


Figure 11 – Lactation curves of dairy ewes positive and negative to the mastitis test (Pulina et al., 1993)

The fight against mastitis in small ruminants is necessary not only because of the economic losses in milk yield and penalties in the payments of milk with high SCC, but also because it is necessary to improve the health status and welfare of animals.

Direct selection for mastitis resistance has been considered inefficient because SCC heritability, as an indirect measurement of udder health, is low in dairy sheep (Table 10), as it is also in dairy cows (Lund et al., 1994).

Table 10 - Heritability of somatic cell count (SCC) in milk of dairy sheep

| Character | h^2 | Breed | Author |
|-------------------|-----------|----------|-----------------------|
| LSCS ^a | 0.13 | Lacaune | Rupp et al., 2002 |
| LSCS | 0.15 | Lacaune | Barillet et al., 2001 |
| Log SCC | 0.09 | Churra | El-Saied et al., 1998 |
| Log SCC | 0.14 | Chios | Ligda et al., 2002 |
| LSCS | 0.12-0.16 | Manchega | Serrano et al., 2003 |

^aLSCS = Lactation somatic cell count

Some studies have indicated that cows with very low SCC levels may be more susceptible to mastitis than cows with higher SCC (Kehrli and Shuster, 1994). Studies based on experimental infection of cows reported that animals resisting udder infection had higher SCC before the pathogenic infection than animals that became infected (Schukken et al., 1998). This may also be true in dairy sheep. In our observations of an experimental flock where *Staphylococcus aureus* were found, we discovered that all the milk samples from animals with clinical signs of mastitis and dry-off of the gland had low SCC (<300.000/ml). This observation, however, needs to be confirmed by a greater number of samples.

Bergonier and Berthelot (2003) proposed a method for estimating the presence of subclinical mastitis. In a series of checks of the same animal during lactation, an udder is

considered “healthy” if every SCC (except possibly 2) is below 500,000 cells per ml, “infected” when at least two SCC are over one million cells per ml and “doubtful” in other cases. Using this method on the 90 Sarda ewes in our dataset with 6 samplings of each ewe, we classified three estimated udder health status (EUS) groups. The EUS classes significantly influenced both milk yield (Figure 12) and composition. The infection of the mammary gland was accompanied by a marked decrease in lactose, and a significant increase in the whey protein derived from blood (serum albumin, lactoferrin and immunoglobulin).

In Figure 13 we show the lactation curves of two groups of Sarda ewes that at the beginning of lactation were homogeneous for milk yield and SCC in milk ($< 5 \times 10^5$ /ml). In our method, animals were classified in two EUS groups as follows: animals with a SCC under 7.5×10^5 /ml throughout the lactation period were considered healthy (H-ewes), while those with a SCC value above 1×10^6 /ml starting from the second sampling date were considered non-healthy (NH-ewes). In reality, the lower milk yield of the NH-ewes was not related to the rate of decline after the peak (i.e. persistency), but was mainly due to the rapid loss of efficiency of synthesis of their secretory cells.

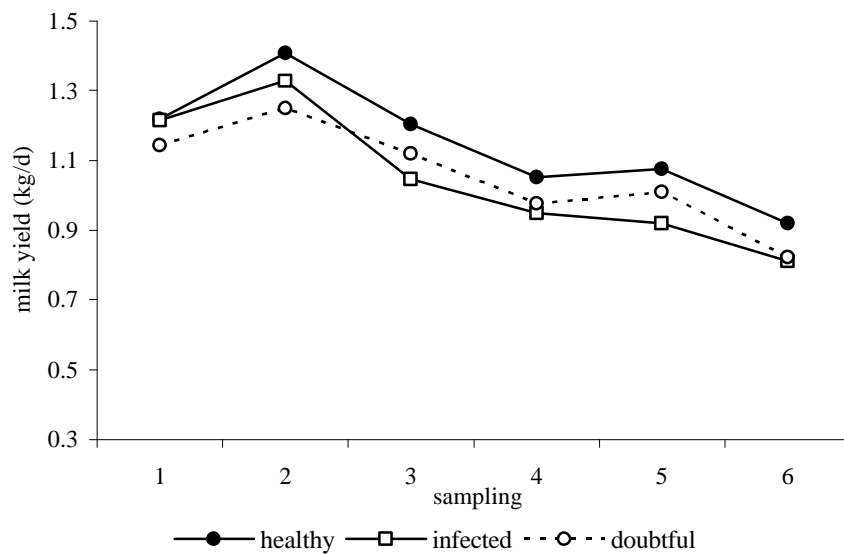


Figure 12 - Milk lactation curve in Sarda dairy ewes with udder classified healthy, doubtful and infected using the method of Bergonier and Berthelot (2003).

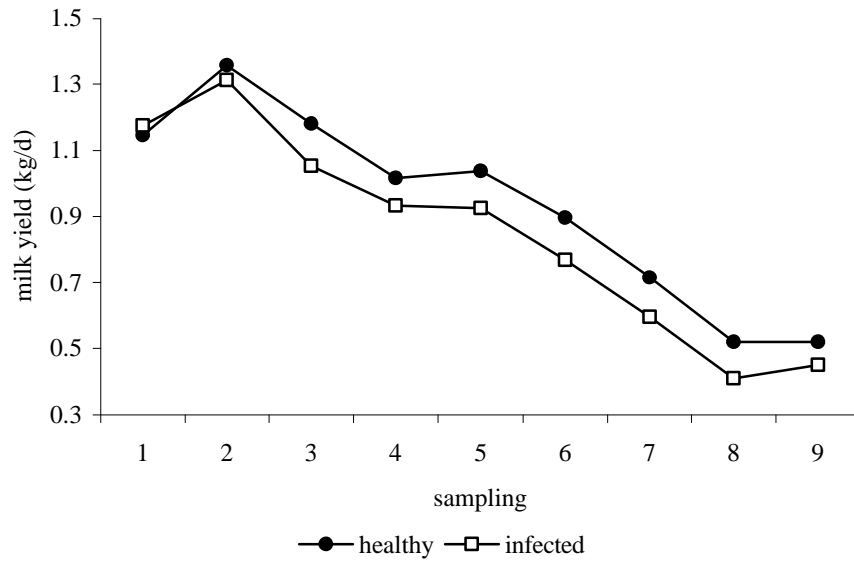


Figure 13 - Milk lactation curve in Sarda dairy ewes with udder classified healthy and infected using our method.

Practical Implications

The economic importance of persistency makes it desirable to have a flock with many ewes with lactation curves as flat as possible.

Even though exogenous administration of hormones (like ST, PRL and OT) effectively increases milk yield, we believe that permanent and profitable results can be achieved by: a) enhancing technical practices, b) focusing on better genetic goals for dairy sheep, c) taking care of udder health.

Genetic improvement for persistency leads to animals with high mammary storage capacity, longer lifetime of secretory cells and high levels of lactogen hormones.

Improving prolificacy increases persistency directly by increasing the population of secretory cells at the beginning of lactation and indirectly by the more complete and frequent evacuation of the udder by the suckling twins.

A larger udder storage cistern makes milk loss due to less frequent milking negligible. In general, a 3x, 2x and 1x daily milking protocol can conveniently be adopted for sheep 1-80 days in milking (DIM), 80-160 DIM and >160 DIM, respectively. However, milk yield gains/losses over the continuous 2X routine must be carefully evaluated, taking into account market milk price evolution, milking and handling costs and the interference with feeding requirements, and especially the DM intake in grazing management conditions.

Finally, udder health has to be continuously monitored by using SCC, conductivity or CMT test. Subclinical mastitis depreciates the value of milk by lowering its quality and severely affects lactation persistency and, lastly, total milk production per ewe.

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References

- Adams, N.R., and Briegel, J.R. 2005. Multiple effects of an additional growth hormone gene in adult sheep. *J. Anim. Sci.*, 83:1868-1874.
- Akers, R.M. 2002. Lactation and the mammary gland. Ed. R.M. Akers, Iowa State Press, Ames, Iowa.
- Allen J.C. 1990. Milk synthesis and secretion rates in cows with milk composition changed by oxytocin. *J. Dairy Sci.*, 73:975-984.
- Baldi A. 1999. Manipulation of milk production and quality by use of somatotropin in dairy ruminants other than cow. *Dom. Anim. Endocrinol.*, 17:131-137
- Baldi A., Chiofalo V., Savoini G., Greco R., Polidori F., and Politis I. 1997. Changes in plasmin, plasminogen and plasminogen activator activities in milk of late lactating ewes: effects of bovine somatotropin (bst) treatment. *Liv. Prod. Sci.*, 50:43-44.
- Baldi A., Modena S., Cheli F., Gandolfi F., Pinotti L., Scesi L. Baraldi, Fantuz F., and Dell'Orto V. 2002. Bovine somatotropin administration to dairy goats in late lactation: effects on mammary gland function, composition and morphology. *J. Dairy Sci.*, 85:1093-1102.
- Barillet, F. 1985. Amelioration genetique de la composition du lait de brebis. L'exemple de la race Lacaune. Ph. D. dissertation, Inst. Natl. Rech. Agron., Paris-Grignon, France.
- Barillet, F. 1997. Genetics in milk production. In L. Piper and F. Ruwinsky Eds. *The genetics of sheep*. CAB International, London, UK, pp. 539-564.
- Barillet, F., Marie, C., Jacquin, M., Lagriffoul, G., Astrue, and J. M. 2001. The French Lacaune dairy sheep breed: use in France and abroad in the last 40 years. *Liv. Prod. Sci.* 71:17-29.
- Battaglini A., De Maria C., Dell'Aquila. S., and Taibi L. 1979. Effetti della soppressione di una mungitura giornaliera sulla produzione e su talune caratteristiche qualitative del latte di pecore di razza Comisana. *Ann. Ist. Sper. Zootec.*, 12: 1-11.
- Bencini R. 1993. The sheep as a dairy animal: lactation, production of milk and its suitability for cheese making. Ph.D. dissertation, The University of Western Australia, Perth, Australia.
- Bergonier, D., and Berthelot, X. 2003. New advances in epizootiology and control of ewe mastitis. *Livest. Prod. Sci.* 79, 1–16.
- Bocquier F., Ligios S., Molle G., and Casu S. 1997. Effect de la photopériode sur la production, la composition du lait et sur les consommations volontaires chez la brebis laitière. *Ann. Zootech.*, 46:427-438.
- Boe F., and Pulina G. 2005. Ovisoft®. A software for dairy sheep farm simulation. In press.
- Borski R. J. 2000. Nongenomic membrane actions of glucocorticoids in vertebrates. *Trends Endocrinol. Metab.*, 10: 427-436.

- Breuer K., Hemsworth P. H., Barnett J. L., Matthews L. R., and Coleman G. J. 2000. Behavioural response to humans and the productivity of commercial dairy cows. *Appl. Anim. Behav. Sci.*, 66: 273-288.
- Burvenich C., VandeputteVan Messom G., Roets E., Massart-leen M., and Peeters G. 1991. Physiological factors affecting milk production in lactating ruminants. *Proceedings of the 9th A.S.P.A. Congress, Rome, Italy:1191-1203*
- Butler W.R., Fullenkamp S.M., Cappiello L.A., and Handwerker S. 1981. The relationship between breed and litter size in sheep and maternal serum concentrations of placental lactogen, estradiol and progesterone. *J. Anim. Sci.*, 53:1077-1081.
- Cannas A., Nudda A, and Pulina G. 2002. Nutritional strategies to improve lactation persistency in dairy ewes. *Proceedings of the 8th Great Lakes Dairy Sheep Symposium, Ithaca, USA:17-59*
- Cannas A., Pulina G., Rassu S.P.G., and Macciotta N.P.P. 1991. Influenza della terza mungitura sulla produzione quanti-qualitativa in pecore di razza Sarda. *Proc. 45th Natl. Congr. S.I.S.Vet., Palermo, Italy:1769-1772.*
- Cappio-Borlino A., Macciotta N. P. P., and Pulina G. 1997a. The shape of Sarda ewe lactation curve analyzed with a compartmental model. *Livest. Prod. Sci.*, 51:89-96.
- Cappio-Borlino A., Portolano B., Todaro M., Macciotta N.P.P., Giaccone P., and Pulina G. 1997b. Lactation curves of Valle del Belice dairy ewes for yields of milk, fat, and protein estimates with Test Day Models. *J. Dairy Sci.*, 80:3023-3029.
- Carta A., Sanna S.R., and Casu S. 1995. Estimating lactation curves and seasonal effects for milk, fat, and protein in Sarda dairy sheep with a test day model. *Livest. Prod. Sci.*, 44:37-44.
- Castillo V., Such X., Caja G., Albanell E., Casals R. 2005. Mid-term lactational effects on once versus twice daily milking in Manchega and Lacaune dairy ewes. *J. Dairy Sci.*, 88 (Suppl. 1): W118 (Abstr.).
- Casu S., Boyazoglou J.B. 1974. Effects de la suppressione de la traite du soir chez la brebis Sarde. *Ann. Zootech. n° Hors-serie:139-144.*
- Chang, Y., Rekaya, R., Gianola, D., and Thomas, D.L. 2001. Genetic variation of lactation curves in dairy sheep: a Bayesian analysis of Wood's function. *Livest. Prod. Sci.*, 71:241-251.
- Chang, Y., Rekaya, R., Gianola, D., and Thomas, D.L. 2002. Genetic variation of lactation curves in dairy sheep: quadratic function versus Wood's model. *Livest. Prod. Sci.*, 77:147-153.
- Chestnutt D.M.B., and Wylie A.R.G. 1995. The effects of frequency of feeding of supplementary concentrates on performance and metabolite and IGF-I status of ewes given silage in late pregnancy. *Anim. Sci.*, 61:269-276.
- Chiofalo V., Baldi A., Savoini G., Polidori F., Dell'Orto V., and Politis I. 1999. Response of dairy ewes in late lactation to recombinant bovine somatotropin. *Small Rum. Res.*, 34:119-125.
- D'Urso G., Avondo M., Bordonaro S., Marletta D., and Guastella A.M. 1998. Effect of sustained-release somatotropin on performance and grazing behaviour of ewes housed at different stoking rates. *J. Dairy Sci.*, 81:958-965.
- Davies, S.R., and Collier, R.J. 1985. Mammary blood flow and regulation of substrate supply or milk synthesis. *J. Dairy Sci.*, 68:1041-1058.
- De Bie L., Berger Y.M., Thomas D.L. 2000. The effect of three times a day milking at the beginning of lactation on the milk production of east friesland crossbreed ewes. *Proc. Great Lakes "Dairy Sheep Symposium", Guelph, Canada:1-9*

- De Maria Ghionna C., Dell'Aquila. S., and Carini S. 1982. Influenza della soppressione di una mungitura giornaliera sulla produzione, su talune caratteristiche qualitative e sull'attitudine alla coagulazione del latte in pecore di razza Comisana. *Zoot. Nutr. Anim.*, 8:407-418.
- Dekkers J.C.M., Ten Hag J.H., and Weersink A. 1998. Economic aspects of persistency of lactation in dairy cattle. *Livest. Prod. Sci.*, 53:237-252 .
- Dell'Orto, Chiofalo V., Savoini G., Zumbo, and Sgoifo-Rossi C. 1996. Effect de l'ijection de somatotropine bovine recombinée (rbST) sur le performances de brebis laitières. Influence de la nature de l'aliment concentré. *Ann. Zootech.*, 45 : 377-383.
- Dimitrov-Ivanov I., and Djorbineva M. 2002. Assessment of welfare, functional parameters of the udder, milk productive and reproductive traits in dairy ewes of different temperament. *EAAP 53rd Annual Meeting*, Cairo: 192 (Abstr.)
- El Saied U. M., Carriero J. A., and San Primitivo F. 1998. Heritability of test day somatic cell counts and its relationship with milk yield and protein percentage in dairy ewes. *J. Dairy Sci.* 81:2956–2961.
- Enne G., Losito de Carvalho R., Rallo F. 1972. Indagine sulla soppressione delle mungiture domenicali e pomeridiane di pecore di razza Sarda. *Riv. Zoot.*, 45:455-472.
- Fernandez N., Rodriguez M., Peris, C., Barcelo M., Molina M.P., Torres A., Adriaens F. 1995. Bovine somatotropin dose titration in lactating dairy ewes. 1. Milk yield and composition. *J. Dairy Sci.*, 78:1073-1082.
- Fernandez N., Rodriguez M., Peris, C., Molina M.P., and Torres A. 1997. Bovine somatotropin dose titration in lactating dairy ewes. 2. Dose determination and factors affecting the response. *J. Dairy Sci.* 80:818-829.
- Flint D.G., Boutinaud M., Tonner E., Wilde C.J., Accorsi P.A., Kolb A.F., Whitelaw C.B.A., Beattie J., and Allan G.J. 2005. Insulin-like growth factor binding proteins initiate cell death and extracellular matrix remodeling in the mammary gland. *Dom. Anim. Endocr.*, 29: 274-282.
- Flint D.J., and Knight C.H. 1997. Interactions of prolactin and growth Hormone (GH) in the regulation of mammary gland function and epithelial cell survival. *J. Mammary Gland Neopl.*, 2:41-48.
- Frimawaty E., and Manalu W. 1999. Milk yield and lactose synthetase activity in the mammary glands of superovulated ewes. *Small Rum. Res.*, 33:271-278.
- Gaal M. 1958. milking Tsigai ewes three times daily at large farms. *Anim. Breed. Abstr.*, 26: 236 (Abstr.).
- Gabina D., Arrese F., Arranz J., Beltran De Heredia I. 1993. Average milk yield and environmental effects on Laxta sheep. *J. Dairy Sci.*, 76:1191-1198.
- Gengler N. 1996. Persistency of lactation yields: A review. *Interbull Bulletin*, 12: 87-96.
- Gonzalo C., Ariznabarreta A, Carriedo. J. A., and San Primitivo F. 2002. Mammary pathogens and their relationship to somatic cell count and milk yield losses in dairy ewes. *J. Dairy Sci.* 85:1460–1467.
- Groen, A.F., Steine, T., Colleau, J.J., Pedersen, J., Pribyl J., and Reinsch, N. 1997. Economic values in dairy cattle breeding, with special reference to functional traits. *Livest. Prod. Sci.*, 49:1-21.
- Grossman M., Hartz S. M., and Koops W. J. 1999. Persistency of lactation yield: a novel approach. *J. Dairy Sci.*, 82:2192-2197.
- Henderson A.J., and M. Peaker. 1984. Feed-back control of milk secretion in the goat by a chemical in milk. *J. Physiol.*, 351:39-45.

- Hooley R.D., Campbell J.J., and Findlay J.K. 1978. The importance of prolactin for lactation in the ewe. *J. Endocr.* 79:301-310.
- Huidobro, F. 1989. Effects of omitting the Sunday afternoon milking on milk yield of manchega ewes. *Anim. Breed. Abstr.* 57:4929
- Jakobsen J., Madsen P., Jensen J., Peersen J., Cristiensen L.G., and Sorensen D.A. 2002. Genetic parameters for milk production and persistency for Danish Holsteins estimated in random regression models using REML. *J. Dairy Sci.*, 85:1607-1616.
- Jamrozik J., Jensen G., Schaeffer L.R., and Liu Z. 1998. Analysis of persistency of lactation calculated from a random regression test day model. *Interbull Bulletin*, 16:64-68.
- Kehrli M. E., and Shuster D. E. 1994. Factors affecting milk somatic cell and their role in health of the bovine mammary gland. *J. Dairy Sci.*, 77:619-627.
- Knight T.W., and Gosling L.S. 1995. Effects of milking frequency and machine-stripping on the yield and composition of milk from Poll Dorset ewes. *New Zealand Agr. Res.*, 38:123-130.
- Labussière J., bennemederbél B., Combaud J.F., and De La Chevalerie F. 1983. Description des principaux paramètres caractérisant la production laitière, la morphologie mammaire et la cinétique d'émission du lait de la brebis Lacaune traitée une ou deux fois par jour avec ou sans égouttage. *Proc. 3th Int. Symp. "ordeno mecanico de pequenos ruminantes"*, Valladolid, Spain:625-652.
- Labussière J., Combaud J.F., and Petrequin P. 1974. Influence de la fréquence des traites et des tétées sur la production laitière des brebis Préalpes du Sud. *Ann. Zootech.*, 23:445-457.
- Labussière J., Dotchewski D., and Combaud J.F. 1981. Caractéristiques morphologiques de la mamelle des brebis Lacaune. Méthodologie pour l'obtention des données. Relations avec l'aptitude à la traite. *Ann. Zootech.*, 30:115-136.
- Leibovich H., Gertler A., Bazer F., and Gootwine, E. 2001. Effect of recombinant placental lactogen and recombinant ovine growth hormone on growth of lambs and milk production of ewes. *Livest. Prod. Sci.*, 68:79-86.
- Ligda C., Mavrogenis A. and Georgoudis A.. 2002. Estimates of genetic parameters for test day somatic cell counts in Chios dairy sheep. *Proc of 7th WCGALP Congress*, Montpellier, Communication: 9-21.
- Little W, Collis K.A., Gleed P.T., Sansom B.F., Allen W.M., and Quick A.J. 1980. Effect of reduced water intake by lactating dairy cows on behaviour, milk yield and blood composition. *Vet. Rec.*, 106: 547-551.
- Lund, T., Miglior, F., Dekkers, J. C. M., and Burnside, E. B.. 1994. Genetic relationship between clinical mastitis, somatic cell count, and udder conformation in Danish Holsteins. *Livest. Prod. Sci.*, 39:243-251.
- Macciotta N. P. P, Vicario D., Di Mauro C., and Cappio-Borlino A. 2004. A multivariate approach to modeling shapes of individual lactation curves in cattle. *J. Dairy Sci.*, 87:1092-1098.
- Macciotta N.P.P., Cappio-Borlino A., and Pulina G. 1999. Analysis of environmental effects on test day milk yields of Sarda Dairy ewes. *J. Dairy Sci.*, 82:2212-2217.
- Macciotta N.P.P., Sanna S.R., Dimauro C., and Cappio-Borlino A. 2003. A multivariate measure of lactation persistency for dairy sheep. *It. J. Anim. Sci.*, 2(suppl. 1):40-42.
- Manalu, W., Sumaryadi, M.Y., Sudjatmogo, and Satyaningtijas, A.S. 1998. Effect of superovulation on maternal serum progesterone concentration, uterine and fetal weights at weeks 7 and 15 of pregnancy in Javanese thin-tail ewes. *Small Rum. Res.*, 30:171-176.

- Manalu, W., Sumaryadi, M.Y., Sudjatmogo, and Satyaningtijas, A.S. 2000. Effect of superovulation prior to mating on milk production performances during lactation in ewes. *J. Dairy Sci.*, 83:477-483.
- Matteri, R.L., Carroll, J.A., and Dyer C.J., 2000. Neuroendocrine responses to stress. The biology of animal stress. Basic principles and implications for animal welfare. (Ed. Moberg G.P. and Mench J.A.). CAB International, Wallingford (UK). 43-76.
- McDougall S., Pankey W., Delaney C., Barlow J., Murdough P.A., and Scruton D. 2002. Prevalence and incidence of subclinical mastitis in goats and dairy ewes in Vermont, USA. *Small Rum. Res.*, 46:115-121.
- McGuire M.A., Bauman D.E., Miller M.A., and Hartnell G.F. 1992. Response of somatomedins (IGF-I and IGF-II) in lactating cows to variations in dietary energy and protein and treatment with recombinant n-methionyl bovine somatotropin. *Nutr. Abstr. Rev.*, 62:2839 (Abstr.).
- McKusick B.C., Berger Y.M., and Thomas D.L. 1999. Effect of three weaning and rearing systems on commercial milk production and lamb growth. *Proc. 5th Great Lakes Dairy Sheep Symposium*, Brattleboro, Vermont, USA:16-31.
- McKusick B.C., Thomas D.L., Romero J.E., and Marnet P.G. 2002. Effect of weaning system on milk composition and distribution of milk fat within the udder of East Friesian dairy ewes. *J. Dairy Sci.*, 85:2521-2528.
- McKusick B.C., Thomas D.L., and Berger Y.M. 2001. Effect of weaning system on commercial milk production and lamb growth of East Friesian dairy sheep. *J. Dairy Sci.*, 84:1660-1668.
- McMurtry J.P., Malven P.V., Arave C.W., Erb R.E., and Harrington R.B. 1975. Environmental and lactational variables affecting prolactin concentrations in bovine milk. *J. Dairy Sci.*, 58:181-189 .
- Mepham T.B. 1987. *Physiology of lactation*. Milron Keynes, Philadelphia, PA.
- Morag M. 1968. The effect of varying the daily milking frequency on the milk yield of the ewe and evidence on the nature of the inhibition of milk ejection by half udder milking. *Ann. Zootech.*, 17:351-369.
- Munksgaard, L., De Passillé A. M., Rushen J., Herskin M. S., and Kristensen A. M. 2001. Dairy cows' fear of people:social learning, milk yield and behaviour at milking. *Appl. Anim. Beh. Sci.* 73:15–26
- Mykus M., and Masar M. 1978. Milk production and labor productivity in sheep milking twice and thrice daily and without stripping. *Proc. 2nd Int. Symp. "la traite mecanique des petits ruminants"*, Alghero, Italy. 263-276.
- Nostrand S. D., Galton D. M., Erb H. N., and D. E. Bauman. 1991. Effects of daily exogenous Noxytocin on lactation milk yield and composition. *J. Dairy Sci.*, 74:2119-2127.
- Nudda A., Bencini R., Mijatovic S., and Pulina G. 2002a. The yield and composition of milk in Sarda, Awassi and Merino sheep milked unilaterally at different frequencies. *J. Dairy Sci.*, 85:2879-2885.
- Nudda A., Feligini M., Battacone G., Murgia P., and Pulina G. 2001. Relationship between somatic cell count, whey protein and coagulation properties in sheep milk. *Proc. 14th ASPA Congr.*, Firenze, Italy. 511-513.
- Nudda A., Pulina G., Battacone G., Cappio-Borlino A., and Brandano P. 2002b. Use of ultrasound technique for measuring mammary cistern size in primiparous and secondiparous dairy ewes. *EAAP 53rd Annual Meeting*, Cairo, Egypt: 220 (Abstr.).
- Nudda A., Pulina G., Vallebella R., Bencini R., and Enne G. 2000. Ultrasound tecnique for measuring mammary cistern size of dairy ewes. *J. Dairy Res.*, 67:101-106.

- Padayatty S.J., Orme S., Zenobi P.D., Stickland M.H., Belchetz P.E., Grant P.J. 1993. The effects of insulin-like growth factor-1 on plasminogen activator inhibitor-1 synthesis and secretion: results from in vitro and in vivo studies. *Thromb. Haemost.*, 70:1009-1013.
- Papachristoforou C., Roushias A., and Mavrogenis A.P. 1982. The effect of milking frequency on the milk production of Chios ewes and Damascus goats. *Ann. Zootech.*, 31:37-46.
- Paranhos da Costa, M.J.R., and Broom D.M. 2001. Consistency of side choice in the milking parlour by Holstein–Friesian cows and its relationship with their reactivity and milk yield. *Appl. Anim. Behav. Sci.*, 70:177-186.
- Politis I., Block E., and Turner J.D. 1990. Effect of somatotropin on the plasminogen and plasmin system in the mammary gland: proposed mechanism of action for somatotropin on the mammary gland. *J. Dairy Sci.*, 73:1494-1499.
- Politis. I. 1996. Plasminogen activator system: implications for mammary cell growth and involution. *J. Dairy Sci.*, 79:1097-1107.
- Portolano B., Todaro M., Spatafora F., Bono G., Margiotta S., Giaccone P., and Ortoleva V. 1996. Confronto fra due differenti modelli della curva di lattazione in pecore da latte di razza Comisana. (Comparison between two different lactation curve models in dairy Comisana ewes). *Zootec. Nutr. Anim.*, 22:323.
- Pryce, J.E., Veerkamp R. F., Thompson R., Hill W. G., and Simm G. 1997. Genetic aspects of common health disorders and measures of fertility in Holstein Friesian dairy cattle. *Anim. Sci.*, 65:353-360.
- Pulina G., and Nudda A. 1996. Aspetti tecnici e fisiologici della mungitura meccanica degli ovini. *L'Informatore Agrario*, 41:69-74.
- Pulina G., Cappio-Borlino A., Macciotta N.P.P. 2001. Using profit equations to derive economic values for milk production traits and feed intake in Sarda sheep. *Zootec. Nutr. Anim.*, 27:145-158.
- Pulina G., Nudda A., Fancellu S., Barbato A. M., and Rubattu R. 2005. Infusion of casein Hydrolizates into mammary gland simulates the omission of one daily milking in goats. *Ital. J. Anim. Sci.*, 4(suppl. 2):386-388.
- Pulina G., Rassu S.P.G., and Cannas A. 1993. The effect of group feeding strategy on milk production in dairy ewes. *Proc. 47th Natl. Congr. S.I.S.Vet., Riccione, Italy.2003-2006*
- Pulina G., Rassu S.P.G., Nudda A., and Battacone G. 2002 Influenza del fotoperiodo e dell'intermungitura sulla produzione di latte in pecore sarde. *Proc. 15th Natl. Congr. S.I.P.A.O.C., Chia, Italy: 230.*
- Purroy Unanua A., and Diaz M.J.L. 1983. Caracteristicas de ordino de raza Churra: produccion y composicion de leche; morfologia de la ubre y cinetica de emision de leche. *Proc. 3th Int. Symp. "Ordeno Mecanico de Pequenos Ruminantes", Valladolid, Spain: 984-993*
- Rekaya, R., Weigel K. A., and Gianola D. 2001. Hierarchical nonlinear model for the persistency of milk yield in the first three lactations of Holsteins. *Livest. Prod. Sci.*, 68:181-187.
- Rovai M., Such X., Caja G., and Piedrafita J. 2002. Changes in cisternal and alveolar milk throughout lactation in dairy sheep. *J. Dairy Sci.* 85(suppl. 1):12 (Abstr.).
- Ruiu A., and Pulina G. 1992. Mastiti ovine, qualità del latte e prospettive di profilassi sanitaria. *L'Informatore Agrario*, 14: 37-40.
- Ruiz R., Oregui L.M., and Herrero M. 2000. Comparison of models for describing the lactation curve of Latxa sheep and an analysis of factors affecting milk yield. *J. Dairy Sci.*, 83:2709-2719.

- Rupp R., Boichard D., Barbat A., Astruc J.M., Lagriffoul G., and Barillet F., 2002. Selection for mastitis resistance in French dairy sheep. Proc. 7th W.C.G.A.L.P., Montpellier, France, Communication 9-28.
- Rushen J, De Passille AM, Munksgaard L. 1999. Fear of people by cows and effects on milk yield, behavior, and heart rate at milking. J. Dairy Sci., 82:720-727.
- Rushen J., L. Munksgaard, P. G. Marnet and A. M. DePassillé. 2001. Human contact and the effects of acute stress on cows at milking. Appl. Anim. Behav. Sci., 73:1-14.
- Schoknecht P.A., Nobrega S.N., Petterson J.A., Ehrhardt R.A., Slepatis R., and Bell A.W. 1991. Relations between maternal and fetal plasma concentrations of placental lactogen and placental and fetal weights in well-fed ewes. J. Anim. Sci., 69:1059-1063.
- Schukken, Y. H., Leslie K. E., Barnum D. A., Mallard B. A., Lumsden J. H., Dick P. C., Vessie G. H., and Kehrl M. E. 1998. Experimental *Staphylococcus aureus* intramammary challenge in late lactation dairy cows: quarter and cow effects determining the probability of infection. J. Dairy Sci., 82:2393–2401.
- Senn M., Gross-Luem S., Kaufmann A., and Langhans W. 1996. Effect of water deprivation on eating patterns of lactating cows fed grass and corn pellets ad lib. Physiol. Behav., 60:1413-1418.
- Serrano M., Perez-Guzman M.D., Montoro V., and Jurado J.J. 2003. Genetic analysis of somatic cell count and milk traits in Manchega ewes. Mean lactation and test-day approaches. Liv. Prod. Sci., 84:1-10
- Shamay A., Shapiro F., Mabjeesh S.J., and Silanikove N. 2002. Casein-derived phosphopeptides disrupt tight junction integrity, and precipitously dry up milk secretion in goats. Life Sci., 70:2707–2719.
- Silanikove, N, A. Shamay, D. Shinder, and A. Moran. 2000. Stress down regulates milk yield in cows by plasmin induced β -casein product that blocks k^+ channels on the apical membranes. Life Sci., 67:2201–2212.
- Silva L.P.T., VanderHarr M.S., Weber Nielsen M.S., and Etchebarne B.E. 2002. Leptin reduces proliferation of a bovine mammary epithelial cell line. J. Dairy Sci., 85(suppl. 1):338 (abstr. 1352).
- Snowder G.D., and Glimp H.A. 1991. Influence of breed, number of sucking lambs, and stage of lactation on ewe milk production and lamb growth under range conditions. J. Anim. Sci., 69:923-930.
- Sölkner J., and Fuchs W. 1987. A comparison of different measures of persistency with special respect to variation of test day yields. Liv. Prod. Sci., 16:305-319.
- Stanton T.L., Jones L.R., Everett R.W., and Kachman S.D. 1992. Estimating milk, fat and protein lactation curves with a test day model. J. Dairy Sci., 75:1691-1700.
- Stelwagen K., and Knight C. H. 1997. Effect of unilateral once or twice daily milking of cows on milk yield and udder characteristics in early and late lactation. J. Dairy Res., 64:487-494.
- Stelwagen K., Grieve D.G., Walton J.S. Ball J.L., and McBride. 1993. Effect of prepartum bovine somatotropin in primigravid ewes on mammogenesis, milk production, and hormone concentrations. J. Dairy Sci., 76:992-1001.
- Stelwagen K., van Espen D.C., Verkerk G.A., McFadden H.A. and Farr V.C. 1998. Elevated plasma cortisol reduces permeability of mammary tight junctions in the lactating bovine mammary epithelium. J. Endocr., 159:173-178.

- Stelwagen, K., Davis S.R., Farr V.C., Prosser C.G., and Sherlock R.A. 1994. Mammary epithelial cell tight junction integrity and mammary blood flow during an extended milking interval in goats. *J. Dairy Sci.*, 77:426-432.
- Swalve H.H. 2000. Theoretical basis and computational methods for different test day genetic evaluation methods. *J. Dairy Sci.*, 83:1115-1124.
- Swalve, H. H. 1995. Genetic relationship between dairy lactation persistency and yield. *J. Anim. Breed. Genet.*, 112:303-311.
- Thomas D. L., Berger Y. M. , and McKusick B. C. 2001. Effects of breed, management system, and nutrition on milk yield and milk composition of dairy sheep. *J. Anim. Sci.*, 79(suppl. E):E16-E20.
- Togashi, K., and C. Y. Lin. 2003. Modifying the lactation curve to improve lactation milk and persistency. *J. Dairy Sci.* 86:1487-1493.
- Tonner E., Allan G.J., and Flint D.J. 2000. Hormonal control of plasmin and tissue-type plasminogen activator activity in rat milk during involution of the mammary gland. *J. Endocrinol.*, 167:265-273.
- Wilde C.J., and Knight C.H. 1990. Milk yield and mammary function in goats during and after once-daily milking. *J. Dairy Res.*, 57:441-447.
- Wilde C.J., Henderson A.J., Knight C.H., Blatchford D.R., Faulkner A., and Vernon R.G. 1987. Effects of long-term thrice-daily milking on mammary enzyme activity, cell population and milk yield in the goat. *J. Anim. Sci.*, 64:533-539.
- Wohlt J.E., Foy Jr V.L., Kniffen D.M., Trout J.R. 1984. Milk yield by Dorset ewes as affected by sibling status, sex and age of lamb, and measurement. *J. Dairy Sci.*, 67:802-807.
- Wood P.D.P. 1967. Algebraic model of the lactation curve in cattle. *Nature*, 216:164-165.
- Zamiri M. J., Qotbi A., and Izadifard J. 2001. Effect of daily oxytocin injection on milk yield and lactation length in sheep. *Small Rum. Res.*, 40:179-185.

MILK FAT SYNTHESIS AND ITS REGULATION IN DAIRY SHEEP

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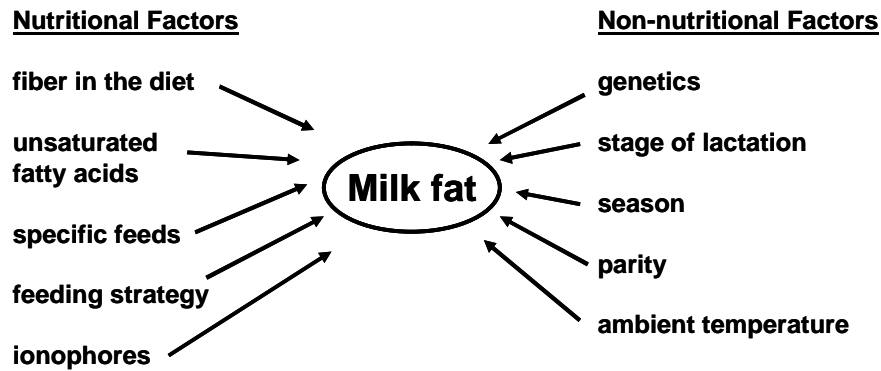
Introduction

Milk and dairy products were recognized as important foods as early as 4000 B.C. as evidenced by rock drawings from the Sahara. Today, the important contribution of milk and dairy products in meeting our dietary requirements for energy, high quality protein and several key minerals and vitamins are well documented. With the projected growth in world population and the increased demand for animal-derived food products as living standards improve, dairy products will undoubtedly continue to be an important dietary source of nutrients (Bauman et al., 2005a). Fat is an important component of milk for a number of reasons. Nutritionally, fat is the major energy component of milk and it accounts for many of the physical properties, manufacturing characteristics, and sensory attributes of milk and dairy products. The fat content of milk is highly variable and the environmental and physiological factors affecting milk fat have been extensively characterized. Furthermore, nutritional quality has become increasingly important in food choices because of consumer awareness of the link between diet and health; importantly, milk fat has been shown to contain a number of bioactive components that may provide benefits to human health which has led to an interest in “designing” milk fat to improve its healthfulness and functional properties. Nutrition is the predominant factor affecting milk fat and it represents a practical tool to alter the yield and fatty acid composition of milk fat. The impact of nutrition on fat content and fatty acid composition of milk in the bovine has been extensively reviewed (Palmquist et al., 1993; Lock and Shingfield, 2004; Lock and Bauman, 2004). Therefore, the purpose of this review is to provide an overview of the biology of milk fat synthesis in ruminants, discuss an innovative method for altering the fat content of sheep milk and its possible application, and consider the manipulation of the fatty acid composition of sheep milk fat.

Milk Fat Synthesis

Fat is the most variable component in the milk of ruminants. The concentration of fat in milk is influenced by animal and environmental factors such as breed, diet, stage of lactation, season of year, ambient temperature, and body condition (Figure 1). Milk fat consists of droplets of triglycerides that are coated with cell membrane (milk fat globular membrane; MFGM). Thus, the majority of the fat content of milk is triglycerides (~95%) with phospholipids, cholesterol, diacylglycerols, monoacylglycerols, and free fatty acids constituting the remainder (Lock and Shingfield, 2004). Ruminants are estimated to have over 400 different fatty acids comprising milk fat triglycerides, but the majority of the fatty acids have chain lengths between four and eighteen carbons. In ruminants, fatty acids in milk fat arise from two sources that contribute equally (molar basis), *de novo* synthesis within the mammary gland and uptake of preformed fatty acids from circulation (McGuire and Bauman, 2002). An overview of the metabolic pathways and some of the key enzymes involved in milk fat synthesis are shown in Figure 2.

Figure 1. Nutritional and non-nutritional factors affecting milk fat content in ruminants.



De novo fatty acids are synthesized from acetate (C₂) and β-hydroxybutyrate (C₄) and include the short and medium chain (4 to 14 carbons) and a portion of the 16 carbon fatty acids. This is different compared to monogastric animals, which primarily use glucose as the carbon source for milk fat synthesis. Acetate and β-hydroxybutyrate are extracted from the blood by the mammary gland and it is estimated that acetate contributes about 90% and β-hydroxybutyrate contributing the remainder of the total carbon in milk fatty acids. *De novo* fatty acid synthesis creates a range of fatty acids with chain lengths of 4 to 16 carbons; mechanisms regulating chain length termination are not clearly understood (McGuire and Bauman, 2002). Ruminant milk fat is unique among mammals in that it contains a high proportion of short-chain fatty acids (4, 6, 8, and 10 carbons). Milk fatty acids derived from circulating lipoprotein triglycerides and non-esterified fatty acids (NEFA) include a portion of the 16 carbon fatty acids and all ≥ 18 carbons. These circulating fatty acids originate from lipids absorbed from the digestive tract and from mobilized body fat reserves. Dietary triglycerides are not soluble in water but are packaged in lipoproteins within the blood. The specific lipoprotein that transports dietary triglycerides to the mammary gland is very-low-density lipoproteins (VLDL). To obtain the fatty acids from the VLDL, the enzyme lipoprotein lipase cleaves the triglyceride into glycerol and NEFA that then are taken up by the mammary cell. NEFA liberated from body fat reserves are also taken up by the mammary gland (Lock and Bauman, 2004).

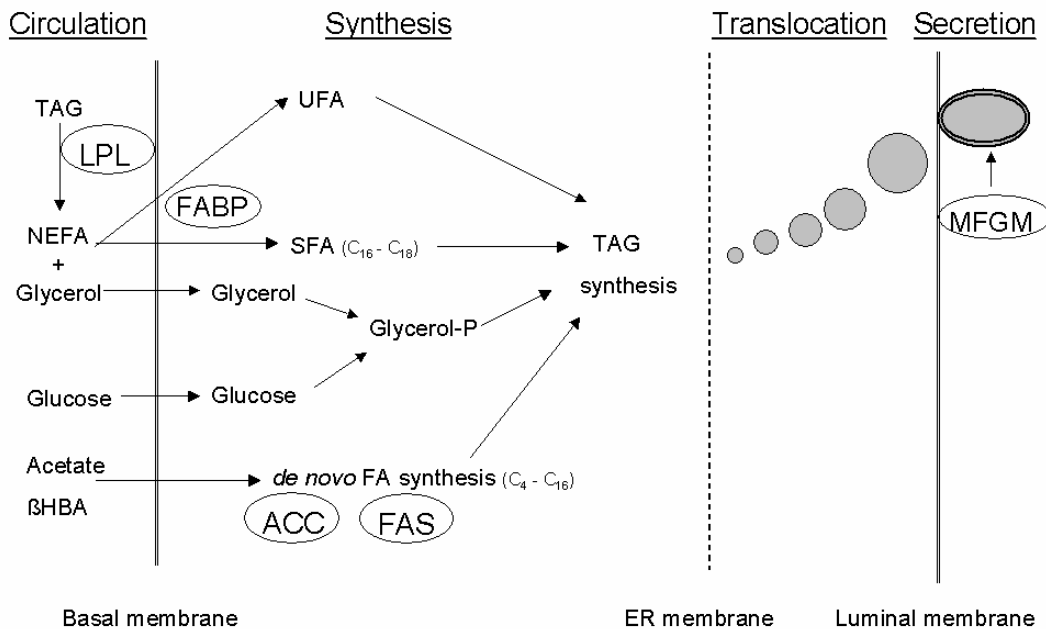
Since milk fat is composed mostly of triglycerides, esterification of the fatty acids is also an important feature of milk fat synthesis (McGuire and Bauman, 2002). Fatty acids from both sources are esterified in the endoplasmic reticulum, where they are attached to the glycerol molecule in an orderly and systematic fashion. There are three sites of attachment to the glycerol molecule. Some fatty acids are positioned at random onto glycerol, while others occupy a specific position. For example, lauric acid (C₁₂) is randomly assigned, while butyric acid (C₄) is positioned primarily on the third carbon (*sn*-3) of the glycerol structure. Once the triglycerides are formed, they coalesce into fat droplets, which move through the epithelial cell toward the luminal side where they acquire the MFGM coat and pinched off into the lumen (Figure 2).

As mentioned previously, milk fat contains a multitude of fatty acids, with a large portion of these produced as intermediates during lipid metabolism in the rumen (Lock and Bauman, 2004). Saturated, monounsaturated, and polyunsaturated fatty acids are all present in ruminant milk fat.

The variety of fatty acids allows the mammary gland to produce triglycerides with a range of fluidity, so that the mammary cell can secrete the milk fat. The fluidity of triglycerides is increased by the use of short- and medium-chain fatty acids that arise from *de novo* synthesis as well as long-chain unsaturated fatty acids (McGuire and Bauman, 2002). The mammary gland also has an additional means to regulate the fluidity of the milk fat via the enzyme Δ^9 -desaturase. This enzyme is very active in ruminant mammary cells inserting a double bond into a variety of saturated and monounsaturated fatty acids effectively lowering the melting point of the fatty acids present in milk. This is critical for the maintenance of the fluidity of both milk fat and cellular membranes. The main action of the Δ^9 -desaturase enzyme is to convert stearic acid ($C_{18:0}$) to oleic acid ($C_{18:1n-9}$). However, Δ^9 -desaturase is also important in the production of *cis*-9, *trans*-11 conjugated linoleic acid (CLA) (Bauman and Lock, 2005).

Figure 2. Milk fat synthesis in mammary cells of ruminants (McGuire and Bauman, 2002).

Acetyl CoA carboxylase, ACC; β -hydroxybutyrate, β HBA; endoplasmic reticulum, ER; fatty acid binding protein, FABP; fatty acid synthase, FAS; glycerol phosphate, glycerol-P; lipoprotein lipase, LPL; milk fat globule membrane, MFGM; nonesterified fatty acid, NEFA; saturated fatty acids, SFA; triglycerides, TAG; unsaturated fatty acids, UFA.



Manipulating Milk Fat Content

The major dietary factors affecting milk fat content are level of effective fiber, level of highly fermentable carbohydrate, presence of rumen buffers, degree of saturation of dietary lipid, and relative rumen availability of dietary fatty acids (Figure 1). Interactions among these factors are key to the impact on milk fat content. For instance, increases in the effective fiber content of the diet tend to be associated with an increased milk fat percent. However, the potential exists with “normal” dietary levels of effective fiber for low milk fat content (McGuire and Bauman, 2002). This is an increasing problem within the dairy cow-industry and is commonly referred to as milk fat depression (MFD). Recent advances in our understanding of MFD has shown that unique fatty acids produced in the rumen can significantly impact the rate and extent of milk fat

synthesis in the mammary gland (Bauman et al., 2005b). Specifically, the conjugated linoleic acid isomer *trans*-10, *cis*-12 CLA has been shown to be a potent regulator of milk fat synthesis and increased production of this fatty acid has been shown to be related to situations in which MFD occurs. Relationships between *trans*-10, *cis*-12 CLA and milk fat synthesis have been examined; there is a curvilinear relationship between the reduction in milk fat yield and the abomasal infusion dose of *trans*-10, *cis*-12 CLA in dairy cows (de Veth et al., 2004). *Trans*-10, *cis*-12 CLA is a very potent inhibitor of milk fat synthesis in dairy cows with a dose of 2.0 g/d (<0.01% of dry matter intake) reducing milk fat synthesis by 20%.

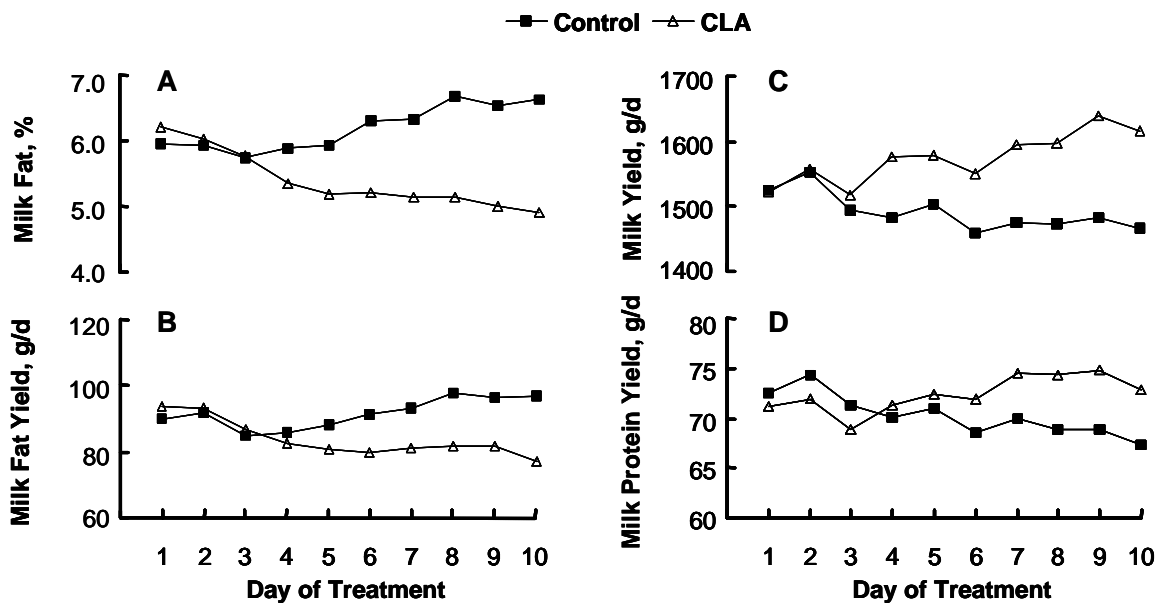
There is a significant feed cost associated with the synthesis of milk fat because it represents the major energy cost in the production of milk components being energetically equivalent to over one-half of the costs associated with milk synthesis. One of the exciting aspects of our work investigating MFD and *trans*-10, *cis*-12 CLA has been the broader implications of the research. In addition to applying this knowledge in dairy production to maintain a normal milk fat production when that is desirable, dietary supplements of *trans*-10, *cis*-12 CLA can also be used as a management tool for reducing milk fat in a controlled manner. A controlled reduction in milk fat output requires a repartitioning in the use of nutrients and a sparing of energy that can be used for other purposes. For example, in the lactating dairy cow, the ability to selectively reduce milk fat yield could be of economic value in situations where there is a quota on milk fat yield. It could also benefit cow well-being by reducing energy demands during times when nutrient intake is inadequate, such as during the transition period at the onset of lactation or under adverse environmental conditions such as heat stress or weather-related feed shortages (Bauman et al., 2005b).

Chilliard et al. (2003) reviewed studies involving effects of lipid supplements on milk fat synthesis in ruminants and concluded there were many similarities, but often goats and sheep responded differently than cows. Most studies of the effects of CLA supplements and *trans*-10, *cis*-12 CLA on milk fat synthesis in ruminants have involved dairy cows. However, two recent reports involving goats indicated that CLA-supplements had little or no effect on milk fat yield, and authors emphasized that goats may be not be suitable models for cows in studies of milk fat synthesis (Erasmus et al., 2004; Schmidely and Morand-Fehr, 2004). Prior to our work, there were no investigations in lactating sheep, whose milk is characterized by higher fat and protein concentrations than that of the cow and goat (Pulina and Nudda, 2005). Thus, we conducted a study to determine if a CLA supplement containing *trans*-10, *cis*-12 CLA would reduce milk fat synthesis in lactating sheep. To achieve this aim, the dose of *trans*-10, *cis*-12 CLA was extrapolated on a metabolic body weight (MBW) basis from the extensive work with dairy cows. We decided to calculate the amount of *trans*-10, *cis*-12 CLA supplementation based on MBW since this concept was initially developed for comparisons of metabolic rate across species and subsequently used for the interspecies calculation of drug dosages and comparisons of animal performance variables including daily milk energy secretion (Blaxter, 1989). The experiment utilized 20 multiparous ewes which were fed grass-hay and a standard ewe concentrate at the rate of 1.8 kg/d. Ewes were milked twice daily through a standard milking parlour designed for ewes. Dietary treatments were: 1) control (unsupplemented diet) and 2) diet supplemented with CLA. The supplement (25 g/d) was mixed into the concentrate allocation on a daily basis and provided 2.4 g/d of *trans*-10, *cis*-12 CLA. To minimize alterations of the *trans*-10, *cis*-12 CLA by rumen bacteria we used a lipid-encapsulated CLA product (BASF AG, Ludwigshafen,

Germany); we have shown previously that this rumen-protected dietary supplement is effective at reducing milk fat synthesis in dairy cows (Perfield et al., 2004).

Compared to the control treatment, CLA supplementation reduced milk fat content from 6.4 to 4.9% (23% reduction) and fat yield from 95 to 80 g/d (16% reduction), and increased milk yield from 1471 to 1611 g/d (10% increase) and protein yield from 68 to 73 g/d (7% increase). Milk protein content and DMI were unaffected by treatment. The reduction in milk fat yield was due to decreases in both *de novo* fatty acid synthesis and uptake of preformed fatty acids. Milk fat content of *trans*-10, *cis*-12 CLA was < 0.01 and 0.12 g/100 g of fatty acids for the control and CLA treatments, respectively. The temporal pattern for milk fat content and yield demonstrated a progressive decline when ewes received the CLA supplement with a significant deviation from control values beginning by days 4 to 5 of treatment, with a reciprocal increase in milk yield and milk protein yield (Figure 3).

Figure 3. Temporal pattern of milk fat content (A), milk fat yield (B), milk yield (C), and milk protein yield (D) of ewes unsupplemented (Control; solid squares) or supplemented with conjugated linoleic acid (CLA; open triangles). Values represent means from 20 ewes.



The present study represented the first to examine effects of CLA on milk fat synthesis in sheep, and these data demonstrate that a CLA supplement containing *trans*-10, *cis*-12 CLA reduced milk fat synthesis in a manner similar to that observed in lactating dairy cows when fed at an equivalent dose (MBW basis). Furthermore, the reduction in milk fat coincided with an increase in milk and milk protein yield. Increases in milk yield and milk protein yield have previously been observed in early lactation (Bernal-Santos et al., 2003) and pasture-fed dairy cows (Mackle et al., 2003). Thus, in situations where nutrient supply may be marginal, CLA-induced milk fat depression may allow a repartitioning of nutrients to support an increase in the synthesis of milk and milk protein. However, nutrient status was adequate in our investigation with lactating ewes. The present study is too limited to allow inferences as to mechanism, but

clearly further investigations of these effects are warranted. An analogous response has been observed in lactating sheep when energy and nutrient supply were increased through the feeding of a supplement composed of animal fat and rumen-protected methionine, and this resulted in an increase in both milk yield and milk protein yield (Goulas et al., 2003). In addition, our study demonstrated that the lactating sheep may represent an effective alternative model to elucidate the mechanism of action by which CLA inhibits milk fat synthesis.

Considering that the majority of sheep milk is used to produce cheese, the effect of CLA-supplementation on milk composition and how this may affect cheese yield and quality is of commercial interest. The effect of milk composition on cheese yield and cheese quality was recently reviewed at this conference (Wendorff, 2002). For most full-fat type cheeses the high fat content of sheep milk is a disadvantage. A casein:fat ratio in sheep milk of 0.70-0.80 would be desirable, however, this ratio is typically lower (0.55-0.65; Table 1), which results in excess fat in sheep milk that typically is lost in the whey. In most cases, sheep milk would need to be standardized by removing some milk fat in order to increase the casein:fat ratio to produce most of the cheese varieties shown in Table 2. High losses of fat in the whey will result in a decreased cheese yield. In our experiment described above, milk from sheep fed the unsupplemented (control) diet had an estimated casein:fat ratio of 0.58, whereas this increased to 0.73 in milk from CLA-supplemented animals, offering the potential to manipulate the diet in order to improve cheese yield and quality. A further example where such a technology could be employed is in the manufacture of Pecorino Sardo. This cheese is produced according to DOP rules and according to those rules the milk cannot be skimmed (M. Griinari, personal communication). A controlled reduction in the fat content of milk may allow for the production of a better quality product, a reduction in the amount of fat lost in the whey, and an increase in cheese yield. We have just completed a follow up experiment to investigate the effect of CLA-supplementation on cheese yield and cheese quality. Milk from different treatments was made into “cheddar” type cheese at the end of the experiment. The animal component of the experiment has been completed and cheese manufacturing and assessment is underway; similar reductions in milk fat content and yields were observed as described previously resulting in the desired changes in the casein:fat ratio being achieved.

Table 1. Casein:Fat ratios for breeds of dairy sheep. Adapted from (Wendorff, 2002).

| Breed | Casein:Fat ratio |
|--------------------------------|------------------|
| Lacaune | 0.60 |
| Boutsico | 0.60 |
| Friesland | 0.63 |
| Italian Species | 0.63 |
| Current Expt. Control | 0.58 |
| Current Expt. CLA Supplemented | 0.73 |

Table 2. Ideal casein:fat ratios in cows milk for commodity cheeses. Adapted from (Wendorff, 2002).

| Cheese | Casein:Fat ratio |
|----------------------|------------------|
| Cheddar | 0.70 |
| Mozzarella | 0.85 |
| Swiss | 0.85 |
| Parmesan | 0.80 |
| Havarti | 0.60 |
| Reduced Fat Muenster | 1.73 |

Manipulating Milk Fatty Acid Composition

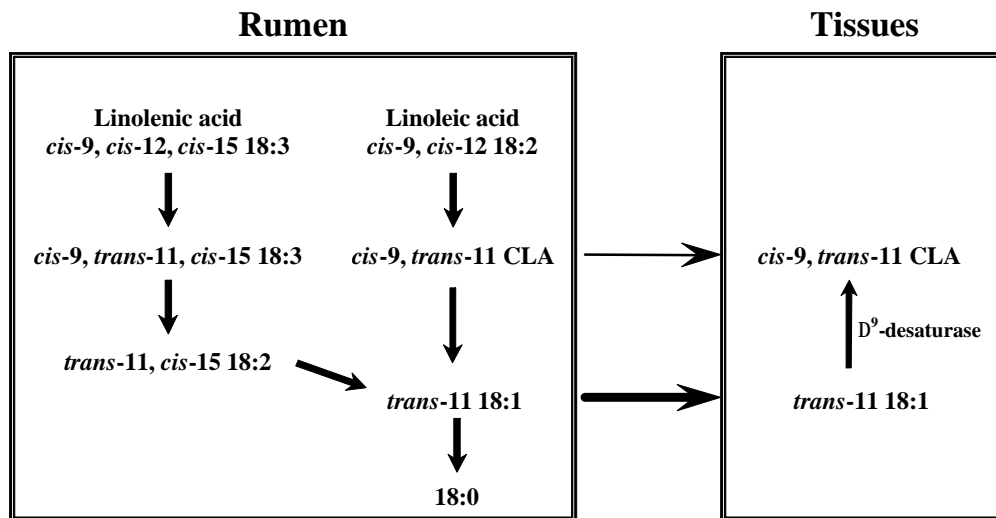
Historically, the goal of agricultural research has been to increase yield and productive efficiency, with little focus given to improving the nutrient profile of food products. However, mounting research evidence and consumer awareness of the potential health benefits of various micro-components in foods has given rise to the concept of functional foods and helped create a demand for foods with improved nutrient profiles (Lock and Bauman, 2004). Thus, producers and scientists are interested in research and agricultural practices that may improve the nutrient profile of food products. Milk fat is relatively more saturated than most plant oils, and this has led to a negative consumer perception and a public health concern related to excessive intake of saturated fats. Consequently, in the past, much of this work has involved studies in which whole-scale changes have been the goal, whereby large shifts in the saturated to PUFA ratio have been sought-after. Modest changes have been achievable, but this can lead to problems relating to product quality and stability. Recent research has demonstrated that generalizations about fat and fatty acids are of little value and often lead to misleading and erroneous public understanding. Rather one must consider the biological effects and nutritional value on the basis of individual fatty acids (Lock and Bauman, 2004). A number of specific fatty acids are now recognized as having beneficial effects on human health, and these include omega-3 fatty acids and *cis*-9, *trans*-11 CLA that are present in milk fat. Enhancing their content in milk fat requires an understanding of the interrelationship between dietary supply of lipid, rumen fermentation and mammary synthesis of milk fat, and the reader is referred to a previous review for a more detailed discussion on this subject (Lock and Bauman, 2004). Although the vast majority of the work investigating the manipulation of the fatty acid composition of milk fat has been carried out in dairy cows, general concepts and strategies can be applied to other ruminants, including dairy sheep. Nudda et al. (2004) recently provided a general overview of the effects of nutrition on sheep milk fatty acid composition.

Milk fat content of eicosapentaenoic (20:5 n-3; EPA) and docosahexaenoic acid (22:6 n-3; DHA) are of interest because of their potential benefits to human health in reducing risk of cardiovascular disease, type II diabetes, hypertension, cancer, and certain disruptive neurological functions (Lock and Bauman, 2004). Consequently, there is an effort to increase consumption of these functional food components due to the low intake of omega-3 and the relationship in the intake of omega-3:omega-6 fatty acids; Western diets typically have a omega-6 to omega-3 ratio of 20-30:1 whereas the ideal ratio is thought to be 4:1 or less (Lock and Bauman, 2004). As a consequence opportunities to enhance omega-3 fatty acids in many foods, including dairy products, are being explored. Milk and dairy products normally contain very low amounts of EPA and DHA, and increasing their content is limited primarily because their biohydrogenation in the rumen is extensive and secondarily because they circulate in specific plasma lipid fractions that contribute minimally to the mammary supply of fatty acids. These challenges must be addressed to achieve substantial increases in EPA and DHA levels in milk fat, and the formulation of supplements of EPA and DHA that are protected from metabolism by rumen bacteria has potential to address the biohydrogenation problem. It is important to note that in order to increase the concentration of EPA and DHA in ruminant fat the supplementation of sources containing these fatty acids (e.g. fish oil) is required, as their synthesis from fatty acid precursors is low. Most work so far has involved dairy cows with little published information on manipulating the omega-3 content of sheep milk. Limited data would indicate that the content of

EPA and DHA in sheep milk is similar to that of cows' milk, with fish oil, and to a greater extent, rumen-protected fish oil allowing for an increase in the omega-3 content of sheep milk (Chikunya et al., 2002; Kitessa et al., 2003). There has also been some success in the use of marine algae to alter EPA and particularly DHA in growing lambs (Cooper et al., 2004).

The intake of *cis*-9, *trans*-11 CLA in humans is of interest because of the potential health benefits it may confer. In particular, the anticarcinogenic activity of *cis*-9, *trans*-11 CLA has been clearly established with *in vitro* cell culture systems and *in vivo* animal models for a wide range of cancer types, with the antiatherogenic properties also now being established (Bauman et al., 2005a). The major dietary sources of *cis*-9, *trans*-11 CLA are foods derived from ruminants, with about 70% and 25% coming from dairy products and red meat, respectively, with *cis*-9, *trans*-11 CLA representing >90% of total CLA found in ruminant products (Parodi, 2003). The presence of *cis*-9, *trans*-11 CLA in ruminant milk and meat is related to rumen fermentation and originates mainly from endogenous synthesis in the mammary gland; only a minor portion comes from production in the rumen. The substrate used to form *cis*-9, *trans*-11 CLA is vaccenic acid (*trans*-11 18:1) produced as an intermediate during rumen biohydrogenation, and the enzyme that catalyzes the reaction is Δ^9 -desaturase (Figure 4). Due to the precursor:product relationship between vaccenic acid and *cis*-9, *trans*-11 CLA, a close linear relationship has been reported for the milk fat content of these fatty acids in dairy cows. This same relationship is shown in Figure 5 for sheep milk fat from our study reported above and a similar relationship was also observed by Nudda et al. (2005).

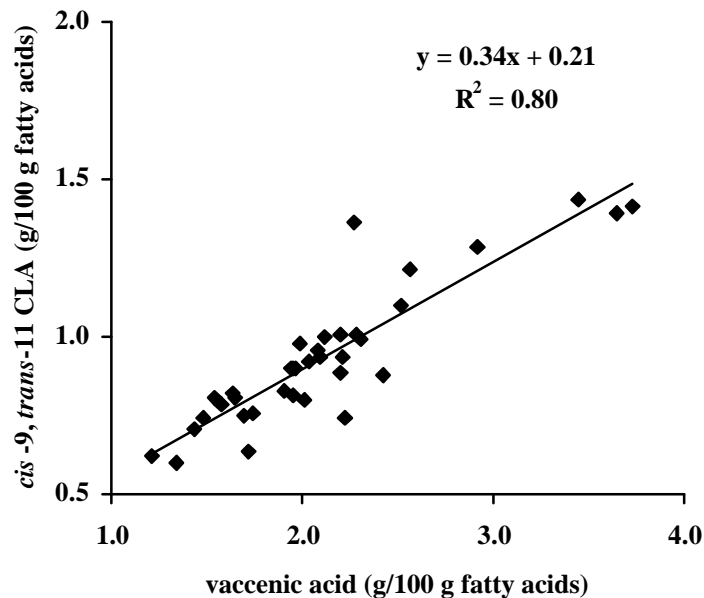
Figure 4. Pathways for the biosynthesis of *cis*-9, *trans*-11 conjugated linoleic acid (CLA) in ruminants. Adapted from Bauman and Lock (2005).



Numerous studies have shown that diet is the most significant factor affecting the *cis*-9, *trans*-11 CLA content of milk fat, and its concentration can be increased several-fold by dietary means (Lock and Bauman, 2004). The key to increasing milk *cis*-9, *trans*-11 CLA is to increase rumen vaccenic acid output, allowing for increased endogenous synthesis in the mammary gland. One strategy is to increase the dietary intake of 18-carbon PUFAs by addition of seeds or plant oils high in linoleic and/or linolenic acids (e.g. soybeans or sunflowers) which results in an

increase in rumen output of vaccenic acid, and to a lesser extent *cis*-9, *trans*-11 CLA. Another means through which dietary and nutritional factors can increase the *cis*-9, *trans*-11 CLA content of milk fat is by inhibiting the terminal step in biohydrogenation. In general, no single bacteria carries out the complete biohydrogenation process; rather one group carries out the steps to convert linoleic and linolenic acids to VA and then another bacteria group carries out the final step to form stearic acid (Lock and Bauman, 2004). Therefore, dietary factors that affect rumen bacteria involved in biohydrogenation, either directly or indirectly via changes in rumen environment, can also affect the *cis*-9, *trans*-11 CLA content of ruminant fat. In particular, increasing the forage:concentrate ratio and the use of fish oil increases *cis*-9, *trans*-11 CLA concentration by this means. A combination of dietary supply of PUFA and modification of the rumen environment can be especially effective to increase the *cis*-9, *trans*-11 CLA content of ruminant fat. The most widely studied of these is the use of fresh pasture, with numerous studies indicating that fresh pasture results in a 2- to 3-fold increase in the *cis*-9, *trans*-11 CLA content of milk fat, but the effect diminishes as the pasture matures. Likewise, seasonal effects on milk *cis*-9, *trans*-11 CLA content have been reported, with the trend that content is greatest when fresh pasture is plentiful, and decreases throughout the growing season. Although the use of fresh pasture has striking effects on enhancing the *cis*-9, *trans*-11 CLA content of milk fat, a similar increase is possible using a combination of standard dietary ingredients such as plant oils/oilseeds and fish oil/fish meal supplements. Increases in *cis*-9, *trans*-11 CLA observed with fish oils and feeding fresh pasture cannot be fully explained in terms of their PUFA content, therefore other factors or components of these feeds must affect rumen bacteria involved in biohydrogenation thereby promoting rumen production of vaccenic acid and *cis*-9, *trans*-11 CLA.

Figure 5. Relationship between *cis*-9, *trans*-11 CLA and vaccenic acid in sheep milk.



Although diet has a major effect on milk fat content of *cis*-9, *trans*-11 CLA, there is also a wide variation among individuals. Even when diet and other physiological variables are similar, there is still a 3-fold range among individuals in the milk fat concentration of *cis*-9, *trans*-11

CLA. Examination of physiological factors has established that milk fat content of *cis-9, trans-11* CLA has little or no relation to milk or milk fat yield, parity, stage of lactation or breed (Lock and Bauman, 2004). This variation must therefore, in large part, be related to individual differences in rumen output of vaccenic acid and to a lesser extent *cis-9, trans-11* CLA, and to the amount and activity of Δ^9 -desaturase. Undoubtedly, the variation in Δ^9 -desaturase among individuals has a genetic basis, and there is currently interest in understanding the genetic variation and heritability of this enzyme. Increasing the activity of Δ^9 -desaturase via selection and/or nutritional manipulation offer further potential to enhance the level of *cis-9, trans-11* CLA in milk through increasing endogenous synthesis (Figure 3). Increasing Δ^9 -desaturase activity would not only impact on the level of *cis-9, trans-11* CLA in milk fat, but would also increase other unsaturated fatty acids that are products of this enzyme. Finally, the final concentration of *cis-9, trans-11* CLA in dairy products is, in large part, related to the *cis-9, trans-11* CLA concentration in the raw milk fat and the fat content of the final product. Any changes in the *cis-9, trans-11* CLA content related to processing or to storage of dairy products are minimal when compared to the variations associated with diet formulations and differences among individual animals.

We have used such feeding regimes and taken advantage of individual animal variation to produce *cis-9, trans-11* CLA-enriched butter for use in biomedical studies with animal models. In a series of studies, we have shown that dietary consumption of *cis-9, trans-11* CLA-enriched butter is effective in reducing the progression and incidence of tumors in a rat-model of mammary cancer. These results are among the first to demonstrate that a naturally produced anticarcinogen, consumed as a component of a natural food, is effective in reducing cancer. Furthermore, vaccenic acid present in milk fat is also anticarcinogenic via its conversion to *cis-9, trans-11* CLA by our own Δ^9 -desaturase enzyme system. Recently, we have shown that naturally-derived *cis-9, trans-11* CLA also has potent antiatherogenic properties. See the review by Bauman et al. (2005a) for a detailed discussion of the biological effects of *cis-9, trans-11* CLA and vaccenic acid.

The increased interest in the effect of bioactive fatty acids in milk fat has led to a number of recent studies reporting the effects of different diets on the fatty acid composition of sheep milk. An example of typical sheep milk fatty acid profile is shown in Table 3 and is taken from our study reported earlier when ewes received the unsupplemented (Control) diet. In general, the unsupplemented ewes had a milk fat content and fatty acid profile similar to other studies with lactating sheep (Rotunno et al., 1998; Sevi et al., 2002). The content of *cis-9, trans-11* in ewes fed the control diet was however, lower than that reported in a survey of ewes when grazing grass (Nudda et al., 2005), but comparable to values when a dried complete diet was fed (Luna et al., 2005). A recent review examined the effect of forage species and stage of growth on the *cis-9, trans-11* CLA content of sheep milk fat under Mediterranean conditions (Cabiddu et al., 2005). As for dairy cows, feeding fresh lush pasture results in the highest *cis-9, trans-11* CLA content of milk fat. Similarly, seasonal changes in the *cis-9, trans-11* CLA content of sheep milk have been reported which were related to pasture quality and availability (Figure 6; Nudda et al., 2005). Finally, it has also recently been reported that the fatty acid composition of dairy products (ripened cheeses and ricotta) produced from CLA-enriched milk were dependent on the fatty acid composition of the starting raw milk, with manufacturing, ripening and storage having little or no effect on the *cis-9, trans-11* CLA content of the final product (Addis et al., 2005;

Luna et al., 2005; Nudda et al., 2005). As shown in Table 4 there was little or no change in the content of important fatty acid in chesses over a four-month period. In general, it is apparent that nutritional strategies to alter the fatty acid composition of sheep milk fat are similar to those that have been examined in dairy cows.

Table 3. Typical fatty acid profile of sheep milk fat.

| Fatty acid | g/100 g | Fatty acid | g/100 g |
|---------------------------|---------|--|---------|
| 4:0 | 4.2 | 18:1 <i>trans</i> -10 | 0.7 |
| 6:0 | 1.9 | 18:1 <i>trans</i> -11 | 1.7 |
| 8:0 | 1.4 | 18:1 <i>trans</i> -12 | 0.3 |
| 10:0 | 3.5 | 18:1 <i>cis</i> -9 | 23.6 |
| 12:0 | 2.1 | 18:2 <i>cis</i> -9, <i>cis</i> -12 | 6.8 |
| 14:0 | 6.8 | 18:2 <i>cis</i> -9, <i>trans</i> -11 | 0.8 |
| 14:1 <i>cis</i> -9 | 0.5 | 18:2 <i>trans</i> -10, <i>cis</i> -12 | trace |
| 15:0 | 0.7 | 18:3 <i>cis</i> -9, <i>cis</i> -12, <i>cis</i> -15 | 0.2 |
| 16:0 | 31.1 | 20:0 | 0.2 |
| 16:1 <i>cis</i> -9 | 0.9 | Other | 2.1 |
| 17:0 | 0.3 | <u>Summation</u> | |
| 18:0 | 9.4 | <C16 | 20.3 |
| 18:1 <i>trans</i> -6 to 8 | 0.5 | C16 & C16:1 | 32.1 |
| 18:1 <i>trans</i> -9 | 0.4 | >C16 | 47.6 |

Figure 6. Seasonal changes in the *cis*-9, *trans*-11 CLA content in sheep milk, cheese, and ricotta sampled every 2 wk from March to June in 2 milk processing plants in North Sardinia (Nudda et al., 2005). Different letters indicate significant differences ($P < 0.05$) between the sampling periods.

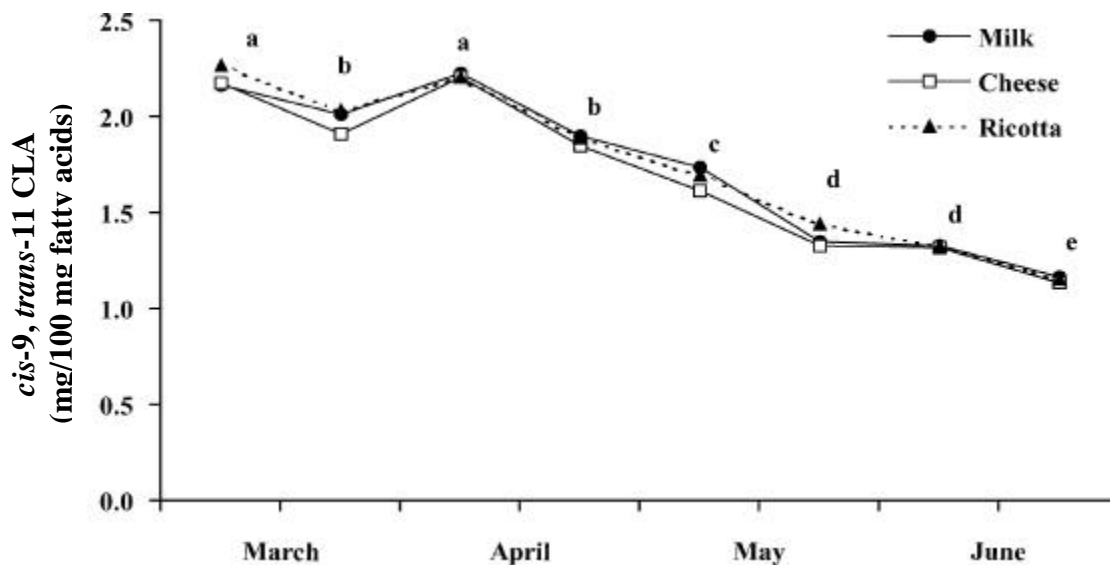


Table 4. Fatty acid composition (g/100 g fatty acids) of milk fat from ewes fed a control diet, or a diet supplemented with in linseed, and cheeses at 1, 2, and 4 months of ripening made from the milk of animals fed the linseed supplemented diet. Adapted from Luna et al. (2005).

| Fatty Acid | Milk | | Cheese | | |
|--|---------|---------|---------|---------|---------|
| | Control | Linseed | 1 Month | 2 Month | 4 Month |
| ? <C16 | 33.5 | 29.2 | 29.2 | 29.3 | 29.2 |
| ? C16 | 29.6 | 26.0 | 26.1 | 25.9 | 26.0 |
| ? >C16 | 37.0 | 44.8 | 44.7 | 44.8 | 45.0 |
| 18:1 <i>trans</i> -11 | 2.4 | 3.6 | 3.6 | 3.5 | 3.7 |
| 18:2 <i>cis</i> -9, <i>trans</i> -11 | 0.8 | 1.0 | 1.0 | 1.0 | 1.0 |
| 18:2 <i>cis</i> -9, <i>cis</i> -12 | 3.3 | 2.8 | 2.8 | 2.8 | 2.8 |
| 18:3 <i>cis</i> -9, <i>cis</i> -12, <i>cis</i> -15 | 0.5 | 1.1 | 1.0 | 1.1 | 1.1 |

Conclusions

In this paper we have given a broad overview of milk fat synthesis in ruminants and how we can control nutrition to manipulate the content and composition of milk fat. Understanding the interrelationship between dietary supply of lipid, rumen fermentation and mammary synthesis of milk fat is of major importance to the dairy industry because the nature of the milk fat fraction influences the manufacturing properties and organoleptic qualities of milk and dairy products. An understanding of these relationships will permit milk fat content and fatty acid composition to be altered through nutritional practices, thereby offering the opportunity for producers to respond to market forces and human health recommendations.

References

- Addis, M., A. Cabiddu, M. Pinna, M. Decandia, G. Piredda, A. Pirisi, and G. Molle. 2005. Milk and cheese fatty acid composition in sheep fed Mediterranean forages with reference to conjugated linoleic acid *cis*-9,*trans*-11. *J. Dairy Sci.* 88:3443-3454.
- Bauman, D. E. and A. L. Lock. 2005. Conjugated linoleic acid. In: W. G. Pond and A. W. Bell (Eds.) *Encyclopedia of Animal Science*. pp. 235-238. Marcel Dekker, Inc., New York, USA.
- Bauman, D. E., A. L. Lock, B. A. Corl, A. M. Salter, C. Ip, and P. W. Parodi. 2005a. Milk fatty acids and human health: potential role of conjugated linoleic acid and *trans* fatty acids. In: K. Sejrsen, T. Hvelplund, and M. O. Nielsen (Eds.) *Ruminant physiology: Digestion, metabolism and impact of nutrition on gene expression, immunology and stress*. Wageningen Academic Publishers, Wageningen, The Netherlands. (in press).
- Bauman, D. E., A. L. Lock, and J. W. Perfield II. 2005b. The role of *trans* fatty acids in the regulation of milk fat synthesis. *Proc. Intermountain Nutr. Conf.* pp. 85-96, Salt Lake City, UT.
- Bernal-Santos, G., J. W. Perfield, D. M. Barbano, D. E. Bauman, and T. R. Overton. 2003. Production responses of dairy cows to dietary supplementation with conjugated linoleic acid (CLA) during the transition period and early lactation. *J. Dairy Sci.* 86:3218-3228.
- Blaxter, K. 1989. *Energy Metabolism in Animals and Man*. Cambridge University Press, Cambridge, UK.

- Cabiddu, A., M. Decandia, M. Addis, G. Piredda, A. Pirisi, and G. Molle. 2005. Managing Mediterranean pastures in order to enhance the level of beneficial fatty acids in sheep milk. *Small Rumin. Res.* 59:169-180.
- Chilliard, Y., A. Ferlay, J. Rouel, and G. Lamberet. 2003. A review of nutritional and physiological factors affecting goat milk lipid synthesis and lipolysis. *J. Dairy Sci.* 86:1751-1770.
- Chikunya, S., L. A. Sinclair, and R. G. Wilkinson. 2002. Influence of dietary n-3 polyunsaturated fatty acids on milk fat composition and performance of lactating Friesland ewes. *Proc. British Soc. Anim. Sci.* pp. 11, York, UK.
- Cooper, S. L., L. A. Sinclair, R. G. Wilkinson, K. G. Hallett, M. Enser, and J. D. Wood. 2004. Manipulation of the n-3 polyunsaturated fatty acid content of muscle and adipose tissue in lambs. *J. Anim. Sci.* 82:1461-1470.
- de Veth, M. J., J. M. Griinari, A. M. Pfeiffer, and D. E. Bauman. 2004. Effect of CLA on milk fat synthesis in dairy cows: Comparison of inhibition by methyl esters and free fatty acids, and relationships among studies. *Lipids* 39:365-372.
- Erasmus, L. J., Z. Bester, T. Fourie, R. J. Coertze, and L. Hall. 2004. Effect of level of rumen protected CLA supplementation on milk yield and composition in Saanen goats. *South African J. Anim. Sci.* 34 (Suppl. 1):42-45.
- Goulas, C., G. Zervas, and G. Papadopoulos. 2003. Effect of dietary animal fat and methionine on dairy ewes milk yield and milk composition. *Anim. Feed Sci. Technol.* 105:43-54.
- Kitessa, S. M., D. Peake, R. Bencini, and A. J. Williams. 2003. Fish oil metabolism in ruminants-III. Transfer of n-3 polyunsaturated fatty acids (PUFA) from tuna oil into sheep's milk. *Anim. Feed Sci. Technol.* 108:1-14.
- Lock, A. L. and D. E. Bauman. 2004. Modifying milk fat composition of dairy cows to enhance fatty acids beneficial to human health. *Lipids* 39:1197-1206.
- Lock, A. L. and K. J. Shingfield. 2004. Optimising milk composition. In: E. Kebreab, J. Mills, and D. Beever (Eds.) *UK Dairying: Using science to meet consumers' needs.* pp. 107-188. Nottingham University Press, Nottingham, UK.
- Luna, P., J. Fontecha, M. Juarez, and M. A. de la Fuente. 2005. Changes in the milk and cheese fat composition of ewes fed commercial supplements containing linseed with special reference to the CLA content and isomer composition. *Lipids* 40:445-454.
- Mackle, T. R., J. K. Kay, M. J. Auldist, A. K. H. McGibbon, B. A. Philpott, L. H. Baumgard, and D. E. Bauman. 2003. Effects of abomasal infusion of conjugated linoleic acid on milk fat concentration and yield from pasture-fed dairy cows. *J. Dairy Sci.* 86:644-652.
- McGuire, M. A. and D. E. Bauman. 2002. Milk biosynthesis and secretion. In: H. Roginski, J. W. Furquay, and P. F. Fox (Eds.) *Encyclopedia of Dairy Sciences.* pp. 1828-1834. Elsevier Sciences Ltd., London, England.
- Nudda, A., G. Battacone, R. Bencini, and G. Pulina. 2004. Nutrition and milk quality. In: G. Pulina (Ed.) *Dairy Sheep Nutrition.* pp. 129-150. CABI Publishing, Oxford, UK.
- Nudda, A., M. A. McGuire, G. Battacone, and G. Pulina. 2005. Seasonal variation in conjugated linoleic acid and vaccenic acid in milk fat of sheep and its transfer to cheese and ricotta. *J. Dairy Sci.* 88:1311-1319.
- Palmquist, D. L., A. D. Beaulieu, and D. M. Barbano. 1993. Feed and animal factors influencing milk fat composition. *J. Dairy Sci.* 76:1753-1771.

- Parodi, P. W. 2003. Conjugated linoleic acid in food. In: J.-L. Sebedio, W. W. Christie, and R. O. Adlof (Eds.) *Advances in Conjugated Linoleic Acid Research*, Volume 2. pp. 101-122. AOCS Press, Champaign, IL.
- Perfield, J. W., A. L. Lock, A. M. Pfeiffer, and D. E. Bauman. 2004. Effects of amide-protected and lipid-encapsulated conjugated linoleic acid (CLA) supplements on milk fat synthesis. *J. Dairy Sci.* 87:3010-3016.
- Pulina, G. and A. Nudda. 2005. Milk production. In: G. Pulina (Ed.) *Dairy Sheep Nutrition*. pp. 1-12. CABI Publishing, Oxford, UK.
- Rotunno, T., A. Sevi, R. Di Caterina, and A. Muscio. 1998. Effects of graded levels of dietary rumen-protected fat on milk characteristics of Comisana ewes. *Small Rumin. Res.* 30:137-145.
- Schmidely, P. and P. Morand-Fehr. 2004. Effects of intravenous infusion of *trans*-10, *cis*-12 or *cis*-9, *trans*-11 conjugated linoleic acid (CLA) on milk fat synthesis and composition in dairy goats during mid-lactation. *South African J. Anim. Sci.* 34 (Suppl. 1):195-197.
- Sevi, A., T. Rotunno, R. Di Caterina, and A. Muscio. 2002. Fatty acid composition of ewe milk as affected by solar radiation and high ambient temperature. *J. Dairy Res.* 69:181-194.
- Wendorff, B. 2002. Milk composition and cheese yield. *Proc. 8th Great Lakes Dairy Sheep Symposium* pp. 104-117, Ithaca, NY.

MANAGING YOUR OWN RETAIL SHOP: MARKETING AND SELF-DISTRIBUTION OF FARMSTEAD CHEESE

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Financial success on a small farm doesn't come without a healthy dose of hard work, trust in our ability to finish the job, and a love of what you do. Farming is the only business where the producer pays retail, sells wholesale, and carries the burden of both incoming and outgoing freight. These are the unfortunate parameters within which we work.

At La Moutonnière Inc., we are always looking for ways to grow in an expanding market ... and to hold the course in a slower one. To add to the challenge, we also want to preserve quality of life for both the humans and the animals in our operation. We spent 2004 designing a new on-farm fromagerie (cheese plant) only to realize that if we opted to go ahead with construction it would vastly limit our client contact. A new fromagerie would have meant exporting to the other provinces of Canada and the U.S., but rather than wanting less contact with clients, we wanted MORE contact with them! So, it was back to the drawing board to rethink our expansion plans.

In April 2004, we were pretty sure we had the answer and we decided to open a booth at Marché Jean Talon in Montreal, Quebec. What follows is the story of the ride we took to get there.

The Opportunity

Since more than 35,000 people do some, or all, of their weekly shopping at this market, it seemed reasonable to assume we would break-even for sure, and maybe even make a profit. As opposed to other farmer's markets where there is a distinct lack of clientele interest (and a boredom factor for the retailer waiting for sales!), Marché Jean Talon is the largest open-air market in North America. Its clientele has "le bec fin" [literally: "fine-beaked" but figuratively a way to express the idea of "gourmet"]. It was close enough to reach by car in 2 hours. Not to mention the fact that we've spent the last 10 years building a reputation and a client base in Montreal. It seemed like a logical move at the time. As it turned out, we had a lot to learn.

Visiting the market, we were immediately struck by the number of retailers selling produce from their own farm, or produce from their region. The potential seemed limitless for our products. From flowers to flans, and turnips to taffy, the market provides producers and market-goers a like, with a riot of colors, smells and tastes. Booths appeared, and then disappeared overnight as farmers and producers arrived to sell their produce at the peak of the season. We also noticed that while there were a few butchers who sold lamb, none of them sold lamb raised on their own farm. Nor was anyone selling their own cheese or wool.

The Objectives

One of our ambitions has always been to have a closer relationship with our clientele. It allows for quicker feedback about our products and as a small business, our ability to respond quickly to changes in the marketplace is a decided advantage. We believe that it is critical to educate the consumer about our products, about how we manage our farm, our respect for the animals, etc. In the end, your job is to educate the consumer. If you do a good job of that, the sale takes care of itself.

It was imperative to be able to present all of our products to clients at the same time and in the same place. This helps build brand recognition and also sensitizes the consumer to the fact that La Moutonnière produces more than just the cheese sample they taste as they pass our booth.

We found that not one of our wholesale clients (over 100 shops and boutiques across the province) carried our entire product line. This was painfully obvious whenever a potential client asked where to go to get a specific product from us. We had to think first about which shop was in their vicinity, and then whether or not that particular shop carried the product in question.

We also wanted to move the office, wrapping, distribution, and commercial kitchen under one roof – to include on-farm sales. (We are still under construction as I write this in September, with the plan to be open in mid October.)

The objective and aim of our own shop at Marché Jean Talon:

1. After selling to over 100 shops/clients over a series of years, we came to a better understanding of the spoken and unspoken rules of retail cheese sales in our province. We also had the meat and fiber to supply our own shop with a wide range of products - enough to meet the needs of most clients. There is nothing worse than only having one variety of cheese in the display fridge. People look once and move on. If the product line is broader, and the products are seasonal in nature, more people return to see what is currently in season.
2. We really wanted to emphasize the seasonality of our business. It is far too easy to fall into the trap of competing with larger, commercial producers. Our strength lies in the fact that we are a small farm with a highly individualized product line. Commercial producers can't compete with our seasonal production, with our unique family of cheese and dairy products, and with our personal touch. For obvious reasons, we can't and don't want to compete with them in their areas of specialty – mass production and distribution. Instead, we have chosen to emphasize strengths that big business can't duplicate.
3. We adhere to European market philosophies and endeavour to make seasonality our strong point. It is our goal to educate our clients and forge a dawning awareness that the seasonal changes of flavour in both cheese and meat are to be appreciated.
4. We needed to identify and contribute to the synergy with our fellow producers. This is one of the major differences between European food culture as it is expressed in Quebec and the rest of North America. For example, we worked with the olive and tomato vendors at Marché Jean Talon to emphasize the seasonality of traditional Greek salads – a synergy which helped even out seasonal fluctuations in feta sales. Graphing the sales of

our feta demonstrates this clearly. As a matter of course, when a client buys feta from us, we send them over to participating vendor booths to buy tomatoes.

The Reality

As someone famous once said, “Success only comes before work *in the dictionary*.” In the real world, the work comes first. Over the first 17 months in our stall, we went from weekend hours only, to being open 7 days a week.

1. Sales started at Easter May 2004 with 5-6 cheeses, some fresh, some aged. We were only open Sat and Sun, and on long weekends we opened on a Friday
2. Easter lamb that clients couldn't believe, especially European immigrants finally able to eat their traditional fare with dairy breed lambs, true milk lamb at 35-45 days old. Very lean and the perfect size (20-24 lbs carcass)
3. After Easter the demand for meat was insatiable, within 6 months we were buying lambs from 2 other farms and the orders started becoming regular for special cuts for restaurants and loyal clients
4. By November, our booth had been relocated 4 times in 7 months, as seasonal booths with a history of having “their spot” returned. We had signs all over the place telling clients where we were in the market. Our clients tolerated the inconvenience and sought us out regardless.
5. Our final move was to the newly constructed part of the market where we would be inside for winter, close to new boutiques and a clientele that continued shopping 12 months out of the year.
6. We made the decision to remain open 7 days a week, which seemed to be the critical piece of advice from other booth owners who sold their wares day in and day out, and had been doing so long enough to understand how important it was to success.
7. This decision to be open 7 days a week raised serious concerns about the financial viability of the booth over the winter months. We were surprised to find that sales stayed at pre-holiday levels throughout the winter months.

Using Our Strengths

Being in a farmstead business, we really had to make the most of our strengths. Competing with large industry is really a backward move. We had to concentrate on what we could do well, that couldn't be copied and mass-produced.

Just take a look at the cheese at your local cheese counter. Some of the fresh cheeses have a shelf life of 6 months. The same cheese made traditionally would only have a shelf life of 2-3 weeks. We believe that these cheeses were designed and made to be at their best during a very limited and specific period of time. In order to extend its shelf-life, it becomes necessary to denature the cheese and to make choices when it is being made that have nothing to do with nutrition, taste, appearance or faithfulness to an artisan tradition.

Most of us in this room will never produce enough fresh milk to do anything more than get stuck in the corner of industry vats. Fresh cheeses are good for 2 things, they create fast cash flow and they generally terrify industry.

The Weekly Management

1. Staff: 3 casual staff (including one that takes stock and prepares orders)
we've found that it is essential to have staff with flexible schedules that can fill in at a moment's notice. Enthusiasm is critical, as is product knowledge. In our case, Catherine, Lucille's daughter who was born and raised in the country, fills this role well.
2. Products
 - Cuts of Lamb:** 4-6 lambs per week. Lambs are delivered to the slaughter plant on Monday night; they are slaughtered on Tuesday and delivered to the butcher on Wednesday. After hanging in a cooler for 6 days, the meat is cut-up and delivered to the booth on Thursday. The meat is kept properly chilled for up to 10 days, at which time we freeze whatever has not sold, which recently has been almost nothing.
 - Cheese:** Orders come on Tuesday and are delivered on Thursday. As sales generally start to lift on a Thursday of each week it was critical that we set up our deliveries so that the freshest products could come hot off the press so to speak and be delivered immediately. This proved especially important for the whey cheeses, like ricotta.
 - Special Orders:** include orders for cheese plates, caterers, restaurants, special events. We require 2 weeks advanced notice.

Choice of Products to Offer

Cheese and cultured products:

1. 3 fresh cheeses
2. 2 whey cheeses
3. Feta
4. A true seasonal raw milk cheese made from milk from the evening milking and that of the next morning, from pasture only.
5. Pasteurised pressed Pyrenees-style cheese
6. 2 blue cheeses (mild and strong)
7. Plain yoghurt
8. Maple syrup flavoured yoghurt
9. 65% heavy cream

Ready made meals with cheese ingredients:

- 1: Spanakopita
- 2: Chocolate desert made with ricotta.

Meat and meat dishes:

1. Legs: whole or boned for cooler months, steaks for summer BBQ's, or cut into cubes for kebabs.
2. Boned and rolled shoulders. Smoked or natural
3. A full range of sausages with sheep meat only, flavours include: merguez, mustard and tarragon, wine and shallots, fine herbs, basil and tomato.
4. "Confit d'agneau" (leg of lamb cooked in duck fat and sold in 120-150gm, 3-4 ounce vacuum packed bags)
5. sliced smoked meat (from the shoulder, leg and boned loin of cull animals)
6. terrine d'agneau (made with cognac, ground lamb and liver)

Wool, hides, and soap:

1. Hides are available either large or small (although we are experimenting with, and have the intent of tanning our own raw hides, we are presently reselling already tanned hides)
2. 2-, 3-, or 4-ply wool in skeins of all natural colours only, nothing dyed and no wool washed with chemicals
3. socks, pure wool, no nylon or dye

As I go through this list, it's important that you understand how we try to realize the potential hidden in every sheep in our operation. A twinning ewe can gross well over 1500\$ Can in products from wool, meat, and dairy.

Products Yet To Master

Hoofs, knuckles, skulls, eyeballs

Pricing

1. Our pricing needs to be competitive with the other shops we distribute to so we don't undercut them, but at the same time we need to be able to offer an advantageous price if they buy directly from us.
2. We have a 30% mark-up over our production cost, which is at the lower end of the scale these days
3. We have specials most weeks that allow us to move more product, particularly as fresh meat gets close to its expiration date and must be frozen. We learned quickly which products weren't selling as our distributor was returning with frozen meat that hadn't sold over the course of the week. It soon became obvious that we either had to discount it, bring it back to the butcher who would make other products from it, or eat it ourselves!
4. We decided on a coupon system where there is a monthly drawing for a prize valued at 50\$ each time you buy \$20 and over of total products.

Promotion / Marketing / Advertising

1. Word of mouth has worked better than anything (check out the "Guerrilla Marketing" books by Jay Conrad Levinson)

2. Tried coupons with discounts - no measurable results
3. Tried weekly advertising with cut-out coupons - no measurable results
4. Newsletter and website bring in a lot of inquiries from the province of Quebec and beyond, but don't actually result in many sales.
5. In general the clientele we see are people who are interested and willing to try new recipes, customers who ask for serving suggestions for the ricotta, etc. Researching and supplying out-of-the-ordinary recipes that are quick and delicious is an important task – providing an appetising photo is even more so. Recipes are always welcome from clients.

Weekly Costs

1. 2004: outside kiosk placement 18\$ per day
2. 2005: 23\$ per day rental during peak demand for sites (May-Oct)
3. 2006: inside placement daily rental 29\$
4. Includes electricity, water, garbage disposal, security
5. Minimum wage for employees

Capital Investments

1. storage fridge: \$1800
2. 2 display fridges: \$1500 each
3. decoration:gazebo: \$500, other \$300
4. scales: \$500
5. cash register: \$200
6. plumbing, hot water: \$100
7. maintenance: \$200

Results and Rewards

1. We can now send people to a place centrally located to our target population where **all** our products can be displayed in one place: meat, wool, hides, cheese, soap, socks, etc. Most importantly, we have the direct contact ourselves with our clients.
2. There are enough requests to visit the farm that we are considering starting farm tours.
3. A big benefit of our choices this year is the pride of being able to show off the rewards of our hard work with yearly prizes in competitions like the one held by the American Cheese Society where we have won 8 prizes in the 3 years we have entered products, plus local prizes as well.
4. The feed-back straight from customers who approve of our farming values and methods, customers who continue to express their confidence in us, their faith that the food they buy is safe, and that they are comfortable with where it comes from. This feedback confirms our decision to open the booth in Montreal. It also is a regular source of encouragement for the whole team – there is a core group of people who have become regular customers. Their purchases underscore our achievements.

5. We have daily visits from chefs looking for something unique that is special. Most restaurateurs and chefs find us either by word of mouth, media or magazine interviews, or referral from other chefs.
6. The decision to concentrate on making more out of our current production rather than simply producing more and having less contact with clients (as we would with an export market) has really paid off.

Price List for Lamb Cuts (\$CAN)

| | |
|-------------------------------|---------|
| Leg of lamb | \$18/kg |
| Cubed leg of lamb (kebabs) | \$19/kg |
| Leg steak | \$19/kg |
| Rolled Shoulder | \$15/kg |
| Shanks | \$15/kg |
| Ground lamb | \$14/kg |
| | |
| Carré d'agneau (rack of lamb) | \$29/kg |
| Loin cutlets (Loin) | \$23/kg |
| Cutlets | \$19/kg |
| Sausages | \$17/kg |
| Smoked lamb | \$25/kg |

Future Challenges

Fresh and frozen milk sales. More “ready to eat meals” with emphasis on health and good eating. Diversify the on-farm shop into a place that sells a broader range of other farm produce

Make the most of the on-farm shop that will be open 3-4 days a week. The shop is not exactly on a road that has a lot of traffic. However, given the fact that the Province of Quebec has established a new “route des fromages” (essentially, a guide for people interested in tasting farmstead cheese as they travel the province), and that for many years, we have had potential clients pull right up to the farm, we expect the on-farm store to be a success as well.

The Good Days ... And The Bad Days!

On the good days, an ecstatic client takes the time to sit and send us email, a letter, or calls us on the phone just to say how thrilled they are to have discovered our booth. This is the stuff that puts a smile on our faces and these are the sales that turn into the most loyal of customers.

On the bad days, 5 refrigeration units break down during the peak of the summer heat, the butcher has forgotten to get the meat ready in time for our delivery and he has also changed sausage recipes without telling us, or better yet, he has put the wrong labels on the product!

We have transformed ourselves from a farm that simply delivered lambs to the sale yards and held out our hand and said, “How much will you pay me?” into a farm that sells all its own lamb (and the lamb from 2 other farms), that caters to individual client’s needs and tells them, “this is our price.”

Final Thoughts

Remember, that farming is the only business where we pay retail, sell wholesale, and pay both incoming and outgoing freight. Make no mistake about it. This has to change if, as individual producers, we ever hope to gain control over the end result on our balance sheets.

HOW TO GRAZE DAIRY SHEEP AND SUPPLEMENT THEIR DIETS IN ORDER TO IMPROVE PRODUCTION

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Introduction

Dairy sheep are most often fed on pasture. In general, feeding dairy sheep involves evaluating their feeding requirements and their intake from grazing, and then calculating what concentrate and hay supplements are needed to cover the deficit. Balancing the diet of grazing animals, in particular lactating ones, is more difficult in certain ways than it is for housed animals. These difficulties include: a) the temporal and spatial variation in nutritive concentration and yield of pasture; b) the feeding behaviour of the sheep; c) the effects of weather conditions (cold/heat, wind, rain) on the animals' nutritive requirements and herbage intake; d) the photoperiod and daylight intensity; e) the interference of management, principally milking operations, on the grazing routine. However, the ability of the animals to self-balance their diets, to a certain degree, and the lower costs of feeding justify widespread use of pasture in the dairy sheep industry.

This publication deals with the use of grazing techniques in high yielding dairy sheep. It points out that high yields and grazing are compatible. It also explains what factors influence herbage intake, how to balance the diets of grazing animals and the best grazing methods to maximise animal yields and stocking rates.

Are Grazing Sheep and High Yield Compatible?

Despite its apparent simplicity, grazing is a complex system. Modelling a grazing flock is indeed one of the most difficult scientific and technical issues, because of the number and magnitude of factors that influence the system. The response to different situations can be greatly influenced by genetic factors through a series of interactions between breed and production system, as demonstrated in New Zealand cows by Bryant et al. (2005) and in sheep by Mavrogenis (1997).

The phenotypic plasticity of genotypes, i.e. the expression of multiple phenotypic states by a single genotype under different environmental conditions, undermines the central dogma of genetics. This assumes that there are no (or only negligible) interactions between genotype and environment deviations on the phenotypic expression of productive traits in dairy animals. The essential assumption in the model proposed by Behera and Nanjundiah (2004) is that a structural gene can be in one of three allelic states. These are: a) 'on', b) 'off' or c) in a plastic state in which the probability of being 'on' or 'off' is influenced by regulatory loci in a dosage-dependent manner. This implies that in different environmental conditions similar sheep genotypes may result in different productive performances. This can be seen in Table 1, from the

high significance of the interaction between feeding system and breed on the milk yield of Cyprus purebred and crossbred dairy sheep (Mavrogenis, 1997).

Sheep selected for their high yield under housed conditions do not necessarily perform at the same level when reared in a grazing system. This suggests that the genetic merit of animals should be estimated by using performances recorded in both housed and grazing conditions, and that the introduction of foreign animals in conditions which differ greatly from those in which they originate should be carefully evaluated.

The broad range in productivity in Mediterranean dairy sheep breeds (Table 2) (Molle and Landau, 2002) is probably the result of the fact that animals adapt to the environment in which they are selected.

Table 1 – Comparative performances of purebred and crossbred sheep in three different feeding systems (Mavrogenis, 1997).

| Variables | Subclass | Number | Milk Yield (kg/year head ⁻¹) |
|-----------|------------------|--------|--|
| System | Semi-intensive | 815 | 130 |
| | Semi-extensive | 1209 | 108 |
| | Extensive | 1012 | 93 |
| Breed | Cyprus Fat-T (L) | 345 | 74 |
| | Chios (C) | 845 | 116 |
| | Awassi (A) | 709 | 117 |
| | CxL | 46 | 116 |
| | AxL | 79 | 95 |
| Effects | System | 3 | P<0.01 |
| | Breed | 5 | P<0.01 |
| | Interaction | 15 | P<0.01 |

Adaptation to the grazing environment means, above all, that the animals have a higher intake of grass per kg of body weight and superior resistance to adverse weather conditions. In order to find the upper limit of milk production in animals fed exclusively on pasture (P), compared to grazing ewes supplemented by 0.5 kg/d of concentrate (P+C) and ewes fed exclusively a complete pelleted diet (C), we re-elaborated the results of 43 groups of lactating Sarda sheep from 18 different experiments.

Table 2 - Performance of some Mediterranean dairy sheep breeds (Molle and Landau, 2002).

| Country | Region | Breed | Lactations/year | Milk yield (kg/year head ⁻¹) |
|---------|---------------|--------------|-----------------|--|
| Italy | Sardinia | Sarda | 1 | 210 |
| | Sicily | Comisana | 1 | 190 |
| France | Roqueforte | Lacaune | 1 | 270 |
| Spain | Castilla-Leon | Manchega | 1.2 | 180 - 200 |
| Israel | | Assaf-Awassi | 1.1 – 1.3 | 320 - 530 |

The distribution of means of milk yield is shown in Figure 1 and the least square means of productive parameters in Table 3. Supplementing grazing with concentrates does not

significantly increase milk production when compared to grazing alone, but it does increase the variability of the means (a sort of standard error). Indeed, the upper 2.5% of means of grazing groups falls over 1,263 g/d, whereas the same datum is 1,473 g/d for supplemented groups. Higher milk yield generally leads to significantly lower fat and protein concentrations in dairy sheep (Pulina et al., 2005), so that the differences in daily yield of Total Utilisable Substances (TUS = the quantity of fat + protein daily produced by a single animal) are lower. However, C groups maintain their advantage over grazing ones: 4.52 vs. 3.30 and 2.91 g TUS/kg BW, respectively for C, P+C and P groups ($P < 0.001$).

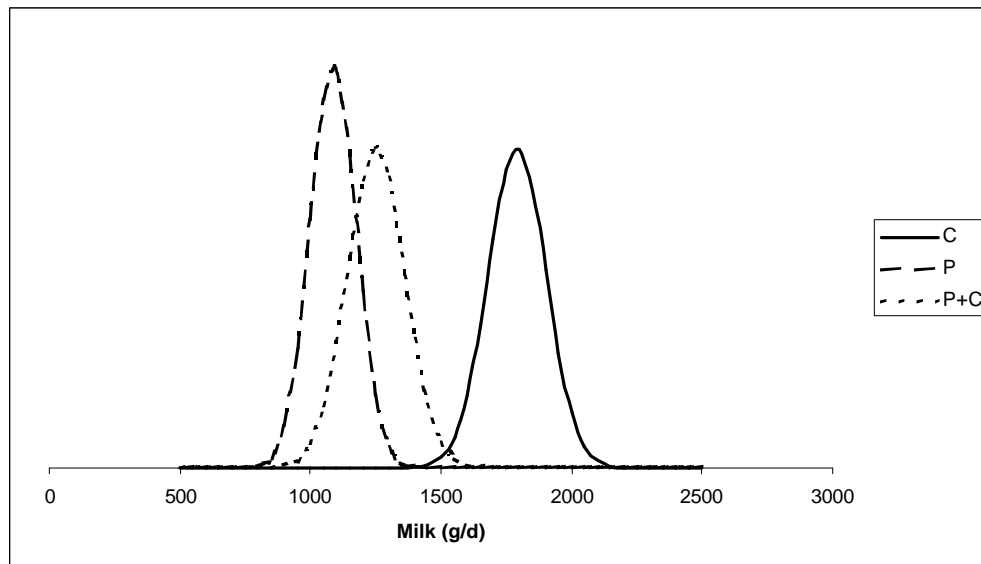


Figure 1 – Distribution of means in daily milk yield of 43 experimental Sarda dairy sheep groups under three different feeding conditions (C = complete pelleted diet; P = pasture; P+C = pasture +0.47 kg DM head⁻¹ of concentrates).

Table 3 – Productive performances of Sarda dairy ewes under three different feeding regimes.

| Feeding | Trials- animals (n.) | Milk yield (g/d) | Milk fat (%) | Milk protein (%) |
|------------------------|-------------------------|-------------------|-------------------|-------------------|
| Complete pelleted diet | 12-86 | 1791 ^a | 5.57 ^b | 5.38 ^b |
| Pasture + concentrates | 12-744 | 1251 ^b | 6.48 ^a | 5.84 ^b |
| Pasture | 19-1078 | 1087 ^b | 6.56 ^a | 5.88 ^a |
| P-value | | <0.001 | 0.003 | 0.057 |

Intake is the principal limiting factor for milk production in grazing animals. Table 4 shows that ewes fed only complete pelleted diets had significantly higher intake than those of the other two grazing groups. This results in a favourable, even if not significant, efficiency feeding index (1.42 kg vs. 1.68 and 1.71 DM per kg of milk produced, respectively, for C, P+C and P feeding systems). By contrast, the feeding cost per kg of total utilisable substances (TUS) produced is more than 2 times higher in C groups, and roughly double in P+C groups, than in regimes which use only grazing. This result justifies the growing importance of pasture as a feeding source, given the increasing use of extensive rearing systems. In other words, intensive systems have lower labour costs, but higher feeding and structural expenses per head.

Table 4 – Feeding intake, efficiency feeding index and feeding costs of Sarda dairy ewes under three different feeding regimes.

| Feeding | Trials-animals (n.) | Intake (g/day) | Efficiency feeding index (kg DM/kg milk) | Cost of TUS* (Euro/kg) |
|-------------------------|------------------------|-------------------|--|---------------------------|
| Complete pelleted diets | 12-86 | 2497 ^a | 1.419 | 3.83 ^a |
| Pasture + concentrates | 12-744 | 1850 ^b | 1.677 | 2.04 ^b |
| Pasture | 19-1078 | 1704 ^b | 1.712 | 1.35 ^c |
| P-value | | <0.001 | n.s. | <0.001 |

*TUS = total utilisable substances = fat + protein yield in kg. Cost €/kg of DM: pasture 0.1, concentrates 0.3.

A mixed feeding regimen seems to be a good compromise, thanks to the interesting economic conversion index and the productive level achievable in groups fed on pasture and supplemented with concentrates. It is noteworthy that the concentrate/pasture substitution index, that is the reduction in the amount of grass DM voluntarily eaten by a sheep supplemented with 1 kg of concentrate DM, is on average 0.69. This explains the positive, even if not significant, effect on milk yield of using concentrate supplements rather than grazing alone.

Appropriate use of concentrates boosts milk production, balances the variability in nutrient concentration of grass, stabilizes the lactation curve, reduces the negative effects of adverse weather conditions and modulates the hormonal responses of animals. At farm level, the concentrate conversion index (CCI), that is to say the total amount of concentrates annually given to the flock divided by the average total milk yield, decreases by 3.4 g as the milk production level of the flock increases by 1 kg, as can be seen from the regression shown in Figure 2 which refers to several dairy sheep farms of Sardinia.

In order to assess the general relationships between milk production and the nutrient content of the diet, which conditions the productive responses of dairy flocks under grazing systems, we collected a series of data from 120 scientific publications on milking sheep (each datum is the average result from an experiment) (Pulina et al., 2005). After screening out incomplete records, data were subjected to multiple regression analysis. This was done to estimate the relationship between the outputs of milk fat or protein yields and the daily protein and fibre intake (amount of NDF [NDF-I] and crude protein [CP-I] ingested, expressed in g/d head⁻¹), body weight (BW, expressed in kilograms) and daily body weight change (dBW expressed in g). Thirty-nine records for fat yield and 32 for protein yield were used for this regression analysis. The estimated equations are the following:

$$[1] \quad \text{Fat (g/d)} = 15.566 (\#) + 0.228 \text{ CP-I} - 0.049 \text{ NDF-I} + 0.497 \text{ BW} (\#) - 0.152 \text{ dBW} \\ (R^2 = 64.0\%; \text{RSD} = 22.5)$$

$$[2] \quad \text{Protein (g/d)} = 30.7 (\#) + 0.260 \text{ CP-I} - 0.111 \text{ NDF-I} + 0.887 \text{ BW} - 0.234 \text{ dBW} \\ (R^2 = 76.9\%; \text{RSD} = 23.12)$$

All parameters are significantly different from zero ($P < 0.05$), except for the scaling factors in both equations and the BW in the fat equation ($\# = P < 0.1$).

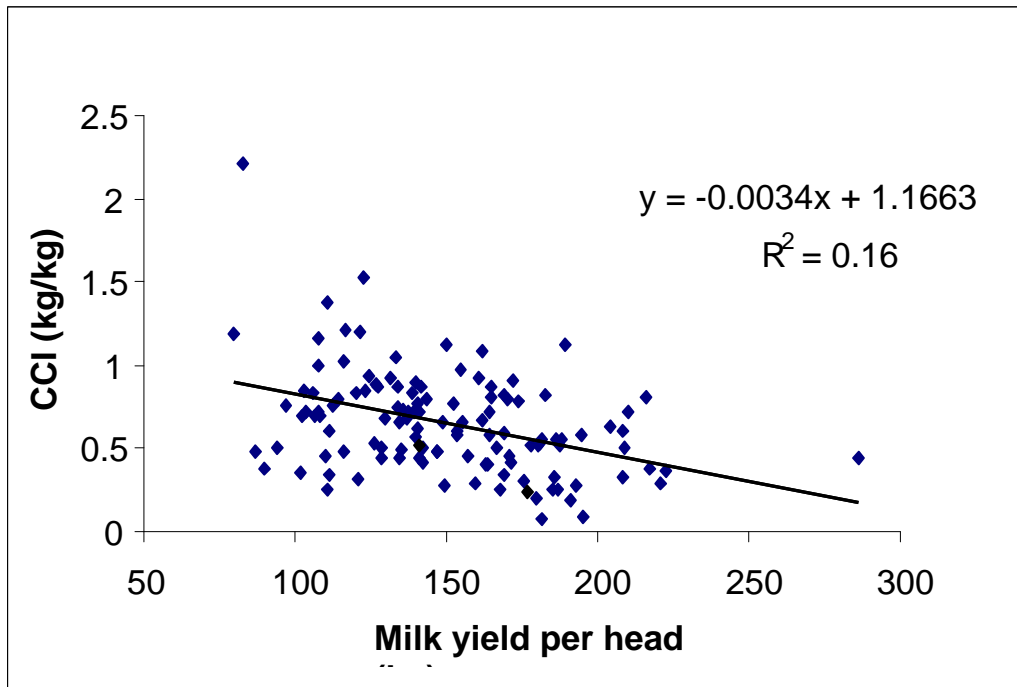


Figure 2 – Relationship between the average milk production level per head per year and the concentrate conversion index (CCI). Each point represents the value for one farm. The data were collected over a 5-year period by the Associazione Regionale Allevatori della Sardegna (ARAS, Regional Extension Service of Sardegna, Italy).

Depending on the sign of the coefficients, test day milk yields of fat and protein are positively affected by the CP intake and depressed by the ingested NDF. Negative variations of BW increase both milk components. This indicates that nutrients are transferred from the animal body to the milk (Pulina et al., 2005).

In conclusion, high production and grazing are compatible, provided that there is a positive interaction between the genotype and the environment, and as long as the herbage intake is not a limiting factor. Given that feeding costs become much lower as more pasture is used in the diet, attention should be paid to optimising the use of production factors, such as concentrates or other feedstuffs, at farm level. This can be done by using a computer-aided model to maximize the profits of the farm.

Factors Affecting Pasture Intake and Diet Selection in Sheep

The animal factors

The importance of certain animal factors in regulating food ingestion is well recognized. Ingvarstsen (1994), in a bibliographic review on intake models for cattle, reported

that, whereas only half of the models include food factors, all models include animal factors as independent variables, in that they influence nutritive requirements.

If body weight changes, then so does intake. This is connected to the basal metabolism that affects requirements, and to rumen volume. One empirical method which is very widely used to predict the intake capacity of ruminants is to calculate it as a percentage of the body weight (for sheep about 4 to 5.5% of BW). The correlation between the body weight of different genetic types and the intake of adult sheep is clear (Table 5). The same tendency is not always observed, however, when the regression within each genetic type is analysed. Indeed, one can say that in this case, because an increase in weight over the normal mature weight is an index of fattening, intake tends to diminish (Forbes, 1995).

Table 5 - Dry matter intake and body weight in various sheep breeds (Avondo and Lutri, 2004).

| Breed | Body weight kg | DM intake kg/day head ⁻¹ |
|-------------------|-------------------|--|
| Frisona orientale | 74.8 | 2.49 |
| Lacaune | 73.2 | 2.67 |
| Chios | 60.0 | 2.24 |
| Delle Langhe | 58.0 | 1.83 |
| Manchega | 57.0 | 2.24 |
| Massese | 52.4 | 1.98 |
| Comisana | 57.4 | 1.99 |
| Churra | 50.0 | 1.83 |
| Sarda | 42.2 | 1.55 |

When pasture conditions are favourable, intake is positively correlated with productive level. However, literature highlights the great variability of this correlation coefficient, with values ranging from 0.2 to 0.8 (Serra, 1998). This variability depends on the stage of lactation. There is a phase when the ewes satisfy their increased nutritional requirements by mobilizing fat reserves. Any attempt to estimate the intake capacity of lactating ewes should therefore take into account their physiological tendency to mobilize body reserves in the early months of lactation and then later to restore them. This means that the fall in intake in the phase after the lactation peak may not always be as marked as expected. Various experiments (D'Urso et al., 1993; Pauselli et al., 1993; Pulina et al., 1992; Trimarchi et al., 1981) on dairy sheep during lactation have found falls in intake lower than 20% while the corresponding falls in milk production were higher than 65% (Table 6).

Table 6 - Dry matter intake and milk production of ewes (Avondo and Lutri, 2004).

| Lactation week | Breed | Intake g DM day ⁻¹ | Milk production g day ⁻¹ | |
|----------------|----------|----------------------------------|--|------------------------|
| 3 | Comisana | 2670 | 2026 | Pauselli et al., 1993 |
| 8 | | 2634 | 1025 | |
| 14 | | 2149 | 693 | |
| 7-9 | Massese | 2200 | 1068 | Trimarchi et al., 1981 |
| 12-14 | | 2200 | 588 | |
| 16-18 | | 2050 | 346 | |
| 6 | Comisana | 1323 | 1077 | D'Urso et al., 1993 |
| 10 | | 1373 | 783 | |
| 14 | | 1820 | 488 | |
| 18 | | 1428 | 424 | |
| 5 from dry | Sarda | 2539 | 1095 | Pulina et al., 1992 |
| 4 from dry | | 2079 | 1005 | |
| 3 from dry | | 2521 | 976 | |
| 2 from dry | | 2042 | 856 | |
| 1 from dry | | 2153 | 721 | |

Given the above, the following equation has been developed to predict intake in Italian milk breeds (Pulina et al, 1996). It takes into account not only the weight and milk production of the animal, but also daily weight changes. In adult animals these can occur through the animal storing or mobilising its body reserves:

$$[3] \quad I = -0.545 + 0.095 \text{ MW} + 0.65 \text{ FPCM} + 0.0025 \text{ BWC}$$

where:

I = DM intake, in kg/head day⁻¹;

MW = metabolic weight (BW^{0.75}), in kg;

FPCM = fat (6.5%) and protein (5.8%) corrected daily milk production, in kg (Pulina et al., 1989)

BWC = body weight changes, in g day⁻¹.

Pasture characteristics

Predicting the feed intake of grazing sheep is much more complex than it is for sheep fed indoors. If animals have free access to pasture, their selective grazing behaviour can significantly modify their intake capacity. This selection is very important, not only for the quality of the diet but also for the herbage intake. In fact, searching activity for the more appetising parts can limit intake more than forage availability does. It has been hypothesised (Arnold and Dudzinsky, 1978; Forbes and Provenza, 2000; Provenza, 1995) that sheep use a sort of selective "wisdom" when selecting. This minimises metabolic discomfort and allows the animals to eat feed according to their nutritional requirements and also to discard toxic matter. Sheep tend to select a diet more digestible and richer in crude protein than the available herbage. Moreover, this

tendency is more marked the higher the number of botanical species in the pasture, on condition that botanical heterogeneity is accompanied by a corresponding spatial differentiation of the various essences. In fact, structural differentiation of pasture facilitates identification and prehension of the most appetising essences or parts of the plant.

Species which are erect in their growth, such as most forage grasses, offer a better chance of the sheep selecting morphological parts of the single plant than do creeping species, such as some spontaneous or cultivated legumes (Table 7) (Avondo and Lutri, 2004).

Table 7 – Protein and digestible organic matter content of the whole plant and of selected parts of various pasture essences (Avondo and Lutri, 2004).

| Botanical essence | Growth habit | Crude Protein % DM | | Digestible organic matter % DM | |
|-------------------|--------------|-----------------------|------------------|--------------------------------------|------------------|
| | | Whole Plant | Selected part | Whole plant | Selected part |
| Grasses | | | | | |
| Barley | Erect | 18.2 | 25.4 | 68.1 | 72.0 |
| <i>Bromus</i> spp | Erect | 15.8 | 23.7 | 69.1 | 73.7 |
| Mixed pasture | Erect | 10.1 | 16.8 | 62.6 | 69.8 |
| Mixed pasture | Erect | 8.8 | 11.3 | 73.4 | 76.6 |
| Mixed pasture | Erect | 10.8 | 16.7 | - | - |
| Legumes | | | | | |
| Vetch | Creeping | 20.9 | 22.2 | 66.4 | 69.1 |
| Clover | Creeping | 21.4 | 26.5 | 75.1 | 75.6 |
| Mixed pasture | Creeping | 16.4 | 18.0 | 68.4 | 68.2 |
| Mixed pasture | Creeping | 16.8 | 20.7 | - | - |

In general, as biomass increases so does intake capacity. However, even with high herbage availability, as pasture quality gets worse, due to the biological evolution toward maturity, searching for less lignified plant parts or essences results in a reduction in time spent eating.

If biomass levels are high and the grass is over 30 cm high, then sheep may trample the grass to reach the tips. As a result some of the biomass is wasted and the sheep spend less time grazing. If, however, the biomass levels are high but the pasture is short and dense, then intake increases because bite prehension is facilitated. Ideally, in order to avoid the negative effects of excessive selective activity by the sheep, the pasture should be dense and not more than 8 -10 cm in height. This can be done by choosing the right type of pasture and maintaining an adequate stocking rate.

Herbage quality can be expressed in terms of digestibility, filling value, crude protein (CP) or structural carbohydrate content. It affects pasture intake. Good quality herbage can enable the "potential" intake to be reached. This is an intake that allows the animal to satisfy its requirements without physical limitations. Generally the levels of intake observed in highly digestible pastures are higher than in lignified pastures. It is also true that if the pasture is highly digestible then the

animals can reduce intake, as they reach the state of satiety earlier, due to the effects of metabolic control.

The correlation between chemical components and intake for the different types of pasture is rather weak. It is difficult to clearly assess the pasture conditions of natural pasture with the type of undifferentiated data on its chemical composition which are available. Mean data does not, indeed, explain all the qualitative differences between essences and certainly does not consider the spatial distribution of these essences, even though they may be of significant importance in selective behaviour.

Most attempts to predict pasture intake by sheep based on feed chemical and nutritional composition have emphasised the important role played by NDF content (Lanari et al., 1993), as this influences rumen wall distension. Table 8 reports some intake prediction equations based on NDF content. The correlation is always negative.

Table 8 - Regression equations between dry matter intake (g/kg metabolic weight) and pasture NDF content.

| Category of forage | Regression equation | |
|--------------------|---|------------------------|
| All forages | $I = 107.4 - 0.644 \text{ NDF}$ | Macchioni et al., 1990 |
| Alfalfa hays | $I = 104.6 - 0.488 \text{ NDF}$ | Macchioni et al., 1990 |
| Miscellaneous hays | $I = 117.4 - 0.760 \text{ NDF}$ | Macchioni et al., 1990 |
| All forages | $I = 134.5 - 1.10 \text{ NDF}$ | Reid et al., 1988 |
| Grass forages | $I = 95.3 + 6.70 \text{ NDF} - 0.0668 \text{ NDF}^2$ | Rohweder et al., 1978 |
| Polyfytes hays | $I = 136.5 - 0.12 \text{ NDF}$ | Dulphy et al., 1990 |
| Miscellaneous hays | $I = 96.5 - 0.38 \text{ NDF} - 0.0000004 \text{ NDF}^4$ | Lanari et al., 1993 |

Effect of supplementary feeding on herbage intake

When feed supplements are used there is nearly always a reduction in pasture intake, because of the substitution effect (S). S is the variation in herbage intake per unit of supplement provided and it can vary greatly, from 0 to 1. In certain conditions it may, indeed, be even lower than 0 or greater than 1. Obviously, the lower the S value, the higher the total feed intake. Intake response to a supplement is strongly influenced by the quantity and quality of the available herbage. When there is little biomass available or its quality is poor, the supplement causes an increase in total dry matter intake and an improvement in animal performance; in these cases S is very low or null. In conditions where there is a large amount of available biomass or its quality is high, the efficacy of supplement is almost nullified due to the high S level. Figure 3 shows the S values found by Molle et al. (1997), when a corn grain supplement was given to dairy sheep grazing for 5 hours/d on good quality ryegrass sward of different height and biomass. One can see S values higher than 1. When biomass reaches DM yields higher than 2 t/ha, all the herbage was substituted by concentrates.

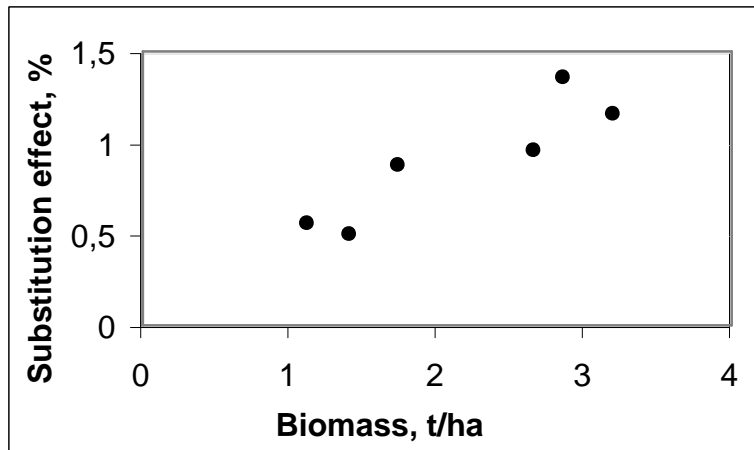


Figure 3 – Influence of ryegrass biomass on the substitution effect of corn grain (from Molle et al., 1997)

The crude protein content of the supplement could have an important effect on both herbage selection and intake. A previous study which developed a model to predict herbage intake in grazing dairy sheep in the Mediterranean environment (Avondo et al., 2002) found that the quantity of crude protein in the supplement (g/d) was negatively correlated with intake. The negative correlation between quantity of DM and intake was less pronounced. Moreover, the effect of the supplement in reducing pasture intake increased as the quantity of crude protein in the herbage increased. These results seem to suggest that protein requirements may play a role in the sheep's self-regulation of intake.

Balancing Diets For Grazing Lactating Ewes

Diet balancing for grazing dairy sheep using nutritional indicators

Optimal dietary nutrient concentration for grazing sheep was given by Cannas (2004). However, due to the uncertainties related to the prediction of the quality or quantity of the sward ingested by the animals, diets balancing in grazing animals is much more difficult than it is for confined ones. In some situations it is even impossible to provide properly balanced diets, especially when pasture is very rich in some specific nutrients (e.g. protein or NDF). In these cases the goal of a nutritionist should be to supply the least unbalanced diet, not a balanced one. In all grazing systems, the process of diet balancing (or that of providing the least unbalanced diet) should be based on the following strategy: the predictions of animal requirements and of pasture intake and quality should be integrated with the appraisal of nutritional indicators able to provide information on actual diet composition, rumen and digestive tract function, presence of metabolic disorders, and level of coverage of the requirements.

The best nutritional indicators so far developed for sheep are yield and quality of the milk, health status of the animals, some blood components, the concentration of urea in the milk, the body condition of the animals, and the characteristics of the faeces. Some of these indicators will be discussed here.

Milk fat and protein concentrations as nutritional indicators

Among the several factors that affect milk fat concentration, some of the most important ones are:

- dietary NDF concentration, which is positively associated with milk fat concentration (Emery, 1988; Bencini and Pulina, 1997);
- milk yield, which is negatively associated with milk fat concentration (Emery, 1988);
- energy balance, which is negatively associated with milk fat concentration in both cows (Grieve et al., 1986; Palmquist et al., 1993) and sheep (Bocquier and Caja; 2001).

Among the above listed factors, energy balance (**EB**) has probably the largest effect on milk fat concentration. In fact, when mobilization of body reserves is high, such as at the beginning of the lactation, the blood concentration of long chain fatty acids (FA) derived from the mobilized body fat triglycerides increases. Part of these FA are used by the mammary gland to produce milk fat, whose concentration increases. Another effect of body reserves mobilization is an increase in the proportion of long chain FA in milk fat. In dairy cows, it was suggested that the variations in milk fat concentration during the lactation could be used to identify across-herd differences in EB (de Vries and Veerkamp, 2000). In dairy ewes, a high negative association between milk fat concentration and EB was reported by Bocquier and Caja (2001):

$$[4] \text{ milk fat concentration (\%)} = 9.65 - 1.22 \text{ EB (UFL/d)} \quad r^2 = 0.76$$

where UFL = 1700 kcal of NEL.

Cannas and Avondo (2002) tested the findings of Bocquier and Caja (2001) by using the data of 6 feeding trials (58 experimental treatments) conducted in Sicily in various dairy sheep farms over a period of eight years (Avondo et al., 1998). Multiparous Comisana lactating ewes were used in all trials. The ewes were fed on pasture and the diet was supplemented with hay and concentrates. Individual herbage, concentrate and hay intake of 440 ewes were measured. All the experimental measurements were divided in 4 classes based on the milk yield of the ewes (< 400 g/d, n = 63; 400-799 g/d, n = 260; 800-1199 g/d, n = 97; 1200-1600 g/d, n = 20).

In the highest milk yield class (1200-1600 g/d), milk fat concentration was inversely associated with dietary NDF concentration, NDF intake, and energy balance (Table 9 and Figure 4). Going from the highest to the lowest milk yield class, these relationships became weaker and, in some cases, not significant (Table 9 and Figure 5). For all classes, the association between milk fat concentration and milk yield was either weak or not significant (Table 9).

Table 9 - Coefficients of correlation and statistical significance for simple regressions developed separately for each production class.

| | Production class | | | |
|-----------------------------|---------------------|---------------------|---------------------|---------------------|
| | < 400 | 400-799 | 800-1199 | 1200-1600 |
| Milk yield (g/d) | | | | |
| Number of data | 63 | 260 | 97 | 20 |
| Dependent Variable | | | | |
| Milk fat content (%) | | | | |
| Independent Variable | | | | |
| Milk yield (g/d) | ns | - 0.28 ^c | ns | - 0.39 ^a |
| Dietary NDF (% DM) | ns | - 0.24 ^c | - 0.44 ^c | - 0.60 ^b |
| NDF intake (% BW) | - 0.21 ^a | - 0.35 ^c | - 0.48 ^c | - 0.89 ^c |
| Energy balance (UFL/d) | - 0.24 ^a | - 0.28 ^c | - 0.42 ^c | - 0.79 ^c |

^a P < 0.10; ^b P < 0.01; ^c P < 0.001; ns = P > 0.1

In the ewes with the highest milk yield, one of the major factors affecting milk fat concentration was their EB. In the same class, NDF intake (% of BW) was positively associated with energy intake (% of BW) ($r = + 0.92$). As energy intake increased, as a result of the increase in pasture (and NDF) intake, the EB improved, probably reducing body fat mobilization and the availability of long chain FA for the mammary gland. As a consequence, milk fat concentration decreased. It is important to highlight that for each experimental treatment the amount of concentrate supplied was the same for all animals, while pasture was fed ad libitum. Therefore, the ewes with the highest milk yield had to eat more pasture (and fiber) than the animals with lower milk yield and requirements. The negative correlation between milk fat concentration and NDF concentration and intake (Table 9 and Figures 4 and 5) is in clear contrast to the positive association between milk fat concentration and NDF previously mentioned (Emery, 1988; Bencini and Pulina, 1997).

In the ewes with low milk yield, factors other than precursor availability were important and milk fat concentration was probably largely affected by individual characteristics. This explains why the association between milk fat and the predictors decreased, as milk yield decreased (Table 9).

Cannas and Avondo (2002) found that if all the ewes with less than 0.65 kg/d of milk yield were excluded from their database, so that the minimum value was equal to the one of the database of Bocquier and Caja (1993; 2001), the relationship between milk fat concentration and EB would have the same slope of equation [4]:

$$[5] \text{ milk fat concentration (\%)} = 6.99 - 1.22 \text{ EB (UFL/d)} \quad (r^2 = 0.14; P < 0.0001)$$

The lower coefficient of determination of equation [5] compared to equation [4] is probably the result of a wider range in the data set used for its development (650-1600 g/d of milk in equation [5] vs. 0.65-3.5 l/d in equation [4]). The fact that the slope of the equation was identical in the two equations suggests that the milk fat concentration decreases by 12.2 g/l for each UFL/d of variation in EB regardless the breed considered. The difference in intercept might be due to the different distribution of the data in the two datasets or might suggest breed differences in the average milk fat concentration. Once these differences are accounted for, milk

fat concentration can be used as a nutritional indicator to monitor the nutritional status (energy balance) of the ewes. More studies are clearly needed to test the relationship between milk fat and EB and the use of milk fat concentration as a nutritional indicator for different breeds and production levels.

The variation in milk fat concentration observed by Bocquier and Caja (1993; 2001) and by Cannas and Avondo (2002), as EB varied, was much larger than that observed in dairy cows by Grieve et al. (1986). This suggests a more important contribution of FA originated from body fat mobilisation in sheep than in cows and supports the advice of using milk fat concentration as a nutritional indicator, at least in ewes in the first months of lactation with medium-high milk yield.

Bocquier and Caja (1993; 2001) also reported a positive relationship between EB and milk protein concentration. However, since this relationship is much weaker than that reported for fat concentration, the use of milk protein as a nutritional indicator does not seem feasible.

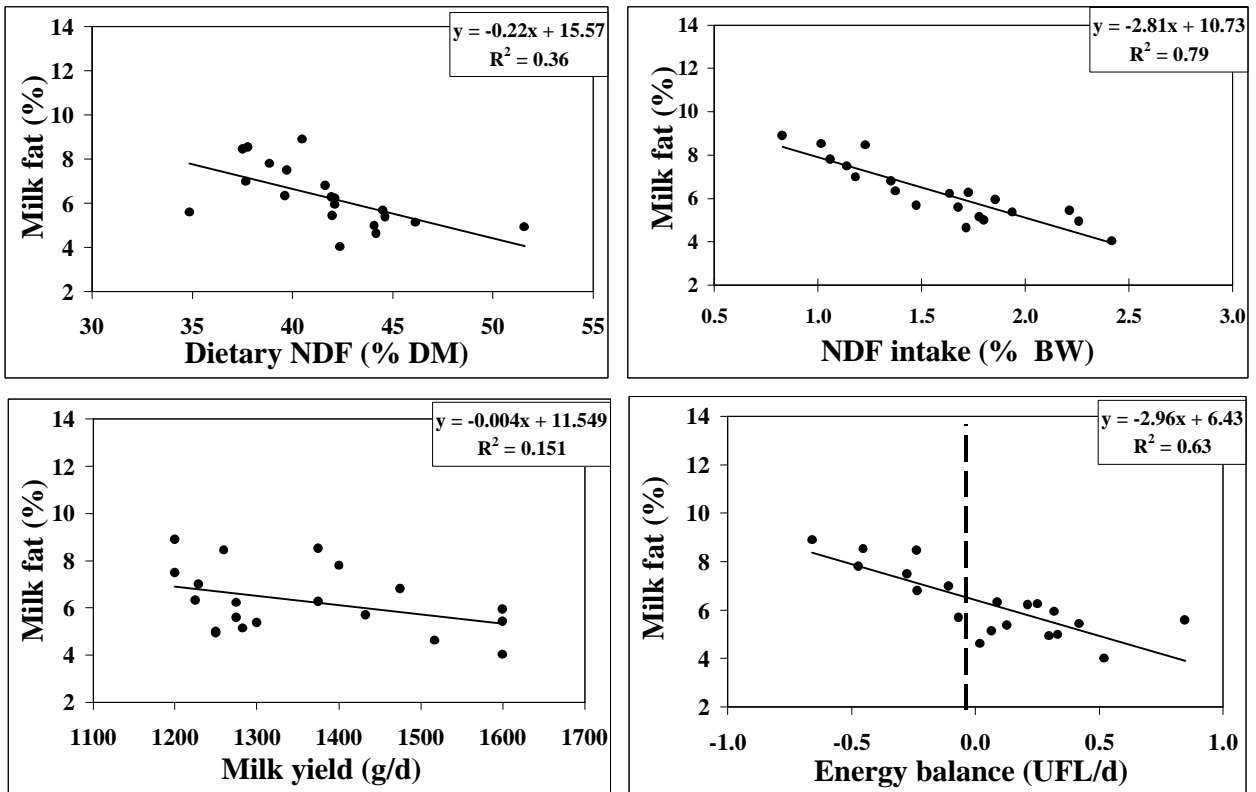


Figure 4 - Relationship between milk fat concentration and dietary and animal characteristics for ewes that produced more than 1200 g/d of milk.

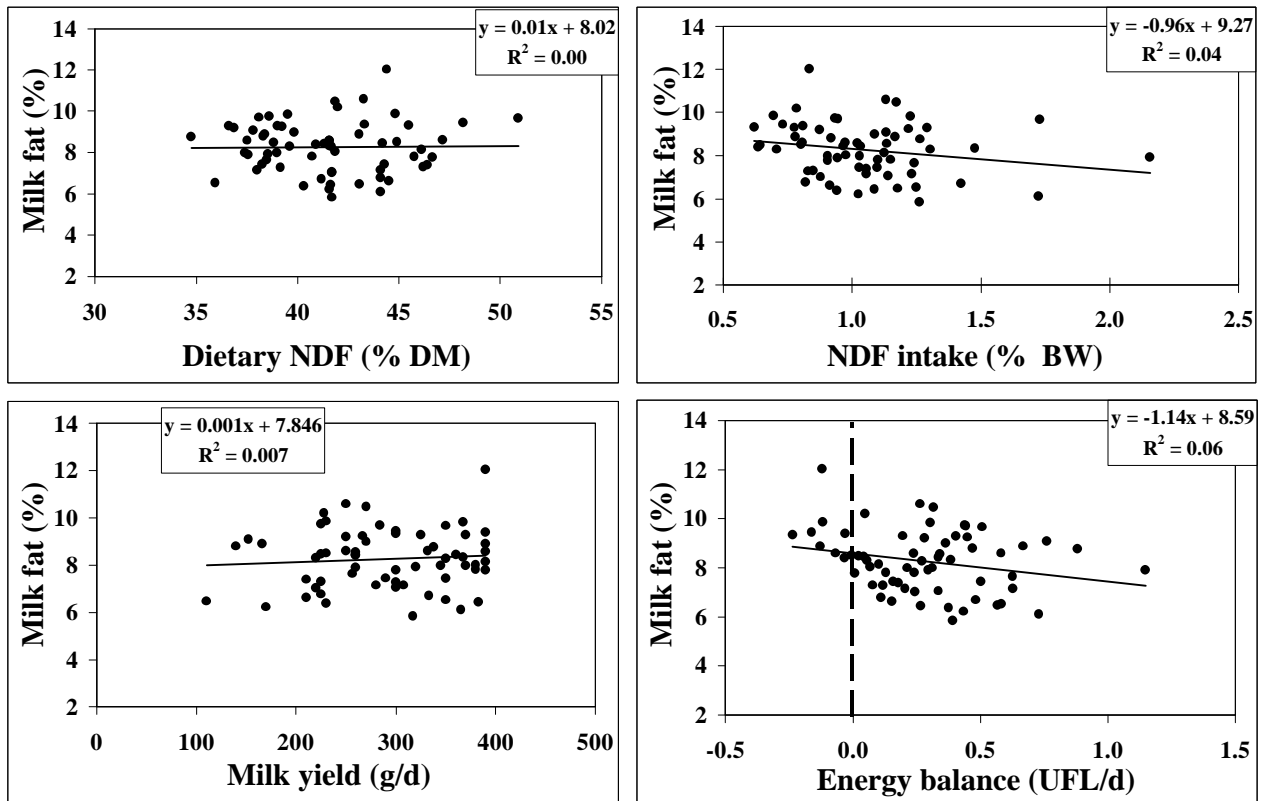


Figure 5 - Relationship between milk fat concentration and dietary and animal characteristics for ewes that produced less than 400 g/d of milk.

The concentration of urea in the milk as a nutritional indicator

As for dairy cows, milk urea (**MU**) is an excellent nutritional indicator of the protein status of dairy sheep. Milk urea originates from the diffusion of blood urea (**BU**) into the mammary gland. Indeed, MU is closely correlated with BU concentration. However, MU is more stable (Baker et al., 1992) and easier to sample than BU.

In ruminants, urea is formed by the liver using ammonia as a major substrate. This process is energetically very costly (e.g. the energy cost of eliminating 100 g of CP in excess of sheep needs is the same as that of producing 200 g of sheep milk). In some cases, this process remarkably affects total energy requirements. The two major sources of ammonia, and thus of MU, are:

- the ammonia formed in the rumen by bacteria fermentation of nitrogen sources (protein and non protein nitrogen, NPN) that is not used by bacteria for protein synthesis. The ammonia in excess is absorbed by the rumen wall and then carried to the liver, where it is converted in urea; and
- the ammonia formed as a by-product in the process of gluconeogenesis, when amino acids are converted to glucose, or in processes of amino acids catabolization.

Despite the importance of MU as a nutritional indicator in dairy cows, systematic studies on its use in dairy sheep are recent. In one of the first studies published on this topic, Cannas et al.

(1998), working with adult Sarda ewes from the 3rd to the 5th month of lactation fed diets at two energy levels, developed relationships to relate MU with dietary CP concentration and intake:

$$[6] \quad \text{MU (mg/dl)} = 4.10 \text{ CP concentration (\% of DM)} - 30.30 \quad (R^2 = 0.98)$$

$$[7] \quad \text{MU (mg/dl)} = 0.14 \text{ CP intake (g/d)} - 15.23 \quad (R^2 = 0.94)$$

The MU values found in this study were compared with the MU or BU reported by various authors in experiments designed to study the effects of diets of different contents or protein quality on milk production. These studies investigated 66 different diets and many different sources of protein, both pure and in various mixtures. The regressions between the dietary CP concentration or CP daily intake and MU or BU suggest that these two variables are closely and linearly correlated, regardless the source of the protein or the feed intake:

$$[8] \quad \text{MU (mg/dl)} = 4.5 \text{ CP concentration (\% of DM)} - 38.9 \quad (R^2 = 0.82)$$

$$[9] \quad \text{MU (mg/dl)} = 0.13 \text{ CP intake (g/d)} - 17.9 \quad (R^2 = 0.56)$$

The regression equations [8] and [9] are similar to the equations [6] and [7], which were calculated using only data from the experiment just described. However, the association between MU or BU and daily CP intake was lower in equation [9] than in equation [7]. This suggests that the ratios among CP and other nutrients in the diet are more important than the total daily protein intake for the control of the haematic level of the urea. This is probably due to the fact that rumen microbial ammonia utilisation is markedly affected by the other nutrients supplied with the diet. The most important nutrients are probably carbohydrates, because when they are fermented in the rumen bacteria grow faster and use rumen ammonia more efficiently, causing a reduction in milk urea. In addition, high energy diets reduce the necessity of ewes to use amino acids as an energy source, so that less ammonia is produced from amino acid catabolism. However, a systematic appraisal of the effects of carbohydrates on milk urea concentration in sheep is lacking. In some experiments these effects were very limited (e.g. Cannas et al., 1998), while in others they were more important (e.g. Cannas et al., 2003). In the latter, an increase in dietary non fibre carbohydrates concentration of 10% of DM induced, for similar dietary CP concentrations, an increase in milk urea of 9 mg/dl.

The close relationship observed between MU and dietary CP protein concentration suggests that the different protein sources of the supplements had little influence on MU. The degradability of the protein sources seems to be less important in sheep than in dairy cattle, probably because the high rumen feed passage rate of sheep reduces the proportion of proteins fermented in the rumen compared to cattle (Cannas, 2004). The effect of dietary rumen degradable OM (RDOM) and CP (RDCP) on milk urea was tested by Landau et al. (2005), who found, for similar dietary CP concentration, a variability of about 5-6 mg/dl of MU depending on the ratios between RDCP and RDOM. This suggests that the values reported in Tables 10 and 11 should be used with a certain flexibility. Higher MU values are expected when either RDCP or the ratio between RDCP and RDOM are high.

In dairy cows high concentrations of MU and BU have been associated with reductions in reproductive efficiency (Ferguson and Chalupa, 1989). Similar findings have been reported in ewes by Bishonga et al. (1994), who found markedly negative effects on sheep embryos cultivated in vitro when MU was equal to or higher than 43 mg/dl of urea, and by Molle et al. (2001), who reported decreased fertility when BU was above 45 mg/dl. High concentrations of MU have been also associated with increased incidence of other disturbances (Table 11).

Milk sampling to measure milk urea

Since MU concentration shows a considerable variability among animals fed the same diet, it should always be measured in pooled samples of milk taken from at least 8 to 10 sheep in the same stage of lactation.

First lactation ewes, due to their higher protein turnover and higher consumption of amino acids as energetic fuels to sustain growth, have 5-10 mg/dl higher MU concentration compared to mature ewes (Cannas, 2004).

The differences in MU concentrations obtained at different moments of milking are small and non-significant in practical terms. Thus, if individual milk samples need to be collected for MU analyses, the first milk produced by the ewes can be used.

Milk urea can be measured in the laboratory by various very accurate analytical methods. It is important to pay attention to the units of measurements used. In some countries milk urea is expressed as "milk urea nitrogen". Since nitrogen makes up 46.65% of the urea molecule, when the analyses are reported as "milk urea nitrogen" the values are about one half than when they are expressed as "milk urea", as it is done in this publication.

Milk urea can be accurately measured on farm using accurate portable analyzers available in the market. Tests based on strips for cow milk may bring to very erroneous estimates when applied to sheep milk (Cannas, 2004).

Reference values of milk urea in sheep

Based on the previous discussion on milk urea and optimal dietary protein concentration, it is likely that MU higher than 40-50 mg/dl is associated with excess dietary protein and lower reproductive efficiency, while values lower than 25 mg/dl are associated with insufficient dietary protein and low milk production. These values are higher than those suggested for dairy cattle. Indeed, when the CP concentration of the diet was the same, MU concentrations were 5-15 mg/dl higher for dairy ewes than for dairy cows, probably because the level of intake in sheep is generally higher than in cattle (Cannas, 2004). At the same time, based on reproductive studies mentioned above, dairy sheep seem to be more resistant to negative effects of N excesses than dairy cattle.

When the sward is young and its CP concentrations are high, MU concentrations higher than 60 mg/dl are often found in sheep. These levels are certainly associated with a large excess of protein intake, poor health status and reproductive efficiency, and increases in energy

requirements. The relationship found between MU and dietary CP concentration (Equation [8]) may be used to estimate the protein concentration in the diet by measuring milk urea (Table 10). This could be particularly useful for grazing animals, for which some knowledge on dietary CP concentration would greatly help the choice of type and amount of feed supplements required to complete and balance the diets.

Table 10 - Relationship between MU or BU and dietary CP concentrations in sheep (based on equation [8]). When dietary CP concentration is unknown, MU or BU may be used for its estimation. The numbers in italics represent the range for lactating ewes fed well-balanced diets.

| | | | | | | | | | |
|----------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| CP (% DM) | 12.0 | 12.5 | 13.0 | 13.5 | 14.0 | <i>14.5</i> | <i>15.0</i> | <i>15.5</i> | <i>16.0</i> |
| Milk or blood urea (mg/dl) | 15.4 | 17.6 | 19.8 | 22.0 | 24.2 | <i>26.4</i> | <i>28.6</i> | <i>30.8</i> | <i>33.0</i> |
| CP (% DM) | <i>16.5</i> | <i>17.0</i> | <i>17.5</i> | <i>18.0</i> | <i>18.5</i> | 19.0 | 19.5 | 20.0 | 20.5 |
| Milk or blood urea (mg/dl) | <i>35.2</i> | <i>37.4</i> | <i>39.6</i> | <i>41.8</i> | <i>44.0</i> | 46.2 | 48.4 | 50.6 | 52.8 |

Usage of MU for dietary formulation

MU can be used to help diet (pasture + concentrates + hay + silages) balancing in many ways:

- to predict average diet CP concentration when pasture intake and quality is unknown (Table 10);
- to define the type of supplements or feeding strategies best suited to reduce MU when it is in excess, or to increase MU when it is too low (Table 11); and
- to indirectly monitor animal's energy balance or health status. For instance, if the diet has a moderate protein concentration and MU is high, it is likely that some stress or excessive energy deficit is inducing a high use of amino acids as gluconeogenic precursors and thus high MU concentration.

Table 11 – Classification of milk urea thresholds, causes and effects in lactating ewes.

| Milk urea concentration | Causes | Effects |
|-------------------------|---|---|
| >45-50 mg/dl | <ul style="list-style-type: none"> • Too high dietary CP concentration • Correct dietary CP concentration but too much degradable CP • Shortage of rumen fermented carbohydrates | <ul style="list-style-type: none"> • Waste of CP • Waste of energy for urea production • Reduced fertility • Diarrhoea, mastitis, mammary oedemas |
| < 20-25 mg/dl | <ul style="list-style-type: none"> • Too low CP dietary concentration • Too low CP degradability with correct dietary CP concentration | <ul style="list-style-type: none"> • Low rumen bacteria number and activity • Low digestibility and rumen vitamin production • Low intake and milk yield • Low fertility • Oedema (intermandibular space) • Poor quality of the fleece; low fleece production |

Body condition score

Body condition score (**BCS**) was one of the first nutritional indicators used for sheep. It can be used to define the optimal state of animal's reserves at various stages of the productive cycle. This application of BCS on lactating ewes has been already covered by INRA (1989) and Cannas (2004), among others, who reported reference values for the various stages of the production cycle. The information derived from BCS measurements and from its variations in the first stages of lactation can be matched with the nutritional information given by milk fat concentration, as previously discussed.

Another use of BCS in diet balancing of grazing sheep is related to the estimation of the energy costs of fattening or of the amount of energy available for milk production in animals that are in negative energy balance. In fact, if predicted changes in BCS, based on diet energy excess or deficiency estimated by diet balancing, match those observed over a certain period of time, it is likely that the inputs regarding pasture intake were correct. To use this approach it is necessary to know the relationship between BCS and body weight (**BW**), which varies depending on the mature size of the breed and of the population considered within each breed. Since this relationship has been studied only for some sheep breeds and populations, Cannas and Boe (2003) developed a model to predict it in ewes of any breed or population. They suggested that the prediction of BW for mature ewes of any sheep breed or population at any BCS (scale 0-5) could be done as long as the mature weight of that breed or population at BCS equal to 2.5 (**BW@BCS 2.5**) is known:

$$[10] \quad BW \text{ (kg)} = (0.594 + 0.163 * BCS) * BW@BCS \text{ 2.5.}$$

Rearranging equation [10], it is possible to estimate the BW@BCS2.5 when current BCS and BW are known:

$$[11] \quad BW@BCS \text{ 2.5} = \text{current BW} / (0.594 + 0.163 * BCS).$$

This equation can be easily applied to identify the BW@BCS 2.5 for a certain breed or population, in case this value is not available for them, by measuring BW and BCS of a group of sheep (possibly more than 10) belonging to the breed or population of interest. Once BW@BCS 2.5 is predicted, equation [10] can be used for all flocks of that breed or population.

This model was further expanded by Cannas et al. (2004) to estimate body energy variations associated with BCS variation.

Faeces as a nutritional indicator

Faeces are currently used as a nutritional indicator in dairy cows (e.g. Bertoni et al., 1999). Since they are one of the final products of the digestion process, their analysis can give a lot of information on the type of diet eaten and on its utilisation. Cannas (2004) proposed a tentative classification of faeces based on their characteristics. However, the same author stated

that there have not been enough studies to use sheep faeces as a nutritional indicator with high confidence. For this reason, his classification should be used with some caution.

Grazing Methods to Maximize the Animal Yield and Stocking Rate

Grazing is a system where there are complex interactions between the animal, the sward, the shepherd, the soil and the climate (Figure 6).

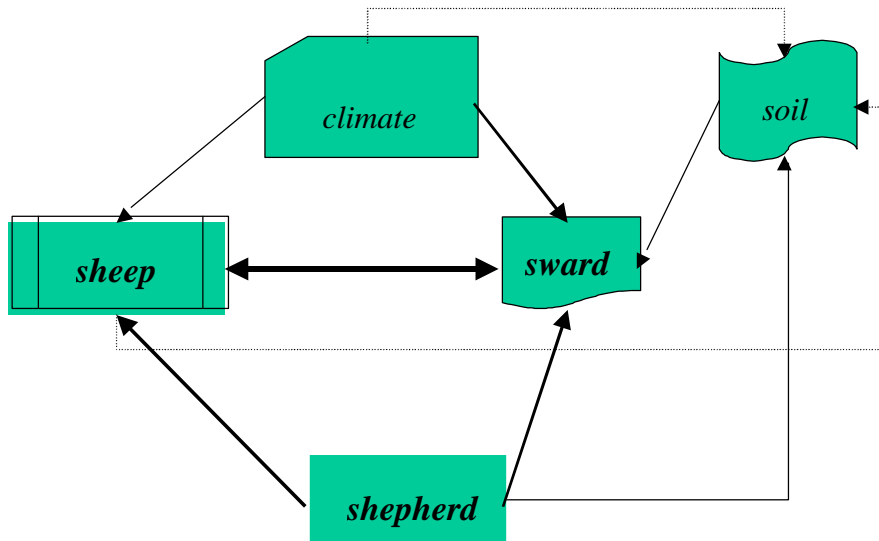


Figure 6 – Grazing as a complex system.

Based on Van Soest (1994) classification, sheep are considered grass-roughage eaters. When sheep are allowed to graze in woodlands, DM from grass forms up 90% of their diet. In similar conditions goats obtain 60% of their diet from woody species (Table 12). In addition, there is a 35% overlap in the diet composition of sheep and goats in winter, and 60% in spring (Leclerc, 1985).

Table 12 – Sheep and goats diet composition in a mixed flock in Corse, France (Leclerc, 1985).

| Species | Sheep | Goats |
|--------------------------|-------|-------|
| Wood | 7% | 61% |
| Graminaceae | 64% | 16% |
| Other herbaceous species | 29% | 23% |

Managing lactating ewes under grazing conditions means optimising feed resources to satisfy their nutritional requirements, taking into account their feeding behaviour. Grazing is basically the interaction between the animals using the sward and the sward itself. The grazing behaviour of herbivores is strongly influenced by the characteristics of the sward and its growth habit, growth rate and eco-physiological development are determined by the stocking density (Molle et al., 2004). Thus two quantities have to be assessed in order to choose the right grazing management system: a) the DM availability of sward and b) the intake of herbage by sheep. The

first of these quantities have been described in detail by Molle et al. (2004) and the second by Avondo and Lutri (2004). They can be summarised as follows:

Methods to assess biomass availability

The available biomass, expressed in tons of dry matter per hectare (t DM/ha), consists of all the dry and green matter present on each surface unit. It can be estimated by measuring the height of the sward, thanks to the strong correlation between these two parameters. The definition may be "undisturbed" sward height, which is measured either empirically or with more precision with a sward-stick (Barthram, 1985), or a system which uses a herbometer to take into consideration the density as well as the height of the sward (Holmes, 1984). These two measurements are closely correlated as shown in Table 13.

Table 13 - Linear regression analyses ($y = a + bx$) between the pasture height (cm) measured with the herbometer ($EH = x$) and with the sward-stick ($SSH = y$) (from Molle et al., 2004).

| Species | Grazing method | Season | Height Range (cm) | | a | b | R ² |
|---------------------|----------------|---------------|-------------------|----------|------|------|----------------|
| | | | SSH | EH | | | |
| Italian ryegrass | Continuous | Spring | 1.2-17.2 | 0.3-14.5 | 1.21 | 1.05 | 0.89 |
| Italian ryegrass | Not grazed | Spring | 3.6-41.4 | 1.5-25.5 | 0.54 | 1.42 | 0.91 |
| Annual ryegrass | Rotational | Winter-Spring | 9.3-30.6 | 4.2-20.2 | 3.59 | 1.29 | 0.97 |
| Meadow ^a | Rotational | Winter | 0.9-49.9 | 1.6-41.1 | 1.33 | 1.23 | 0.95 |

^a Annual ryegrass or pure Sulla

After measuring sward height with a herbometer, the available biomass is calculated using the relationships shown in Table 14 (Molle et al., 2004).

Table 14 - Linear regression analyses ($y = a + bx$) between biomass availability (y, t DM/ha) and the height (x, mm) measured using the herbometer (Molle et al., 2004).

| Species | Grazing method | Season | Range, mm | a | b | R ² |
|------------------|----------------|---------------|-----------|--------|-------|----------------|
| Annual ryegrass | Rotational | Winter-Spring | 56 – 417 | 0.116 | 0.013 | 0.84 |
| Italian ryegrass | Rotational | Winter-Spring | 37 – 290 | 0.016 | 0.01 | 0.75 |
| Italian ryegrass | Continuous | Winter-Spring | 30 – 90 | 0.32 | 0.04 | 0.61 |
| Italian ryegrass | Continuous | Late Spring | 30 – 90 | 0.22 | 0.07 | 0.85 |
| Sulla | Rotational | Winter-Spring | 58 – 678 | 0.793 | 0.01 | 0.75 |
| Burr medic | Rotational | Winter-Spring | 12 – 330 | -0.026 | 0.016 | 0.57 |

Two simple equations that estimate the biomass availability of Mediterranean pasture (P, in kg/ha of DM) as a function of its height (h, in cm) have been developed by Filigheddu and Pulina (1986).

[12] winter period $P = 180 + 40 h$ ($r = 0.425$)

[13] spring period $P = -44 + 80 h$ ($r = 0.69$)

Grazing methods

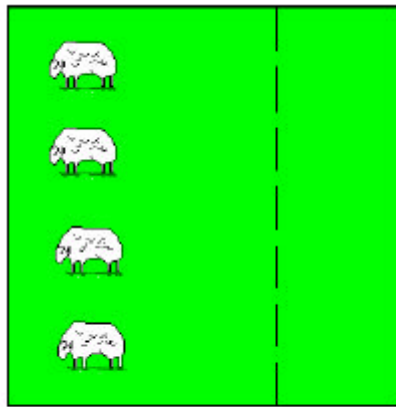
Grazing methods are the key to achieving the maximum yield of milk per hectare and per year, and to maintaining the productivity of the pasture and the health of sheep over time. A particular grazing method is a formula designed for managing the flock in a definite pasture sector. In other words, the basic question that the shepherd always faces is “how many sheep should be fed in a given paddock, and for how long?”.

The scheme of principal grazing methods, reviewed by Molle et al. (2004), is shown in Figure 7, while Table 15 reports their advantages and disadvantages, based on long-term experiments carried out by the Istituto Zootecnico e Casenario per la Sardegna (Sardinia, Italy).

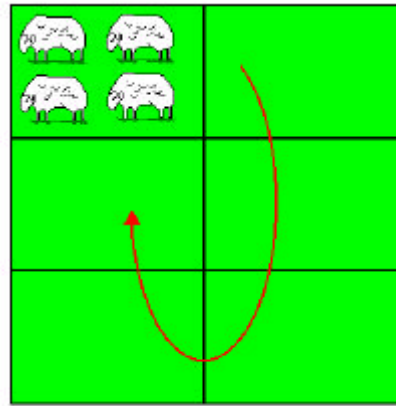
Table 15 - Guidelines for the choice of grazing methods (Molle et al., 2004).

| Type of pasture | Conditions of use | | | Graz. method |
|--|-------------------------------|------------------------------|---|---------------------|
| | Forage habit of growth | Forage production | Stocking rate ^a | |
| Natural or semi-natural pastures, cereal stubble | Prostrate or slightly upright | Low-medium (1-5 t DM/ha) | Low-medium (1-5 head/ha) | Continuous stocking |
| Forage crops of grass and legumes | Upright | Medium – high (5-10 t DM/ha) | Medium-high (5-10 head/ha) | Rotational grazing |
| High quality legume forage crops, forage crops containing anti-nutritional factors | Various | Various | Various, generally high (10-15 head/ha) | Rationed grazing |
| Sorghum spp., Maize | Upright, high sward height | Very high (> 10 t DM/ha) | Very high (> 15 head/ha) | “Zero grazing” |

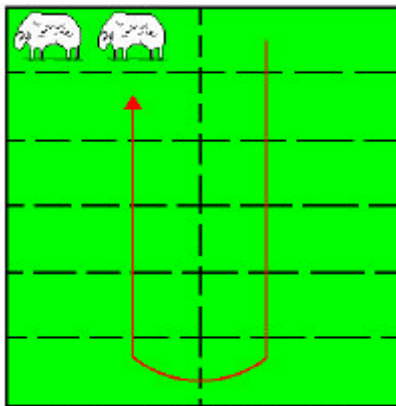
^a These are indicative values of annual stocking rates based on long-term experiments carried out by the Istituto Zootecnico e Casenario per la Sardegna (Sardinia, Italy).



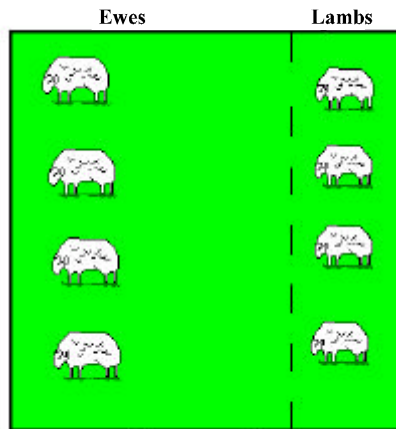
Continuous stocking



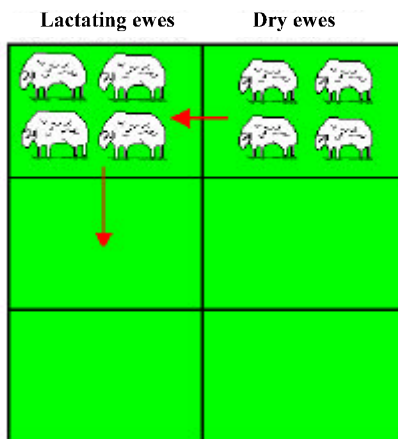
Rotational grazing



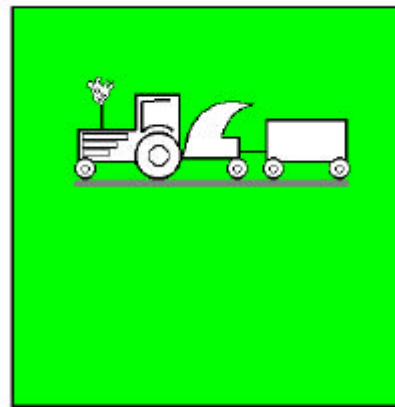
Strip grazing



Creep grazing



Leaders followers



Zero grazing

Figure 7 - Grazing methods. Dotted lines refer to uninterrupted transferable fences with the exception of “Creep grazing”, where fences include selective gates (from Molle et al., 2004).

How should the number of paddocks be calculated?

Rotational, strip and leaders-followers grazing methods require that the number (N) and the dimension (H, in ha) of each sector of pasture be assessed. For a given sward canopy, it is necessary to know (Brandano and Rossi, 1975):

1. the optimum range of sward height to start grazing (usually, 5-10 cm);
2. the occupancy period of a sector (O). This is the maximum number of days the animals remain in a given sector to avoid them grazing the re-growing grasses (usually, 4-8 days);
3. the stay period of a sector (S). This is the number of days a group of animals (lactating ewes, dry ewes, replacement maiden ewes, etc.) remains in a given sector (usually it is calculated by dividing the occupancy period by the number of groups G);
4. the rest period (R). This is the minimum number of days that should pass before the same sector is used again (it depends on the season and sward canopy, ranging from 20 days in spring - early summer, to 40 in late summer - autumn).

The formula to obtain the number of sectors (N) is:

$$[14] \quad N = (R + O)/S$$

For example, with R = 20 days, O = 4 days and G = 2 (so that S = 2), the sectors needed are 12. If one assumes that the pasture has the same productivity, then the dimension of each paddock is easily calculated. Of course the farm itself and the major paddocks have fixed fences, while secondary or mobile fences split up the paddocks into the required sectors, as is shown in Figure 8.

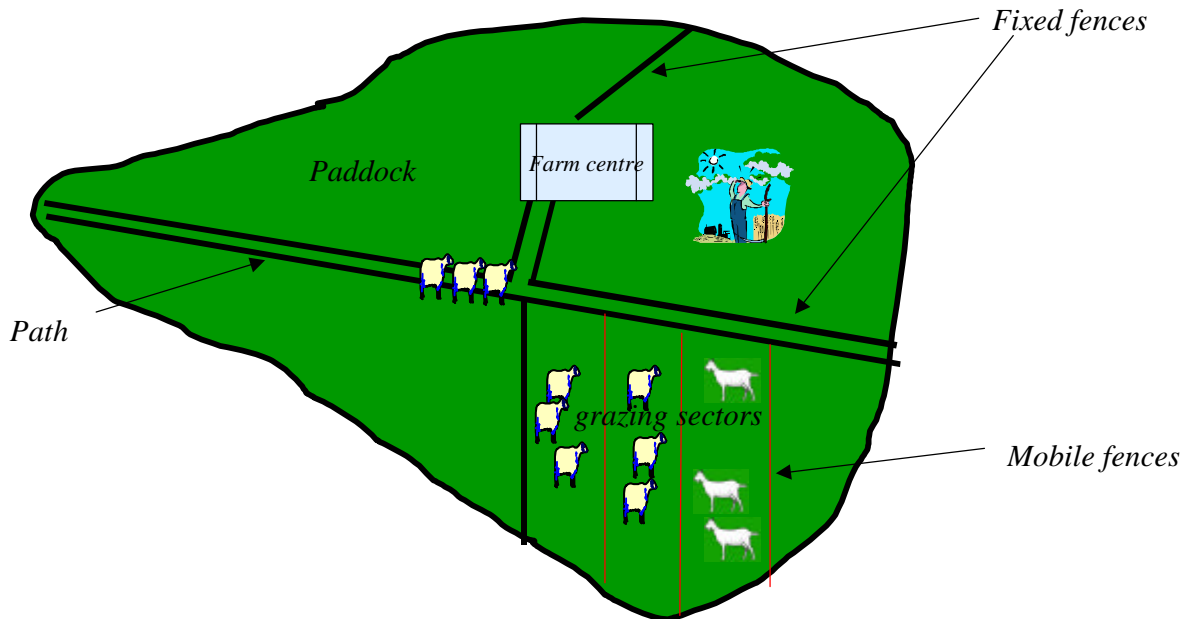


Figure 8 – Schematic representation of fixed and mobile fences arrangement in a dairy sheep farm to allow different grazing systems.

Practical Recommendations

A visual method to estimate pasture quality and herbage intake

Table 16 reports a pasture classification based on characteristics observable by visual inspection. This classification (Avondo, 2005) has been developed on the basis of herbage intake and crude protein content of the selected diets of lactating ewes in conditions where the height and density of herbage, the biomass, the biological stage, and the pasture heterogeneity vary. All these variables in combination can provide highly valid information on whether the pasture is usable.

Pasture intake is the result of interaction between the animal and the herbage at its disposal. The different types of pasture in the table offer the animal different feeding possibilities. On pasture type 1 (and to a lesser extent on pasture type 2), young and compact herbage allows the sheep to take large bites that are easy to chew and taste good. On pastures type 3 and 4, because some of the herbage lignified, the animal takes small bites after having first identified the most tender parts. This selective activity significantly improves the qualitative characteristics of the diet compared to the values for available herbage, and is associated with a notable reduction in dry matter intake with respect to better types of pasture. The animal nearly always selects matter that is richer in protein. This must be taken into consideration when formulating feed supplements. Indeed, when pasture quality is mediocre, a high protein supplement is often administered (supplements up to 20% of crude protein), without considering that it is exactly in these herbage conditions that there is more selection of higher protein parts of herbage. This allows the sheep to intake significantly better diets than would be expected.

Table 17, referring to the empirical classification in Table 16, reports the mean expected intake for each pasture typology, with different supplement levels, for a lactating ewe producing 3 l/d and weighing 60 kg. The same table also indicates the percentage increases expected in the protein content of the selected diet at pasture compared to the available herbage protein content.

Table 16 - Description of four pasture types, classified on the basis of characteristics observed on visual inspection (and relative data obtained from measurements or chemical analysis) (Avondo, 2005).

| Pasture type | Biomass | Density | Biological stage | Height | Herbage distribution |
|---------------------|---|--------------------------------------|--|---------------------------------|--|
| 1: excellent | High (>3.0 t DM/ha) | High Dense and compact herbage | Tender (light green) herbage (CP>16% DM) | Low and uniform (6 -10 cm) | No uncovered areas |
| 2: good | Medium (2.0-3.0 t DM/ha) | Medium Less compact herbage | Tender (light green) herbage (CP>16% DM) | Medium-low (not over 20 cm) | Nearly no uncovered areas |
| 3: mediocre | High (not lower than 3.5-4 t DM/ha) | Medium-low | Less tender (dark green) herbage (10%<CP<16%, on DM) | Medium-high (20-35 cm) | Uncovered areas, uneven height |
| 4: poor | Low (<2 t DM/ha) | Low Scarce herbage | Herbage in senescence (yellow) (CP<10% DM) | High or medium-high (>35 cm) | Biomass unevenly distributed with large uncovered areas |

Table 17 - Expected pasture intake and selective activity, for body weight and milk production, respectively, equal to 60 kg and 3 kg/d.

| Pasture type | Concentrate kg/d | Pasture intake kg/d | Variation in protein content of the diet selected compared to herbage content |
|--------------|---------------------|------------------------|--|
| Excellent | 0.5 | 2.5 - 3.0 | < +10% |
| | 1.0 | 2.2 - 2.6 | < +5% |
| Good | 0.5 | 2.3 - 2.8 | +5% - +20% |
| | 1.0 | 2.0 - 2.5 | +5% - +10% |
| Mediocre | 0.5 | 2.2 - 2.7 | +25% - +40% |
| | 1.0 | 1.9 - 2.4 | +15% - +30% |
| Poor | 0.5 | 1.2 - 1.4 | > +60% |
| | 1.0 | 1.1 - 1.3 | > +40% |

Practical guidelines to supplement grazing ewes

Grazing on immature and lush pastures

When pastures are lush and immature, such as during spring, they are rich in protein (20-30% CP, DM basis) and poor in fibre (NDF<45%, DM basis). This occurs both in grasses, especially when heavily fertilised with N, and legumes. These types of pastures in general guarantee high DMI and milk yield. Unfortunately, the high DMI is associated with high CP intake, with a large proportion of CP in the form of non-protein nitrogen (NPN) or very soluble protein. In both cases, CP rumen fermentation is very quick and excess of rumen ammonia and nitrogen intake occurs most of the times, unless pasture use is limited to few hours per day. In general, this excess is particularly high in the first hours after the beginning of the grazing. Immature pastures are also poor in fibre and do not sufficiently stimulate rumination. In these cases sheep do not produce enough saliva, which is important as it buffers rumen pH. With these types of diets, concentrates can reduce rumen pH, especially when the concentrates are supplied in one or two meals per day, as usually occurs in grazing dairy ewes milked once or twice per day. With young and lush pastures it is difficult to predict rumen conditions and the effects of concentrate supplements. The high CP concentration of the pasture stimulates rumen ammonia production, which increases rumen pH, but at the same time, the low NDF concentration of ruminable fiber decreases rumination and saliva production, with higher risks of acidosis when large amounts of starch are supplied. In practice, both situations can be observed, depending on whether high CP or low NDF has the dominant effect.

For all these reasons, supplements (hay, silages and concentrates) should not be used to increase DM or energy intake but to guarantee diets nutritionally more balanced and to reduce the negative digestive and metabolic effects associated with excess nitrogen intake and low rumen pH.

Assuming that the ewes are fed concentrates twice per day (at milking) and graze during the day and, in some seasons, at night as well, certain feeding and pasture management techniques can reduce the risks involved in grazing the animals on young swards as follows:

- a) concentrates supplied during milking should have low CP concentration, not more than 12% to 13% of DM, and the protein should have low rumen degradability. Negative effects of soluble N supplements on the milk yield of ewes grazing young pastures have been reported (Malik et al., 1999). In addition, simulations done with the CNCPS Sheep (Cannas et al., 2004) have shown that with immature and CP rich pastures, even when there is a high excess of rumen N, the MP requirements of the ewes might not be satisfied (Cannas, unpublished);
- b) concentrates supplied during milking should have a fairly high fibre concentration (from 17% to 20% of crude fibre; from 25% to 35 % of NDF), so that they stimulate rumination and compensate for the low fibre content of the pastures, and high starch concentration, to supply energy to the bacteria. The fairly high fibre concentration should be achieved by adding to concentrates mixtures feeds with highly digestible fibre, such as soybean hulls or beet pulps, to the concentrate. These fiber sources stimulate rumination in sheep (but not in cows) and also provide energy to bacteria. A mixture of slow fermenting (maize or sorghum) and fast fermenting (barley, oats or wheat) starch sources should be used, so that a sufficient release of energy can occur even after many hours from the last supply of concentrates. The overall goal is to improve the synchronisation of the fermentation of the proteins of the sward with that of the energy sources given at milking;
- c) nitrogen fertilisation should be carefully managed and sheep should not graze pastures for several days after fertilisation, especially when low temperatures or drought reduce the conversion of N fertilisers into plant proteins;
- d) when the sward is wetted by dew, grazing time should be reduced and the flock should be brought on pasture in the late morning. If the ewes go on pasture several hours after the morning milking, during which they received the first supply of concentrates, it is advisable to supply some feedstuffs shortly before grazing time. This practice avoids that they eat the pasture too fast, thus reducing the risk of ammonia overload. The supplements should be rich in energy and digestible fibre, and low in protein. For this third meal (assuming that the other two supplies of concentrate occur at the morning and evening milkings) the best supplements are, in order of preference, beet pulp, maize silage and silages made from wheat, barley or oat grains at milk-dough stage mixed with some grains. Pelleted feeds may also be used, as long as they have the characteristics described above. Besides limiting the rate of intake in the first hours of grazing, the third meal guarantees a supply of energy for rumen bacteria during the first hours of grazing, so that they can be more efficient in using rumen ammonia. In addition, it helps in splitting the daily allowance of supplements in several meals;
- e) good quality hay and silages should be added at night when the ewes are indoors, especially when grazing time is restricted to avoid excessive CP intake; and
- f) grazing time, amount and type of concentrates and of stored forages, and number of meals should be based not only on the quality and availability of the pasture but also on the indications derived from an integrated analysis of all nutritional indicators. In the short term, special emphasis should be given to milk urea concentration and to the characteristics of the

faeces, while BCS and milk fat concentration can be used to monitor medium-term dietary effects.

Grazing on mature pastures

Mature pastures generally have low CP and high NDF concentrations, especially if grasses are dominant. Low protein concentration reduces rumen N availability and high NDF concentration increases the rumen fill of the diet and reduces energy availability. Indeed, the NDF of mature plants usually has a low degradation rate and is also rich in lignin, which decreases the extent of digestion. The overall result is a decrease in intake, microbial activity and microbial protein supply and a shortage of gluconeogenic precursors and thus of glucose, with subsequent reduction in milk yield.

Assuming that the ewes are fed concentrates twice per day (at milking) and graze day and night, the following feeding and pasture management techniques can help in maximizing DMI and milk yield:

- a) supplements should be rich in CP, to compensate for the low CP concentration of the pasture. High CP supplements can markedly increase pasture intake, milk yield and milk coagulability (Nudda et al., 2004). The proper amount and quality of CP necessary to integrate grazing should be based on milk urea concentration and on faeces characteristics. The same nutritional indicators should be used to monitor the diet once the supplements are supplied and when major dietary changes occur;
- b) if grazing is supplemented with hay or silages, their quality should be as high as those used for lactating dairy cows with high levels of production. Feed intake is more negatively affected by high fibre content in sheep than in cattle (Cannas, 2004). Chopping and grinding can remarkably increase hay and silage intake in sheep (Cannas, 2004). However, if only poor quality (high NDF and lignin concentration) stored forages are available, they should not be chopped, so that the ewes can select the most digestible parts and discard the others;
- c) if the ewes are in mid-late lactation, supplements should be high in pectin and digestible fibre, such as soy hulls, beet pulps or citrus pulps. This avoids the use of large amounts of starch rich feeds, which in this stage cause a decrease in milk yield and excessive fattening (Cannas, 2004); and
- d) if the amount of supplements to be given at milking is high, it is advisable to use a concentrate mix with a fairly high content of effective (ruminable) fibre, so that the risk of grain overload is reduced. Rumen buffers should be also included in the concentrate mix.

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References

- Arnold G.W., and Dudzinsky M.L., 1978. Ethology of free-ranging domestic animals. Elsevier, North Holland, N.Y.
- Avondo M., 2005. Prediction of feed intake in the Italian dairy sheep. *Italian J. Anim. Sci.*, 4, (Suppl.1):35-44.
- Avondo, M., Bordonaro, S., Marletta, D., Guastella, A.M., D'Urso, G., 2002. A simple model to predict the herbage intake of grazing dairy ewes in semi-extensive Mediterranean systems. *Livest. Prod. Sci.*, 73:275-283.
- Avondo M., Marletta D., Bordonaro S., Guastella A.M., and D'Urso G., 1998. In: *Pasture Ecology and Animal Intake. Potential for and Consequences of Extensification of Beef and Sheep Production on the Grassland of the EC.* Occasional Pub. No. 3:191-196.
- Avondo M., and Lutri L., 2004. Feed intake. In "Dairy sheep nutrition" (G. Pulina ed.), CAB International, Cambridge, USA:65-77.
- Baker, L. D., Ferguson, J. D., and Ramberg, C. F., 1992. Kinetic analysis of urea transport from plasma to milk in dairy cows. *J. Dairy Sci.* 75 (Suppl.1): 181.
- Barthram G. T., 1985. Experimental techniques: the HFRO sward-stick. The Hill Farming Research Organisation. Biennial Report 1984 – 1985:29-30.
- Behera N., and Nanjundiah V., 2004. Phenotypic plasticity can potentiate rapid evolutionary change. *J. Theor. Biol.*, 226:177-184.
- Bencini R., and Pulina G. 1997. The quality of sheep milk: a review. *Australian J. Exp. Agric.*, 37:485-504.
- Bertoni G., Calamari L., and Trevisi E. 1999. Sistema diagnostico integrato per la valutazione delle lattifere. *Inf. Agr.* 55 (35), Suppl.: 5-66.
- Bishonga C., Robinson J. J., McEvoy T. G., Aitken R. P., Findlay P. A., and Robertson I. 1994. The effects of excess rumen degradable protein in ewes on ovulation rate, fertilization and embryo survival in vivo and during in vitro culture. *Anim. Prod.* 58:447.
- Bocquier F., and Caja G., 1993. Recent advances on nutrition and feeding of dairy sheep. *Proceedings of the 5th International Symposium on "Machine milking of small ruminants"*, Budapest, Hungary: 580-607.
- Bocquier F., and Caja G., 2001. Production et composition du lait de brebis: effets de l'alimentation. *Prod. Anim.* 14 (2):129-140.
- Brandano P., and Rossi G., 1975. La razionale utilizzazione dei pascoli ed i problemi inerenti la determinazione del carico. *Inf. Agr.*, 32:20139-20148.
- Bryant J., Lopez-Vollabos N., Holmes C., and Pryce J. 2005. Simulation modelling of dairy cattle performances based on knowledge on genotype, environment and genotype by environment interactions: current status. *Agricultural Systems*, in press.
- Cannas A., 2004. Feeding of lactating ewes. In "Dairy sheep nutrition" (G. Pulina ed.), CAB International, Cambridge, USA:79-108.
- Cannas A., and Avondo M., 2002. Relationships among milk fat content, energy balance and NDF intake in lactating ewes fed at pasture. *Book of Abstracts of the 53rd Annual meeting of the European Association of Animal Production*, Cairo, Egypt:55.
- Cannas A., and Boe F., 2003. Prediction of the relationship between body weight and body condition score in sheep. *Ital. J. Anim. Sci.*, 2, suppl. 1:527-529.
- Cannas A., Cabiddu A., Bomboi G., Ligios S., and Molle G. 2003. Effects of dietary non-fiber carbohydrates concentration on intake, in vivo digestibility and milk yield in Sarda ewes.

- Book of Abstracts of the 54th Annual Meeting of EAAP:344.
- Cannas, A., Pes, A., Mancuso, R., Vodret, B., and Nudda, A., 1998. Effect of dietary energy and protein concentration on the concentration of milk urea nitrogen in dairy ewes. *J. Dairy Sci.* 81:499-508.
- de Vries M.J., and Veerkamp R.F., 2000. Energy balance of dairy cattle in relation to milk production variables and fertility. *J. Dairy Sci.*, 83:62-69.
- D'Urso G., Avondo M., and Biondi L., 1993. Effects of supplementary feeding on grazing behaviour of Comisana ewes in a Mediterranean semi-extensive production system. *Anim. Feed Sci. Techn.*, 42:259-272.
- Dulphy J.P., Jailler M., Jamot J., and Bousquet H., 1990. Amélioration de prévision de la valeur alimentaire de certains foin au laboratoire. *Fourages*, 121:65-78.
- Emery R.S., 1988. Milk fat depression and the influence of diet on milk composition. *Veterinary Clinics of North America. Food and Animal Practice*, 4 (2):289-305.
- Ferguson, J.D., and Chalupa, W. 1989. Impact of protein nutrition on reproduction in dairy cows. *J. Dairy Sci.* 72:746-765.
- Filigheddu S., and Pulina G. 1986. Stima della produzione quantitativa e qualitativa dei prati-pascoli avvicendati della Gallura in base alla rilevazione di alcuni parametri tecnici. In: *Foraggicoltura e Zootecnia Gallurese in regime asciutto*, ERSAT Publishing:129-143.
- Forbes J.M., 1995. Voluntary food intake and diet selection in farm animals. CAB International, Wallingford, UK.
- Forbes J.M., and Provenza F.D., 2000. Integration of learning and metabolic signals into a theory of dietary choice and food intake. In "Ruminant physiology: digestion, metabolism, growth and reproduction" (P. B. Cronjé ed.), CABI Publishing: 3-19.
- Grieve D.G., Korver S., Rijpkema Y.S., and Hof G. 1986. Relationship between milk composition and some nutritional parameters in early lactation. *Livest. Prod. Sci.*, 14:239-254.
- Holmes C.W., 1984. The Massey grass meter. *Dairy farming annual*, Massey University:26-30.
- Ingvartsen K.L., 1994. Models of voluntary food intake in cattle. *Livest. Prod. Sci.*, 39:19-38.
- Institut National de la Recherche Agronomique (INRA). 1989. Ruminant Nutrition. Recommended allowances and feed tables. (R. Jarridge ed.). INRA, Paris.
- Lanari D., Tibaldi E., and D'Agaro E., 1993. Equazioni di stima dell'energia lorda, della digeribilità della sostanza organica e dell'ingestione volontaria di sostanza secca in ovini per alcune categorie di alimenti italiani. *Zoot. Nutr. Anim.*, 19: 57-71.
- Landau s., Kababya D., Silikanove N., Nitsan R., Lifshitz L., Baram H., Bruckental I., and Mabjeesh S.J. 2005. *Small Rumin. Res.*, 58:115-122.
- Leclerc B., 1985. Utilisation du maquis Corse par des caprins et des ovins. II Comparaison du regime des ovins e des caprins. *Acta Oecologia Applicata*, 6:303-314.
- Macchioni P., Bosi P., and Casini L., 1990. Ricerche sulla previsione dell'ingestione volontaria di foraggio negli ovini. *Zoot. Nutr. Anim.*, 16: 323-330.
- Malik B., Nicol A.M., and Van Houtert M. 1999. Sources of excess nitrogen affects nutrient partitioning in lactating ewes. *Proc. Of the New Zealand Soc. Anim. Prod.*, 59:158-161.
- Mavrogenis A.P., 1997. Comparative performance of purebred and crossbred sheep in three different production systems. *CHIEAM, Option Mediteraneens, Seminaires Mediteraneens*, serie A:181-185.
- Molle G., Ligios S, Fois N., Decandia M., Casu S., and Bomboi G., 1997. Responses by dairy ewes to different sward heights under continuous stocking either unsupplemented or

- supplemented with corn grain. *Options Méditerranéennes, Serie A*, 34: 65-70.
- Molle G., and Landau S., 2002. Feeding management. In "Encyclopedia of dairy sciences" (H. Roginski, J.W. Fuquay, and P.F. Fox eds.), Academic Press, London:2498-2507.
- Molle G., Decandia M., Ligios S., Fois N., Treacher T.T., and Sitzia M., 2004. Grazing management and stocking rate with particular reference to the Mediterranean environment. In "Dairy sheep nutrition" (G. Pulina ed.), CAB International, Cambridge, USA:191-211.
- Molle G., Sanna S.R., Ligios S., Branca A., Oppia P., Caria A., Corda A.R., Demuru G., Fressura G., and Ruiu G. 2001. Influenza dell'alimentazione sui risultati riproduttivi della pecora Sarda. *L'informatore Agrario*, (7):75-81.
- Nudda A., Battacone G. Bencini R., and Pulina G., 2004. Nutrition and milk quality. In "Dairy sheep nutrition" (G. Pulina ed.), CAB International, Cambridge, USA:129-149.
- Palmquist D.L., Beaulieu A.D., and Barbano D.M. 1993. Feed and animal factors influencing milk fat composition. *J. Dairy Sci.*, 76:1753-1771.
- Pauselli M., Morgante M., Duranti E., Casoli C., Ranucci S., and Mahrabi H., 1993. Effetto dell'alimentazione sulla produzione e sullo stato metabolico di pecore in lattazione. *Proceedings of the 10th National Congress ASPA*, Bologna, Italy:325-331.
- Provenza F.D. 1995. Postdigestive feedback as an elementary determinant of food preference and intake in ruminants. *J. Range Manag.*, 48:2-17.
- Pulina G., Bettati, T., Serra, F.A., and Cannas, A., 1996. Razi-O: costruzione e validazione di un software per l'alimentazione degli ovini da latte. *Proceedings of the 12th National Congress S.I.P.A.O.C.*, Varese:11-14.
- Pulina G., Macciota N., and Nudda A., 2005. Milk composition and feeding in the Italian dairy sheep. *Ital. J. Anim. Sci.*, 4 (suppl. 1):5-14.
- Pulina G., Rossi G., Cannas A., Brandano P., Rasso S.P.G., and Serra A., 1992. The use of a pelleted feed as stimulator of chewing activity in sheep. *Proceedings of the 43th Annual Meeting of the EAAP*, Madrid, Spain:376.
- Pulina G., Serra A., Cannas A., and Rossi G., 1989. Determinazione e stima del valore energetico di latte di pecore di razza Sarda. *Proceedings of the 43th Congress S.I.S.Vet.*, Pisa, Italy:1867-1870.
- Reid R.L., Jung G.A., and Thayne W.V., 1988. Relationship between nutritive quality and fiber components of cool season and warm season forages: a retrospective study. *J. Anim.S ci.*, 66:1275-1291.
- Rohweder D.A., Barnes R.F., Jorgensen N., 1978. Proposed hay grading standard based on laboratory analysis for evaluating quality. *J.Anim.Sci.*, 47, 747-759.
- Serra A., 1998. La valutazione degli alimenti ed il razionamento negli ovini da latte. *Dottorato di ricerca Thesis*, Perugia (Italy).
- Trimarchi G., Rossi G., Secchiari P., and Ferruzzi G., 1981. Influence de la concentration energetique de la ration sur les performances des brebis laitieres. *Proceedings of the "International Symposium on Pastoral Sheep Farming Systems in Intensive Economic Environments"*, Tel Aviv:3-12.
- Van Soest P.J., 1994. *Nutritional ecology of the ruminant*. Cornell University Press, Ithaca, NY.

MAXIMIZING PRODUCTION ON PASTURE

David Major
Major Farm and Vermont Shepherd, Ltd.
Putney, Vermont, USA

The title of this talk is “Maximizing production on pasture,” but as I begin to think about how I pasture my sheep I realize I pay as much attention to the health and quality of the milk and cheese, the animals, and the grass and soils as I do to the production. So I am going to rename this talk, “Pasture systems for maximizing the health, quality and production of the farm and its products.

Everything is a balance on the farm. When I made the morning pasture for the 176 ewes we are milking currently, I had to decide whether to make the area 30 X 300 feet or 300 X 300 feet or anything in between. The animals have their own needs - too little, and they'll quit producing; too much and they'll become sick with acidosis. And the pasture has its own needs - the more evenly and thorough the days grazing the better. Do the needs of the animals coincide with the needs of the pastures? Never exactly. So I try to strike a balance. I give the sheep a little lecture on the way out of the barn. Sheep, I say, I've given you a really good meal today, but you'd better finish in up or I'm not going to be able to give you such a good meal another day.

Major farm is actually a couple of older farms, Major Farm and Patch Farm, now combined as one. It is approximately 250 acres. We milk 220 sheep, though usually not more than 200 at any one time. We make all our own hay and raise most of our own lambs. The numbers of sheep and lambs on the farm vary over the year from a minimum of 275 to a maximum of 700.

The farms yearly production cycle is timed to take advantage of our pastures. 2/3rds of the ewes lamb in March, The remainder lamb in late May. The lambs nurse for one month after birth, and then they're moved to pastures where they are moved daily. The ewes are milked almost the entire pasture season, from mid-April to mid-November.

I will sketch out for you the nature of our pasture management for the different groups of ewes, then I will detail for you a few lessons I have learned over the years to keep up the health and production of the pastures and the sheep, what I have learned about the pastures' effect on product quality, and a few ways to make the whole process work efficiently.

The Milkers

We give our milkers new pasture space every 12 hours, after every milking. This does not mean that they are moved to an entirely different spot every milking. Rather, I make their pasture larger and larger with every milking until about 3 days pass, and then I start on a new area. This allows lazy me to move the pipe and water trough only every three days, plus it gives me some flexibility in being able to compensate for my mistakes. On day one, I like to make the first pasture of a new area bigger than I think the milkers will need. Then I can make the

succeeding add on pastures smaller if need be and let the milkers finish their meals with the leftovers from the first pasture.

The Lambs

Our lambs we wean at 30 days. Even at the first spring weaning we try to make sure that the lambs have at least a few days grazing experience with their moms before the weaning. This reduces the weaning stress considerably, as the lambs then have some association between grazing, food and their mom. We move the lambs to a new pasture every day. In their case, we do not just expand a previous day's pasture. Instead we give them an entirely new space. The reason for this is parasites. These young lambs are very susceptible to worms and coccidia; giving them a clean pasture every day reduces the parasite stress considerably. In addition, we try to put the lambs on either hayfield regrowth or pastures that have not been grazed since before the winter. Like all our sheep, the lambs have access to clean water 24 hrs a day. And we feed their grain supplement in plastic troughs not on the ground in order to reduce the threat of parasites and Johnnes disease.

The Clean Up Crew

We have one other group of sheep grazing. These we title "The Clean up Crew" because they do just that, cleaning up areas that the milkers or lambs do not graze thoroughly, grazing more distant pastures and rough pastures whose regrowth we will need for our late fall and early winter stock pile. The clean up crew consists primarily of the 45-50 yearlings we bring into the flock every year, plus any dry ewes we have kicked out of the milking crew. We do not breed our replacements to lamb at one year of age exactly for this reason; we need a clean up crew to properly manage the pastures.

Pasture Health and Production

My thoughts about the days or weeks work priorities usually begin with an assessment of the pastures. The productivity and quality of the pastures is so important to the productivity and health of the sheep as well as the production levels and quality of the cheese that my attention must go to the pastures first. Needless to say, pastures are a place where nutrients are cycled around and around with the help of the sun, rain, and sheep. Some pastures are endowed with more nutrients than others - deeper soils and greater fertility. But I've come to realize that in pastures as in people, what matters is not so much what you are endowed with, but what you make of it. I have a number of pastures with great soil, sun, and moisture, and I have a number of very steep, ledgy, generally infertile and northerly pastures: both are capable of equally excellent forage, only one in greater quantity. The trick is to cycle the few nutrients fast enough in the steep, ledgy pastures that the plants get to the point where they are stressed and go to seed or go dormant in desperation. On a poorer pasture, you cannot let the sward height grow as high as you can on a fertile pasture, or the quality of the grass will be much lower. In practice, this means that the poorer pastures may need to be grazed at least as frequently as the fertile pastures.

I have found that the most stable pastures and the ones on which the animals do best are pastures with a wide diversity of species. Once we had two researchers from the USDA evaluate the pasture species on two ten square meter areas. They found 35 varieties in one area and 65 in another area. I find my sheep do especially well with a nice mix of orchard and bluegrass, clovers, dandelion, and plantain.

My primary method of pasture improvement is to graze or crop the pastures often. This causes the nutrients to cycle faster, generally making for more fertile forage. I try where possible to mix haying and pasturing, both as a method of parasite control and a way to eliminate any unproductive plants and allow the sun to penetrate to the roots, stimulating growth. Where I do not hay, I do clip all but the steepest pastures once a year after the grasses have gone to seed. I do this for my own sake; it helps me better judge how the sheep are grazing if I'm not looking between tufts of dead grass stems, and it helps stimulate new palatable growth especially in those areas mixed with sedges and rushes and other plants the sheep don't like to eat later in the season.

I also over winter sheep on pastures that need more fertility. This means that I feed them hay on the snow, in different spots through the winter so that the entire area is covered in a thin manure and straw pack by spring. Then I spread a little clover, orchard grass or other seed into the pack a day or so before the sheep leave so that their hooves drill in the seed which combines with the hay seed creates a fine fertile pasture by mid-summer. Otherwise, I do not plow and reseed pastures, I do not fertilize them, and the only way I eliminate weeds like thistle and burdock is by hand; I do quite a bit of that on our many acres of pasture.

Sheep Health and Production

Now the sheep. You would think that the health and production of the sheep go hand in hand. But this is not necessarily the case. In a basic way I have to balance one versus the other as I make the farm decisions of the day. And I am always on the look out for tools to achieve both maximum production and perfect health. We use 14 to 16 percent pellets to supplement the dairy ewes in the parlor. The supplement is high in fiber and energy and we feed only 1/2 to 3/4 lb of it per day. We participated in a 3-year-long research project to help develop this feeding program, and it was detailed at a previous dairy sheep conference. Interestingly enough, the fine, intensively rotated pastures often seem so rich that the milkers get scours, acidosis and laminitis or hoof problems. I have several methods for reducing these digestion issues. I give them a little hay to nibble on when they come into the barn. Also I provide baking soda (sodium bicarbonate) free choice next to the salt. And most important, I let the sward height of the pasture grow a little higher, say 6-9 inches rather than 3-6.

Product Quality

We make a fine farmhouse cheese with an excellent reputation. Much of the flavor of the cheese comes from the plants in the pastures. We keep careful track of what pasture the sheep are grazing with each batch of cheese. Plainly, the flavors vary from batch to batch as the sheep move from flat bridge field to the higher and drier hilltop. Our attempts to maintain varied and

diverse forage have much to do with the success of our cheese in the market place. It pays for us to sacrifice some production for pastures that lead to a full flavored cheese unique to our valley.

AN INTEGRATED APPROACH TO THE SAFETY OF RAW MILK CHEESE

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Background

The following paper was first presented at the 2004 Annual Meeting of the American Dairy Science Association during a Symposium titled “Perspectives on Raw Milk Cheeses”. A version of this paper was published as a two-part article in the Cheese Reporter on August 27 and September 3, 2004. The original ADSA presentation has been revised slightly to consider regulatory developments that have occurred since the Symposium in 2004.

I would like to preface my remarks by stating up front that I am not a food microbiologist and have no new data to present on the safety of raw milk cheese. However, as a cheese technologist at the University of Vermont these past 19 years I have had ample opportunity to observe and work with raw milk cheesemakers for almost two decades. I have been strongly influenced by that experience, and my goal here is to offer a somewhat different perspective on raw milk cheeses that perhaps will challenge you to think a little more broadly.

I have titled this presentation “An Integrated Approach to the Safety of Raw Milk Cheeses” because this issue is not simply about safety and microbiology. Without question, safety is paramount. I believe that all sides agree on this, and I certainly hold that view. However, there are also other, secondary, considerations that should be taken into account as we seek the best course of action to assure safety. Therefore, I will attempt to integrate some of these secondary, often non-scientific, considerations into this conversation on raw milk cheese safety.

I will focus on three major points. First, I will try to convince you that raw milk cheesemaking in the U.S. is worth saving. In other words, in our quest to improve the safety of cheese, we should strive for a win-win solution that achieves the appropriate level of safety while preserving the option for U.S. cheesemakers to produce, and the American public to consume, raw milk cheeses. That does not mean, however, that we should be satisfied with the *status quo* when it comes to safety. In my view, there are some genuine concerns that need to be addressed. Therefore, I will also make the case that the safety of raw milk cheese needs to be enhanced. The question is...how to accomplish this? I will conclude by proposing that mandatory pasteurization of all milk for cheesemaking is not the best approach to enhance cheese safety at this time. There are other win-win approaches that should be considered first. As I present these three points, I encourage you to be dually critical, but keep an open mind.

Let's begin by examining some of the reasons why raw milk cheeses are worth saving. I'd like to consider this from the perspective of my home state of Vermont first, because the reasons for preserving raw milk cheesemaking are especially compelling for Vermont. Here's why. Vermont is a rural, agricultural state, and its agriculture is disproportionately dominated by

dairy farming. In fact, Vermont agriculture is the most dairy-dependent of any state in the nation. At the same time, dairy farmers in Vermont, as in many states, face serious economic challenges for reasons that are largely beyond their control. Perpetually low commodity milk prices erode the farmer's ability to make a decent living, and the future of Vermont's dairy industry is becoming increasingly dependent on the production of value-added products. This is certainly true with respect to cheesemaking. The future lies in the production of value-added, not commodity, cheeses.

Therefore, it is important to identify those characteristics that make cheese value-added. In Vermont, many of the value-added agricultural products share a common profile that looks something like this. They are perceived to be hand-crafted or somehow artisan in nature. They are distinctive in quality and character in ways that set them apart from their conventional and commodity counterparts. They often embrace or symbolize in the minds of the consumer a sustainable and environmentally balanced approach to agriculture, and an approach that supports small-scale family farming. And they are products that are somehow linked to Vermont itself and the beautiful Vermont landscape. Thus, when consumers purchase these products they often are not simply buying a distinctive food. They are buying into a place and a way of thinking. Raw milk cheeses produced on small family farms fit seamlessly into this way of thinking. In other words, raw milk cheesemaking is a very good fit for Vermont agriculture at a time when we urgently need more "good fits".

Add to this the fact that there is considerable potential for market growth because much of the raw milk cheese consumed in the U.S. is imported. Only a small fraction is actually produced domestically, therefore there is plenty of room for domestic cheesemakers to increase their market share. Thus, raw milk cheesemaking has the potential to become even more important to Vermont agriculture in the future, and therefore to the State's economy as a whole. Agriculture wields a particularly powerful multiplier effect on the Vermont economy because tourism is Vermont's number one industry, and agriculture, the working landscape, dairy farms, and tourism are inseparable. Vermont needs tourism, tourism needs dairy farms to maintain the picturesque working landscape, dairy farms need value-added products to survive, and raw milk cheeses constitute a growing value-added niche of dairy products. So of course raw milk cheesemaking is worth saving, at least from Vermont's perspective. Thus, it is not surprising to find strong public support in Vermont for this fledgling industry, and that Vermont's elected officials reflect that support. Furthermore, there are other regions of the country where local economies enjoy some of these same benefits from the presence of artisan farmstead raw milk cheese producers.

But the issue is much larger than simply the parochial needs of Vermont or a few similar regions in the U.S. Raw milk cheeses are worth saving because, nationwide, there is a growing public appreciation and demand for these cheeses. Part of this is simply that the American public is traveling internationally far more now than ever before. Americans experience raw milk cheeses in Europe, return to the U.S., and seek to enjoy them here. But there is something else going on that I think is much more important in the long run. We are witnessing a growing philosophical and cultural divide in this country over agriculture and food. This divide is characterized by a growing sentiment among some Americans that all is not well in conventional American agriculture, in the way that we mass-produce, process and market our food, and more broadly in the way that we view food as a society. This attitude of mistrust is being fueled by a

number of concerns, among which include a lack of confidence in the wholesomeness of our food, concerns about the sustainability, environmental impact, and humanness of our agricultural practices, and a sense that our culture, tradition and quality of life are being dragged down by a disconnected and unhealthy attitude towards food and agriculture. All of these concerns are inter-related in a way that defines a world-view that characterizes a growing movement in this country

If you want an example of what this movement looks like, check out the Slow Food USA® web site (www.slowfoodusa.org). Slow Food is a grass-roots organization that originated in Italy and is steadily gaining ground in the U.S. Here is how Slow Food USA describes itself:

“Recognizing that the enjoyment of wholesome food is essential to the pursuit of happiness, Slow Food U.S.A. is an educational organization dedicated to stewardship of the land and ecologically sound food production; to the revival of the kitchen and the table as the centers of pleasure, culture, and community; to the invigoration and proliferation of regional, seasonal culinary traditions; and to living a slower and more harmonious rhythm of life.”

This statement captures the essence of what this movement is about. The raw milk cheese issue has mobilized groups like Slow Food because it embodies, or symbolizes, many of the core beliefs of this movement. Therefore, any effort by the industry or the regulatory establishment to ban raw milk cheeses is viewed as an attack on their deeply held core values. Now, it's tempting to conclude that groups like Slow Food USA® fall way outside of the mainstream and do not represent the American public. If you hold this view, be careful. Do not underestimate the extent of this cultural divide, because there is an element of truth to this movement that resonates deeply with a growing segment the American public. Europe is way ahead of us in this way of thinking. If you want to see where U.S. attitudes about agriculture and food will likely be in ten or twenty years from now, look to where Europe is today. We are headed in that direction. When viewed from that perspective, banning raw milk cheeses at this point in time runs the risk of becoming a backward-looking approach to an issue that deserves a forward-looking solution.

Finally, raw milk cheeses also are worth saving to avoid unnecessary friction with our European trading partners. We live in a global economy and with respect to food and agriculture, the difference between the U.S. and Europe is more than a philosophical and cultural divide, it's a chasm. For many E.U. countries, preserving raw milk cheesemaking is a high priority. Indeed, the EU has gone to great lengths for more than a decade to develop science-based win-win regulatory solutions designed to assure safety while maintaining raw milk cheese production. Clearly, the stakes are high for Europe because raw milk cheesemaking is a big industry and, frankly, America represents a lucrative export market for some of those cheeses. But beyond simple economics, a U.S. ban on raw milk cheeses could be viewed as another example of American unilateral decision-making. Why? Because other respected countries are approaching the issue of cheese safety differently, and arriving at different conclusions.

Take Australia, for example. Australia requires that milk for cheesemaking must either be pasteurized (holding at a temperature of at least 72°C for no less than 15 seconds) or

thermized (holding at a temperature of at least 62°C for no less than 15 seconds), providing the final product is stored for at least 90 days at a temperature not below 2 °C. However, an alternative process can be used if it can be demonstrated that this process will achieve an equivalent level of safety as cheese prepared from milk that has been heat-treated. Applying this “principle of equivalence”, the Australians have concluded that certain raw milk cheeses made to specific European standards, such as Emmental and Parmigiano Reggiano, achieve a level of safety comparable to that obtained through pasteurization. Consequently, Australia allows the import and sale of several hard Swiss and Italian cheese varieties. Recently, Australia reviewed the safety of Roquefort cheese at the request of the French government and concluded that this cheese also satisfies the appropriate standard for safety. We in the U.S. need to consider how other countries, like Australia, are coping with cheese safety as we seek to find our own solutions. Of course the U.S. reserves the right to act as it deems necessary to protect the American public, but we also we need to be sensitive to concerns about regulatory unilateralism.

Let’s now consider the safety issue. I believe that there are some legitimate concerns about safety, and that the safety of raw milk cheeses needs to be enhanced. Based on what I see happening out there in the real world, I have three major concerns. First, I find it troubling that small farmstead cheesemakers, who typically are the ones that produce raw milk cheeses, often lack technical training. Not always by any means, but often enough to raise red flags. Some of them have no technical training at all, and that has serious implications for food safety. To my knowledge, Wisconsin is the only state that requires its cheesemakers to complete a course of technical training in the form of a licensing requirement. I applaud Wisconsin for holding its cheesemakers to a higher standard of training and knowledge. In my opinion, inadequate technical training is a significant risk factor associated with raw milk cheese safety. It needs to be addressed.

Second, regulatory oversight is being stretched rather thinly in some regions by this growing industry of small cheesemakers. By their very nature, small cheesemakers are very labor intensive from the standpoint of regulatory oversight. Increasingly, regulatory inspectors are faced with the dual challenge of having more small cheesemakers to inspect, and more cheesemakers who haven’t had the proper technical training and who, therefore, require more time and attention from the inspectors. And it’s taxing the system in some regions.

Finally, to complicate matters, there appears to be growing interest on the part of U.S. raw milk cheesemakers to venture into producing higher risk cheeses. I’m referring to a group of washed rind and natural rind cheeses, aged for more than sixty days but not much more, that are essentially new to the U.S. market and which carry a comparatively high degree of risk. Their manufacture is characterized by relatively slow acidification and low cooking temperatures, which render them vulnerable to the growth of pathogens during cheesemaking. These conditions also give rise to a final cheese with relatively high moisture content. Furthermore, the pH of these cheeses often increases during aging, sometimes quite dramatically. Consequently, these cheeses present relatively few hurdles to unwanted microbial growth, thus elevating their inherent risk. The increased interest in producing these cheeses from raw milk, combined with inadequate technical training on the part of some cheesemakers and a regulatory infrastructure stretched thinly in some regions raises some red flags concerning food safety in my view. The question is...what to do about it?

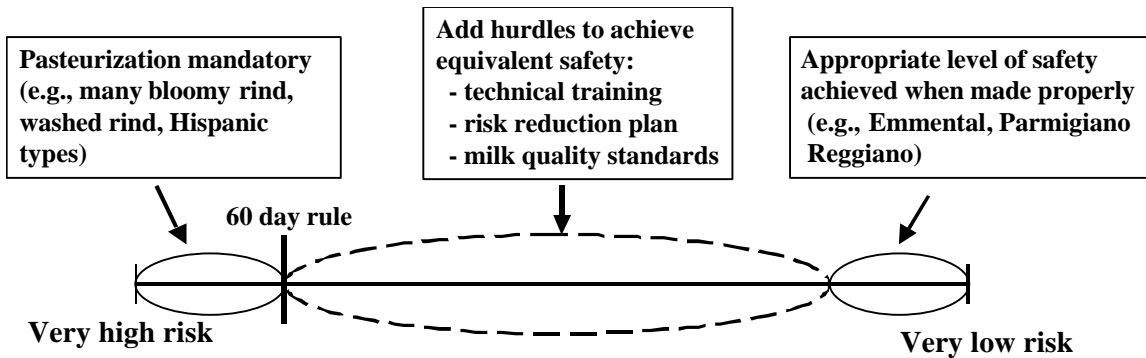
And that brings me to my final point, which is that mandatory pasteurization is not the best approach to enhance cheese safety at this time. If raw milk cheeses are indeed worth saving, we should first attempt to find a win-win solution that achieves the appropriate level of safety, is practical and can be effectively implemented, and avoids placing unnecessary burdens and restrictions on producers and consumers of raw milk cheeses. Only if that fails should we resort to mandatory pasteurization, and then only if the need for mandatory pasteurization to assure safety is supported by good science.

But even more importantly, from a food safety perspective it is difficult to justify a blanket requirement for pasteurization because some raw milk cheeses already achieve the appropriate level of safety. For example, extensive research on several of the hard Swiss and Italian raw milk cheeses has shown very convincingly that these specific cheeses, when made according to carefully defined standards, have extremely low levels of risk. Thus, a strong case can be made that these specific raw milk cheeses automatically achieve an appropriate level of safety when made properly. Pasteurization isn't necessary. As noted earlier, the Australians came to this conclusion after extensive reviews of these particular cheeses, and also for Roquefort. The point is, it is very hard to argue on scientific grounds that ALL milk for cheesemaking must be pasteurized to assure an appropriate level of safety. It depends on the type of cheese.

On the other hand, current U.S. regulations permit some raw milk cheeses to be produced that do pose significant risk, perhaps more risk than we are willing to accept. What do we do about them? I believe that in most if not all cases, the appropriate level of safety can be achieved by adding new safeguards to their production. This is the approach that the European Union has taken. Such safeguards might include a minimum requirement for technical training of cheesemakers, the implementation of an approved risk reduction (HACCP-type) program and the establishment of strict microbiological standards and routine surveillance of raw milk supplies. Also, finished product testing for specific pathogens is an option, but the preferred approach in my view is to assure safety by equipping cheesemakers with essential knowledge, monitoring raw milk quality and applying effective risk reducing measures during cheesemaking and aging.

Let me illustrate what this approach might look like in the American context. Shown below is a schematic representation of the range of risk associated with raw milk cheeses. At one end of the spectrum are a group of cheeses such as Emmental and Parmigiano Reggiano that have been shown convincingly to achieve the appropriate level of safety because of the microbiological hurdles built into their manufacture, aging and chemical composition. At the other end of the spectrum are cheeses that lack microbiological hurdles and thus carry high associated risk. Under current U.S. regulations, most of the highest risk cheeses must be made from pasteurized milk by default, because they cannot withstand the minimum sixty-day aging requirement for cheese made from unpasteurized milk. One can argue that the "sixty day rule" has served us well for more than half a century by acting as a "gatekeeper" to prohibit the most risky cheeses from being produced from raw milk. Falling between the sixty-day rule and the very low risk cheeses is a large group of cheeses that span a wide range of associated risks. Judging from the European experience, many if not all of these cheeses can be produced safely from raw milk provided that adequate hurdles are incorporated into their manufacture. Generally

speaking, the risks associated with these cheeses recede gradually as their aging requirement increases. Thus, raw milk cheeses that are aged for only slightly more than 60 days warrant the greatest concern and stand to benefit most by implementing additional safeguards to reduce risk.



Furthermore, based on our history with the sixty-day rule, another approach to enhance safety might be to adopt a more conservative “gatekeeper” by replacing the sixty-day aging requirement with a longer one, such as ninety days. By default, this would effectively reduce the number of higher risk cheeses that could be produced from unpasteurized milk. I’m not advocating that the sixty-day rule be changed, but it could be pursued as an option to mandatory pasteurization if deemed necessary to assure safety.

In closing, I realize that these are simplistic solutions to a complex problem, and that the devil is always in the details. However, the point that I’d like to leave you with is that there are options. In our quest to assure safety we should keep an open mind and use good science and common sense to explore the options in a thoughtful and constructive manner. Doing so offers the best chance for arriving at a solution that we can all consider win-win.

FARMER PANEL ON LABOR

**Mark Fischer
Woodcock Farm
Weston, Vermont, USA**

- If you are milking plus making cheese somewhere between 50 and 75 evenings, you need extra help.
- Finding quality, responsible farm help is difficult.
 - The pay is not high.
 - There may be no or only a few benefits.
- Farm hours add up fast.
- Milking time frame.
- Interns:
 - Positive:
 - They are cost effective.
 - Have varied backgrounds.
 - Usually young and energetic.
 - Negative:
 - Usually students with a short time to work.
 - Have nothing to lose (if they leave).
 - Need constant direction (you are a teacher as well).
 - Are with you all the time.
 - Room and board - make sure they have their own space or they will be in yours.

**FARMER PANEL ON LABOR
HOW TO ATTRACT AND TRAIN YOUR LABOR FORCE, YEAR AFTER YEAR:
SUCCESSFUL METHODS AND CHALLENGES**

**Bob Works
Peaked Mountain Farm
Townshend, Vermont, USA**

Background

Seasonal Labor Tradition
Beneficial Pay/Benefits
“Free” vs. Paid
General Labor vs. Targeted

Where/Sources

Offshore vs. Domestic
Commuters vs. Live-Ins
Referrals vs. Strangers
Farmers vs. Foodies
Postings/Internet
They might find you...

Motivations/Preparations: Theirs/Yours

Housing
Training
Evaluation/Discipline
Retention

Cautioning Tales

What can go wrong.....and right; War stories from the field.



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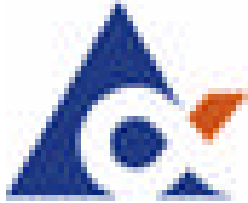
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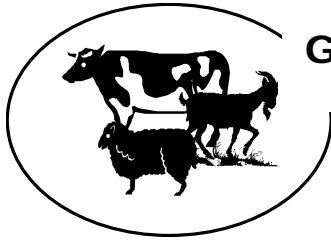


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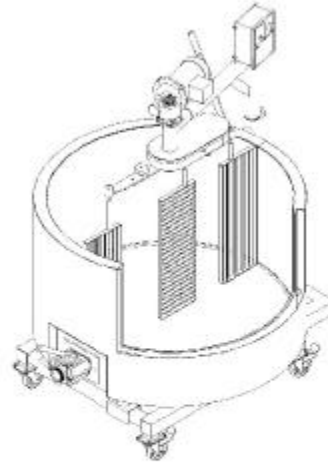
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