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*Proceedings of the 16<sup>th</sup> Annual*

***GREAT  
LAKES  
DAIRY  
SHEEP  
SYMPOSIUM***



**November 11 – 13, 2010  
Eau Claire, Wisconsin, USA**



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*Proceedings of the 16<sup>th</sup> Annual*  
***GREAT LAKES DAIRY SHEEP***  
***SYMPOSIUM***

November 11 – 13, 2010

Ramada Inn Convention Center  
Eau Claire, Wisconsin, USA

**Organized by:**

Dairy Sheep Association of North America, 1675 Observatory Dr.,  
Madison, Wisconsin 53706, USA (<http://www.dsana.org/>)

**Assisted by:**

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

University of Wisconsin-Madison, College of Agricultural and Life Sciences,  
Department of Animal Sciences, Madison, Wisconsin, USA  
(<http://www.ansci.wisc.edu/>)

University of Wisconsin-Extension, Cooperative Extension, Madison, Wisconsin,  
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Clockwise from top right:

Dairy ewes in milking parlor, Irish Cream Sheep Dairy, Bushnell, Nebraska, USA  
– photo provided by Bill Halligan family

Artisan sheep milk cheese, Black Sheep Creamery, Chehalis, Washington, USA  
– photo provided by Brad and Meg Gregory

Entrance to cheese curing cave, Shepherd's Ridge Creamery, St. Croix Falls,  
Wisconsin, USA  
– photo provided by Jeff and Vicky Simpkins

Sheep milk in bags for freezing, Irish Cream Sheep Dairy,  
Bushnell, Nebraska, USA  
– photo provided by Bill Halligan family

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## Program of Events

### Thursday, November 11, 2010

- 8:45 a.m.     **Registration**, Ramada Inn Convention Center, Eau Claire, Wisconsin, USA
- 9:20 a.m.     **Welcome**, Bill Halligan, President, Dairy Sheep Association of North America, Bushnell, Nebraska, USA
- 9:30 a.m.     **Getting Started in Sheep Dairying**  
Jeff and Vicky Simpkins, Shepherd's Ridge Farm, St. Croix Falls, Wisconsin, USA
- 10:15 a.m.    **Farm Management Decision-Making**  
Bill, Virginia, and Cody Halligan, Irish Cream Sheep Dairy, Bushnell, Nebraska, USA  
Travis Burrows and DaNay Spurge, Old Chatham Shepherding Company, Old Chatham, New York, USA
- 11:00 a.m.    **Dairy Sheep Feeding 101**  
Dr. Claire Mikolayunas, Department of Animal Sciences, University of Wisconsin-Madison, Madison, Wisconsin, USA
- 11:45 a.m.    **Lunch**
- 12:45 p.m.    **Lamb Rearing Producer Panel**  
Tom and Laurel Kieffer, Dream Valley Farm, Strum, Wisconsin, USA  
Brad and Meg Gregory, Black Sheep Creamery, Chehalis, Washington, USA
- 2:00 p.m.     **Feeding and Management of Young Lambs**  
Dr. Robin Rastani, Milk Specialties Global, Carpentersville, Illinois, USA
- 2:45 p.m.     **Visit Sponsors and Break**
- 3:15 p.m.     **Mastitis in Dairy Sheep**  
Dr. Pamela Ruegg, Department of Dairy Science, University of Wisconsin-Madison, Madison, Wisconsin, USA
- 4:00 p.m.     **European Cheesemaking Perspectives**  
Ivan Larcher, Larcher Consulting, Les Touches, Cheniers, France
- 4:45 p.m.     **General Annual Meeting – Dairy Sheep Association of North America**
- 6:00 p.m.     **Sheep Milk Cheese Reception**

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## Program of Events (cont.)

### **Friday, November 12, 2010**

- 8:30 a.m.     **Milk Recording and Genetic Improvement**  
Dr. David L. Thomas, Department of Animal Sciences, University of  
Wisconsin-Madison, Madison, Wisconsin, USA
- 9:30 a.m.     **Sire Referencing Program**  
Dr. Claire Mikolayunas, Department of Animal Sciences, University of  
Wisconsin-Madison, Madison, Wisconsin, USA
- 10:00 a.m.    **Visit Sponsors and Break**
- 10:30 a.m.    **Antibiotic Testing in Milk**  
Daniel L. Scruton, Vermont Agency of Agriculture, Food and Markets,  
Montpelier, Vermont, USA
- 11:15 a.m.    **Ontario Dairy Sheep Industry**  
Mike Foran, Ontario Ministry of Agriculture Food and Rural Affairs, Guelph,  
Ontario, Canada
- 12:00 p.m.    **Lunch**
- 1:00 p.m.     **Milk Quality for Cheesemaking**  
Dr. Bill Wendorff, Department of Food Science, University of Wisconsin-  
Madison, Madison, Wisconsin, USA
- 2:00 p.m.     **The Art of Utilizing Sheep Milk for Cheese**  
Robert L. Wills, Cedar Grove Cheese, Inc., Plain, Wisconsin, USA
- 3:00 p.m.     **Visit Sponsors and Break**
- 3:30 p.m.     **Unique Characteristics of Sheep Milk**  
Ivan Larcher, Larcher Consulting, Les Touches, Cheniers, France
- 4:30 p.m.     **Cheese Aging Techniques**  
Mateo Kehler, Cellars at Jasper Hill, Greensboro, Vermont, USA
- 7:00 p.m.     **Banquet** – Pre-registration required

### **Saturday, November 13, 2010**

- 8:15 a.m.     **Board Buses for Farm Tours**, Ramada Inn Convention Center  
Shepherd's Ridge Dairy, St. Croix Falls, WI – Jeff and Vicky Simpkins  
Spooner Agricultural Research Station, Spooner, WI – UW-Madison Faculty  
and Staff
- 4:00 p.m.     **Buses return to Ramada Inn Convention Center and symposium  
concludes**



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## Sponsors

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[eckermanst@antigopro.net](mailto:eckermanst@antigopro.net)

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<http://www.hiddenspringscreamery.com/contact.php>

**Ovinshire Farm**, 511 Frog City Rd., Ft. Plain, NY 13410; [tmack@frontiernet.net](mailto:tmack@frontiernet.net)

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Please support these sponsors as you purchase equipment, supplies, and services for your dairy sheep farm or sheep milk processing facility.

## **GETTING STARTED IN SHEEP MILK DAIRYING**

**Jeff and Vicky Simpkins  
Shepherd's Ridge Creamery  
St. Croix Falls, Wisconsin, USA**

### **Background and Decisions to Start a Sheep's Milk Dairy**

Our decision to build a dairy sheep operation began with our desire to do something in agriculture. We had looked into beef, buffalo, beefalo, hogs, and farm raised deer. We also investigated ostriches, emus, and chinchillas. Our criteria for selection of operations included ease of handling, seasonal production (allowing for some down time), and multiple streams of income. Sheep seemed a good fit given our limited amount of land (160 acres), low crop base and hilly terrain.

Sheep met the ease of handling requirement and the potential for twins and triplets would allow for rapid building of flock from within. Sheep are also well suited to our terrain. We took some classes on lambing and keeping sheep, in Pipestone, Minnesota, and built up a successful meat sheep operation. We were looking for value-added possibilities and ways we could increase Ag Tourism at our farm. We sold lamb to ethnic groups from nearby Minneapolis. These same groups, plus local customers, also bought our seasonal vegetables, eggs, and pastured poultry. The work was enjoyable but the returns were not adequate. We were looking for ways to increase profits so we could farm and get some extra income when the time came to retire from our jobs in the medical field. We then saw sheep being milked at the Spooner Research Station. We attended a few dairy sheep symposiums and visited farms that were milking sheep. We could see this adding another stream of income to our operation.

Sheep's milk can be a value added product along with the meat. The farms we visited in Wisconsin, Vermont, and New York were for the most part small and the size of operation we were looking for. The milking was seasonal which was very appealing. Soon after exploring the facets of sheep's milk dairying we read an article about Love Tree Farms where Dave and Mary Falk were making cheese from sheep's milk. Cheese making was part of our family history so the idea intrigued us. When we saw that the cash margins increased markedly between fluid milk and making cheese, a decision was made for Vicky to obtain a cheese maker's license. Consultants from the Dairy Business Innovation Center in Madison helped us in our planning process and enabled us to meet producers who were in the process or had finished constructing their dairies. We then made plans to construct a milk parlor and a creamery.

### **Animal Selection**

There appeared to be two ways to acquire a dairy flock. The first was to purchase dairy ewes. This would be relatively expensive entry. As well as expensive, mistakes that novices would surely make would have more dramatic results. We chose to start our dairy flock with Dorsett ewes. This decision was made for several reasons. They were available in our area and affordable. They are known to be good mothers (if you choose to leave the lambs on the mothers

for a month) and fair milkers as well as hardy (read, will survive beginners). We selected ewes for longer frames, udder conformation and who had produced twins.

The decision was to breed the Dorsett ewes to dairy rams. We chose Lacune and East Friesian rams because of their well known production characteristics and availability in Wisconsin. We were impressed with the milking ewes we saw at Dream Valley Farm and at the Spooner Research Station. Both the owners /managers were very knowledgeable about these breeds. The terminal cross has yet to be decided. We will retain a meat breed along with the dairy crosses to increase genetic variability and hardiness. It takes approximately 4-6 years before the dairy genetics are fully appreciated. The key to the terminal cross is balancing the hardiness and carcass qualities of the meat breed (1/2 of the lambs are male) with the characteristics of the dairy sheep that give you high milk production and components. You also have to be willing to aggressively cull.

### **Farm Improvements**

The next step was to focus on pasture improvements. We are renovating pastures to forty percent clover, and twenty percent of each Orchard, Timothy, and Brome grasses. The increase in clover helps with the protein demands needed by dairy sheep. Fourteen permanent paddocks were created with permanent lanes. Electronet fencing is used to split the paddocks in half, resulting in 28 paddocks. This system allows us to rotational graze our sheep every 2 to 3 days. More paddocks are planned to accompany an increased number of animal units and allowing pasture rotation every day to day and a half. All of the perimeter fencing is woven wire. High tensile fencing was tried initially but did not work on our farm and proved to be an expensive mistake. We will be trying 4 strand fiber wire fencing to subdivide paddocks. Hay fields are being replanted to alfalfa.

We made some changes in our barn when converting to dairy sheep. The barn is divided into four flexible sections. The sections are adjusted for size depending on the number of animals being held in them. The four groups are pregnant ewes, milking ewes, nursing lambs and weaned lambs. To start we have all the ewes together. As they lamb the ewes and lambs are placed in 4' x 6' jugs for 3 days. After 3 days the lambs are moved to a staged nursing pen. Here they are started on bottles and advanced to a bucket and then a LacTech machine. The milking ewes are moved to a pen connected with lanes to and from the milking parlor. A fourth pen is established as lambs are weaned at 30 days or 30 lbs whichever comes last. As the population of each pen changes, the partitions are moved to accommodate the population. We lamb at the end of February and have added overhead doors and passage doors to make the building far more weather tight. We have added many electrical outlets to make heat and lighting much easier. We will be building a lamb building next spring to accommodate a larger number of lambs and to decrease the stress of the lamb and ewe upon separation.

### **Dairy Plant Design**

There were no existing dairy buildings on our property so we started with a clean slate. We believe this made the planning definitely easier and possibly less expensive. After talking to existing producers, we then determined our minimal needs for a milk parlor.

These producer conversations generated common threads that led us to design considerations that hinged on a few constructs. First, to allow for easy expansion, second, minimum labor for day to day operation, third is design in twice the storage you think you need and fourth is comfort for both animals and people. The milk parlor was built according to specifications recommended by DeLaval, the company with the milking equipment we felt would work best for us.

We then added what we wanted and what we could afford. Extra room with large, low observation windows in the parlor was desired to accommodate visitors of all ages. This would enhance the ag-tourism aspect of the farm. A pit parlor was designed to be wide enough so 3 people could easily maneuver. We elected to go with a low-line system so we could milk with a lower vacuum for better udder health and to minimize fat cell rupture and increase milk quality. A 'clean-in-place' system was installed to decrease labor. The milk parlor design allows power washing, top to bottom. A gutter system and grinder pump were built into the pit to allow quick clean-up after milking. We placed in-floor heat in all rooms, *including the pit*, taking into consideration our need to be comfortable with advancing age and that any hired help will perform better if comfortable.. To offset the cost of heat, we installed a wood fired boiler that is able to heat the two buildings and two 100 gallon water heaters. This insures sufficient hot water for pipe line cleaning, personal use and to heat and clean the cheese vat. A propane back up boiler was installed to provide automatic heat if needed. An office area was included that can be converted into a classroom, again providing opportunities for ag-tourism and classes. We put in a laundry room and bathroom, realizing how much having these amenities would save us time and make us more comfortable. The building was modular in design so we could eliminate rooms without complete redesign if our lender did not approve our business plan.

Knowing that most contractors have very little experience in constructing Ag buildings, Jeff manually drew up the original plans. We then had an architect change the plans to computer assisted drafting. We then did what we consider the most important step in the process which was to have the Food Safety Inspector and the Milk Inspector go over the plans with us and the architect. These inspectors made just a few, but significant, changes that would have been quite expensive revisions had we not consulted them first. The blueprints were complete before we ever interviewed contractors. We then presented the plans to contractors and took bids.

Even with thorough planning, and excellent communication between all the inspectors, we experienced multiple, frustrating, construction glitches. We had anticipated setbacks but not to the extent we experienced. We lost our first season to construction problems and equipment problems. We did make some decisions before breaking ground that we felt eased the process. We planned a short milking season our first milking year to decrease the stress on the sheep and to ease into the process. We didn't milk a full season until this year, our third, as our sheep now have enough dairy breed percentage to make a full season. Our goal is to milk 200 dairy ewes to allow us to make 20,000 pounds of sheep milk cheese a year and to enable us to sell some milk for cash flow.

We have had some pleasant surprises. We did not realize we would enjoy milking the sheep so much! The process has proved to be relaxing and a time to be together. Milking sheep for us

has had many unexpected advantages over milking cows. If a sheep steps on you..... Sheep flop is generally pellets vs. flop for cows. In a pit parlor this is significant!!! Milking gives you time to get to know your animals as so much time is spent with them! The sheep dairy has brought countless people to our farm. This traffic has increased our sales of cheese, eggs, poultry, produce and lamb. This type of dairy is still unique in our area and the interest is high. Many people have expressed the desire to see the family farm be present in our area as it was generations ago. Some changes in family dynamics, have resulted in us raising our grandchildren. This has meant we have found it necessary to hire a full time employee. He has proven to be our greatest asset. However, we have made multiple changes in our business plan and our goals and know it will take more time to realize the profits that were previously anticipated. The jewels to take away from this are:

**If it was easy everyone would do it!!!**  
**The key to success is the ability to implement plan “B”**  
**Stuff happens,,,,,,a lot**  
**Don’t quit your day job right away**

# **FARM MANAGEMENT DECISIONS MAKING AT IRISH CREAM SHEEP DAIRY**

**Virginia, Cody, and Bill Halligan  
Owners of Irish Cream Sheep Dairy  
Bushnell, Nebraska, USA**

## **Background**

Irish Cream Sheep Dairy was started in the spring of 2005 using the Dorset ewe flock that we had raised and been running over the past 30 years as our foundation flock. The fall of 2004 Virginia found an old magazine article and picture of Shepherds Dairy in Anselmo, NE. This one picture was the spark of the idea of a way to add a value added market to our operation and the start of more work than we thought possible, even though Virginia came from a cow dairy background; she should have known better. Much of the dairy's success has been due to the fact that our two married children and their families came back home to add labor and their valuable individual expertise to running and managing the dairy. That being said, we have been able to increase ewe numbers every year and in 2010 milked 648 head. We raise and select our own replacement ewe lambs and the balance of the lambs are fed out. This past year we have expanded our lamb sales into the Denver restaurant market. The milk is frozen and is shipped to California for yogurt. The management is the family members with hired milkers. We are located in the panhandle of western Nebraska 20 miles from Colorado and 10 from Wyoming. The elevation is 5,000 feet and the annual rainfall is 14 inches. This is what is called the high dry plains. Within 20 miles there is over 2,000 acres of irrigated alfalfa that will make 3 cuttings per year and produce excellent dairy hay.

## **Past and Current Management Decisions**

We toured Wisconsin in January of 2005 and from the research we did it was decided to convert our meat sheep operation to a sheep dairy. Our goal was set at 500 milking ewes and to sell all of the milk fluid or frozen. The lambs would be weaned during the first 2 days of birth and be raised up and marketed as in the past. We found in the first couple of years that much of the research and data that we had found didn't line up with our dairy, due to the fact, that there is a very limited amount of research in the sheep dairy industry in the United States as a whole and because we were the only sheep dairy of this size located in the center of the states, which meant our environment, climate, feed, and resources are different compared to other sheep dairies. So, by using our cow dairy background and some trial and error and a lot of our own, on the dairy, research we have been able to achieve our goals.

The parlor and pens were designed to support the initial goal and the expansion over the last six years has been made in steps. The lamb feeding the first year was limited by selling the wether lambs at 80 pounds. We have expanded the pens and feeders so we can feed the lambs to 120 pounds. Last year we had a Denver chef visit our dairy and through his contacts have expanded the sale of buck lamb carcasses into the Denver restaurant market. The decision to expand this part of the operation was done over a number of years in steps as the labor and capital were available.

The milking was done by the family the first years, but the majority of the milking has been turned over to hired help the past few years. The labor pool is very limited in our area and the labor turn over is high, however we have been fortunate to have found employees that can do a good job of milking. Milking is a constant routine that can be taught and preformed by the hired help, however, it is one of the most important jobs on the dairy and has to be done correctly and because of it's importance management checks in and monitors the milking's every day. By not having the family milk it takes a lot of pressure off time schedules. We were not able to afford all hired milkers until we reached 500 head of milking ewes.

Since the availability of dairy ewes was very limited when we started we had to build our own dairy genetic base, through breeding and selection of our ewe lamb crops. Two years ago we had achieved that goal and the decision to expand beyond the original 500 head goal was made. The pens and sheds were large enough for 700 head and the milkers were able to get all the ewes though the parlor twice a day with an 11 to 12 hour rest period for the ewes. We have a double 12 cascading parlor. We are still doing minor updates to the parlor to increase efficiency but have been lucky that no major updates were needed.

The first year we milked we shipped the milk chilled to Ft. Collins, CO. That buyer shut down, but we were able to find a buyer in California while we were at the DSANA symposium in Vermont. We had to build a freezer that winter that would hold 10 - 2000 pound pallets. This was a major expense but has worked well. We purchased a new freezer that is made with 4ft by 8 ft cammed panels. The freezer company recommended two freezer units and I think this was a good decision. Two years later production was up to where there was not enough room to freeze and store all the milk until we could build a semi load, so we doubled the size of the freezer by uncammings and adding panels (freezer is 28x38). This year we had to add a third freezer unit to the freezer due to the large amount of milk to be froze each day. (It takes about 12 hrs to freeze a 44 to 45lb bag of milk.) The freezing ability of the cooler is very important since the more chilled milk you bag the longer it takes to freeze. If you are going to freeze the milk and store the pallets in the same freezer as we do room it is very important that you have room for the pallets and freezing racks otherwise mother gets very cranky. This summer we were freezing close to 3000 pounds of milk very day and filling a truck every 2 weeks, so if any thing went wrong people got very nervous and up tight.

We were able to find a local trucking company that has freezer trailers going to California. This has been very fortunate for us since they always need back hauls to get to the coast. The lack of a good trucking service would make it much harder to get the milk shipped timely. We now ship 20 pallets (approx. 40,000 lbs) which is a full load for a semi. When we are milking at our peak we need the truck on a specific day and time or we run out of room in the cooling tank. We are looking at putting in a larger cooling tank this year to take some of the pressure off.

The herd health is handled by family members. We have not had any major health problems with the milking ewes. We vaccinate with CD prior to lambing but no other scheduled shots at this time. We try very hard to keep the ewes' environment clean and our drier climate aids in our flock health. We will use medicine if we have a ewe that is sick but don't have to treat many ewes through the year. Keep in mind that we only get 14 inches of moisture on the average and the last 6 years have been below average. We have had to cull a number of ewes for prolapsing



and belly ruptures both of which are highly heritable, possibly from outside bucks brought in since these issues arose after starting the dairy and possibly because dairy breeds are more susceptible. We feel that this is a genetic weakness in the dairy breeds being used, however we have not identified any breed or line of bucks that is any worse than the others. Our ewes are sheared once a year a month prior to lambing and poor technique on the shearers part might also have been the cause of these issues.

The health problems of the baby lambs during the first 30 days have been a different story, the past 2 years. We have been using automatic feeders to feed the lambs milk replacer for 30 days. The death loss during this 30 days has been higher than we had when the lambs were raised on ewes. We expected the death loss to be more on milk replacer but not as high as we have experienced. Two years ago we pulled the lambs off the mothers between 12 & 36 hours last year we pulled the lambs within the first 12 hrs. of birth. The lambs are fed a starter pellet and alfalfa hay at free choice from day one. Once the lambs reach 30 days they are weaned off milk and continue on dry feed in self feeders. This year we will be making some changes and making some adjustments to get that first 30 days under control. The dairy lambs do not perform as well as the meat breeds but we have been able to leave them as bucks and this helps the gain. I would caution that if you leave the lambs bucks you have to push them with a high corn ration so you have them at the sale weight before they are over 150 days old. Make sure you have a buyer that can use the bucks. Even though they are excellent tasting not all buyers can use them in their marketing plan.

We feel one of the most essential components of the sheep dairy for top production is nutrition. One of our greatest challenges the first few years was finding a nutritionist that would work with us to balance rations and make mineral and vitamin supplements. The last 2 years we have been using Hubbard Feeds they have been very helpful and are willing to learn about the dairy sheep industry. We feed a TMR ration using a vertical auger mixer. The base ration is corn silage, alfalfa, and cracked corn and a special mineral supplement and soybean meal added. All the ewes are bunk line fed.

The parlor was built the first spring when we started milking. The equipment was purchased used, from a small cow dairy. We added an electronic pulsate r controller, automated tank washer and automated line washer. The automatic washing equipment has added efficiency and more sanitary conditions to the milk barn.

### **Future Management Planning**

We do not necessarily plan on further expansion, but to continue to strive to make the dairy more efficient and cost effective while maintaining a uniform, top quality, high yielding product. A few of the areas we will be adjusting are:

- Converting from milk replacer to cows milk on our lambs.
- Spreading out the lambing season so we can be milking year round.
- Expanding our lamb market.

## MANAGEMENT PRACTICES AT OLD CHATHAM SHEEPHERDING COMPANY

**Travis Burrows and DaNay Spurge  
Old Chatham Shepherding Co.  
Old Chatham, NY**

Old Chatham Shepherding Company was started in 1993 by Tom and Nancy Clark. The farm started with 150 ewes for breeding to East Friesian Rams, the original flock has now grown to more than 1000 East Friesian crossbred ewes.

Great cheese is made from great milk, and high quality milk is produced from high quality pasture and from carefully managed and healthy animals. A staff of 2 full time and 4 part time employees, work 7 days a week milking 250 to 350 ewes twice a day from August to May. Although the facilities at the Old Chatham Shepherding Company are state of the art, the farming is done the old fashioned way, without the use of routine antibiotics or herbicides and pesticides. We are proud of our farm and welcome visitors anytime.

Decisions at Old Chatham Shepherding Company (OCSC) have changed in the last few years to make the farm more efficient and cost effective. Decisions are based on the fact that we need 90 plus gallons of fresh milk per day to produce our products. In order to have a large enough quantity of milk to produce our products we rely on other farms. In the past year we have helped 5 local farms start up and begin milking sheep to help supply us with fresh milk during the spring and summer months, as well as purchasing frozen milk from several other farms to blend with the fresh milk to meet our needs. With the large variation in frozen milk and the differences between early lactation and late lactation it is crucial to have a consistent supply of high quality fresh milk year round. This is where our farm fills in the gaps and produces more fresh milk when our other farms are beginning to dry off or are not producing at all.

With the demand for fresh milk, and the sheep milk industry growing another goal for OCSC is to raise and supply high quality milking ewes and rams to farms interested in expanding their operations or just starting out in the milking industry.

To keep up with the need for more sheep milk as well as the need for breeding stock we have made new management changes to aid in the our operations. Some of the changes have been in breeding, lamb raising/weaning, and genetic selections of our ewes.

### **Breeding**

At OCSC breeding takes place out of season. Due to the supply of local fresh milk during the normal sheep milking season (February- October) our farm is required to breed ewes to lamb when most others are drying off. Our breeding season takes place starting in March and goes through July. We use a combination of Light treatment and CIDRs to get our ewes to cycle. We are now focusing on milking only from the months of August to May when fresh milk supply is limited. The other months of the year we are focused on making feed and raising replacement breeding stock as replacements or to sell.

For the ewes that are not milking at the time of breeding, CIDRs are used to get them pregnant. CIDRs are placed in the ewe for 7-14 days. At the time of the removal of the CIDR the ewes are given a dose of PMSG or PG 600 causing them to ovulate. Once the CIDR is pulled the ewes are then placed in small groups with selected rams and usually cycle and breed within 36-72 hrs after the CIDR is removed. This protocol resulted in a 92 % conception rate with large twins and triplets. We have noticed a higher number of lambs per ewes and all ewes lambed within 24 hrs of each other. Using the CIDRs has really allowed us to tighten our lambing time as well as predict milk production more accurately.

The process of breeding milking ewes as well as our yearlings, takes place while our ewes are being milked. We follow the light treatment protocol, which exposes the ewes to 20 hrs of light per day for 3 months. This process starts November 1 and the lights are then turned off February 1. The ewes are exposed to natural light to simulate the short day length. After 2 month of natural light the ewes are then introduced to our highest valued rams in large numbers. The combination of the light treatment as well as the “Ram Effect” causes the ewes to cycle and breed resulting in pregnant ewes that are due in September. We have an 85% conception rate and most ewes are bred on their second heat cycle bringing the lambing into an 18 to 21 day period. As for the lambs resulting from this breeding program, they are all sold because we do not know the fathers of these lambs. Our replacements come from our Ewes that we used CIDRs on. Between these 2 methods of breeding we usually have 300 plus ewes bred between September and October.

## **Genetics Selection**

Genetic selection is a slow process. Over the past few years we have been selecting ewes for one trait only. This was total milk yield. Through metering our ewes monthly and good record keeping we have improved our ewes overall milk production. Our flock is now averaging 800 to 1000lb lactations for ewes on their second lactation. With the help of Cornell University we have incorporated the EBV software into our own database. The EBV software helps us evaluate our sheep based on milk production. The EBV program uses information from our database including, family history, total milk yields, and metering data. The EBV data is a basis for most breeding decisions. Now that we have our milk production to this level we are now selecting on other traits. Our focus has turned to the udders for shape, teat length and placement as well as how quickly they milk out. The ideal udder for our milking system with automatic take off is a high tight to the body udder with teats pointing down with teats about an inch long. The udder should be able to be milked out in a minute or two. Other traits we are looking at are attitude in the parlor and how quickly they breed back. Ewes need to come into the parlor and stand there. With the large numbers of ewes on the farm and many new replacements coming in it has given us the opportunity to be very selective with our ewes and it is proving to be a very effective way of improving the flock.

Since our company produces products like cheese and yogurt, we have recently been working with Cornell University students to work on and monitor the components of our milk. Each batch of cheese and each load of milk is tested for, pH, Somatic cell, fat content and protein. All of this information is compiled in a database with the goal to maximize production based on the components in the milk. We also use this information to back track if a product is outstanding or

poor. The information on the milk can help us recreate a product or prevent future problems. For right now only the bulk tanks are tested for components but in the near future we will start testing every one of our ewes for components bi-monthly with the goal to select ewes that will be ideal for cheese making.

## **Milking**

As we all know all good products come from good milk. The quality of our milk starts in the barn; our milking pens are bedded regularly with straw and cleaned every 4-6 weeks to keep our sheep clean and dry.

When entering the parlor for the first time each ewe is marked with a colored piece of tape that corresponds to a date when they entered the parlor/lambled. Colostrum is milked out and the ewes' udder is evaluated. A decision is made whether we will keep her or cull her based on her udder conformation. If she makes it into the parlor a C.M.T test is performed the ewe. If an ewe is tested negative her tape is removed, and if she is positive a sample is taken and sent to Quality milk for pathogen testing. We will check her somatic cell as well and if she is low we will continue to milk her until the test results are back. However on the rare occasion that the ewe has a high somatic cell we will put a do not milk band on her and continue to hand milk her until her cell count goes down or the results come back. Once the results are in we decide the proper action to take to correct the problem. The bulk tank is monitored weekly to see if there are changes in the milk. This gives us an early detection for any problems may be starting in the flock.

When it comes to milking, we try to take every precaution to keep the sheep healthy and producing the highest quality milk. Each sheep in the parlor is stripped every milking to check for any signs of a problem. Following the stripping each ewe is then pre-dipped. The pre-dip is allowed to sit on the teats for 1 min to disinfect. After 1 minute each teat is the wiped with an individual paper towel. Once the udders are clean milking takes place using our automatic take off system to prevent over milking of the udders. Milking usually takes 15-18 minute with 2 people to milk 48 ewes. Milking time is kept to a minimum to prevent over milking and injury to the sheep. After milking and before the ewes leave the parlor they are post-dipped with a thick long lasting teat dip. To allow for maximum effectiveness of the teat dip a fresh ration is fed to the ewes in their pens to keep the ewes standing for 30 min to allow their teat ends to close and a barrier to form from the teat dip. At the end of their lactation each ewe is given a dry cow treatment to help prevent/fix and infection in the udder to prepare them for the next lactation. Following these practices keeps our somatic cell counts low and very little mastitis is seen in our milking flock.

Other recent changes that we have made in the past few years was the decision to use long day lighting and 16 hr milking periods ( *Effects of Milking Interval on Alveolar Versus Cisternal Milk Accumulation and Milk Production and Composition in Dairy Ewes*. B.C. McKusick, D.L, Thomas, Y.M. Berger and P.G. Marnet) towards the end on the lactation period. Long day lighting begins in late September and continues until light treatment begins November 1. Lights are on in the barn for 16 hours to help eliminate the ewes wanting to dry off to breed. The lights not only help keep ewes in milk that lambled earlier in the year but we have seen increases in the

days of milk in ewes that freshen in the fall. We have seen that ewes that lamb in the fall are reaching their maximum milk production normally but maintaining that high level of production while the lights are on. Compared to former years when the ewes would begin to dry off in late December they are now milking well into the spring. The second change that we made to aid in milking was going to 16 hrs between milkings towards the last few months of milking. Doing this maximized the udder of the ewes and reduces labor costs and costs in the parlor. We would milk at 6:00am, 10:00pm and then the following day at 2:00pm. Switching to the 16hrs had no change on the quantity or quality of our milk. The sheep only took a few days to adjust to not coming into the parlor 2 times a day but there yields never dropped. The time between milk shifts is much longer which allowed us to get more done on the farm during the day. The only downfall was the milking hours and finding people to milk them. However the savings in parlor supplies and labor makes working the strange hours worthwhile.

### **Lamb Raising**

Basically there are three different weaning techniques used in the dairy sheep industry. At OCSC we raise all of our lambs completely artificially. In the past and many sheep farms still do this, when a lamb is born the lambs and their mothers are placed in a small pen or lambing jug. This is done to allow the lambs to suckle and receive colostrums from the ewe. We have eliminated this step by removing the lambs before they have the chance to suckle on their mothers. However the occasional lamb does, if it is born late at night. As soon as a lamb is born it is removed from the ewe and placed in a box with its siblings. The lamb's navels are dipped and the boxes are labeled with their mother's number. The ewe is then milked out to get the colostrums to feed to the lambs. This method also gives us the opportunity to evaluate the ewes before placing them into the milking flock. The lambs are then fed colostrums two to three times within the first 12 hours. Having them isolated in boxes allows us to ensure that every lamb get enough colostrum. The lambs are in the boxes for two days or until they are nursing from a bottle well. Once we decide they are eating well the lambs are tagged with a flock ID and their tails are docked. After leaving their boxes in the office they are moved to our green house where they are offered free choice hay, grain and water along with two feedings of milk for approximately 30 to 35 days. At day 35 the lambs are off milk vaccinated and placed in pens according to age and given free choice hay and grain for up to 5 months of age. The lambs then graduate to fresh pasture or haylage depending on the time of year. Switching to this method has resulted in healthier lamb crops with very little loss. They are growing so well that we are seeing heat cycles at 4 to 5 month of age. We are breeding at a younger age and they are entering the parlor with great udders and high volumes of milk.

To wrap up, many changes have been made to the farm to hopefully help move the Sheep milking industry forward. Our farm has seen a dramatic increase in production as well as decreased cost by making minor changes in our protocols. Even though our farm in milking while most others have dried off applying these changes can be applied to any farm milking any time of the year.

## **DAIRY SHEEP FEEDING 101**

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### **Basic Diet Composition**

The formulation of diets for any animal is based on balancing the nutritional requirements for the animal at various stages of production with the nutritional components of feeds offered and ultimately consumed. When producers provide a feed-stuff, or an 'as-fed' feed, it will contain the nutrients that the animal needs, including protein, energy, fiber, vitamins and minerals. However, these nutrients are only available in the dry matter (DM) portion of a feed; the remainder is simply water.

### **Dry Matter Intake**

A ewe's requirement for daily intake is based on her body size and level of production. Knowing that she only acquires nutrients in the DM portion of the feed, she will adjust daily feed intake to meet her dry matter intake (DMI) requirements, and potentially her nutritional requirements.

Previous authors have suggested that dairy ewes can consume 4 to 6 % of their body weight (BW) in DM per day. Avondo and Lutri (2004) presented data of various breeds with weights of 93 to 165 lb and milk production levels of 2.4 to 4.4 lb/d. However, dairy ewes in North America can average over 200 lb and produce up to 6.5 lb/d. In a confinement feeding trial at the Spooner Station, intake levels between 3.2 and 3.9 % of BW for ewes producing 5.3 to 5.7 lb/d (Mikolayunas-Sandroek et al., 2009). In a feeding trial with lactating ewes consuming clipped, fresh forage, ewes in mid-lactation (average 104 DIM and producing an average of 5.2 lb milk/d) consumed 6.1 to 6.2 lb DM/d, or 3.16% of their body weight (Mikolayunas et al., 2010). Therefore, ewes in early lactating may consume 4% of their BW/d, but DMI will reach near 3.5% of BW by mid-lactation. One explanation for this variation across data sets is that large ewes may eat less DM (as % of BW) due to the increased size of their rumen, which can hold feed longer and extract more nutrients per lb DM than smaller ruminants.

Based on an average level of intake of 3.7% BW, a "typical" dairy ewe weighing 200 lb may consume 7.4 lb DM/d. Based on this level of intake, she would need to consume 49 lb of fresh pasture (at 15% DM), 14.6 lb silage (at 50 % DM) or 8.3 lb dry hay (at 88% DM). Due to the high water content of pasture and the size of a ewe's rumen, she may have a hard time eating such a quantity of pasture. Only if pasture availability is high would this ewe be able to consume enough DM from pasture.

## Energy

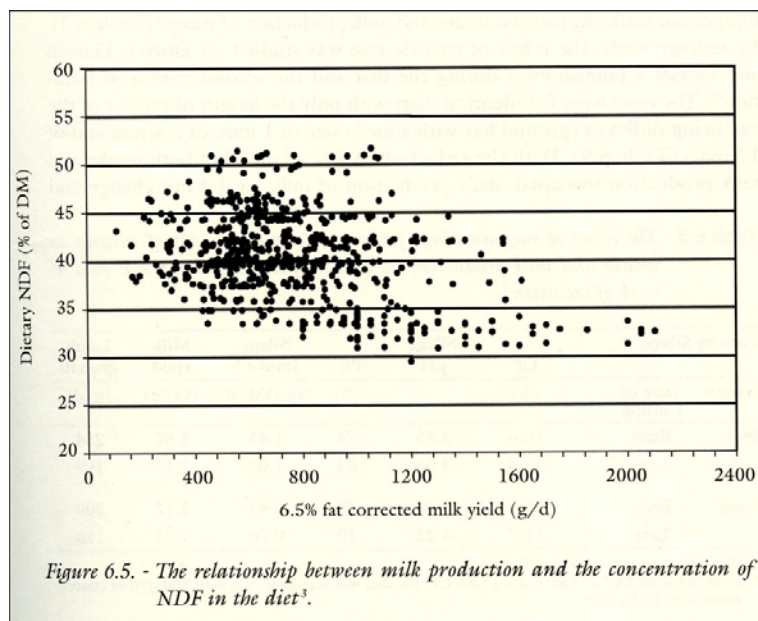
According to the Small Ruminant Nutrition System (2006), a 200 lb ewe with a milk production level of 5.68 lb/d (5.5% fat and 4.8 % protein) has an energy requirement of about 2 times maintenance requirements or 3.5 Mcal/d for maintenance and 3.7 Mcal/d for lactation.

Energy for ruminants comes primarily from two types of carbohydrates, fibrous carbohydrates (measured as neutral detergent fiber or NDF) and non-fiber carbohydrates (NFC). Both sources are fermented in the rumen primarily to produce energy for microbial growth. In the process, fermentation by-products are released, including methane, carbon dioxide, heat and volatile fatty acids. The volatile fatty acids (VFA) released include acetate, butyrate and propionate, which are absorbed across the rumen wall and used by the ruminant for muscle growth, adipose tissue formation, and lactation.

**Fiber.** Fibrous carbohydrates (fiber, NDF) contain cellulose and hemicellulose and are bound to lignin in plant cell walls. The fiber particles contribute to rumen health by stimulating chewing action and saliva production by the ruminant. Saliva contains sodium bicarbonate, which helps to maintain a neutral rumen pH for rumen microbes. The slow fermentation of fibrous carbohydrates stimulates the production of acetic acid, a precursor of milk fat. A reduction in dietary fiber is associated with a decrease in rumen health and a depression in milk fat. If dietary NDF levels are too high, this can have a negative impact on DMI and thus milk yield.

In lactating dairy ewes, data from 621 ewes were collected over ten feeding trials (Avondo and Cannas, 2001). The results, presented in Figure 1, indicate that milk yield increases as dietary NDF decreases. Dry matter intake was maximized at NDF levels of 37% of DM. Thus, the recommended level of NDF in the diet of lactating ewes is 33 to 41% of DM (Table 1).

**Figure 1. The relationship between milk production and NDF concentration in the diet (Cannas, 2002).**



**Table 1. Optimum concentrations of NDF, CP and NFC depending on production level of the sheep (Cannas, 2002).**

Nutrient (% of DM)	Production level of 6.5% fat corrected milk yield (lb/d)				
	1.1-1.8	1.8-2.4	2.4-3.1	3.1-3.7	3.7-5.0
NDF	45	44	41	38	33
CP	15	15.5	16	16.5	17
NFC	28	28	31	33	38

While there are specific recommendations for fiber particle size for lactating dairy cows, these recommendations cannot be broadly applied to sheep. Diets which contain too many long fiber particles limit intake due to their fill effect. There is a limit to the amount of time that ewes will spend ruminating each day (10 hr/d). Chopping or grinding feed is one way to increase DMI in sheep.

**Non-fiber carbohydrates.** Non-fiber carbohydrates (NFC), including simple sugars and starch, ferment quickly in the rumen. These sugars provide an energy source for microbial growth. Since their fermentation is nearly complete, NFC yields more VFA than NDF carbohydrates. The fermentation of dietary NFC promotes the production of propionic acid, an important precursor of milk lactose. Since lactose is the main osmole in milk, the amount of lactose produced is closely related to the amount of milk produced. In dairy ewes, lactose levels average 4.8%. Recommended NFC levels are indicated in Table 1. If NFC levels are too low, then DM intake, fiber digestion, and milk yield may be limited. If NFC levels are too high, the large increase in VFA will contribute to rumen acidosis and decreased intake and milk production. In addition, high NFC may contribute to body fat deposition in late lactation ewes due to hormonal regulation and energy partitioning (Cannas, 2002).

The type and level of carbohydrates affect the growth of rumen microbes, which are the main sources of protein for ruminants and the production of VFA. Therefore, the levels of these two energy sources must be closely monitored to avoid health problems and limits to production. Based on typical energy levels in pasture forage (NRC, 2007), Table 2 indicates that while NDF levels may be adequate, forages alone cannot provide adequate NFC to meet the needs of high producing dairy ewes. Grain supplements such as corn and barley can provide supplemental NFC to a forage-based diet.

**Table 2. Nutrient content of common feedstuffs.**

Nutrient	Grass	Mixed	Legume	Corn	Barley	Soybean Meal
	Pasture	Pasture	Pasture			
NDF	50	44	38	10	18	15
NFC	18	18	23	76	64	28
CP	19	23	25	9	13	48

(Compiled from Combs, 1999 and NRC, 2007)

### Protein

In addition to energy requirements, lactating ewes require protein to produce protein-rich milk. Protein is made up of amino acids, which are essential for tissue and wool growth, milk production, and gluconeogenesis. Ruminant requirements for amino acids may be supplied



either by dietary protein which escapes rumen degradation (RUP) or by microbial protein synthesized from rumen degraded dietary protein (RDP) or non-protein nitrogen. Microbial protein can account for 60% of the protein reaching the small intestine and is abundant in essential amino acids (Wattiaux, 1999). Therefore, maintaining a healthy rumen environment supports rumen microbial growth and supplies protein to the host sheep. Table 1 indicates that high producing ewes require a diet of 16-17% crude protein (CP).

## **Feed Testing**

How do your own feeds compare? Many states have one or more forage testing labs. For a relatively low price (around \$15-\$20 per sample), the lab will analyze your feeds for DM, NDF, CP, NFC, vitamins and minerals.

To take a pasture sample (adapted from West Virginia University Extension Service, 2003):

In order to mimic what the sheep are eating, take the sample right before the sheep enter the pasture. Walk throughout the field and collect 30 to 40 small “grab” samples by reaching down and grabbing a section of forage. Samples should represent what the sheep are eating, go grab the forage at a height of 4 inches above the soil surface. Don’t grab weeds that the sheep would avoid. In order to avoid over-sampling the good forage, walk in a specific pattern throughout the field, grabbing samples at a set number of paces.

Additional information may help to determine forage availability and quality. In order to estimate forage dry matter availability, measure the height of the forage canopy using a ruler. You may also want to note the date the sample was taken and the number of days since ewes were in the pasture.

Once the sample has been collected, mix the forages and place a subset of the sample into a plastic bag. Remove all of the air and place in the freezer as soon as possible. Freezing reduces protein breakdown and loss of nonstructural carbohydrates due to respiration. You can deliver this sample to a local forage lab or send the sample on ice. Samples may also be dried before sending in the mail by placing the sample on a window screen next to a breezy window. Turn the sample often to reduce spoilage. Place dried sample in plastic bag for shipment.

To take a hay sample (adapted from National Forage Testing Association recommendations):

Using a hay corer (available via your local extension office or feedmill), take 20 core samples from random locations throughout the hay stack.

To take a haylage sample:

Baled haylage may be sampled similar to hay, using a hay corer. Haylage stored in a silo may be sampled via grab samples after removing the outer silage. Take 15- 20 random grab samples from the feed bunk or feed wagon.

For more information and a list of local testing labs, visit the National Forage Testing Association Website (<http://www.foragetesting.org>).

## Ration Balancing

So, now what? In order to balance your own ration, you can create a spreadsheet by hand or using a computer program (ex: Excel). Table 3 gives an example calculation. Example 175 lb ewe producing 4 lb of milk/d. Her requirements include the following:

- Dry Matter = 175 lb body weight \* 3.75% of body weight = 175 \* 0.0375 = 6.6 lb DM/d
- NDF = 33-35 % of DM
- CP = 16-17% of DM

Feed	# As-fed	DM %	# DM Fed	NDF %	NDF Fed	CP%	CP Fed
Alfalfa Hay	5.3	90	4.8	43	2.3	18	0.95
Corn	2	90	1.8	9	0.18	9	0.18
Total	7		6.6		2.46		1.13
					= 2.46/6.6		= 1.13/6.6
					= <b>37%</b>		= <b>17%</b>

The next step is to check the ration for NFC, vitamins, and minerals (especially calcium and phosphorus).

In addition, you can use ration balancing software. The most relevant program, the Small Ruminant Nutrition Calculator, is available for free at the following website:

<http://nutritionmodels.tamu.edu/srns.htm>. In this program, you can use example feeds or insert analyses from your own feeds.

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## **RAISING DAIRY LAMBS TRIALS AND TRIBULATIONS OF DREAM VALLEY FARM**

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This paper is a summary of our experiences in raising lambs with a focus on the past four years. During this time period we went from implementing a mixed weaning system to weaning all ewes at two-three days. This included significant improvements in facilities, investments in automated milk replacers and setting up work flow systems to improve consistencies in how ewes and lambs are managed throughout the year. This paper includes topics that we find are critical to raising lambs and dairy sheep profitability.

### **Ewe Health**

We have seen the importance of maintaining excellent flock health and assuring very good body condition as the ewes transition from milking to lambing. This begins around August 1 with de-worming using Safeguard, as they are still milking. A vasectomized ram is also introduced to help synchronize their estrus. The ewes are on high quality pasture during this time, and still receive 1 pound of shell corn daily in the parlor. Their body condition has usually declined since the previous winter but is quite recoverable before lambing again. The fertile rams are introduced 15 days later, at about 80 ewes per ram. When milking stops around the first of October, the ewes will be strictly grazing on nice autumn pastures – assuming weather conditions have provided for this. At all times, the ewes have free choice access to a high quality sheep mineral mix and fresh water. After the first hard freeze, they are de-wormed with Cydectin to avoid parasite adaptation of resistance. We are moving toward the use of more organic inputs, having found a source of organic hay and a local lead on organic grains. There seems to be an increasing body of research linking chemicals and GMOs to reduced animal health. De-worming is a challenge that can be partially managed with smart grazing techniques yet we will need to find alternative sources of parasite control, especially for the younger animals.

Shearing takes place in late November or early December, to allow for some wool re-growth before the coldest part of winter. The same day they receive their booster of Covexin 8, and 3 ml BOSE to assure good selenium levels, which prevents ring womb and assists with lambing. At shearing time, the ewes are re-started on 1 pound per day of shell corn. Good nutrition is essential for the ewe, especially at this time. By now they are on good quality hay or haylage.

Upon shearing, the flock is moved to their space in and outside of the lambing barn. They stay on the same feed regimen, with hay and grain fed in the pens outside of the barn. They are now shut inside the barn each night, which makes lambing management more efficient. Most ewes do seek out the comfortable shelter of the barn to lamb. Shutting them in at night offers several advantages: it helps the flock to stay warmer during those cold nights, which means lambs born at night will have a better chance of making it until we check again in the morning, it

allows for easier identification and segregation of ewes and their lambs, and it allows us to sleep at night, rather than needing to be out there at all hours.

We have found that shearing too close to lambing in the winter seems to link to higher incidents of ruptured abdominal walls and vaginal prolapses.

## **Birthing**

As indicated earlier, ewes are locked in the barn at night beginning 10 days pre-estimated date of first lambs due. Tom does the first check in the morning between 4:30 and 5:00 am. Laurel and the rest of the farm help come at 6:00 am. Morning chores are often completed by 9:30 – 10:00 except for the weeks of heaviest lambing. A noon check is done by Tom. Our hired farm help arrives about 4pm for afternoon chores and working with new lambs. Laurel does a night check between 9:30 and 10:00 pm. If during either of night or early morning checks, lambing activity is heavy or problems are encountered, we can call on the two-way radio for help. It is vitally important for both of us to maintain our health and wellness during this time period. We plan for good meals, Tom plans for naps during the day, Laurel naps between dinner and the evening check.

We don't separate ewes into lambing pens before they lamb unless the ewe is showing signs of stress, has been showing signs of lambing without results, or the ewe has some special needs. If a ewe is separated into a lambing pen, she'll get a heat lamp in her pen for her comfort and the lambs if she should lamb when we're not out there. Newly lambed ewes, especially those who have had a challenging birthing process receive a pail of warm water as soon as they are done lambing. We don't want them to become chilled.

We allow the "grandmothers" to assist in licking off the lambs. This gets lambs dry, up and moving more quickly in especially the cold weather. Lambs can move around under the ewes and stay warm. If they get a few slurps off of another ewe, this doesn't seem to matter. This is especially helpful if the mom has more than two lambs. Occasionally a lamb gets laid on by not being separated from the flock. We are willing to sacrifice a few lambs to assure that we get the sleep we need to sustain ourselves. Lambing is much more fun when we're healthy and relatively well-rested.

Lambs stay with their moms in a jug for two days to allow for sufficient colostrum intake. Navels are dipped with Triiodine, ears are tagged with metal permanent farm ID tags (ewes left, rams right). Ewe lambs docked (3-4 inches). Rams left whole and not docked. We use marking paint to note which lambs are singles, twins, triplets, quads or quintuplets.

We typically do not tube lambs at birth. Lambs are tubed with ewe's colostrum when the air temperature is exceptionally cold, when a lamb is slightly chilled and looks like it needs a boost, all quads and quintuplets, and when we need to get to bed and want to be sure the lambs have what they need until the next check. Colostrum is milked out and frozen from high producing ewes that have more than their lambs are using. This is saved to support lambs from yearlings who may not have sufficient colostrum or to supplement these lambs because the yearling colostrum doesn't have as many antibodies as the older ewes.

Super chilled lambs can be challenging to revive. As of yet, we've not used the injection of glucose into the navel as a treatment --- perhaps we'll try it this year. A super chilled lamb has a very cold mouth, is very stiff and lethargic. We've had success using the following methods. With the heated nursery, we have a place that lambs can receive direct heat from the floor and with a heat lamp. We also have a few large heavy plastic storage containers that serve as a warm, draft-free space for lambs to warm up. Rub the lamb down with dry towels trying to replicate the vigorous massage that the ewes provide in stimulating the lamb.

Another option is to give the lamb a warm-water bath and massage to assist with elevating the body temperature. When the mouth is warm and an ever so slight sucking reflex begins (when a finger is slipped into the mouth) tube the lamb with 3-4 ounces of warm colostrum and a small amount of NutriDrench. When lamb starts to cry, the lamb goes back to mom, or we may just start it on bottle feeding fresh colostrum. This will depend on the number of lambs the ewe has and the vigor of the lamb. We are also trying to assure that the ewes are getting sufficiently milked out by the lambs so we don't have milking and udder problems later on.

If we have a lamb that is just not thriving with the colostrum, we've started using the California Mastitis Test (CMT) in the lambing barn to determine if the ewe has mastitis. If this is a problem, the lambs get supplement and the ewe gets treated with organic product. We have not been using this product long enough to tell if it really helps or not in treating mastitis. At this point the results seem mixed but are better than using antibiotic mastitis treatment with the added advantage that with organic treatments, we do not have to worry about inhibitor problems. Milk withhold is determined by the CMT or somatic cell lab results.

## **Artificial Feeding**

Our lamb nursery is a room approximately 22 feet x 24 feet, with an adjacent work room of 8 feet x 22 feet. Construction consists of a hydronically heated concrete floor, treated lumber and steel liner panels, fluorescent lighting, a circulating and exhaust fan, two slide-by windows, and sufficient electrical and water supply for 4 milk replacer machines. We create the lamb pens using cut-off hog panels so they are easy to step over. The room allows for 6 or 7 pens capable of handling about 20 lambs each. The floor is concrete and offers no absorbency, so the pens are lightly bedded with straw and cleaned daily.

The exhaust fan and circulating fans run constantly through the lambing season. We also keep the windows cracked open, even during the coldest nights. Because the floor is heated, the lambs stay plenty warm.

There is a work aisle down the middle of the room. Last year we used 2 machines to feed the four pens along one side of the room, and will be adding a third machine for the other pens this year. After a couple of years hand mixing and hauling milk replacer to the lambs in pails, we are completely sold on the work-saving efficiency and constant quality of milk supplied by these machines. They are relatively low tech, but also not very expensive. All of our automatic feeders and nipple pails are rigged with the same nipple, so the lambs never have to adjust to something different.

## **Transition of Lambs from Ewe to Milk Replacer**

During morning chores, the ewes that and lambs that are to be separated are marked and put in a holding pen until afternoon chores. The ewes have a unique color on their tails, so they can be easily identified in the parlor for CMT testing. Lambs are removed from the ewe at the start of afternoon chores to the nursery and receive no milk until the next morning. The ewes are taken to the milking parlor and join the flock for evening milking. Up to fifteen lambs are placed in a pen. If we have weaker lambs at birth or smaller lambs from multiple births, we often have a small pen in the nursery to give them a bit of extra attention.

The next morning, milk replacer is mixed (sometime with ewe's milk if there is frozen milk available) and put in a bucket with multiple nipples. Buckets and nipples situation requires lambs to suck up through a tube from the start. We've found that this saves on our time and that the lambs continue to have to work for their food making the transition through each stage of artificial feeding. Lambs are offered the nipples on the buckets and marked with a chalk marker when they have eaten. When a lamb has three chalk marks on their backs (usually by the second morning in the nursery) they are transferred to another pen in the nursery with an automatic milk replacer machine.

After about 7 days in the nursery, when we're certain that the lambs are adjusted to the milk machine, the lambs are transferred into larger pens in the unheated barn. Each of these pens accommodates about 70 lambs, and is supplied by one machine with 6 nipples. These machines are located inside of insulated plywood boxes about 5 ft wide x 4 ft deep x 3 ft tall. There are two machines in each of two boxes, serving four pens. These lambs also have free choice access to a 20% protein creep mix consisting mainly of soybean meal and corn fed out of hanging chicken feeders. We keep these pens freshly bedded and use some barn lime to help control odors and bacteria. Each morning and evening all of the lambs are gotten up and forced to move around. Lambs that look a bit off are taken to the milk machine and strongly encouraged to get a good drink. They are marked with orange paint for observation. They may be given some NutriDrench and/or probiotic paste and their numbers written down on one of the white boards as lambs to be watched. Each pen in the barn has an assigned number written on the wall so lambs can be located for observation by the next shift of staff.

The lamb's temperature is also taken. If they have a fever, they are treated with an antibiotic and may be put into a sick pen, depending upon how sick the lamb is. Antibiotic is given for three days morning and night with probiotic paste. Lambs that are treated are also written down in the farm health log (three ring binder).

At 28 to 30 days of age, or 25 to 30 pounds, the lambs are weaned from milk replacer. We do this by turning off the milk replacer to the machine, and allowing the lambs to suck only water for 1 or 2 days. They still have free choice creep ration and water in pails. It is important that they do not have hay during this transition time, as some will eat only hay, which will leave them short of their requirement for protein and energy. In the past we have tried a gradual weaning by turning off the machine half of each day. This doesn't work for us because the lambs hoard when the machine is back on, and some will drink too much, causing bloat.

Depending on weather conditions, the backlog of lambs in the barn, etc., the lambs that are doing well on feed, hay, water, and mineral will be moved to larger pens located away from the barns. Each pen has a freeze-proof waterer and is set up with a 1000 pound turkey feeder for grain and a bunk feeder for hay, along with a rotating mineral feeder. Access to all of these is free choice.

When they reach about 45 to 50 pounds, the market rams are sold, and the others are switched to a slightly lower protein (15%) and higher fiber grain ration. At roughly 75 pounds, the ram lambs remaining – which are either selected as breeding rams or will be processed locally for our freezer, are separated from the ewe lambs. The rams continue to grow out on the grain and hay regimen, and the ewes are started on hay and/or pasture rotation. The ewe lambs are de-wormed with Valbazen.

### **Journey of Lambing Methods and Results**

Each year of lambing and milking presents new challenges, some successes and, usually something that totally takes us by surprise. We maintain breeding, lambing, general health, and milk production records. The record keeping takes time, but provides valuable information in being able to see a full picture of what is happening within our flock. Our goal, as with most producers, is to be profitable. The records have helped our operation to reach this goal.

Throughout the season, communication between all farm staff is essential. White boards and markers are set up in each of the barns, the nursery, the milking parlor, the nursery milk house, etc. A three-ring binder is kept in the lambing barn to track all health treatments, unusual occurrences, deaths, etc. Lambing books track all abortions, births, birthing and weaning dates, identification, lamb sires, etc. Notepads on clipboards are available for whatever. All staff are expected to leave messages on the white boards at the end of their shifts for the next shift. These messages can include who to watch for what, what treatments were given and need to be given, temperatures taken, etc. Lead staff are instructed on taking temperatures, giving medications, organic treatments, etc.

We have changed our lamb rearing process significantly over the past four years and decided to go back and review the data for this symposium to see if the data bear out any of the conclusions we think we're seeing. About every three to four years, we take a farm planning retreat to develop a three-five year plan for our farm. At our most recent retreat (about five years ago) we decided that if we were to continue in the sheep dairy business we needed to improve the profitability significantly, reduce our labor, and reduce our stress. This resulted in the decision to build the new lambing barn and nursery. The following information tracks that process in terms of lambing process, lamb survival, and milk production.

Our lambing situation up through 2006 was to lamb in a very old barn with an attached hoop barn. Lambs were typically kept with their mothers until about 15 days at which time they were put on a mixed system of weaning (with the ewes during the day, separated at night) until full weaning at about 30 days. This worked to keep lambs alive early, but there were certainly some losses at weaning for those lambs that didn't transition to grain well. Also, this resulted in

significant mastitis in the ewes that held back milk for their lambs and resulted significant loss of milk for sale. The milk that was for sale was lower in protein and especially butterfat.

In 2007, we attempted early weaning only without having a warm facility and ongoing free choice milk replacer available to the lambs; we experienced significant lamb loss because of engorging, piling up to stay warm, and lack of thriftiness. It was very disheartening to see these beautiful lambs die because we couldn't properly take care of them.

In December 2008, we began construction of the new barn. As things go, the barn was not completed before lambing began. The nursery didn't have a floor (sand), the fans weren't installed, and the heat was provided by a propane heater... not the best of situations. Needless to say, our first year in the new barn provided a significant learning curve. All lambs were fed on buckets which required significant labor. Again, the engorging continued because milk would either run out or freeze in the pails. The sand floor was difficult to keep clean and absorbed the urine. Without the proper ventilation, we had some pneumonia problems. Also the weaned lambs were housed in the old barn which seems to host and sustain a myriad of disease microbes just waiting for the lambs to arrive. In addition, with the grading done to accommodate the new barn, the old barn became a collection point for the mid-winter melt. We suddenly found our lambs navigating six inches of water in their living space.

To add more difficulty to the 2008 season, during the six weeks prior to lambing and up through mid-lambing, the ewes had received poorer quality hay than what we would typically feed. This problem was equally shared by our hay supplier who had difficulty getting good hay bailed and by us not having the feed tested early on and managing that closely. Focus on the building construction took focus off the ewe health which overall resulted in a less than profitable milking season. The poor nutrition resulted in a very low lambing rate. We suspect that many embryos were absorbed as the ewes attempted to survive on the poor quality hay. Also, the ewes were sheared too close to lambing and we were hit with a long stretch of below zero weather.

By the 2009 lambing season, the nursery floor and heating were in place, however, the ventilation was still incomplete and we didn't have automated milk machines in place. We were using wood chips to bed which seemed to increase the ammonia build up rather than reduce it. Lambs were still engorging somewhat because the milk pails were filled morning and night. The milk would get pretty cold and lambs wouldn't drink it. Also, there was some variability in how staff were mixing the milk.

This was also the year of the bloating explosion many of us experienced. Something else was going on in the flock this year as we experienced more adult ewe deaths, lamb birth defects and several cases of identified cancers in the ewes. This is a mystery to us...perhaps some toxic exposure that we'll never know of.

2010 was by far our most successful year. Tom paid acute attention to ewe nutrition throughout the season. Forage was tested and fed according to ewe condition and needs. Grain rations were adjusted to meet the ewe's needs by adding pelleted concentrates to assure sufficient proteins, carbohydrates and supplements were being received by the ewes. Ewes were in good

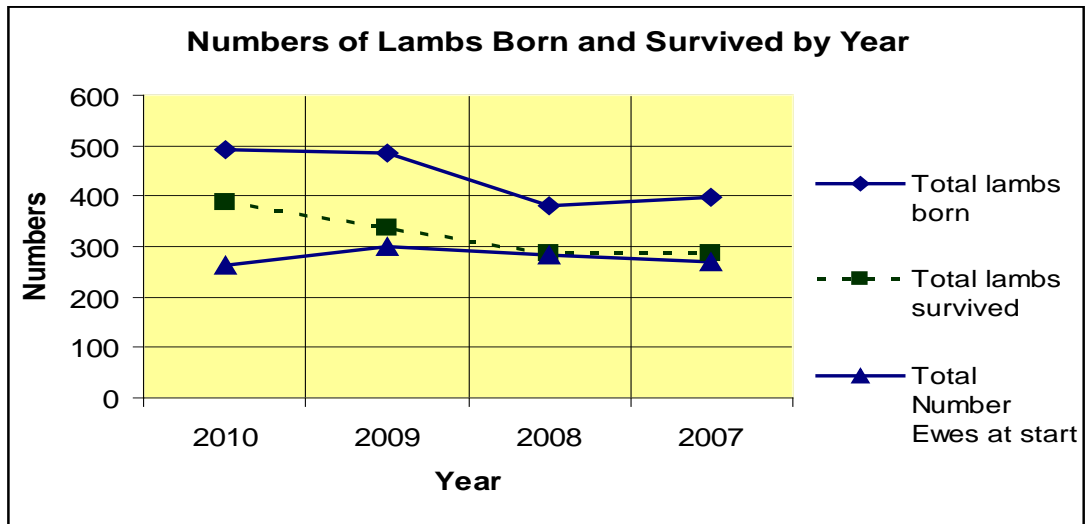


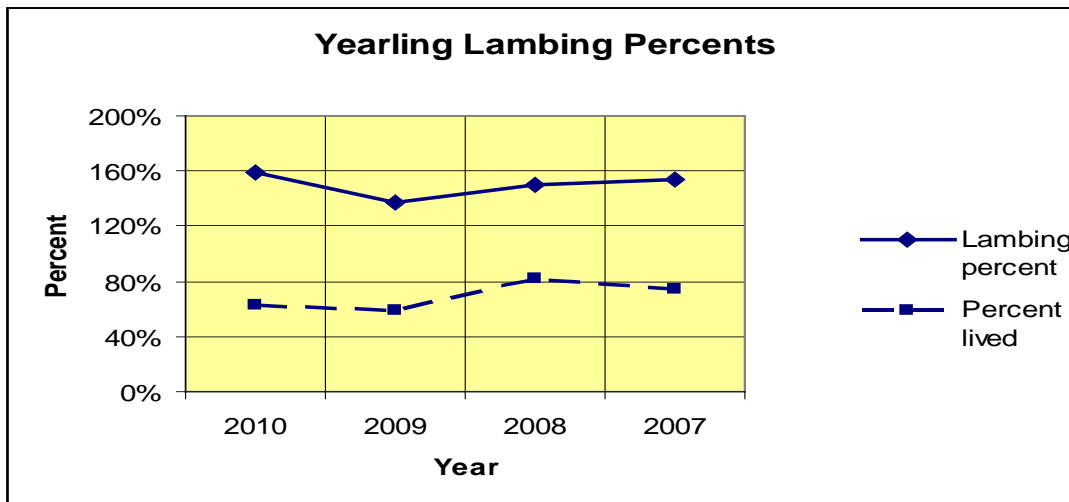
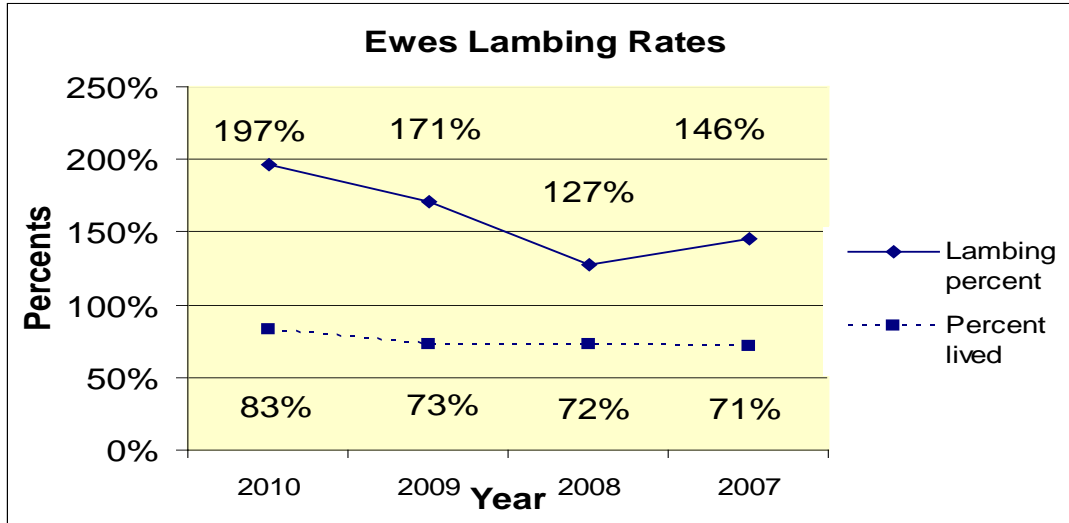
condition coming into lambing, calm and had about a one-inch growth of wool. We experienced no ruptured abdominal walls and very few prolapses.

Lambs were very vigorous at birth and adjusted to the milk replacer relatively well. We had two automatic milk replacer machines in the nursery and four in the new barn which was set up for receiving the lambs. The old barn was used minimally this year and we have plans to take it down yet this fall. We saw a shift in lamb deaths from the earlier times to later in the season --- many were three to four months old at death. This suggests several things to pay attention to next year: better parasite control, and closer attention to the ration mix (many of the deaths appeared to be linked to overeating – larger thriving lambs on too high of concentrate). We also had a strange stretch of lameness that occurred among the lambs which we never had diagnosed.

2010 was also our most profitable year in milking sheep. We had the highest lamb survival rate, our highest lambing percentage, and highest milk production yield, and our highest overall component testing. Lamb and milk prices were also very good. Perhaps, we're finally starting to figure this sheep milking out. At the same time, we know there is much more we can do to improve.

As we've gained knowledge on nutrition and lamb care, made ewe management a priority, and had the facilities to provide better care, our conception rates, lamb survival rates, and milk production per ewe have all improved. This has lead to farm profitability even when all stored feeds are purchased. The following charts show some of the key comparisons across the years and provide us some clear direction for areas to work on and improve.





Each year is an adventure with something to learn. The journey into the 2011 lambing season has begun. The ewes are all bred, eating fall pasture with hay supplement, and will receive their final worming dose now that the hard freezes have come to the fields. Shearing is being set up and the vaccines have been ordered.

There are several things we plan to do this year to try to improve the overall lamb survival rates and lamb health:

1. Test all hay. Feed organic haylage to ewes during late gestation and milking.
2. Give yearling ewes an extra booster of Covexin 8 to build up antibodies for their lambs.
3. Work more closely with the veterinarians to diagnose any signs of chronic health problems with the lambs.
4. Try to develop a way to prevent lamb pile up on cold winter nights in the lamb barn.
5. Wean all lambs onto organic grains and forage. Experiment with organic parasite control.

6. Pay attention and continue to work with all staff to pay attention to the details and read sheep behavior. Early intervention is essential.
7. Take time to enjoy the beauty and contentment of sheep and lambs who are living healthily on the rolling hills we call Dream Valley Farm.

Management and ongoing attention to detail are essential. We never seem to know quite enough and mistakes always have consequences. We learn much from the ideas and practices of other producers. The weather always provides an unknown for us to adjust to. However, each of the past four years has seen a decrease in our labor and our stress and an increase in our profitability. Perhaps it's time for another Dream Valley Farm planning retreat.

## **SHEEP MILK PRODUCTION INCLUDING 30-DAY WEANING SYSTEM**

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We bought our 130 acre farm in 1993. The farm was started in the 1890's with the barn being built in 1894 and the main house built in 1900. There is a second house built by one of three brothers when two of them took on the family farm. We started farming by producing the traditional local crops of sweet corn, peas, and some wheat. We have also produced grass seed and grass hay.

We started milking sheep 10 years ago as a response to dietary needs of our middle son. He was allergic to cow's milk when born and weaning him meant finding a different source of milk. We found that sheep's milk most met his dietary needs and our animal husbandry talents. (Do we have any?) After playing at home cheese making for a few years, we got our milking license in 2004 and cheese producer's license in 2005. We froze all our first year's milk and used that to start our first year's cheese production.

Working up to breeding 75 ewes in fall 2007, we had a total of about 100 sheep on our farm. In December of that year our river valley experienced a major flood that killed about 74 of our sheep. Through some donations and purchases of new stock, we are back to breeding 75 ewes for this coming year.

We have been using a 30-day weaning system based on these factors:

Labor – amount of time we have to deal with ewes and lambs and cheese making. At lambing time, we do not hire any labor

Space – our barn yard and current buildings limit us as to how many separate groups of animals we can have

Cost – Milk replacer has proved expensive and in combination with possibility of extra labor costs, means not enough margin to justify its' use

Lamb growth – lambs have not grown as fast as leaving lambs on the mothers

We have been measuring milk production by metering monthly during the milking season. In 2008 with a rather mixed bag of good and bad milkers, we averaged around 300 lbs milk per ewe after weaning. We have culled the bottom 20 – 25 producers each year and for 2010, we averaged 435 lbs after weaning. After again culling the bottom 20 this year, we will hope to top 500 lb average. These are all actual measurements, no adjustments. We started milking March 7 and milked for 182 days when the majority of the ewes were near being dry. Our top four producers gave between 700 to 740 lbs after the 30 day weaning and all four started milking 14 days after the first milking day. They took another month of occasional milking to dry off. Next year we will plan to keep them milking for at least that whole month.

In 2010 we had 163 lambs born to 77 ewes (2.11 lamb average). 13 lambs died at birth or early. We kept 18 ewes as replacements, sold most of the rest as starter ewes for dairy or to "homesteaders". Seventy-seven, mostly wethers and some ewe lambs were sold as "lawnmower"

sheep to a farmer who rents out sheep and goats for that purpose. Most of those are then butchered in fall and replaced in the spring. Most all of our lambs were sold at weaning; we didn't grow any out except our replacement ewes.

## FEEDING AND MANAGEMENT OF YOUNG LAMBS

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### Goals

To achieve a successful lambing program, one must set goals that are realistic and attainable, but an improvement upon past lambing seasons. These goals may be an incidence level of mortality, growth to be attained by weaning or based on health of the lambs. Measure and record events (lambing- date and time, birth weight, colostrum consumed, health data, weaning weight, etc.), and then try to improve upon your current level animal care and husbandry, or continue to attain the high level of animal care and husbandry at your farm.

One goal that is always on the minds of those that raise lambs is keeping lambs alive. Incidence of mortality is high in lambs, with some estimates of 16% dying in the first 10 days of life, and 20% dying before weaning. A lamb mortality study that was conducted at the Sheep Experimental Station in Idaho found that of the lambs that died 46% had scours, 20% died of starvation, and 8% died of pneumonia. The main risk factors were prolonged birthing episodes and lack of adequate colostrum. With attention to detail during the lambing process and diligence, a mortality incidence of 5% or less is attainable.

Other goals frequently focus on growth and health of lambs. A growth goal can be tripling the birth weight of lambs by weaning. However, to achieve this goal both birth and weaning weights must be measured to determine if the goal can be attained. Regarding health, the goal may be to reduce the amount of treatments to lambs by improving prevention and/ or catching the symptoms of illness sooner.

### Colostrum

Intake of good quality colostrums is essential for lambs, as it is associated with survivability and future health. Colostrum is the “first milk” that ewes produce after lambing. Ewe colostrums composition has 7% fat, 4% casein and 5% lactose on an as is basis (Hadjipanayiotou, 1995). The high amount of fat is essential to lambs, as they are born with only 2 to 4.5% of brown fat as a percent of body weight and they have a large body surface area. The extra energy helps keep the lambs warm. Newborn lambs are susceptible to hypothermia due to their large surface area relative to body weight and low body fat reserves. Colostrum also contains high concentrations of antibodies which protects the lambs against a infectious agents. Lack of adequate colostrums is associated with decreased survivability and increased mortality (Vihan, 1988).

The easiest way to remember the keys of colostrum management is to use **the 3Qs: Quantity, Quick, and Quality.**

1. The **quantity** of colostrum that a lamb needs is 3.2 oz per pound of body weight (xxx, 1986). This is 20 percent of body weight. For example, if the lamb weighs 5 lbs, 1 lb of colostrum should be fed to that lamb. A 60 cc syringe holds about 2 ounces of colostrum.

2. Colostrum should be consumed **quickly** after birth. However, the lamb cannot consume all of the colostrum in one feeding. At least half of the colostrum should be consumed by the lamb in the first 4 to 8 hours of life. This allows the antibodies to be absorbed prior to gut closure. The remaining colostrums should be consumed within 24 hrs of birth.
3. The **quality** of the colostrum is important too. It should have high levels of antibodies, be pathogen-free and disease-free.
  - a. Older ewes have more antibodies in their colostrums than younger ewes. This is due to their exposure to more infectious agents over their lifetime.
  - b. Care must be taken to assure cleanliness during collection of colostrum or prior to the lamb nursing. Ewes udders and bellies should be sheared and the area should be kept as clean as possible. If colostrums is collected, the ewe's udder and teats should be sanitized and the containers kept clean.
  - c. Ewes should be disease-free, and not be carriers of Ovine Progressive Pneumonia (OPP), Johnes, or other diseases that may be passed on to the lamb through colostrums consumption.

There are a few ways to handle colostrum management with sheep. The ewe and lamb(s) should be in a lambing pen (also known as a jug or claiming pen). Prior to placing the ewe in the pen, one should clean the ewes belly and udder. This will help ensure that the colostrum is pathogen-free upon suckling. The close proximity of the ewe with her lamb(s) will help with bonding and lessen environmental distractions.

**Lambs suckling colostrum directly from the ewe.** Many producers choose to have the lambs to suckle on the ewe. In this case, check the ewe's udder to assure that there are not wax plugs in the teats, as these will prevent the lambs getting colostrum. After about 1 hr, producers should check the lambs' for full bellies to ensure that colostrum has been consumed. If colostrum has not been consumed 2 hours after birth, colostrum should be obtained from the dam and fed to the lamb with a bottle or stomach tube. Oftentimes, with multiple lambs per ewe, the smaller lambs will not receive adequate colostrum, and may need to be fed colostrum with a bottle or stomach tube.

**Lambs fed colostrum from a bottle or stomach tube only.** This method requires more labor. However, producers can be assured that the lambs have been fed the proper quantity and quality of colostrum in a quick manner. This method should also be used for lambs from dams that are carriers of diseases such as OPP.

**Lambs fed a mix of colostrum from a bottle or stomach tube and from the ewe.** If producers want to keep their lambs with the ewes, I recommend this option. Within the first 2 hours of birth, lambs should be fed at least 4 oz colostrum from a bottle or stomach tube. This ensures that some of the colostrum needed in the first 4 to 8 hours is consumed. The lamb can then be placed with the ewe to receive the remainder of the colostrum. Producers should check the lambs' for full bellies at regular intervals to ensure that colostrum has been consumed. If the producer is not sure that colostrum has been consumed from the ewe, additional doses of colostrum can and should be bottle-fed at that time.

## Feeding Young Lambs

The Nutrient Requirements of Small Ruminants from 2007 does not include the requirements of lambs less than 20 kg (or 44 lb) and the Nutrient Requirements of Sheep (6<sup>th</sup> ed; 1985) does not include requirements for lambs less than 10 kg (22 lb). My assumption for why this critical time period early in life was not included is that the committees assumed that all lambs are reared on with their mothers, and are not fed large amounts of supplemental feeds until 4 months of age.

Milk or milk replacer is the source of the majority of nutrients for lambs. Milk replacers traditionally had been thought of as just being used for orphaned lambs. However, milk replacers allow producers to feed lambs a consistent feed with no pathogen load. There are a number of milk replacers on the market. Research with a 30% fat, 24% protein milk replacer resulting in average daily gains of 0.55 lb, compared with 0.44 lb when a 20% fat, 24% protein milk replacer was fed (Glimp, 1972). For best results, select a milk replacer with a high level of fat (30%, on a DM basis, equivalent to 5% on an as is basis) and a moderate level of protein (23 to 25%, on a DM basis, equivalent to 3.8 to 4.1% on an as is basis).

Creep feed is fed in addition to milk or milk replacer. Lambs usually begin consuming the feed at 7 to 10 days of age. Lambs will increase the amount of creep feed that they consume with time, and will be consuming significant amounts beginning at 3 to 4 weeks of age. The creep feed should be palatable, and can either be texturized or pelleted. Consumption of this grain is essential for development of the rumen. Free-choice water should be provided at all times to encourage grain intake.

## Lamb Management

There are three rearing systems that are commonly used with dairy sheep production herds. These were evaluated by research conducted by the group at the University of Wisconsin (McKusick et al., 1999). The groups include:

- **Day 1 system:** Ewes are weaned from their lambs at 24 hr postpartum and then machined milked twice a day, while the lambs are reared on milk replacer. This allows all of the milk from the ewes to be sold. This system does require the most labor (artificial rearing of the lambs and milking of the ewes twice a day).
- **Day 30 system:** Ewes nurse their lambs for 30 days. At 30 days the lambs are weaned and the ewes are milked twice a day. If the lambs cannot consume all the milk that the ewe produces, the ewe will either not produce as much milk or possibly get mastitis.
- **Mixed system:** Ewes nurse their lambs for 30 days. However, beginning one week after lambing, the ewes are separated from their lambs from late afternoon through early morning, and machine milked once daily in the morning. No additional milk replacer is supplemented to the lambs.

Ewes with lambs on the day 1 treatment had the greatest milk production (239.6 L or 544 lb), followed by ewes with lambs on the mixed system (205.4 L or 467 lb), and then ewes with lambs on the day 30 system (148.6 L or 338 lb). The milk from ewes with lambs on the mixed system (still suckling) had lower milk fat and milk protein content than the milk from ewes with lambs on the day 1 system (artificially reared; 3.24 vs. 4.88% milk fat; 5.36 vs. 5.52% milk protein).



The adjusted 30 day weaning weights of the lambs were similar, and all lambs tripled their birth weights by weaning. In the time period from 30 days to 120 days of life, lambs that were artificially raised on milk replacer had lower average daily gains compared with their cohorts (0.70 lb/d vs. 0.78 lb/d). The reason for this difference is unclear. However, these data offer more options for sheep producers in the management of lambs.

Lambs can be fed in groups, if they are similar in size and age. In these cases, lambs are fed an acidified milk replacer, which is kept cool to prevent excessive bacterial growth, and lambs are fed either from a container with multiple nipples or from a fence-line with equally spaced nipples. In these group feeding situations, the nipples and milk containers must be cleaned on a regular basis. If a producer fails to do so, an increase in illness will likely occur due to the increase in environmental pathogen load. Producers may want to reduce the amount of milk replacer fed as weaning approaches to encourage lambs to consume more creep feed.

Weaning occurs at about 30 days of age in sheep herds. Lambs are generally consuming enough creep feed at this time, and thus, are able to maintain their needs from the grain. If a lamb is not growing well or had a rough start, consider delaying weaning by 7 to 14 days.

#### **Take Home Messages:**

- Set goals that are realistic and attainable, but an improvement upon past lambing seasons. These will help your farm continue to improve and be successful
- Remember the 3Qs of colostrum management: Quantity, Quick, and Quality.
- Milk or milk replacer and creep feed are the main sources of nourishment for lambs. If a milk replacer is used it should be high in fat and moderate in protein (30% fat, 23 to 25% protein).
- There are 3 commonly used systems of rearing lambs from dairy ewes: Day 1, Day 30 and mixed systems. Each system has plusses and minuses. Lambs seem to grow well on all the systems.

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# MASTITIS IN DAIRY SHEEP

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## **Introduction**

In the U.S., dairy products made with sheep milk are considered specialty foods that are generally purchased by consumers who have little exposure to the realities of sheep farming. Consumers assume that they are purchasing high quality, safe dairy products produced by healthy ewes and harvested under hygienic conditions. It is our responsibility as caretakers of sheep to ensure that these expectations are met. Mastitis is an important disease of dairy sheep because it reduces both animal wellbeing and the quantity and quality of milk. Mastitis is also an important disease because it reduces production efficiency and profitability of the dairy sheep farmer. Understanding and preventing mastitis is essential to achieving successful management of a dairy sheep operation.

## **Definition of Mastitis**

Mastitis is a disease that occurs in several different forms. *Clinical mastitis* is the term used for mastitis that presents with obvious clinical symptoms occurring in the milk or in the ewe. Signs of clinical mastitis may include abnormal appearance of milk (presence of clots or serum), swelling, redness or necrosis of one or more half udders, or severe systemic symptoms such as anorexia (off feed), fever or agalactia (greatly reduced or no milk production). *Subclinical mastitis* is defined as inflammation of the udder that is characterized based on measuring the number of inflammatory cells in the milk. This form of mastitis is not visually detectable and requires testing of the milk to identify affected sheep.

In North America, most sheep are kept for production of meat and most research literature discusses symptoms of mastitis occurring in ewes that are nursing lambs. In this population, only clinical mastitis is likely to be diagnosed. This lack of emphasis on milking ewes has led to an overemphasis on the occurrence of clinical mastitis and a lack of appreciation for subclinical mastitis. While there are no national studies assessing the incidence of clinical mastitis in dairy ewes milked in the U.S., based on research in other regions, clinical mastitis is thought to occur in less than 5% of ewes per year (Bergonier et al., 2003). The experience of the UW milking flock at Spooner is typical. Since, 2008, the UW Madison milking flock has experienced clinical mastitis in 1-3% of the ewes each year.

Ewes that are affected with subclinical mastitis produce milk that appears visually identical to milk produced from healthy ewes but the milk is produced from glands that have been damaged by bacteria and thus produce less quantity of milk that is of lower quality. While little U.S. data is available to define the prevalence of subclinical mastitis, researchers believe that up to 30% of ewes in some flocks may be affected. One interesting study from Israel compared milk production and milk characteristics in ewes with one healthy half udder and one subclinically infected half udder (Table 1, Leitner, et al., 2004). All of the subclinical infections

were caused by coagulase-negative Staphylococci (CNS). A large impact of subclinical infection on milk yield was identified and the milk produced in the affected half udders was of much poorer quality and resulted in reduced curd yield. This research emphasizes the need for producers to identify ewes affected with subclinical mastitis and the important need to implement management programs that prevent infections leading to subclinical mastitis.

Table 1. Impact of subclinical mastitis caused by CNS on milk yield and milk characteristics. (from Leitner et al., 2004).

	Healthy Half Udder	Infected Half Udder	Effect
Milk Yield per Milking	1.7 lb/milking	0.79 lb/milking	46% reduction
SCC (cells/ml)	311,000	4,999,000	16X increase
Whey (grams/liter)	11.9	12.8	8% increase
Casein (mg/ml)	45.9	40.5	12% reduction
Fat	64.9	61.7	5% reduction
Clotting time (seconds)	413	919	2.2X longer

### Causes of Mastitis in Dairy Ewes

In almost all instances, mastitis is caused by a bacterial infection. The infection occurs when teats are exposed to enough pathogenic bacteria to overwhelm teat end defenses. Almost any bacteria can theoretically cause mastitis but several groups of pathogens are commonly obtained from milk samples of affected ewes. While most bacteria can cause both clinical and subclinical mastitis, *Staphylococcus aureus*, *Pasteurella hemolytica* and various yeasts and molds are the organisms that have been frequently reported to be recovered from milk samples of ewes affected with clinical symptoms. Bluebag (clinical mastitis with a hard, cold swollen udder) is typically caused by either *Pasteurella hemolytica* or *Staph aureus*. In contrast, subclinical mastitis in ewes is most commonly caused by CNS. Coagulase-negative staphylococci are considered to be minor pathogens in dairy cows but behave as major pathogens in dairy sheep. Other pathogens that are typically recovered from subclinical mastitis infections in ewes include *Corynebacterium* spp., Yeast, *Streptococcus* spp., *Enterobacteria* spp. and *Staphylococcus aureus*. Sometimes, ewes may be subclinically infected in the immediate postpartum period but apparently healthy at later periods (Table 2). However, ewes with subclinical CNS infection are much more likely to remain as chronic subclinical infections as compared to other pathogens (except for yeast infections).

Mastitis causing bacteria are often categorized as “contagious” if the source is thought to be infected milk that came from a ewe with subclinical mastitis or “environmental” if the bacteria are considered as opportunistic pathogens that normally reside in the housing environment of the sheep. However, this delineation is not as clear for dairy sheep as it is for dairy cattle. For example, the likely source of CNS is skin on the teats or inner legs of ewes (this skin often contacts teats) but because many CNS infections become long term chronic infections, it is possible that CNS could be shed in milk from an infected udder and then spread via the milking equipment to other ewes. Yeast and mold infections in ewes are often associated with non-hygienic administration of intramammary treatments and great care must be taken when these treatments are used (Spanu, et al., 2008).

Table 2. Outcomes of half udder milk samples (n = 390) obtained in the postpartum period and 14-21 days post lambing in the UW Spooner dairy research flock after lambing in 2008.

At Lambing	Outcome at 14-21 days post lambing			
	No Growth Both sampling periods	No bacteria recovered (cured)	Same bacteria recovered (chronic)	Different bacteria recovered (new infection)
No Growth (n = 299; 77%)	289 (97%)	Not applicable (NA)	NA	10 (3%)
CNS (n = 35; 9%)	NA	14 (40%)	20 (57%)	1 (3%)
Corynebacterium spp (n = 12; 3%)	NA	10 (83%)	0	2 (17%)
Other (n = 10; 3%)	NA	10 (100%)	0	0
Enterobacteria (n = 7; 2%)	NA	4 (57%)	1 (14%)	2 (29%)
Mixed (n = 6; 2%)	NA	5 (83%)	0	1 (17%)
Bacillus (n = 5; 1%)	NA	4 (80%)	0	1 (20%)
Yeast (n = 12; 3%)	NA	1 (8%)	11 (92%)	0

In rare instances, the lentivirus that causes Ovine Progressive Pneumonia (OPP) has been associated with mastitis in sheep (Deng et al., 1986). Mammary gland symptoms are associated with lesions in secretory tissue. While it is known that this virus has an affinity for mammary glands, the disease is a slowly progressive disease that results in weight loss, greatly reduced milk production and other symptoms that make it unlikely to become widespread in flocks that are used for dairy production.

### Determining the Cause of Mastitis

There is no way to diagnose mastitis based on the appearance of the milk or the ewe. The only way to determine the cause is to submit a milk sample to a laboratory for culture. Aseptically obtained milk samples must be used to identify the bacteria that are causing subclinical mastitis. The following equipment is needed to ensure that a useful sample is collected: sterile, single use disposable plastic vials with tight fitting caps and at least 15 ml capacity; nitrile or latex gloves to reduce contamination of samples with bacteria present on the samplers' hands; and alcohol soaked cotton, gauze or baby wipes for adequate teat sanitation. Before obtaining the sample, the udders should be clean and dry and a strip cup should be used to collect 2-3 streams of foremilk from each half udder. Teats should be sanitized using an approved teat disinfectant (such as 0.5% iodine) that remains on the teats for 20 to 30 seconds prior to removal. The procedure for collecting the sample is as follows: *Thoroughly dry the teat* with a single use cloth or paper towel. Scrubbing of the teat end should be vigorous to fully sanitize the teat using 70% ethyl or isopropyl alcohol. If both teats are sampled a separate swab must be used for each sample. Sanitation is not complete until the surface of the swab remains clean after it is used and the sanitized teat should not be allowed to contact the legs of the ewe. The cap should be removed from the sample vial without touching the inside and it should be held so that the inner surface faces down. Milk from the teat to be sampled can be directed at an angle into the sampling vial. A sample size of 3-5 ml is usually adequate. The cap should be

immediately replaced after the sample is obtained. Milk samples need to be cooled immediately and should not be placed on warm surfaces (such as the top of milk lines) for any significant amount of time. If samples are to be submitted to a diagnostic laboratory, they should be submitted within 24 hours of collection. If samples cannot be processed within 24 hours, they should be frozen until transported to the lab.

Bacteria often shed cyclically or in low numbers so it is important to recognize that laboratory methods used for the recovery of mastitis pathogens are not perfect. The failure to recover bacteria from a milk sample does not necessarily mean that bacteria are not present in the gland. Approximately 35% of milk samples obtained from dairy cattle with mastitis will be culture negative when a single milk sample is examined and it is likely that similar proportion of milk samples obtained from dairy ewes will be falsely negative. If a ewe has chronically increased SCC but is culture negative the best strategy is to assume that the udder remains infected and resample the ewe later.

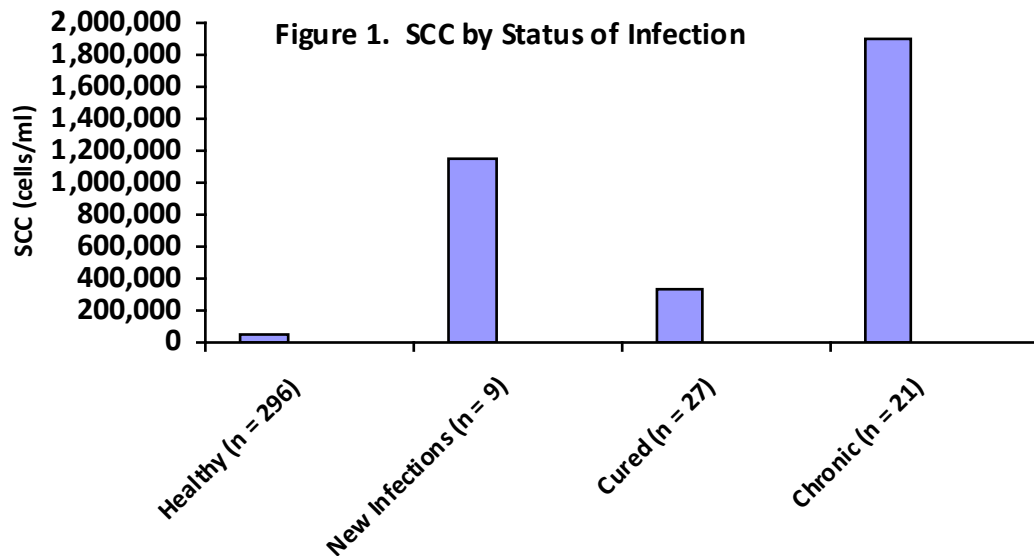
### **Detection of Subclinical Mastitis**

Subclinical mastitis occurs when a mastitis pathogen infects one or more udder halves but does not cause enough disruption of secretory tissue to result in visibly abnormal milk. In these instances, the immune system of the ewe responds to the bacterial invasion by sending white blood cells (WBC) to the inflamed udder half to combat the invading bacteria. Somatic cell counts measure the number of WBC and udder epithelial cells that are present in milk and are an indication of a healthy immune response to infection. Sheep produce milk using biological processes that are similar to dairy cows. Thus, the types of cells and proportions of cells present in sheep milk are more similar to dairy cows rather than goats and standard methods used to count somatic cells in cows' milk are considered accurate for counting somatic cells in ewes' milk. In both dairy sheep and dairy cows, a significant increase in somatic cells occurs almost exclusively in response to bacterial infection of the mammary gland.

In an uninfected half-udder, the SCC count is generally lower than 200,000 to 400,000 cells/ml (Bergonier, et al., 2003). Higher counts are almost always associated with bacterial infections and indicate the presence of subclinical mastitis. Many healthy half-udders have SCC values that are less than 100,000 cells/ml (Pengov, 2001). The SCC of The SCC of half-udder milk samples, by status of intramammary infection for samples obtained from the UW Spooner Research Flock in spring 2008 is shown in Figure 1.

The bulk tank SCC is an indication of the quality of milk and will increase when ewes develop subclinical mastitis. Dairy sheep producers should monitor bulk tank SCC and manage the flock to maintain SCC less than 300,000 cells/ml. Ewes with even mild chronic subclinical mastitis infections can be expected to produce about 5% less milk as compared to ewes with healthy udders (Spanu, et al., 2008). Management of milk quality is impossible without knowing how many ewes are affected with subclinical mastitis. Dairy sheep producers should feel confident in using SCC values to identify ewes with subclinical mastitis. Somatic cell counts in ewes are quite specific for infection. Ewes with a single half-udder infection will normally have high SCC in the infected half udder and low SCC in the healthy half udder. For example, in 39 ewes with intramammary infections in a single half udder, the SCC of the healthy half udders

was 195,000 cells/ml as compared to 1,329,820 cells/ml in the infected halves (unpublished data). Using this data, half-udders that were infected were 6 times more likely to have SCC >400,000 cells/ml as compared to half-udders that were healthy. This data indicates that the CMT paddle or other ewe-side SCC tests (such as the PortaSCC or the Direct Cell Counter (DCC, Delaval)) can be used to help producers identify subclinical infections.



Dairy shepherds should consider monitoring production and SCC of each ewe on a monthly basis using a DHIA service. If DHIA is not available, producers should use a monthly individual ewe SCC test such as CMT, PortaSCC or DCC to assess udder health each month. Monthly SCC data can be used to select ewes that should have milk submitted for culturing or to identify chronically infected ewes for interventions such as treatment or culling, target specific ewes for intramammary dry off therapy or identify risk factors for mastitis such as stage of lactation, housing or milking management. When using individual ewe or half-udder SCC values, a threshold of 200,000-400,000 cells/ml should be used to identify ewes that have subclinical mastitis. Care must be taken to accurately use the CMT to identify ewes with subclinical mastitis. The CMT is scored using a 5 point scale (negative, trace, 1,2,3). Milk containing 200,000-400,000 cells/ml would result in CMT scores of “trace.” Trace CMT scores are difficult to read and the expected appearance of the CMT reaction is defined as: “slight precipitate, best seen by tipping, disappears with continued movement.”

### **Risk Factors for Mastitis**

Risk factors for subclinical mastitis are not well defined for intensively managed milking sheep in North America. European research in Mediterranean countries has indicated that most of the variation in mastitis is associated with differences in herd management (Gonzalo et al, 2005). In the same study, higher producing breeds were at greater risk of mastitis and the use of dry off treatment resulted in less mastitis (Gonzalo et al., 2005). Mastitis in milking sheep is usually caused by bacteria that live on skin (such as CNS), and it is sensible to conclude that practices that reduce exposure of teat ends to bacteria should result in reduced prevalence of mastitis. Udders, inner legs and tails (if left long) should be as clean as possible. Pastures and

other housing for ewes should be managed to provide a clean and dry place for all ewes to rest. Milking equipment should be clean, well maintained and provide stable teat end vacuum. Teat cup liners should be observed for wear and replaced in accordance with the manufacturers recommendations. Practices that improve udder hygiene and reduce teat exposure to bacteria are likely to result in less mastitis. For example, all teats of milking ewes should be disinfected post-milking using a commercially available teat dip product. Mastitis can spread from infected ewes to healthy ewes if bacteria present in milk from a subclinically infected half udder are allowed to contact healthy teats. It is important to identify chronically infected ewes and either cull or milk them last to reduce the risk of infecting healthy ewes. It may also be important to review nutritional management. While there is no research data examining the effect of selenium or vitamin E deficiency on the incidence of mastitis in sheep, these nutrients are known to be important in ensuring immune function and deficiencies have been associated with increased mastitis in dairy cattle.

### **Treatment and Prevention of Mastitis**

Ewes that develop clinical mastitis are often seriously ill and should be treated immediately according to protocols that have been developed in consultation with the flock veterinarian. Most treatments for clinical mastitis are administered systemically and the ewe may require supportive therapy such as intravenous fluids.

There is virtually no research literature that describes efficacy or economics of treatment during the lactation period of ewes affected with subclinical mastitis. Most subclinical mastitis in dairy sheep is caused by CNS and the behavior of CNS in sheep is uniquely different than the behavior of CNS in dairy cows. Thus, extrapolation of recommendations developed for CNS infections in dairy cows is probably not appropriate. Clinical trials are needed to determine if intramammary treatments result in economically beneficial outcomes in subclinically affected lactating dairy sheep. The use of intramammary dry off treatment has been shown to positively influence milk yield and SCC in the subsequent lactation and is recommended (Gonzalo, et al., 2004; Spanu, et al., 2010). However, administration of intramammary treatments does increase the risk of mastitis caused by yeast bacteria and selective dry off treatment can be recommended in flocks that have a relatively low prevalence of subclinically affected ewes. Milk samples obtained from ewes with 3 or more monthly somatic cell counts  $\geq 400,000$  cells/mL in the previous lactation were 6 to 8 times more likely to be positive for mastitis pathogens in the next lactation as compared to milk samples obtained from ewes with SCC below that threshold and that threshold may be appropriate to identify ewes that should receive dry off treatment (Spanu, 2009).

Additional management strategies that may be helpful to control subclinical mastitis include the use of post-milking teat disinfection, culling of chronically infected ewes (identified by several months of SCC  $>400,000$  cells/ml) and in some instances the use of pre-milking teat disinfection.

## Usage of Antibiotics and Residue Testing in Dairy Sheep

There are no antibiotic compounds that are approved for treatment or prevention of mastitis in milking sheep. Drugs that are used for these purposes are considered by the FDA to be administered in an “extralabel” manner and this usage must be prescribed and supervised by a licensed veterinarian. The administration of a drug that is approved for treatment of another sheep disease (such as the use of ceftiofur for treatment of pneumonia) to treat mastitis is also considered as extralabel usage. The prescribing veterinarian must have an established veterinary client patient relationship (VCPR). The VCPR specifies that the veterinarian is personally acquainted with the farm and available for consultation if necessary, has examined the animals and has knowledge of flock management and has sufficient knowledge to make a diagnosis and prescribe the drug. When a valid VCP exists, the veterinarian is considered to have assumed responsibility for making medical judgments about the health of the ewe and the producer has agreed to follow the instructions provided by the veterinarian. Not all drugs can be administered to food producing animals, even by veterinarians. The FDA has prohibited the following compounds from all extralabel usage in food producing animals: chloramphenicol, clenbuterol, diethylstilbestrol, dimetridazole, dipyrone, ipronidazole, other nitroimidazoles, fluoroquinolones, glycopeptides antibiotics, and nitrofurans. Extralabel usage of phenylbutazone (“bute”), enrofloxacin (Baytril) and all sulfonamides are also prohibited in dairy cattle and thus should be considered as prohibited in all animals used for dairy production. FDA regulations also prohibit all administration of compounded drugs (homemade combinations of drugs).

Drugs administered to lactating sheep are very likely to result in residues in the milk. Residues can occur for both antibiotic compounds and compounds such as antiparasitic drugs. Veterinarians who prescribe extralabel treatments must include a label with a clearly defined withholding time for both meat and milk. The purpose of the withholding time is to ensure that the milk does not contain drug residues. The sale of milk containing residues is illegal and detection of drug residues in milk that has entered the food chain will result in considerable fines. This issue is quite important for dairy sheep producers because milk withholding periods for sheep that receive antibiotics (or other drugs) are not well defined. At least one study has indicated that withholding periods for some antibiotics given to sheep should be longer than periods recommended for the same drugs administered to dairy cows (Pengov and Kirbis, 2009). Very long durations (>1 month) of milk residues have been reported for both doramectin (i.e. Dectomax) and ivermectin compounds (Imperiale, et al., 2003, Imperiale, et al., 2004)) and these products should not be administered to lactating sheep. Antibiotic residue screening tests can be used on sheep milk to help prevent the occurrence of antibiotic residues. Flocks that use dry off treatment should routinely check the comingled milk in the early lactation period to ensure that residues are not present. The best way to prevent residues is to ensure that all the requirements for extralabel drug usage are met, ewes that receive treatments should be marked and segregated from the milking flock and a permanent record of all treatments given to ewes should be maintained.

## Conclusions

Mastitis is an important disease of dairy sheep and the prevalence of mastitis varies among flocks depending on flock management. Most mastitis occurs in a subclinical form and



producers who do not routinely measure individual ewe SCC will not be able to determine the impact of subclinical mastitis on production and milk quality. Most subclinical mastitis in ewes is caused by CNS which should be considered as major mastitis pathogens in sheep. Prevention of infection is the key to control of mastitis and good hygienic housing and milking practices are a necessity to minimize the impact of this disease in dairy sheep flocks.

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# EUROPEAN CHEESEMAKING PERSPECTIVES

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## Making Sheep Cheeses - A New Fashion?

The oldest written record of cheese dates from the fourth millennium BC, when a Sumerian stockbreeder meticulously kept his accounts in cuneiform on clay tablets. The beginnings of cheese-making, though, goes back long before this. The history of cheese probably began with a fortunate accident as far back as 12,000BC somewhere between the Balkans and Middle East Turkmenistan and Iran. The nomadic people who inhabited this area constantly moved from place to place, stopping only for short periods of time to allow their sheep and goats to graze.

No-one can say for sure how the first cheese was made, but it seems a fair guess that it happened accidentally when milk was stored in a skin bag made from the stomach of a young animal, or perhaps left out in the open in a shallow bowl. People soon realized that the whey made a palatable drink, while the curd could be eaten fresh, or perhaps dried and shaped. These early cheeses would have been rudimentary, soft and fresh, made from goat's or ewe's milk, and with a limited shelf life, not unlike some of the fresh cheeses made today.

Each region had its own traditions and made its own distinctive cheeses, which evolved according to climatic conditions, local needs and the types of milking animals raised. In the steep, dry hills of Greece, for example, cheese was made mainly from goat's and ewe's milk, whereas in northern parts of Europe, cow's milk became more widely used.

Ewe's milk has been used as a source of cheese since ancient times. Although it is expensive to produce, it is the basis of great benchmark cheeses such as Roquefort in France, Manchego in Spain, and the extensive range of Pecorino types made in Italy. Ewe's milk is also commonly mixed with goat's milk to make Feta in Greece and Haloumi in Cyprus.

*Cows gradually replaced sheep as dairy animals because they produced a significantly greater volume of milk per animal, and climatic conditions in temperate regions made them far more economic for making cheese. Most ewe's milk cheeses are now made in remote regions with a Mediterranean climate, or in elevated, sparse regions where the landscape is unsuited to cows or goats.*



European perspectives :

COUNTRY	1990	2006	VARIATIONS %
Bulgaria	272.113	107.535	- 60.5
France	240.320	262.776	+ 9.4
Greece	673.352	752.171	+ 11.7
Hungary	48.773	3.637	- 92.5
Italy	663.400	553.510	- 16.6
Portugal	91.246	100.010	+ 9.6
Romania	404.719	545.425	+ 34.8
Spain	329.910	403.000	+ 22.2

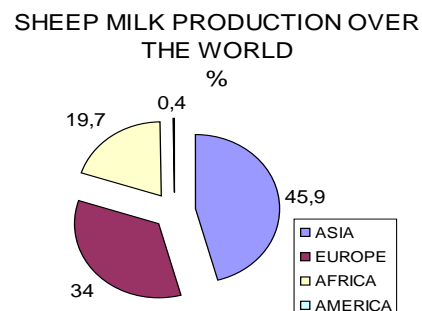
Evolution of sheep milk production – x1000 L (Fao, 2006)

The evolution in these countries during the last years has not been uniform. This way, the production has increased in Greece, Spain, Romania, France and Portugal, whereas it has descended in Italy and Bulgaria, and has collapsed in Hungary. It is necessary to emphasize the growth of 22 % registered in Spain, increase that not always has had a perfect adjustment to the growth of the demand of cheeses of this type, which has motivated certain crisis of oversupply and low prices of the milk in last two years.

In Europe (EU 15), sheep’s milk represents 2.3% of total milk produced

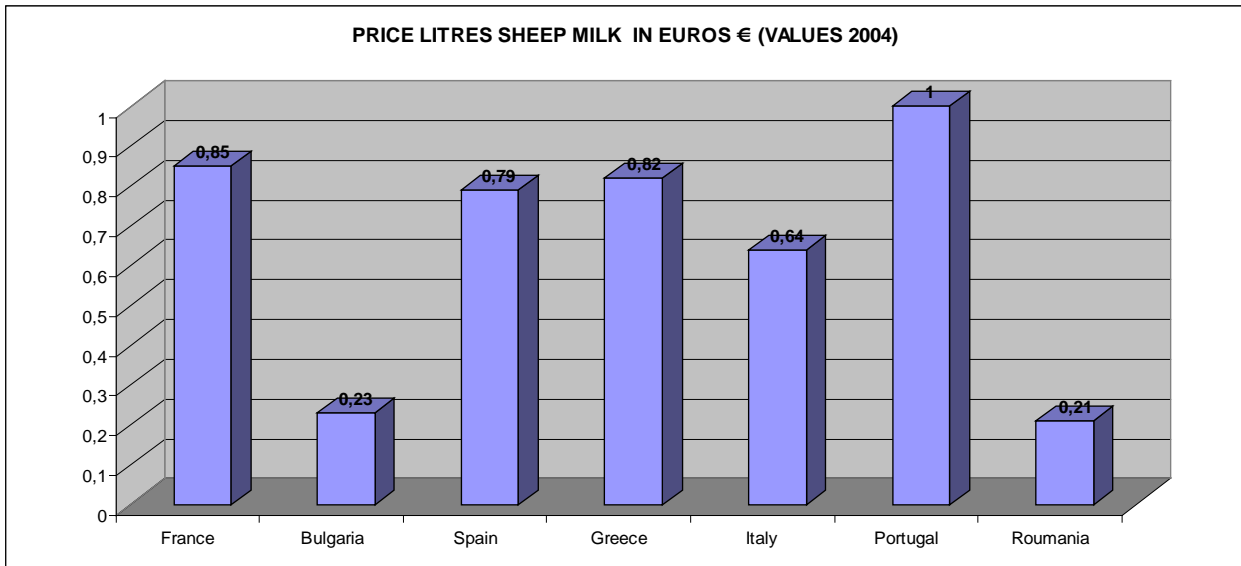
TOTAL VOLUME OF MILK in EU (L)	SHEEP MILK
128,814,000,000	2,962,721,000

Inside the EU the production of sheep’s milk has not stopped growing from 1980, passing from 1.600 million liters in this year to near 2.900 in 2006, which supposes an increase near to 50 %. This evolution owes so much to the increase of the consumption of these cheeses of quality, the production of sheep’s milk in the EU is localized on the Mediterranean area and the Black sea, being only nominal in other countries. Stand out as principal producing countries Greece, Italy, Romania, Spain and France in this order.



A deeper analysis reveals differences between these countries. France is the country with the most efficient productive and structured systems, produces 170 liters / sheep / Y, in a few very concrete zones and for very typified products and of high value. At the far end one finds Greece and Romania, with very extensive and slightly specialized systems (75 liters / sheep / year), where the majority of the sheep are milked occasionally for the production of local products (in many Greek systems of production together sheep and goats are milked). Finally, in an

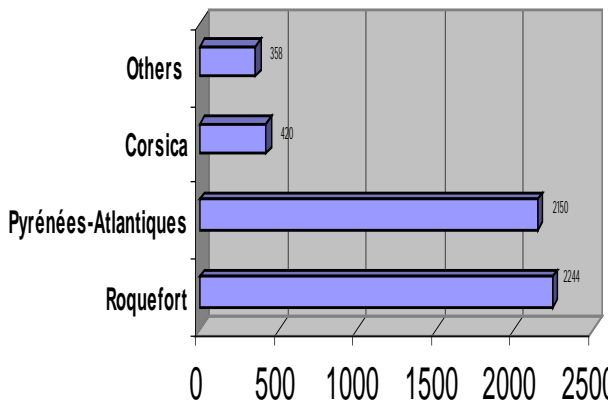
intermediate situation one find Spain (110 lts / sheep / year) and Italy (90 lts / sheep / year), where traditional systems coexist still with already very specialized others.



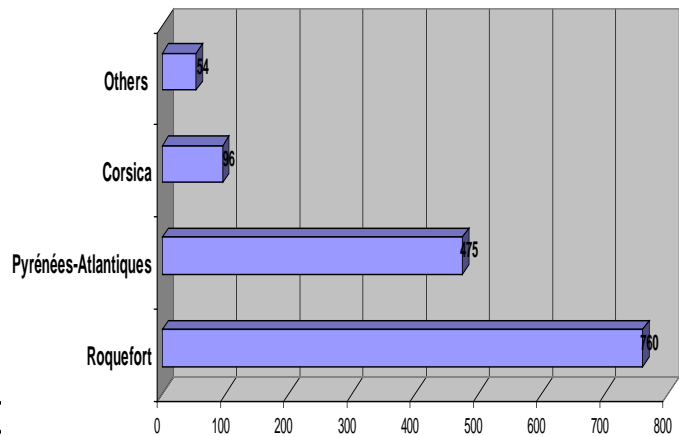
**Sheep Milk Industry in France** (source Institut Elevage – 2006)

France’s production of sheep milk represents 260 Millions L for a herd of 1,500,000 milking sheep (25% of total sheep herd). Major part of this milk is dedicated to cheese’s production, estimated at 60,000 Tons/year. This herd is distributed on 5,200 farms. Contrary to the others breeding sectors which are scattered on the whole national territory, sheep’s milk production is localized on 3 traditional areas: Radius of Roquefort, Pyrénées-Atlantiques and Corsica.

**Number of farms having Dairy Sheep**



**Quantity of Dairy Sheep x 1000**





**PYRENEES – ATLANTIQUES**  
 Sheep : Manech Têtes Noire and Rousse, Basco-Béarnaise  
**CHEESE : AOC OSSAU-IRATY**  
 43% of farms  
 34% of sheep

**ROQUEFORT**  
 Sheep : Lacaune  
 Cheese AOC **ROQUEFORT**  
 43% of farms  
 55% of sheep

**CORSICA**  
 Sheep : Corse  
 Cheese : AOC **BROCCIU**  
 9% farms  
 7% of sheep

**Dairy sheep and characteristics (milking season 2007) :**

**Lacaune**



**Corsica**



**Rousse Manech Noire**

**Basco-Béarnaise**



ZONE	RACE	Dairy sheep	Milk's quantity (Litres)	Milking duration (Days)
Roquefort area	Lacaune	157401	290	165
Pyrénées	Basco-béarnaise	17675	153	141
	Manech Tête Noire	11663	134	138
	Manech Tête Rousse	60559	177	149
Corsica	Corse	19150	139	178

#### Characteristics of French Sheep Dairy Farms (Institut Elevage Survey 2000)

- Production localized in 3 majors area (96% of dairy sheep) : Roquefort, Pyrénées, Corsica : 3 zones with a specific landscape / climate (Mountain, dry; arid; steep)
- Family based farms : an average of 2 working units with 1.9 Family based working units.

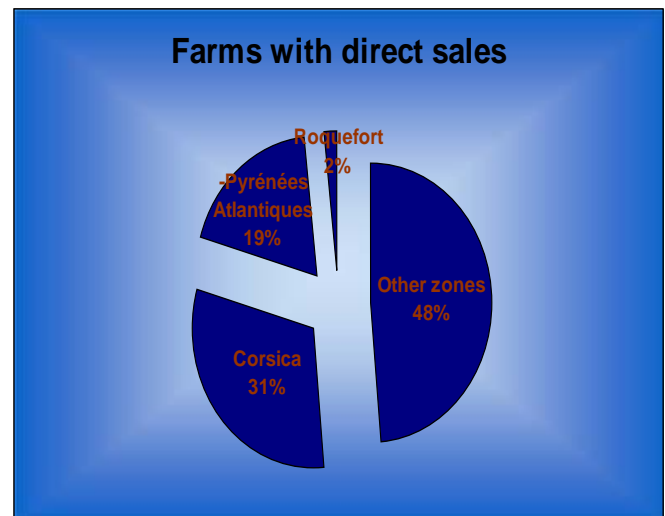
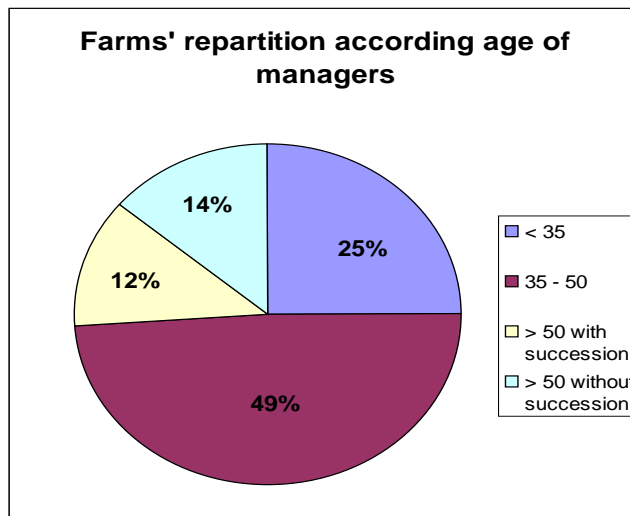
	TOTAL WORKERS	FAMILY WORKERS
ROQUEFORT	2.3 Units	2.1 Units
PYRENEES	1.8 Units	1.8 Units
CORSICA	1.5 Units	1.3 Units
OTHERS AREAS	2.0 Units	1.8 Units
AVERAGE	2.0 Units	1.9 Units

Presence of employees related to farm size:

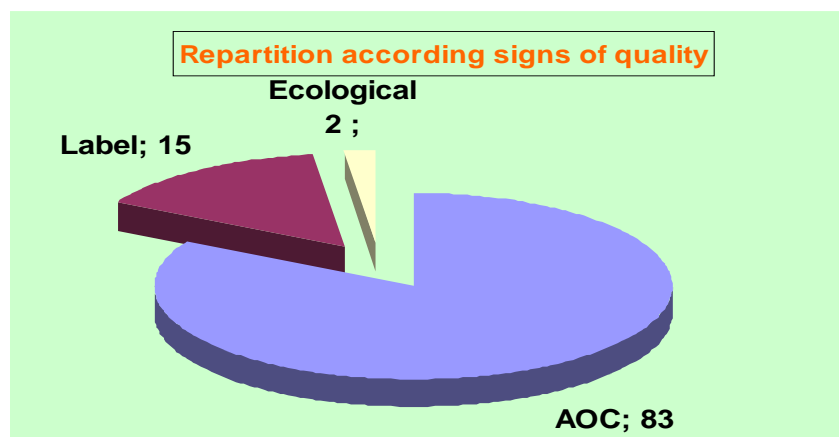
	Farms without permanent employee			Farms with permanent employee		
	Number of farms	Arable land (without pastures)	Dairy sheep	Number of farms	Surface cultivated (without pastures)	Dairy sheep
Roquefort	2213 (88%)	65.2 Ha	289	301	96.8 Ha	397
Pyrénées	2444 (99%)	24.1 Ha	189	36	44.2 Ha	289
Corsica	493 (94%)	26.8 Ha	170	29	82.6 Ha	362
Other areas	263 (85%)	34.6 Ha	161	45	60.9 Ha	215
AVERAGE	5413 (93%)	41.7 Ha	227	411 (7%)	87.2 Ha	365

## Characteristics of French Sheep Dairy Farms (Institut Elevage Survey 2000)

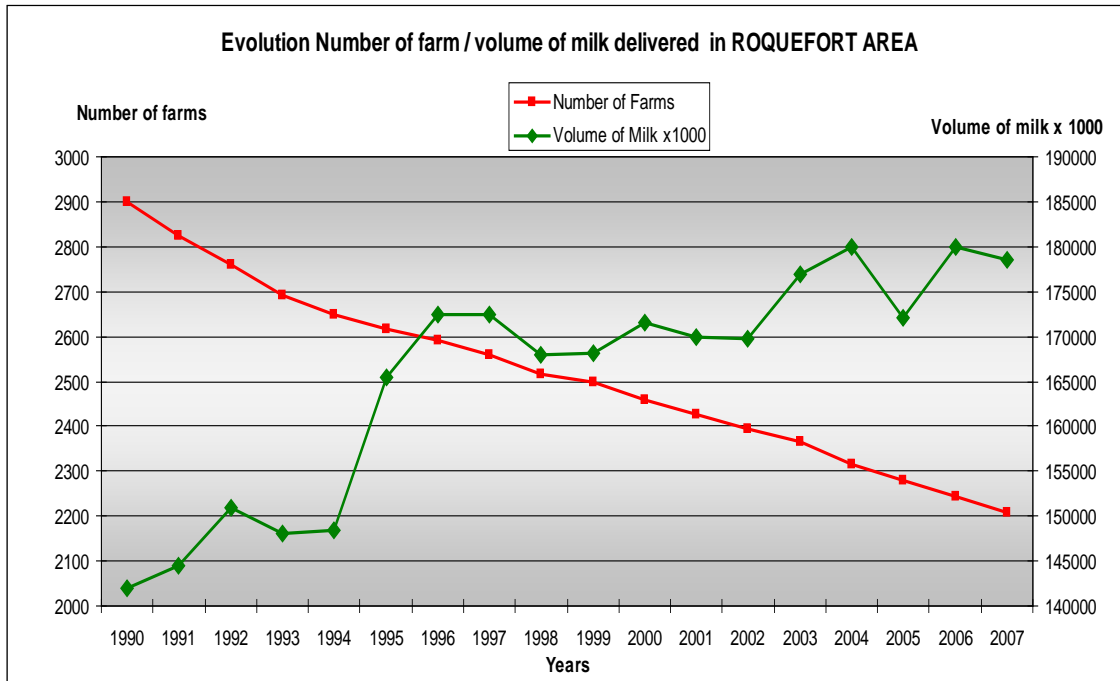
- Sheep farmers is a young population : compared to other breeding sectors, farm managers are relatively young : 25% have less than 35 years old. Generally speaking, perspectives of succession are positive because only 14 % of them are more than 50 years old and have no succession.
- Herds with an average of 236 dairy sheep (300 in Roquefort area, 180 in other zones).



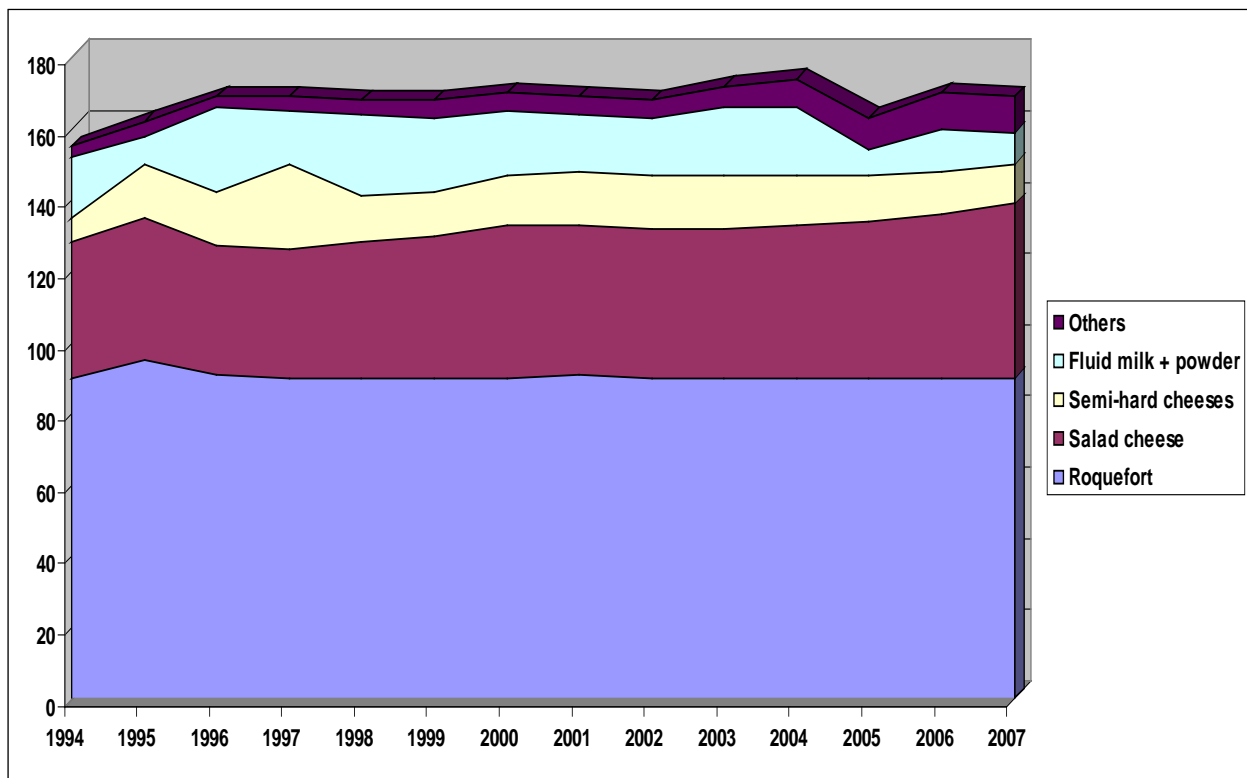
- 17% of the farms transform on-site for direct sales, with a big difference according regions related to tourism and collection of milk for AOC cheeses (Roquefort – Ossau-Iraty- Brocciu)
- 86% of the farms are engaged in networks with official signs of quality : AOC – Label – Ecological, with a major preference for AOC systems.



## Roquefort Area

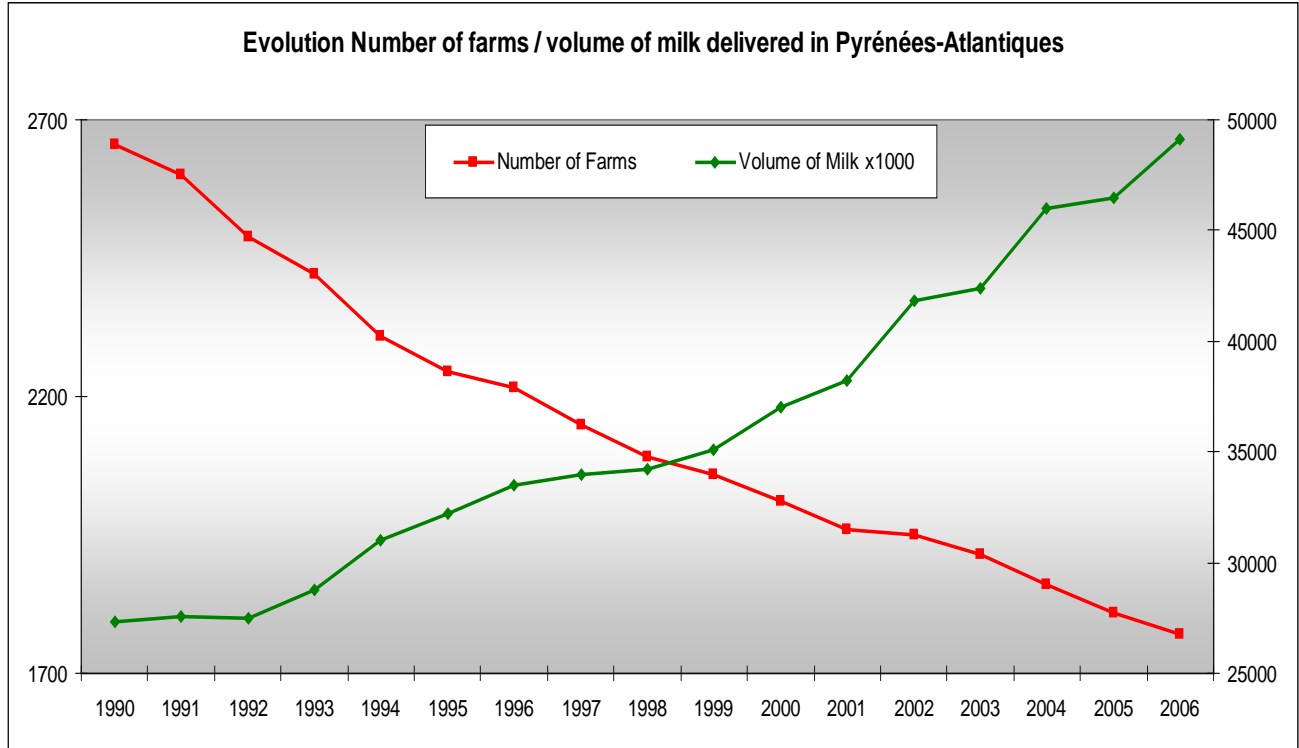


## Roquefort area: Evolution of volumes according industrial use

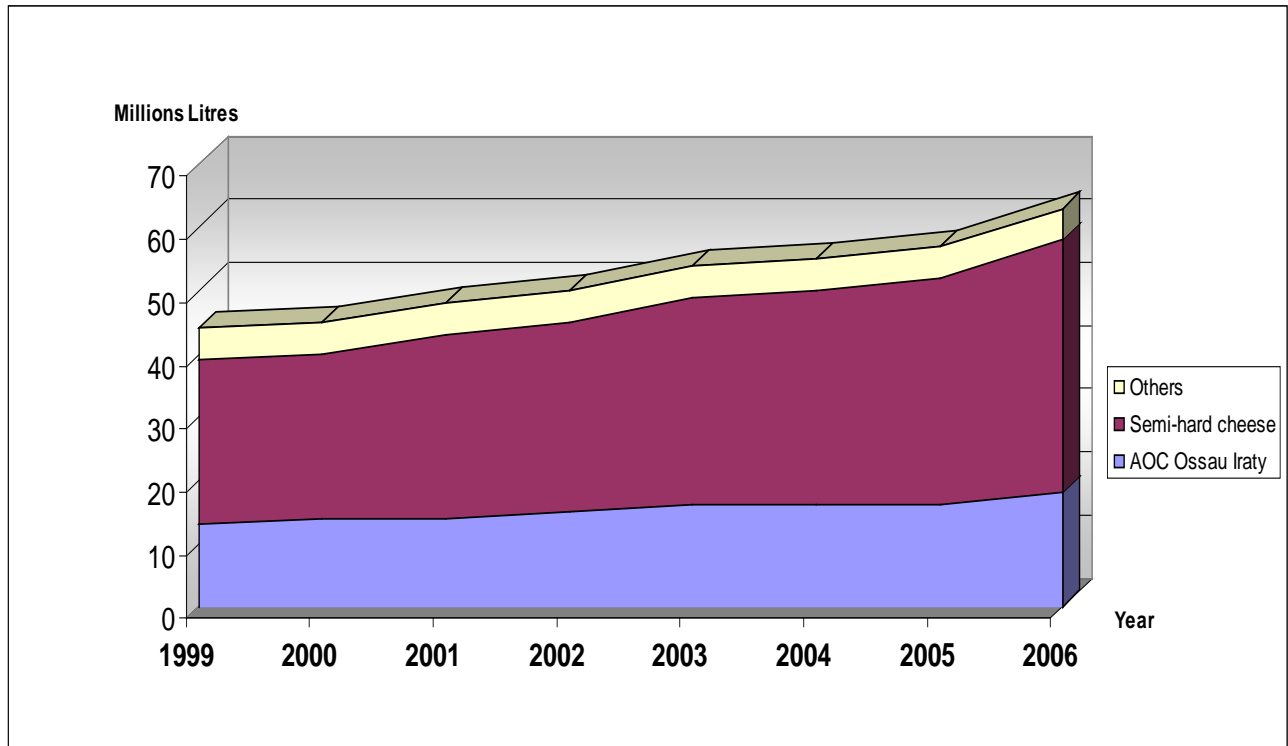




## Pyrenees Area



## Pyrénées area: Evolution of volumes according industrial use

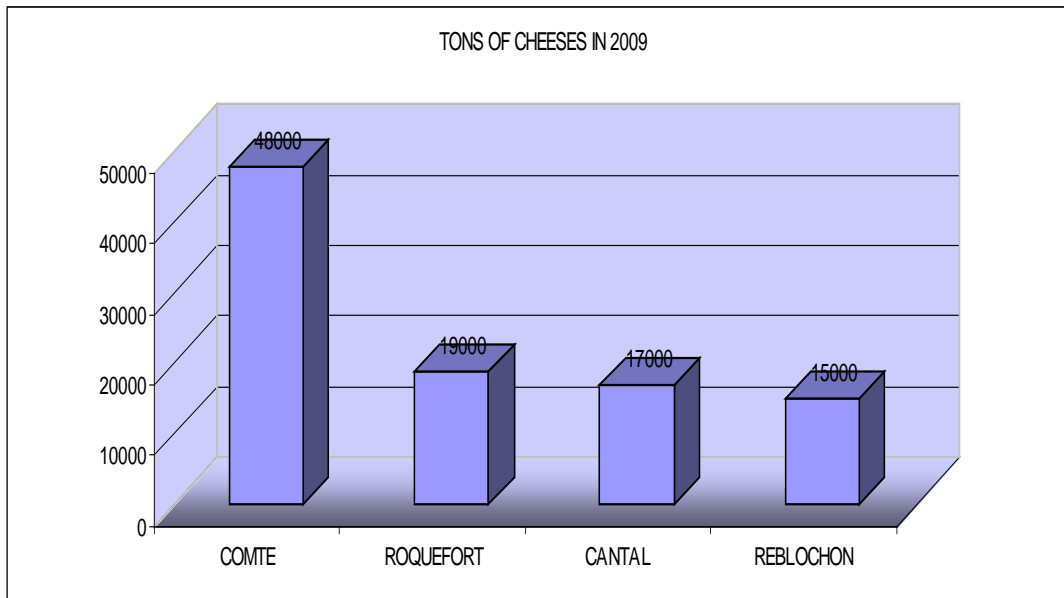
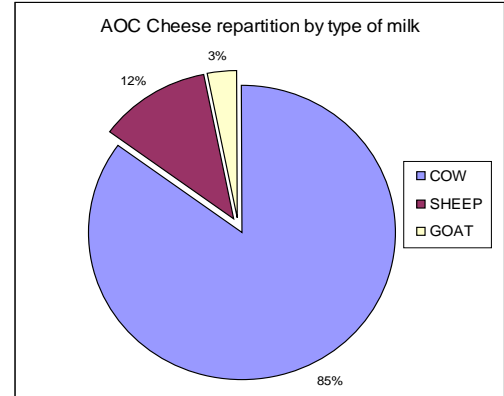


## Production of Sheep Milk Cheese in France

With 72% of sheep farms engaged in AOC network, this quality sign is a real booster for the sheep milk's economy. In terms of volume, quantity of AOC sheep milk cheeses arrives in second position, cow's milk remaining the largest

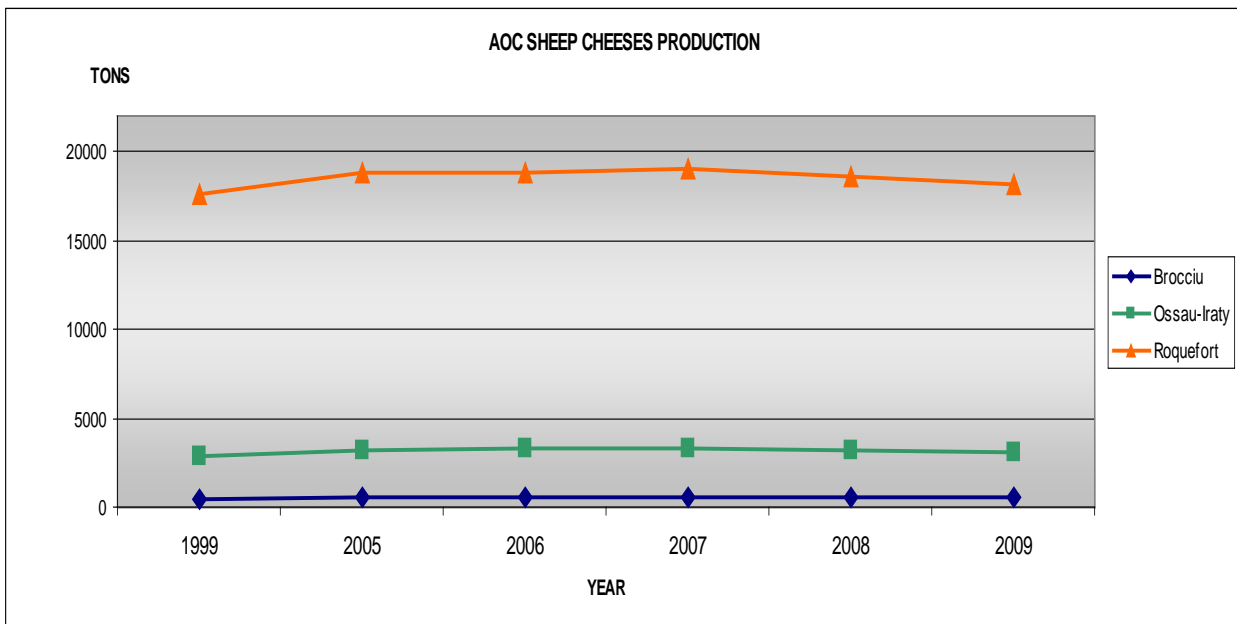
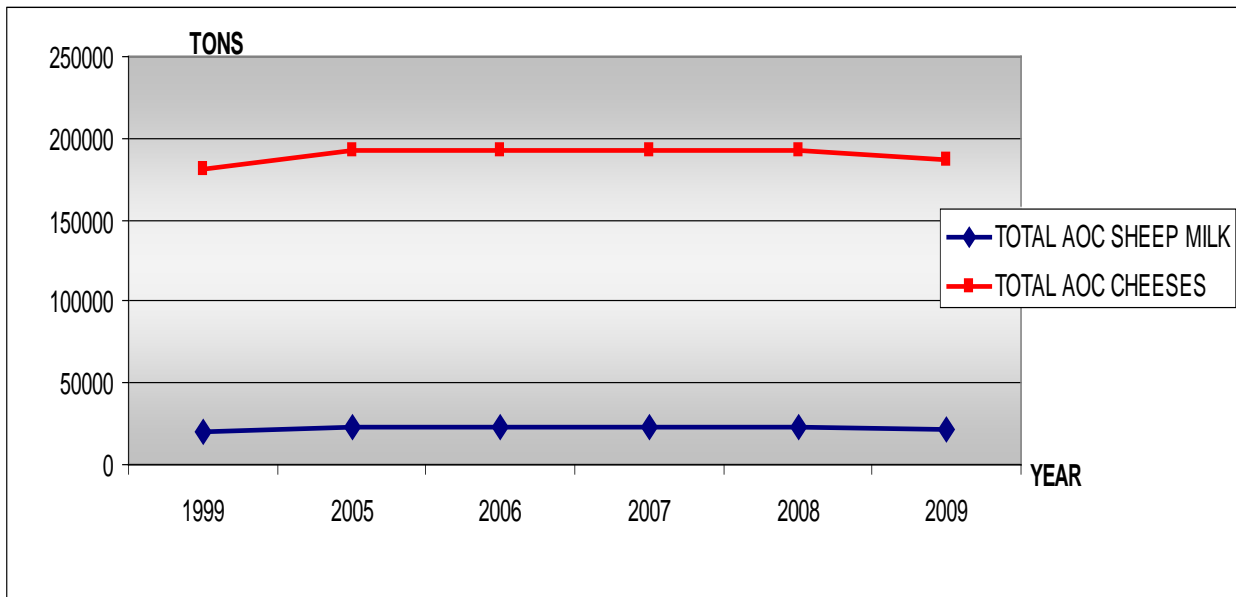
### AOC in Brief – 2009

- Total of AOC cheeses in 2009 : 187429 tons
- Sheep milk cheeses : 21762 tons
- 1999 – 2009 : + 3.9% ; 2008-2009 : -2.9%
- 71.8% (134574 tons) made with raw milk.
- 7.9% are farmstead cheeses, 1350 farmers.
- Annual Gross income : 1.5 Billion euros
- 16% of France aged cheeses
- 78% of raw milk cheese's production
- Price about 53% more than "non-AOC" cheeses
- Better resistance to "credit-crunch" (+2.6% Vs -0.5%)



	<i>Savoy 3 AOC</i> (Abondance, Beaufort, Reblochon)	<i>Auvergne</i> Saint Nectaire	<i>Central Massif</i> Roquefort	<i>Jura</i> Comté	<i>France</i> Average
Number of direct employees for 100,000L of milk produced and processed	2.7	2.8	7.1	1.5	0.76

Amongst the 260 Millions liters of sheep milk, mainly processed into cheeses, 44.5% (115Millions L) of the milk is processed in 3 AOC cheeses (*Appellation Origine Contrôlée*) :



*ROQUEFORT*



*OSSAU-IRATY*



*BROCCIU*



SHEEP MILK ECONOMY IN SPAIN :

Source : FAO – Spanish Ministry of Agriculture)

	WORLD	EU 27	SPAIN
Production (Tons)	8,723,243	2,765,829	403,000
% of total milk	1,60	2,30	5,40
% of sheep milk	100	31,7	4,6

**Manchego**



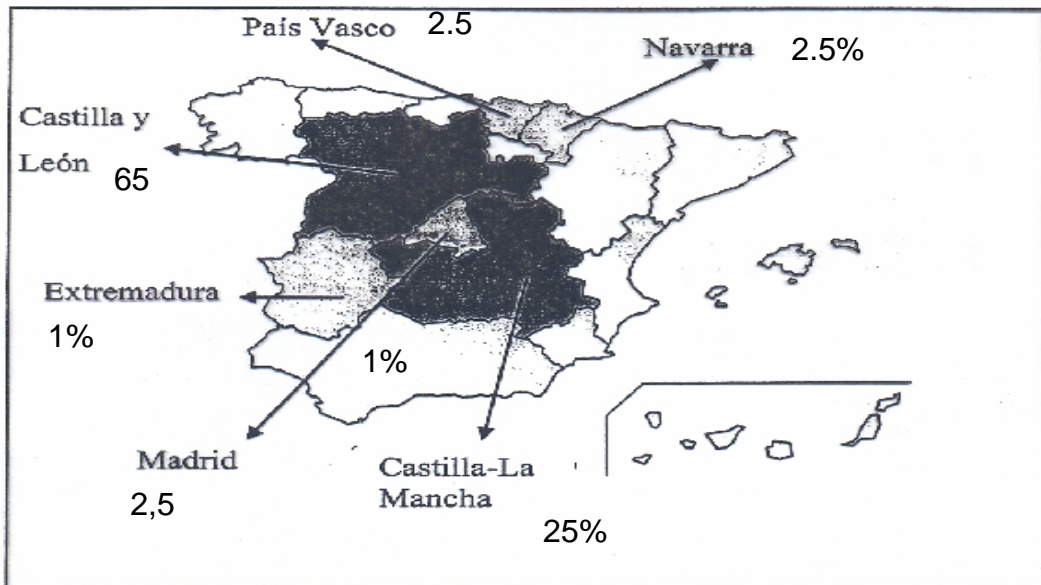
**Idiazabal**



**Roncal**

In Spain, sheep's milk represents 5.3% of total milk produced. Spanish sheep milks represents 15% of European sheep's milk.

Sheep milk production in Spain



## Sheep Cheese Economy in Spain

SPECIES	TONS 1994	% 1994	TONS 2004	% 2004	VARIATIONS %
MIX MILK	132,900	59	108,177	38.5	- 18.6
COW	71,600	31.8	125,600	43.5	+ 75.4
SHEEP	14,000	6.2	35,400	12.5	+ 152.9
GOAT	6,750	3	15,500	5.5	+129.6
TOTAL	225,250	100	284,677	100	+ 26.4

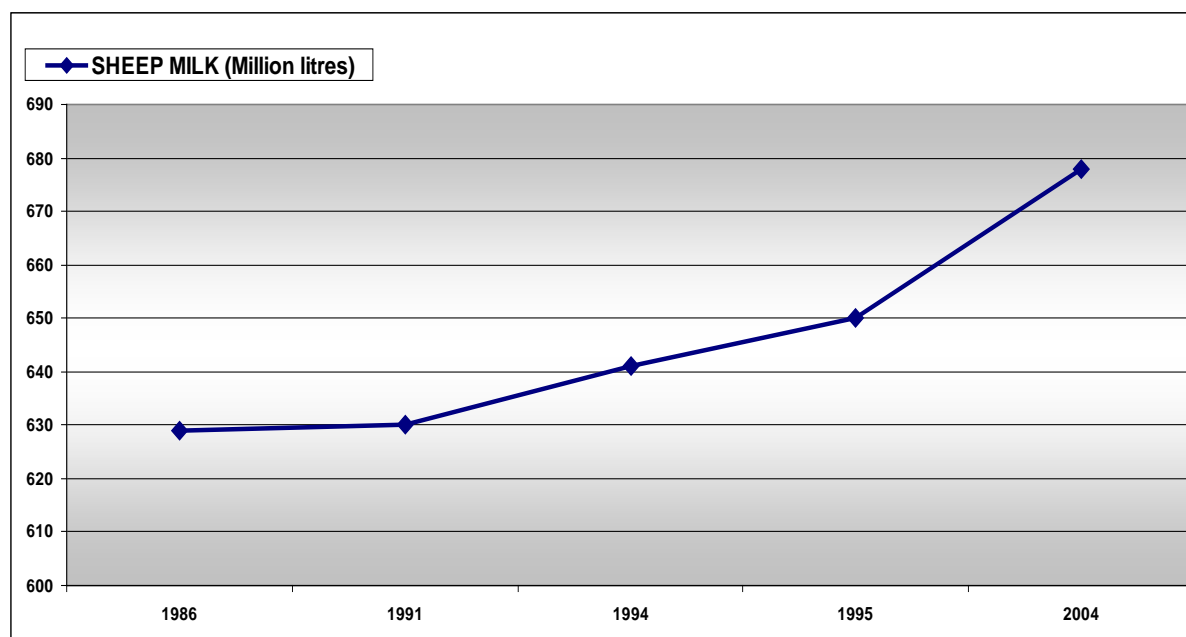
YEAR	1997	2004	VARIATION %
Kg of cheese / capita	5,7	11	+ 93%

## Sheep Milk Economy in Greece

Source: FAO – Greek Ministry of Agriculture)

In 2004, sheep economy in Greece:

- Production of milk : 678 Million liters
- Production transformed at the farm (M liters) : 231 (34%)
- Production of cheeses: total of 226,000 tons with 189,000 t made of sheep and goat milk.
- Production : 98.5 l / lactation
- Units processing sheep milk : average of 600 (2000 in 60's)



Increasing of production beg. 2000 is linked to FETA recognition: in EU, FETA is a Greek PDO: all feta production moved to Greece (Before 2002, Denmark and Germany : 60,000 Tons each, 14,000 Tons in France).

- Sheep farming is an important agricultural activity in Greece, since it contributes highly in the country's gross agricultural production value. Recently, sheep milk production received further attention because of the increased demand for feta cheese and also because of the excessive price level suffered by the consumers, in contrast with the prices paid at the farm level. Unlike other developed countries, the production of sheep milk in Greece is equally important as the production of cow milk.
- Sheep farming is one of the most important agricultural activities in the country since it constitutes main or side activity for a large number of farms. Greek sheep farms aim at the production of both milk and meat, but over 60% of their total gross revenue comes from milk. Recently, the sheep farming activity has received further attention because of the excessive demand for feta cheese which consists mainly of sheep milk (Feta cheese has PDO since 2002, application effective in October 2007).



- The nature of the sheep farming activity and its ability to profitably utilize less fertile soil has caused its expansion in many agricultural areas of Greece, and traditionally its concentration in isolated and less favored areas. In these areas the prevailing farm type is the small, extensive, family farm. Almost 63% of the Greek sheep farms have a number of sheep less than 50. Furthermore, almost 85% of the Greek sheep farms are extensive and have low invested capital. Apart from sheep farming found in mountainous and less favored areas, more intensive and modern farms have appeared, recently, especially in lowland areas. The different production systems identified in the country have different technical and economic characteristics and achieve different levels of productivity.



**Kasseri**

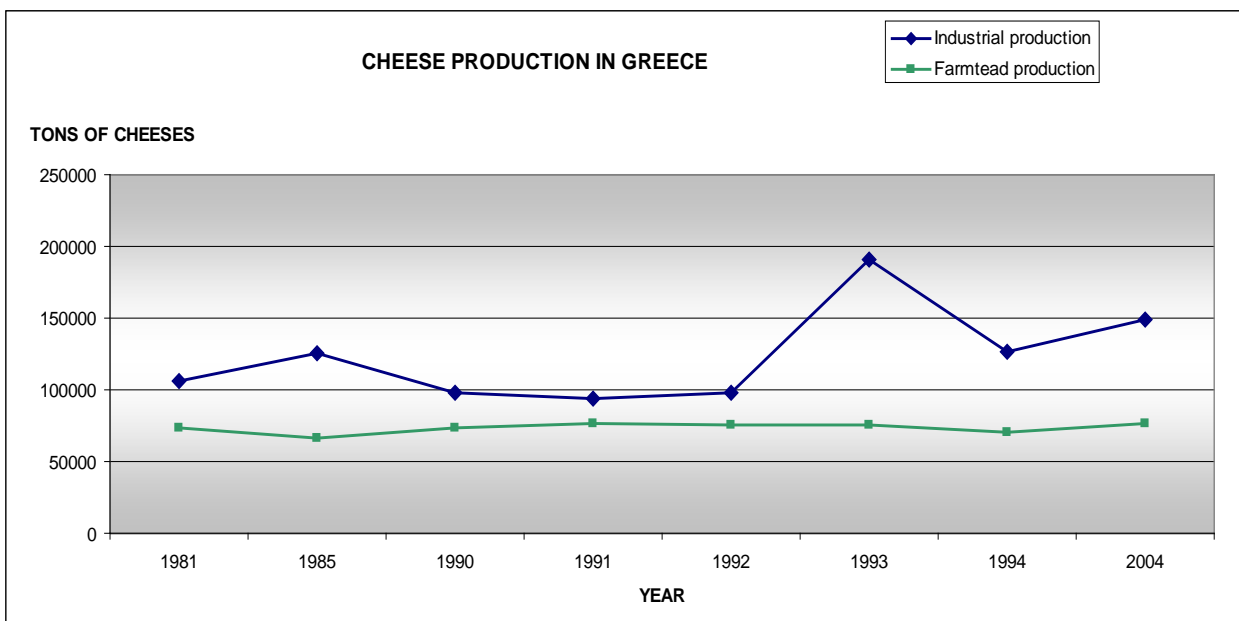


**Kefalotiri**



**Mizithra**

## Sheep Cheeses in Greece



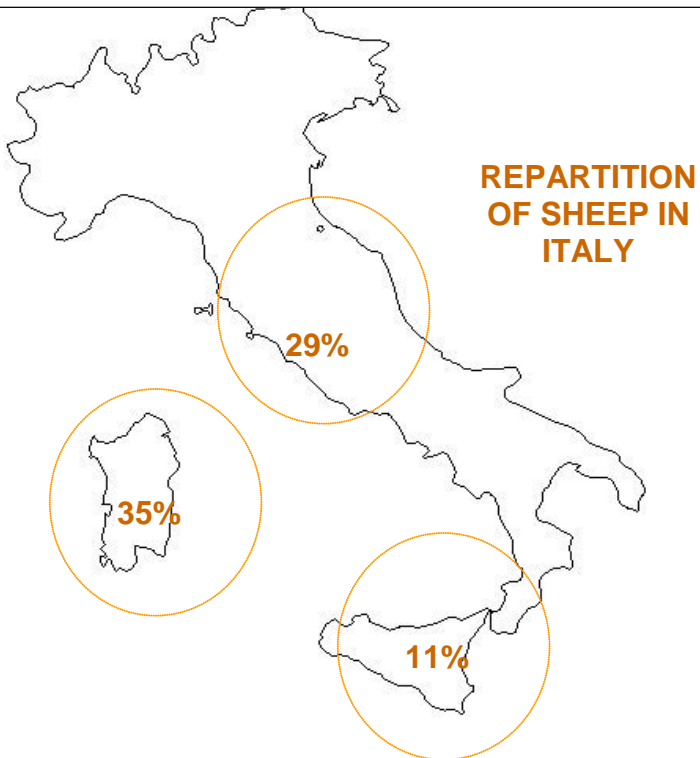
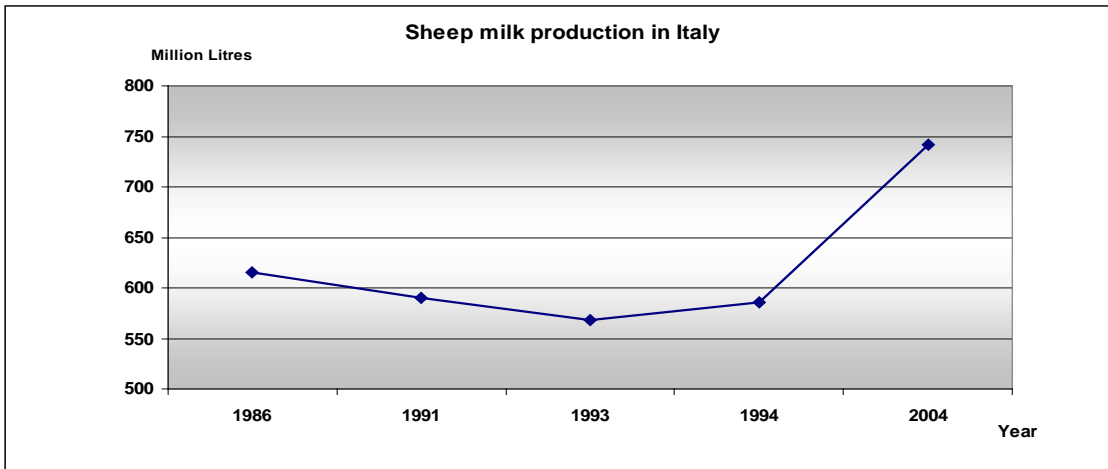
CHEESES	PRODUCTION (TONS)	TYPE OF MILK
ANEVATO	20	S - G
GALOTIRI	49	S - G
GRAVIERA AGRAFA	1030	S - G
GRAVIERA CRETE	3270	S - G
GRAVIERA NAXOS	400	S - G-C
KALATHAKI LIMNOS	120	S - G
KASSERI	3759	S - G
KATIKI DOMOKOS	30	S - G
KEFALOGRAVIERA	2189	S - G
KEFALOTIRI	3580	S - G
KOPANISTI	25	S - G-C
LADOTIRI MITILINI	70	S - G
MANOURI	315	S - G
METSOVONE	120	S - G-C
MPATZOS	10	S - G
XINOMIZITHRA CRETE	100	S - G
PICTOGALA CHANIA	20	S - G
SFELA	20	S - G
FETA	77797	S - G
FORMAELLA ARACHOVA	40	S - G
ANTHOTIRO	2591	S - G
MIZITHRA	5051	S - G
TELEMES	4267	S - G-C
MIZITHRA XIRI	2387	S - G

## Sheep Milk Economy in Italy

(Source: FAO – Assolatte)

In 2004, sheep economy in Italy:

- Production of milk: 742 Million liters
- Production transformed at the farm (M liters): 138 (19%)
- Production of cheeses: 95 000 Tons
- Production: 100 to 250 l / lactation
- Units processing sheep milk: average of 70 in Sardinia



The increasing of sheep milk in Italy is related to 3 factors :

- Collapsing of sheep meat economy : switch to milking sheep
- Improvement of breeding techniques
- Genetic selection



## Sheep Cheese Economy in Italy

Sheep cheeses in Italy are mainly represented by hard and semi-hard cheeses, easier to store in area with very hot climate. Major sheep cheese produced is Pecorino Romano (AOP), localized in Sardinia and Latium (Lazio, south of Roma), this production utilizes 30% of total sheep's milk.

CHEESE	TYPE OF MILK	PRODUCTION (Tons)
Canestrato Pugliese	S	62
Casciotta d'Urbino	S,C	200
Fiore Sardo	S	120
Murrazano	S,C	300
Pecorino Romano	S	38431/28400*
Pecorino Sardo	S	25000/12000*
Pecorino Siciliano	S	3200
Pecorino Toscano	S	2850/5060*
Raschera	S,C,G	160
Robiola di Roccaverano	S,C,G	55
TOTAL SHEEP CHEESES		67460
TOTAL MIX MILK CHEESES		70000



Fiore Sardo



Pecorino sardo



Pecorino romano



Robiola di Roccaverano

## Conclusions and Perspectives

- Even if we often qualify the small ruminants as « the poor man's cow », economics and development's perspectives are very positive for sheep (and goat) milk cheeses as we notice an increasing of production in most of European countries.
- Production of sheep milk's cheeses can be a vital source of revenues in some countries (areas) and/or a specific skill with very high value added (PDO – AOP cheeses)
- All over Europe, the main question is about the transmission of this production: succession, economics of the farms, workers, lack of land, regulations ....
- Quality signs (PDO / PGI / AOP ...) are powerful motors of the rural economy: those labels really permit to boost the production volumes (ex: Feta in Greece), sometimes detrimental to milk's price.
- All values / data concerning sheep milk production are either very difficult to find and verify, or begin to be old, not really representative of what is happening “now”

## MILK RECORDING AND GENETIC IMPROVEMENT

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Non-genetic factors such as nutrition, health programs, climate, housing, milking technique, etc. have a large effect on milk and lamb production of dairy sheep. However, these factors tend to have only temporary effects on production. For example, a particular ewe will produce large quantities of milk if well fed, but she will produce less milk if she is fed less. However, a dairy sheep's genetic make-up (genotype) is a permanent part of its biology that is always present. The animal's genotype sets the upper limit of its productive ability, and the genotypes of subsequent generations are improved through selection and/or crossbreeding.

### Selection

Selection is the act of determining which individuals are allowed to be the parents of the next generation. In order to make genetic improvement from generation to generation, ewes and rams selected to be parents need to have above average genetic values. Since we do not know the actual genotype or genetic value of an animal, selection is based on performance records of the animals. Performance is determined by both the genetic value (breeding value) and non-genetic (environmental) effects, and the goal is to select animals that have high levels of performance due to high breeding values and not due to good environments.

The increase in breeding value per year in a flock of dairy sheep due to selection is predicted by the following formula:

Increase in breeding value per year = (Genetic Variation x Selection Intensity x Accuracy of Breeding Value) / Generation Interval

Genetic variation – Flocks or population that have greater genetic variation among the animals will have greater genetic improvement per year than flocks or populations that are very uniform genetically.

Selection intensity – If a smaller proportion of available animals are selected, there is a greater opportunity to select truly superior animals, and genetic improvement is increased. If fewer animals are selected, selection intensity is increased.

Accuracy of breeding value – Breeding values are estimated from performance records. If performance records are accurate and indicative of genetic value, breeding values estimated from them will be more accurate, and genetic improvement is increased.

Generation interval – Generation interval is the average age of the parents when the lambs are born. Use of younger ewes and rams as parents will result in greater genetic improvement per year.

These four factors are not independent of each other. For example, in order to have a flock of very young ewes and a decreased generation interval (good for genetic improvement), a producer

would need to keep many ewe lambs back as replacements, which results in a low selection intensity (bad for genetic improvement). Therefore, there are trade-offs between these four factors. This discussion of selection will concentrate on obtaining accurate estimates of breeding value.

**Animal Identification.** All selection programs start with individual and unique identification of all rams, ewes, and lambs. The most common method of identification is the use of visual ear tags with a unique number. Electronic identification of sheep using either an electronic ear tag or rumen bolus can also be used.

**Performance Records.** Pedigree and performance records need to be maintained on each animal. The usefulness of these records is greatly enhanced if they are maintained electronically in a computer spreadsheet such as EXCEL. This allows easy manipulation of the data.

The performance traits to record should be limited to those for which selection will be practiced. Milk yield is the most important trait to record in a dairy sheep flock. Additional lactation traits that would be desirable to record would be milk composition (% fat and protein) and lactation length. Udder conformation traits may also be worthwhile recording. Since lamb production is an economically important trait, even in dairy sheep operations, the number of lambs born or raised by each ewe should also be recorded.

**Heritability.** Heritability of a trait is the proportion of phenotypic variation that is due to breeding value variation or, more simply, it is the proportion of differences between animals in performance that is due to differences in their breeding values. Traits of higher heritability are under greater genetic control than traits of lower heritability. A performance record for a trait of higher heritability is a better indicator of an animal's breeding value than a performance record for a trait of lower heritability. Table 1 presents estimates of heritability for some traits of dairy sheep.

Table 1. Heritability of dairy sheep traits.

Trait	Heritability
Milk, fat, or protein yield	.30
Fat %	.35
Protein %	.45
Udder shape	.25
Udder height/depth	.15
Rear udder attachment	.15
Teat placement	.25
Teat size	.20
Litter size born	.10

**Milk Yield.** Daily milk yields of individual ewes can be measured by weight if milking into buckets or by volume if using metering jars in a pipeline parlor. Milk yields then are recorded in liters, kilograms or pounds. Many of the metering jars are in metric units of volume (e.g. milliliters, liters), but most North American dairy sheep producers prefer to report milk yield by weight. A standard conversion for sheep's milk is: 1.0 liter = 1.036 kilograms = 2.279 pounds.

Official regulations regarding milk testing for all species, including sheep, are defined by the International Committee for Animal Recording (ICAR, <http://www.icar.org>). Individual milk recording should begin 4 to 15 days after the start of the machine milking period, and should be done every 28 to 34 days during the lactation period. The most accurate method of milk

recording is Method A4. At each recording date, the milk yield of each ewe is recorded at both the morning and evening milking, and the two yields are summed for the daily yield.

Since milk recording is time consuming, and therefore expensive, some alternative methods of milk recording are presented by ICAR. These alternate methods are not as accurate as Method A4, but they are far superior to no recording at all. With Method AC, individual milk yield is only recorded at one of the daily milkings, either the morning or evening milking. Total flock yield for the day is determined by measuring the total amount of milk in the tank from the two milkings. The sum of all individual tests is subtracted from total daily flock yield, and this difference is divided by the sum of all individual tests from the one milking. The resulting number is multiplied by each ewe's individually recorded yield to estimate the ewe's yield during the milking when she was not individually recorded. The actual yield and the estimated yield for each ewe are summed to estimate daily yield. A numerical example is below:

Example of Method AC:

- Total milk in tank after the a.m. and p.m. milking = 500 pounds
- Sum of all individual tests performed at the a.m. milking = 300 pounds
- $(500 - 300)/300 = .67$
- Actual production of a ewe at the a.m. milking when she was individually recorded = 3 pounds
- Estimated production of the same ewe at the p.m. milking =  $3 \times .67 = 2$  pounds
- Estimated daily production of this ewe =  $3 + 2 = 5$  pounds

A less precise method of estimating milk yield than either Method A4 or AC is Method AT. With Method AT, individual recording is only done at one milking per day, but the recorded milking is alternated between the a.m. and p.m. milking on alternate recording days. For example, a.m. milk is recorded in February, p.m. milk is recorded in March, a.m. milk is recorded in April, p.m. milk is recorded in May, and so forth. On each recording day, the amount of milk recorded at the one milking is multiplied by 2 to obtain an estimate of daily milk yield.

Once individual daily milk yields have been determined or estimated at approximate monthly intervals using one of the above methods, these daily yields are used to estimate total yield during the milking period. The following formula is used:

Estimated milk yield =  
[production 1st test day x no. days between start of milking and 1st test day]  
+ [(prod. 1st test day + prod. 2nd test day)/2 x no. days between 1st and 2nd test day]  
+ [(prod. 2nd test day + prod. 3rd test day)/2 x no. days between 2nd and 3rd test day]  
+ .....  
+[(prod. next to last test day + prod. last test day)/2 x no. days between next to last and last test day]  
+ [prod. last test day x no. days between last test day and end of milking).

Table 2 presents the estimated total milk yield of a ewe with eight test day milk yields measured at 28 day intervals using the above formula. Her estimated total milk yield is 837.4 pounds. These calculations are easily accomplished using a spreadsheet program like EXCEL.

Table 2. Estimated total milk yield calculated from daily milk yields.

Date	Event	Test day milk yield, lb.	Estimated interval milk yield, lb.	Estimated cumulative and total milk yield, lb.
1/21/2010	Start			
1/26/2010	Test 1	4.9	24.5	24.5
2/23/2010	Test 2	8.4	186.2	210.7
3/23/2010	Test 3	6.2	204.4	415.1
4/20/2010	Test 4	5.1	158.2	573.3
5/18/2010	Test 5	3.4	119	692.3
6/15/2010	Test 6	1.8	72.8	765.1
7/13/2010	Test 7	1.2	42	807.1
8/10/2010	Test 8	0.5	23.8	830.9
8/23/2010	End		6.5	837.4

In the dairy cattle and dairy goat industries, there are national programs in place that use lactation milk yields on individuals and all relatives to calculate an estimate of genetic value or PTA (Predicted Transmitting Ability) for each animal for milk yield. In order to improve the herd, producers simply select replacement cows/does and bulls/bucks with high PTAs and cull cows/does with low PTAs. Unfortunately, there are no national programs to calculate genetic values for dairy sheep in North America so selection and culling decisions need to be based on the lactation records of the individual or the dam.

Before these lactation records can be used in selection and culling decisions, they need to be adjusted for known non-genetic factors. Adjusted lactation records will provide a more accurate estimate of an animal's genetic value than unadjusted records. One of the most obvious non-genetic factors affecting milk yield is ewe age. On average, ewe lambs produce less milk than older ewes, not because they are necessarily poorer genetically, but because they are just younger. Table 3 presents "Age of Ewe" adjustment factors for lactation milk yield calculated from several thousand lactation records collected at the Spooner Agricultural Research Station. These factors adjust milk yield to a 4-year-or-older ewe equivalent. An interpretation of these adjustment factors is: 1) a ewe lamb is expected to produce 65% less milk than a 4-year-old ewe, 2) a 2-year-old ewe is expected to produce 14% less milk than a 4-year-old ewe, and 3) a 3-year-old ewe is expected to produce 6% less milk than a 4-year-old ewe.

If more than one weaning practice is used in your flock, lactation yields should also be adjusted for this non-genetic effect. Table 3 also presents adjustment factors for three weaning systems that have been used at the Spooner Agricultural Research Station:

DY1 = Lambs are removed from the ewe within 24 to 48 hours after birth and raised on milk replacer. The ewes are milked twice per day after removal of their lambs.

MIX = Lambs are nursed by the ewe for the first 30 days after birth. During this 30 day period, lambs are separated from their dams overnight, the ewes are milked once per day in the morning, and then the ewes are returned to their lambs until the evening. After this 30 day period, the lambs are weaned onto dry diets, and the ewes are milked twice per day.

DY30 = Lambs are raised by their dam for the first 30 days. After this 30 day period, the lambs are weaned onto dry diets, and the ewes are milked twice per day.

Ewes on the DY30 system and ewes on the MIX system are expected to produce 33% and 16%, respectively, less total milk than ewes on the DY1 system (Table 3).

Table 3. Age of ewe and weaning system multiplicative adjustment factors for lactation milk yield.

Non-genetic factor	Adjustment
Age of ewe, years:	
1	1.65
2	1.14
3	1.06
4 and older	1.00
Weaning system:	
DY30	1.33
MIX	1.16
DY1	1.00

An example of the use of these adjustment factors is presented in Table 4. Ewe 8005 has a lower actual milk yield than ewe 6038 (682 vs. 826 pounds). Ewe 8005's lower milk yield is largely due to the fact that she is younger than Ewe 6038. In addition, Ewe 8005 was under the MIX weaning system, and Ewe 6038 was under the DY1 weaning system. By using the adjustment factors in Table 3, Ewe 8005 as a 4-year-old ewe with DY1 weaning is expected to produce 902 pounds of milk – 76 more pounds than Ewe 6038 at the same age and with the same weaning system. Therefore, Ewe 8005 is expected to have a higher genetic value for milk yield than Ewe 6038. This example shows the importance of adjusting lactation records for known non-genetic effects before they are used in selection or culling decisions.

Table 4. Example of adjusting milk yields to a common age of ewe and weaning system.

Ewe	Actual milk yield, lb.	(Age of ewe, yr.) Adjustment	(Weaning system) Adjustment	Adjusted milk yield, lb.
8005	682	(2) x 1.14	(Mix) x 1.16	902
6038	826	(4) x 1.00	(DY1) x 1.00	826

If PTA's were available for milk yield for dairy sheep in North America, identification of genetically superior individuals would be easier, and the rate of genetic improvement would be faster than if adjusted lactation milk yields are used as the selection criteria. However, relatively large amounts of genetic progress are still possible by using these adjusted records.

By using estimates of genetic parameters and other assumptions, an estimate of the improvement in milk yield can be calculated. If replacement ewe lambs are selected from the

30% best ewes for average adjusted lactation yield, and if the average age of ewes in the flock is 4 years, the expected increase in flock milk yield from ewe replacement selection is 5.6 pounds of milk per ewe per year. Additional genetic progress can be expected from ram selection. If replacement ram lambs are selected from the 5% best ewes for average adjusted lactation yield, and if the average age of rams in the flock is 2 years, the expected increase in flock milk yield from ram replacement selection is 19.8 pounds of milk per ewe per year. Therefore, ram and ewe selection together is expected to increase flock milk production by 25.4 pounds or gross income by \$19.05 per ewe (assumes milk is worth \$0.75/pound). On a 200-ewe flock, this is an increase in income from milk of \$3,810 per year. Implementation of a genetic improvement program is not easy, but it can pay large financial rewards.

The above calculations assume that all the selection pressure is on milk yield, and this never happens in reality. There will be some selection on other traits which will lessen the amount of genetic improvement in milk yield. In the above example, ram selection results in 3.5 times more genetic progress than ewe selection. This is due to the fact that fewer rams are needed than ewes, and the selection intensity is higher on rams than on ewes. However, a 200-ewe flock cannot continually use only its own rams or inbreeding will start to decrease performance. Therefore, there need to be many flocks engaged in an active program of genetic improvement so that unrelated superior rams can be identified in other flocks for use in your flock.

**Additional Traits.** While milk yield should receive major attention in a selection program, there are additional traits that are of importance that should receive some attention. Once milk yield is at a high enough level, some selection pressure on milk composition (% fat and % protein) should be practiced in order to increase the total yield of milk fat and protein. On milk testing days, a sample of milk from each ewe should be sent to a certified milk testing laboratory for determination of % fat and protein. These percentages are multiplied by the daily milk yield to determine daily fat and protein production. The daily fat and protein yields can be substituted for the milk yields in the previous formula to obtain an estimate of yield of milk fat and milk protein during the lactation. The estimated lactation yields of fat and protein are divided by the estimated lactation milk yield to determine the average % fat and % protein over the entire lactation. A simple average of the % fat and % protein values from each test day will give you an upward biased estimate of total lactation milk composition because % milk components tend to increase in late lactation when milk production is lowest.
















Desirable udder conformation is related to both milk yield and ease of machine milking. Characteristics of a desirable dairy ewe udder are:

1. Large udder, primarily in circumference
2. Strong udder cleft – two well-defined udder halves
3. Udder not below the hocks
4. Teats at the bottom of the udder
5. Teats of adequate length and diameter, but not too large

Udder conformation deteriorates with increased milk production and with increased age. Udder conformation traits are moderately heritable (Table 1) so reasonable amounts of improvement can be expected from selection. However, intensive selection for small, well-shaped udders can have a negative effect on milk yield. Spanish researchers have developed a scoring system for

some of the more important udder traits (Figure 1) so that udder conformation can be quantified. Scoring udders of ewes each lactation will allow producers to identify lines of ewes or sires that produce poor udders.

Figure 1. Scoring system for udder traits.

Variable	Evaluation		
	1 point	5 points	9 points
Udder depth			
Udder attachment			
Udder shape			
Teat placement			
Teat size			

Lamb production, number of lambs marketed per ewe per year, is a very important trait for economic viability of a dairy sheep operation. Lamb production has been of even more importance the past year than in previous years since we have been experiencing record high lamb prices, and these high prices are expected to continue for at least the next few years. Fortunately, both the East Friesian and Lacaune dairy breeds have naturally high prolificacy so selection for increased litter size should definitely be secondary to selection on lactation traits in most operations. Making sure that your ram replacements come from dams with both high lifetime milk yield and high lifetime lamb production is probably sufficient selection pressure on prolificacy.

### Crossbreeding

Breed complementarity and hybrid vigor are the two reasons that crossbreeding is used in many livestock operations. Breed complementarity is the utilization of the strong points of two or more breeds. For example, some dairy sheep producers may wish to improve the growth, feed



efficiency, and carcass merit of their market lambs. This could be done by mating a Hampshire or Suffolk ram to the bottom portion of the dairy ewes and selling all of the resulting lambs. This crossbreeding system takes advantage of the high litter size of dairy ewes and the good growth of blackfaced rams to produce lots of lambs with better growth and carcass traits than if they had been of straight dairy breeding.

Hybrid vigor is the increased performance of crossbreds compared to the average performance of the purebreds that made up the cross. Table 5 presents estimates of individual hybrid vigor (increased performance from the production of crossbred lambs from purebred ewes) and maternal hybrid vigor (increased performance from the production of crossbred lambs from crossbred ewes). Pounds of lamb weaned per ewe mated is expected to increase by 18% if the lambs are crossbred instead of purebred, and a further increase of 18% is expected if these crossbred lambs are produced from crossbred ewes. For lamb production, an increase over purebred production of over 36% when crossbred lambs are produced from crossbred ewes cannot be ignored. The existence of this high amount of hybrid vigor is a major reason why the vast majority of the lambs marketed each year are crossbreds. You will note that I have arbitrarily decreased the amount of maternal hybrid vigor that might be expected for some of the lamb traits if the lambs are reared artificially. Milk yield also shows hybrid vigor – a crossbred ewe resulting from the crossing of two different purebreds is expected to produce 6% more milk than the average of the two purebred breeds.

Table 5. Estimates of hybrid vigor for lamb production and milk yield.

Trait	Individual, %	Maternal, %
Conception rate	2.6	8.7
Litter size	2.8	3.2
Lamb survival	9.8	2.7 (0.9)
No. lambs weaned/ewe mated	15.7	14.8 (13.0)
Lamb weaning weight	5.0	6.3 (2.1)
Lamb wt. weaned/ewe mated	17.8	18.0 (14.2)
Lactation milk yield	6.0	-

Following are the results of a simulation of production and gross income from a crossbreeding system utilizing East Friesian, Lacaune, and Hampshire sheep. Table 6 presents the expected performance of these breeds as purebred ewes producing purebred lambs. These data are estimated from the performance of these breeds at the University of Wisconsin-Madison. Hampshire lambs are expected to weigh more at 90 days of age than lambs of the two dairy breeds. Between the two dairy breeds, the number of lambs raised to 90 days per ewe is expected to be about the same (1.58). East Friesian ewes give birth to more lambs but their survivability is

lower compared to Lacaune ewes. The Lacaune lambs are expected to be slightly heavier at 90 days of age, and East Friesian ewes are expected to produce slightly more milk than Lacaune ewes.

Table 6. Expected performance of purebred ewes producing purebred lambs.

Breed	Fertility, %	Litter size, no.	Lamb survival, %	Lambs at 90 d / ewe, no.	Lamb 90 d wt., lb.	Lb. lamb at 90 d / ewe	Milk yield, lb.
E. Friesian	96	1.98	83	1.58	66	104	695
Lacaune	96	1.86	88	1.57	68	107	665
Hampshire					80		

Figure 2 presents a possible crossbreeding system using these three breeds. The replacement dairy ewes are produced by rotating between East Friesian and Lacaune sires. East Friesian rams are mated to ewes whose sire was a Lacaune ram, and Lacaune rams are mated to ewes whose sire was an East Friesian ram. Approximately 30% of the flock ewes are bred to dairy rams and produce replacement ewes for the entire flock and some male dairy market lambs. The remaining 70% of the flock ewes are bred to Hampshire rams to produce good market lambs, and all the Hampshire-sired lambs (males and females) are sold as market animals.

Figure 2. Three-breed rotational-terminal crossbreeding system.

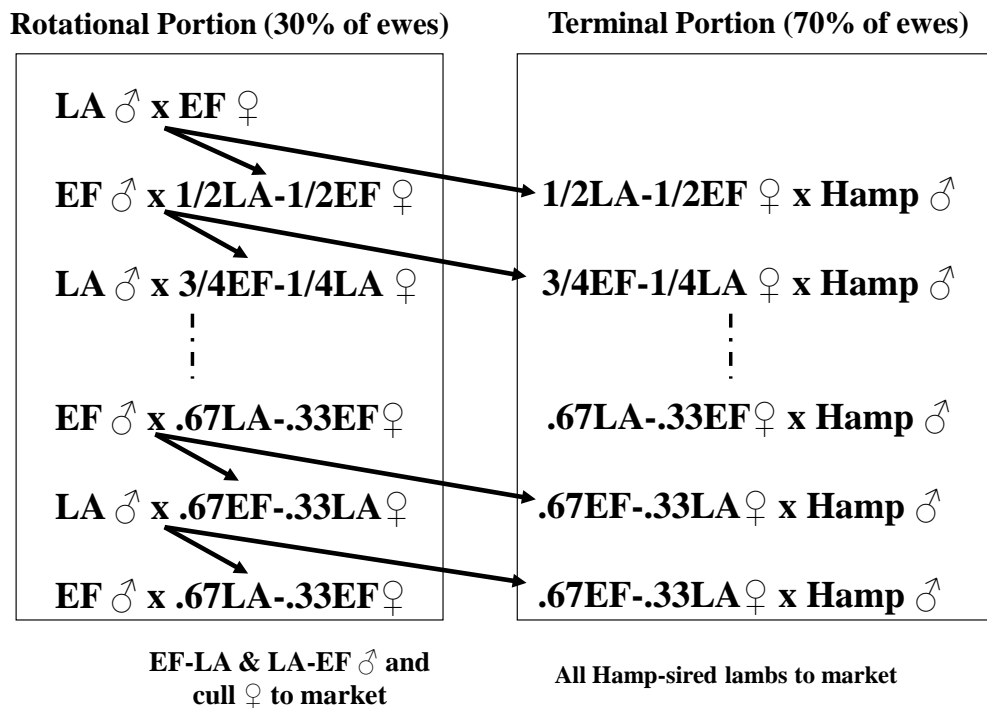


Table 7 presents the estimated gross income per ewe for a flock of purebred East Friesian, a flock of purebred Lacaune, and a flock in which the crossbreeding system in Figure 2 is used. The flocks of purebred East Friesian and Lacaune ewes are expected to have gross incomes of approximately \$658 and \$638, respectively. This compares to a gross income per year of approximately \$724 for ewes in the crossbreeding system in Figure 2. The crossbreeding system is expected to generate \$66 to \$86 more per ewe than purebreeding with East Friesian or Lacaune. On a flock of 200 ewes, this is \$13,200 to \$17,200 more gross income from crossbreeding. Just as was shown for the economic value of selection, crossbreeding offers the promise of large financial gains.

Table 7. Estimated gross income from purebreeding and crossbreeding.

System	Lb. lamb sold at 90 d / ewe	Lamb price, \$/lb.	Lamb income, \$/ewe	Milk yield, lb.	Milk price, \$/lb.	Milk income, \$/ewe	Total income, \$/ewe
<u>Purebred</u>							
E. Friesian	91 <sup>1</sup>	1.50	136.50	695	.75	521.25	657.75
<u>Purebred</u>							
Lacaune	93 <sup>1</sup>	1.50	139.50	665	.75	498.75	638.25
<u>Roto-terminal crossbreeding system</u>							
Rotation (30% ewes)	86 <sup>1</sup>	1.50	129.00	707	.75	530.00	659.00
Terminal (70% ewes)	147	1.50	220.50	707	.75	530.00	750.50
Overall	129	1.50	193.50	707	.75	530.00	723.50

<sup>1</sup> Weight of lamb sold per ewe does not include the ewe lambs retained for replacement (0.20 lambs per ewe in purebreds and 0.67 lambs per ewe in the rotation).

If the demand for dairy replacement ewes is strong, a dairy sheep producer may prefer to not breed any ewes to a terminal sire like the Hampshire. The producer may wish to keep his/her options open and have excess dairy ewe lambs available for sale if there is demand. In this case, the producer could rotationally mate all ewes in the flock to East Friesian and Lacaune rams as demonstrated in the left side of Figure 2. Eventually the ewes in the flock would be of two types: 2/3 East Friesian, 1/3 Lacaune or 2/3 Lacaune, 1/3 East Friesian. This flock would be expected to produce 119 lb. of lamb per ewe (not including the ewe lamb replacements needed to maintain flock numbers) and 707 pounds of milk per ewe. If no replacement dairy ewe lambs were sold from this flock and all excess dairy lambs were sold as market lambs, there would still be \$708 of gross income per ewe which is only \$16 less income per ewe than expected by using a Hampshire ram on 70% of the ewes as in Figure 2. There would be potential for greater income per ewe than the \$708 if some of the excess dairy ewe lambs could be sold as replacements at greater prices than market lambs. In an expanding dairy sheep industry, this may be a better crossbreeding strategy than using a Hampshire ram on a portion of the flock.

For the most part, the industry is using a crossbreeding system more like the dairy rotation described in the paragraph above than the rotational-terminal system in Figure 2. The difference between practice and the pure rotation on the left side of Figure 2 is that the dairy rams used in practice are often an East Friesian-Lacaune cross. The use of dairy-cross rams on dairy-cross ewes will result in less hybrid vigor than the use of pure dairy rams on dairy-cross ewes in an organized rotation.

To maximize the performance of either the rotational-terminal or the rotational systems, there needs to be good sources of purebred East Friesian and Lacaune rams. Some dairy sheep flocks should be breeding purebred animals so that there is a ready source of purebred rams for crossbreeding systems. As can be seen in Table 7, these purebred flocks would be expected to produce less milk and fewer lambs than crossbred flocks, but their income could be greater than indicated in Table 7 due to the sale of purebred breeding rams for a premium price. While there may be enough purebred East Friesian animals in North America to provide purebred East Friesian rams to producers wishing to crossbreed, there are not enough purebred Lacaune flocks in North America (none in the U.S.) to provide the needed purebred Lacaune rams. As the industry grows and as new genetics is made available, purebred flocks of the dairy breeds should be established to service the larger commercial dairy sheep industry.

# SIRE REFERENCING PROGRAM

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## Background

The dairy sheep industry is relatively young in North America, with few genetic lines. According to Berger, in 2009 there were less than 30 genetic lines of dairy sheep in the United States and Canada. Due to restrictions on importation from many European countries, none of these importations into North America occurred after 1998. Between 1993 and 2002, genetic lines were traded between the United States and Canada. However, with the discovery of the first case of BSE in 2002, the border between the United States and Canada was closed to all live animal importation.

These limits to genetic improvement through importation emphasize the need for producers to improve genetics through within-flock and between-flock selection. Evidence of the potential improvement from within-flock selection can be seen at the Spooner Agricultural Research Station.

As previously reported, milk production of ewes in the Spooner flock has continued to increase from an average of 176 lb milk/mature ewe/lactation in 1996 to an average of 755 lb milk/mature ewe/lactation. In this time, there have been many changes to flock management which have contributed to this increase. Some of the factors include lambing time, length of lactation, weaning system, nutrition, general management skills, and genetic selection.

Since 2004, there has been standardization in some of these management techniques. The majority of lambs are weaned at day 1 (less than 15% are allowed to nurse to 30 days). The genetic make-up of ewes has stabilized to 50 to >75% dairy genetics. Based on the number of years of management, many of the initial management challenges have been overcome. Due to selection using milk production records, average milk yield has continued to increase (Table 1).

Table 1. Change in milk yield and days in milk for yearling and mature ewes in Spooner flock.

		2004	2010
Yearling Ewes	Av. lactation length (days)	492	522
	Av. milk yield (lb/lactation)	162	193
Mature Ewes	Av. lactation length (days)	755	859
	Av. milk yield (lb/lactation)	212	228

Among dairy rams utilized in the Spooner flock, Casellas and Thomas (2005) reported the calculated breeding values of all East Friesian rams used at the Spooner Research Station. From this analysis, two rams originating from Holland and Germany had the highest breeding values for improving milk yield among offspring. With sufficient milk production records, producers could identify high quality genetics within North American dairy sheep lines.

In cooperation with the United States Department of Agriculture Animal Improvement Programs Lab (AIPL; Beltsville, MD), we have begun to create a template for milk production records for dairy sheep. The AIPL currently evaluates dairy cattle and dairy goat milk production records, making results public via its website: <http://aipl.arsusda.gov/>. Working with two data sets from Wisconsin farms, we are in the process of entering the data and evaluating the genetic merit of ewes and rams across these flocks. The following information must be included in the submission file.

### **Pedigree Data**

#### **Animal**

Breed (XX = < 50% dairy, XD = 50-75% dairy, DD = > 75% dairy  
DO = Dorset, EF = East Friesian, LA = Lacaune, KA = Katahdin)

Country of Origin

Eartag (12 digit code identifies state/province (3 digits), farm (3 digits), animal (6 digits))

Birthdate

Multiple birth type (1, 2, 3, 4)

Sire Breed

Country of Origin

ID (coded to 12 digit number)

Dam Breed

Country of Origin

ID (coded to 12 digit number)

### **Lactation Data**

Date left flock

Lambing date

Litter size

Weaning system (Day 1, 30 Days, Mixed)

Total Lactation: Lactation number

Date

Days in Milk (tested)

Actual Lactation Length (from lambing to dry-off)

Number of test days

Total milk yield

Total fat yield

Total protein yield

For each test date: Days in milk at test

Number of milkings tested (1, 2)

Number of milkings sampled (1,2)

% milk shipped

Milk yield

Fat yield

Protein yield

Somatic cell count

Currently, the AIPL conducts genetic evaluations for performance of dairy cattle three times per year and evaluations for dairy goats annually (July). Genetic evaluations are conducted on milk, fat, and protein yield, fat and protein percentage, productive life, and somatic cell score. Figures 1 and 2 are examples of the most recent evaluations for dairy goats.

Figure 1. Example analysis of dairy goats bucks. Accessed October 27, 2010 at <ftp://aipl.arsusda.gov/pub/adga/topbuck>

AI												1
USDA-DHIA GENETIC EVALUATIONS FOR TOP 15% OF BUCKS WITH RECENT DAUGHTERS FOR JULY 2010												
REGISTRATION NUMBER	NAME	HERDS	DAUS	LACTS	REL	----PREDICTED TRANSMITTING ABILITIES-----					PCTILE	
						MILK	FAT	FAT %	PROT	PROT %		
					(%)	(LB)	(LB)	(%)	(LB)	(%)		
001329054 AM	COACH FARMS PERRYN	2	22	49	57	368	12.8	-0.02	10.4	-0.04	99	
001049959 AM	COACH-FARMS LINX	2	107	283	65	407	6.3	-0.33	10.2	-0.09	99	
001103549 AM	COACH-FARMS LINCOLN	3	31	99	59	322	10.5	-0.05	8.5	-0.06	98	
000920015 AM	COACH-FARMS ZACHARY	3	113	365	73	364	7.9	-0.21	8.0	-0.12	98	
000974406 PB	COACH-FARMS KALTHIUS	3	82	242	76	236	7.4	-0.05	7.5	0.01	97	
001338415 PB	SUNSHINE ROSEMA REMEDY	2	9	12	47	220	8.6	0.02	6.1	-0.03	97	
001165450 PB	SUNSHINE REHMA REPRISE	3	39	66	67	193	7.0	-0.01	6.3	0.01	96	
001312983 PB	SUNSHINE MALOVOR MUSCAT	2	45	102	58	258	4.9	-0.19	6.0	-0.08	96	
001340326 AM	REDWOOD HILLS JAEGER	5	10	17	54	127	6.3	0.06	5.1	0.05	95	
000663711 PB	TANGLEROOT RISING SUN	14	121	389	87	86	4.0	0.03	5.7	0.13	94	
001113298 AM	THREE-RINGS TITAN	3	8	13	58	124	5.6	0.04	4.9	0.04	95	
001255119 PB	SUNSHINE GYNIRY GYRO	3	5	8	46	145	5.9	0.02	4.6	0.00	94	
001075088 AM	MAMM-KEY WN SPIKE	4	25	44	75	149	2.4	-0.14	4.8	0.00	93	
001085273 PB	SUNSHINE SEIGN SEDRIC	7	13	30	77	40	4.6	0.13	4.0	0.12	93	
001283063 AM	MAMM-KEY MS MURPHY	2	60	173	59	230	1.9	-0.27	4.4	-0.11	92	
001278555 PB	POPLAR-HILL SLOW AXEL	2	22	37	63	98	1.8	-0.08	4.5	0.06	92	
001294104 AM	POPLAR-HILL FLASH PROPELLER	2	6	13	42	149	0.7	-0.21	4.5	-0.01	91	
000760205 AM	MILK-E-WHEY ZINDER A&M	4	16	43	57	83	3.8	0.03	3.0	0.02	90	
181155091 AM	MAMM-KEY SLAMMER'S TITANIUM	5	12	26	60	189	3.1	-0.16	2.9	-0.13	90	
000720150 PB	POPLAR HILL SUN CHARIOTEER	4	124	419	81	56	3.7	0.07	2.8	0.04	90	
000916291 PB	BAYVIEW IMPROVER	5	6	9	45	43	4.0	0.10	2.7	0.06	89	
001096362 PB	SUNSHINE REHMA RELENT	3	5	10	57	96	3.9	0.01	2.2	-0.04	88	
001149772 PB	SUNSHINE CONINA CONDOR	5	58	92	73	13	4.1	0.16	2.6	0.09	89	
181172381 AM	THREE-RINGS WASABI	3	5	7	62	46	5.6	0.17	1.5	0.00	88	
001061227 PB	SUNSHINE REHMA REUTER	3	19	52	66	-49	1.3	0.13	3.1	0.21	87	
001190806 PB	BAYVIEW ULTIMATE WARRIOR	2	5	11	40	5	3.5	0.14	1.9	0.07	87	
001271542 AM	TEMPO AQUILA FREELANCE	4	32	56	66	50	2.5	0.02	2.0	0.02	86	
000733112 PB	LE CHEVRIER RMN ROC	16	20	42	81	-18	-0.9	-0.02	3.0	0.16	86	
001185600 PB	BLUFF-TOP BG PUTT	3	13	30	54	-45	2.7	0.19	1.4	0.12	85	
001422620 AM	REDWOOD HILLS REVOLUTION SPEED	2	5	7	41	75	0.3	-0.11	2.0	-0.02	85	

Figure 2. Example analysis of dairy goats does. Accessed October 27, 2010 at <http://aipl.arsusda.gov/pub/adga/topdoe>

REGISTRATION		Name	SIRE	HERDS	DAU	EQ	LACTREL	--PREDICTED TRANSMITTING ABILITIES---					
HERD	NUMBER							MILK	FAT	FAT %	PROT	PROT %	PCTILE
							(%)	(LB)	(LB)	(%)	(LB)	(%)	
13145568	21CDT0223		000920015	1	5.6	3	64	509	13.0	-0.21	12.4	-0.12	96
13145568	21CDT0239		001186752	1	4.7	3	62	542	14.2	-0.20	14.6	-0.07	98
13145568	21CDW0191		001388096	1	0.0	2	51	387	14.1	-0.00	11.6	-0.01	95
21105454	001384421	AM COACH FARMS JOLIE	001097115	1	4.1	3	59	485	13.3	-0.16	11.3	-0.13	95
21105454	001509247	AM COACH FARMS CHARRUD	001186752	1	5.4	6	65	496	15.3	-0.10	13.0	-0.08	98
21105454	21CDR0075		181851792	1	4.0	5	60	519	11.6	-0.27	12.8	-0.11	96
21105454	21CDR0159		001049959	1	3.4	5	62	520	14.5	-0.16	13.4	-0.09	98
21105454	21CDR0235		001136345	1	3.2	6	63	475	14.7	-0.10	11.5	-0.11	96
21105454	21CDR0261		001097111	1	5.1	4	64	400	15.6	0.04	11.5	-0.03	96
21105454	21CDS0011		181173276	1	2.7	4	59	497	13.5	-0.17	12.4	-0.10	96
21105454	21CDS0028		001186751	1	0.0	5	57	444	18.5	0.09	14.1	0.02	99
21105454	21CDS0038		181173276	1	2.2	4	59	573	15.4	-0.20	16.6	-0.03	99
21105454	21CDS0107		001202460	1	6.0	5	64	439	16.0	-0.00	13.5	0.00	98
21105454	21CDS0120		001186752	1	6.6	4	66	547	15.3	-0.17	13.6	-0.12	98
21105454	21CDS0141		001186752	1	7.5	4	66	491	11.3	-0.25	13.1	-0.07	96
21105454	21CDS0149		001202460	1	3.3	4	61	496	14.7	-0.13	13.6	-0.06	98
21105454	21CDS0150		001097115	1	6.0	4	64	541	14.4	-0.19	14.9	-0.06	99
21105454	21CDS0221		001186751	1	6.1	4	64	514	13.5	-0.19	12.7	-0.11	97
21105454	21CDS0222		001186751	1	2.9	4	60	477	12.3	-0.19	11.9	-0.10	95
21105454	21CDT0003		001186752	1	5.3	4	64	456	18.7	0.08	14.4	0.01	99
21105454	21CDT0127		001320721	1	2.1	4	59	507	16.4	-0.08	12.0	-0.13	97
21105454	21CDT0135		001202460	1	2.8	3	59	568	10.0	-0.39	14.5	-0.11	97
21105454	21CDT0140		001202460	1	5.3	4	63	605	14.9	-0.25	17.3	-0.04	99
21105454	21CDT0201		000920015	1	0.0	3	57	554	14.6	-0.20	12.9	-0.15	97
21105454	21CDT0220		001186752	1	0.0	4	55	500	11.7	-0.24	13.3	-0.07	96
21105454	21CDT0238		001186752	1	2.7	4	61	472	11.5	-0.21	12.3	-0.08	95
21105454	21CDT0240		001186752	1	0.0	4	57	445	12.8	-0.13	12.1	-0.06	95
21105454	21CDV0008		001320724	1	0.0	3	54	598	15.3	-0.23	15.5	-0.10	99
21105454	21CDV0010		001320722	1	0.0	3	54	609	13.9	-0.29	16.0	-0.09	99
21105454	21CDV0028		001320721	1	2.2	4	58	494	14.3	-0.14	12.9	-0.08	97
21105454	21CDV0041		001186752	1	7.0	4	65	521	15.1	-0.14	14.1	-0.07	98
21105454	21CDV0049		001329054	1	0.0	3	54	433	13.3	-0.09	12.1	-0.04	95
21105454	21CDV0058		000920015	1	0.0	3	56	522	12.4	-0.24	12.7	-0.12	96
21105454	21CDV0059		001320722	1	4.7	3	62	582	16.2	-0.18	15.5	-0.08	99
21105454	21CDV0070		001097115	1	5.5	3	64	479	15.4	-0.08	12.3	-0.09	97

In these evaluations, the predicted transmitting ability (PTA) indicates the expected change in progeny performance compared to the average of the population. Therefore, the transmitting ability is the genetic advantage that an individual transmits to its offspring. These values are based on the animal's own records and the performance of known relatives across herds and thus across environments. For example, a doe with a milk PTA of 368 lb will produce 148 lb more milk than a doe with a milk PTA of 220 lb, if their dams had similar genetic merit. The actual difference would not be exactly 148 due to slight differences in genetic makeup or environment. The greater the number of records that contribute to the evaluation, the stronger the predictive value of the evaluation.

### Literature Cited

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## ANTIBIOTIC TESTING OF SHEEP MILK

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### Background

For over a decade sheep milk was allowable in the Grade “A” market using antibiotic testing methods that were given temporary approval using testing that was known to be effective for milk from cattle. There had been assurances made when sheep milk was allowed into the Grade “A” market that validation studies to demonstrate suitable tests that would work for sheep milk would be performed. Manufacturing grade milk has similar issues in that the manufactured milk standard requires antibiotic testing of all milk with a test approved by FDA.

The NCIMS, together with FDA, is responsible for the FDA Grade A Pasteurized Milk Ordinance (PMO). There is a technical committee dedicated to issues for types of livestock that wish to be considered for Grade “A” as well as other issues that arise on dairy livestock other than cattle. That committee is called the Other Species Committee and is currently chaired by Lynn Hinckley and vice chair is Dan Scruton. In 2007 FDA informed the Other Species Committee that an antibiotic residue validation study specifically for sheep milk must be completed. From a public health perspective it was unacceptable to assume that the tests validated for goat and cattle milk would also give the same result when used with sheep milk. The temporary approval given to sheep to use a specific group of tests that had not been validated for sheep was to be rescinded in 2009 effectively removing sheep milk from the Grade “A” program. It also would have made sheep milk ineligible for the USDA manufactured milk program.

A number of companies were asked to participate in the validation study and three had shown interest but, in the end only one company agreed to participate. This one company saved the sheep milk industry, because if a validation had not been done there would no longer be an antibiotic test acceptable to FDA. This company, Charm Sciences, donated time and materials to help a small industry and therefore they should be congratulated. FDA worked with the sheep milk industry by preparing the Study Protocol and reviewing the study results within the allotted time period. During the 2009 NCIMS conference, the study was accepted and sheep milk remained eligible to be a Grade “A” product. This was the result of cooperation between FDA, Industry, states and sheep milk producers doing what was necessary to maintain the ability of sheep milk processors to produce and sell sheep milk products.

Chris Hykema of New York Department of Agriculture and Markets was the key player who oversaw the study. The study includes two major phases. Phase one involves taking sheep milk and spiking it with antibiotics to see if the test can accurately find the drugs at the levels specified in the study. The second phase involves treating sheep with antibiotics and testing the milk regularly until the results are all negative to see if the test works on individual sheep milk. During this phase milk samples were frozen until they could be transported to the laboratory for testing.

## **Challenges Facing Regulators**

One of the challenges is what milk needs to be tested. One would think this was a straightforward question but it is not. In the Grade A program the term used is all “bulk milk pickup tankers” some states have inferred that does not include producer dealer operation where there isn’t a tank truck or where no comingling with other farms occurs. On the manufactured milk side the situation is murky for a different reason. It requires drug testing for all milk “shipped for processing or intended to be processed on the farm where it is produced” shall be tested but it adds that it shall be done “according to procedures established by the appropriate State regulatory agency”. It goes on to say that test used have to be validated, and the validation approved by FDA. The question raised is can state promulgate rules that do not include drug testing?

## **Challenges Facing Processors**

Sheep milk processors have the challenge of only having one test available. In the past one of the test FDA had given temporary approval to did not use a reader so it had a lower up-front cost than the Charm SL that does include a reader. To help mitigate that Charm Sciences has made a number of refurbished units available at a significantly reduced cost. It is anticipated that eventually all drug test kits will include readers so this is not a long term issue.

## **What is Vermont Doing?**

Vermont’s main sanitation standard is the PMO and we regulate all farms and processors to be in substantial compliance with the standards laid out in the PMO. We also consider our main function is to protect public health. All of our sheep producers are having all of their milk tested utilizing the approved test. For the non-grade “A” products we allow the processor to freeze a sample each day they process and our inspectors pick them up each month and take them to our lab where they run the samples using the state’s approved equipment. We charge \$8.00 per sample for this service. The processors have the option of having any lab certified under the NCIMS program run the sample. Anyone producing a Grade “A” product such as yogurt, or a product to be sold fresh, must have the sample run using fresh milk. The 2400 form used as instruction to the certified labs requires that all milk be run fresh but where the protocol approved by FDA used frozen samples for part of the testing we do not consider this a significant deviation. Our goal is to have all of the milk tested and shown to be negative before any finished product is sold. With aged cheeses the frozen milk system was a reasonable alternative. The producers must identify every batch and hold it until the testing is completed.

## **What Next?**

It is anticipated there will be a proposals sent to the NCIMS to clarify the frozen milk issue and the bulk milk issue. This should at least set a level playing field across the US. Those states that have their own rules and regulations will have to do similar changes or risk the loss of their ability to ship products to other states. States are only obligated to accept cheese and other dairy

products into their state if they were produced in substantial compliance with the minimum standards set out in the FDA Grade “A” PMO and the USDA manufactured milk standard. Some have suggested the Other Species Committee should get other tests approved but the challenge there is the study was offered to wide group of companies and all but Charm Sciences declined to participate. There is significant cost in setting up the study and it will be difficult to raise the money needed for a second round of studies and even then we need companies to volunteer to have their test kits validated.

## DAIRY SHEEP UPDATE – ONTARIO

**Mike Foran**  
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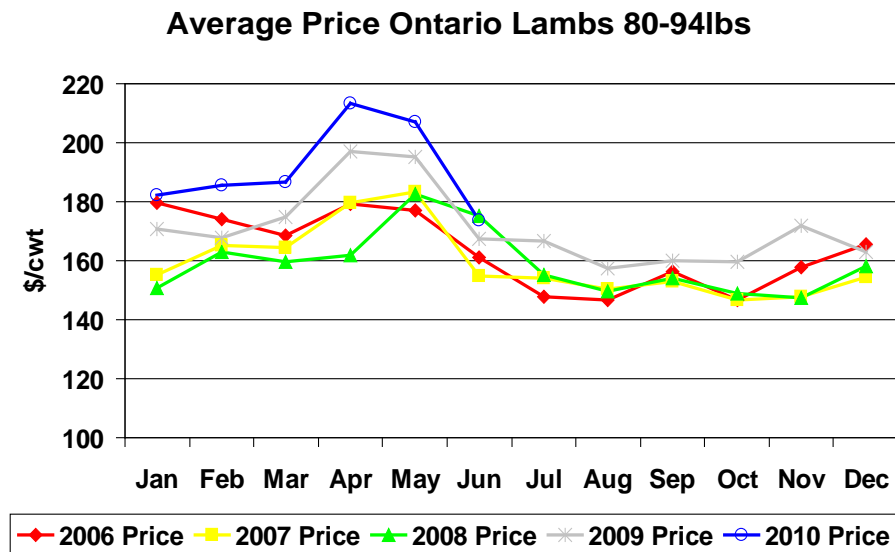
Ontario's dairy sheep industry has seen some growth in recent years. There are about 60 dairy sheep farms. The industry is quite diverse. There are 20 small hand milking operations milking 60 sheep or less, farms milking between 100 and 300 and a couple farms milking over 500 sheep. There are 4 on farm processing facilities. There are a variety of reasons why Ontario has seen growth in dairy sheep:

### Stable Sheep Milk Processing Sector

The main reason for growth in the dairy sheep sector has been stable sheep milk processors dedicated to producing quality sheep milk products.

### Demand For Lamb In Ontario - Milk Plus Meat Enhances Profitability

Canadian producers supply approximately 40% of lamb currently purchased by domestic consumers. Approximately 50% of the new immigrants to Canada in the last census period between 2001 and 2006 came to live in Ontario. Foreign born individuals make up 28.3 percent of Ontario's population. Many of these people come from countries with a much higher annual consumption of lamb than Canada. This has contributed to a slow but steady rise in the per capita consumption of lamb over the last decade. The average monthly prices received for 80 – 94 lb lambs in 2009 were generally higher than the previous three years. This trend has continued into the first half of 2010 with producers receiving some of the highest prices ever seen in Ontario.



Source: Statistics Canada

Yearly Average Prices for 80 to 94 lb. Lambs (dollars / hundred lbs)			
	Ontario	Quebec	US (US \$) San Angelo, TX
2010	191.43	N/A	131.37
2009	170.93	N/A	102.75
2008	158.85	150.72	101.70
2007	159.01	154.80	97.35
2006	163.34	162.87	94.33
2005	148.11	141.98	97.78
2004	109.81	115.36	96.73

*Source: Red Meat Division, Agriculture and Agri-Food Canada*

The Ontario sheep industry is in an enviable position in agriculture with the domestic marketplace demanding their product. The biggest challenge for the industry is to improve supply to the marketplace before consumers either find the product somewhere else or become used to substituting other meat products for lamb. The sheep industry is expected to continue to grow as prices remain good.

### **Ontario Dairy Cow Sector**

The cost and availability of cow milk quota may have some impact on an Ontario farmer's decision to consider dairy sheep. Below is a very brief explanation of the very complex dairy cow supply management / quota system.

Dairy Farmers of Ontario (DFO) administers the supply management system for cow milk production in the province. The milk quota system matches production to domestic demand, meaning there are almost no exports. Quota value / cost (in Ontario) is \$25,000 / kg of daily butterfat production. For average production this equates to approximately \$25,000 per cow. At present quota is extremely hard to buy as demand is far greater than supply. The September 2010 price paid to Ontario farmers (within quota) after marketing expenses like trucking was \$74.68 per hectoliter. If milk is shipped over quota, the producer receives no money for the over production and is charged for the shipping. Milk price is based on a formula that is equal to cost of production plus a fair return on labour and capital.

4,200 farms

320,000 cows

Ave herd size = 76 cows

Total Ontario production annually ~ 2.5 billion litres ~ 5.7 billion pounds

### **Other Trends / Issues Impacting the Dairy Sheep Sector in Ontario**

The dairy goat industry has seen significant growth in 2006, 2007 and 2008. Ontario is now has 265 dairy goat producers. The dairy goat industry is not supply managed. At present there are very few new entrants to the industry as Ontario is close to a milk surplus situation.

There have been a few hog producers who have successfully switched to dairy sheep or dairy goats. The hog industry in Ontario has experienced very low prices for a number of years with many producers looking at growth industries to invest in.

The trend toward local food has helped the dairy sheep industry. The Government of Ontario is supporting local food through the Market Investment Fund (OMIF). This is a provincial initiative to promote consumer awareness of Ontario-produced foods and encourage Ontarians to buy locally. The objectives of the Ontario Market Investment Fund are to develop opportunities through trade events, marketing campaigns and industry research initiatives that foster partnerships and collaboration for the promotion of Ontario foods. Below are examples of projects funded through OMIF

Kitchener-based 100 Mile Markets used innovative methods to buy and distribute product to local food institutions, food service and retail customers. The company used a variety of marketing campaigns that included a web portal, point of sale displays, vehicle signage, literature and samples.

Fifth Town Artisan Cheese encouraged cheese lovers to visit one of Ontario's tourist and wine regions, Prince Edward County. The company's dairy is located near wineries and tourist areas. Fifth Town used promotional channels like a website, brochure and advertising. It also conducted market research via social media channels.

Prince Edward County developed and executed a marketing campaign focused on promoting locally made food and beverage items including cheese, meat, maple syrup, jams, chocolate, crackers, wine and beer. Among the activities are:

- Creating a new partnership with the Prince Edward County Wine Growers Association.
- Creating opportunities for cross-marketing with producers (i.e. Maple syrup, cheese makers, meat producers, brewers and restaurateurs).
- Increasing overnight stays associated with events promoting local foods and wines and encouraging return visits in the off-season.
- Increasing sales of local food and beverage items through a marketing campaign using print, radio, online, and trade shows.

## **Research Projects**

Two small ruminant research projects started in the summer of 2010. The Department of Population Medicine, Ontario Veterinary College (OVC) and the Veterinary Science and Policy Unit, Ontario Ministry of Agriculture Food and Rural Affairs (OMAFRA), have received government and Animal Health Strategic Investment funding for two small ruminant projects. The first is a Johne's project entitled *Johne's Disease in Ontario's small ruminant dairy industries: prevalence, potential risk factors, and performance comparison of serum, milk and fecal diagnostic methods*; and the second is a *Coxiella burnetii* / Q Fever project entitled *A proposal to determine the prevalence of Coxiella burnetii infection in sheep flocks and goat herds in Ontario and their farm workers*.

Johne's Disease (JD) is an economically important disease impacting the dairy industries; however, information on the prevalence of this disease in Ontario, as well as Canadian, dairy goat herds and dairy sheep flocks is scarce. This study will determine the prevalence and distribution of JD in Ontario dairy goat herds and dairy sheep flocks, and will investigate potential farm-level and animal-level risk factors for the disease. A total of seven different diagnostic tests, involving blood, milk and fecal samples will be used, including the test considered as standard for surveillance (fecal culture). The results of these tests will be compared against each other and in comparison to fecal culture. These test validations will allow for informed recommendations to be made to veterinarians, industry groups and small ruminant producers on diagnostic testing, test interpretation, and surveillance for JD. The results of this study will contribute to our understanding of epidemiology of JD in Ontario dairy goats and dairy sheep, and will help to inform future JD management and control programs in these growing industries.

Infection of sheep flocks and goat herds with *Coxiella burnetii* is known to occur in Canada. *C. burnetii* has been recognized as a cause of abortion in small ruminants and, in particular, goats, and has also been documented as a significant cause of human illness in Canada. Q Fever is a reportable disease in humans in Ontario, although usually fewer than five cases are reported each year. The objectives of this study are: to determine the prevalence of *Coxiella burnetii* infection in Ontario sheep flocks and goat herds; to determine the seroprevalence of *Coxiella burnetii* infection in farm workers on sheep and goat farms in Ontario; and to examine specific risk factors and outcomes of animal health and productivity in sheep and goat farms infected with *Coxiella burnetii*. The results of this study will contribute to our understanding of the epidemiology of *Coxiella burnetii* in Ontario sheep and goats, as well as humans, and will allow for more informed recommendations to be made to small ruminant producers, veterinarians, medical professionals and government.

A milk quality course / module that examines all aspects of milk production will be developed specifically for small ruminant dairy producers. Dr. Paula Menzies, Associate Professor and Sheep Research Coordinator, Ontario Veterinary College was successful in obtaining funding for this project through the OMAFRA /- University of Guelph partnership program called "Knowledge, Translation and Transfer) KTT.

Small Ruminant Veterinarians of Ontario (SRVO) is a new organization, established in part due the increase in dairy sheep in Ontario.

The objectives of SRVO include:

- providing members with continuing education in the production practices, health and welfare of small ruminants,
- speaking as a unified voice for small ruminant veterinarians to government, industry and producers on topics concerning the continued health and welfare of our patients,
- promoting and encouraging veterinary students and new graduates to take an active interest in small ruminant medicine.

**Premier's Award For Agri-Food Innovation Excellence.** This annual award recognizes that farmers have always been innovative in the running of their businesses and will foster even greater innovation across the province. Over the last few years the Dairy sheep industry has been

well represented in the Premier's Award. This has raised the profile and awareness of this small industry.

**Regional Winner WoolDrift Farm**, the first commercial sheep milking operation in the province, has shepherded the growth of Ontario's sheep milk industry. Owners Chris Buschbeck and Axel Meister were the first to import East Friesian dairy sheep embryos into Canada and continuously improved the genetics of the flock, resulting in sales across North America. These innovators have attracted farmers to the sheep milk market through various educational symposiums and workshops.

**Regional Winner - Eric Bzikot, Best Baa Dairy** has created a value-added venture for his farm that also benefits other producers. A processing plant and a small co-op have been established for the sale of sheep milk product. The dairy currently produces 12 types of artisan sheep cheese, two types of yogurt and is looking at potential in the ice cream market. With distribution to 60 stores and restaurants, Best Baa is creating innovative growth opportunities for Ontario's sheep milk product market.

**Premier's Award Winner- FifthTown Artisan Cheese Company** is combining tradition with innovation - the fine craft of artisan cheese-making, in a modern, green environment. The dairy is the largest cheese manufacturing facility in Eastern Ontario to process goat and sheep milk. It's also Canada's only certified Platinum LEED (Leadership in Energy and Environmental Design) dairy. This state-of-the-art facility's solar, wind and geothermal technologies have helped reduce its energy consumption by 60 per cent. The dairy's sustainability theme is carried throughout the entire enterprise, from environmentally-friendly waste processing to green cleaning agents and biodegradable packaging. Their chevre (goat cheese) packaging, for instance, is a corn-based container that is 100 per cent biodegradable. The dairy has also created subterranean caves crafted out of poured cement to age its cheese. The walls are left unfinished and natural, providing a steady, cool environment with little energy required. Fifth Town Artisan Cheese Company has received multiple industry 'green building' awards for using environmentally friendly materials, such as sustainable wood and an innovative, green concrete mix. The dairy has also garnered top awards for its products, and promotes cheese education by offering regular cheese tasting seminars, courses and summer internships.

The outlook for the dairy sheep industry is bright. Many existing dairy sheep producers may expand their flocks, and there is likely to be some new producers and processors.



# MILK QUALITY FOR CHEESEMAKING

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## **Background**

Over 15 years ago, the University of Wisconsin-Madison accepted the mission of furthering research on dairy sheep production and management. Since then Dr. David Thomas of the Animal Sciences Department and Yves Berger of the UW Agricultural Research Stations have been conducting extensive research on the genetics and management systems impacting sheep milk production (McKusick et al., 1999; Thomas et al., 1999). Extensive research on handling and processing sheep milk has also been conducted by faculty and staff within the University of Wisconsin Food Science Department (Casper et al., 1998; Casper et al., 1999; Jaeggi et al., 2003; Jaeggi et al., 2005; Kilic, 1999; Ponce de Leon-Gonzalez et al., 2003; Rauschenberger et al., 2000; Wendorff, 2004). This report will cover some of the research on various aspects of quality of sheep milk that have a direct impact on the cheesemaking potential of sheep milk.

There are several facets to milk quality when it comes to quality affecting cheesemaking. Those would include microbiological quality, quality based on composition, and quality based on functionality. Quality parameters can affect the safety of cheese, the yield of cheese and the performance of the cheese.

## **Microbiological Quality**

Federal and state milk quality standards are set as minimal quality standards for milk for fluid consumption and further processing into dairy products. The federal standard for Grade A milk indicates that raw milk shall not exceed 100,000 bacteria per ml of milk while the Wisconsin Grade B standard mandates that raw milk shall not exceed 300,000 bacteria per ml of milk (WDATEP, 2009). The somatic cell count (SCC) for both Grade A and Grade B milk must be less than 750,000 per ml. Both Grade A and Grade B milk must be cooled to less than 45°F within 2 hours of milking and must be free of drug residues, pesticides and toxic substances.

Code of Federal Regulations (CFR) (FDA, 2009) defines milk as “the whole fresh, clean, lacteal secretion obtained by the complete milking of one or more healthy cows, goats, sheep, water buffalo, or other hoofed mammal”. Raw milk from the farm must be of one species only and any mixture of milk from species is considered adulteration. A simple and rapid qualitative procedure for detecting the presence of cow milk in sheep milk has been developed (Wendorff, 2007). The test can detect the presence of bovine immunoglobulin (IgG) in sheep milk at concentrations of cow milk as low as 1.0% within 20 minutes.

Many milk processors will encourage their producers to provide raw milk with higher quality than the minimal state regulatory standards. They will pay quality premiums for providing milk that has microbiological quality that matches or is better than targeted microbial specifications.

One such set of quality targets, proposed by Cornell University Quality Milk Program, is shown in Table 1.

**Table 1.** Proposed milk quality standards by Cornell University.

	CFUs/ml
Standard Plate Count (SPC)	<10,000
Coliform Count	<10
Preliminary Incubation Count (PI)	<20,000
Lab Pasteurized Count	<300
Psychrotrophic Count	<1000

Ref., (Boor et al., 1998)

Some cheese plants will establish their own quality premium programs. One California goat cheese plant has established quality standards of: SPC + <25,000/ml, LPC = <375/ml, and coliforms = <375/ml.

ATCP 60 (WDATCP, 2009) requires raw milk at the farm to be cooled to less than 45 °F within 2 hours of milking. The blend temperature of the cooled evening and warm morning milk must not exceed 50°F. This requirement is based on the fact that the generation time for psychrotrophic spoilage bacteria is increased from 2.25 hours at 50°F to 12 hours at 40°F. Proper cooling of the milk is critical for control of quality problems from lipase or protease enzymes during storage of raw milk.

### Quality Based on Composition

Since milk costs represent over 85-90% of the cost of producing cheese, it is critical to review factors influencing milk composition and resulting cheese yield. Fat and casein are the two primary milk components that are recovered in the cheesemaking process and are directly related to cheese yield. Since the price for raw sheep milk, in the United States, is over four to five times that of cow milk, it is especially critical for the manufacturers of sheep milk cheeses to be able to estimate cheese yields from milk of varying composition. The breed of sheep will certainly impact not only the volume of milk produced but the composition of milk, also. Table 2 shows typical milk composition for some of the major dairy breeds of sheep in the US and one of the major Greek breeds of dairy sheep.

Lactational or seasonal changes in milk composition will also significantly impact cheese yields. Milk from East Friesian-crossbred ewes was obtained at three different stages of the milking season (early, mid and late milking season) in 2002 and 2003 from the Agricultural Research Station of the University of Wisconsin-Madison located in Spooner, Wisconsin. Milk was collected from ewes starting at day 4 after lambing. Average composition of the sheep milk for each portion of the 2002 milking season is shown in Table 3.

**Table 2.** Impact of breed of sheep on milk composition.

SHEEP	E. Fresian	Lacaune	Manchega	Awassi	Chios
Milk fat, %	6.5	7.4	7.8	6.6	7.9
Protein, %	5.2	5.6	6.0	5.7	6.2
Lactose, %	4.9	4.7	4.3	5.0	4.1
Total solids, %	17.0	18.6	19.0	18.2	19.1
Ash, %	0.9	0.9	0.9	0.9	0.9

Ref., (Haenlein & Wendorff, 2006)

**Table 3.** Milk composition during 2002 milking season.

	February milk	May milk	August milk
Total solids, %	19.28	18.81	17.29
Milk fat, %	7.58	6.74	6.59
True protein, %	5.33	5.27	5.09
Casein, %	4.34	4.33	4.25
C/F ratio	.57	.65	.64
SCC/ml	480,000	360,000	390,000

Ref., (Wendorff, 2004)

Total solids, milk fat, and total protein decreased as the season progressed. Casein concentration was similar in early and mid-season milk, but lower in late season milk. Early season milk contained a higher percentage of whey proteins as indicated by the lower casein to true protein ratio. The higher fat and protein in early lactation milk was also observed by McKusick et al. (1999) when lambs were weaned at day 1 and ewes milked twice daily. The slightly lower fat and true protein in August Milk was varied from the typical lactational trends of higher fat and protein in late lactation ovine milk reported by other workers (Barron et al., 2001; Pellegrini et al., 1997; Requena et al., 1999). This most likely was due to the impact of hotter temperatures during the month of August or poorer pastures resulting in lower solids milk similar to that experienced in bovine milk (Barbano & Sherbon, 1984; Lawrence, 1991).

Average composition of the sheep milk from the 2003 milking season that was used for soft cheese production is shown in Table 4. Trends in fat, protein, and total solids were similar to that of the 2002 milking season although the concentrations of each were slightly reduced.

**Table 4.** Milk composition during 2003 milking season.

	January milk	May milk	September milk
Total solids, %	17.88	16.61	17.70
Milk fat, %	6.38	5.92	6.77
True protein, %	5.23	4.79	5.48
Casein, %	4.37	4.02	4.52
C/F ratio	.68	.68	.67
SCC/ml	310,000	400,000	470,000

Ref., (Wendorff, 2004)

Predictive cheese yield formulae were developed from the research trials from each milking season using the Van Slyke cheese yield equation as shown below:

$$\text{Van Slyke Cheese Yield} = \frac{[(RF \times \% \text{ Fat in milk}) + (RC \times \% \text{ Casein in milk})] \times RS}{(100 - \% \text{ Moisture of cheese})}$$

$$RF = \frac{(\% \text{ fat in cheese} \times \text{cheese wt})}{(\% \text{ fat in milk} \times \text{milk wt})}$$

where *RF* is the fat recovered in cheese, *RC* is the casein recovered in cheese and *RS* represents the other milk solids and added salt recovered in cheese. *RF* values were determined experimentally for each cheese trial by dividing the amount of fat in milk by the amount of fat recovered in cheese (% fat in cheese x cheese weight / % fat in milk x weight of the milk). *RC* can be approximated from milk and cheese composition by dividing total cheese casein (paracasein) by total milk casein. We found that *RC* was 0.96 for early and mid-season milks and 0.94 for late-season milk. *RS* values for each cheese were calculated by substituting the *RF* and *RC* values into the following equation:

$$RS = \frac{RF \times \% \text{ Fat in milk}}{[(RF \times \% \text{ Fat in milk}) + (RC \times \% \text{ Casein in milk})] \times FDM}$$

where fat in dry matter (**FDM**) was determined experimentally as follows:

$$FDM = \frac{\% \text{ Fat in cheese}}{(100 - \% \text{ Moisture of cheese})} \times 100$$

The fat, casein, and solids retention factors and cheese yields are shown in Tables 5 and 6.

**Table 5.** Cheese yield and retention factors for hard pressed sheep milk cheese in 2002.

	February milk	May milk	August milk
FDM in cheese, %	56.2	53.5	53.7
RF value	.84	.84	.83
RC value	.96	.96	.94
RS value	1.07	1.08	1.08
Cheese yield, %	18.45	17.29	16.78
CACY, %	18.52	17.38	16.75

CACY = cheese yield adjusted to 39% moisture. Ref., (Wendorff, 2004)

Composition adjusted cheese yields (CACY) were calculated at 39% moisture for hard pressed cheese and 50% for the soft ripened cheese. Substantial differences in composition-adjusted % cheese yields, and small differences in % fat and % nitrogen recoveries between trials, indicate that differences in milk composition (casein and fat) was the major factor responsible for differences in cheese yield.

**Table 6.** Cheese yield and retention factors for soft sheep milk cheese in 2003.

	January milk	May milk	September milk
FDM in cheese, %	55.1	54.8	54.7
RF value	.82	.81	.82
RC value	.96	.96	.94
RS value	1.01	1.01	1.03
Cheese yield, %	21.08	17.35	17.35
CACY, %	19.09	17.37	17.06

CACY = cheese yield adjusted to 50% moisture. Ref., (Wendorff, 2004)

Results of this study showed that seasonal changes had a significant impact of milk composition, cheese composition and cheese yield. However, fat and protein recoveries in the cheese were not significantly different over the season. Cheese yields were directly related to the level of fat and casein in the initial milk. Results of our study did show that the Van Slyke Cheese Yield Formula could be effectively be used to predict cheese yield from sheep milk. Table 7 lists the recommended retention factors to be used for estimation of cheese yields for hard and soft cheeses from sheep milk. Factors may have to be adjusted slightly for late lactation milk.

**Table 7.** Recommended retention factors for Van Slyke Cheese Yield Formula for sheep milk.

	Soft cheese	Hard cheese
RF value	.82	.84
RC value	.96	.96
RS value	1.01	1.08

Ref., (Wendorff, 2004)

The state and federal milk quality standards both have a limit on somatic cells in raw milk (WDATEP, 2009). SCC is often used to differentiate between healthy and infected mammary glands in ruminants. Table 8 shows the effect of three different levels of SCC on milk composition and cheese yields in sheep milk. Casein content and casein to true protein ratio (C/TP) decreased with increasing SCC. As the level of SCC increased, the time required for curd formation also increased. Cheese yields decreased as SCC increased. Lower yields were attributed to lower casein and fat contents of the higher SCC milk.

**Table 8.** Impact of somatic cell count (SCC) on milk composition and cheese yield.

Component	<100T SCC/ml	100T-1000T SCC/ml	>1000T SCC/ml
Total solids, %	16.69	16.84	14.38
Milk fat, %	5.49	5.67	4.86
True protein, %	4.90	4.98	4.69
Casein, %	3.99	3.97	3.72
C/TP, %	81.42	79.66	79.32
Cheese yield %	16.03	15.97	15.09

Ref., (Jaeggi et al., 2003)

In 2001, McKusick et al. reported on two early milking treatments along with the traditional 30-day weaning system. The early milking treatments included: 1) ewes weaned from their lambs at 24 h postpartum, ewes machine milked twice daily, and their lambs raised artificially (**DY1**); and 2) beginning 24 h postpartum, ewes separated from their lambs for 15 h during the evening, ewes machine milked once daily in the morning, and their lambs allowed to suckle for 9 h during the day (**MIX**). They indicated that the low level of fat in the MIX milk could be due to failed milk ejection at milking or influenced by the lack of transfer of milk fat from the alveoli to the cistern from the time ewes were separated from the lambs every evening to the time the ewes were milked the following morning. Average composition of the early lactation whole milk for each weaning system is shown in Table 9. Total solids, milk fat, protein, and casein were significantly lower in the MIX milk as compared to the DY1 milk. The casein/true protein ratio was identical for both milks.

**Table 9.** Composition of early lactation ovine milks from two weaning system treatments.

	MIX	DY 1
Total solids, %	14.24	18.51
Milk fat, %	2.72	6.78
Total protein, %	5.51	6.13
True protein (TP), %	5.18	5.72
Casein, %	4.32	4.75
Casein/TP, %	83.00	83.00
Casein:fat ratio	1.59	0.70

Ref., (Jaeggi et al., 2008)

Cheeses produced from the two sources of milk in the initial trial were uniquely different in composition (Table 10). With the depressed milk fat level in the milk from the MIX weaning

system, the resulting fat level and fat-in-dry-matter (FDM) in the cheese was significantly lower than the fat content and FDM in the cheese from the DY1 treatment. Protein content of the cheese from the MIX system was higher than the cheese from the DY1 system. With the lower total solids and fat in the milk from the MIX system, the actual cheese yield was lower than for milk from the DY1 weaning system.

**Table 10.** Impact of weaning system on cheese yield and composition.

	MIX	DY1
Cheese yield, %	12.9	18.1
Moisture, %	42.6	40.2
Milk fat, %	18.2	29.4
Protein, %	27.5	24.6
Salt, %	1.8	1.3
MNFS, %	52.1	56.9
FDM, %	31.7	49.2

Ref., (Jaeggi et al., 2008)

Since there was a substantial difference between milk from the MIX weaning system and the DY1 system, the question arose as to whether the fat or protein characteristics in the milk from the MIX weaning system were different from the milk from the DY1 system. To compare the milk components on an equivalent basis, we decided to standardize the DY1 milk to closely match the casein:fat ration of the milk from the MIX treatment. This would give us cheeses with comparable gross composition for further assessment. Average composition of the standardized early lactation milks and corresponding cheeses yields from the two weaning systems are shown in Table 11. The targeted C:F ratio for the standardized milks was 1.6.

**Table 11.** Milk composition and cheese yield if milks were standardized to a C/F ratio of 1.6.

	MIX	DY 1
Total solids, %	14.10	14.86
Milk fat, %	2.73	2.94
True protein, %	5.16	5.77
Casein, %	4.35	4.83
Casein/TP, %	84.00	84.00
CACY yield, %	13.2	13.7

[CACY = composition adjusted cheese yield at 45%]. Ref., (Jaeggi et al., 2008)

By standardizing the milks to a comparable C:F ratio, cheeses produced had comparable protein contents and FDM values. No significant differences were observed in coagulation rate or in time from set to hooping for the two sources of milk. There were no significant differences in cheese yields of the weaning systems before brining. Results from the preliminary portion of this study showed that early lactation milk from two different weaning systems varied significantly in gross composition and cheesemaking potential. However, if the DY1 milk was standardized to the same casein:fat ratio as the MIX milk, fat and protein recoveries during cheese manufacture and cheese yields before brining were comparable. Cheesemakers would

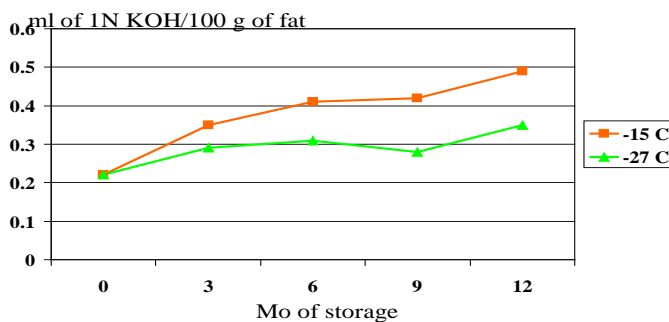
need to adjust payment for the early lactation milk on a cheese yield basis from MIX weaning systems to be economically feasible in comparison to milk from DY1 weaning systems.

### Quality Based on Functionality

There are also additional quality factors that can impact how the components of the sheep milk respond in the cheesemaking process and thus affect the overall quality of the resulting cheese. In the first several years of sheep milk production in Wisconsin, commercial cheese plants experienced some problems with milk quality and stability with frozen raw milk supplied by the dairy sheep cooperative. Some of our research studies concentrated on the projected shelf life of the frozen raw sheep milk and factors impacting raw milk quality during frozen storage (Wendorff, 1998).

ADV for milk stored at  $-15^{\circ}\text{C}$  were significantly higher than for those samples stored at  $-27^{\circ}\text{C}$  (Figure 1).

Figure 1. Acid degree value (ADV) of frozen raw milk



In spite of the increases in ADV with storage, samples did not exhibit a rancid flavor within the 12 months of storage. Several researchers (Antifantakis et al, 1980; Needs, 1992) have reported an increase in free fatty acids with frozen storage of sheep milk.

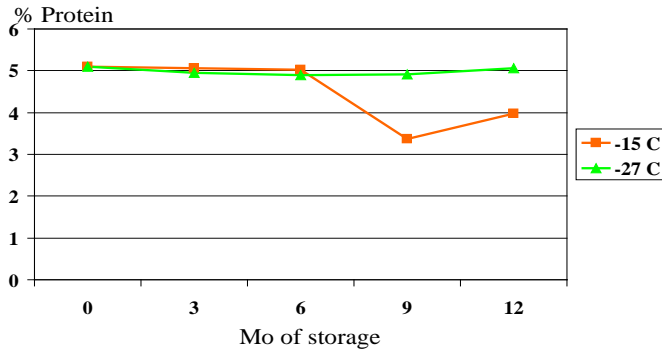
After 6 months of frozen storage at  $-15^{\circ}\text{C}$ , thawed milk samples exhibited protein destabilization with flocculated protein settling at the base of containers (Wendorff, 2001). After 9 months of storage, over 20% of the protein was lost in the sediment (Figure 2). Samples stored at  $-27^{\circ}\text{C}$  exhibited good protein stability throughout the 12 months of storage. To preserve high quality sheep milk in frozen storage, we would recommend that milk should be rapidly frozen and stored at temperatures of  $-20^{\circ}\text{C}$  or lower for no more than 6 to 12 months (Wendorff, 2001; Zhang et al., 2006).

With transport of frozen raw sheep milk to processing plants, cheesemakers have complained of poor cheesemaking properties in some lots of frozen sheep milk that had been transported in the frozen state during the summer months. Some questions have arisen concerning the potential temperature abuse of the frozen milk during transit with the possibility of partial thawing and refreezing of the milk. To study abusive handling during shipping, ten 40 lb. bags of fresh, refrigerated sheep milk was received from the Spooner Research Station and placed in a commercial freezer at  $-29^{\circ}\text{C}$  ( $-20^{\circ}\text{F}$ ). The frozen sheep milk was stored for 6 weeks at that



temperature. At six weeks, one bag of milk was removed from the freezer and placed in the adjoining cooler at 4.4°C (40°F) for 24 hr. After 24 hr., the bag was again placed in the freezer and refroze. This treatment was to simulate the potential loss of temperature in a refrigerated trailer for short duration before the temperature was brought back in line with freezing temperatures. This bag of milk had thawed about 2 inches in depth around the edges and sides of the bag by the end of 24 hr. of the abusive temperature.

Figure 2. Intact Protein in Frozen Milk



A second bag of frozen milk was removed from the freezer and placed at the ambient lab temperature of 24.4°C (76°F) for 4 hr. The milk was then placed back in the freezer and refrozen. This treatment was to represent the potential abuse of being placed on a loading dock during transit and not being transferred directly to proper freezing temperatures from the delivery truck. This bag had about 1 inch of liquid milk around the edges and sides of the bag before being refrozen. The two abused bags of milk plus the properly frozen control sample were stored at -29°C (-20°F) for an additional two months.

True protein analyses of the thawed milk samples showed no significant differences between the abused milk samples and the control sample. The abusive treatments apparently did not destabilize the casein in the frozen milk sufficiently to precipitate the casein during the 2 months of frozen storage after the temperature abuse and refreezing process. Results of the cheesemaking trials are shown in Table 12.

**Table 12.** Influence of abusive storage treatments on composition and yield of semi-soft sheep milk cheese.

	Control <sup>1</sup>	24R <sup>1</sup>	4A <sup>1</sup>
Cheese yield <sup>2</sup> , %	20.62 <sup>a</sup>	20.48 <sup>a,b</sup>	20.19 <sup>b</sup>
Cheese moisture, %	43.98 <sup>a</sup>	42.29 <sup>a,b</sup>	40.94 <sup>b</sup>

<sup>1</sup> Control = maintained in frozen state at -29°C, 24R = 24 hr abuse at 4°C and refroze, 4A = 4 hr abuse at 24.4°C and refroze.

<sup>2</sup> Cheese yield measured after hooping for 16 hr and before brining.

<sup>a,b</sup> Means within the same row without a common superscript differ ( $P < 0.05$ ).

Ref., (Wendorff, 2008).

Initial pH of milks, coagulation rate, cut times and whey pHs were similar for all 3 sources of milk. Cheese yield was significantly reduced with the 4 hr abuse at ambient temperatures and refreeze treatment. That abused milk also produced cheese with lower moisture content. The 24 hr abused sample at refrigeration temperatures and refreeze treatment was not significantly different than the control milk after 3.5 months of frozen storage. There was no significant difference in moisture-free cheese solids recovered from all three sources of milk. From the results of the cheesemaking trials, it appears that the milk left out in ambient temperatures for 4 hr and refroze lost some water binding capacity in the milk proteins. The treatment was not severe enough to destabilize casein and precipitate it in the thawed milk, but was severe enough to impair some of the functionality of the proteins.

Extensive studies have been reported on the freezing and storage of frozen sheep milk but little has been reported on the best procedure for thawing of frozen sheep milk for production of cultured products. Previous researchers primarily used a slow thaw procedure in refrigerated storage for thawing frozen sheep milk. Commercial processors would like to use a quicker method for thawing frozen sheep milk for more efficient processing. An additional study was conducted to determine the influence of thawing procedure on the cheesemaking qualities of frozen sheep milk. Samples were stored at  $-27^{\circ}\text{C}$  for 2 months prior to conducting the thawing studies. For the thawing studies, samples were thawed under one of the following conditions: 1) slow thaw at  $4^{\circ}\text{C}$  ( $40^{\circ}\text{F}$ ) for 24 hr, 2) sample was thawed in a water bath at  $32^{\circ}\text{C}$  ( $90^{\circ}\text{F}$ ), 3) sample was thawed in a water bath at  $54.5^{\circ}\text{C}$  ( $130^{\circ}\text{F}$ ), and 4) sample was rapidly thawed in a microwave under the defrost cycle.

When milk is frozen and stored at  $-27^{\circ}\text{C}$ , over 96% of the water is in the frozen state and the solids in the unfrozen portion is over 75% (Morr, 1975). This solids concentration approaches that of a partially dried product. During the freezing process, proteins are partially dehydrated and the soluble calcium is decreased as it shifts to colloidal inorganic calcium (Lin et al, 1994). During the thawing of frozen milk, the proteins will become rehydrated again and some of the colloidal calcium will shift back to soluble calcium. The soluble calcium contents of the thawed milks are shown in Table 13. The slow thawed milk at  $4^{\circ}\text{C}$  was significantly higher in soluble calcium than the milk thawed at  $32^{\circ}\text{C}$  or thawed in the microwave. The soluble calcium content of milk thawed at  $54.5^{\circ}\text{C}$  was not significantly different than that in milk slow thawed at  $4^{\circ}\text{C}$ . The quicker thawing procedures did not allow the soluble calcium content to equilibrate to the level that was attained by the slow thawing procedure. Shufflebarger (1995) reported that it takes approximately 8 hr at  $4^{\circ}\text{C}$  for the soluble calcium content to equilibrate when reconstituting nonfat dry milk. Soluble calcium aids in the aggregation of the rennet-altered casein micelles in the rennet coagulation of milk in the cheesemaking process (Morr, 1975). The time from rennet addition to cutting of the curd was 9 min for the slow thawed milk, 10 min for the  $54.5^{\circ}\text{C}$  and  $32^{\circ}\text{C}$  thawed milk, and 12 min for the microwave thawed milk (Table 13).

**Table 13.** Influence of thawing procedure on soluble calcium content and coagulation time of frozen sheep milk.

Thawing procedure	Soluble calcium (mg of Ca/100 ml of milk)	Coagulation time <sup>1</sup> (min)
24 h @ 3.8°C	32.50 <sup>a</sup>	9 <sup>a</sup>
32°C water bath	29.55 <sup>b</sup>	10 <sup>b</sup>
54.5°C water bath	31.95 <sup>a,b</sup>	10 <sup>b</sup>
Microwave defrost	27.11 <sup>b</sup>	12 <sup>c</sup>

<sup>1</sup> Coagulation time is the time of rennet addition to the time of cutting the curd.

<sup>a,b</sup> Means within the same column without a common superscript differ ( $P < 0.05$ ).

Ref., (Wendorff et al., 2008a) \_\_\_\_\_

The yields of curd at hooping and cheese yields after pressing are given in Table 14.

**Table 14.** Influence of thawing procedure on yield of semi-soft cheese produced from frozen sheep milk.

Thawing procedure	Yield of curd, % (1 h)	Cheese yield, % (24 h)
24 h @ 3.8°C	20.50 <sup>b</sup>	16.85
32°C water bath	20.67 <sup>b</sup>	16.75
54.5°C water bath	21.24 <sup>a</sup>	16.70
Microwave defrost	20.59 <sup>b</sup>	16.67

<sup>a,b</sup> Means within the same column without a common superscript differ ( $P < 0.05$ ).

Ref., (Wendorff et al., 2008a).

Initial yield of curd at hooping for milk thawed at 54.5°C was significantly higher than the other thawed milks. However, after draining and pressing, cheese yields from all thawed milks were not significantly different. Cheese moisture content of the cheese from 54.5°C thawed milk was significantly higher than the other cheeses. This was probably due to denaturation of some of the whey proteins with the higher thawing temperature and retention of moisture by those denatured whey proteins in the cheese.

Results of this study did not conclusively identify one thawing procedure that was optimum for maximum cheesemaking potential of frozen sheep milk. The slow thawing procedure at 4°C did provide the greatest concentration of soluble calcium in the milk for the most efficient coagulation of the milk and most effective syneresis of whey during the cheesemaking process. However, it did not yield any significant increase in cheese yield over the other thawing procedures. The 54.5°C thawing procedure yielded a comparable cheese yield to the slow thawing procedure but retained significantly more moisture in the final cheese. This was most likely due to partial denaturation of whey proteins in the thawing treatment and greater moisture retention by the denatured proteins. Accordingly, we would not recommend thawing frozen sheep milk in a vat pasteurizer or at process temperatures above 50°C.

If a cheesemaker wants to thaw frozen sheep milk quicker than the slow thaw procedure at 4°C, we would recommend thawing the milk at 32°C. At that temperature, the coagulation and syneresis rates were only slightly decreased and the final cheese yield and moisture were not significantly different from the slow thaw procedure. Since the cheese yield and cheese moisture were not significantly different for the 32°C and the microwave thawed milk from that of slow thawed milk, we assume that the rehydration of the casein and equilibration of soluble calcium were sufficient for good cheesemaking potential from the frozen milk. In previous studies (Wendorff, 1996), we found that casein rehydration in nonfat dry milk reconstituted at 32° C for 2 hr was sufficient so that the casein functioned the same as that of fresh milk. This temperature is also very functional since it is close to the same temperature that would be used for manufacture of raw milk hard cheeses. However, in most cases we would recommend pasteurization of the thawed sheep milk prior to cheesemaking to eliminate potential pathogens and to inactivate the native lipases to control rancidity in the final cheese.

### Physical Properties Impacting Cheese Quality

Milk composition can certainly influence the variety of cheeses that can be produced from a single milk source. Species of the milk source can also impact the variety of cheese that could be produced from that milk source. Since sheep milk contains a higher proportion of  $\alpha_{s1}$  casein, the body of the cheese would be firmer and body breakdown would be slower than the comparable cow's milk cheese. One type of cheese that seems to be sensitive to species differences is eyed-cheeses e.g., Swiss or Emmentaler cheese. Green and Grandison (1985) reported that curd firmness is closely related to the content of  $\alpha_{s1}$ -casein in milk and  $\alpha_{s1}$ -casein is basic to the formation of the network in the curd. As shown in Table 15, there are unique differences in casein composition of different species of milk.

**Table 15.** Casein composition of various species milk.

<i>Casein</i>	<i>Cow</i>	<i>Goat0</i>	<i>Sheep</i>
$\alpha_{s1}$ , %	35	5	(56)
$\alpha_{s2}$ , %	10	25	---
$\beta$ , %	40	50	33
$\kappa$ , %	15	20	11

Ref: Anifantakis, E.M., 1986)

Sheep milk cheese had higher fat and lower moisture than the cow milk cheese (Table 16). This was the result of having sheep milk with a lower casein:fat ratio. Protein and salt concentrations were not significantly different between the two cheeses. As with our previous study with smeared cheeses (Wendorff, et al., 2008b), the body of the sheep milk cheeses was much firmer than the cow milk cheeses. This was most likely due to the higher  $\alpha_{s1}$ -casein and higher calcium content in sheep milk (Anifantakis, 1986). Kalatzopoulos (1970) noted that curd from sheep milk obtained a final firmness twice that of curd from cow milk due to the differences in the casein systems of the two milks. With the denser curd, less salt was able to penetrate into the sheep cheeses during brining. At 1 mo of age, each of the cheeses was evaluated for eye formation. The cow milk Baby Swiss cheese was slightly overset with many dime-sized eyes. The body of the cheese allowed for good eye formation even though it was overset. The sheep

milk cheese did not form eyes as the curd was too dense. When CO<sub>2</sub> was formed in the cheese in the warm room, it expanded the mechanical openings to form definite slits or cracks.

**Table 16.** Composition of Baby Swiss-type cheeses at 1 mo of age.

	<i>Cow</i>	<i>Sheep</i>
Moisture, %	41.38	37.88
Milk fat, %	31.22	34.62
Protein, <sup>1</sup> %	23.49	23.64
Salt, %	1.12	0.87
FDM, <sup>2</sup> %	53.26	55.73
S/M, <sup>3</sup> %	2.71	2.29

<sup>1</sup>Total % N X 6.31. Ref., (Wendorff et al., 2009)

<sup>2</sup>Fat in the dry matter.

<sup>3</sup>Salt as a percentage of the moisture phase.

Flavor acceptability scores for each of the cheeses at 1, 2, and 3 mo of age are shown in Table 17.

**Table 17.** Flavor acceptability<sup>1</sup> scores for Baby Swiss-type cheeses at 1, 2, and 3 mo of age.

<i>Age of cheese</i>	<i>Cow</i>	<i>Sheep</i>
1 month	5.4	2.6
2 months	4.3	4.3
3 months	5.7	2.8

<sup>1</sup>Based on a 7-point Hedonic scale, 1 = extremely unacceptable; 7 = extremely acceptable Ref., (Wendorff et al., 2009).

Flavor scores indicated that the sheep milk cheese never did approach an acceptable Swiss cheese flavor. The sensory panelists indicated the aged cow milk cheese was a very acceptable aged Baby Swiss cheese with a slightly soft body. They criticized the sheep milk cheese as lacking Swiss appearance and character and having too intense “clean barny” flavor.

Several cheesemakers had reported to us difficulty in trying to produce a smear-ripened sheep milk cheese. They reported difficulty in getting the smear organisms to properly grow on the surface of sheep milk cheese to produce the desired flavor and aroma of a typical smear-ripened cow milk cheese. One vat each of cow milk (227.2 kg of milk) and sheep milk (91 kg) Brick cheese were made from the unstandardized whole milk. Sheep milk cheese had higher fat and lower protein than the cow milk cheese (Table 18). This was the result of having sheep milk with a lower casein/fat ratio. Moisture, salt and S/M percentage were not significantly different between the two cheeses. The body of the sheep milk cheese was much firmer than the cow milk cheese. This was most likely due to the higher  $\alpha_{s1}$ -casein and higher calcium content in sheep milk (Anifantakis, 1986). Kalatzopoulos (1970) noted that curd from sheep milk obtained a final firmness twice that of curd from cow milk due to the differences in the casein systems of the two milks.

Sensory evaluation of the two cheeses was conducted at 8, 16, and 24 weeks of age. At 8 wk of age, the cow milk cheese had a clean lactic flavor typical of a mild Brick cheese while the sheep cheese had a slight acid flavor with a very slight bitter note. The body of the cow milk cheese was slightly firm while the body of the sheep cheese was definitely firm. The difference in body was consistent with the difference experienced in the initial cheeses as a result of the higher  $\alpha_{s1}$  casein content of the sheep milk. Addition of the starter and coagulant was based on the total casein content of the milks; however, sheep milk typically has over 50% more  $\alpha_{s1}$  casein than cow milk (Anifantakis, 1986). In a previous study (Ponce de Leon-Gonzalez et al., 2002), we found that  $\alpha_{s1}$  casein in reduced-fat Muenster cheese was completely hydrolyzed at 120 d of age while in a similar cheese containing 80% cow milk/20% sheep milk, the  $\alpha_{s1}$  casein was completely hydrolyzed after 180 d of age. At 16 wk of age, the cow milk cheese had the typical body and flavor of a smear-ripened Brick cheese. The sweet, sulfury, pungent flavor had permeated to the inner portion of the cheese. The sheep milk cheese had the typical Brick flavor at the surface of the cheese but the body of the cheese was still much firmer than the cow milk cheese. The interior of the cheese had a mild Brick flavor with a slight oxidized flavor from the sheep milk fat. At 24 wk of age, the cow milk cheese had a slight ammonia odor and a musty and slight bitter flavor. The body of the cheese was still acceptable. The sheep milk cheese had a good clean Brick type flavor with a slight hint of sheep fat. The body of the cheese was still firmer than that of the cow milk cheese.

## **Conclusion**

Over the past 15 years, the University of Wisconsin-Madison Food Science Department has identified and investigated numerous quality factors impacting sheep milk and the impact on cheese quality. U.S. cheesemakers have been able to apply some of these findings to their operations and have aided in the growth of the dairy sheep industry in the upper Midwest. Over the past 10 years, 3 cheesemakers have won Best in Show awards in major cheese contests with cheeses using sheep milk. With continued concentration on quality aspects of sheep milk, additional winners should be forthcoming in the future.

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# **CHEESE MAKERS FACE THE CHALLENGE OF SYNCHRONIZED LACTATION**

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## **Abstract**

This paper presents data from Cedar Grove Cheese production of Dante cheese for the Wisconsin Sheep Dairy Cooperative. Ewe milk composition and cheese yield vary widely from month to month. Factors affecting yields appear to include both season and stage of lactation. While yields are high in Spring and Fall, optimal strategies for cheese making differ in each season.

## **Background**

In early years, members of the Wisconsin Sheep Dairy Cooperative (WSDC) froze a considerable portion of their milk. Cheese makers were able to blend frozen milk with fresh milk creating a blend that disguised seasonal effects. Nonetheless, there were drawbacks to use of frozen milk. While the damage to the milk was reported to be minimal, the opportunities for contamination of the milk during storage, transportation, and thawing were considerable. Moreover, the logistics of handling the frozen milk were labor intensive and added to the cost of cheese making. Torn bags would leak if the milk thawed before it was removed from the bag. Cheese makers had to be careful not to let pieces of plastic get into the cheese. And valuable vat space was taken up waiting for milk to thaw.

For the past five years, Cedar Grove Cheese has been converting milk into cheese that is sold by the WSDC. After the first year, Cedar Grove Cheese refused to use frozen milk for the reasons indicated above. Sales of the products have risen to the point that little if any milk needs to be frozen. However, the exclusive use of fresh milk has revealed challenges of seasonal differences that were previously less significant. Many years ago, farmers would synchronize their cow production with winter calving and maximum use of pastures. Over time, with more stored feed, electricity and artificial insemination, cow farmers chose to smooth their income stream by spacing calving over the year. Today, few cheese makers have experienced the impacts of lactation stages on milk quality and cheese production.

Sheep are naturally more attuned to seasonal changes in light, making off-season breeding more difficult. The synchronization of stages of lactation requires cheese makers to revive an old art. One challenge is to separating the impacts of lactation stages from the impacts of changes in feed and nutritional requirements of animals. Coordination between cheese makers and sheep farmers may have potential to improve product quality.

Seasonal changes in milk quality accompany and complicate the impacts of lactation stages. Cedar Grove Cheese has been heavily involved in developing products from cow farms that use rotational grazing. The cheeses vary depending on the plant and mineral quality of pastures, temperature, water composition and availability, and even the number and type of pests. Many

farmers choose to have cheese made from their milk only during the seasons with the most favorable conditions. Others, like Otter Creek Organic farm have had us make cheese in each season and have celebrated the differences among their seasonal cheddars. We have learned how to compensate for the relatively soft texture of seasonal grass-based dairy products. Some artisan and farmstead dairies use seasonal calving. But often, as with Pleasant Ridge Reserve, the cheese is only made when grass and milk quality are optimal and otherwise milk is combined with milk from other farms.

## **Seasonal Milk Quality and Cheese Yields**

Some prior analyses have looked at seasonal milk quality and cheese yield variations in sheep milk. Jaeggi, et al. examined milk composition and cheese yield from the herd at the Agricultural Research Station of the University of Wisconsin in 2002 and 2003. That herd is part of the milk supply of the WSDC. They examined frozen milk aggregated over three months, which they identified as early, middle and late season. They found that early season milk was high in solids, fat and casein relative to the middle season. In 2002, they examined August milk and found it had slightly lower solids levels than May. Cheese made from the May and August milk had similar composition, with lower fat and higher protein levels than February. In 2003, they looked at September milk finding it had higher solids fat and casein levels than May. Protein recovery was lower than in the middle season, perhaps because of the impact of heat on the casein content of the milk. In general, they concluded that the seasonal milk composition differences had little impact on coagulation or recovery of solids in cheese making.

Most early studies also examined only a few stages of the season. Abilleira, et al. examined composition and coagulation properties of sheep milk over a six month (February through July) lactation cycle. They analyzed the impacts of feed management and part-time grazing on milk quality. Unlike Jaeggi, et al., the study found a steady increase in fat and casein across the seasons. Notably, the study covered a shorter time period and thus may have missed the impacts of early and late lactation. Milk pH dropped slightly over the season and the coagulation time lengthened by a few minutes. The authors concluded that grazing was beneficial to cheese quality.

An earlier study, by Sevi et al., compared sheep in Southern Italy that were bred early for Autumn lambing with those that had more traditional Winter lambing. They found that regardless of the lambing season, milk had a higher somatic cell count and poor coagulating behavior in late lactation compared to early- or mid-lactation. The authors suggest that the somatic cell count increase could be avoided with better herd management, temperature control and environmental cleaning. Plasmin levels were observed to increase in late lactation. Lactose content of milk also decreased with stages of lactation and appeared to be replaced by chloride. This result may well have been related to the observed increase in somatic cell counts. Autumn-lambing ewes had more hay and concentrates and less grazing time. As a result, the milk from Autumn-lambing ewes averaged higher in solids but poorer in herd health and renneting characteristics.

Evidence at Cedar Grove Cheese was consistent with earlier studies indicating influences of both seasonal feed regimes and stages of lactation. We were not able to separate the two

influences. Cedar Grove Cheese has received milk from the WSDC over a season that is longer than that covered in most other studies. We are not sure whether this is a result of stretching lactation for more than the typical 180 days or of some greater variation in lambing dates across the herds and animals providing milk.

Table 1 compares milk component and quality pattern reported in the previous studies with those found in the milk from WSDC. Cedar Grove milk quality results are averaged over loads received in 2009 and 2010. The sample size was low for each period. In general, the protein content shows fairly level to slightly rising protein values with some dropoff when sheep are put on pasture. The highest tests were found at the end of the extreme end of the lactation cycle. Different studies found different levels of the components in the tables below. These differences reflect different breeds of sheep and environments. The tables are used to look at trends over time in the variables within each study rather than focusing on the differences among studies.

Table 1. Protein content of milk by month

	Cedar Grove	Sevi (Winter)	Abilleira	Jaeggi
February	5.10		4.65	5.33
March	5.04	4.86	4.76	
April	4.68		4.89	
May	4.90	5.25	5.17	5.27/4.79
June	4.68		5.19	
July	4.73	5.33	5.19	
August	5.47			5.09
September	6.25			5.48

Similar results are found for butterfat tests, Table 2. The results for presented by Jaggi et al. included two results for May, 2002 and 2003. The August result is for 2002 and shows a slight decline in butterfat. The September result shows a large increase from the 5.92 percent in May of 2003. The differences between years and locations are large, but again the late lactation shows substantially higher solids levels.

Table 2. Butterfat content of milk by month

	Cedar Grove	Sevi (winter)	Abilleira	Jaeggi
February	6.36		5.35	7.58
March	6.21	6.35	5.65	
April	5.87		6.10	
May	6.00	6.89	6.92	6.74/5.92
June	6.15		7.28	
July	6.54	6.90	7.54	
August	6.77			6.59
September	8.75			6.77

Table 3 gives some idea of milk quality trends found by different researchers. No tendency for somatic cell counts to rise is found for Wisconsin milk. Only the Spanish study found

increasing somatic cell counts and those stayed within a normal range. These results seem to differ from evidence from cows that suggests a tendency toward mastitis in late lactation animals. Farmers seem to be protecting animal health effectively. Somatic cells do not appear to be a significant problem for sheep cheese makers. Cedar Grove Cheese measures of standard plate counts are also shown. WSDC bacteria plate counts are uncommonly high during most periods. They seem to be somewhat lower during the periods when animals would be expected to be outside. Both early and late lactation have extremely high plate counts. We cannot say whether these are attributable to housing conditions or lactation stages. In either case, they seem to be the primary source of cheese making challenges.

Table 3. Milk quality measures by month (000s)

	Cedar Grove SCC	Cedar Grove Plate	Sevi (winter) SCC	Abilleira SCC	Jaeggi SCC
February	372	697		263	480
March	365	176	627	277	
April	330	99		314	
May	450	49	603	428	360/400
June	397	330		432	
July	450	190	623	467	
August	280	160			390
September	310	840			470

### Implications of Seasonal Milk Quality Variation for Cheese Making

Some cheese customers have expressed an unwillingness to purchase cheese made with late lactation sheep milk. They report that the cheese is not as good. We examined the literature and the data to try to get clues as to the sources of these problems and consider potential solutions. The evidence does not seem to support some of the received wisdom.

Foremost among the factors cited in literature has been the impact of high somatic cell counts. Evidence presented here does not indicate that extraordinarily high somatic cell counts are found in late lactation milk from sheep. On the other hand, very high levels of plate counts were found in early and late lactation milk used at Cedar Grove Cheese. These plate counts may reflect animal health, insufficient cleaning or environmental and feed sources. Likely the high bacteria counts are indicative of microorganisms that degrade milk components and cause off flavors in cheese. Late lactation milk of poor quality may have high levels of plasmin or psychrotropic bacteria that cause proteolysis, or breaking of proteins. This would cause the observed slower rates of coagulation. It also would cause premature release of calcium phosphate from casein micelles and slow acid development. Its slower acid development results in retention of calcium phosphate, higher moisture and uncharacteristic flavor development. The cheese will also potentially develop excessive crystal growth as it ages. There is not much that cheese makers can do to offset the impacts of milk that has been degraded before the process begins.

Yields of late lactation milk are extraordinarily high. Milk production by the animals is lower and the levels of fat and protein are elevated. Moisture levels also tend to be high. Yields of Dante before aging ranged from 18.4 percent in February to a low of 16.18 percent in June to 19 percent in August. These yields reflected changes in solids content of the milk due to pasture and heat. In September, average Dante yield was 21.5 percent. That also reflected the extraordinary high solids and somewhat elevated moisture content of the cheese.

Not only are the solids higher, but the ratio of fat to protein tends to increase at the end of lactation after staying fairly steady in other phases and across feed regimes. This can contribute to soft cheese body. Typically calcium levels are also elevated in late-lactation milk, although we do not have evidence that occurs in the sheep milk. One strategy would be to add calcium chloride to firm the curds, but that is not useful if calcium is already high. Our experience has been that calcium chloride addition in this situation is not effective. Cheese makers can cook the cheese to higher levels, stir longer and add some additional salt to the curd in order to lower the initial moisture level of the cheese. However these efforts too may slow the activity of starters after the cheese is made and alter the cheese flavor. The strategy is especially challenging in surface salted or brined cheeses which will expel the excess moisture in the salting stage rather than in the whey and retain more minerals.

## **Conclusion**

We examined the impacts of lactation cycles and seasonality on cheese made from sheep milk. We have experienced, and heard from others, problems associated with late-lactation milk.

Cheese making in late lactation requires patience to build body. Adding calcium chloride has little impact, adding starter cultures results in cheese with high moisture and weak body. Problems appear to be primarily due to high bacteria and enzyme levels in the milk. These lead to degradation of milk protein prior to cheese processing and result in uncharacteristic flavor development and weak texture.

Several strategies have been used to counter the late-lactation challenge. Frozen milk from earlier stages has been added to improve the average milk quality. Frozen milk has its own problems with quality and logistics. Another option would be to put some herds or animals on early lambing schedules. Apparently that option introduces challenges in animal husbandry that most farmers do not want to address. Furthermore, Autumn lambing results in more confinement of milking animals and higher feed costs in this part of the world. Confinement seems to be one of the contributing factors to milk quality problems. A third option is one that we have chosen, namely to use the late-lactation milk for processing of mixed milk cheeses. By combining the sheep milk with cow milk, we are able to overcome many of the cheese making challenges. Nonetheless, the sheep milk has the potential to degrade the mixed milk cheeses as well, resulting in rancid or bitter flavor development in the Mona cheese.

Probably the best strategy will be to terminate milk shipping before the milk quality deteriorates. The high cheese yields are tempting, but the potential for cheese that is not up to standards presents a real danger.

## UNIQUE CHARACTERISTICS OF SHEEP MILK

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Larcher Consulting  
23220 Chéniers, France

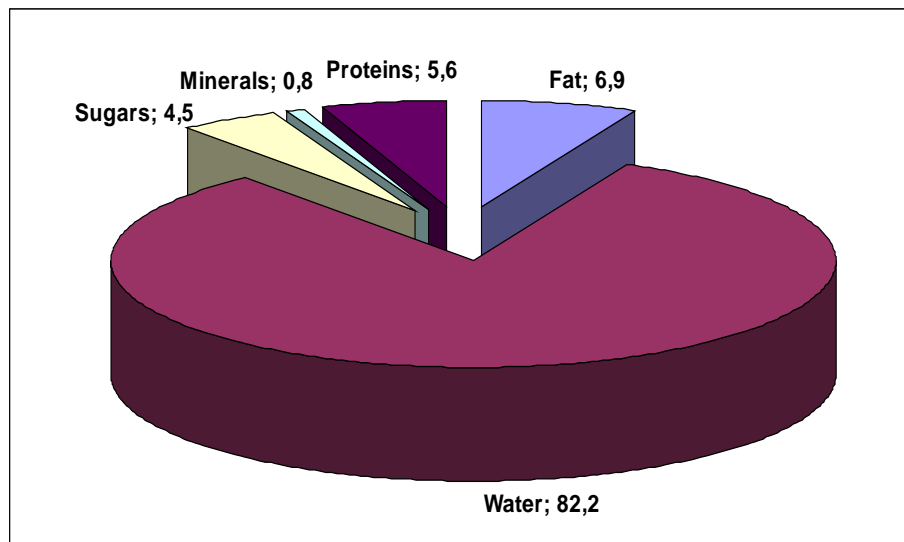
### Milk: Cheese making aptitude linked to composition

A good cheese making milk presents the following characteristics:

- high cheese making yield : Kg of cheese / 100 L of milk
- a final cheese with organoleptic characteristics conform to customers expectations
- a final cheese which composition respects regulations (Fat / DM)

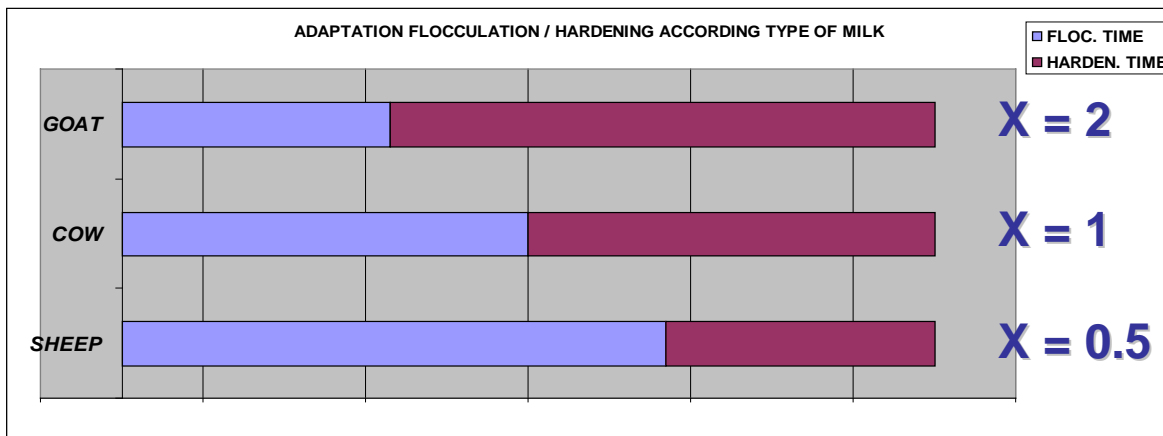
For Cheesemakers, milk's quality is expressed above all by its richness, i.e fat and curdling proteins content. On this point, differences between species are very important. Amongst the 3 major dairy species, sheep milk is the richest one and goat's the poorest. Sheep's milk contains an average of 81% water, 7% fat, 6% proteins, 5% sugars, and about 1% minerals and vitamins.

This medium composition is affected by numerous factors like race, production's system, season ... Thus we can observe following variations: 80 to 86% for water, 5.7 to 9.3 % for fat, 4.7 to 6.3% for proteins. These variations require adaptation of the cheese making recipe.



Sheep's milk, mostly dedicated to cheese production, is rarely standardized. In order to respect regulations about Fat/Dry matter in cheeses, it is very important to consider the ratio Fat/Protein and not only the protein content, in addition to the total Useful Dry Matter content (Fat+Proteins).

- Twice more fat in sheep's milk than cow/goat (*less drainage ability*)
- Twice more proteins (*higher and faster hardening of the gel*)
- Slightly less lactose than cow's milk (*less risks of post-acidification*)
- Twice more minerals (*better storage ability and higher buffer power; limited impact of acidification*)
- Compared to Cow and Goat's milk, during the rennet coagulation, sheep's milk is flocculated and gets firmer in a shorter time. This firmness is stronger than what would suggest the examination of contents (proteins). Thus, if we plan to make the same cheese with the 3 different milks, we will have to adjust Flocculation Time and Hardening Time, mainly playing with rennet dosage.

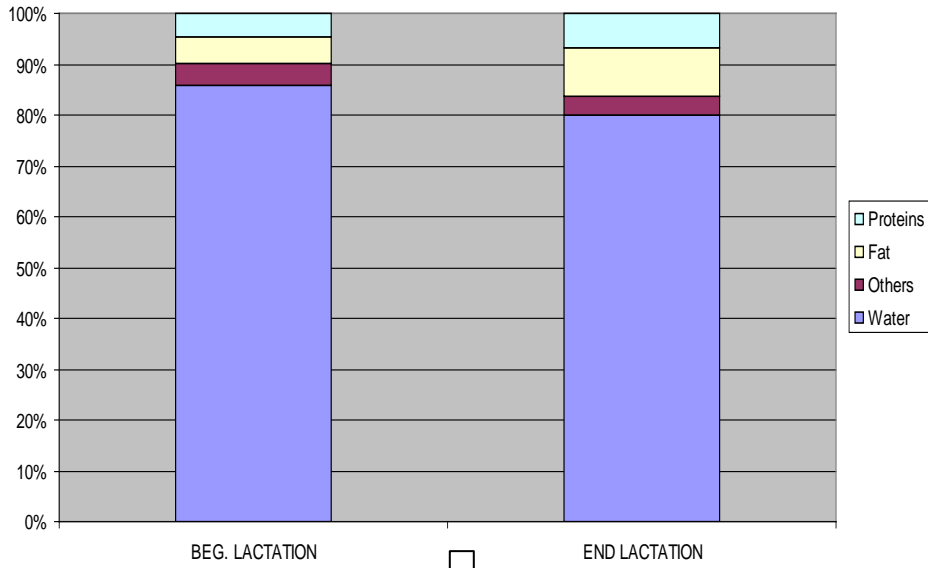


Working with the same ratio will lead to an « overset » curd with sheep milk (too firm, impossible to cut/drain), and a very weak curd with goat's milk (too soft, lot of damages, fines particles ...).

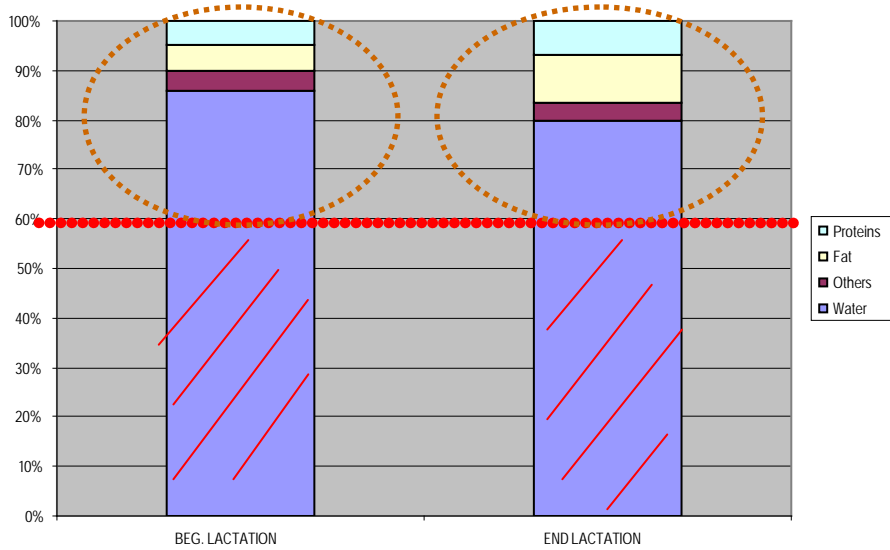
With a composition changing over the lactation period, it is necessary to adjust the « recipe » otherwise final cheeses will be different : with a richer milk, less water needs to be removed, but paradoxally this water is harder to drain off (lot of fat limiting syneresis):

- add water to the milk
- increase drainage temperature
- cutting the curd sooner (less HT)

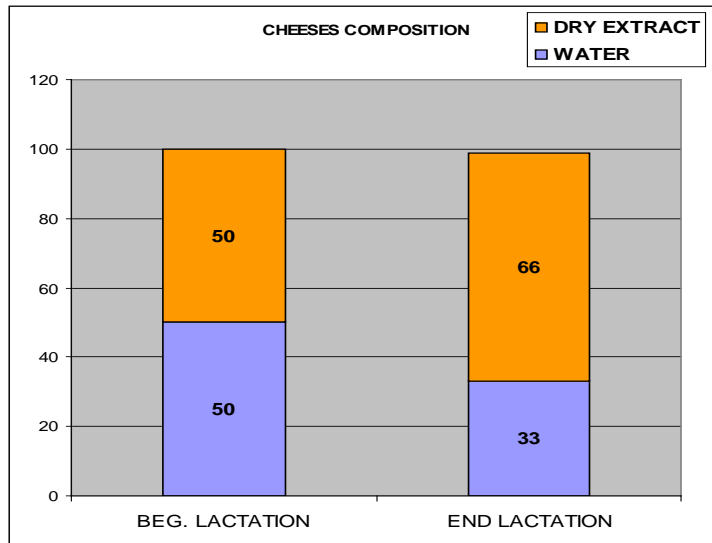
### MILK COMPOSITION



### PROCESSED INTO CHEESE



Making cheese with a standardized procedure ...

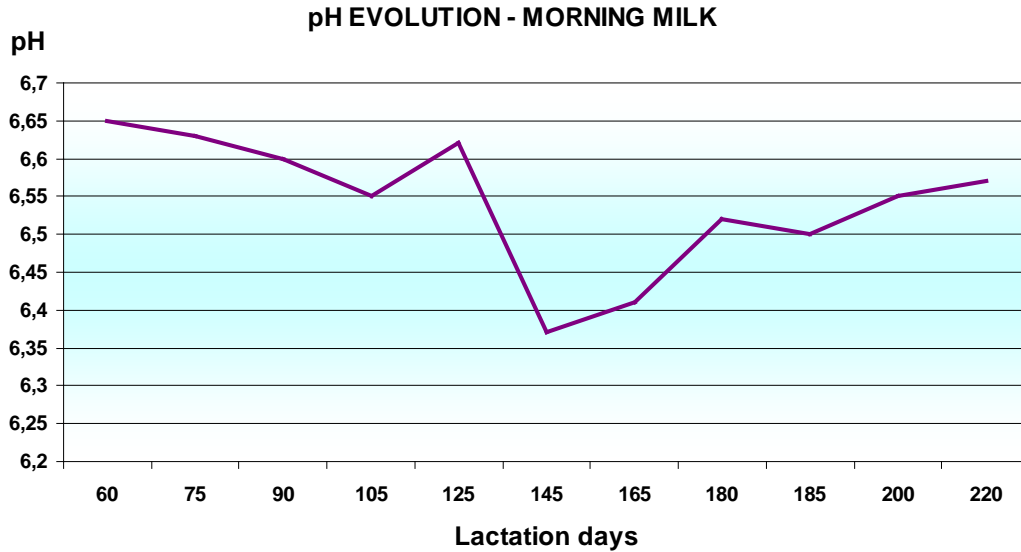


Makes different cheeses ....

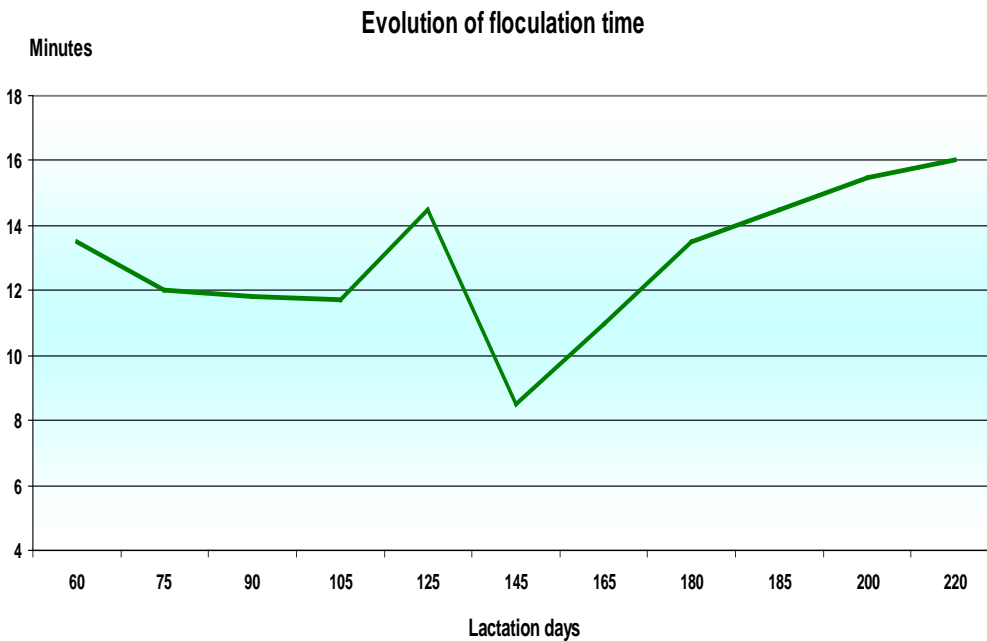


## Influence of pH Evolution on Flocculation Time

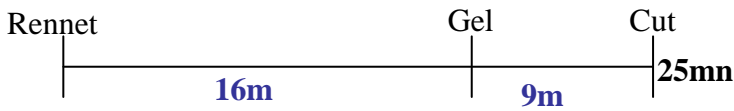
Average values on 146 sheep – Morning milk – La Farge 1989



pH of the milk at renneting has a direct influence on curdling speed, decreasing the time needed to create the gel. In case of «cutting by the clock », we will cut very firm curd in case of low pH (leading to a moister cheese), and weaker curd at higher pH (drier cheese).

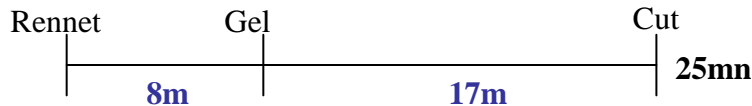


### If pH 6.6



*Weaker gel at cut, cutting smaller, drier curd then drier cheese*

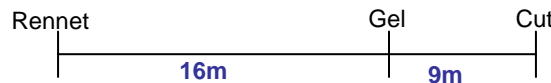
### If pH 6.35



*Firmer gel at cut, cutting bigger, moister curd then moister cheese*

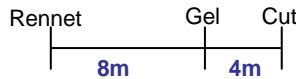
## **Influence of pH evolution on Flocculation Time**

### If pH 6.6



Total time of 25 mn, production of dry cheese with a **X factor of 0.5**

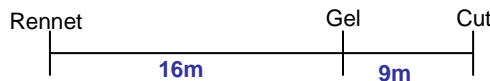
### If pH 6.35



In this case, we respect the ratio flocculation / hardening so the curd will have the same firmness at cutting, but total coagulation time is very short : organization problem, different acidification profile, different molding pH = different texture !!

## **Adjustments:**

### If pH 6.35



In order to correct the flocculation time and keep the same ratio (ex. 0.5) between flocc. and hardening, we can adjust 2 factors: **temperature and rennet dose.**

Temperature: if we decrease curdling temperature, the flocculation time will increase, and will thus correct the total coagulation time. The problem of moving the temperature is it is going to affect also the starter's activity (slow down), so we might lose the control of the acidification profiles (affecting the texture).

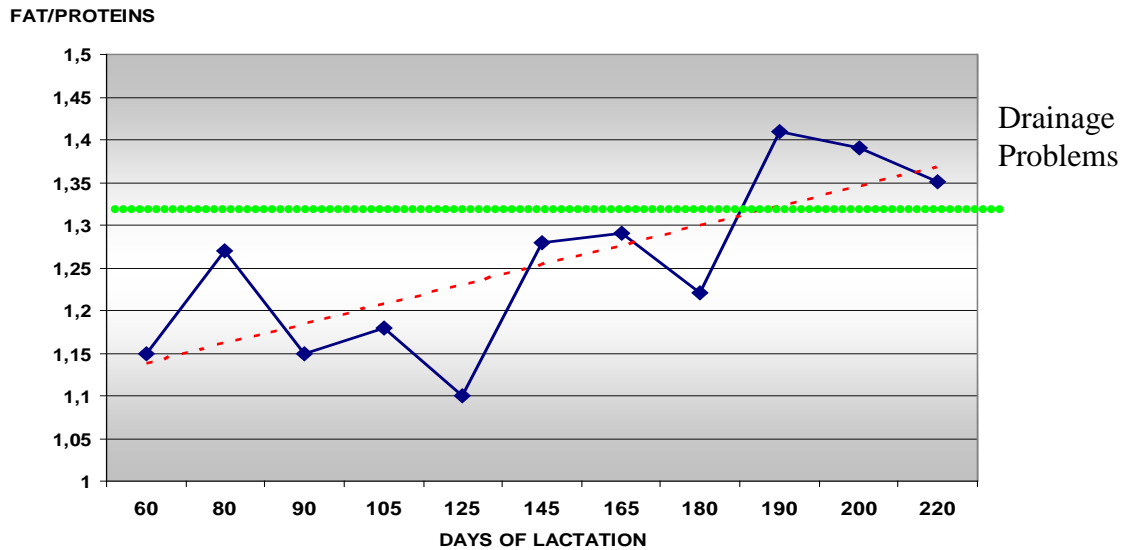
Dose of rennet: decreasing the dose of rennet will increase the flocculation time (correction also of total coagulation time) but without any consequence on the others parameters.

## Evolution of Ratio Fat / Protein on Morning milk

(Average of 146 milks, La Fage, 1989)

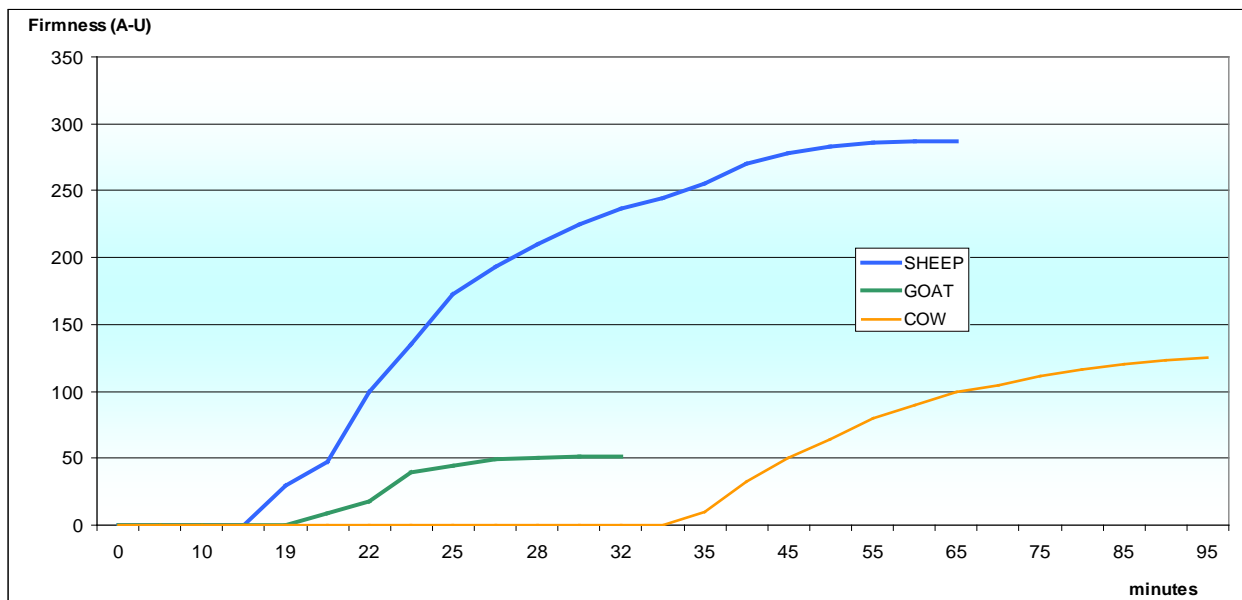
Considering Fat is inhibiting the drainage of the curd and partially impeach the clotting of caseins (big molecules in between), the more fat in the milk, the less drainage of the curd. Thus, particular attention will have to be observed during the end of lactation concerning the drainage of the curd :

- some Cheesemakers «**dilute**» **the milk with water** to help the curdling and favor the drainage.
- Some **increase scalding temperature in vat** to liquefy fat and help drainage
- Others work on **curdling mechanisms**, cutting sooner (weaker curd) and/or smaller.



## Behaviour of Sheep Milk During Curdling:

(Tracés du Torsiomètre de Plint, doc. Techno, INA PG)



Sheep milk, particularly rich in caseins and micellar calcium, is characterized by a flocculation time similar to goat's milk, a hardening speed sharply superior and a final gel's firmness twice superior to the cow's milk gel.

### **Sheep Milk's Behaviour After Heat Treatment**

Abstract from the study of F. Remeuf and K. Raynal: Effect of calcium addition, acidification, ultrafiltration and storage on renneting properties of heated goat's, ewes and cow's milk.

Following the heat treatment 80°C (176°F) / 1 mn of 3 types of milk (sheep, cow and goat), various corrective methods have been studied to observe their impact on coagulation properties of the milks.

- storage 24H at 25°C
- addition of Calcium (5 mmol/l , equivalent to 10% of total calcium in milk)
- Acidification to pH 6.3

### **Context:**

In dairies, milk is often heat treated to decrease bacteria's population but those treatments modify the structure of the casein's micelle, affecting the curdling properties of the milk. Major consequence is modification of soluble proteins, those one will cover the K-casein responsible of the curdling with the rennet (limited action of rennet and less micelles aggregation leading to weak curd).

Heat treatments also lead to precipitation of soluble calcium (creating calcium phosphate), calcium needed during the curdling. Thus gel formation and hardening will be limited due to lack of calcium available. In this context, what are the tools available to re-establish curdling aptitude of milks after heat treatments? Are those tools equivalent whatever the type of milk?

### **Calcium Balance:**

Quantity of soluble calcium decreases by 5 to 10% after heat treatment (80°C/1mn)

- Storage 24H/25°C does not permit to correct / re-establish the calcium balance in Sheep and goat's milk, a light increasing in cow's milk.
- CaCl<sub>2</sub> addition in sheep and goat's milk (3mmol) permits to obtain a concentration in soluble calcium little bit superior to the one in fresh milk while in cow's milk it is just reaching fresh milk value. Goat's milk is the one showing the biggest impact of CaCl<sub>2</sub> addition.
- An acidification of the milk (-0.2 pH) leads to calcium content superior to the one in fresh milk. Again, goat's milk is the most affected (positively) milk.

### **Enzymatic Reaction and Curdling Time:**

In cow's milk, curdling time (time needed after rennet addition for gel formation) passes from 1300 seconds to 1560 seconds (+20%, same increasing for sheep's milk) after a heat treatment of 80°C/1mn, while goat's milk is not really affected (+8%).

- Storage 24H/25°C permits to re-establish the curdling time of a fresh milk for sheep's milk, negative effect on goat's milk and no impact in cow's.
- CaCl<sub>2</sub> addition decrease CT (shorter than fresh milk's), with a stronger impact on cow then sheep, not really significant in goat's milk.

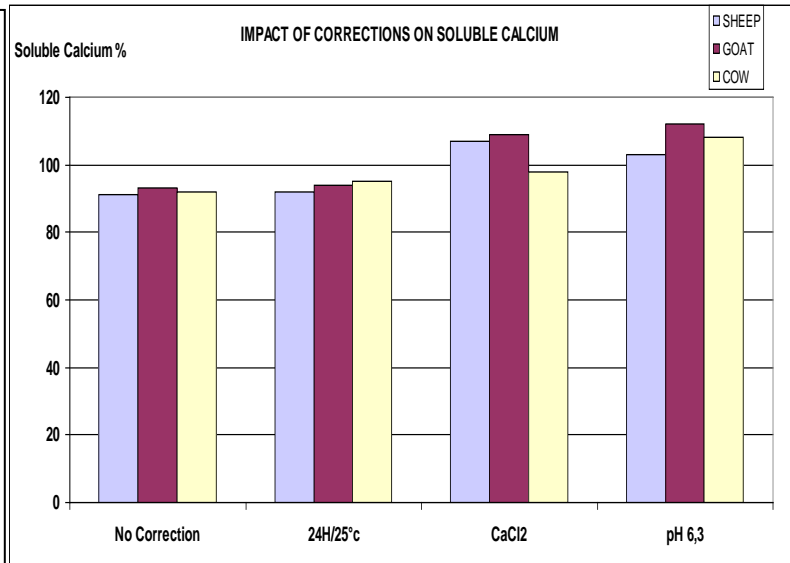
- Acidifying the milk also permits to decrease the curdling time (increases micelles volumes, limits negative charges ensuring repulsion, an increases quantity of soluble calcium available for curdling), with a higher effect on sheep, then cow, then goat's milk.

### Specifically on sheep's milk:

After heat treatment, a correcting maturation is necessary to re-establish the calcium balance (linked to gel's firmness, curdling speed, syneresis, yield).

2 methods can be applied : CaCl<sub>2</sub> addition and/or acidification of the milk prior renneting.

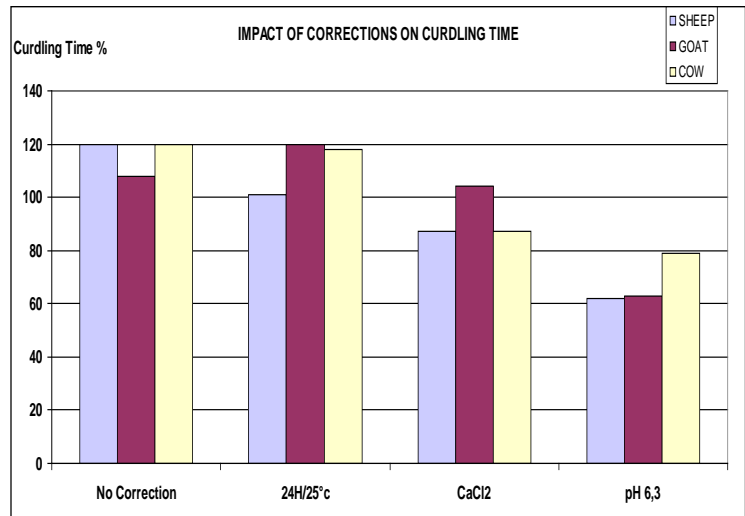
Concerning CaCl<sub>2</sub> addition do not overpass 20ml/100L (500g/l) to limit risks of bitterness.



### In sheep's milk:

An « over-correction » of the curdling time with excessive addition of CaCl<sub>2</sub> or with a massive acidification may lead to a very fast set : if the cheesemaker works « by the clock » without measuring CT, we may cut over-set curd, too firm, with less ability for draining off the whey.

Theoretically speaking the best solution to correct curdling time would be to mature the milk 24H/25°C.



### Hardening Kinetic:

The hardening kinetic is measured with a “Formagraph” and is called K<sub>20</sub> : time needed to obtain a certain firmness, related to hardening speed. After the heat treatment, K<sub>20</sub> is multiplied by 1.4 / 1.6 / 2 for sheep / goat / cow; Cow's milk is the most affected by heat treatment in terms of hardening speed:

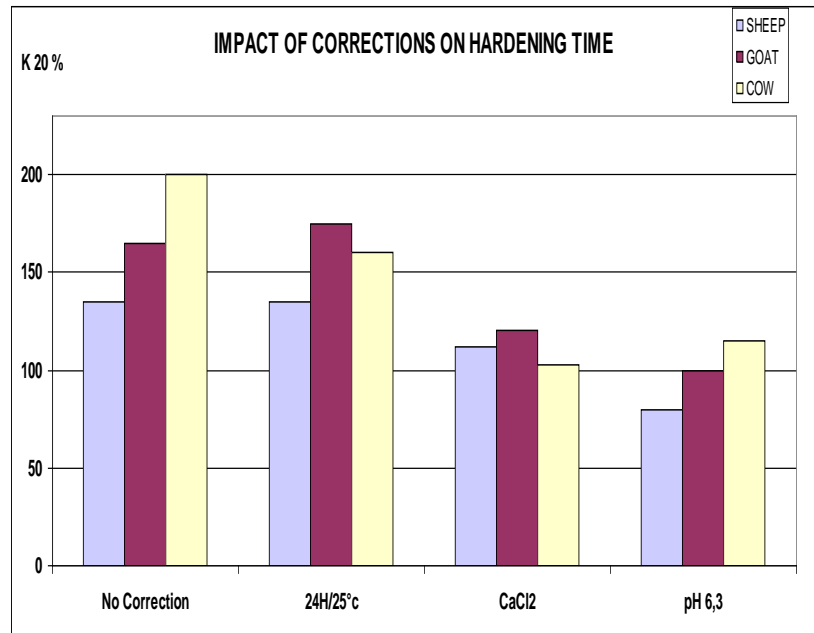
- Storage 24H/25°C doesn't really affect hardening kinetic, excepted concerning cow's milk, where K<sub>20</sub> decreases a bit.
- CaCl<sub>2</sub> contributes to decrease K<sub>20</sub> (faster kinetic) for cow's and goat's milks, but is less significant for sheep's milk (-17% for sheep milk, - 50% for cow's milk)

- Acidifying the milk permits to re-establish K20 for all milks (86% for sheep, 100% goat, 120% for cow).

### In sheep's milk:

Due to the exceptional composition of sheep's milk, this one never faces lack of hardening, it always get very firm in a very short time. More, the problem can be opposite: it gets too firm too quick, impeaching proper cutting and drainage because the curd is too firm.

Thus in sheep cheese making, there is no particular interest of maturing the milk to correct the Hardening speed, as it is always too fast.



### Evaluation of Firmness:

The firmness is evaluated by the Formagraph using a parameter called **A15**: measuring the firmness of the curd 15mn after the flocculation time. Heat treatment leads to an important decreasing of curd's firmness in all milk, but particularly on cow's milk.

- Storage 24H/25°C doesn't really affect firmness of the curd for small ruminants, corrects a bit for cow's milk.
- CaCl<sub>2</sub> contributes to increase the firmness of cow's milk gel but is not really significant for small ruminants' milks.
- For the 3 types of milk, acidification permits to recover the firmness of the curd (90% of "fresh milk curd's firmness) but relatively speaking, the impact is lower for sheep and goat's milk.

### Drainage Aptitude:

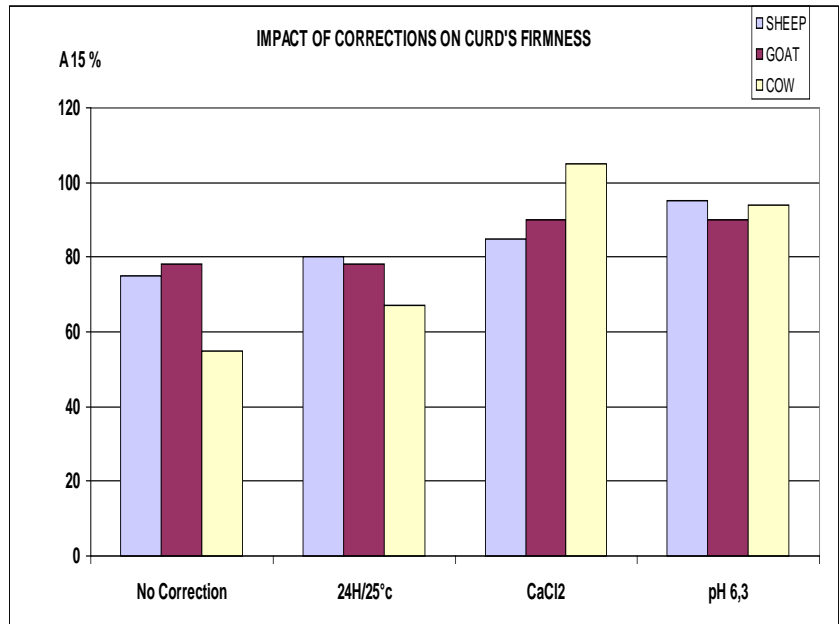
Sheep milk gel's drainage aptitude is seriously damaged following heat treatments, much less for goat's milk. This will influence production of dry cheeses (Manchego, Pecorino) made from heat treated milk: be careful of drainage ability.

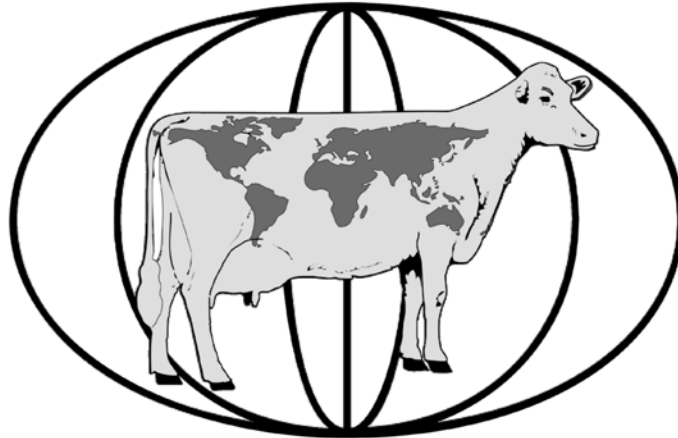
- Storage 24H/25°C doesn't affect volume of whey extracted (drained) from the gels.
- With CaCl<sub>2</sub> addition, cow's and goat's present a drainage aptitude similar to the fresh milks. Nevertheless, concerning sheep's milk, there is no significant improvement of drainage ability, even doubling the quantity of Calcium added.

- Acidifying the milk is much more significant for sheep's milk : volume of whey drained passes from 17% to 70% of the normal volume drained off a fresh milk's curd. For cow's and goat's, improvement is off 10% only.

**In sheep's milk:**

Due to the exceptional composition of sheep's milk, this one never faces problems of weak / soft curds. Same as the Kinetic, an excessive firmness in the curd is more related to drainage troubles. Thus, working on re-establishing the curd's firmness will have impact on final cheese yield (ensuring the best yield as possible) but will not have significant impact on the technology itself.





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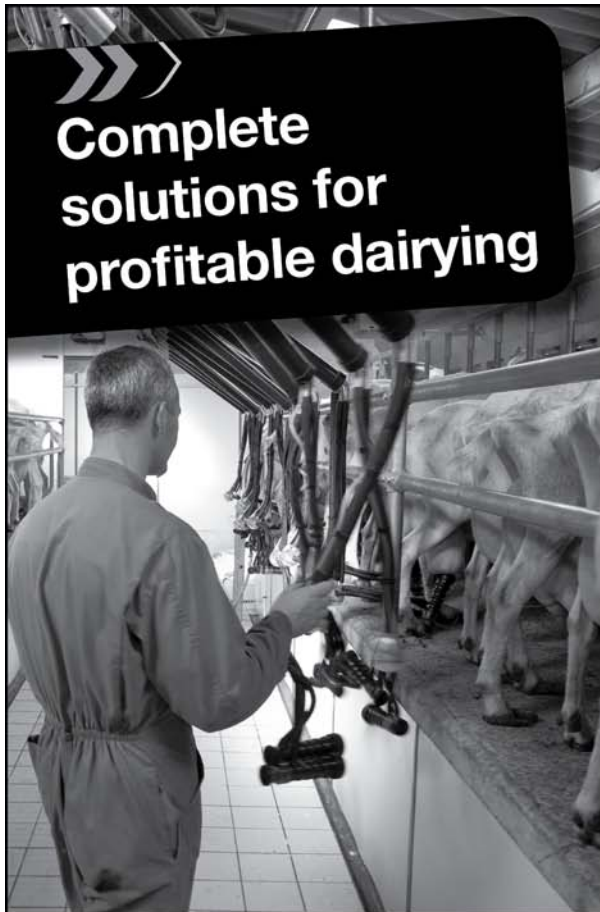
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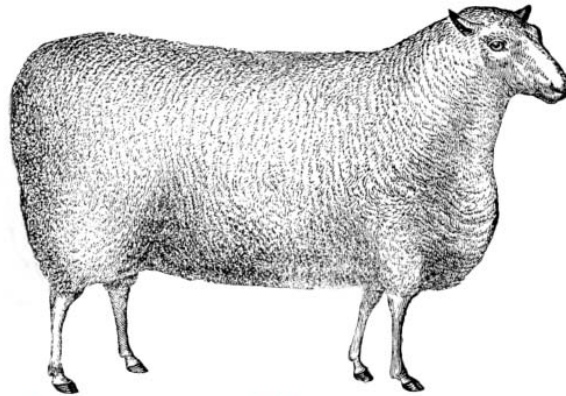
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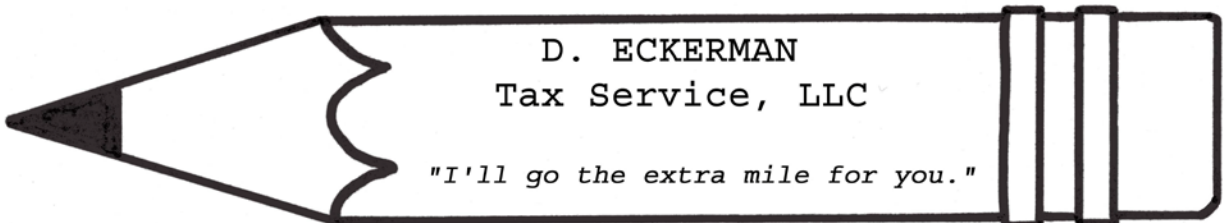
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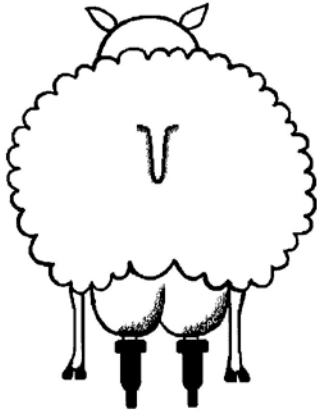
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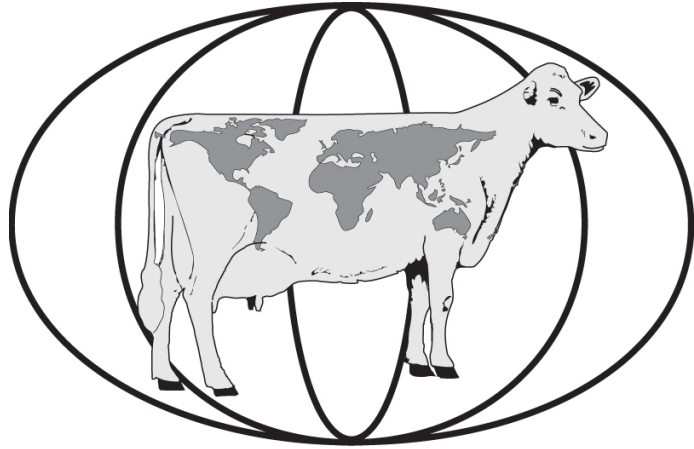
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