Proceedings of the 17th Annual

GREAT LAKES DAIRY SHEEP SYMPOSIUM

November 3-5, 2011
Petaluma, California, USA

Proceedings of the 17th Annual

GREAT LAKES DAIRY SHEEP SYMPOSIUM

November 3-5, 2011

Sheraton Sonoma County
Petaluma, California USA

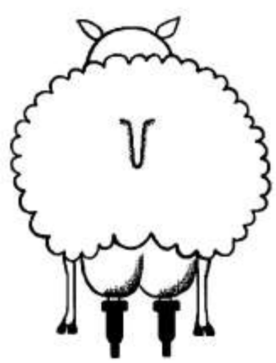
Organized by:

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

Assisted by:

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, USA (http://www.uwex.edu/ces/animalscience/sheep/)



Symposium Organizing Committee

Chair: Cindy Callahan, Petaluma, California, USA
Bill Halligan, Bushnell, Nebraska, USA
Laurel Kieffer, Strum, Wisconsin, USA
Rebecca King, Royal Oak, California, USA
Claire Mikolayunas, Madison, Wisconsin, USA
David Thomas, Madison, Wisconsin, USA

Proceedings Edited and Compiled by:

Claire Mikolayunas, Madison, Wisconsin, USA

Photographs on the Cover:

Clockwise from top right:

San Andreas sheep milk cheese,
Bellwether Farms, Petaluma, California, USA

Dairy lamb on a sunny day,
Bellwether Farms, Petaluma, California, USA

Dairy ewe and lamb on California coast
Barinaga Ranch, Marshall, California USA

'Outstanding in the Field' dinner at Barinaga Ranch
Barinaga Ranch, Marshall, California USA

Table of Contents

Program of Events

<u>**Thursday, November 3, 2011**</u>

8:45 a.m. **Registration**, Sheraton Sonoma County, Petaluma, California

9:10 a.m. **Welcome**
Bill Halligan, President, Dairy Sheep Association of North America, Bushnell, Nebraska, USA

9:15 a.m. **Getting Started in Sheep Dairying**
Terry Felda, Tin Willows Farm, Ione, Oregon USA

10:00 a.m **Investing in Relocatable Infrastructure: Organic Creamery and Milking Parlor**
Carleen and Joel Weirauch, Weirauch Farm and Creamery, Nocasio, California USA

11:00 a.m. **Milking Machine Design for Sheep**
Dr. Beate Maassen-Francke, Business Unit Milking & Cooling, GEA Farm Technologies GmbH, Germany

12:00 a.m. **Lunch**

1:00 p.m. **Properties of Sheep Milk for the Manufacture of Cheese and Yogurt**
Dr. Nana Farkye, Professor, Dairy Products Technology Center, California Polytechnic State University, San Luis Obispo, California, USA

2:15 p.m. **Practical Sheep Cheese Processing**
Liam Callahan, Bellwether Farms, Petaluma, California, USA

3:15 p.m. **Visit Sponsors and Break**

3:45 p.m. **Cheese Marketing Expertise**
Debra Dickerson, Cowgirl Creamery, San Francisco, California, USA

6:00 p.m. **Sheep Milk Cheese Reception**

Program of Events (cont.)

Friday, November 4, 2011

8:30 a.m. **Food Safety and Farmstead Cheesemaking**
Dr. DJ D'Amico, Vermont Institute of Artisan Cheese, Burlington, Vermont USA

9:30 a.m. **Situation of Sheep Milk Production in Europe**
Dr. Beate Maassen-Francke, Business Unit Milking&Cooling, GEA Farm Technologies GmbH, Germany

10:15 a.m. **Visit Sponsors and Break**

10:45 a.m. **Creative Lamb Marketing**
Dr. Stephanie Larson, University of California Cooperative Extension, Santa Rosa, California, USA

11:45 a.m. **Artificial Insemination: The Gateway to Superior Milk Production**
Martin Dally, Super Sire Ltd, Lebanon, Oregon, USA

12:30 p.m. **Lunch**

1:30 p.m. **Annual Meeting of Dairy Sheep Association of North America**

2:30 p.m. **Genetics of Lamb Survival**
Dr. David L. Thomas, Department of Animal Sciences, University of Wisconsin-Madison, Madison, Wisconsin, USA

3:15 p.m. **Visit Sponsors and Break**

3:45 p.m. **Methods of Pregnancy Diagnosis in Sheep**
Gary Veserat, Veserats Consulting, Woodland, California, USA

4:45 p.m. **15 Years of Research at Spooner Ag Research Station**
Dr. David L. Thomas, Department of Animal Sciences, University of Wisconsin-Madison, Madison, Wisconsin, USA

7:00 p.m. **Banquet** – Pre-registration required

Saturday, November 13, 2010

8:00 a.m. **Board Buses for Farm Tours**
Bellwether Farms, Petaluma, CA – Cynthia and Liam Callahan,
Haverton Hill Dairy
Weirauch Farm & Creamery, Nocasio, CA - Carleen and Joel Weirauch

4:00 p.m. **Buses return to Sheraton Sonoma County and symposium concludes**

Sponsors

Platinum:

Babcock Institute for International Dairy Research and Development, 460 Animal Sciences Building, 1675 Observatory Dr., University of Wisconsin-Madison, Madison, WI 53706-1205, USA; http://babcock.cals.wisc.edu/

Gold:

Dairy Connection, Inc., 501 Tasman St., Suite B, Madison, WI 53714; http://www.dairyconnection.com/

GEA Technologies, 1880 Country Farm Drive, Naperville, IL 60563; http://www.westfalia.com/

Land O'Lakes Animal Milk Products Co., 1080 County Road F West, Shoreview, MN 55126, USA; http://www.lolmilkreplacer.com/

Milk Products, Inc. (Sav-a-Lam), 435 E. Main St., P.O. Box 150, Chilton, WI 53014; http://www.milkproductsinc.com/#

National Livestock Producers Association, 13570 Meadowgrass Drive, Suite 201, Colorado Springs, CO 80921; http://www.sheepandgoatfund.com/

Wisconsin Sheep Dairy Cooperative, N50768 Cty Rd D, Strum, WI 54770; http://www.sheepmilk.biz/

Silver:

Everona Dairy, 23246 Clarks Mountain Road**,** Rapidan, Virginia 22733; http://everonadairy.com/

Bronze:

Cheese Labels, 3745 South 159th Street, New Berlin WI 53151; http://www.cheeselabels.com/

Fromagex, 62 Des Ateliers, Rimouski, Quebec GSM 1B2; http://www.fromagex.com/

Grober Nutrition 415 Dobbie Drive, Cambridge, Ontario; http://www.grobernutrition.com/

Irish Cream Sheep Dairy, P. O. Box 96, Bushnell, NE 96128; http://irishcreamsheepdairy.com/

Ovinshire Farm, 511 Frog City Rd., Ft. Plain, NY 13410; tmack@frontiernet.net

Page & Pedersen International, Ltd., 158 West Main St., Hopkinton, MA 01748; http://www.pagepedersen.net/

All 2011 sponsors are gratefully thanked for their generous support of the 17th Great Lakes Dairy Sheep Symposium and for their interest and support of the North American dairy sheep industry. The symposium would not be possible without the financial support of these sponsors.

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 DAIRYING

Terry Felda
Tin Willows Sheep Dairy
Ione, OR

In talking to some folks about this symposium in general and my presentation specifically, they wanted to know 'what were my greatest obstacles in getting started'. Since those obstacles seemed to vary week to week I wasn't sure where to start!

From initial phone call to license granted, it took about 2 years of negotiation, planning and work to build my facility. When you look at my pictures, you might wonder why it took so long! But let me give you some quick background.

Tin Willows Sheep Dairy is located in eastern Oregon, surrounded mostly by dry-land wheat farms. On average, we get about 10-13 inches of moisture per year. When I decided to leave Philadelphia to go into agriculture, I looked at everything from garlic to ginseng. But having sold cheeses in specialty shops I knew the demand for sheep milk cheeses was as strong as my research said it was. I also could see that local/farmers markets and the sustainable farming trends were not fading away soon. I also figured it didn't take a brain surgeon to milk a sheep. I mean how hard could it be?

Did I mention I had never been close to a sheep, never even touched one until I bought my own?

Obstacle One: Learning how to move and work with sheep.

When I moved to Oregon, I worked for a time on a large sheep ranch. That was invaluable experience. That ranch had 3500 head of sheep. That is 3500 individual opportunities to become comfortable with the normal birthing process as well as the complications such as prolapses, deformities, breech births, lamb grafting and the list goes on. It could take years to be exposed to that level of variety in a smaller operation. Other benefits included being able to see how much work was involved and how dirty it often is. Those books and magazines with lambs gamboling across lush lawns never show what the laundry looks like!

My first year, I had about 45 head which were in a borrowed barn with two acres of weeds, dirt and my having to toss hay over the fence. I lambed there with a borrowed generator for lights, ramshackle jugs and about six weeks experience on that large sheep ranch to guide me. I did some things right, and no doubt lots of things wrong. Those were the days when my girls would bust out of the fences on a daily basis. Well truth be told, I couldn't keep them in period. I developed a reputation for having sheep on the road and eating the ditches. They were especially fond of the wheat and barley fields down the road. I never knew where they were.

Obstacle Two: Learning how to lamb.

Obstacle Three: Learning to build sheep tight fence.

And then I tried milking them. I would separate the lambs off at night, leaving the ewes in the barn. I was working with my dairy inspector to get my license, but I was having trouble finding a suitable place to set up a dairy. In case you haven't noticed, I bought sheep without a single idea of where they would live. I think I was unique in this feature, buying the horse before the cart. I didn't own property, didn't have a lease, in fact now that I think about it, I'm not sure where I was living then! I think my sheep and I were all bordering on being homeless. But maybe that is another story.

I had tried to research which milking equipment to buy. I had read about CFM 's (I am still not sure what they are) and PPM's (pulsations per minute) and tried to ask questions on the dairy sheep yahoo site. I looked for articles showing pros and cons about equipment and how to use it. I couldn't find any. I talked to Hambys, studied the Parts Department catalog and became even more confused than when I first started out. It would be easy in Wisconsin to tour another dairy, even milk for a day or so. But not here in eastern Oregon. Even the closest Starbucks is an hour away. The nearest sheep dairies were all five to six hours away – one way. I actually did drive to see them in operation but they weren't milking then. All I was able to see were empty barns and equipment on a shelf. Deciding that something was better than nothing, I bought a "home dairy" setup with decades old surge milkers and an even older surge vacuum pump and a package diary cleaning kit, figuring I probably would not use it more than two years if only because I would grow beyond its' abilities. I think it cost me about $1500.00. I was right; I did rapidly grow beyond it. But more importantly, using that old equipment showed me what I like and do not like in equipment. For example, little green shut off valves that have to be opened and closed for vacuum. I do not like those. And today I have better, thanks in part to Tom and Laurel Keiffer at Dream Valley Farm in Wisconsin. I got my money's worth out of that old stuff and even more importantly, have absolutely no regrets about kicking it all to the back of the barn. Those old milkers are sitting on a shelf waiting to be sold for scrap. The vacuum pump is still working though and it powers my new cluster cleaner. Now that's a piece of equipment worth buying.

Obstacle Four: Learning what equipment to buy -and how it works.

My first milking setup was so pitiful I'm almost embarrassed to talk about it. Frankly, it conjures up so many bad memories, I don't even like to think about it. But while I still did not have my license, I wanted to practice milking. So I rigged up a stanchion with an old head gate and bungee cords. It sat on top of a straw bale and I put grain into a bucket behind it. The girls were penned into a small corral behind me, and I'd push one of them into this small "stall" I fixed up. I think they had to jump over the milker to get into it. After she was milked I'd open up the side panel and push her out. The downside was that the girls who had already been milked could reach the grain bucket through the panels and so I spent a considerable amount of time pushing them away while trying to milk the one in front of me who was also quite busy trying to keep her grain to herself. The first one-third ran over me trying to get in to the grain. It was a constant battle just to get one in, while keeping the rest out. The second third came in fairly politely and easily. The last third didn't. Come in. At all. That group involved kicking, rolling on the ground, bodies hurtling through the air, bawling and screaming, dust and dirt flying everywhere and then there's what the sheep were doing too. It took hours. Why I'm still milking is beyond me.

Obstacle Five: Getting my head examined.

Obstacle Six: Learn how to set up a good milking system for you and your sheep.

By fall, I had run out of borrowed ground, weeds and time. A friend and former sheep farmer suggested I send my sheep to the Williamette Valley on the western side of the state to run on grass seed fields all winter. We penciled it out and I realized I couldn't feed 40 head and their lambs for the price of sending them to the Valley. Also, the lamb buyers are on that side of the state so I would get a better price there than here on the east side. The other major benefit was the fact that I would not have to drive miles just to toss hay over the fence all winter. So that's what I've been doing for the past four years or so. Every October my sheep are shipped to Albany until about the middle of February. They are sheared there, the wool sold at some point later on. I have them trucked back to eastern Oregon for lambing season.

Obstacle Seven: Learn to think outside the box. Find a way to make your dairy work for you.

I have had some problems with this arrangement. The weather is milder on the west side of the state, but it's also wetter. The girls are often standing in water ankle deep for weeks at a time. Foot-rot is a major issue. So is pneumonia. I lose about five sheep every year which is major problem. Transportation costs are not getting cheaper. But the biggest problem has been that last month or so of gestation and the return trip. The last two years I have had some significant losses from 'twinning disease", mineral depletion and especially last year, transport tetany. Back in early February of 2011, while still in the Valley, the girls were sheared, vaccinated and wormed in one day. The sickest were then crowded into a livestock trailer and hauled 6 hours minimum back to eastern Oregon where they were put out in the middle of the night to waiting feed and water. They had gone almost 48 hours without either, and also had the stress of trailering and vaccinating, not to mention the fact they were about one month out from lambing. Right after getting them back, we worked on their feet, trimming hoofs and pushing them through numerous foot baths for the foot-rot. They started dying. And the ones that didn't die, aborted. Babies were born weak to even weaker mothers. I had a train wreck on my hands. It took a while to figure out what was happening. I took in dead lambs for lab samples; there were wool and fecal samples. We put out molasses tubs and bovine blulite in the water. The vet and I spent hours trying to figure out how to stop it. It took a while to figure out because I wasn't there when the sheep were being sheared and severely stressed so it took some time for me to piece the problem together. It was clear what the result of the problems were, what I was looking for was "why" and "How to Make Sure It Never Happened Again".

Obstacle Eight: Train Wrecks Happen.

Obstacle Nine: My learning curve is littered with carcasses.

There is more to that story. For the past two years I had a business partner. While I was trying to figure out exactly why we were having losses, lambing the rest of the girls, installing a completely new vacuum system, milking and cleaning equipment and bulk tank and getting ready to milk in April, for reasons that have nothing to do with the above scenario, that partnership ended in May.

In April, I started milking 22 ewes and immediately all 22 had mastitis. Every last one of them. It was back on the treadmill of trying to figure out why. It was immediately clear that the problem had to originate in the new milking equipment I had bought. I got the Interpuls 205 milking clusters, Coburn buckets, pretty standard equipment. I also bought a cluster cleaner that, like everything else, did not come with instructions on how to use or install it. Calling the dealer got me nothing. After talking several times with the Vet, calling the Gregory's, my milk buyers at Black Sheep Creamery (no milk yet! Sorry), feeding Omnigen nutritional supplements and countless hours of hair pulling, I called the Coburn rep in Oregon for help. It cost me $650 but he was there the next day. He looked at everything from the way the milk entered the bucket to how I washed my equipment and what chemicals I used. He was the one who straightened out the cluster cleaner issue. We set up a five gallon bucket for the cleaner, changed to a different detergent and sterilizer and the mastitis went away. The Coburn rep was worth every penny, I just wish I had thought to call him in from the start.

Obstacle Ten: My learning curve is also splattered with spilled milk. Don't cry over it.

The first year I got licensed, we sold 1800 pounds, then 9,000, then 15,000. I had planned on greatness this year. I didn't get it. Between the problems in the lambing barn, then the milking barn coupled with the distractions surrounding the partnership I made another grievous error. I thought I could simply add corn to the hay I was feeding and be fine. That was a mistake. I had the hay tested and discovered it was about 16% protein. Combine that with the corn and I was doing nothing and going nowhere. Corn is approximately 10% protein and when you take the average of each feed in your ration, the overall protein level is too low to generate a strong milk return. I talked to Claire at the University of Wisconsin, who graciously helped me work out a better feedplan. Since it was halfway through the summer, I wouldn't be able to re-coup the losses, but we thought I would at least be able to maintain where I was for the remainder of the season. So I bought soybean meal at tremendous cost. Then when I couldn't get that for a time, I grabbed expensive bags of 16% dairy cow feed. The corn ran out and it wasn't such a good buy either anymore. I ended up buying bags of grain plus the soybean meal. I couldn't justify the soybean meal anymore, so I stopped that. Eventually, I was feeding just bags of mixed grains and maybe some 16% feed. When I look at my feed costs this summer, combined with the marginal amount of milk I produced, I cringe. Frankly, the season couldn't end fast enough.

I milked more sheep but sold almost exactly what I did last year. My friend Stacy, who happens to be the town's preacher, calls this my "growth year". I have other, less kind words for it.

There's more to this story as well. It's hard to describe in words, but to say I do all this on a shoestring is to play down how tattered and frayed that string is. With the exception of my milking buckets, hoses and inflations, everything I have is borrowed, salvaged or just plain used. The buildings I have been using the past five years, thanks to the kindness of one family, are architecturally demanding. In other words, my milking stand is only about 12 inches off the ground. I milk on my knees. I don't have a problem with it, but my hired help does and my knees probably will sooner than later. The first year or two I pulled a rope to open each headlock. Four headlocks, four ropes. When I was given an old metal 8 head stanchion, I thought I was in tall cotton. No more ropes.

I carry the buckets from the milkhouse to the barn and back again. Originally, we poured the milk into one gallon freezer bags. We put that milk into a freezer and chilled it down there because we didn't have a bulk tank. My dairy inspector and I were comfortable that with the small amount being frozen and in such small bags, it was chilling down fast enough. Now we pour the chilled milk into 2 gallon buckets and freeze those.

It is very labor intensive, there's no denying that. Now I have a bulk tank to clean every other day. But it's easier to fill the buckets than the bags. My cluster cleaner is a major upgrade. If you can afford it, buy one. I have to continually remind myself that I am a Grade A dairy, even if I don't look like it. I spent a great deal of time this summer focusing on reducing my bacteria levels. I want to be consistently at 'raw milk' levels, not just good enough for cheese. I think I have a system in place now that will keep me there.

Some of you might be marveling at the fact I got my license at all with such a meager startup. The key to that revolves around two things. I worked very closely with my dairy inspector, Laura. At first, she simply spouted rules and regulations, talked about the physical requirements for the facility; concrete, something called 3A stainless steel the list goes on. But in continually talking to her, showing her different materials, pointing out how they don't conflict with the PMO, in general asking her to think outside the box, she did. She got excited about licensing her first sheep dairy. I'm sure that might not be the case everywhere. But my persistence paid off in this case.

And I think that's the second key to it all. I just never give up – even when I probably should. A while back, I figured out what my start-up costs were. I think, including sheep, that old surge system, various medicines, odds and ends, recycled panels, electric fencing, etc., it cost me about $8,000 - $10,000 to get licensed. Again, I do not own any land, so those costs are strictly for animals and materials.

My goals for 2012? This year I got talked into switching to Day 3 instead of the Day 30 weaning approach I had been using. God help me, I'm gonna try. I'm not sure exactly how I'm going to make this work by myself – I may have to leave some lambs on their mothers just to lessen the work load. I am also going to make a nuisance of myself with Claire. I need help establishing a feed plan that's consistent in maximizing my milk return. That includes grain or protein blocks and molasses tubs for energy while they're in the valley. There are a few other goals I've drawn up but those are the major ones.

The minor ones include building a new barn to get me off my knees, a new lambing facility because I lost the last one when the partnership dissolved, a facility to feed about 100 lambs… and the list keeps growing.

The primary thing that I take away from my experience is that there is no right or wrong. There might be a “better” or “worse” for each farmer though. If you don’t have 200 acres of grass, find another way to make your dairy work. If you don’t have unlimited start-up funds, figure out how to do it cheaper. If milking at 5am is unimaginable, then milk at 7 or 9.

Take advantage of programs like the Farm Service Agency or the FSA. Long before I had a farm that I wanted to buy or had decided to upgrade all of my equipment, I had met with my local loan officer. She and I discussed future options, how my business operates, the sheep dairy industry in general. By the time I was ready to discuss a loan, she was already well aware of the details of Tin Willows Sheep Dairy and more importantly, excited to help make it grow. I am very aware that I would not be where I am if I had not had help. While life in eastern Oregon has not always been easy, it seems that there is always someone interested in what I am doing and trying to figure out how to help me succeed. The resource of other people’s wisdom has been invaluable.

Talk to people, get other ideas on how to do things. Ask for help – and think outside the box.

INVESTING IN RELOCATABLE INFRASTRUCTURE: ORGANIC CREAMERY AND MILKING PARLOR

Joel and Carleen Weirauch
Weirauch Farm & Creamery
www.weirauchfarm.com
Petaluma, CA USA

Joel Weirauch has been working towards the production of a farmstead sheep cheese business since learning to make cheese in the France a decade ago. In 2004 he married his wife, Carleen Weirauch and the couple were presented with two East Friesian yearling ewes as a wedding gift. They cautiously increased their flock size as they became accustom to raising the specialized dairy breeds. They hand milked their ewes and made small quantities of sheep cheese for their household and eventually began producing their first commercial product: a sheep milk soap of which they still sell at farm markets (In the US, milk used for the production of a soap product is not regulated as it is for human consumption). Still working toward the eventual goal of a commercial cheese operation, the couple developed a long term plan based on the following two constraints: 1) access to enough land where they could also live and 2) limited finances.

To formulate their business plan they visited with experts in the field: farmers, local dairies, cheese makers, cheese consultants, inspectors, real estate agents, land trusts, open space organizations, non-profit groups and even met with other new start ups interested in cooperative projects. They eventually settled in on investing in infrastructure, not pasture. The nonprofit, CA Farmlink (www.californiafarmlink.org) linked them with local land owners that welcomed their vision of a farmstead sheep dairy and creamery on their property. A contract was drawn up that was sensitive to their growth over a three year period, use permits were secured and the Weirauch's finally began the remodel of two used portable classroom trailers that would eventually be transformed into relocatable creamery and dairy facilities.

Creamery, 40' x 12' trailer (USDA Certified Organic, mixed use processing facility)
July 2011: First cheese production in creamery is of an Organic *cow* cheese made with purchased local milk. The cow cheese is a year round product (offsetting some of the initial expense of the new sheep dairy), while the non organic sheep cheese is a seasonal product. Anticipated first sheep cheese in creamery, March 2012.

Dairy-Milking Parlor, 30' x 10' trailer
November 2011, Still under construction...better hurry up, lambing begins in February!

Dairy Exterior (under construction)

Creamery Exterior (complete)

Creamery Interior (cheese make room)

Creamery Interior (cheese aging room)

MILKING MACHINE DESIGN FOR SHEEP

Beate Maassen-Francke
Business Unit Milking & Cooling
GEA Farm Technologies GmbH
Germany

Introduction

The correct design of a milking installation is essential for optimal milking results. Proper settings maintain the health and well-being of the sheep as well as increase the productivity of the milker. These are the key factors for the economic success of a dairy. Coordinated design of all components comprising a milking installation is the most efficient system in respect of capital and operating costs.

In the last decade requirements for milking installations for small ruminants were published based on research and practical studies from France, Spain, Norway, Italy and other European institutes and organizations (Billon et.al, 2002; Billon, 2004). Finally in 2007 the international committee of standardization of milking installation integrated the requirements for sheep and goats into the existing ISO standards for milking machines, which are called ISO 5707, ISO 6690 and ISO 3918. The requirements are added there in Annex D. The ASABE, the US organization follows now the international standards as well.

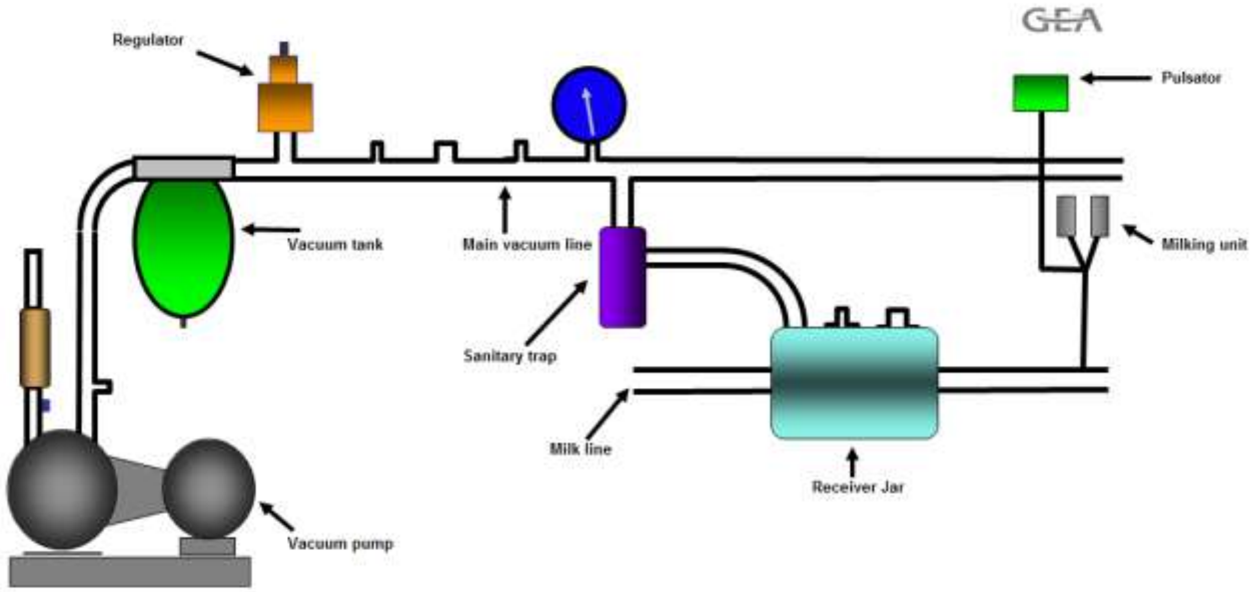
As in cows the ewe needs special requirements to be milked in a good, economical and healthy manner. Therefore it is necessary to have a closer look on the main components of a milking installation:

- The vacuum system
- The pulsation system
- The milk system
- The cleaning system
- The milking unit
- Environmental issues like influence of the altitude of the farm and the other important factor: the operator
-

Each component of a milking installation must be configured in such a way that the ewe can produce milk in an excellent quality without having negative effects on its physiological needs regarding udder health or other health issues. Furthermore the operator needs to work in a comfortable environment. The well balanced cooperation of milking technique- ewe-operator is evident to receive a profitable margin.

The main components of a milking system

Figure 1: Main components of a milking system (Brechbuehl, 2011)



The vacuum system

The vacuum system consists of

- Main vacuum line
- Vacuum pump
- Vacuum regulator
- Pulsation line

The measurement for vacuum capacity is kPa or mHg, which is only used in the US.

The vacuum pump capacity is dependent on the
- The altitude of the farm
- Size of the milking parlour
- The number of operators
- Number of milking units
- The type of cluster being used

The performance of the vacuum system is dependent on the dimensions of the vacuum lines and the capacity of the vacuum pump. For the technical side that means that there needs to be enough effective reserve to maintain the vacuum.

There are two ways to maintain the effective reserve:
- The operator who has the skill to let as less air into the system as possible
- The use of professional milking equipment:
  - a non conventional milking unit with teat cup valves
  - process control unit supplying vacuum exactly at that time when it is needed

When measuring vacuum losses it has been found out that the vacuum drop between Vp to Vr (vacuum pump to the regulator) shall not be more than 2 kPa (0.59 inHg) and between Vr to Vm (regulator and receiver jar) shall not exceed 1 kPa (0.29 inHg) otherwise it has a negative impact on animal welfare (Sevi et al., 2009) and udder health (Billon, 2004). To be in that range the correct dimension of the vacuum line is essential – is the main vacuum line too small the vacuum drops increase. The velocity increases and therefore the fluctuations increase as well. Fluctuations occur due to bad regulated systems. It could be that the vacuum regulator or the frequency converter do not work in the appropriate manner or are installed incorrectly.

Proper working of the milking installation requires the knowledge of the altitude of the farm: in areas up to 300 m (984.28 ft) above sea level an atmospheric pressure of 100 kPa (29.53 inHg) shall be assumed to the vacuum pump capacity. Above 300 m (984.28 ft) you need a higher pump capacity – tables exist to calculate the additional air needed (ISO 6690; ISO 5707).

The installation of a vacuum pump shall be outside of the parlour. It is not only necessary to reduce the noise, but as well to have clean air in the parlour instead of oil filled air especially when using oil greased pumps. A separate utility room where the water boiler, heat recovery, electrical installations are situated is the ideal place.

Using a frequency converter is an energy saving equipment, which reduces noises and get the right vacuum capacity when you need it. It should be placed near the vacuum pump to have low impact of electrical noise.

If you install a frequency converter the regulator has only the function of a safety valve. The regulator shall be put as close to the uncontrolled air inlet – that means close to the milker.

Vacuum level

Studies show the importance of vacuum level and vacuum fluctuations on animal welfare issues. Vacuum fluctuations are often associated with an increase in mammary infections. An Italian study with Sarda ewes on the island Sardinia, where the normal working vacuum level is between 42 and 44 kPa (12.40 and 12.99 inHg) showed higher vacuum fluctuation in an installation with a vacuum level of 42 kPa (12.40 inHg) compared to 28 kPa (8.27 inHg). It was shown that it is possible to milk at regularly low vacuum levels to permit more comfortable milking without liner slips and milking unit fall offs. In general the average working vacuum in low line systems shall be at 36 kPa (10.63 inHg). There should be the condition of a complete emptying of the udder and no significant increase in milking duration (Panzzona et al., 2007). The effect of low vacuum was conducted by Caria et al. (2008). Vacuum fluctuations in low vaccum measured in the milk line and in the short milk tube were less compared to 44 kPa (12.99 inHg). Gonzalo et al. (2005) found a positive correlation r=0.24 for log BTSCC (bulk tank somatic cell count) and vacuum level.

Using high line, mid-line or low line installations can be a matter of habit or tradition in certain areas. Practice shows that high line installation requires a higher working vacuum level of 2- 3 kPa (0.59- 0.89 inHg) than low line installations.

Pulsation system

The pulsation system consists mainly of a pulsator which can either work pneumatically or electronically. Both systems are available today. In small operations, bucket milking machines or small mobile milking system the pneumatic pulsator is used. In bigger installations and installations with control units, detachers, milkmeters the electronically working pulsator is mainly used. This can either be a single pulsator or a double pulsator. That means 2 milking units are served by one pulsator.

Pulsation means the complete evacuation and then admission of air in the intermediate chamber of every teat cup. The full movement of the liner from opening through closing to opening again is referred to as the pulsation cycle. The pulsator rate in dairy sheep varies from 90 to 180 cycles/min. The most common values are 120, 150, 180 cycles/min. No significant differences were found regarding intramamary infection of 150 and 180 cycles/min. (Peris et al., 2003).

The pulsation cycle is divided into 4 individual phases like shown in Figure 2.

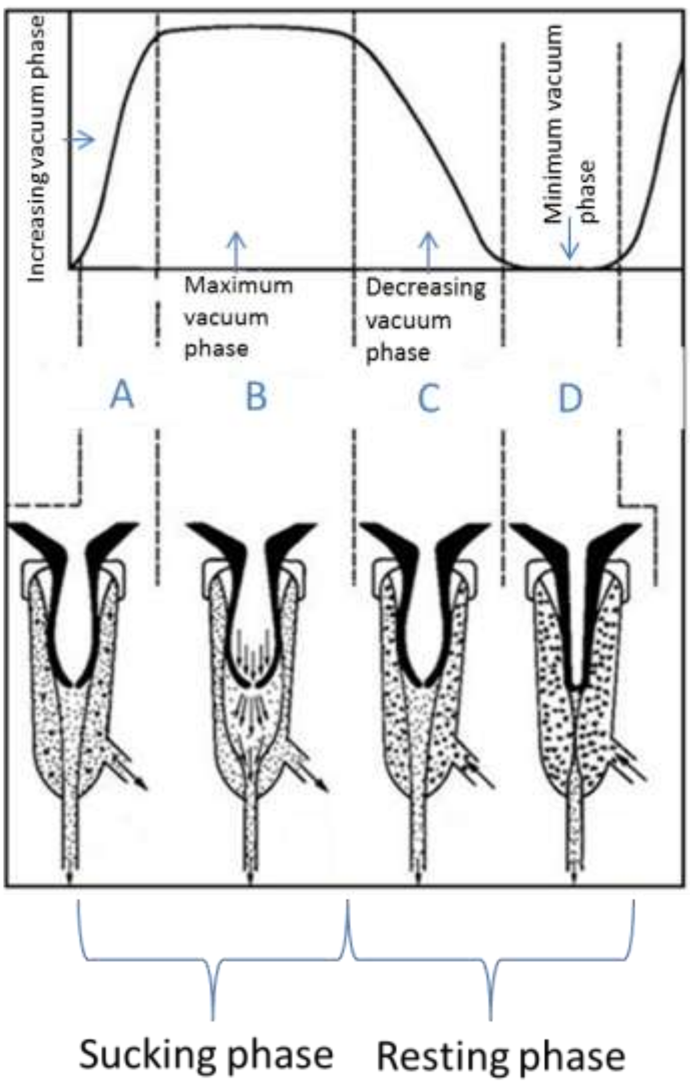


Figure 2: Pulsation phase and liner movement (Schulze Wartenhorst, 2007).

Phase a: increasing vacuum phase
Phase b: maximum vacuum phase
Phase c: decreasing vacuum phase
Phase d: minimum vacuum phase

Description of Phase a

In simple terms, phase a can be described as being responsible for the opening of the liner. However, this opening does not take place across the whole length of phase a, but during the final third of the phase depending on the collapse force of the liner, i.e. shortly before the start of phase b. If this phase is too short, the liner will open very quickly. This can lead to an additional vacuum being created inside the liner due to a very fast increase in volume. If phase a is too short, it will promote sprayback of milk. Phase a being too long, the result will be a shortened ineffective phase b and thus can reduce the speed of milking.

Description of phase b

In phase b, the liner is open and milk flows from the teat. The length of phase b determines the speed of milking whereby upper limits should be observed as these could lead to undesirable secondary effects. If phase b is too long, for example, more and more bodily fluids will be drawn into the tip of the teat. The d phase will no longer be long enough to massage the fluids being collected at the teat tip up the teat. Consequently, the teat will harden, it will become more and more difficult to open the teat sphincter and the milk flow will be reduced accordingly. A negative effect on teat condition is the result. This effect can as well result into an unpleasant feeling of the animal so that the ewe will react more and more frequently by kicking off the cluster.

If phase b is too short, the rate of milking will be reduced due to the fact that the opening time of liner lasts not long enough.

Description of phase c

During phase c, the liner will close. The length of this phase is the defined factor which determines the time at which the liner closes. Just like opening, the actual closing movement is dependent on the collapse force of the liner and takes place during the first third of phase c.
If phase c is too long, depending on the pulse ratio set in each case, the length of the relief phase during phase d may be reduced so that the time specified here will no longer be sufficient for a good relief on the teat. However this again clearly shows that phases c and d are interconnected. If c is made longer, d will become shorter and vice versa. If phase c is too short, the liner will close on the teat too quickly which is unpleasant for the animals. If phase c is too long, it might reduce the length of phase d.

Description of phase d

During phase d the liner remains closed and while it is closed, it will exert a massaging pressure on the teat. Any fluids that accumulate will be massaged out of the tip of the teat into the upper part of the teat and back into the blood circulation. This will keep the teat end in a soft condition for milking. If phase d is too short, a sufficient relief effect cannot be realised. The two conditions that apply have to have a certain pressure and this pressure has to be maintained at the

teats for a certain length of time. Finally, the bodily fluids being sucked into the teat must be moved away from the teat end and massaged into other areas of tissue. That takes time.
If the d phase is too long, all blood and bodily fluids have been massaged out of the tip because the pressure has been applied to the tip of the teat for too long. Now, of course, it will take longer for this teat to be able to open the teat channel to the full extent during the next phase when the teat liner will be opened again. If phase d is too short, there will be an insufficient relief, it will have a negative effect on teat condition, milk flow will be reduced and the risk of mastitis can increase.

For cows the ISO standard wants the b phase to be not less than 30 % of the pulsation cycle. Phase d shall be not less than 150 ms or 15 % of the pulsation cycle. For dairy ewes no standards are given for the length of each phase. But it is recommended that the c phase shall be between 15-20 % of the pulsation cycle.

The d phase is often longer than in cows. Studies from Peris et al. (2003) showed that the d phase varies: at a pulsation rate of 120 cycles/min from app. 40 % to 33 % at a pulsation rate of 180, pulsation ratio in this study was 50:50. Intermammary infection and change in teat thickness were similar with the two assayed pulsation rates. Good practical results are seen with an a phase being app. 20% and a b-phase of 28-32 %. With an a-phase being in that range the pump force of the liner is under control and the opening of the liner is not too fast. Pazzona et al. (2007) said that it is advisable to adopt a pulsation rate of 150 cycles/min and a pulsation ratio of 50 %. This combination allows a faster milk extraction, avoiding the negative effects on vacuum level and stability caused by the 60 % pulsation ratio.

There are two different types of pulsation: Simultaneous pulsation or alternate pulsation. Both ways are used in the world. According to Billot (2004) there is no evidence to favour one or the other type of pulsation from a scientific view. If the sheep has a very high milk flow and milk yield then an alternate pulsation is an option to avoid flooding of claw or teat cup.

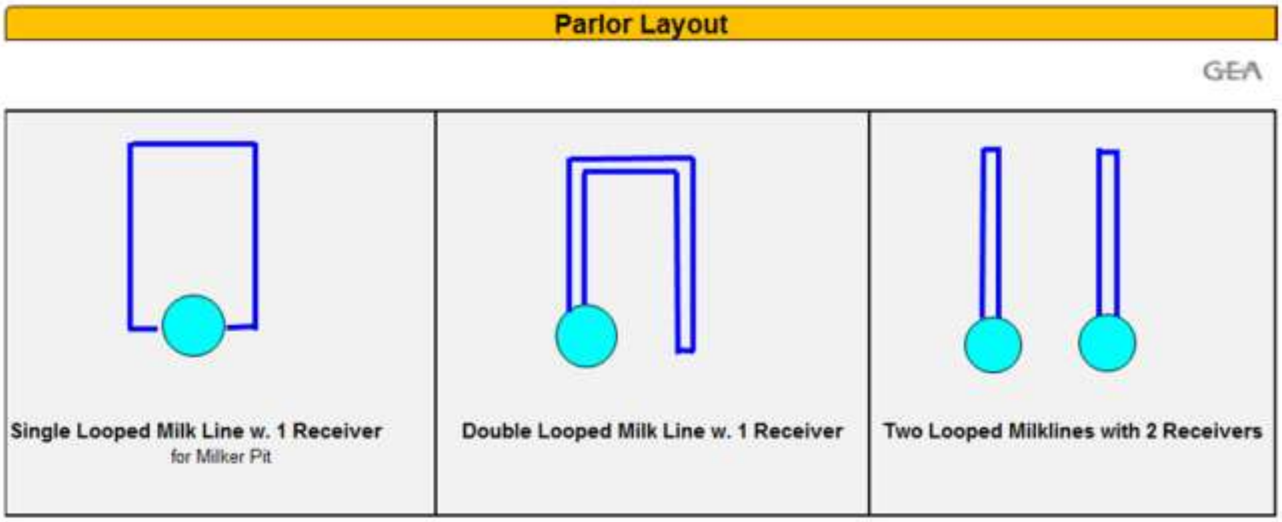
Milk system and milkline dimensions

The milk system is the part of the milking installation where milk and air is flowing. The milk lines, the milk inlet valves, the receiver, the delivery line and the long milk tube belong to that system. In general the milk lines shall be designed in such a way to show provisions for a good drainage capability.

The dimension of milk line is dependent on the number of milking units, the length and slope of the milk lines, the amount of milk and air that comes into the system.
Milk lines can be designed in single or double loops or in dead-end configurations which also influenced the dimension of the milk line.

The terms of high level, mid level and low level milking is determined by the position of the milk lines: a high level milking system is a system where the milk inlet is more than 1. 25 m (49.21 inch) above animal standing level; mid level: 0 - 1.25 m (0- 49.21 inch); at low level the milk line is below the animal standing level.

Figure 3: Configurations of milk lines in parlours



The milk flow of sheep varies between breeds. Therefore three types of milk flow curves with three different peak milk flows of 0.8kg/min (1.76 lb/min); 1.3 kg/min (2.87 lb/min) and 2.7 kg/min (5.95 lb/min) formed the base to predict the milk amount in sheep installations. The breed Lacaune was predicted at 0.8 kg/min (1.76 1.76 lb/min); Manchega, Churra, Laxta at 1.3 kg/min (2.87 lb/min) and the Sarda at 2.7 kg/min (5.95 lb/min). Furthermore the milking time was taken into consideration which was stated as short milking time (milking time < 120 sec.) and long milking time (milking time > 120 sec.). For the mentioned breeds a short milking time was described.

Table 1 and 2 show the influence of the breed and the resulting milk flow as well as the type of cluster on the dimension of the milkline. Milking East Friesian sheep at a 2“ milk line with a slope of 1 % the maximum number of milking units is 9. Milking ewes with high milk flows the maximal number is 4 units. Using a non conventional cluster in the same configuration the number of units is unlimited. A higher slope leads to more clusters per slope, but a 2 % slope can often not be realised due to building barriers.

The dimension of the milk line has an impact on vacuum stability. Caria et.al. (2008) found out that using a 76 mm (3”)milk line compared to a 50 mm (2”) showed positive effects on milking routine that was not interrupted by liner slips and milking units fall off. To be on the safe side when installing a new parlour the genetic and phenotypic improvement of the sheep breed shall be taken into consideration. Parlours shall last for 20 years.

Table 1: No of milking units per slope (conventional standard milking unit w/o automatic shut off)
[Short milking time < 120 sec. and attachment time 5 sec.]

Diameter of milkline	Ewes with milkflow 1.3 kg/ min (2.87 lb/min) Manchega, Churra, Laxta, East Friesian			Ewes with milkflow 2.7 kg/min (5.95 lb/min) Sarda		
	Slope in %					
Looped milkline	0.5	1	2	0.5	1	2
40/38 (1.5")	1	2	4	1	1	2
51/48.5 (2")	3	9	u	1	4	u
63/60 (2.5")	u	u	u	6	u	u
76/73 (3")	u	u	u	u	u	u

u = unlimited

Table 2: No of milking units per slope (non-conventional milking unit with automatic teat cup valves)
[Short milking time < 120 sec. and attachment time 5 sec.]

Diameter of milkline	Ewes with milkflow 1.3 kg/ min (2.87 lb/min) Manchega, Churra, Laxta, East Friesian			Ewes with milkflow 2.7 kg/min (5.95 lb/min) Sarda		
	Slope in %					
Looped milkline	0.5	1	2	0.5	1	2
40/38 (1.5")	4	9	u	2	5	u
51/48.5 (2")	u	u	u	8	u	u
63/60 (2.5")	u	u	u	u	u	u
76/73 (3")	u	u	u	u	u	u

u = unlimited

The milking unit

The International Standard differentiates between 4 types of milking units

- Standard Milking Unit
  - Conventional standard milking unit w/o automatic vacuum shut off
  - Conventional standard milking unit with automatic vacuum shut off
- Special Milking Unit
  - Non conventional milking unit with automatic teat cup valves
  - Non conventional milking units with automatic teat cup valves and detacher

As mentioned above the non conventional unit with teat cup valve offers a safe attachment without unintended air leakage. If the cluster falls off, the valve shuts immediately. The air leakage and the resulting vacuum drop are reduced to a minimum. The operator has not to worry about air admissions. Even untrained operators can work well with these clusters.

Good trained people in small operations can also work very easily with traditional milking units. They often know their ewes, their habits and can counteract to some unexpected issues. If you work with more than 6 units an automatic detacher or a second milker shall be on site.

Liner

In dairy sheep installations esp. where there is no automatic detachment the transparent silicon liner combined with a transparent teat cup has the advantage that the milker sees the decreasing milk flow compared to a rubber liner. This is one little helper to reduce overmilking which often occurs in sheep milking installations due to the short milking duration of the ewe.

Silicone liners show better gripping. Teat cup fall offs and liner slips are reduced. Hard liners may increase stripping, because it moves more slowly and the open phase can be longer than with a soft silicone liner. Silicone liners are less deleterious on the teat and liner climbing seems to be less. The collapse force shall be at 10 kPa (2.95 inHg) (Marnet, 1997).

Short milk tube and long milk tube

The short milk tube shall have an internal diameter of at least 9 mm (0.35 inch). According to ISO standard (2007) the long milk tube in sheep installations shall not exceed an internal diameter of 14.5 mm (0.57 inch) in order to limit harmful agitation of the milk. To avoid unnecessary vacuum drops the long milk tube should be as short as practicable.

Claw

If the cluster is combined with a claw it shall be good in handling and fit into the palm of a hand. The volume capacities of claws in practice are between 80 and 120 ccm.

Cleaning of the milking installations

Besides milking the cleaning performance of the milking installation is very important for a hygienic production of the valuable sheep milk. The ovine milk is very rich in solids, fat and protein. Therefore a successful cleaning of the complete installation is the base a safe.raw product and healthy animals.

Next to adequate cleaning and disinfection agents the installation has to be designed in such a way that no cleaning or disinfection solution can contaminate the milk. To reduce residues in the milk line, milk tubes and milking unit the layout of the installation shall be designed to have an adequate circulation volume and an appropriate velocity of 7 to 10 m/sec (15.66 to 22.37 mph). In sheep milking installations very often the design of the cleaning is neglected or it is mentioned that the vacuum capacity needed for cleaning can be divided into half to that of cows as there are only 2 cups instead of 4 cups used for milking. This is a popular fallacy. The design of a milking installation has always been carried out according good performance of milking and cleaning.

Practical hints to keep in mind when designing a sheep milking installation:

- Sheep breed – predicted milk flow, long or short milking duration
- Size and type of a parlour
- Low line installation / high line installations
- Type of milking unit
- Altitude of farm
- Length of vacuum line
- Length of milk line
- Configuration of milk line
- Number of milkers
- Expected working vacuum

Conclusion

Designing a milking installation for sheep bears careful considerations before starting the operation. A good preparation of what is needed and what will happen in the future is the key factor for a successful installation.

The correct design is based on empirical evaluated data contributed into the ISO standards. The equations include figures on the sheep being milked, the type of milking unit to be used, the type of parlour and the number of operators to choose the right vacuum pump capacity, the correct dimension of milk and vacuum lines. Correct layout of milking installations from the beginning offers the operator a pleasant and comfortable working place and the sheep an environment to produce good quality milk. In well-balanced systems all components are aligned properly. Vacuum pumps, milk lines and all other parts are accurately sized for the most efficient and productive way of milking sheep.

Literature Cited

Billon, P., Fernandez Martinez, N., Ronningen, O., Sangiorgi, F., Schuiling, E., 2002 : Quantitative recommendations for milking machine installations for small rumimants. Bulletin of the International Dairy Federation

Billon, P., 2004: The Designing of small and medium sized milking machines for dairy sheep, In: Proc, 10th Great Lake Dairy Sheep Symposium, Wisconsin, Nov. 4-6, 2004

Brechbuehl, B. 2011: Excel program for design of milking installations, internal communication GEA FT

Caria, M., Murgia, L., Pazzona, A., 2008: Effect of low vacuum on sheep milking. Int. Conf. on Innovation Technology to Empower Safety, Health and Welfare in Agriculture and Agro-Food Systems, Sept. 15-17, 2008, Ragusa, Italy

Gonzalo, C., Carriedo, J.A., Blanco, M.A., Beneitez, E., Juarez, M.T., De La Fuente, L.F., San Primitivo F., 2005: Factors of variation influencing bulk tank somatic sell sount in dairy sheep. J.Dairy Sci. 88: 969-974

ISO 3819 2007: Milking machine installations – vocabulary

ISO 5707 2007: Milking machine installations - construction and performance

ISO 6690 2007: Milking machine installations – mechanical tests

Marnet, P.G. 1997. Ewe management for improved milk yield and quality. Proc. Third Great. Lakes Dairy Sheep Symposium, April 4, Madison, WI. 5-11

Pazzona, A.; Caria, M., Murgia, L., Sistu, L., 2007: Effects of low vacuum levels on vacuum dynamics during milking; Proc. 17th Nat. Congr. ASPA, Algehro, Italy

Peris C., Diaz, J.R., Segura, C., Marti, A., Fernandez, N. 2003; Influence of pulsation rate on udder health and teat thickness changes in dairy ewes. J. Dairy Sci. 86(2):530-537

Schulze Wartenhorst, B. 2007: Basic Milking part 2; internal communication GEA FT

Sevi et al., 2009: Factors of welfare reduction in dairy sheep and goat; Ital. J. Anim. Sci. Vol. 8 (suppl.1), 81-101

PROPERTIES OF SHEEP MILK FOR THE MANUFACTURE OF CHEESE AND YOGURT

Nana Y. Farkye, Ph.D.
Professor
Dairy Products Technology Center
California Polytechnic State University
San Luis Obispo, CA 93407

Sheep milk production

All sheep and lamb inventory in the United States as of January 1, 2011, totaled 5.53 million head, down 2 percent from 2010. Breeding sheep inventory decreased to 4.12 million head on January 1, 2011, down 2percent from 4.19 million head on January 1, 2010. (http://www.nass.usda.gov/Statistics_by_State/Illinois/Publications/Farm_Reports/2011/IFR-3203.pdf accessed, 9/24/11)

The dairy sheep industry is in its infancy in the United States. Worldwide, sheep milk production is highest in China, followed by the Greece, Turkey, Syria, Romania, Iran and Italy – all with annual production above 500,000 metric tons (http://faostat.fao.org/site/339/default.aspx accessed 9/24/11). The USDA does not keep track of sheep milk production in the U.S. There are approximately 100 dairy sheep farms in the U.S. - found mostly in New England and the Upper Midwest. There are several large commercial sheep dairies in New York and California (http://www.sheep101.info/dairy.html; accessed 9/24/11).

Composition of Sheep Milk

Table 1 shows the composition of sheep's milk. Sheep milk is highly nutritious, richer in vitamins A, B, and E, calcium, phosphorus, potassium, and magnesium than cow milk. Sheep's milk also contains higher levels of protein and fat than in cow's milk. Sheep's milkfat is generally smaller in diameter and has higher surface area than cow's milkfat which plays a role in creaming. Sheep's milkfat also contains a higher portion of short and medium chain fatty acids (C4-C12) than in cow's milkfat. The C4-C12 fatty acids represent ~23% in sheep milk compared to 13% in cow's milk (Anifantakis, 1986). Most distinct for sheep's milk is its high content of the fatty acid, capric acid [C10:0].

Sheep's milk is relatively high in proteins – containing ~5.8% crude protein. Milk proteins contain 15.65% nitrogen. The percent nitrogen is determined by the Kjeldahl method. The Kjeldahl nitrogen value is converted to milk protein by multiplying by a factor of 6.38 (100 ÷ 15.65). For example, if sheep milk is determined to contain 0.90% nitrogen by Kjeldahl analysis, then its protein content is 0.90 x 6.38, or 5.8%. Use of the Kjeldahl method assumes that all of the nitrogen milk is contained in protein. However, this is not the case. A portion of the nitrogen in milk comes from non-protein sources, such as urea and uric acid. These other protein sources are called non-protein nitrogen (NPN). NPN does not contribute to cheese yield.

There are two major types of protein in milk. The proteins in milk other than NPN are called True Proteins. There are two types of True Proteins in milk. These are caseins and whey proteins – which represent, respectively, 80 and 20% of the total protein in milk.

Table 1. Chemical Composition of Sheep's milk

	Sheep	Cow
Dry matter (%)	18	13
Fat (%)	5.5	3.8
Protein (%)	5.5	3.4
Lactose (%)	4.7	4.8
Ash (%)	0.85	0.7
Sodium (mg/100 ml)	33	55
Potassium (mg/100 ml)	188	145
Calcium (mg/100 ml)	207	125
Magnesium (mg/100 ml)	8	13
Phosphorus (mg/100 ml)	125	90
Chloride (mg/100ml)	71	110
Percent distribution of fat globules <4.5 μm	88	81.3
Mean diameter of fat globule (μm)	3.2	3.6
Surface for 1 g fat	1.99 m^2	1.79 m^2

Source: Kammerlehner (2009)

Caseins are the most important proteins in cheesemaking because caseins are coagulated by rennets or milk-clotting enzymes (e.g., chymosin). The distribution of caseins in sheep's milk is: 47-56.5% α_s-casein, 28.2-36% β-casein and 10.6-12.1% κ-casein. When added to milk, chymosin hydrolyzes the specific peptide bond, Phe_{105}-Met_{106} in κ-casein resulting in de-stabilization of caseins and formation of a curd in the presence of calcium ions. Because of the high protein and calcium contents in sheep's milk, it has a higher firming rate and firmer curd at cutting than cow milk.

Seasonality in sheep milk production

Sheep milk production is seasonal – lasting only 5-6 months. Hence, sheep milk may be frozen and stored until a sufficient quantity of milk is available to sell or make cheese (Antifantakis et al., 1980; Young, 1985). Freezing does not affect the cheese-making qualities of the milk. de la Fuente et al. (1997) studied the effects of chilling for 1-7 days at 3 and 7°C and at -18°C for 3 months. They reported that freezing was less detrimental to chilling on the rennet properties of sheep milk. Similar results were obtained by Bastian (1994). Freezing at -15°C or -25°C for 6 months had minor effects on milk and cheese composition – although freezing was reported to reduce actual yield of cheese (Zhang, et al. 2006;

http://www.sheep101.info/dairy.html; accessed 9/24/11). For a comprehensive review on the quality of sheep milk, see Bencini and Pulina (1997).

Somatic Cells

The U.S. Grade "A" PMO sets the upper limit of somatic cells counts (SCC) in raw milk as less than 750,000 cells per mL for individual producer milk (PMO, 2009). However, normal SCC in cow's milk is less than 68,000 cells per ml (Djabri et al., 2002). Normal somatic cell count (SCC) in sheep milk is about 75,000 cells per ml (Ariznabarreta et al., 2002; Gonzalo et al., 2002). The rise in SCC is a general indication of mastitis that affects milk quality and milk yield loss. Healthy ewe's produce ~880 ml of milk per day while ewe's infected with mastitis produce 791 ml milk per day (Gonzalo et al., 2002). Mastitis in sheep results in decreased lactose, β-casein, α-lactalbumin and potassium contents. Levels of sodium, γ-casein (breakdown product of β-casein), serum albumin and immunoglobulin G are known to increase in mastitic sheep milk. High SCC – exceeding 1,000,000 cells per ml in sheep milk results in increased firming rate and soft curd at cutting (Pirisi et al. 2000). Similar results on the influence of SCC on the manufacture of hard sheep's milk cheeses were reported by Jeaggi et al. (2003).

Cheesemaking from sheep's milk

Several popular cheeses made from sheep's milk are known worldwide. Notable cheeses made from sheep's milk and their countries of origin are given in Table 2.

Table 2. Notable cheeses made from sheep's milk

Cheese	Country of Origin
Pecorino Romano	Italy
Kaschkaval	Bosnia
Bjalo Sirene	Bulgaria
Feta	Greece
Roquefort	France
Manchego	Spain

Source: Kammerlehner (2009)

Figure 1 shows a flow diagram showing typical steps during cheese manufacture while Figure 2 shows the basic relationships between milk components during typical cheesemaking.

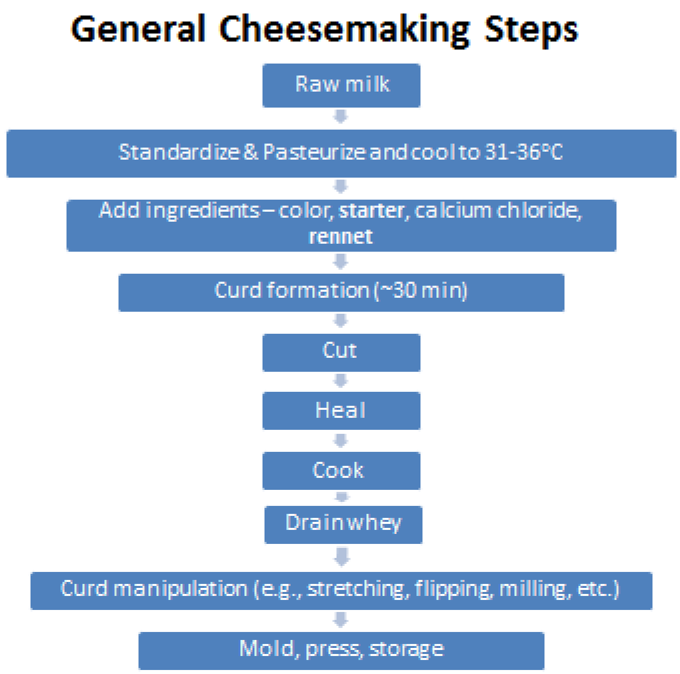


Figure 1. Flow diagram of typical cheesemaking steps.

The major components of milk of importance to cheesemaking are protein (casein) and fat because they influence the yield of cheese. Lactose and minerals (especially, calcium phosphate) influence acidification during cheesemaking and buffering of the cheese.

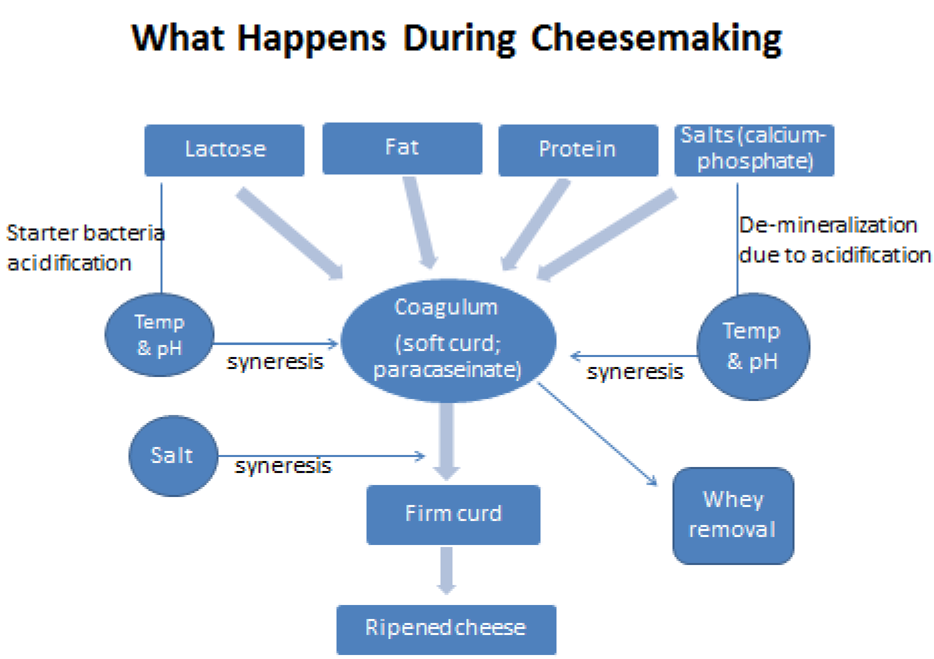


Figure 2. Relationships between milk components during cheesemaking

Starter bacteria added during cheesemaking metabolizes lactose in milk at cheesemaking temperatures to produce lactic acid which causes partial demineralization in the curd after coagulum formation. Increased temperature during cooking of the curd and acidification cause syneresis and whey loss from the curd. Addition of salt retards microbial growth, slows down acidification and causes further whey loss resulting in firm cheese curds that are pressed or molded into finished cheese.

The yield of cheese depends on the milk constituents – fat and casein – into cheese and the final moisture content. For standard of identity cheeses, the Code of Federal Regulations limits the maximum amount of moisture and minimum amount of fat (on dry basis) that a specified cheese can have. For example, the CRF specifies a maximum of 39% and minimum FDB of 50% for Cheddar cheese. To meet minimum regulatory standards and achieve desired quality and economic benefit, it is desirable to standardize cheese milk to optimal casein to fat ratio for each cheese. Because a rapid test for casein is not available, the casein level in milk can accurately be estimated as 0.78-0.8×P (where P is the protein content in the milk). Theoretical cheese yields can be calculates using the Van Slyke and Price (1979) cheese yield equation (below) or modifications thereof. The equation originally developed for Cheddar cheese assumes that 93% fat recovery and that all the casein except 0.1 lb per hundredweight is recovered in the cheese. In addition, the formula assumes that salt plus all other milk solids represents 9% of the weight of fat and casein retained in the cheese.

Cheese yield

$$Y = \frac{(0.93 \times F + C - 0.1) \times 1.09}{1 - w}$$

Assumptions

- F = lb fat per 100 lb milk; assumes 93% fat recovery under normal cheesemaking conditions
- C = lb casein per 100 lb milk; assumes 0.1 lb casein is lost in whey from 100 lb of normal milk
- W = pounds water per 100 lb cheese
- Factor 1.09 assumes other constituents of milk plus added salt contributes to 9% of the weight of fat and casein retained in cheese

Table 3 shows calculated Cheddar-type cheese yields from sheep milk containing different levels of protein (casein) and fat, and assuming maximum moisture of 39% in the finished cheese. As expected, the theoretical yields are dependent on the fat and casein contents in the milk. Hence, accurate measurements of fat and protein contents are important and standardization of the milk before cheesemaking is important for yield.

Table 3. Sample calculated yields for Cheddar type cheese from sheep's milk using the Van Slyle and Price equation.

Fat (%)	Protein (%)	Casein (%)	Moisture (%)	Calculated yield (%)	Yield per lb fat	Yield per lb casein
6.61	5.25	4.18	39	18.27	2.76	4.38
5.5	5.5	4.23	39	16.52	3.00	3.91
4.97	4.44	3.39	39	14.14	2.84	4.17
6.82	5.59	4.23	39	18.71	2.74	4.42

Yogurt from sheep's milk

Because of its high solids content, sheep's milk is ideal for the manufacture of yogurt without stabilizer. The U.S. Code of Federal regulations (CFR131.200) specify that yogurt is a milk product made by culturing milk with *Streptococcus thermophiles* and *Lactobacillus bulgaricus* and contains a minimum of 8.25% solids not fat and 3.25% fat for full fat yogurt, 0.5-2.0% fat for lowfat yogurt and <0.5% fat for nonfat yogurt. In addition, yogurt must have titratable acidity of greater than 0.9% expressed as lactic acid.

The general processing steps for the manufacture of set-style and stirred yogurts are given in Figures 3 and 4, respectively. Also because of its high protein content, sheep's milk is well suited for the manufacture of Greek-style strained yogurt.

Set-style Yogurt Manufacture

Yogurt Mix (at least 15% milk solids for sheep's milk)

↓

Heat mix (85°C × 30 min; 90-95°C × 40-60 s or 3 – 5 min)

↓

Cool to 68°C and homogenize (1,000 to 3,500 psi)

↓

Cool to 43-46°C

↓

Inoculate (1:1, 1:2 or 1:3 ratio of *Lactobacillus bulgaricus* and *Streptococcus thermophilus*)

↓

Fill cups

↓

Incubate at 43-46°C until firm (~4-5 h)
(Desirable pH of 4.5–4.6 and TA of 0.9%)

↓

Chill immediately to 4.4°C for storage.

Figure 3. General manufacturing steps for set-style yogurt.

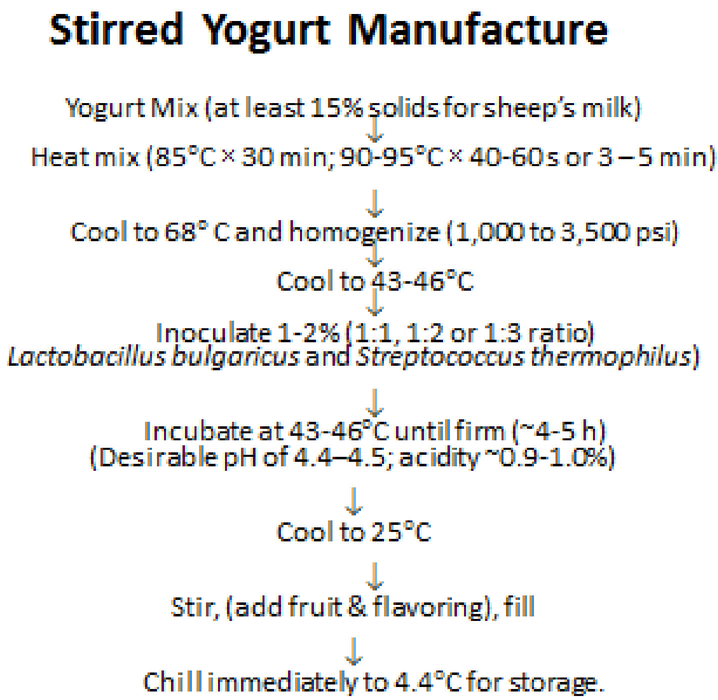


Figure 4. General manufacturing steps for stirred yogurt.

The heat treatment given to milk for the manufacture of yogurt is important for product quality and safety. The milk (or mix) is heated at a high temperature to eliminate pathogens and undesirable microorganisms. Heat treatment also causes denaturation of whey proteins which increases their water-holding capacity. Heat denatured whey proteins forms complexes with the caseins and improved gelation and yogurt structure. In traditional processes for making yogurt, sheep milk is boiled, filled into containers at 95°C followed by cooling to 45°C, inoculated with starter and fermented to the desired pH then transferred to cold storage. This process results in a set-type yogurt with a crusty layer (Tamine and Robinson, 1991). In industrial methods for manufacturing yogurt, sheep milk is standardized to a desired fat content, heat treated at 91-95°C and homogenized at 13.8 MPa first-stage and 3.5 MPa second-stage prior to incubation at 45°C with yogurt starter and cooling after the desired acidity is reached. Homogenization of the milk improves firmness and reduces syneresis in sheep milk yogurt (Tamine and Robinson, 1991).

Due to lack of availability of sheep's milk year round, sheep milk may be frozen prior to being used for yogurt manufacture. The stability of the milk during storage depends of freezing temperature and size of block frozen. Anifantakis et al. (1980) suggests adding 2 g sodium citrate and 0.1 g ascorbic acid each per 100 g sheep milk in order to improve stability during storage for up to 11 months. The frozen milk may be thawed and heated prior to yogurt making. Although increased free fatty acids content occurs in frozen sheep's milk, yogurt made from the thawed milk was acceptable. High SCC count exceeding 3,000,000 cells per ml in sheep milk results in off flavors such as bitterness and piquant taste in yogurt (Vivar-Quintana et al., 2006).

Conclusions

The conversion of sheep milk into cheeses and yogurts in the U.S. continues to gain popularity. However, research on sheep milk products is limited. Increased research to improve quality and consistency of sheep milk products in the U.S. is needed.

References

Anifantakis, E.M. (1986). Comparison of physic-chemical properties of ewe's and cow's milk. In, Proceedings of IDF seminar on Production and Utilization of Ewe's and Goat's Milk. Bulletin #202. Int. Dairy Federation. Brussels.

Antifantakis, E., C. Kehagias, I. Kotouza, and G.Kalatzopoulos. (1980). Frozen stability of sheep's milk under various conditions. Milchwissenschaft 35: 80-82.

Ariznabarreta A, C. Gonzalo and F. San Primitivo. (2002) Microbiological quality and somatic cell count of ewe milk with special reference to Staphylococci. J Dairy Sci 85, 1370-1375

Bastian, E. D. (1994). Sheep milk coagulation: Influence of freezing and thawing. Cultured Dairy Prod. J. 29(4):18-21.

Bencini. R. and G Pulina (1997). The quality of sheep's milk. A review. Australian J. Exp. Agric. 37:485-504.

Djabri, B., N. Bareille, F. Beaudeau, and H. Seegers. (2002). Quarter milk somatic cell count in infected dairy cows: a meta-analysis. Vet. Res. 33: 335–357.

de la Fuente, M. A., T. Requena, and M. Jua´rez. (1997). Salt balance in ewe's and goat's milk during storage at chilling and freezing temperatures. J. Agric. Food Chem. 45:82-88

Gonzalo, C., A. Ariznabarreta, J.A. Carriedo and F. San Primitivo. (2002). Mammary pathogens and their relationship to somatic cell count and milk yield losses in dairy ewes. J. Dairy Sci. 85: 1460-1467.

http://www.nass.usda.gov/Statistics_by_State/Illinois/Publications/Farm_Reports/2011/IFR-3203.pdf; accessed, 9/24/11

http://faostat.fao.org/site/339/default.aspx ; accessed 9/24/11

http://www.sheep101.info/dairy.html; accessed 9/24/11

Jaeggi, J. J., Govindasamy-Lucey, S., Berger, Y. M., Johnson, M. E.,McKusick, B. C., Thomas, D. L., and W.L. Wendorff. (2003). Hard ewe's milk cheese manufactured from milk of three different groups of somatic cell counts. J. Dairy Sci., 86:3082–3089.

Kammerlehner, J. (2009). Cheese Technology. Published by Author. Freising, Germany.

Pirisi, A., G. Piredda, M. Corona, M. Pes, S. Pintus, A. Ledda. (2000). Influence of somatic cell count on ewe's milk composition, cheese yield and cheese quality. Proceedings of the 6th Great Lakes Dairy Sheep Symposium. November 2-4, 2000. Guelph, Ontario, Canada.

PMO. (2009). Grade "A" Pasteurized Milk Ordinance. U.S. Department of Health and Human Services. FDA. College Park, MD.

Tamime, A.Y. and R.K. Robinson. (1991). Yogurt Science and Technology. 2nd ed. CRC Press, Boca Raton. pp 312-313.

Van Slyke, L.L. and Price, W.V. (1979). Cheese.Ridgeview Publishing Co. Reseda, CA. pp 64-65.

Vivar-Quintana, A.M., E. Beneitez De La Mano and I. Revilla. (2006). Relationship between somatic cell counts and the properties of yoghurt made from ewes' milk. Int. Dairy J. 16:262–267.

Zhang, R.H., A.F. Mustafa, K.F. Ng-Kwai-Hang and X. Zhao. (2006) Effects of freezing on composition and fatty acid profiles of sheep milk and cheese. Small Ruminant Research 64:203–210.

Young, P. (1985). The freezing of sheep milk for storage and transport. Sheep Dairy News 2(2):7-8.

FOOD SAFETY AND FARMSTEAD CHEESEMAKING

Dennis D'Amico
University of Vermont
Burlington, Vermont, USA

Background

Historically, cheesemaking was a practice conducted on farms. In 1851 the factory system for cheesemaking was introduced and quickly came to dominate the cheesemaking industry. By the beginning of the 20th century, farmstead cheesemaking had all but disappeared (Kindstedt, 2005). During this time almost all cheese in the United States was manufactured from raw, unpasteurized milk. Figures from 1938 show that more than 95% of the cheese produced in Wisconsin, the nation's leading cheese producer at the time, was made from raw milk. Until the mid-1900s, the majority of cheeses produced were so-called American varieties such as Cheddar, Colby and the like (Johnson et al., 1990). At this time cheese was not considered a significant source of foodborne illness. During the almost 50 year period between 1883-1931 there were only 17 recorded outbreaks in North America resulting in just over 500 cases and 11 deaths (Fabian, 1946). These numbers, however, are likely only a fraction of the true incidence. Research into the role of heat treatments and pasteurization of cheesemilk began in Wisconsin in 1907. Although focused on improving the consistency and quality of cheese, heat induced inactivation of pathogens was noted. Despite the numerous advantages provided, the heat treatment and pasteurization of milk was met with resistance by US cheesemakers due not only because of the increased costs of additional equipment and the increase in workload and time required but also because the cheesemaking technique differed including the use of defined starter cultures (Johnson et al, 1990).

Cheese as a source of foodborne disease changed dramatically following 42 cheese related outbreaks in North America during the relatively period from 1932-1945 resulting in more than 2,300 cases and 106 deaths (Fabian, 1946). Most of these outbreaks were linked to cheeses made from raw milk that were consumed shortly after manufacture. Following two major outbreaks of typhoid in the US in 1944, the Surgeon General suggested that all cheese be made from pasteurized milk or adequately cured. It was also recommended that states implement appropriate programs and sanitation. That same year industry issued its own recommendations. Among other suggestions, pasteurization and heat treatments were encouraged. It was also stated that if aging of cheese was to be used to protect public health, the conditions should be defined, in terms of time and temperature, for each cheese (Johnson et al., 1990). That same year individual states begin to establish similar but differing regulations requiring pasteurization or aging. The curing durations ranged from 60-120 days, some with temperature specified, others without. Given the issues with interstate commerce such varying regulation presented, there was a clear need for all states to adopt uniform regulation. This opportunity came in 1947 when the FDA began to hold hearings to discuss newly proposed standards for cheese varieties (21 CFR 133; USFDA, 2006). During said hearings it was stated that "…manufacturers of cheese shall take reasonable precautions to render the finished cheese safe…" (Johnson et al., 1990). Unfortunately scientific research on the behavior of pathogens in cheese during again was scant at the time. Despite this lack of supportive data aging was endorsed with a disclaimer. It was known that pathogens in cheese tend to die when held at ≥35°F. The length of "safe" holding was unknown but it was considered "unreasonable" to require holding to insure death of all pathogens. Since no reported outbreaks had been recorded from cheese held ≥60 days it was deemed reasonable to expect that cheese held for ≥ 60 days at ≥ 35°F would be safe (Johnson et al., 1990). The final rule regulating the manufacture of cheese was promulgated in 1949. As determined by an individual cheese's Standard of Identity cheesemakers were given 3 options. One, they could pasteurize milk for cheesemaking. Second, if using raw or heat-treated milk, the resulting cheese must be cured for a specified amount of time as defined by the Standard. This is typically no less than 60 days at ≥ 35°F. Lastly, cheeses for further manufacturing require neither. In the end, the newly defined standards allow for more than 30 varieties of cheese to be legally made from raw milk. After more than 60 years the Standards remain relatively unchanged (Johnson et al., 1990; USFDA, 2006).

Old Regulations, New Issues.

Although the Standards of Identity haven't changed, the pathogens of concern certainly have. Not only has the list of pathogens of concern lengthened, many have been shown to survive beyond 60-days in various cheeses. For example, pathogens that have historically plagued the dairy industry such as *Staphylococcus aureus* and *Salmonella* have been shown to survive well beyond 60 days in Cheddar (Johnson 1990; Goepfert et al. 1968; Hargrove et al. 1969). More recently, emerging pathogens including *Listeria monocytogenes* and *Escherichia coli* O157:H7 have been shown to survive beyond a year in Cheddar in certain circumstances (Ryser and Marth, 1987; Reitsma and Henning, 1996; Schlesser et al, 2006; D'Amico et al, 2010).

Despite the documented survival of pathogenic bacteria in cheese following the promulgation of the Standards of Identity in 1949, there have been infrequent large, cheese associated outbreaks since. In a review of the epidemiological literature from 1948-1988 there were only 6 documented outbreaks due to US produced cheeses. The use of raw milk was only implicated in one outbreak each in the US and Canada. In fact, post-pasteurization contamination was cited as the most frequent cause (Johnson et al., 1990). Similarly, in a review of CDC data from 1973-1992 there were 32 cheese-associated outbreaks reported. Eleven of these were attributed to contamination at the farm, during manufacturing or during processing. None were associated with raw milk cheese aged for at least 60 days (Altekruse et al., 1998).

Perhaps the most dramatic change since the implementation of cheese regulation has be the recent increase in the number and size of artisan and farmstead operations. According to Roberts (2007) there were only a handful of artisan producers in 1980 and up to approximately 75 by the 1990's. In 2000 this number increased to around 200 and more than doubled by 2006 reaching more than 400. The concern with such explosive growth from a food safety standpoint is that artisan operations are often considered higher risk. There is also the increased risk of an adjacent farm in farmstead operations. Artisan producers often lack resources, capital and technical expertise. This is particularly problematic as artisans are making higher risk cheeses. In addition, those producers manufacturing cheese from raw milk, a higher risk behavior in itself, are too often relying on 60-day aging as a means of achieving food safety. The concerns surrounding this renaissance were brought to the forefront following two outbreaks of *E. coli*

O157:H7 linked to raw milk, artisan cheeses. The first, linked to consumption of raw milk Gouda, resulted in 38 illnesses with 15 hospitalizations. In their follow up investigation the FDA also found O157 in Cheddar cheeses produced by the same manufacturer in the same facility. Another pathogen, *L. monocytogenes*, was detected in several cheese varieties produced at this facility and on a cheese mill suggesting that this piece of equipment served as a source of contamination. The FDA also noted major deficiencies in plant design, traffic control, good manufacturing practices (GMPs), and the like. A short time later consumption of a mold-ripened soft cheese manufactured from raw milk was linked to 8 illnesses. As with the Gouda case, follow up investigation revealed numerous violations including wood fixtures, walls and floors soiled with grime and/or dirt, as well as the accumulation of manure, mud and straw on floor (see forms 483 on FDA.gov for full reports).

Based on these investigation reports it is unclear as to what the definitive source of contamination was in these cases. While the use of contaminated raw milk is plausible, these investigation reports suggest that both manufacturers were deficient in basic GMPs and were producing cheeses in unsanitary environments. Research in our lab suggests that the incidence of pathogens in raw milk intended for the manufacture of raw milk cheeses is comparatively low. We collected raw milk samples on a weekly basis from 11 farms totaling 133 milk samples from June-September. *Staph. aureus* was isolated from at least one milk sample on 73% of the farms visited and 34.6% of all samples analyzed. Despite the presence contamination levels were low and not likely to present a food safety hazard in properly manufactured cheese. *L. monocytogenes* was detected in 2.3% which is consistent with other national surveys of bulk tank milk. However, 2 samples were from the same farm 6 weeks apart which may skew this comparison. *E. coli* O157:H7 was detected in a single goat's milk sample and *Salmonella* was not detected in any of the 133 samples (D'Amico et al., 2008). A similar survey was conducted in 2008 with 21 VT farms and *Staph. aureus* was the only pathogen recovered (D'Amico and Donnelly, 2010). Results from the FDA's Domestic and Imported Cheese Compliance Program from 2004-2006 also suggest that contamination of cheese, particularly domestically produced cheese, is not particularly common and that the focus should be placed on imports. For example, of the 2,181 samples tested for *L. monocytogenes*, only 2.4% were positive. Furthermore, 52% of these positives were imported Mexican-style soft cheese or soft-ripened cheeses, primarily from France and Italy. Similarly, *Salmonella* was found in 1.3% of samples with 82% produced in Mexico or Central America. *E. coli* O157:H7 was only found in 3 of 3,360 samples including imported Mexican-style soft and imported soft-ripened cheeses. Similar to our raw milk survey results, *Staph. aureus* was the most common pathogen detected in 6.9% of samples. No samples reported as positive for enterotoxin production (D'Amico and Donnelly, 2011).

Going Forward.

As previously noted, after 60 years the "60-day rule" is still currently the law. Producers must realize, however, that it is not a universally validated means of pathogen control or an umbrella CCP for use in HACCP plans. As recommended prior to the promulgation of said rule, the impact of aging must be determined for each cheese with the realization that sufficient aging may not be feasible for some cheese varieties. The use of heat-treatments, including pasteurization, is still a desirable practice for these higher risk cheeses although post-processing recontamination remains a concern. While the 60-day rule may stay on the books unchanged, the passage of the Food Safety Modernization Act in 2011 could bring major changes to the regulatory landscape. Already we have seen increased inspections across the entire industry with a focus on “high risk” facilities. Data from a recent survey of American Cheese Society members indicated that the number of respondents reporting FDA inspections increased from 8% in 2009 to 74% in 2010. In addition to increased inspection rates, inspectors are now taking upwards of 300 environmental samples for *Listeria*. Although this data is not confirmed, the FDA has reportedly found *L. monocytogenes* in 31% of plants inspected during a recent survey of facilities manufacturing soft cheeses.

The VIAC Approach to Cheese Safety.

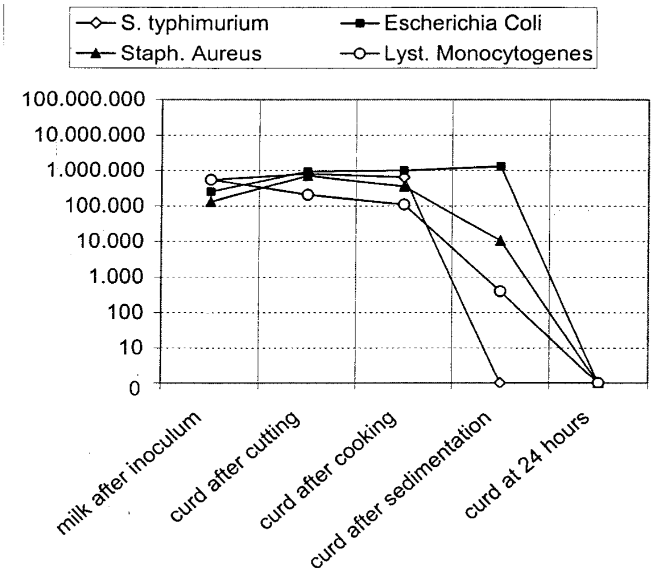
In preparation for FSMA, and for cheese safety in general, the Vermont Institute for Artisan cheese works to provide education and technical assistance to cheesemakers to design and implement comprehensive, individualized Risk Management Programs (RMP). We work to help producers identify hazards and preventive measures to control said hazards. We can utilize available resources to demonstrate that hazards are adequately controlled to meet out outcome (or performance) objectives. These efforts all form part of what has been referred to as validated outcome-driven control. The basic steps are similar to those of traditional HACCP-based systems beginning with a hazard analysis and hazard assessment taking into account pathogens from sources including animal feed, the farm and food processing environments, raw milk and so forth. Next we identify outcome or performance objectives which typically consist of target microbial levels in cheese at consumption. We then must determine the impact of a well-defined cheesemaking process. Using information from this step will help determine performance objectives for raw milk. We then work to design individualized RMPs considering the role of both the farm and the facility. Lastly we work to identify monitoring and verification procedures. For clarification, validation is the process of obtaining evidence that a control measure or combination of control measures, when properly implemented, is capable of controlling the hazard to a specified outcome. Monitoring activities are observations or measurements of control parameters to assess whether a control measure is under control. Lastly, verification consists of evaluations, in addition to monitoring, to determine whether a control measure is or has been operating as intended.

The following is an example of the process. First, a hazard analysis may identify the pathogens *Mycobacterium bovis/tuberculosis, Brucella* species, *Bacillus cereus, Yersinia enterocolitica, Campylobacter jejuni/coli, Clostridium botulinum,* enterotoxigenic *Staphylococcus aureus, Salmonella* species, various *Escherichia coli* (ETEC, EIEC, EHEC, STEC, etc.), *Listeria monocytogenes* and *Aeromonas hydrophilae* among others. A hazard assessment would likely shorten this list to enterotoxigenic *Staph. aureus, Salmonella* species, EHEC, STEC, and *L. monocytogenes* as those reasonably likely to occur. Next we must determine the outcome objective for each of the pathogens identified in the hazard analysis. For example we know from the literature that *E. coli* O157:H7, when present in raw milk, is typically found at levels from <1-10 CFU/ml. We also know from the literature that the minimum infectious dose for this pathogen is between 10-100 cells. So assuming a 100g serving size, we would set our outcome/performance objective at <0.01 CFU/g of finished cheese. This would mean if someone were to consume a serving of cheese they would ingest <1 cell. You can also use microbiological criteria as a guide. In our example this would be <0.04 CFU/g (or absent in

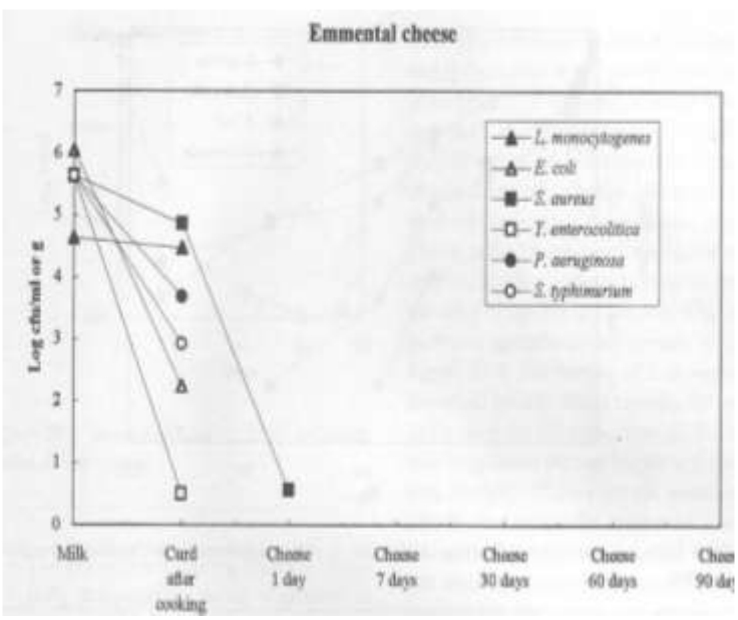
25g) of finished cheese. In either case our degree of control required given a possible level of 10 cells/ml of raw milk would be a net reduction of >3 log CFU/g (or 1000 CFU/g). The easiest way to achieve this reduction would be pasteurization which completely eliminates all recognized human pathogens with a substantial window of safety. Although it may not completely eliminate all pathogens in raw milk thermization can also produce significant reductions. For example, research has shown that a heat treatment of 67.5°C (153.5°F) for 16.2 seconds can reduce *L. monocytogenes* populations by 5-logs (100,000 CFU). Less aggressive treatments can produce similar reductions in other pathogens of concern including *E. coli* O157:H7 and *Salmonella* (most strains; 64.5°C (153.5°F); 16.2 sec) as well as *Campylobacter* and *Yersinia* spp. (63°C (145.4°F); 16.2 sec) (Johnson et al., 1990).

The next, and arguably most difficult step, is to determine the impact of our specific cheesemaking process and/or final composition on hazard behavior. Although applicable to all cheeses, it is of utmost importance in pasteurized milk products to determine whether or not the final composition of our cheese supports the survival and/or growth of pathogens introduced post-pasteurization and post-processing. To determine the impact of our specific cheesemaking process on pathogen behavior we can use a variety of options. The first and easiest is predictive mathematical modeling. Unfortunately there are not enough models currently available that are applicable to the vast range of cheeses being produced. The best option is to conduct a challenge study using the defined cheesemaking process and target pathogens or surrogate organisms for those pathogens. This method is unfortunately both difficult and costly for the average producer. This leaves us with the third option: using supportive data. Supportive data would include data from the literature such as challenge studies conducted on a similar cheese or records from extensive testing to support the assumption that a producers current process results in the absence of pathogens in the environment, milk and/or final product. It must be noted that it is unclear whether or not this would be considered an acceptable approach or how much data would be necessary to support such claims.

Supportive data from challenge studies will, however, help in determining the risk associated with a general type of cheese as the risk, and impact of aging, varies due to the effects of processing techniques such as curd cooking, acidification, salting and the like as well as intrinsic characteristics such as water activity, moisture, pH, and salt content. The New Zealand Food Safety Authority (2010) recently identified 3 categories of cheese. Category 1 includes cheeses where a combination of factors eliminate pathogens that may be present in raw milk. In category 2, pathogens if present in raw milk may survive but the product does not support growth. Lastly, cheeses within category 3 have limited factors, if any, that inhibit survival and growth of pathogens. An example of a category 1 cheese would be Parmigiano Reggiano. In these types of extra hard cheeses the cooking and pressing of curd at high temperatures (53-56°C) inactivates pathogens.



Additional hurdles include a low water activity (0.9) and a long aging period (9-12 months) (Panari et al. 2001). Thus it is not surprising that there have been no recorded outbreaks due to Italian-type extra hard cheeses in the US. Category 1 also includes hard cheeses that include a curd cooking step such as Emmental. High temperature, long duration curd cooking (52-54°C; 45 min) and pressing (hours at 50°C) has been shown to inactivate various pathogens.



As with the extra hard Italian cheeses, Emmental and similar cheeses have additional hurdles such as a fairly low pH (5.2), low moisture (~35%) and a long aging process (> 120 days) (Bachmann and Spahr, 1995). These cheeses, and those that undergo similar technology, can be produced safely from raw milk as the cheesemaking process provides the necessary pathogen reduction.

Category 2 is probably the largest and most ambiguous group of cheeses including, for example, the likes of many blue varieties. Research has shown that pathogens such as *L. monocytogenes* can survive and even grow during the manufacturing process followed by a gradual decline during aging. Despite the fairly rapid reduction in population levels in our example, *L. monocytogenes* can survive for long durations (>120 days) (Papageorgiou and Marth 1989). It should also be noted that the final composition of this cheese may support survival, but it does not support growth.

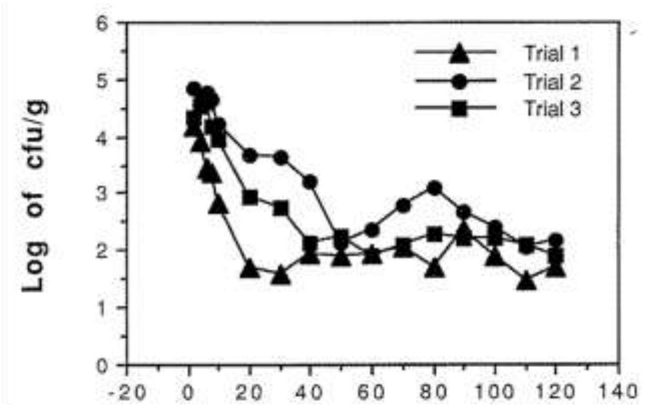
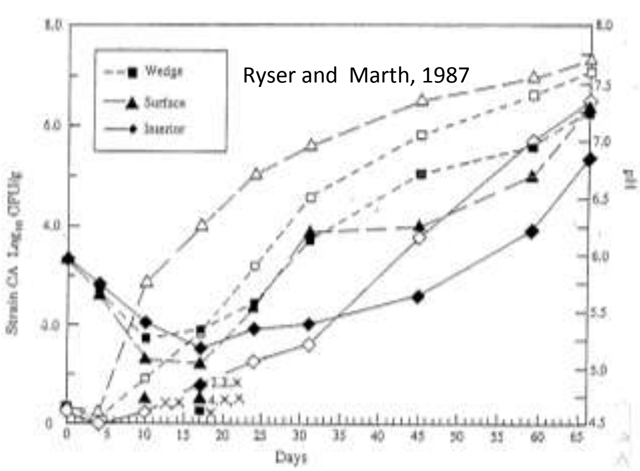


Figure 3. *Survival of* L. monocytogenes *strain Scott A and changes in pH during ripening of blue cheese.*

Category 3 encompasses the highest risk cheeses including surface mold-ripened varieties. These types pose substantial risk in cheeses manufactured from both raw and pasteurized milk. This is particularly true for *L. monocytogenes* contamination which can come from both raw milk and the processing environment. Surface flora growth during aging results in increasing pH (~4.6 → 7.5) which promotes the growth of growth of *L. monocytogenes* in the cheese core and ripening surface (Back et al., 1993; D'Amico et al., 2008; Gay and Amgar, 2005; Genigeorgis et al., 1991; Ryser and Marth, 1987). In such a case 60-day aging, or any aging in cases, inadvertently contributes to risk. Manufacturing cheeses in this category from raw milk is considered considerably risky.



Although the manufacturing process of cheeses in category 2 is not fully bactericidal, the gradual decline during aging can be utilized in our outcome-driven control model. If we go back to our example of *E. coli* O157:H7 we can complete the process for a Cheddar cheese using some data from the literature. As you can see in the graph below from D'Amico and others (2010) an equation is provided for the inactivation of *E. coli* O157:H7.

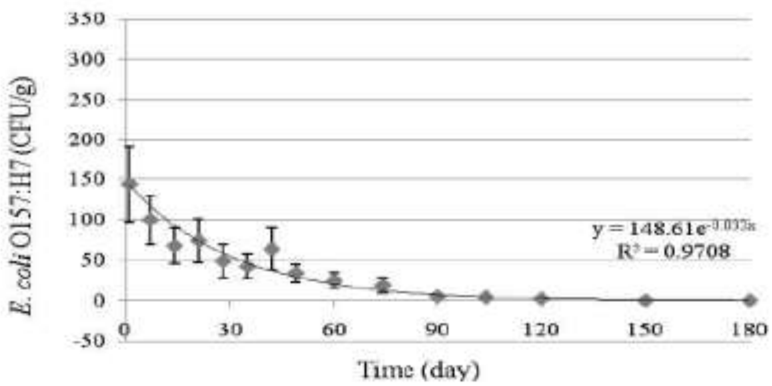


FIGURE 1. *Counts (mean ± SEM) of* Escherichia coli *O157:H7 during the aging of stirred-curd Cheddar cheese (all strains combined).*

Knowing that the level of pathogen in milk will increase 10-fold due to physical entrapment in curd during manufacture (see D'Amico et al., 2010) we can reset the equation, $y=(CFU/ml \times \sim 10)*e^{-0.033}$, and plug in various levels of *E. coli* O157:H7 expected to be in the raw milk. If we use 1 CFU/ml we would still have 1 CFU/g of cheese after 60 days. In order to reach the performance/outcome objective of <0.01 CFU/g with milk contaminated at 1 CFU/ml, we would have to age this cheese for >210 days at a temperature >9°C. If we set the performance objective for milk to <1 CFU/ml the aging duration would drop to >140 days at the same temperature. It must be noted that the results from the literature are only valid for the conditions specified and do not necessarily apply to all Cheddar, but should provide substantial support for cheeses with similar production technology and physicochemical characteristics. The equation is also only valid for the pathogen levels used in the experiment and does not take into account that pathogen behavior varies by initial population levels where lower initial populations often display a lower degree of growth compared to higher initial populations which often display a higher degree of growth. The equation is also an approximation as bacterial inactivation during aging is not linear. As shown in the above example there is comparatively rapid death followed by prolonged survival. Given these caveats, cheesemakers should consider an additional window of safety such as longer aging than the equation predicts.

The idea that the same level of food safety can be achieved through various hazard control measures and inspection and certification systems is referred to as the Principle of Equivalence. A prime example of its application to cheese is that of Australia New Zealand Food Standards Code. Under the code cheesemakers can make raw milk extra hard cheeses if the curd is heated ≥ 48 °C, the cheese is stored ≥6 months at ≥ 10 °C, and the final moisture content is <36%. Similarly, if thermized milk (≥ 62 °C for 15 seconds) is used the cheese must be stored for at least 90 days at 2 °C. Australia also allows the importation of hard Swiss varieties (Emmental, Gruyère, and Sbrinz) and extra hard grating cheeses (Parmigiano Reggiano, Grana Padano, Romano, Asiago, Montasio). These cheeses would be considered Category 1 varieties. It is interesting to note that the importation of the blue cheese, Roquefort, was also permitted following thorough Risk Assessment that considered the fact the process is tightly controlled and monitored including a drop in pH from 6.5 to <5.0 in 6-8 hours, and to a pH of 4.8 within 24 hours. The cheese must also reach a water activity of ~0.92 and be aged at least 90 days. Given that the process not fully bactericidal, safety relies heavily on additional systems in place including, but not limited to animal health, breeding, traceability and HACCP, as well as microbiological testing of raw milk and final product (Australia New Zealand Food Authority, 2005).

The development and implementation of a comprehensive risk management program is similar to the additional systems previously mentioned for Roquefort. Briefly, programs focus on limiting risk of raw milk contamination through animal health and mastitis management programs, water and feed quality and safety programs for example. We work on standard operating procedures for milk harvesting, cooling, storage and transport to limit the risk of pathogen development on the farm side. On the cheese side we work to exact control of the cheesemaking process. Programs are also aimed at reducing pathogen levels where applicable and limiting the risk of recontamination. Lastly, we work to identify monitoring and verification procedures including milk testing and environmental sampling. Unfortunately it is difficult to eradicate naturally occurring hazards so interventions can only help to control or minimize risks. Thankfully many generic frameworks for minimum standards are available including the HACCP-based Canadian Quality Milk Program, the FAO/IDF Guide to good dairy farming practice, the Codex Code of Hygienic Practice for Milk and Milk Products (CAC/RCP 57-2004) and the New Zealand Food Safety Authority Codes of Practice: Raw Milk Products.

Verification is integral to the success of any food safety program. The most common verification activity in our programs is microbiological testing. Producers should establish raw milk suitability criteria including allowable limits for total aerobic bacteria, coliforms, and *E. coli* for example. Consistent levels within allowable limits would suggest that milking hygiene and other risk management efforts on the farm are under control. This can also be applied to our previous example where our performance objective for milk was <1 CFU/ml of *E. coli*. If levels are higher outside our normal acceptable limit, hygiene efforts may not have been under control for this lot of milk. In such a situation where *E. coli* is detected, a producer may choose to test further for serotype O157:H7. Some producers may choose to establish raw milk safety criteria even though testing for pathogens can be quite expensive. I typically advise producers to instead consider testing milk filters for pathogens. Recent research has shown that filter testing may be a more sensitive herd-level screening method (Van Kessel et al., 2011). Filters are also a convenient sample to collect and ship and they can be composited over time to save on testing costs. Lastly, producers may consider testing fresh cheese to verify that the cheesemaking process was under control. Again, using our previous example we may set a limit of <10 CFU/g *E. coli* in fresh cheese before aging. Environmental sampling can also be used as a verification activity for assessing the efficacy of prerequisite programs. In this case we would be looking for total aerobic bacteria, coliforms or even *Enterobacteriaciae*. Some producers may choose more rapid, in-house tests such ATP bioluminescence and/or protein residue swabs.

There are also additional and essential programs that work in accordance with, and can thus be considered part of, our risk management plans. These include prerequisite programs such as Sanitation Standard Operating Procedures and GMPs. Producers should also implement a water sampling, testing and treatment programs. Other programs also required under FSMA that must be included in any food safety plan are supplier verification and recall/traceability programs. Perhaps the most important program for producers of both raw and pasteurized products is an Environmental Pathogen Monitoring program. In the case of cheese, we are most concerned with finding and eradicating *L. monocytogenes* contamination. As with most wet processing environments, *Listeria* spp. is found in artisan cheese facilities. In a 2006 survey (D'Amico et al., 2008), 9 facilities were sampled consisting of 30 food contact surfaces samples (FCSs) and 30 non-food contact surface samples (NFCSs). Overall 7.5% of sites were positive for *Listeria* spp. and 2.1% yielded *L. monocytogenes* including a subtype associated with multiple outbreaks of listeriosis. This survey was again conducted in 2008 in 8 facilities with a focus on sites with a high probability of contamination (D'Amico and Donnelly, 2009). Similar, but higher, incidences were noted with 10.7% of samples positive for *Listeria* spp. and 4.7% positive for *L. monocytogenes.* Perhaps the most interesting observation was that 9 sites were positive in both surveys suggesting persistent contamination.

Using the data from our process validation procedures producers can detail the processing steps, acceptable tolerance criteria and monitoring procedures for their cheesemaking process. If any heat treatments are being employed it is necessary to define the time and temperatures used. Such processes are commonly monitored using recording thermometers. Regardless of prior treatment of milk, we must describe the time/temperature profile utilized during the cheese make and define the acceptable amount of variation. This process is easily monitored and recorded using a data logging thermometer. Similarly, acidification profiles and acceptable variance must be defined. Monitoring would consist of a combination of pH and titratable acidity measurements taken at specified times throughout the process. We also need to define our brine composition and concentration. These parameters can be monitored using a salinometer and pH meter.

End Product Testing.

The overall goal of the aforementioned Risk Management approach is to reduce our risks and build as much safety into our products as possible. This effort is necessary as food safety cannot be tested into a product. Producers who choose to do end product testing for pathogens may do so to enhance their confidence that contamination has minimized or reduced but this confidence will vary with the statistical validity of sampling plan chosen. Unfortunately most sampling plans are not statistically reliable. End product testing in general is not often reliable because contamination is often sporadic and difficult to detect. Even when contaminated, pathogen levels are often low and/or not evenly distributed. As we have seen in previous examples, pathogen levels can also change over time so a result at one point in time is not applicable to another. The following figure shows an example of organism die-off and random distribution (Deibel and Deibel, 2005).

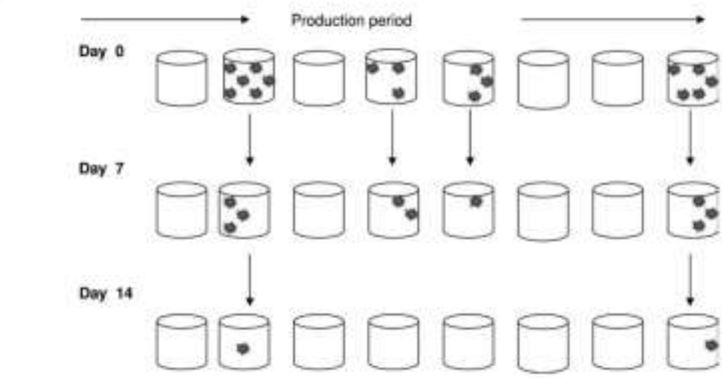


Figure 23.16. Organism die off. (Figure courtesy of Deibel Laboratories, Inc.)

Producers are faced with sort of a Catch-22 situation where the better one controls contamination; the less likely they are to find it with same testing plan. It is also important to remember that a negative result does not always mean true absence of a pathogen.

The fact that pathogen levels can change over time is a particular problem in the case of *Staph. aureus*. It is not the organism itself necessarily, but the enterotoxin produced by some strains of *Staph. aureus* that can result in cheeseborne intoxications. As you can see in the graph below from Deibel and Deibel (2005), if one were to test at point A they may find 1,000 *Staph. aureus/*g. At this level we are not typically concerned about the presence of toxin.

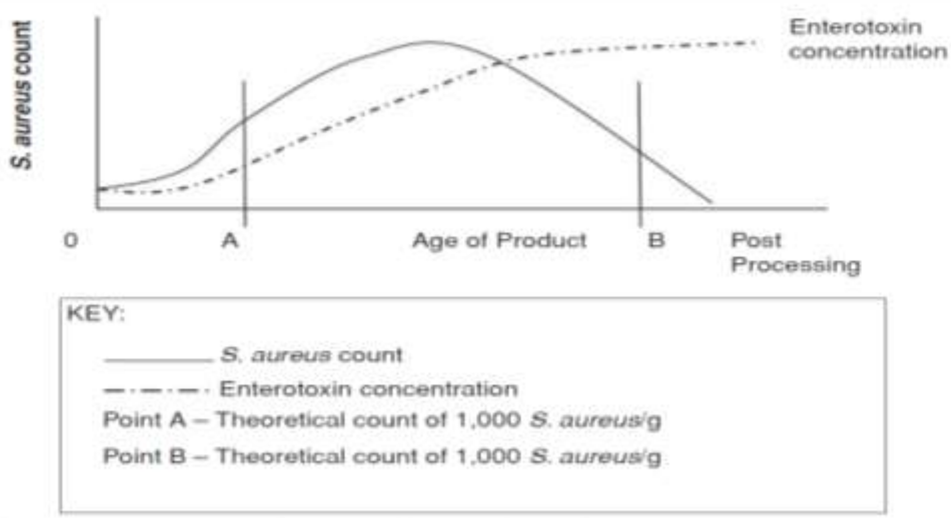


Figure 23.32. Theoretical growth of *S. aureus* and the production of toxin in a product. (Diagram courtesy of Deibel Laboratories, Inc.)

If that same producer tested at point B, they would again find 1,000 *Staph. aureus/*g. At this point, however, the organism has grown to dangerous levels and produced enterotoxin prior to dying off. So at point B the producer may inaccurately conclude that levels are not high enough to be concerned with enterotoxin production despite its presence. Current European Union regulation takes this into account, recommending that samples be taken when the pathogen level is expected to be the highest which will vary from cheese to cheese.

Perhaps the easiest way to determine sampling plan stringency would be to use the International Commission on Microbiological Specifications for Foods (ICMSF) table below.

Table 1 Plan stringency (Case) in relation to degree of health hazard and conditions of use

	Conditions in which food is expected to be handled and consumed after sampling in the usual course of events		
Type of hazard	Reduce degree of hazard	Cause no change in hazard	May increase hazard
Health hazard, moderate, direct, limited spread	Case 7 n = 5, c = 2	Case 8 n = 5, c = 1	Case 9 n = 10, c = 1
Health hazard, moderate, direct, potentially extensive spread	Case 10 n = 5, c = 0	Case 11 n = 10, c = 0	Case 12 n = 20, c = 0
Health hazard, severe, direct	Case 13 n = 15, c = 0	Case 14 n = 30, c = 0	Case 15 n = 60, c = 0

n = the number of samples, c = the number of samples which may exceed the limit.

These sampling plans take into account both the degree of health hazard presented and the conditions of product use and handling. Just remember that no sampling plan can replace a well-developed and implemented food safety program.

References.

Altekruse, S. F., B. B. Timbo, J. C. Mowbray, N. H. Bean, and M.E. Potter. 1998. Cheese-associated outbreaks of human illness in the United States, 1973 to 1992: sanitary manufacturing practices protect consumers. *J. Food Prot*. 61:1405-407.

Australia New Zealand Food Authority (ANZFA). 2005. Final assessment report application A499 to permit the sale of Roquefort cheese. Available at: http://www.foodstandards.gov.au/_srcfiles/A499_Roquefort_FAR_FINALv2.pdf. Accessed 22 April 2008.

Bachmann, H. P., and U. Spahr. 1995. The fate of potentially pathogenic bacteria in Swiss hard and semihard cheeses made from raw milk. *J Dairy Sci*. 78: 476-83.

Back JP, S.A. Langford, and R.G. Kroll. 1993. Growth of *Listeria monocytogenes* in Camembert and other soft cheeses at refrigeration temperatures. *J. Dairy Res*. 60:421-9.

D'Amico, D. J., E. Groves, and C.W. Donnelly. 2008. Low incidence of foodborne pathogens of concern in raw milk utilized for farmstead cheese production. *J. Food Prot*. 71:1580-1589.

D'Amico, D. J., M.J. Druart, and C.W. Donnelly. 2008. 60-Day aging requirement does not ensure safety of surface-mold-ripened soft cheeses manufactured from raw or pasteurized milk when *Listeria monocytogenes* is introduced as a postprocessing contaminant. *J. Food Prot*. 71: 1563-1571.

D'Amico, D.J, and C.W. Donnelly. 2008. Enhanced detection of *Listeria* spp. in farmstead cheese processing environments through dual primary enrichment, PCR, and molecular subtyping. *J. Food Prot*. 71: 2239-2248.

D'Amico, D.J, and C.W. Donnelly. 2009. Detection, isolation, and incidence of *Listeria* spp. in small-scale artisan cheese processing facilities: A methods comparison. *J. Food Prot*. 72: 2499-2507.

D'Amico, D.J, and C.W. Donnelly. 2010. Microbiological quality of raw milk used for small-scale artisan cheese production in Vermont: Effect of farm characteristics and practices. *J. Dairy Sci*. 93:134-147.

D'Amico, D.J., and C.W. Donnelly. 2011b. FDA's Domestic and Imported Cheese Compliance Program Results: January 1, 2004—December 31, 2006. *Food Prot. Trends*. 31:216–226.

D'Amico, D. J., M.J. Druart, and C.W. Donnelly. 2010. Behavior of *Escherichia coli* O157:H7 during the manufacture and aging of Gouda and stirred-curd Cheddar cheeses manufactured from raw milk. *J. Food Prot*. 73: 2217-2224.

Deibel, C.T. and R. H. Deibel. 2008., p. 529-573. Laboratory Analysis of Milk and Dairy Products. *In* R.C. Chandan, A. Kilara, N.P. Shah (ed.), Dairy Processing & Quality Assurance. 1st ed. Wiley-Blackwell, Ames, Iowa.

Fabian, F.W. 1946. Cheese and Its Relation to Disease. *Am. J. Pub. Health* 37: 987-996.

Food Standards Australia New Zealand. 2008. Australia New Zealand Food Standards Code. Part 4: Primary Production Standards. Available at: http://www.foodstandards.gov.au/foodstandards/foodstandardscode.cfm/. Accessed 15 March 2011.

Gay, M., and A. Amgar. 2005. Factors moderating *Listeria monocytogenes* growth in raw milk and in soft cheese from raw milk. *Lait*. 85:153-170.

Genigeorgis C., M. Carniciu, D. Dutulescu, and T.B. Farver. 1991. Growth and survival of *Listeria monocytogenes* in market cheeses stored at 4 to 30C. *J. Food Prot*. 54:662-668.

Goepfert, J.M., N.F. Olson, and E.H. Marth. 1968. Behavior of *Salmonella typhimurium* during manufacture and curing of cheddar cheese. *Appl. Microbiol*. 16:862-866.

Hargrove, R.E., F.E. McDonough, and M.A. Maltingly. 1969. Factors affecting survival of salmonella in Cheddar cheese and Colby cheese. *J. Milk Food Technol*. 32:480-484.

Johnson, E. A., J.H. Nelson and M. Johnson. 1990. Microbiological safety of cheese made from heat-treated milk, Part I. Executive Summary, Introduction and History. *J. Food Prot*. 53:441-452.

Kindstedt, P. 2005. American farmstead cheese: the complete guide to making and selling artisan. Chelsea Green. White River Junction, Vermont.

New Zealand Food Safety Authority (NZFSA). 2009. Animal Products (Raw Milk Products Specifications) Notice 2009. Available at: http://www.nzfsa.govt.nz/dairy/publications/specifications/final-raw-milk-spec.pdf. Accessed 21 June 2010.

Panari, G., S. Perini, R. Guidetti, M. Pecorari, G. Merialdi, and A. Albertini. 2001. Study about the behaviour of potentially pathogenic bacteria during the manufacture of Parmigiano-Reggiano cheese. *Scienza e Tecnica Lattiero Casearia*. 52:13-22.

Papageorgiou, D. K., and E.H. Marth. 1989. Fate of *Listeria monocytogenes* during the manufacture, ripening and storage of feta cheese. *J. Food Prot*. 52: 2-87.

Reitsma, C., and D. Henning. 1996. Survival of enterohemmorrhagic *Escherichia coli* O157:H7 during the manufacture and curing of cheddar cheese. *J. Food Prot*. 59: 460-464.

Roberts, J. 2007. The Atlas of American artisan cheese. Chelsea Green. White River Junction, Vermont.

Ryser, E. T., and E. H. Marth. 1987. Fate of *Listeria monocytogenes* during the manufacture and ripening of camembert cheese *J. Food Prot*. 50: 372-378.

Ryser, E. T., and E.H. Marth 1987. Behavior of *Listeria monocytogenes* during the manufacture and ripening of cheddar cheese. *J. Food Prot*. 50:7-13.

Schlesser, J.E., R. Gerdes, S. Ravishankar, K. Madsen, J. Mowbray, and A.Y. L. Teo. 2006. Survival of a five-strain cocktail of *Escherichia coli* O157:H7 during the 60-Day aging period of Cheddar cheese made from unpasteurized milk. *J. Food Prot*. 69:990-998.

U.S. Food and Drug Administration (USFDA). 2006. Code of Federal Regulations. Chapter 1, Subchapter B. Title 21 Part 133: Cheeses and related cheese products. Department of Health and Human Services. Available at: http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/CFRSearch.cfm?fr=133.182. Accessed 10 October 2007.

Van Kessel, J.A.S., J.S. Karns, J.E. Lombard, and C. Kopral. 2011. Prevalence of *Salmonella enterica, Listeria monocytogenes,* and *Escherichia coli* Virulence Factors in Bulk Tank Milk and In-Line Filters from U.S. Dairies. *J. Food Prot*. 74: 759-768.

SITUATION OF MILK SHEEP PRODUCTION IN EUROPE

Beate Maassen-Francke
GEA Farm Technologies
Business Unit Milking&Cooling
Germany

Introduction

The number of sheep in Europe decreased from 147 mio to 132 mio. sheep, but the number of sheep being milked increased from 27.0 mio to 29.7 mio sheep in the last 5 years (FAO, 2011). That is 23 % of the total heads of sheep being milked in the world.

Milk sheep production in Europe largely depends on the region, where the sheep are situated. Table 1 shows the distribution between the different European regions:

Table 1: Number of milking sheep in different parts of Europe (FAO, 2011)

Region	Number of milking sheep	Number of all sheep	% of milking sheep
Eastern Europe	10.392.410	33.950.239	31 %
Northern Europe	56.400	40.598.226	0.1 %
Southern Europe	17.990.595	45.784.611	39 %
Western Europe	1.264.108	12.068.613	11 %

The Northern part of Europe has many sheep, but not even 1 % are being milked. Western Europe has a proportion of 11 % of the milked sheep. Except in France, sheep are often used for the production of lamb meat and landscape conservation in these parts of the continent. At the coasts and the dikes of Germany, Netherlands and in other Northern parts of Europe grazing of sheep is very common.

In the Mediterranean area the production of ovine milk has a long tradition. Some processed products like Feta cheese from Greece, Manchega cheese from Spain or Roquefort from France belong to the so called PDO (Protected Designation of Origin) and PGI (Protected Geographical Indication) cheeses and are well-known products. According to the European law theses products have to be produced in a special region or according to a special tradition. Other countries like Switzerland or eastern European countries like Russia, Poland are quite new in the field of professional sheep milk production. Therefore it is quite difficult to get reliable and stringent production data from all European countries.

Nevertheless the Ministries of Agricultures of different European countries, the statistical administration of the European community called EUROSTAT and the FAO provide statistical data also for niche products.

But not only between regions but also between countries in the regions the percentage of sheep being milked varies: The range is from 3 % in Slovenia to more than 80 % in Greece (FAO, 2011).

Table 2: Distribution of number of sheep and dairy sheep in the European countries (FAO, 2011)

	Number of sheep					Number of dairy sheep			
Country	1996	2006	2009	Diff.	1996	2006	2009	Diff.	% of all sheep
Austria	365.250	325.728	333.181	-32.069	19.000	22.000	22.426	3.426	6,73%
Belgium	161.000	153.976	126.219	-34.781					
Bulgaria	3.383.034	1.602.255	1.474.850	-1.908.184	2.140.000	1.222.492	1.198.110	-941.890	81,24%
Cyprus	250.000	272.192	267.308	17.308	142.000	136.000	133.000	-9.000	46,76%
Czech Repu	134.009	148.412	196.913	62.904	55.063	36.000	64.500	9.437	32,76%
Denmark	170.000	206.000	103.977	-66.023					
Estonia	49.800	49.600	78.200	28.400					
Finland	114.500	116.653	117.673	3.173					
France	10.556.000	8.908.106	7.715.200	-2.840.800	1.373.000	1.330.425	1.230.000	-143.000	15,94%
Germany	2.954.000	2.560.300	2.350.400	-603.600			21859		0,93%
Greece	8.869.000	8.791.457	8.994.000	125.000	7.180.951	7.053.872	7.000.000	-180.951	77,83%
Hungary	977.000	1.405.000	1.236.000	259.000	67.200	127.000	66.197	-1.003	5,36%
Ireland	5.543.400	5.973.200	4.778.000	-765.400					
Italy	10.667.970	7.954.000	8.175.200	-2.492.770	6.676.000	5.500.000	5.542.300	-1.133.700	67,79%
Latvia	72.155	41.600	67.100	-5.055					
Lithuania	32.300	29.208	47.500	15.200					
Luxembourg	7.971	9.644	8.824	853					
Malta	16.000	14.642	12.843	-3.157	11.000	8.438	8.699	-2.301	67,73%
Netherlands	1.627.000	1.376.000	1.099.000	-528.000					
Poland	551.570	300.802	286.376	-265.194	45.000	20.000	14.303	-30.697	4,99%
Portugal	3.482.000	3.583.000	3.144.600	-337.400	530.000	540.000	443.650	-86.350	14,11%
Romania	10.380.900	7.611.000	8.882.000	-1.498.900	6.973.000	5.445.500	7.583.000	610.000	85,37%
Slovakia	427.844	320.487	361.600	-66.244	158.088	194.000	214.000	55.912	59,18%
Slovenia	39.118	129.352	138.958	99.840	1.591	3.466	2.904	1.313	2,09%
Spain	21.323.000	22.451.627	19.718.200	-1.604.800	3.198.000	3.248.078	2.412.000	-786.000	12,23%
Sweden	469.000	479.700	540.487	71.487					
United King	42.086.000	34.722.000	32.038.000	-10.048.000					

Many breeds in many countries

Europe has quite a variety of breeds in the different countries – there are a lot of local breeds being indigenous and usually farmed under less intensive production systems and some breeds which are spread out in other European countries.

One example is the East Friesian milk sheep: it is a large framed animal, which has its origin in the northern part of Germany. It was exported to other countries and is often crossbred with other local breeds. The most well known is the Assaf sheep which is a cross bred from the Arab breed of Awassi and the East Frisian sheep. Another famous milk breed is the Lacaune sheep of French origin. Lacaune is a very well bred sheep where the genetic improvement was done in an organized strategic manner. The genetic improvement was 2,2 % for milk yield, the phenotypic milk yield increased from 100 kg to 250kg per lactation in 40 years (Peters and Zumbach, 2008). Besides being milked in France it is now also milked e.g. in Spain, Germany, Czechoslovakia. In Italy the main area of milking sheep is the island Sardinia with the breed Sarda. In Spain often the Churra and Manchega are used for high production systems, besides Castellano and Laxta. The Assaf breed is becoming more and more popular in Spain when farmers want to rapidly improve the average herd milk yield. But in some cases the Quality Labels or Appellations of Origin for cheeses limit the introduction of foreign genotypes to local breeds (Ugarte et al., 2001; pers. commu., 2011). In Greece and Cyprus the breed Chios is the main breed. (Ringdorfer, 2008).

Milk Production

Sheep milk production in Europe increases in the last years from 2000 with 2.88 mio tons to 3.15 mio tons in 2009 (FAO, 2011). Greece, Spain, France, Italy, Cyprus, Austria and Romania reported a higher milk yield than 5 years ago. For example: The operations in Spain produced 421.8 thousand tons of sheep milk in 2005 and 506.7 thousand tons in 2009. This shows an increase of 20% (Eurostat, 2011).

ICAR (International Committee of Animal recording) regularly asked all member states for data of milk recording in milk sheep. The on-line database started in 2004. The information is not updated regularly. It is based on voluntary information given by the member states. Not all member states share their information. France and Spain have the most recorded animals in their countries whereas Greece has the lowest recorded ratio of all named countries.

Table 3: Number of recorded dairy sheep based on data summarized by ICAR (2011).

Country	No of dairy sheep	No of recorded sheep	Recorded year	% of recorded sheep
Greece	7.000.000	87.889	2007	1.3
France	1.230.000	301.823	2009	24.5
Italy	5.542.000	479.897	2009	8.7
Spain	2.412.000	398.293	2010	16.5
Germany	20.000	683	2009	3.4
Slov. Republic	216.000	16.791	2010	7.8

Performance tests on different genetic traits have a high impact on success orientated breeding. In the dairy sheep production in Europe there has to be a balance of costs to benefit. Therefore the costs for recording have to be kept affordable.

Some breeding programs working with nucleus breeding schemes have been successfully integrated in France, Spain, and Italy. Besides milk yield, also udder configuration and udder health as somatic cell count are used in the estimation of a breeding value. To have the most effect on breeding values the artificial insemination has to be spread wider. This is sometimes difficult to realize as the results varies in between the breeds and in some cases the prolificacy is not as successful as natural breeding.

Production methods

Weaning systems. In operations working with local breeds the ewes are mainly milked after a suckling period of 30 days, in some cases 42 or even 60 days (ICAR, 2011). Farms working more intensively or having Lacaune or Assaf sheep milk the ewes directly after birth. High prolificacy rates and high milk prices increase the artificial rearing of lambs right after the colostrum phase. In Switzerland e.g. the lambs are fed with frozen colostrums, the male lambs are fattened with cow's milk. Mostly the lambs stay app. 3 weeks at their mother dam then the lambs are reared artificially until they weigh between 20 to 40 kg (44 lb to 88 lb).

Bigger farms have separate areas for the lambs, esp. when they are reared artificially. The temperature is often kept at 20°C for the small ones.

The EU directives about biological production and labeling (EU Directives 834, 2007 and 889,2008) and the biological trade organization “BioLand” of Germany for biologically produced products say that the weaning period of lambs shall last 45 days, during which the lamb has to be fed with natural milk (Bioland, 2011). Therefore some production schemes have the lambs at their mothers (mainly in Italy and France) whereas others feed their lambs with cow milk or are allowed to feed whole milk powder.

Breeding management. Even if the EU is only 79 % self sufficient in sheep meat (Spedding, 2010), the farmers themselves esp. the milk producing farmers have their difficulties in getting their lamb meat sold.

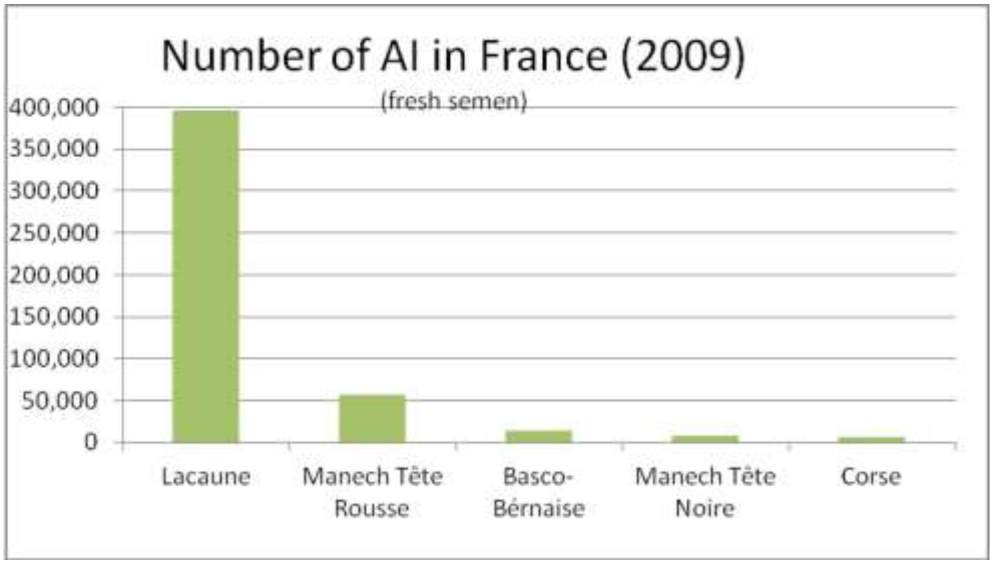
In the northern parts of Europe lamb meat consumption traditionally is lower than in the Southern parts, therefore some experiments are going on in prolonging the lactation length which is more and more common in goat milking. That reduces the peaks of labour during the lamming period and reduces lamb loss. Practical experiments by dedicated farmers in Germany milking Lacaune are trying to change their breeding scheme. They bring the ram to the ewe when the ewe has less than 0.8 l. In flocks where the average herd level is 500 kg the benchmark is < 1.0 l not before then.

Some farmers practice a year milking by dividing their flock into four groups for a quarter year wise lamming. One group – lambing June to August; second group end of October to beginning of November; third group beginning of January; fourth group in March. This scheme is combined with the milk yield threshold (Schaefer, 2011).

Artificial insemination. Artificial insemination is not wide spread all over Europe. If it is used the insemination often takes place with fresh semen and the cervical method. The intrauterine method with the laparoscopy procedure is often too expensive even it this method shows reasonable results with frozen semen. (David et al., 2008). The main users of this breeding instrument are France and Spain.

Figures 1 and 2 describe the distribution of the number of inseminations in the different breeds. In France mainly Lacaune sheep are inseminated artificially. In Spain it is the breed Manchega where an organized breeding programme exists.
No artificial insemination is used in Germany, Switzerland and Austria, esp. not in the organic working farms.

Figure 1: Distribution of number of AI across breeds in France (ICAR, 2011)

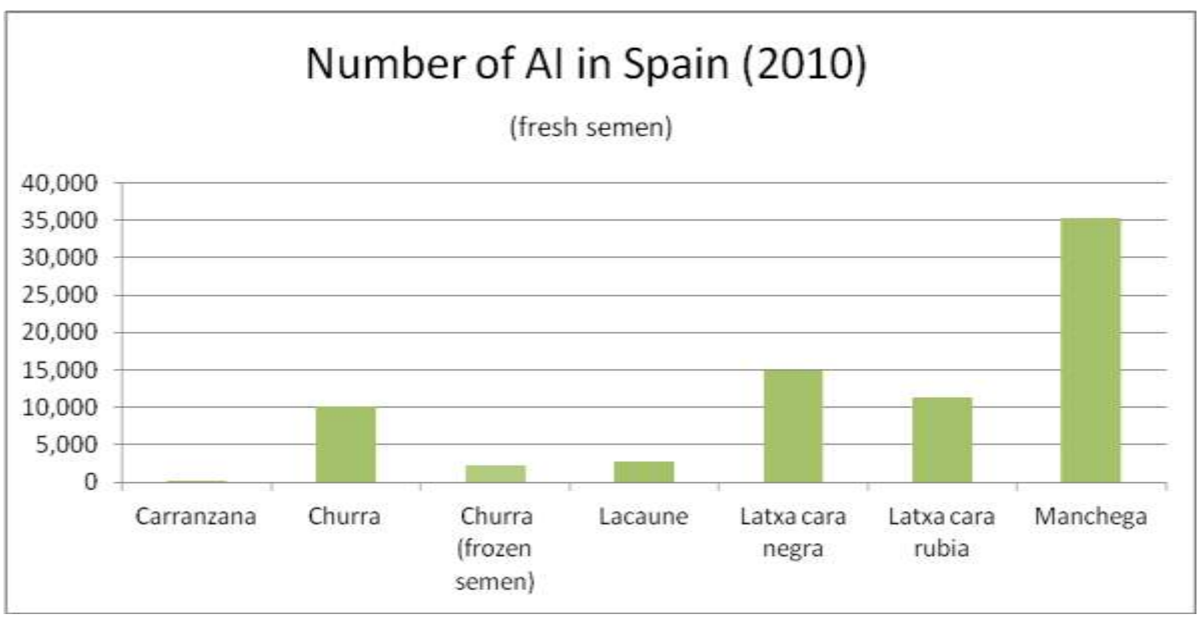


Selection criteria e.g. for Lacaune in France are:

- Milk yield
- Fat and protein
- SCC
- Udder score

In 2009 480.905 artificial inseminations were carried out. That is app. 30 % of all inseminated animals.

Figure 2: Distribution of AI across breeds in Spain (ICAR, 2011)



Selection criteria in Spain are:

- Milk yield
- Fat and protein
- Lactose
- SCC
- TSE resistance (Transmissilbe spongioform enzephalitis – Scrapie)
- Udder score

In 2010 63.312 artificial inseminations were carried out. That is app. 4 % of all inseminated animals.

Size of farms. Size of farms varies. There are bigger farms with 650 and more sheep in all countries, but small size farms with 40-50 sheep as well. The smaller ones often milk in bucket installations, whereas the bigger ones have 2x24 to 2 x 40 or carousels with 40 to 64 stalls. In the northern and western parts of Europe the farmers often milk by themselves whereas in bigger installations in Greece, Spain, Italy people from African or Asian countries are working. In bigger farms the demand for automation like automatic detachment or milk metering gets higher.

Organic farms. Data of organic sheep farming are available, whereas data only for milk sheep are not. In 2009 3.2 % of all sheep were kept under conditions to sell an organic product either milk or meat. This is an increase of nearly 1 % in 3 years. 2006 2.5 Mio sheep were kept in organic farms. In the Northern and eastern parts of Europe many of the sheep farmers work the organic way, whereas in the traditional "sheep" countries the percentage is below 10 %.

Table 4: Distribution of number of sheep kept under organic production requirements

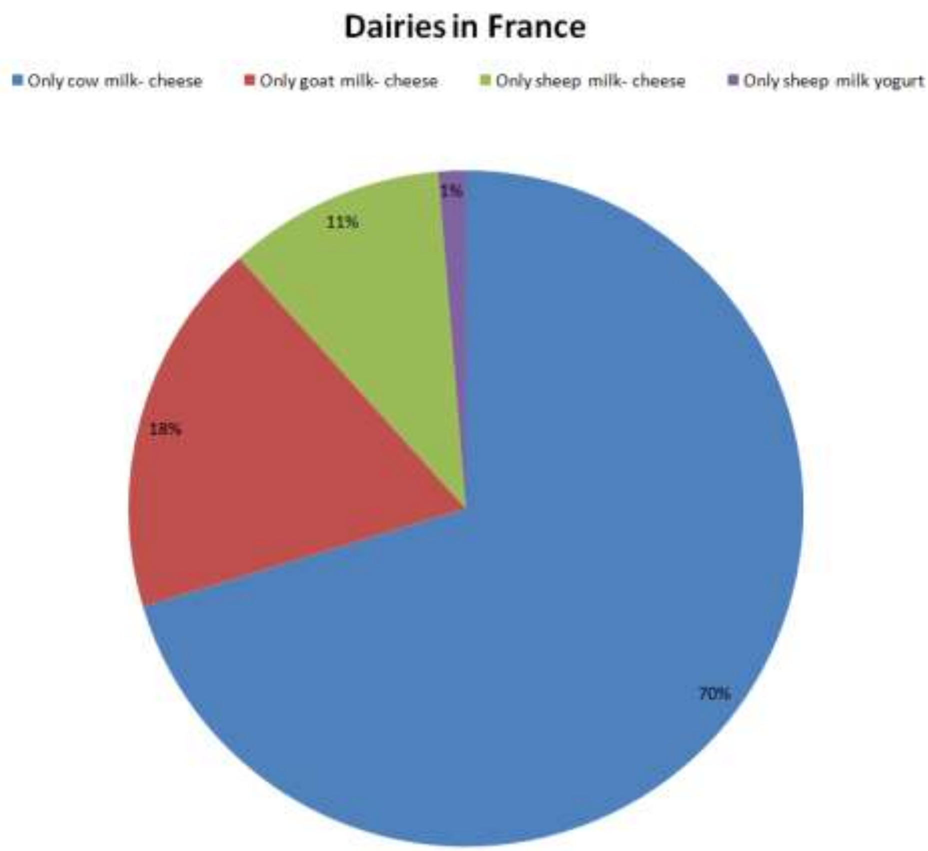
Number of sheep				Number of sheep in organic breedings			Percentage of organic breeding sheep to conventional breeding		
Country	2006	2009	Diff.	2006	2009	Diff.	2006 in %	2009 in %	Diff.
Austria	325.728	333.181	7.453	-	-	-	-	-	-
Belgium	153.976	126.219	-27.757	13.330	9.211	-4.119	8,66	7,30	-1,36
Bulgaria	1.602.255	1.474.850	-127.405	1.054	5.831	4.777	0,07	0,40	0,33
Cyprus	272.192	267.308	-4.884	-	612	-	-	0,23	-
Czech Republik	148.412	196.913	48.501	39.967	53.038	13.071	26,93	26,93	0,00
Denmark	206.000	103.977	-102.023	12.445	10.640	-1.805	6,04	10,23	4,19
Estonia	49.600	78.200	28.600	20.723	39.374	18.651	41,78	50,35	8,57
Finland	116.653	117.673	1.020	11.316	11.935	619	9,70	10,14	0,44
France	8.908.106	7.715.200	-1.192.906	-	-	-	-	-	-
Germany	2.560.300	2.350.400	-209.900	-	250.600	-	-	10,66	-
Greece	8.791.457	8.994.000	202.543	259.275	357.499	98.224	2,95	3,97	1,03
Hungary	1.405.000	1.236.000	-169.000	-	11.123	-	-	0,90	-
Ireland	5.973.200	4.778.000	-1.195.200	38.000	31.400	-6.600	0,64	0,66	0,02
Italy	7.954.000	8.175.200	221.200	852.115	658.709	-193.406	10,71	8,06	-2,66
Latvia	41.600	67.100	25.500	23.103	31.251	8.148	55,54	46,57	-8,96
Lithuania	29.208	47.500	18.292	8.507	13.001	4.494	29,13	27,37	-1,76
Luxembourg	9.644	8.824	-820	-	425	-	-	4,82	-
Malta	14.642	12.843	-1.799	-	-	-	-	-	-
Netherlands	1.376.000	1.099.000	-277.000	8.874	23.000	14.126	0,64	2,09	1,45
Poland	300.802	286.376	-14.426	28.338	39.159	10.821	9,42	13,67	4,25
Portugal	3.583.000	3.144.600	-438.400	-	-	-	-	-	-
Romania	7.611.000	8.882.000	1.271.000	86.180	51.470	-34.710	1,13	0,58	-0,55
Slovakia	320.487	361.600	41.113	87.607	102.134	14.527	27,34	28,25	0,91
Slovenia	129.352	138.958	9.606	22.920	35.751	12.831	17,72	25,73	8,01
Spain	22.451.627	19.718.200	-2.733.427	212.190	459.364	247.174	0,95	2,33	1,38
Sweden	479.700	540.487	60.787	34.038	86.741	52.703	7,10	16,05	8,95
United Kingdom	34.722.000	32.038.000	-2.684.000	747.299	884.810	137.511	2,15	2,76	0,61

Processing milk

In the newer “dairy sheep” countries like Germany, Austria most farmers process the milk on farm. The availability of a higher commercialization for processing sheep milk is not given in a huge distribution. There are only 2 small dairies in the southern part of Germany, one is processing 4000 l/day and makes a variety of 19 different cheeses. The farmers have to bring their milk to the dairy; therefore the regional distribution is low.

In France pure sheep milk is processed by 89 dairy processors. That is a percentage of 12 % of all dairies in France. The high specialization is seen in these figures.

Figure 3: Dairies in France divided by products from different species (based on agreste, 2011)



Herd management. According an EU directive from January 1st, 2008 it is mandatory that sheep and goats can be traced in an electronically way. That means they need an electronic identification. The transformation into a regulation is dependent on each European country. In Germany e.g. the regulation was put into force 2 years later January 1st, 2010. In Germany ear tags are used, in the Mediterranean mainly rumen boli. Electronic implants are not widely used at the moment. In France the electronic identification of sheep was already started in 2004 with the goal of traceability and quality management. (Margin, 2007). The electronic number alone is not useful for the famer, if he cannot assign a certain event to this identification number. But the obligatory use of an identification method can be the door to a higher acceptance of modern herd management in sheep production. The barrier of high costs is minimized.

The permanent electronic identification is the key feature for precision livestock farming. Accurate identification is needed for effective husbandry practices, including feeding, breeding and health management. In practice e.g paint marking may assist in temporary identification but cannot assist an ongoing management. Individual or group data of the animals is the core field of herd management to manage and organize the herd, to plan and arrange appointments as well as to organize labour. Furthermore the identification of special needs animals, high performing or weak performing sheep and creating a structured breeding scheme according to the performance of the ewe are possibilities using herd management systems in an economic way. But the precondition for the significance of a management system is a good data base. The farmer has the responsibility to conduct regular data maintenance. Not all data have to be entered as soon as they appear, but those data which the farmer decided on must be cared for. Only with an accurate and diligent data base the herd management programs are a powerful tool for decision making.

Milk price. As mentioned before the production schemes esp. the lamb raising and weaning period is dependent on the milk price. Table 5 shows the development of milk prices in several European countries (Eurostat, 2011). As sheep milk in most of the countries is not based on a quota system like in cow's milk the price is relatively different in the countries. Nevertheless in most of the countries the price increased during the past 10 years, the exceptions are Portugal and Spain. Those countries have had stable prices since 2000. The highest prices are received in Switzerland, followed by Austria and Greece. In some countries like Germany, The Netherlands, the Baltic States and Northern Europe no valid data exists. Especially in Switzerland the milk price varies – in times when not much milk is available the price rises to 2,88 € per kg milk (1,90 USD per lb).

Table 5: Milk price in Euro cent/kg milk in different European countries (Eurostat, 2011)

Country	2000	2005	2010
Bulgaria	30,61	38,65	45,38
Greece	79,64	89,56	95,38
Spain	76,07	76.47	76,67
France			87,40
Italy			70,00
Cyprus		76,28	86,00*
Hungaria	48,61	52,26	54,16*
Austria		100,00	112,00
Portugal	95,29	94,08	94,20
Romania	23,59	30,66	35,14
Slovakia	36,01	56,09	82,33
Switzerland			221,00**

*data from 2007/2008, **data from 2011

Prices for slaughtered lamb . In countries where consuming lamb meat is a tradition for decades the price is higher than in Germany or The Netherlands. Nevertheless Germany e.g. imported 9 % more lamb meat in 2011 (Jan. to June) than in 2010.

Table 6: Prices in €/kg (USD/lb) for lambs (warm slaughter weight) – calendar week 34/2011 (MEG, 2011)

Country	Price in €/kg (USD/kg)	Price in USD/lb
Germany	4,55 (6,06)	2,75
France	5,91 (7,87)	3,57
The Netherlands	4,96 (6,61)	3,00
United Kingdom	4,50 (6,00)	2,73
Spain	5,97 (7,95)	3,61

Conclusion

In general there is little information available on the production of sheep milk in Europe compared to all statistics for dairy cows and cattle. Nevertheless the data from the FAO and Eurostat show that the dairy sheep production in Europe is a stable and in some countries an increasing niche market. The variety of breeds and production systems makes it difficult to find a strategy of the one fits all. But to be successful in the dairy sheep sector everything should fit together: the people, the animal, the environment, the landscape, and communalization and last but not least the technique to produce high quality food.

Literature Cited

Agreste (2011) : http://www.agreste.agriculture.gouv.fr/IMG/pdf_prodlait2011T1-2.pdf

BIOLAND- Richtlinien: Fassung vom 15. März 2011 http://www.bioland.de/fileadmin/bioland/file/bioland/qualitaet_richtlinien/Bioland_Richtlinien_15_M%C3%A4rz_2011.pdf

Christou K., 2011: personal communication

David I, Robert-Granie C., Manfredi E., Lagriffoul G., Bodin L. (2008): Environmental and genetic variation factors of artificial insemination success in French Dairy sheep. Animal 2:7; p-979-986

DURCHFÜHRUNGSBESTIMMUNGEN VERORDNUNG (EG) Nr. 889/2008 DER KOMMISSION vom 5. September 2008 mit Durchführungsvorschriften zur Verordnung (EG) Nr. 834/2007 des Rates über die ökologische/ biologische Produktion und die Kennzeichnung von ökologischen/ biologischen Erzeugnissen hinsichtlich der ökologischen/ biologischen Produktion, Kennzeichnung und Kontrolle, ABI. Nr. L 250 vom 18.09.2008, S.1

EG- ÖKO- BASISVERORDNUNG VERORDNUNG (EG) Nr. 834/2007 DES RATES vom 28. Juni 2007 über die ökologische/ biologische Produktion und die Kennzeichnung von ökologischen/ biologischen Erzeugnissen und zur Aufhebung der Verordnung (EWG) Nr. 2092/91, ABI. Nr. L 189 vom 20.07.2001, S.1 Geändert durch: Verordnung (EG) Nr. 967/2008 des Rates vom 29.September 2008, ABI. Nr. L264 vom 03.10.2008, S.1 (Gemeinschaftslogo)

FAOSTAT (2011): http://faostat.fao.org

ICAR – data milk sheep enquiry (2011): http://www.waap.it/sheep_enquiry/

Marguin l., 2007. The use of electronic ear tags for sheep in France EAAP Publication no. 121,2007, p. 115-120

MEG Marktinfo (2011): Marktbericht Schaf- und Lammfleisch, Schafzucht 17/2011 p.25

Proceedings of the 2nd SAFO Workshop (2004): Organic livestock farming: potential and limitation of husbandry practice to secure animal health and welfare and food quality. http://orgprints.org/00003148

Ringdorfer F. (2008): Stand der Entwicklungen in der Milchschafhaltung in Europa; DGfZ Schriftenreihe – Heft 50 p 6-12, 2008

Schaefer, Sebastian (2011): personal communication

Spedding A., 2010: the world lamb market. RuSource- the rural information network

Statistisches Bundesamt, Germany (2011): http://www.destatis.de/jetspeed/portal/cms/Sites/destatis/Internet/DE/Content/Publikationen/Fachveroeffentlichungen/LandForstwirtschaft/ViehbestandTierischeErzeugung/Viehhaltung,templateId=renderPrint.psml

Ugarte E., Ruiz R., GabinaD and Beltran de Heredia (2001): Impact of high yielding foreign breeds on the Spanish dairy sheep industry. Livestock production Science, Vol. 71, Issue1; p. 3-10

CREATIVE LAMB MARKETING

Stephanie Larson, PhD.
University of California Cooperative Extension
Santa Rosa, California, USA

Introduction

Ever since Biblical times, sheep have been used for food and wool. Sheep provided the necessary warm clothing early civilizations needed to allow them to explore and inhabit colder regions of the world. For thousands of years, shepherds have been the symbol of tender caring, while at the same time protecting and developing their industry and its traditions of caring and stewardship. The industry evolved to include the production of meat and cheese for many, many people. Unfortunately, years past, mutton was the meat associated with sheep, until it fell from favor after World War II.

Luckily for sheep and lamb producers, lamb has been rediscovered by many consumers, which now prefer lamb over other lean meats. This demand for *lean meat* and low-fat products by consumers has given way to new production methods, processing practices and quality control procedures that have resulted in new, leaner lamb. Federal grading and the American Sheep industry (ASI) Certified Fresh American Lamb program also provided measures of leanness that assure consumers of a high quality, lean product.

Although lamb will often command price premiums, consumers have shown they are willing to pay a premium. This new discovered product – lamb, gives producers and creative marketers a renewed opportunity for marketing.

Commodity marketing

The marketing of lamb can be divided into two broad categories: commodity and direct (to the consumer). The majority of lambs sold in the United States are through the commodity market. This includes selling lambs at a public livestock auction; to an order buyer, broker, or dealer. In commodity markets, a producer is selling a bulk, generic product which identity is generally lost in the marketing process. Some auctions organize special sales prior to the major Christian and Muslim holidays. Many producers will sell in a cooperative or marketing pool and that buyer then selling to a direct, nontraditional market.

There are numerous advantages to selling lambs through a conventional market. It is easy. It is convenient and usually available. Payment is guaranteed and prompt. Commodity marketing favors large commercial and low-cost producers and those in close proximity to terminal markets. However, producers become price taker and not price makers. If a producer wants to increase returns, direct marketing methods should be implemented into their business plan and a creative marketing plan should be developed.

Direct Lamb Marketing

Creative lamb marketers are usually producers with small scale operations with a unique interest in promotion of their product. The sales could be in either whole or half lambs or a further processed meat. Marketers will need to move past production, to the processing and marketing aspects of their businesses, thus creating a new value added product. They will need to have an understanding of the product they are now producing and marketing. The issues to address will included: 1) estimating the yield of meat from a live lamb; 2) selecting options for slaughtering, cutting, wrapping and freezing; 3) establishing delivery procedures: and 4) deciding on billing and payment procedures.

Regulations

Before developing a marketing program, a producer should check the laws for selling lamb either wholesale, retail or both. For more information about meat processing and marketing requirements: http://www.fsis.usda.gov. USDA (federal) inspection requires lamb to be federally inspected for on-farm sales, at farmers' markets, internet sales, Community Support Agriculture (CSAs), to restaurants and retail stores. When lamb is moved from a processing plant or to a sales point, it must be transported in a refrigerated vehicle which maintains the meat at the property temperature. Food safety is a growing concern and all necessary precautions should be taken to ensure a safe, whole product is delivered to the consumer.

Creative Markets

More and more lamb producers are turning to niche markets as a way to increase markets sales. Quality niches based upon special or unique product characteristics were available to direct and niche marketers within each of the market outlets. Niche markets available to producers are many and which one (or more) chosen will depend on many things. The proximity to processing plants, distribution centers, and urban populations will help determine which market is best. Several market potentials are: 1) *on farm/freezer* market; 2) the *Halal and kosher* certification (ethnic/religious) market; 3) *retail food store* sales; 4) the *restaurant* market; 5) *internet* sales; 6) *Farmer's Markets*; 7) *Community Supported Agriculture* (CSAs); 8) *Branded* product; 8) *targeted* grazing. The services provided, product offered, facilities needed and management considerations for selling will differ for each of these markets. A business plan is strongly recommended before entering into any of these markets.

On-farm/freezer markets target individual consumers that are familiar with the producer, the farm or have sampled the product at other events. For the most part, whole lambs are sold. No special facilities are required on the farm and lambs must be sold live and removed from the farm by the customer for further processing. When conducting on farm sales, it is important to note that some states do not permit on-farm slaughter by the customer. Producers are advised to check local and state laws pertaining to on-farm slaughter of livestock. Unfortunately, USDA's on-farm slaughter exemption is open to interpretation.

The marketer can also take the lamb to a USDA inspected plant for processing and then the customer give further direction for the lamb. The customer might take the lamb carcass whole to have it processed further at a cut and wrap facility. In this scenario, the marketer may need to arrange: 1) delivery of lambs to slaughter facilities; 2) cutting, wrapping and freezing of the meat; 3) getting the packaged meat to the consumer; and 4) billing and maintaining records for the operation. A high degree of consumer interaction and education was required to target this market since some customers may not be familiar with the cutting of a lamb carcass.

Halal and kosher certification marketing can be on lambs that meet slaughter and handling requirements of the Muslim and Jewish faiths, respectively. To qualify for the Halal designation, the head of the lamb or sheep must be turned toward Mecca, Saudi Arabia, and the slaughterer must say a specific prayer before quickly slitting the animal’s throat. All blood is to be drained out of the animal before it can be butchered.

In contrast, the kosher slaughter of lamb is performed by a believing Jew, usually a Rabbi or a person with written authorization from a rabbinical authority. This person must be knowledgeable in the ritual laws of slaughtering as even the condition of the knife used in the slaughter was important to the process. The slaughterer must quickly sever the animal’s trachea and esophagus and then the carcass inspected before it can proceed through the kosher process. All visible and perceived imperfections in the carcass, especially the lung cavity, are grounds for kosher rejection. As with the Halal process, all blood is drained drain out of the carcass before butchering.

Retail food store sales can be a market when large volumes of “branded” lamb are sold. Often one marketer will buy several lots of lambs from a variety of producers, raised under certain certified program. A single producer will need to have a large volume of product to sell directly to a retail store. Retail stores, like Whole Foods, require lambs to be certified under humane treatment protocols to be marketed through their stores.

Restaurant markets usually want mostly primal and sub primal cuts of fresh lamb. Individual restaurants don’t have chefs with the knowledge of how to cut up a lamb, let alone cook the entire carcass. Producers will need to communicate with chefs about what products will be available and the frequency of need. The marketer will also need to develop a marketing plan for the remaining cuts of lamb left over that the restaurant does not use.

Internet sales can target customers located over a wide geographical area. These consumers will need to be educated on how to buy, store and prepare the lamb receive. Whole carcasses, half-carcasses, quarter-carcasses and individual cuts can be sold through this market. Excellent shipping procedures need to be developed because the freshness of lamb product and customer satisfaction will relate to the timeliness and care with which the product delivery. It will also increase customer returns. More and more potential customers use this market and it can lead to increased sale returns.

Farmer's markets are an increasing opportunity for producers to sell their lamb directly to the public. The requirements for selling meat at a farmers' market vary by state and market. Product liability insurance may be required. There could be a lot of paperwork required to sell at a Farmers Markets, and there will be increase costs including labor, packaging and individual's time. It will be important to develop a business plan that includes all aspects of this market.

Community Supported Agriculture (CSAs) is yet another method to market different cuts of lamb. Through a CSA, a marketer can market their lamb as *Local,* a growing popular method to market lamb. It follows the *"Know your Farmer, Know your Food"* mantra. Many consumers have shown their support of buying local lamb through a CSA program. Documentation or definition of "local" - where and how the animals are raised, will help marketing efforts. Another marketing tool will be to include recipes from local chefs which use the local lamb. Consumers are "want to be" chefs and having a recipe include with the lamb, can increase marketing opportunities.

When selling individual cuts at Farmers Markets and through CSAs, the marketer needs to consider the many ways to cut up a lamb carcass. Customers usually want the more desire or known cuts of lambs. The five primal cuts of a lamb carcass are the leg, loin, rack, shoulders, and foreshank and breast. Different retails cuts can further be obtained from the primal cuts. Sometimes, whole lambs are purchased for roasting or the entire lamb can be cut into chunks or ground. Marketers will need to know what to except from the lamb carcass so the products can be priced accordingly.

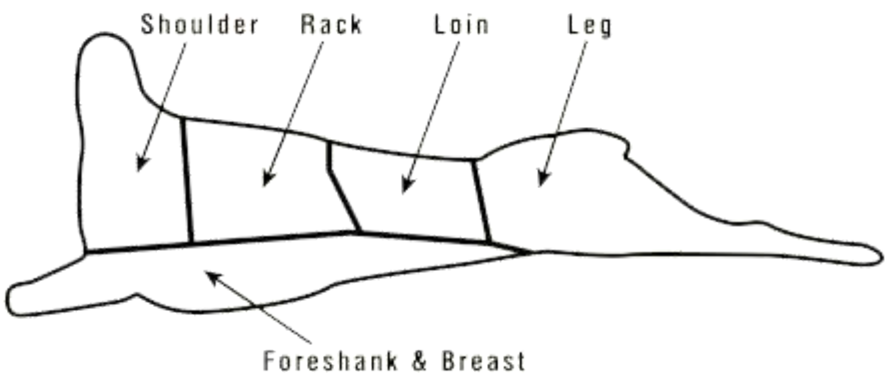


Figure 1. Lamb Carcass

Table 1. Yield from a Lamb Carcass

Approximate yield (lbs) of various cuts from lamb carcasses		
Carcass weight	**41-55**	**55-65**
Foresaddle	21-25	25-35
Hindsaddle	20-25	25-30
Leg	6-9	9-13
Loin	6-8	8-11
Sirloin	$\leq$ 2	2-3
Tenderloin	$\leq$ 0.5	0.5-1.5
Rack	4-5	5-7
Shoulder	14-19	19-23
Flank	$\leq$ 0.5	1-1.5
Breast	$\leq$ 2	2-3
Foreshank	0.5-1	1-1.5
Source: Institutional Meat Purchase Specifications (IMPS, 1996)		

Branded products - Natural, organic, grass fed and/or hormone and antibiotic free have been used to market lamb. These claims need to be verified by a third party certifier and paperwork is required to document these claims. Research has shown that beef fed a grass fed diet have been shown to enhance total conjugated linoleic acid (CLA) (C18:2) isomers, **trans** vaccenic acid (TVA) (C18:1 t11), a precursor to CLA, and omega-3 (n-3) FAs on a g/g fat basis, (Daley et. al 2010). Information like this could be used to increase product value chains, thus increasing market sales.

Targeted grazing is a unique way to market lambs through a grazing program that uses them to achieve an ecological resource goal. The marketer can continue to use these lambs through the grazing season or they could sell lambs through different marketing chains when the market weights are reached.

Promotion and Advertising

The goal of a marketing program is to increase the visibility, acceptance and quantity sold of the specific lamb product. One of the most important ways to market is through word-of-mouth but it can be time consuming. The most important way to ensure return customers is to provide courteous service and a consistent, quality product. Other methods used to target direct marketing can include store demonstrations, festivals, i.e. paring lamb with local wine events, promotional leaflets, school tours of farms, internet coupons, and Facebook.

Challenges for Creative Marketing

Creative marketers face a number of challenges in operating a financially successful business. Producers struggle with continuing customer interaction issues and the availability of quality slaughtering and processing plants. Also, the limited knowledge of required capital, labor and time required affects a marketer's ability to gain market acceptance for value-added products. Creative marketers will need to allocate more time interacting with the public than they would have in traditional, commodity marketing.

Conclusions

There are many opportunities for lamb producers to increase sales through value added products. Potential markets for lamb has not been reach in many areas of the country. The challenge will be to increase the awareness of current and potential lamb consumers to the quality lamb products available from local producers. The local, innovative methods of creative marketers will only increase the consumption of lamb and maintain the long standing appreciation of the sheep industry and its history.

References

Daley, Cynthia A., Amber Abbott[1], Patrick S Doyle, Glenn A Nader and Stephanie Larson. A review of fatty acid profiles and antioxidant content in grass-fed and grain-fed beef. Journal of Nutrition. 2010, 9:10.

ARTIFICIAL INSEMINATION:
THE GATEWAY TO SUPERIOR MILK PRODUCTION

Martin R. Dally
Super Sire Ltd.
Lebanon, OR, USA

Introduction

Artificial insemination is the gateway towards the use of top dairy sires, both domestically and internationally. It offers progressive dairy producers the opportunity to make previously unthought-of genetic gains in a very short period of time. Rapid genetic gains can be made in milk quality and milk quantity due to their moderately high inheritability estimates. This is especially true when East Frisian and Lacaune semen is used because of their inherent superior milking ability.

Background

For many years artificial insemination of sheep was thought to be impractical, mainly due to the difficulty of detecting estrus and controlling the ewe's estrus cycle. The inability to freeze ram semen was another factor which limited the wide use of artificial insemination. Today, with the use of progestogen and PMS-G therapy, the synchronization of the ewe's estrus cycle is possible. In addition, ram semen can readily be frozen which opens the door to interstate as well as international movement of semen. This has now allowed the dairy sheep industry the opportunity to import genetics from counties with well established sheep dairy industries.

However, even with these technological breakthroughs the conception rate through of the use of artificial insemination remained relatively low and therefore was not practical for the commercial producer. The main reason for the lower conception rate was that semen could only be placed at the opening of the cervix or slightly inside the cervix. The anatomical structure of the ewe's cervix made the penetration of the cervix nearly impossible. Cervical insemination rates using fresh and frozen semen are approximately 50 and 25 percentages, respectively. It was known that if semen could be deposited in the uterus as is the case with dairy cattle, the conception rate would improve to the point where AI of sheep would be practical on a commercial basis.

In 1982 Australian researchers developed the laparoscopic insemination procedure (LAI) which revolutionized the sheep insemination AI technique. Conception rates using this technique with frozen semen generally range from 60% to 80% when a skilled technician uses the LAI technique to place semen directly into the ewe's uterus. Bear in mind that conception rates can vary greatly depending on semen quality, breed of sheep, management of the ewe flock, time of year ewes are inseminated and the skill of the technician.

Another advantage of LAI is that a lower number of spermatozoa are required per insemination compared to cervical AI. The number of spermatozoa needed for LAI is at least one third of that required for cervical AI when cryopreserved semen is used. Once an ejaculation of semen is collected thru the use of an artificial vagina it is then evaluated for potency and diluted for freezing. It is then processed into 40 to 50 quarter cc French straws for use in LAI. One straw is required for LAI and contains between 40 and 60 million spermatozoa, post thawing. Straws are stored in liquid nitrogen at -196 C (-185 F). Prior to insemination, the straws are thawed in a warm bath at 37 to 38 C (98.6 to 100.4 F) for 90 seconds.

Procedure

Prior to the surgery the ewe's estrus cycle must be synchronized by means of hormone therapy. This normally involves inserting a CIDR (controlled intervaginal drug release) containing progesterone or a sponge impregnated with progestogen into the ewe's vagina and this is left there for 12 to 14 days. During this period progesterone or progestogen is slowly absorbed through the vaginal wall into the ewe's capillary system. The increased level of progesterone or progestogen inhibits follicle development and prevents the ewe from coming into estrus. Once the CIDR or sponge is removed (12 to 14 days after inserting) the progesterone or progestogen level drops off and follicles develop. At the time the CIDR or sponge is removed, the ewes are given an IM injection of PMS-G to tighten up the degree of synchronization. Normally 400 iu of PMS-G are given, however, the level of PMS-G can vary depending on age of animal, time of year, body condition and the desired level of multiple births. Insemination should take place between 56 and 62 hours after sponge removal or 50 to 57 hours after CIDR removal.

At 24 hours before surgery both feed and water should be withheld from the ewes. This reduces the contents of the rumen and bladder. A full rumen or bladder may hinder locating the uterus and increase the chance of puncturing the rumen or bladder during surgery. At 5 to 10 minutes before surgery the ewes may be given an IM injection of a mild tranquilizer. Ewes are then placed on a laparoscopic cradle and the posterior abdominal region in the area of the pubis is surgically prepared by removing the wool and disinfecting the skin. Approximately 5 inches anterior of the udder and 2 inches on both sides of the mid-line, the ewe is given an injection of a local anesthetic. The cradle is then placed in its surgical position.

The ewe is now lying on her back at an approximate 40 degree angle with her head in the downward position. Two small incisions approximately one half inch in length are made in the skin at the site where the local anesthetic was injected to facilitate puncturing the abdominal wall with a trocar. The muscles of the abdominal wall are not cut; the muscle fibers are separated when the trocar is inserted into the abdominal cavity. Once the cannula is removed at the completion of the insemination, the fibers return to their normal position in relation to each other. Once the abdominal wall is punctured the trocar is removed from the cannulas and an endoscope and manipulating probe are placed in the cannulas and into the abdominal cavity. An endoscope is a special telescope with a fiber optic light, which permits the technician to view the ewe's reproductive tract. A small amount of carbon dioxide is placed into the abdominal cavity, which helps isolate the uterus from the other organs. The carbon dioxide also has a mild anesthetic effect on the ewe. The probe is then used to bring the uterus into the proper position for insemination. In some cases it is not necessary to use the probe since the uterus may already be in the proper position. The less the reproductive tract is manipulated, the better the conception rate. Once the uterus is in the correct position, the probe is removed and replaced by the inseminating gun containing the thawed semen.

The technician then punctures the uterine horn half way between the uterine bifurcation and the utero-tubal junction as seen in Figure 1. The semen is injected directly into the lumen of the uterus. The inseminating needle which enters the uterus wall is extremely fine having an outside diameter of 0.04 mm. The same procedure is then repeated on the other uterine horn. The insemination procedure normally takes only 2 to 5 minutes.

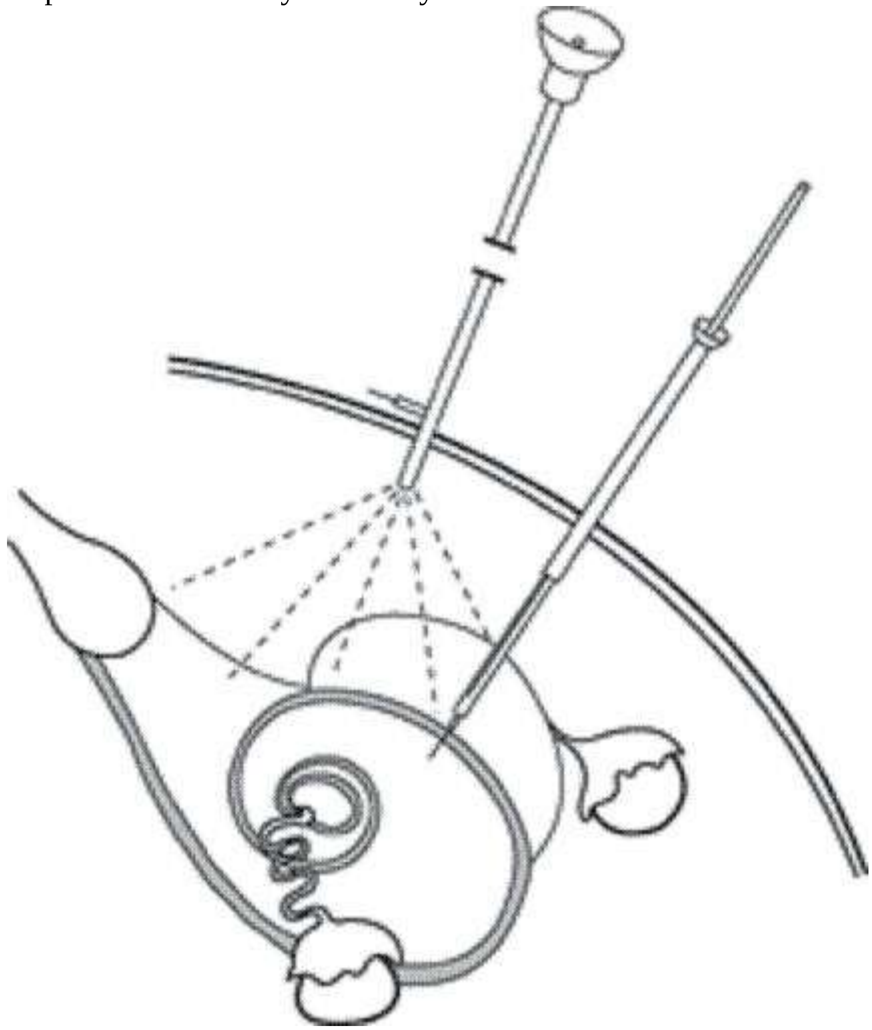


Figure 1 Laparoscopic AI. Instruments inserted in the female, with the palpator. Source: FAO 83, 1991

Once the horns have been inseminated, the cannulas are removed and a topical antibiotic spray is applied to the two small incisions. In some cases bleeding may occur which is due to the perforation of surface blood vessels. If excess bleeding takes place michel wound clips can be used to close the wound. The ewe is removed from the cradle and allowed to walk to a holding pen. Ewes normally start eating within minutes of being placed in the holding pen. The incidence of infection as a result of the surgery is extremely low if proper hygiene and sanitation is followed.

References

Chemineau, P., Y. Cagnie, Y. Guenin, P. Orgeur and J. C. Vallet. 1991. Training Manual on Artificial Insemination in Sheep and Goats. FAO Animal Production and Health Paper 83. Rome.

Evans, G. and W> M> C> Maxwell. 1987. Salamon's Artificial Insemination of Sheep and Goats. Butterworths. Sydney.

GENETICS OF LAMB SURVIVAL

David L. Thomas
Department of Animal Sciences
University of Wisconsin-Madison
Madison, Wisconsin, USA

Summary

Lamb survival is an economically important trait in commercial sheep production. Lamb survival exhibits a large amount of individual and maternal hybrid vigor, and breed differences exist for lamb survival. Therefore, the greatest opportunities to genetically improve lamb survival are to utilize breeds known for high lamb survival in mating systems that produce crossbred lambs from crossbred ewes. Low estimates of direct and maternal heritabiliteis for lamb survival, a negative correlation between direct genetic and maternal genetic effects for lamb survival, and lack of effective selection criteria for ewe rearing ability suggest that selection for improved lamb survival will be difficult at the present time. Development of improved selection criteria and genomic selection may result in reasonable amounts of selection response in the future.

The Problem

The most recent report on sheep death losses in 2009 from the USDA indicates that lamb mortality represents a major economic loss to the sheep industry. USDA estimates that 3,690,000 lambs were born in 2009 in the U.S. (NASS, 2010b), and 228,500 of these lambs died from non-predator causes (6.2% lamb mortality) (NASS, 2010a). In many of the western states where most of the sheep are located, lambs are not counted until they are docked at a few weeks of age. Since many lamb deaths take place very early in life (see below), the 6.2% estimate of lamb mortality is very much an underestimate of the true lamb death loss in the U.S. I would estimate that the actually lamb loss from all non-predation causes including abortions, stillbirths, hypothermia and other causes early in life is at least twice the estimate above - 15% or higher. At the current high price for market weight lambs (~$225/head), a 15% non-predator lamb mortality translates into an annual loss of potential income to the U.S. sheep industry of approximately $125 million.

The majority of lamb deaths occur early in the lamb's life. A study of lamb deaths from birth to weaning at 30 or 60 days of age from 1989 through 1997 at the Spooner Agricultural Research Station, University of Wisconsin-Madison, USA reported a 9.9% mortality (536 deaths prior to weaning/5425 births) (Berger, 1997). Of the total deaths prior to weaning, 77% (411/536) of the lambs were born dead or died within the first 3 days of life. Southey et al. (2001) reported that of 8,642 lambs born in a flock at the USDA Meat Animal Research Center, Clay Center, Nebraska, USA, 18.8% died by 120 days of age, and 81% of these deaths occurred before weaning at 50 days of age. The major causes of lamb deaths in the U.S. in 2009 were: weather related, primarily hypothermia (25.6% of deaths), lambing problems (14.5%), respiratory problems (12.6%), internal parasites (7.9%), and the disease enterotoxemia (6.3%) (NASS, 2010).

There are several ‘Best Management Practices” for improving lamb survival such as health management and vaccination programs, proper nutrition of pregnant ewes, lambing management, prevention of predation, and proper lamb nutrition. Good management practices are essential for high lamb survival, but breed choice, selection, and crossbreeding may offer ways to genetically improve lamb survival even further.

Breed Choice

There are reports in the scientific literature of differences between breeds for lamb survival, which is a good indicator that lamb survival is determined, to some extent, by the genotype of the lamb and/or the dam.

Table 1 presents results from some published research studies of the survival of F1 (first-cross) lambs sired by different breeds of rams. Within each study, the breed of dam of the lambs was the same. Therefore, the maternal breed environment is the same for each lamb, and differences between lambs from different breeds of sire is an estimate of one-half the direct genetic breed differences for survival.

Table 1. Breed of sire means for lamb survival from selected studies.

Breed of sire of the lamb[a]	No. of sires/lambs	Survival period	Survival, %	Reference
Oxford	?/1182	Birth – 8 to 14 weeks	67.2	Smith, 1977
Hampshire	?/982		63.2	
Suffolk	?/1014		58.1	
Texel	19/?	Birth – 51 days	86	Leymaster and Jenkins, 1993
Suffolk	20/?		77	
Barbados	12/168	Birth – 56 days	91.9	Bunge et al., 1993
Finnsheep	12/148		91.4	
St. Croix	12/178		89.5	
Combo-6	12/173		82.3	
Booroola Merino	12/162		80.7	
Romanov	19/?	Birth – 56 days	94.1	Freking and Leymaster, 2004
Finnsheep	23/?		93.0	
Texel	21/?		90.7	
Dorset	20/?		90.0	
Montadale	19/?		89.1	

[a]Within a study, the sires were bred to the same breed of ewe. All lambs were first crosses with the breed of dam in common.

The studies presented in Table 1 are a select group of studies that have sampled a large number of rams and produced a large number of lambs from each breed. Between studies, the difference in percentage lamb survival between the highest and lowest sire breed ranged from 5.0% to 11.2%. This means that for every 100 lambs born in a flock, the use of the breed of sire with the highest lamb survival rate would be expected to result in 5 to 11 more lambs surviving than the breed of sire with the lowest lamb survival rate or approximately $680 to $1,500 more income.

Determining which breed of sire is genetically superior for lamb survival is not easy. The results of only four studies are presented in Table 1. It would be desirable to have additional studies with these same breeds to determine if the results presented here are repeatable as well as more studies with additional breeds. However, given these limitations, the studies presented in Table 1 do give some indication of breed genetic differences. It appears that Suffolk sires may be poorer for lamb survival and Finnsheep, Romanov, and the hair breed sires of Barbados and St. Croix may be superior for lamb survival compared to some other breeds.

Breed differences for lamb survival can also be estimated by observing differences in survival of lambs from dams of different breeds or crossbreds. Since ewes provide both genes and a maternal environment to their lambs, such comparisons give estimates of both direct genetic breed effects and maternal genetic breed effects. It takes well-designed experiments to disentangle the direct genetic effects from the maternal genetic effects.

Crossbred ewes containing Finnsheep or Romanov breeding have been shown to produce lambs with higher survival rates in several studies. Table 2 presents results from the review of Thomas (2010) on the performance of Northern European short-tailed breeds of sheep, of which the Finnsheep and Romanov breeds are members, in studies conducted in Canada and the U.S.

Table 2. Mean lamb survival to weaning, averaged across studies, of Finn-cross and domestic/domestic-cross lambs in North America

	Survival, %		Finn - Domestic		
% Finn	Finn	Domestic	Diff.[a]	% diff.[b]	No. of studies
25%					
Unadj.[c]	77	80	-3	-4	7
Adj.[d]	75	69	+6	+9	3
12.5%					
Unadj.[c]	87	86	+1	+1	6
Adj.[d]	85	82	+3	+4	2

[a]Difference between the Finn and Domestic means in each row.
[b]((Finn mean – Domestic mean)/Domestic mean) * 100.
[c]Lamb survival is unadjusted for lamb's litter size.
[d]Lamb survival is adjusted for lamb litter size by including type of birth or type of birth and rearing in the model or lambs were raised from birth artificially on milk replacer.

Table 2 presents the lamb survival of one-quarter and one-eighth Finnsheep lambs from one-half and one-quarter Finnsheep ewes, respectively, compared to non-Finnsheep lambs. Finnsheep ewes give birth to larger litters than almost all other breeds in North America, and it is well known that percentage of deaths increases as the number of lambs in the litter increases. When the number of lambs in the litter is not considered, one-quarter Finnsheep lambs from one-half Finnsheep ewes have a lower lamb survival than domestic breeds or crossbreds. However, this appears to be an effect of the increased litter size of one-half Finnsheep ewes. If the data are adjusted for litter size, the one-quarter Finnsheep lambs have 9% higher survival rates than the domestic breed lambs, i.e. within the same litter size, lambs of Finnsheep breeding are expected to have greater lamb survival than lambs of domestic breeding. As would be expected, the Finnsheep advantage for lamb survival, adjusted for litter size, is less for one-eighth Finnsheep compared to one-quarter Finnsheep lambs (Table 2).

The positive effect of Finnsheep breeding on lamb survival appears to be totally due to the Finnsheep genes provided to the lamb (direct genetic effect) because the Finnsheep maternal effect for lamb survival is estimated to be negative (Thomas, 2010), largely due to lower milk production of Finnsheep ewes compared to other breeds.

Composite breeds of sheep containing Finnsheep breeding have been developed in North America: Outaouais Arcott (49% Finnsheep), Rideau Arcott (40% Finnsheep), and Polypay (25% Finnsheep). Due to their Finnsheep composition, these breeds would be expected to have higher lamb survival than most other familiar breeds or crosses in North America. The Romanov is one breed which may be superior to the Finnsheep for lamb survival. A large study conducted at the U. S. Meat Animal Research Center, Clay Center, Nebraska, USA (Casas et al., 2004) found that lambs from one-half Romanov ewes had a greater lamb survival (unadjusted for litter size) than lambs from one-half Finnsheep ewes (87.3 vs. 85.4%) even though the one-half Romanov ewes had a greater litter size than the one-half Finnsheep ewes (2.20 vs. 2.05).

There also is evidence that suggests that breeds traditionally managed under low-input or no-input management systems at lambing time (e.g. hill breeds of U.K.) have greater lamb survival than breeds traditionally managed intensively at lambing time (Dwyer and Lawrence, 2005; Dwyer, 2008). In the study of Dwyer et al. (1996), Scottish Blackface and Suffolk embryos were transferred to Scottish Blackface and Suffolk ewes so that all four combinations of ewe breed and embryo breed were represented. All ewes received a single embryo. Ewe breed had little effect on lamb behavior shortly after birth. Blackface lambs from both breeds of ewe stood twice as quickly and were more likely to suckle within the first 2 hours of birth than Suffolk lambs, suggesting the probability of greater lamb survival of Blackface lambs.

Many breeds have not been adequately evaluated for productive performance. All breeds, including those that have been well-evaluated in the past, change genetically over time due to directed selection or random chance (genetic drift). Therefore, there will always be a need for well-designed experiments to compare available breeds of sheep under common management systems for all production traits including lamb survival.

Selection

In order for genetic progress to be made for any trait, genetic variation must exist for the trait (e.g. the trait has to have a heritability greater than zero). Heritability is an estimate of the proportion of phenotypic variation that is due to additive genetic (breeding value) variation. Perhaps more simply stated, heritability is an estimate of the proportion of the differences between animals in performance for a trait that are due to their genetic differences. If there are no genetic differences between animals in a population, there will be no progress from selection.

Neal Fogarty, a sheep researcher recently retired from the New South Wales Department of Primary Industries, Orange, New South Wales, Australia, and his colleagues have published reviews of genetic parameter estimates for traits in sheep from the world scientific literature (Fogarty, 1995; Safari and Fogarty, 2003; Safari et al, 2005). Safari et al. (2005) reported heritability estimates for 29 sheep production traits from 326 studies. Sixteen of these studies estimated the direct heritability of lamb survival, and the average heritability of these 16 estimates was 0.03 – the second lowest average heritability among the 29 different traits. This suggests that there is very little additive genetic variation for lamb survival. Within a breed, the primary reason that some lambs survive and some lambs die is due largely to environmental effects and only slightly to the genes that they possess, i.e. lambs that die almost always have negative environmental effects and lambs that survive almost always have positive environmental effects.

In addition to the effect of a lamb's genes on its survival, consideration also needs to be given to the effect of the dam on the lamb's survival through the maternal environment that she provides. This includes the uterine environment provided to the fetus, the maternal care at lambing, and her milk production. The extent to which these traits are under genetic control and their relationship with lamb survival is captured in the maternal heritability for lamb survival. The review by Safari et al. (2005) reported an average maternal heritability for lamb survival of 0.05 from 8 studies. While this maternal heritability is still relatively small, it is almost twice the estimate for the direct heritability. Therefore, the genetic differences among dams for maternal traits are more important for lamb survival than the genetic differences among lambs for survival.

A complicating factor in selection for lamb survival is that almost all studies have shown a negative correlation between direct genetic and maternal genetic effects for lamb survival, and some of the estimates are quite high (-0.61 to -0.75) (Everett-Hincks et al., 2005; Welsh et al., 2006; Cloete et al., 2009). The existence of this negative genetic correlation indicates that some genes that cause high lamb survival also result in poor maternal traits that negatively affect lamb survival and genes that cause poor lamb survival also result in good maternal traits that positively affect lamb survival.

The fact that the direct and maternal heritabilites are low and the direct-maternal genetic correlation is negative does not mean that selection for improved lamb survival is a total waste of time. Since the heritabilities are not zero and the genetic correlation is not -1.00, selection may still result in some genetic improvement, but the improvement in lamb survival is expected to be slower than improvement in more heritable traits. Since lamb survival is a trait with large economic value, even small genetic improvements can have a large impact on flock profitability.

There are examples of selection experiments for lamb rearing ability that have shown progress over time. High Efficiency (HE) and Low Efficiency (LE) lines of Merino sheep for lamb rearing ability were established in Australia in 1974 (Haughey, 1983). The HE line was established with females from ewes that had weaned at least one lamb in 3 or 4 years out of 4 years, and the LE line was established with females that had failed to wean all their lambs in 2, 3, or 4 years out of 4 years. All surviving ewe lambs in each line were retained. Rams utilized in each line were selected from the best dams in the HE line and from the poorest dams in the LE line. From 1980-1982, 6 to 8 years after establishment of the lines, the HE line had 20.2% and the LE line had 33.6% lamb mortality from birth to weaning.

Two lines of Merino sheep have been divergently selected since 1986 in South Africa (Cloete et al. 2005 and 2009). Ram and ewe lamb replacements in the High line have been selected from ewes that have generally weaned more than 1 lamb per mating, and ram and ewe lamb replacements in the Low line have been selected from ewes that have generally weaned less than 1 lamb per mating. From 1998 to 2002, after 12 to 16 years of selection, 67% of lambs in the High line and 47% of lambs in the Low line were multiple-born so selection had an effect on litter size. However, even though the High line had a greater litter size, it also had a higher lamb survival to weaning than the Low line (80% lamb survival for the High line vs. 71% lamb survival for the Low line) (Cloete et al., 2005).

It appears that selection for improved lamb survival can be effective, but the genetic improvement per year may be quite low. Lamb survival also has an upper limit of 100%. If a flock already has a relatively high lamb survival of 95% or higher, there would be little opportunity or need to select for increased lamb survival. However, if lamb survival is low (80% or lower) under reasonable levels of management, selection for improved lamb survival may be desirable.

We currently do not have the necessary knowledge to recommend the most effective manner in which to select for improved lamb survival. A practical approach would appear to be selection of replacement ewe and ram lambs from dams that successfully rear their lambs to weaning. While this appears to be a very simple and workable selection criterion, there are questions on how to implement it for which we do not have good answers. For example, consider the following scenarios:

1. Ewe A gives birth to and raises a single lamb in each of four lambings at 1, 2, 3, and 4 years of age. Ewe B gives birth to and raises 1, 1, 2, and 2 lambs in four lambings at 1, 2, 3, and 4 years of age, respectively. Both ewes raised 100% of their lambs. Which ewe is most likely to be genetically superior for lamb survival. You don't know, but you would probably select Ewe B and her progeny because she was challenged with twin lambs and succeeded in raising them.
2. Ewe C gives birth to 2, 2, and 2 lambs and weans 1, 1, and 2 lambs at 1, 2, and 3 years of age, respectively, for a survival percentage of 67%. Ewe D gives birth to and raises 1, 1, and 2 lambs at 1, 2, and 3 years of age, respectively, for a survival percentage of 100%.

You would probably select Ewe D and her progeny. Ewe C was challenged with twin lambs in her first two years and failed to raise all of them.

3. Ewe E gives birth to and raises 2 lambs in her first lambing for a survival percentage of 100%. Ewe F gives birth to 2, 2, 2, and 2 lambs and weans 1, 2, 2, and 2 lambs at 1, 2, 3, and 4 years of age, respectively, for a survival percentage of 88%. I would probably choose Ewe F and her progeny even though she has a lower survival rate for her lambs. With a lowly heritable trait like lamb survival, more performance data on an individual greatly increases the accuracy of the estimated genetic value. Ewe F was challenged with twins 4 times and only failed once. However, a case could be made for Ewe E who succeeded in raising twins as a ewe lamb, which is a less common occurrence than raising twins as a 2, 3, or 4 year old ewe.

The scenarios above indicate that the selection criterion cannot be simply the percentage of lambs born that survived to weaning or the total number of lambs that survived to weaning.

Since most of the genetic progress in a flock comes from sire selection, a practical recommendation would be to select replacement rams from older ewes that have had a large proportion of multiple births and raised all or most of their lambs. For ewe replacement selection, a producer may wish to establish independent culling levels for lambing percentage (e.g. at least 1.7 lambs born per lambing) and lamb survival (e.g. at least 80% of the lambs born survived to weaning). Ewe lambs would only be considered for a replacement if their dam met both criteria. One or both of these criteria could be increased or relaxed if too many or not enough dams met the original criteria. However, it should be noted that some authors are very apprehensive about using lamb survival, defined as the proportion of lambs in a litter that survive, in sheep selection programs. Everett-Hincks and Cullen (2009) reported a very low heritability of 0.01 for proportion of lambs in a litter that survive from a large data set in New Zealand involving 24 flocks and 31,651 ewes. They concluded, “This study showed that there is little to be gained from including litter survival in sheep selection programs because heritabilities and repeatabilities for the litter survival traits were very low.” They suggested that proxies for maternal care at lambing time such as reproductive hormone levels may be better selection criteria.

There is much research to be done to determine the best selection criteria in order to develop estimates of genetic value (Expected Progeny Differences, EPD) for lamb rearing ability. The National Sheep Improvement Program currently calculates an EPD for number of lambs weaned per ewe lambing that is the best estimate we currently have available for genetic merit for lamb rearing ability. However, selection on this EPD will also result in increased litter size. Many producers may already have high enough litter size and may wish to only improve lamb survival. Animal genomics holds real promise for identifying differences between animals in their DNA profiles that are related to direct genetic and maternal genetic effects for complex traits such as lamb survival. Selection based on a combination of performance data and a DNA test could improve the accuracy of selection.

Mating Systems – Inbreeding and Crossbreeding

Inbreeding. Inbreeding is the mating of related males and females, and the progeny resulting from such a mating are inbred. Inbreeding is quantified by the inbreeding coefficient (Fx) which can vary from 0 to 1. Table 3 presents the inbreeding coefficients of progeny resulting from different types of matings.

Inbreeding generally results in a decrease in performance called “inbreeding depression.” Inbreeding depression occurs for virtually all production traits in sheep, but it is especially large for lamb survival. The average decrease in lamb survival from inbreeding estimated from over 5,400 lamb records from 6 studies from an old review (Lamberson and Thomas, 1984) was -2.8 lambs surviving out of 100 lambs born for each 0.01 increase in Fx. This suggests that lambs resulting from the matings of half-brothers to half-sisters (progeny with Fx = .125) would be expected to have approximately 35 fewer lambs survive out of 100 lambs born compared to lambs born from unrelated parents. Inbreeding is to be discouraged.

Table 3. Minimum inbreeding coefficient (Fx) from different types of matings involving relatives.

Mating type	Minimum Fx of progeny
Sire - Daughter	.25
Son - Dam	.25
Full sibs	.25
Half sibs	.125
Sire - Granddaughter	.125

While most flocks avoid intentional inbreeding, it is impossible to avoid some inbreeding with purebreeding. All animals within a breed are somewhat related, and an estimate of an average inbreeding coefficient of at least 0.02 is to be expected in most breeds. Therefore, a lamb mortality rate among purebred lambs of approximately 6% might be expected just due to the negative effects of inbreeding.

Crossbreeding. Crossbreeding is the mating of rams and ewes of different breeds or different breed combinations, and it results in hybrid vigor. Hybrid vigor is the increased performance of crossbred animals over the average performance of the purebreds that made up the cross. Individual hybrid vigor is the increased performance due to the individual being a crossbred, and maternal hybrid vigor is the increased performance of an individual due to its dam being a crossbred. Hybrid vigor is the recovery of performance lost from inbreeding depression in pure breeds.

Inbreeding results in a large decrease in lamb survival, but crossbreeding results in the opposite effect – a large increase in lamb survival. Individual and maternal hybrid vigor for lamb survival to weaning averaged from many studies is estimated to be 9.8% and 2.7%, respectively (Nitter, 1978; SID, 2002). This means that a sheep producer can expect about 10 more lambs surviving to weaning from 100 lambs born if the lambs are crossbred compared to being purebred. An additional 3 more lambs survive to weaning per 100 lambs born if the crossbred lambs are produced from crossbred dams compared to producing crossbred lambs from purebred dams. These potential increases in lamb survival from hybrid vigor cannot be ignored, and virtually all commercial sheep producers should be producing crossbred lambs from crossbred ewes.

An example of the amount of individual hybrid vigor obtained from crossing Targhee and Suffolk sheep is presented in Table 4. These data are from a study conducted at the Dixon Springs Agricultural Center (DSAC), University of Illinois using purebred rams and ewes from a flock of Targhee (ILT) and Suffolk (ILS) sheep resident at DSAC, a flock of Suffolk (NDS) sheep established from importations over 3 years from North Dakota State University, and a flock of Targhee (OHT) sheep established at DSAC from importations over 3 years from Ohio State University (Long et al., 1989). The data are from over 1,300 matings.

Production of crossbred lambs from purebred ewes resulted in 3.88 kg (13.8%) more weight of lamb weaned per ewe mated than production of purebred lambs (Table 4). The major factor causing increased ewe productivity when crossbred lambs were produced was the increased survival rate of crossbred compared to purebred lambs (5.4 more lambs surviving to weaning per 100 lambs born or 6.8% advantage of crossbred lambs over purebred lambs).

Table 4. Productivity of purebred Suffolk and Targhee ewes producing purebred or crossbred lambs and estimates of individual hybrid vigor.

Ram	Ewe	Fertility, %	Prolificacy, no. lambs/ewe lambing	Lamb survival, %	Lamb 90-d wt., kg	Ewe productivity, kg
ILS	ILS	80.2	1.50	79.0	30.82	27.74
OHT	OHT	92.8	1.43	77.2	27.33	27.16
NDS	NDS	83.1	1.69	76.6	26.40	27.02
ILT	ILT	90.7	1.63	81.5	25.75	30.65
Purebred ave.		**86.7**	**1.56**	**78.6**	**27.58**	**28.14**
ILS	OHT	91.2	1.40	85.1	29.33	30.20
OHT	ILS	86.7	1.63	87.6	28.78	34.55
NDS	ILT	88.7	1.62	83.9	28.34	31.48
ILT	NDS	82.4	1.81	79.3	26.93	31.86
Crossbred ave.		**87.2**	**1.62**	**84.0**	**28.34**	**32.02**
Hybrid vigor		**0.5**	**0.06**	**5.4**	**0.76**	**3.88**
% hybrid vigor		**0.6**	**3.5**	**6.8**	**2.8**	**13.8**

References

Berger, Y. M. 1997. Lamb mortality and causes – A nine year summary at the Spooner Agricultural Research Station. In: Proceedings of the 45th Annual Spooner Sheep Day. Dept. of Animal Sciences, UW-Madison. p. 33-40. (http://www.ansci.wisc.edu/extension-new%20copy/sheep/Publications_and_Proceedings/Pdf/Nutrition%20and%20Health/Lamb%20mortality%20and%20causes.pdf).

Bunge, R., D. L. Thomas, T. G. Nash, and R. L. Fernando. 1993. Performance of hair breeds and prolific wool breeds of sheep in southern Illinois: Effect of breed of service sire on lamb production of Suffolk and Targhee ewes. J. Anim. Sci. 71:321-325.

Casas, E., B. A. Freking, and K. A. Leymaster. 2004. Evaluation of Dorset, Finnsheep, Romanov, Texel, and Montadale breeds of sheep: II. Reproduction of F1 ewes in fall mating seasons. J. Anim. Sci. 82:1280-1289.

Cloete, S. W. P., I. Misztal, and J. J. Olivier. 2009. Genetic parameters and trends for lamb survival and birth weight in a Merino flock divergently selected for multiple rearing ability. J. Anim. Sci. 87:2196-2208.

Cloete, S. W. P., A. J. Scholtz, J. J. E. Cloete, and J. B. van Wyk. 2005. The ability of Merino ewes and lambs to reunite after separation, as affected by divergent selection for ewe multiple rearing capacity. Australian J. Exp. Agric. 45:1131-1137.

Dwyer, C. M. 2008. Genetic and physiological determinants of maternal behavior and lamb survival: Implications for low-input sheep management. J. Anim. Sci. 86:E246-E258.

Dwyer, C. M. and A. B. Lawrence. 2005. A review of the behavioural and physiological adaptations of hill and lowland breeds of sheep that favour lamb survival. Appl. Anim. Behavior Sci. 92:235-260.

Dwyer, C. M., A. B. Lawrence, H. E. Brown, and G. Simm. 1996. Effect of ewe and lamb genotype on gestation length, lambing ease and neonatal behaviour of lambs. Reprod. Fertil. Dev. 8:1123-1129.

Everett-Hincks, J. M. and N. G. Cullen. 2009. Genetic parameters for ewe rearing performance. J. Anim. Sci. 87:2753-2758.

Everett-Hincks, J. M., N. Lopez-Villalobos, H. T. Blair, and K. J. Stafford. 2005. The effect of ewe maternal behaviour score on lamb and litter survival. Livestock Prod. Sci. 93:51-61.

Fogarty, N. M. 1995. Genetic parameters for live weight, fat and muscle measurements, wool production and reproduction in sheep: a review. Anim. Breeed. Abstr. 63:101-143.

Freking and Leymaster. 2004. Evaluation of Dorset, Finnsheep, Romanov, Texel, and Montadale breeds of sheep: IV. Survival, growth, and carcass traits of F1 lambs. J. Anim. Sci. 82:3144-3153.

Haughey, K. G. 1983. Selective breeding for rearing ability as an aid to improving lamb survival. Australian Vet. J. 60:361-363.

Lamberson, W. R. and D. L. Thomas. 1984. Effects of inbreeding in sheep: A review. Anim. Breed. Abstr. 37:191-202.

Leymaster, K. A. and T. G. Jenkins. 1993. Comparison of Texel- and Suffolk-sired crossbred lambs for survival, growth, and compositional traits. J. Anim. Sci. 71:859-869.

Long, T. E., D. L. Thomas, R. L. Fernando, J. M. Lewis, U. S. Garrigus, and D. F. Waldron. 1989. Estimation of individual and maternal heterosis, repeatability and heritability for ewe productivity and its components in Suffolk and Targhee sheep. J. Anim. Sci. 67:1208-1217.

NASS (National Agriculture Statistics Service). 2010a. Sheep and goat death loss. NASS, Agricultural Statistics Board, USDA. 18 pp. (http://usda.mannlib.cornell.edu/usda/current/sgdl/sgdl-05-27-2010.pdf).

NASS (National Agriculture Statistics Service). 2010b. Sheep and goats. NASS, Agricultural Statistics Board, USDA. 7 pp. (http://usda.mannlib.cornell.edu/usda/nass/SheeGoat//2010s/2010/SheeGoat-07-23-2010.pdf).

Nitter, G. 1978. Breed utilization for meat production in sheep. Anim. Breed. Abstr. 46:131-143.

Safari, E. and N. M. Fogarty. Genetic parameters for sheep production traits: estimates from the literature. Tech. Bull. Vol. 49. NSW Agriculture, Orange, Australia. http://www.sheep.crc.org.au/articles.php3?rc=145.

Safari, E., N. M. Fogarty, and A. R. Gilmour. 2005. A review of genetic parameter estimates for wool, growth, meat and reproduction traits in sheep. Livestock Prod. Sci. 92:271-289.

SID Sheep Production Handbook. 2002. American Sheep Industry Association, Inc. Centennial, Colorado. Vol. 7, p. 22.

Southey, B. R., S. L. Rodriguez-Zas, and K. A. Leymaster. 2001. Survival analysis of lamb mortality in a terminal sire composite population. J. Anim. Sci. 79:2298-2306. (http://jas.fass.org/cgi/reprint/79/9/2298).

Thomas, D. L. 2010. Performance and utilization of Northern European short-tailed breeds of sheep and their crosses in North America: a review. Animal 4:1283-1296.

Welsh, C. S., D. J. Garrick, R. M. Ens, and G. B. Nicoll. 2006. Threshold model analysis of lamb survivability of Romney sheep. New Zealand J. Agric. Res. 49:411-418.

WASB (Wisconsin Agricultural Statistics Bulletin). 2010. Wisconsin Field Office, NASS, USDA. 64 pp. (http://www.nass.usda.gov/Statistics_by_State/Wisconsin/Publications/Annual_Statistical_Bulletin/AnnBull_2010_final_web.pdf).

METHODS OF PREGNANCY DIAGNOSIS IN SHEEP

Gary Veserat MS, PAS
Veserats Consulting
Woodland, CA 95776

Overview

Intensive sheep management and controlled breeding techniques, such as artificial insemination and out-of season breeding, increase the need for a cost effective - accurate and practical test for early pregnancy diagnosis in ewes. Traditional methods such as non-return to estrus, udder development, and abdominal ballottement are not satisfactory. In addition, radiography, and various biological tests are accurate techniques; however they are impractical under farm conditions. Methods of pregnancy diagnosis depending on visualization of the conceptus or determination of its secretory products in the ewes blood or in the milk are the most accurate and specific methods for pregnancy.

In the early 1980's, B-mode ultrasonography was introduced in the veterinary field and used for pregnancy diagnosis in mare and then received large acceptance for diagnosing pregnancy in all domestic animals. Transrectal and eventually Transabdominal ultrasonography was recommended as a simple, rapid and practical method for early pregnancy diagnosis in sheep. However, the accuracy of this technique is greatly variable. In the early 1990's, pregnancy-associated glycoproteins (PAG) were isolated from domestic ruminants and "laboratory tests" were developed for their determination in the ewes blood or in the milk.

Various practical methods have been used for pregnancy diagnosis in sheep. Both pregnancy and fetal numbers are accurately diagnosed by using radiography after Day 70 of the gestation. Rectal-abdominal palpation technique detects pregnancy with an accuracy of 65% to 100% from Days 50 to 110 of gestation, however it has a low (20% to 60%) accuracy for determining multiple fetuses. Progesterone assays have a high sensitivity (90% to 100%) at Days 16 to 18. Ovine pregnancy specific protein B assay accurately detects pregnancy (100%) from Days 26 after breeding onwards. The accuracy of progesterone and Ovine pregnancy specific protein B assays for determining fetal numbers is relatively low. A-mode and Doppler ultrasonic techniques accurately detect pregnancy during the second half of gestation. Fetal numbers cannot be determined by A-mode ultrasound, while the Doppler technique needs extensive experience to achieve accuracy. Transrectal B-mode, real time ultrasonography identifies the embryonic vesicles as early as day 12 after mating, but the sensitivity of the technique for pregnancy is very low (12%) earlier than 25 days after mating. Transabdominal B-mode ultrasonography achieved high accuracy for pregnancy diagnosis (99%+) and the determination of fetal numbers (99%+) at Days 30 to 105 of gestation. *Real-time, B-mode ultrasonography appears to be the most practical and accurate method for diagnosing pregnancy and determining fetal number in sheep*.

Introduction

Early detection of pregnancy is of economic value to sheep industry. Non pregnant ewes could be sold, reducing feed expenses, while non-pregnant lambs could be marketed at higher price than they would bring as mature ewes. Separation of the sheep flocks into pregnant and non-pregnant ewes might reduce reproductive and production losses in form of abortions, stillbirths and production of weak lambs.

Predictions of the number of fetuses would allow appropriate nutritional management of the ewes in late gestation that will prevent pregnancy toxemia, minimize prelambing feeding costs, optimize birth weight, weaning weight and survivability of lambs and reduce the incidence of dystocia. In addition, the accurate information on the stage of gestation would be useful to dry off lactating females at adequate period and to monitor the females near term.

Methods of pregnancy diagnosis

Various methods have been used to diagnose pregnancy in sheep. These methods can be classified as less practical such as the management method (*non-return to estrus*), abdominal palpation, radiography, and ballottement; and the *most practical methods* such as rectal abdominal palpation, blood assays and ultrasonography.

Radiography. From the 1960's through the 1980's researchers reported 90% to 100% accuracy for diagnosing pregnancy and determination of the fetal number, respectively after 70 days of gestation. Besides the accuracy, the technique is "quick"; 400 to 600 ewes can be tested per day under farm conditions. The cost of the equipment and the potential health hazard to the operator may limit its use in the field.

Rectal Abdominal Palpation. In the 1970's pregnancy diagnosis in sheep by gentle insertion of a lubricated glass rod (*0.5 inches in diameter and 20 inches long*) into the rectum of ewe lying on its back. The free hand is placed on the posterior abdomen while the rod was manipulated with the other hand. At the early stage of pregnancy, the sensitivity of the technique for diagnosing pregnancy is low but increased with progressing of the pregnancy reaching the highest accuracy (100 %) at Days 85 to 110 after mating. Although this technique is simple, cheap and quick (150 ewes can be examined per hour), it had a low accuracy in diagnosing multiple fetuses and was more hazardous with respect to rectal and abortion.

The technique of bimanual palpation of small ruminants was developed in the mid-1990's. This method includes digital palpation per rectum combined with abdominal manipulation. By using this technique pregnant ewes were accurately diagnosed based on enlarged cervix, position of the uterus, palpation placentomes and /or fetal parts, asymmetry and /or marked distension of uterine horns and inability to palpate the ovaries.

Hormonal / Blood Assays

Progesterone. Measurement of blood progesterone is a reliable indicator of the functional corpus luteum (*pregnancy*). The accuracy of progesterone for detecting pregnancy is high, however it's low for diagnosing non-pregnancy. Early embryonic death, uterine and/ or ovarian pathology may be the source of the false positive cases. After 100 days after breeding, the accuracy of progesterone assay for pregnancy diagnosis is 98% in ewe lambs and 99% in mature ewes.

Estimating the fetal number, serum progesterone concentration is significantly higher in ewes carrying two and three fetuses than those carrying one fetus. There is also a positive relationship between the number of fetuses and the mean plasma progesterone concentrations after the second half of pregnancy.

Regarding the fetal sex, progesterone concentrations of ewes giving birth to male and female lambs were not significantly different.

Assessment of Pregnancy Protein

Pregnancy specific protein B (PSPB). Pregnancy specific protein B was first detected in the bovine placenta in the early 1980's, is secreted by the embryo/developing fetus. The physiological role of PSPB during pregnancy might be the maintenance of *corpus luteum* by stimulating prostaglandin E2 production.

Ovine pregnancy-associated glycoprotein (ovPAGs) Ovine pregnancy-associated glycoproteins (ovPAGs) are synthesized by the developing embryo. During research in the early 1990's, the concentration of ovPAG in ewes was detectable in about two-thirds ewes at Week 3 and in all ewes by Week 4 after mating. After lambing, the PAG levels decrease rapidly reaching virtually zero by the fourth week postpartum.

Ultrasonography.

In the past 30 years, three types of ultrasonographic systems were used for pregnancy diagnosis in the small ruminants:

A-mode ultrasound (Amplitude-depth or echo-pulse) In this system, the transducer containing one crystal emits ultrasound waves which penetrate the tissues under the skin and the sound waves are reflected when they meet a high acoustic impedance interfaces – reflective structure (*pregnant uterus or fluid-filled structures*). The transducer receives the reflected echoes and converts it into peaks on oscilloscope with horizontal scale representing the depth of the reflecting structure or into audible signal.

In the early 1980's researchers used the reflection of ultrasound at depth 3.5 inches or greater as a positive sign of pregnancy in ewe and reported better than 85% to 95% sensitivity in the period from three months to four months (90 to 120 days) after mating. A-mode ultrasound is a quick, convenient and simple technique, but it cannot predict the fetal number or the viability of the fetus.

Doppler ultrasound. Doppler devices utilize the Doppler shift principle to detect the fetal heartbeats and flow of blood in uterine and fetal vessels. During the mid-1980's researcher's determined an external Doppler transducer can give almost 100% accuracy for diagnosing pregnancy after about Day 110 of gestation.

The predictions of fetal numbers, using the external Doppler technique, and when used by skilled operators gives about 85% accuracy for diagnosing single and multiple fetuses at Days 80 to 95 of gestation. Doppler devices have not been used successfully for estimating ovine gestational age.

Real-time, B-mode ultrasonography [**Transrectal OR Transabdominal*****].*** Real-time B-mode ultrasonic scanning of the uterus in sheep appears to offer an accurate, rapid, safe and practical means for diagnosing pregnancy, determination of fetal numbers and estimation of gestational age.

Diagnosis of pregnancy

By using transrectal ultrasonography (7.5MHz), embryonic vesicles of the ewes can be identified at Day 12 after mating, while the first visualization of the embryo is at about Day 19. The sensitivity of 5MHz transrectal ultrasonography for detecting pregnant ewes is greatly variable (10% to 98%) at less than Day 25 of gestation. Thereafter, the sensitivity increases between 65% and 90% at Days 25 to 50, depending on the breed, age and parity of the ewes, *experience of the operator* and the technique of the examination.

Determination of the fetal number. By using transrectal ultrasonography (7.5 MHz), single and multiple pregnancies in sheep are accurately detected at Day 25. By using transabdominal ultrasonography, the accuracy of experienced operator for determination both single-and multiple-bearing ewes was 99 % from Days 45 to 95 of gestation.

Estimation of gestational age. When the date of mating is unknown, monitoring fetal development allows estimation of gestational age.

Crown-Rump length (CRL). By using transrectal ultrasonography (7.5 MHz), researchers in the late 1990's reported a high correlation between the crown- rump length and the gestational age from Days 19 to 48 of gestation.

Fetal head diameter. Fetal head diameters including the biparietal diameter (BPD) - *width of skull*, the occipito-nasal length (*length of the skull*) and the diameter of the eye orbit (EO) were used to predict the stage of gestation in sheep. Regarding the biparietal diameter (BPD), in the late 1990's researchers used ultrasonography to measure the BPD of sheep from Days 32 to 90 and found a high correlation between the measured diameters and the gestational age. During the late 1980's researchers found the occipital-nasal length to accurate, showing a linear increase till Day 80. Regarding the diameter of the fetal eye orbit, in the late 1990's reported that the ovine fetal orbit increased in diameter from 2 mm at Day 35 to 17 mm at Day 90 of gestation and it gave a high correlation with the fetal age.

Thoracic diameter (TD). Ultrasonographic measurements of the ovine fetal thoracic diameter showed high correlation with the fetal age from Days 23 to 90 of gestation during the 1990's.

Fetal heart rate (FHR). By using 7.5 MHz ultrasonography, the rhythmic pulsations within the ovine embryonic vesicle were first detected at Day18 after mating.

Placentome size. During the 1990's placentomes could be detected by transrectal ultrasonography (5 MHz) at Day 30. At this period the placentomes appeared as echogenic areas on the surface of endometrium. By Day 42, the ovine placentomes presented cup-shaped forms and reached the maximum size by Day 74. There was a poor correlation between placentome size and ovine gestational age due to great variation in the size of placentomes in the same observations.

Determination of fetal sex. Depending on the location of the genital tubercle of the ovine fetus, researchers during the late 1990's using ultrasonography for detecting male and female fetuses was 100% and 75%, respectively from Days 60 to 70 of gestation on very small ewe numbers.

Summary

Early detection of pregnancy and determination of the fetal numbers have economic benefits to sheep producers. The method used for pregnancy diagnosis should be simple, accurate, rapid, inexpensive, practical and safe for both operators and animals. Accurate pregnancy diagnosis can be achieved by blood assays, however, their accuracy for differentiating single and multiple fetuses would not be regarded as sufficiently high to be of practical value and are expensive. Rectal abdominal palpation is a simple, cheap and quick method, however its accuracy for determining multiple pregnancies is low and it may cause abortion or rectal perforation. Doppler technique requires great skill to achieve high accuracy for prediction of fetal numbers. Radiography and transabdominal B-mode ultrasonography accurately diagnose both pregnancy and fetal numbers, but transabdominal B-mode ultrasonography technique is cheaper than the first one and has the advantages of being safe and able to detect the fetal viability. The optimum time for using transabdominal or transrectal ultrasonography in sheep ranges from 45 to 100 days of gestation. Pregnancy detection from day 25 to 45 can also be used effectively, with a "confirmation" check from day 45 on.

FIFTEEN YEARS OF DAIRY SHEEP RESEARCH AT THE SPOONER AGRICULTURAL RESEARCH STATION, UNIVERSITY OF WISCONSIN-MADISON

David L. Thomas[1] and Yves M. Berger[2]
University of Wisconsin-Madison
[1]Madison and [2]Spooner, Wisconsin, USA

Brief History of the Spooner Station

The Spooner Agricultural Research Station is located in northwestern Wisconsin and is the oldest of the 12 research stations operated throughout the state by the College of Agricultural and Life Sciences of the University of Wisconsin-Madison. The Spooner Station was established in 1909 with a donation of 80 acres of land to the University of Wisconsin by the city of Spooner. The station currently occupies 388 acres and has active research programs in field crops, pasture, horticulture, and sheep production.

Sheep were added to the station in 1936 after an outbreak of brucellosis in the small dairy herd resulted in disposal of the cattle. Carl Rydberg was the first true resident manager of the sheep program at the station from 1941 until his retirement in1980. He was followed by Tom Cadwallader (1980-1988) and Yves Berger (1989-present). The faculty members in the Department of Animal Sciences on the Madison campus most involved with the sheep research program at Spooner were Art Pope (1946-1989) and Dave Thomas (1991-present). The original ewes were commercial western whiteface, and these were graded-up to Shropshire. With changes in breed popularity and needs for research, the flock over time was composed of Shropshire, Suffolk, Targhee, Finnsheep-Targhee, Romanov-Targhee, Dorset-cross, and the present dairy breeding of East Friesian and Lacaune.

The first dairy sheep research program in North America was established by Dr. Bill Boylan at the University of Minnesota in 1984, but this program ceased in about 1996 with his retirement. The dairy sheep program at the Spooner Station had its start in the summer of 1993 with the importation of two ½ East Friesian, ½ Rideau rams from the flock of Hani Gasser, Chase, British Columbia, Canada. Construction on the double-12 sheep milking parlor started in April 1995. The first ewes were milked starting in April 1996, and with the collection of the first milk yield data shortly after, the dairy sheep research program was off and running. At the present time, the program at the Spooner Station is the only dairy sheep research program in North America.

Summaries of the results of some studies conducted at the station on dairy sheep production follow. The studies selected for summarization are those whose results may have the greatest opportunity for the improvement of the efficiency of dairy sheep production. In addition, several studies have been conducted in the Department of Food Science on various processing aspects of sheep milk, and these are not summarized here. Results of most of the processing studies can be found online in the Journal of Dairy Science by searching for the main authors of W. Wendorff and J. Jaeggi.

The successful completion of these studies was due in large part to the dedicated staff at the Spooner Agricultural Research Station. We also had the opportunity during the past several years to work with two excellent graduate students, Brett McKusick and Claire Mikolayunas, who earned their M.S. and Ph.D. degrees in Animal Sciences through these projects. They not only conducted the work, but also conceived the hypotheses and designed the experiments for most of the following studies. Without their efforts, there would be much less to present in this review.

Breed Comparisons

Low Percentage East Friesian-Crosses Compared to Dorset-Crosses. The first dairy sheep genetics available in North America for commercial dairy sheep production were on the farm of Hani Gasser, Chase, British Columbia, Canada who had imported frozen semen of East Friesian (EF) rams from Switzerland and used it to inseminate his Rideau ewes. From this breeder, we purchased two 1/2 EF x 1/2 Rideau rams in 1993, one 3/4 EF x 1/4 Rideau ram in 1994, and one 7/8 EF x 1/8 Rideau ram in 1995. Three different Swiss EF rams sired the four EF-cross rams.

Crossbred ewes of 1/2 Dorset x 1/4 (Romanov or Finnsheep) x 1/4 Targhee breeding (commercial ewes) were randomly assigned to either an EF-cross ram or polled Dorset ram in a single-sire mating pen during the late summers or autumns of the four years from 1993 to 1996. The Dorset rams were purchased from Wisconsin breeders from rams consigned to the Wisconsin Ram Test Station. Most female lambs resulting from these matings were retained as replacements. By mating EF-cross ewe lambs to one of the EF-cross rams, lambs with up to 50% EF breeding were produced.

Growth data were available for 420 lambs from EF-cross sires and 216 lambs from Dorset sires and an additional 546 lambs from EF-cross dams and 150 lambs from Dorset-cross dams. Reproduction data were collected from 338 matings of EF-cross ewes and 146 matings of Dorset-cross ewes. Milk production data was available from 246 EF-cross lactations and 76 Dorset lactations.

East Friesian-cross lambs had greater ($P < 0.05$) birth, weaning, and postweaning weights than Dorset-cross lambs. When lambing at 1 and 2 yr of age, EF-cross ewes gave birth to .27 more ($P < 0.05$) lambs per ewe lambing, reared .15 more ($P < 0.05$) lambs per ewe mated, had 33.5 more ($P < 0.05$) d in lactation, and produced 1.9 times more ($P < 0.05$) milk and more ($P < 0.05$) weight of milk fat (+2.2 kg) and milk protein (+2.2 kg) than Dorset-cross ewes (Table 1). The EF-cross ewes produced milk with a lower ($P < 0.05$) percentage fat and protein compared to Dorset-cross ewes which was expected given the negative relationship between milk yield and percentage milk fat and protein. The EF-cross ewes and lambs in this study were of 12.5 to 50.0% EF breeding and provided a strong endorsement for the use of dairy sheep genetics over domestic meat/wool genetics for commercial sheep dairies.

Table 1. Lactation performance[1] of young East Friesian-cross and Dorset-cross ewes

Trait	Breeding of ewe	
	Dorset-cross	East Friesian-cross
Number of lactations	76	246
Lactation length, d	92.7[a]	126.2[b]
Milk yield, lb.	125.2[a]	240.0[b]
Fat, %	5.5[a]	5.02[b]
Fat yield, lb.	7.3[a]	12.1[b]
Protein, %	5.42[a]	4.97[b]
Protein, lb.	7.0[a]	11.9[b]
Somatic cell count, $\log_{10}$	4.99	5.02

[1]Ewes were milked starting approximately 30 days after parturition.
[a,b]Means within a row with no superscript in common are different ($P < 0.05$).

East Friesian and Lacaune Breeds. As purebred rams and semen of the East Friesian breed became available after 1995, several different rams were used in the flock. In addition, the first Lacaune genetics in the U.S. was imported by the Spooner Station from the U.K. (semen from 3 rams) and Canada (2 rams) in 1998. An analysis of performance records through 2005 was conducted to determine the effect of East Friesian and Lacaune genetics on lactation traits and litter size. Progeny from 20 East Friesian (5 crosses and 15 pure) and 6 Lacaune sires were included in the analysis. Presented in Table 2 is the expected performance of pure East Friesian and Lacaune ewes at 3 years of age when they are milked from 1 or 2 days after lambing.

Table 2. Expected performance of pure East Friesian and Lacaune 3-year-old ewes.

Trait	Breed	
	East Friesian	Lacaune
Lactation length, d	188.6[a]	180.3[a]
Milk yield, lb.	790.4[a]	759.3[a]
Fat yield, lb.	45.9[a]	48.7[a]
Fat, %	6.3[a]	6.5[b]
Protein yield, lb.	39.5[a]	40.1[a]
Protein, %	5.2[a]	5.3[b]
Somatic cell count, $\log_{10}$	2.24[a]	2.43[b]
Litter size, no.	1.97[a]	1.84[b]

[a,b]Means within a row with no superscript in common are different ($P < 0.05$).

The major differences between the samples of East Friesian and Lacaune genetics in North America for the traits in Table 2 is a higher percentage of milk fat and protein in Lacaune and a higher litter size in East Friesian. Lactation length and yield of milk, fat, and protein are similar between the two breeds.

Weaning Systems

In 1998, 99 EF-cross ewes in second and third parity were utilized to compare milk production and lamb growth under three weaning systems. One group of ewes (DY1) was weaned from their lambs between 24 and 36 h postpartum and machine milked twice daily for the entire lactation. Their lambs were raised on milk replacer until approximately 30 d of age. Another group of ewes (MIX) were separated from their lambs at 5:00 p.m. each day and milked once daily each morning at 6:00 a.m. from 24 to 36 h after parturition. After the morning milking, ewes were returned to their lambs. MIX ewes were milked twice daily following permanent weaning of their lambs at approximately 30 d of age. The final group of ewes (DY30) were left to raise their lambs and not initially milked. Approximately 30 d postpartum, ewes were weaned from their lambs and milked twice daily.

Table 3. Ewe lactation, lamb growth, and economics of three weaning systems.

	Weaning system		
Trait	DY1	MIX	DY30
Ewe lactation traits:			
Lactation length, d	183.4	179.2	182.9
Machine milking period, d	182.4[a]	178.2[a]	152.3[b]
Commercial milk yield, lb.	572.2[a]	518.8[b]	377.7[c]
Fat yield, lb.	29.0[a]	24.0[b]	18.5[c]
Fat, %	5.1[a]	4.5[b]	4.8[a,b]
30-d fat, %	4.8[a]	2.8[b]	-
Protein yield, lb.	30.1	26.6	19.8
Protein, %	5.3	5.1	5.2
Lamb growth traits:			
30-day weight, lb.	33.9	31.9	33.0
120-day weight, lb.	96.1[e]	101.0[d]	104.1[c]
Economics:			
Total lamb & milk receipts, $	506.52	458.23	415.25
Additional expenses, $	87.16	14.40	-
Receipts – expenses, $	420.86	446.47	415.81

[a,b]Means within a row with no superscript in common are different (*P* < 0.05).
[c,d,e]Means within a row with no superscript in common are different (*P* < 0.10).

Milk yield differed (*P* < 0.05) among the three weaning systems (DY1 = 572 lb., MIX = 519 lb., and DY30 = 378 lb.). Lamb weights at 30 d of age when they were weaned from milk replacer or their dams were not significantly different among the weaning treatment groups (averaged 33 lb. across treatments). However, lamb weights at 120 d of age were lighter (*P* <

0.10) for lambs from DY1 ewes (96 lb.) than for lambs from DY30 ewes (104 lb.). Lambs from MIX ewes had intermediate 120 d weights (101 lb.). The lamb growth data suggest that artificial rearing of lambs has a slight negative effect on lamb postweaning gain relative to the effects of either limited suckling or *ad libitum* suckling preweaning. Relative to the DY30 system, income from milk and lamb over expenses was +$30.66 for the MIX system and +5.05 for the DY1 system.

The economic returns assumed no price differentials for milk composition. Milk from MIX ewes had a lower ($P < 0.05$) fat percentage (4.53%) than milk from either DY1 (5.06%) or DY30 (4.81%) ewes. The lower milk fat percentage of MIX ewes was most dramatic during the first 30 d when they were suckling their lambs during the day. During this period, MIX ewes had a milk fat percentage of 2.80% while DY1 ewes at the same stage of lactation had a milk fat percentage of 4.82%. If price discounts were in place for low-fat milk, the MIX system would have less of an economic advantage than projected in this study. Even so, the MIX system is attractive over the other two systems because the ewes raise their lambs and still produce 85% as much milk as DY1 ewes.

Subsequently, more detailed studies conducted on the UW-Madison campus determined that the low milk fat from MIX ewes while they are nursing their lambs is due to low oxytocin release in these ewes during milking. Oxytocin is released as a result of teat and udder stimulation, usually at the time of suckling. Oxytocin is an integral part of milk ejection (the contraction of the alveoli within the udder that causes secreted milk to flow down a system of ducts and canals into the storage part of the udder known as the cistern). During machine milking, if there is no release of oxytocin, secreted milk remains in the alveoli along with large quantities of milk fat. The MIX ewes experienced impairment of oxytocin release and the milk ejection reflex because they knew that after milking they would be reunited with their lambs. The milking machine captured their cisternal milk but not their alveolar milk where most of the fat is found.

Fat Supplementation

Megalac Rumen Bypass Fat (Church and Dwight Co., Inc.), a calcium salt of long-chain fatty acids (CSFA), was added to the diets of dairy ewes in early lactation in 1999. The CSFA was mixed in a ration of whole shelled corn and a protein pellet and fed in the milking parlor to provide .22 lb. of CSFA per ewe per day.

Ewes lambed over a six-week period starting on February 10 and were randomly allocated to a DY1 or MIX system as they lambed. The trial started on February 17 and ran for 8 wk. During the first and third 2-wk periods, all ewes received the unsupplemented diet, and during the second and fourth 2-wk periods, all ewes received the CSFA supplemented diet.

The CSFA supplementation had no effect on milk yield but tended to depress milk protein percentage in both DY1 and MIX ewes. The CSFA supplementation resulted in a large ($P < 0.05$) increase in milk fat percentage of approximately +1.19 percentage units in DY1 ewes but had no effect on milk fat percentage of MIX ewes during the milking-suckling period. Therefore, fat supplementation may be a method to increase fat percentage in ewes that have weaned their lambs, but it is not a solution to the low fat percentage of milk from ewes that are still suckling their lambs.

Milking Intervals

Three-Times-a-Day Milking. During 2000, 125 mature East Friesian crossbred ewes were utilized to compare traditional twice-a-day milking (2X) with three-times-a-day milking (3X) during the first 30 days of lactation. After day 30 of lactation, all ewes were milked twice-a-day. All lambs were weaned from their dams within 24 hours after parturition, and ewes were immediately assigned to a milking treatment. During the 30-day treatment period, 3X ewes produced a total of 27.7 lb. more ($P < .05$) (+15.2%) milk than 2X ewes (209.4 versus 181.7 lb.). Even though 3X produced significantly more milk than 2X during the first 30 days of lactation, the value of the increased amount of milk was less than the labor costs for the extra milking each day.

16-Hour Milking Interval. A trial was conducted in 2001 to determine if the milking interval could be extended from 12 to 16 hours starting in mid-lactation without a significant drop in milk yield. Forty-eight third lactation East Friesian crossbred ewes were utilized. Twenty-four ewes were kept on the 12 hour milking interval (12H, milked daily at 6:00 a.m. and 6:00 p.m.) and 24 ewes were switched from the 12H interval on approximately day 90 of lactation to a 16 hour milking interval (16H, milked at 6:00 a.m. and 10:00 p.m. one day and at 2:00 pm. the following day and then repeating). Lactation performance was measured through day 180 of lactation.

During the 90-day treatment period, 16H ewes produced about 28% more ($P < .05$) milk at each 6 a.m. milking than 12H ewes, and there was no difference between treatments in the total amount of milk produced. The percentage of fat and protein and somatic cell count was not different between the two treatments. From mid- to late lactation, it appears that the number of milkings can be reduced by 25% without a decrease in milk production.

Table 4. Lactation performance of ewes milked at 12 or 16 hour intervals from day 90 to 180 of lactation.

	Milking interval	
Trait	12 hour	16 hour
Total number of milkings	180	135
6 a.m. milk yield, lb.	1.43^{b}	1.83^{a}
Adjusted 24-hour milk yield, lb.	2.95	2.97
Total milk yield, lb.	262.0	259.6
Total parlor time, h	38.1	27.9

^{a,b}Means within a row with no superscript in common are different ($P < 0.05$). No test of statistical significance was possible for total number of milkings or total parlor time.

Machine Stripping

Due to the large cisternal storage capacity and non-vertical teat placement in most dairy ewes, machine stripping is commonly performed to remove milk not obtained by the machine. However, stripping requires individual manual intervention, lengthens the milking routine, and could inadvertently lead to overmilking of other ewes in the parlor. The objective of this experiment was to estimate the effect of omission of machine stripping on milk production and parlor throughput.

East Friesian crossbred dairy ewes that had been machine milked and stripped twice daily from d 0 to 79 post-partum, were randomly assigned to two stripping treatments for the remainder of lactation: normal stripping (S, n = 24), or no stripping (NS, n = 24). NS ewes yielded 14% less commercial milk during the experiment (NS = 232.2 lb., S = 269.9 lb.), but had similar lactation length, milk composition, and somatic cell count compared to S ewes.

Average machine-on time for S ewes was 10.4 seconds per ewe longer ($P < 0.10$) than for NS ewes because of stripping, which may have resulted in overmilking of some ewes in the S group. A milking simulation in a double-12 parlor with one or two milkers and stripping or no stripping was conducted. With one milker, elimination of stripping increased the number of ewes milked per hour by 49% (from 103 to 153 ewes per hour), and the number of ewes overmilked per side decreased from 11 out of 12 to 0 out of 12. With two milkers, elimination of stripping increased the number of ewes milked per hour by 20% (from 138 to 166 ewes per hour), and the number of ewes overmilked per side decreased from 4 out of 12 to 0 out of 12.

These results collectively indicate that elimination of machine stripping will reduce milk yield per ewe, but the loss in milk yield may be somewhat or completely compensated for by increased parlor throughput and the overmilking of fewer ewes.

Grazing and Supplementation on Pasture

Pasture Compared to Drylot for Lactating Ewes. In1998, 97 milking ewes had been maintained in drylot from early to mid-lactation where they received grain twice per day in the parlor at milking and alfalfa hay during the day in drylot. From mid-lactation to the end of lactation, 48 ewes remained in the drylot and the remaining 49 ewes were grazed during the day on a kura clover-orchard grass pasture. The pastured ewes had 10.5% greater ($P < .05$) lactation milk yields than the ewes in drylot (405 versus 367 lb.). As a result of this trial, all lactating ewes in subsequent years have been grazed during the grass-growing season.

Supplementation on Pasture. Trials were conducted in 2005 and 2006 to determine the efficacy of supplementation of lactating ewes while grazing high quality kura clover-orchard grass pastures.

In trial 1, 56 three-year-old grazing dairy ewes in early (21 days in milk) or late (136 days in milk) lactation were fed 0 or 2.0 lb./day per ewe of supplement (16.5% crude protein mixture of corn and a soybean meal-based high-protein pellet). Supplementation had similar effects in both early and late lactation ewes. Supplemented ewes had higher ($P < 0.01$) milk production (3.50 vs. 2.99 lb./day, respectively), lower ($P < 0.10$) milk fat percentage (5.75 vs. 6.00%, respectively), and lower ($P < 0.01$) milk protein percentage (4.84 vs. 5.04%, respectively) than unsupplemented ewes (Table 5).

Protein has a high nitrogen content. If protein intake is in excess of the needs of the rumen microflora, high levels of protein nitrogen in the form of urea are excreted in the urine, feces, and milk. Therefore, milk urea nitrogen (MUN) is a good indicator of the efficiency of protein utilization by the microflora of the rumen. MUN levels were similar between supplemented and unsupplemented ewes but were above recommended levels for dairy sheep, indicating an excess intake or inefficient utilization of protein. It appeared that the ewes benefited from the increased energy in the supplement. However, the protein in the pasture, which varied from 16 to 30 % during the grazing season, may have been adequate for the level of milk production of these ewes, and the additional protein in the 16.5% crude protein supplement may not have been necessary. This conclusion resulted in another supplementation trial the following grazing season.

In trial 2, 96 two-, three-, and four-year-old grazing dairy ewes in mid-lactation (112 days in milk) were randomly assigned to 4 treatments of 0, 1, 2, or 3 lb./day per ewe of whole corn. Average test-day milk production increased, milk fat percentage decreased, and milk protein percentage was not changed with increasing amounts of corn supplementation (Table 6). MUN levels for all four groups were within the range suggested for dairy sheep and decreased with increasing amounts of corn supplementation. This suggested that protein levels in the high quality legume-grass pasture were adequate for milk production in these ewes and utilization of pasture protein improved with increasing dietary energy intake from whole corn.

Table 5. Lactation performance of supplemented[1] or unsupplemented ewes grazing a legume-grass pasture.

Trait	Unsupplemented	Supplemented
Test day milk yield, lb.	2.99[b]	3.50[a]
Milk fat, %	6.00[c]	5.75[d]
Milk protein, %	5.04[a]	4.84[b]
Milk urea nitrogen, mg/dL	24.9	25.1

[1]2 lb./day of a 16.5% crude protein mixture of corn and a soybean meal-based high protein pellet.
[a,b]Means within a row with no superscript in common are different ($P < 0.05$).
[c,d]Means within a row with no superscript in common are different ($P < 0.10$).

Table 6. Lactation performance of grazing ewes unsupplemented or supplemented with corn.

Trait	Whole corn supplementation, lb./ewe/day			
	0	1	2	3
Test day milk yield, lb.	2.86[a]	2.90[a]	3.10[b]	3.17[b]
Milk fat, %	6.26[b]	6.40[b]	6.09[b]	5.89[a]
Milk protein, %	5.29	5.41	5.37	5.39
Milk urea nitrogen, mg/dL	18.9[a]	17.1[b]	13.6[c]	13.6[c]

[a,b,c]Means within a row with no superscript in common are different (*P* < 0.05).

Level of Protein and Rumen Undegraded (By-Pass) Protein

Dietary protein is provided to ruminants in the form of rumen degraded protein (RDP) and rumen undegraded (by-pass) protein (RUP). RDP is utilized by the microflora of the rumen, and the microbial protein is then utilized by the animal. RDP fed in excess of the needs of the rumen microflora is excreted in the feces or as urea in the urine or milk. RUP or by-pass protein cannot be utilized by the rumen microflora but is utilized directly by the animal. High-producing ruminants, like lactating dairy ewes, may increase their productivity if RUP is added to rations already adequate in RUP. A study was conducted in 2008 to test this hypothesis.

Three diets were formulated to provide similar energy concentrations and varying concentrations of RDP and RUP: 12% RDP and 4% RUP (12–4) included basal levels of RDP and RUP, 12% RDP and 6% RUP (12–6) included additional RUP, and 14% RDP and 4% RUP (14–4) included additional RDP. Diets were composed of alfalfa-timothy cubes, whole and ground corn, whole oats, dehulled soybean meal, and expeller soybean meal (SoyPlus, West Central, Ralston, IA).

There was no effect of dietary treatment on dry matter intake. The 18% crude protein diet with the high level of RDP (14-4) resulted in no more milk production than obtained with the 16% crude protein diet with a lower level of RDP and the same level of RUP (12-4). However, the 18% crude protein diet with the high level of RUP (12–6) increased (*P* < 0.01) milk yield over both the 14-4 and 12-4 diets (Table 7). This is strong evidence for the inclusion of RDP in diets of lactating ewes.

Milk urea N concentration was greater (*P* < 0.05) in the 14–4 diet and tended to be greater (*P* < 0.10) in the 12–6 diet compared with the 12–4 diet, indicating that the excretion of urea N in this study was more closely related to dietary crude protein concentration than to protein degradability (Table 7).

Table 7. Lactation performance of ewes fed diets with varying levels of rumen degraded (RDP) and undegraded (RUP) protein.

Trait	% RDP:%RUP		
	12:6	14:4	12:4
Test day milk yield, lb.	4.51[a]	3.96[b]	3.94[b]
Milk fat, %	6.13	6.37	6.18
Milk protein, %	4.74	4.95	4.80
Milk urea nitrogen, mg/dL	26.3[a,b]	27.4[a]	23.4[b]

[a,b]Means within a row with no superscript in common are different ($P < 0.05$).

Legume Content of Forage

Our previous trials with dairy ewes fed stored feeds indicated a positive effect of rumen-undegradable protein (RUP) supplementation on milk yield. However, dairy sheep production in the United States is primarily based on grazing mixed grass-legume pastures, which contain a high proportion of rumen-degradable protein. Two trials were conducted in 2008 and 2009 to evaluate the effects of high-RUP protein supplementation and varying levels of legume in legume-grass forages on lactation performance.

In a cut-and-carry trial, 16 multiparous dairy ewes in mid-lactation were randomly assigned 1 of 2 protein supplementation treatments, receiving either 0.0 or 0.66 lb. of a high-RUP protein supplement (Soy Pass, LignoTech USA Inc., Rothschild, WI) per day. Within supplementation treatment, ewes were full-fed freshly cut forage of varying percentages of orchardgrass:alfalfa dry matter: 25:75, 50:50, 75:25, and 100:0. Supplementation with a high-RUP source tended to increase ($P < 0.10$) milk yield by 9%. Milk yield, milk protein yield, and milk urea nitrogen increased with increased percentage of alfalfa (Table 8).

In a grazing trial, 12 multiparous dairy ewes in mid lactation were randomly assigned to receive either 0.0 or 0.66 lb. of a high-RUP protein supplement (SoyPlus, West Central Cooperative, Ralston, IA) per day. Within supplementation treatments, ewes grazed paddocks that contained the following percentages of surface area of pure stands of orchardgrass:alfalfa: 50:50, 75:25, and 100:0. Milk yield, milk protein yield, and milk urea nitrogen increased with increased percentage of alfalfa in the paddock (Table 8).

In conclusion, supplementing with high-RUP protein tended to increase milk yield, and increasing the proportion of alfalfa in the diet increased dry matter intake, milk yield, and protein yield of lactating dairy ewes fed or grazing fresh forage.

Table 8. Lactation performance of ewes supplemented with rumen undegraded protein (RUP) and fed or grazing forage of varying proportions of alfalfa.

	Supplement		% alfalfa in forage			
Trait	No RUP	RUP	0	25	50	75
Cut-and-carry trial:						
Milk yield, lb./d	3.94[f]	4.29[e]	3.83[g]	4.07[f]	4.27[e]	4.29[e]
Fat yield, lb./d	0.27	0.27	0.26	0.27	0.27	0.28
Protein yield, lb./d	0.20	0.21	0.19[a]	0.20[a]	0.21[b]	0.22[b]
Milk urea nitrogen, mg/dL	12.3[b]	15.1[a]	10.9[d]	12.7[c]	14.3[b]	16.8[a]
Grazing trial:						
Milk yield, lb./d	3.63	4.00	3.41[g]	3.92[f]	4.11[e]	
Fat yield, lb./d	0.23	0.25	0.22	0.25	0.25	
Protein yield, lb./d	0.19	0.21	0.17[a]	0.20[a,b]	0.22[b]	
Milk urea nitrogen, mg/dL	18.2[a]	19.8[a]	15.0[b]	19.8[a]	22.1[a]	

[a,b,c,d]Means within a row and treatment with no superscript in common are different ($P < 0.05$).
[e,f,g]Means within a row and treatment with no superscript in common are different ($P < 0.10$).

Prepartum Photoperiod and Milk Production

Dairy ewes in late pregnancy were exposed to short days (8 hours of light and 16 hours of light) or long days (16 hours of light and 8 hours of light) for 6 weeks prior to lambing. Short day ewes produced more ($P < 0.05$) milk than long day ewes over the subsequent 180-day lactation (3.87 vs. 3.52 lb./ewe/day) with no difference between treatments in fat or protein percentage. This suggests that ewes in late gestation in early winter when day length is short may be expected to produce more milk than ewes in late gestation in late winter or spring when daylength is increasing.

Chronological List of Dairy Sheep Research Articles From the Spooner Agricultural Research Station

Many of these articles can be found online. Go to http://www.ansci.wisc.edu/Extension-New%20copy/sheep/Publications_and_Proceedings/res.html for articles in the Proceedings of the Spooner Sheep Day, Proceedings of the Biennial Spooner Sheep Day, Proceedings of the Biennial Spooner Sheep Dairy Day, and Proceedings of the Great Lakes Dairy Sheep Symposium; to http://www.journalofdairyscience.org/ for articles in the Journal of Dairy Science; to http://jas.fass.org/ for articles in the Journal of Animal Science; and to http://www.sciencedirect.com/science/journal/09214488 for articles in Small Ruminant Research.

1995

Berger, Y.M. and D.L. Thomas. 1995. Growth and reproduction of 1/4 East Friesian lambs. Proc. 43rd Annual Spooner Sheep Day, Dept. Meat and Animal Sci., Univ. of Wisconsin, Madison. pp. 10-12.

1996

Berger, Y.M. 1996. Lamb and milk production of East Friesian crossbred ewe lambs. Proc. 44th Annual Spooner Sheep Day, Dept. Animal Sci., Univ. of Wisconsin, Madison. pp. 14-20.

Berger, Y.M. 1996. Electronic identification of dairy sheep. Proc. 44th Annual Spooner Sheep Day, Dept. Animal Sci., Univ. of Wisconsin, Madison. pp. 44-45.

Berger, Y.M. and D.L. Thomas. 1996. Development of a dairy sheep research facility. Proc. 44th Annual Spooner Sheep Day, Dept. Animal Sci., Univ. of Wisconsin, Madison. pp. 46-48.

Berger, Y.M. and D.L. Thomas. 1996. Growth and reproduction of 1/4 East Friesian lambs. Proc. Great Lakes Dairy Sheep Symposium, Wisconsin Sheep Breeders Cooperative, Madison, Wisconsin. pp. 62-64.

1997

Berger, Y.M. 1997. Lamb mortality and causes – A nine year summary at the Spooner Agricultural Research Station. Proc. 45th Annual Spooner Sheep Day, Dept. Animal Sci., Univ. of Wisconsin-Madison. pp. 33-40.

Berger, Y.M. 1997. Is the sheep production system at the Spooner Agricultural Research Station Economically Viable? Proc. 45th Annual Spooner Sheep Day, Dept. Animal Sci., Univ. of Wisconsin-Madison. pp. 46-48.

Berger, Y.M. and D.L. Thomas. 1997. Early experimental results for growth of East Friesian crossbred lambs and reproduction and milk production of East Friesian crossbred ewes. Proc. 3rd Great Lakes Dairy Sheep Symp., Wisconsin Sheep Breeders Cooperative, Madison, Wisconsin. pp. 12-21.

Berger, Y.M. and D.L. Thomas. 1997. Early experimental results for growth of East Friesian crossbred lambs and reproduction and milk production of East Friesian crossbred ewes. Proc. 45th Annual Spooner Sheep Day, Dept. Animal Sci., Univ. of Wisconsin-Madison. pp. 12-20.

1998

Berger, Y.M. 1998. An economic comparison between a dairy sheep and a non-dairy sheep operation. Proc. 4th Great lakes Dairy Sheep Symp., University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 32-39.

Berger, Y.M. 1998. An economic comparison between a dairy sheep and a non-dairy sheep operation. Proc. 46th Annual Spooner Sheep Day, Dept. Animal Sci., Univ. of Wisconsin-Madison. pp. 55-62.

Berger, Y.M. and R.A. Schlapper. 1998. Raising lambs on milk replacer. Proc. 46th Annual Spooner Sheep Day, Dept. Animal Sci., Univ. of Wisconsin-Madison. pp. 6-14.

Casper, J.L., W.L. Wendorff, and D.L. Thomas. 1998. Seasonal changes in protein composition of whey from commercial manufacture of caprine and ovine specialty cheeses. J. Dairy Sci. 81:3117-3122.

McKusick, B. C., Y. M. Berger, and D. L. Thomas. 1998. Early experimental results of the effects of three weaning systems on commercial milk yield, milk composition and lamb growth of American East Friesian-cross and Dorset-cross ewes and lambs. Proc. 46th Annual Spooner Sheep Day, Dept. Animal Sci., Univ. of Wisconsin-Madison. pp. 15-28.

Thomas, D. L., Y. M. Berger, and B. C. McKusick. 1998. Milk and lamb production of East Friesian-cross ewes in northwestern Wisconsin. Proc. 4th Great lakes Dairy Sheep Symp., University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 11-17.

Thomas, D. L., Y. M. Berger, and B. C. McKusick. 1998. Milk and lamb production of East Friesian-cross ewes. Proc. 46th Annual Spooner Sheep Day, Dept. Animal Sci., Univ. of Wisconsin-Madison. pp. 40-48.

Wendorff, W. 1998. Updates on sheep milk research. Proc. 4th Great lakes Dairy Sheep Symp., University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 51-58.

1999

Casper, J.L., W.L. Wendorff, and D.L. Thomas. 1999. Functional properties of whey protein concentrates from Caprine and Ovine specialty cheese wheys. J. Dairy Sci. 82:265-271.

McKusick, B. C., Y. M. Berger, and D. L. Thomas. 1999. Effects of three weaning and rearing systems on commercial milk production and lamb growth. Proc. 5th Great lakes Dairy Sheep Symp., University of Wisconsin-Madison, Dept. of Anim. Sci. and University of Vermont, Center for Sustainable Agriculture pp. 16-31.

McKusick, B. C., Y. M. Berger, and D. L. Thomas. 1999. Rumen-protected bypass fat for dairy ewe commercial milk production. Proc. 5th Great lakes Dairy Sheep Symp., University of Wisconsin-Madison, Dept. of Anim. Sci. and University of Vermont, Center for Sustainable Agriculture pp. 69-80.

McKusick, B. C., Y. M. Berger, and D. L. Thomas. 1999. Preliminary results: Effects of udder morphology on commercial milk production of East Friesian crossbred ewes. Proc. 5th Great lakes Dairy Sheep Symp., University of Wisconsin-Madison, Dept. of Anim. Sci. and University of Vermont, Center for Sustainable Agriculture pp. 81-92.

McKusick, B. C., Y. M. Berger, and D. L. Thomas. 1999. Rumen-protected bypass fat for dairy ewe commercial milk production. Proc. 47th Annual Spooner Sheep Day, Dept. Animal Sci., Univ. of Wisconsin-Madison. pp. 15-26.

McKusick, B. C., Y. M. Berger, and D. L. Thomas. 1999. Effects of three weaning/rearing systems on commercial milk production and lamb growth. Proc. 47th Annual Spooner Sheep Day, Dept. Animal Sci., Univ. of Wisconsin-Madison. pp. 33-48.

McKusick, B. C., Y. M. Berger, and D. L. Thomas. 1999. Preliminary results: Effects of udder morphology on commercial milk production of East Friesian crossbred ewes. Proc. 47th Annual Spooner Sheep Day, Dept. Animal Sci., Univ. of Wisconsin-Madison. pp. 49-60.

Thomas, D. L., Y. M. Berger, and B. C. McKusick. 1999. Preliminary results: Survival of high-percentage East Friesian lambs. Proc. 5th Great lakes Dairy Sheep Symp., University of Wisconsin-Madison, Dept. of Anim. Sci. and University of Vermont, Center for Sustainable Agriculture pp. 64-66.

Thomas, D. L., Y.M. Berger, and B. C. McKusick. 1999. Milk and lamb production of East Friesian-cross ewes in the north central United States. In: F. Barillet and N. P. Zervas (Ed.) Milking and Milk Production of Dairy Sheep and Goats - Proc. 6th Int. Symp. on the Milking of Small Ruminants, 1998, Athens, Greece. pp 474-477. EAAP Pub. No. 95. Wageningen Pers, Wageningen, The Netherlands.

2000

Berger, Y.M. 2000. As a sheep producer, should I consider sheep dairying? Proc. 48th Annual Spooner Sheep Day, Dept. Animal Sci., Univ. of Wisconsin-Madison. pp. 42-44.

de Bie, Linda, Y. M. Berger, and D. L. Thomas. 2000. The effect of three times a day milking at the beginning of lactation on the milk production of East Friesian crossbred ewes. Proc. 6th Great lakes Dairy Sheep Symp., Guelph, Ontario, Canada. University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 1-9.

McKusick, B.C. 2000. Physiologic factors that modify the efficiency of machine milking in dairy ewes. Proc. 6th Great lakes Dairy Sheep Symp., Guelph, Ontario, Canada. University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 86-100.

McKusick, B.C. 2000. Physiologic factors that modify the efficiency of machine milking in dairy ewes. Proc. 48th Annual Spooner Sheep Day, Dept. Animal Sci., Univ. of Wisconsin-Madison. pp. 16-26.

McKusick, B. C., Marnet, P.-G., Y. M. Berger, and D. L. Thomas. 2000. Preliminary observations on milk flow and udder morphology traits of East Friesian crossbred dairy ewes. Proc. 6th Great lakes Dairy Sheep Symp., Guelph, Ontario, Canada. University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 101-116.

Thomas, D.L., Y.M. Berger, and B.C. McKusick. 2000. East Friesian germplasm: Effects on milk production, lamb growth, and lamb survival. Proc. American Soc. Anim. Sci., 1999. Available at: http://www.asas.org/jas/symposium/proceedings/0908.pdf.

Thomas, D. L., Y. M. Berger, B. C. McKusick, and R. G. Gottfredson. 2000. Comparison of East Friesian-crossbred and Lacaune-crossbred ewe lambs for dairy sheep production. Proc. 6th Great lakes Dairy Sheep Symp., Guelph, Ontario, Canada. University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 10-16.

2001

Berger, Y.M. 2001. Milking equipment for dairy ewes. Proc. 7th Great lakes Dairy Sheep Symp., Eau Claire, Wisconsin. University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 9-16.

Chang Y. M., R. Rekaya, D. Gianola and D. L. Thomas, 2001. Genetic variation of lactation curves in dairy sheep: A Bayesian analysis of Wood's function. Livestock Prod. Sci. 71:241-251.

de Bie, L., Y. M. Berger, and D. L. Thomas. 2001. The effect of three times a day milking at the beginning of lactation on the milk production of East Friesian crossbred ewes. Proc. 49th Annual Spooner Sheep Day, Dept. Animal Sci., Univ. of Wisconsin-Madison. pp. 39-47.

Jaeggi, J. J., Y. M. Berger, M. E. Johnson, R. Govindasamy-Lucey, B. C. McKusick, D. L. Thomas, and W. L. Wendorff. 2001. Evaluation of sensory and chemical properties of Manchego cheese manufactured from Ovine milk of different somatic cell levels. Proc. 7th Great lakes Dairy Sheep Symp., Eau Claire, Wisconsin. University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 84-93.

McKusick, B. C., P.-G. Marnet, Y. M. Berger, and D. L. Thomas. 2001. Preliminary observations on milk flow and udder morphology traits of East Friesian crossbred dairy ewes. Proc. 49th Annual Spooner Sheep Day, Dept. Animal Sci., Univ. of Wisconsin-Madison. pp. 55-70.

McKusick, B. C., D. L. Thomas, and Y. M. Berger. 2001. Is machine stripping necessary for East Friesian dairy ewes. Proc. 7th Great lakes Dairy Sheep Symp., Eau Claire, Wisconsin. University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 116-128.

McKusick, B. C., D. L. Thomas, and Y. M. Berger. 2001. Effect of reducing the frequency of milking on milk production, milk composition, and lactation length in East Friesian dairy ewes. Proc. 7th Great lakes Dairy Sheep Symp., Eau Claire, Wisconsin. University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 129-135.

McKusick, B. C., D. L. Thomas, and Y. M. Berger. 2001. Effects of weaning systems on commercial milk production and lamb growth of East Friesian dairy sheep. J. Dairy Sci. 84:1660-1668.

McKusick, B. C., D. L. Thomas, and Y. M. Berger. 2001. Effect of omission of machine stripping on milk production and parlor throughput in East Friesian dairy ewes. Proc. 49th Annual Spooner Sheep Day, Dept. Animal Sci., Univ. of Wisconsin-Madison. pp. 71-73

McKusick, B. C., D. L. Thomas, and P.-G. Marnet. 2001. Milk storage within the udder of East Friesian dairy ewes over a 24 hour period. Proc. 7th Great lakes Dairy Sheep Symp., Eau Claire, Wisconsin. University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 199-211.

McKusick, B. C., M. C. Wiltbank, R. Sartori, P.-G. Marnet, and D. L. Thomas. 2001. Can the ovary influence milk production in dairy ewes? Proc. 7th Great lakes Dairy Sheep Symp., Eau Claire, Wisconsin. University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 186-198.

McKusick, B. C., M. C. Wiltbank, R. Sartori, P.-G. Marnet, D. L. Thomas, and Y. M. Berger. 2001. Effect of presence or absence of corpora lutea on milk production of mid-lactation dairy ewes. Proc. 49th Annual Spooner Sheep Day, Dept. Animal Sci., Univ. of Wisconsin-Madison. pp. 74-76.

Thomas, D. L. 2001. Choice of breed for dairy sheep production systems. Proc. 7th Great lakes Dairy Sheep Symp., Eau Claire, Wisconsin. University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 1-8.

Thomas, D. L., Y. M. Berger, B. C. McKusick, R. G. Gottfredson, and R. Zelinsky. 2001. Comparison of East Friesian and Lacaune breeding for dairy sheep production systems. Proc. 7th Great lakes Dairy Sheep Symp., Eau Claire, Wisconsin. University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 44-51.

Thomas, D. L., Y. M. Berger, and B. C. McKusick. 2001. Effects of breed, management system, and nutrition on milk yield and milk composition of dairy sheep. J. Anim. Sci. 79(E. Suppl.):E16-E20. Available at: http://www.asas.org/jas/jas0913.pdf.

Thomas, D. L., Y. M. Berger, B. C. McKusick, and R. G. Gottfredson. 2001. Comparison of East Friesian-crossbred and Lacaune-crossbred ewe lambs for dairy sheep production. Proc. 49th Annual Spooner Sheep Day, Dept. Animal Sci., Univ. of Wisconsin-Madison. pp. 48-54.
Tolman, B. and B.C. McKusick. 2001. The effect of growth rate on mammary gland development in ewe lambs: A review. Proc. 7th Great lakes Dairy Sheep Symp., Eau Claire, Wisconsin. University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 143-155.
Wendorff, W.L. 2001. Latest developments in the use of raw milk for cheesemaking. Proc. 7th Great lakes Dairy Sheep Symp., Eau Claire, Wisconsin. University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 165-169.
Wendorff, W.L. 2001. Freezing qualities of raw ovine milk for further processing. J. Dairy Sci. 84(E. Suppl.):E74-E78.
Wendorff, W.L. and S.L. Rauschenberger. 2001. Effect of freezing on milk quality. Proc. 7th Great lakes Dairy Sheep Symp., Eau Claire, Wisconsin. University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 156-164.

2002

Berger, Y.M. 2002. Economics of winter milking for medium to large dairy sheep operations. Proc. 8th Great lakes Dairy Sheep Symp., Cornell University, Ithaca, New York. University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 118-126.
Chang, Y. M., R. Rekaya, D. Gianola and D. L. Thomas. 2002. Genetic variation of lactation curves in dairy sheep: quadratic function versus Wood's model. Livestock Prod. Sci. 77:147-153.
McKusick, B. C., D. L. Thomas, Y. M. Berger, and P.G. Marnet. 2002. Effect of milking interval on alveolar versus cisternal milk accumulation, and milk production and composition in dairy ewes. J. Dairy Sci. 85:2197-2206.
McKusick, B. C., D. L. Thomas, J. E. Romero, and P.G. Marnet. 2002. Effect of weaning system on milk composition and distribution of milk fat within the udder of East Friesian dairy ewes. J. Dairy Sci. 85:2521-2528.
McKusick, B. C., M. C. Wiltbank, R. Sartori, P. G. Marnet, and D. L. Thomas. 2002. Effect of presence or absence of corpora lutea on milk production and composition of mid-lactation dairy ewes. J. Dairy Sci. 85:790-796.
Ponce de Leon-Gonzalez, L., W. L. Wendorff, H. H. Ingham, D. L. Thomas, J. J. Jaeggi, and K. B. Houck. 2002. Influence of Ovine milk in mixture with Bovine milk on the quality of reduced fat Muenster-type cheese. J. Dairy Sci. 85:36-42.
Thomas, D.L. 2002. Dairy sheep – The research emphasis starting in 1993. Proc. 50th Annual Spooner Sheep Day, Dept. Animal Sci., Univ. of Wisconsin-Madison. pp. 89-93.
Thomas, D. L., Y. M. Berger, and B. C. McKusick. 2002. The effect of IBR/PI3 and Pasteurella vaccination on the mortality rate of high percentage East Friesian lambs. Proc. 8th Great lakes Dairy Sheep Symp., Cornell University, Ithaca, New York. University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 95-101.
Wendorff, W.L. 2002. Milk composition and cheese yield. Proc. 8th Great lakes Dairy Sheep Symp., Cornell University, Ithaca, New York. University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 104-117.

2003

Jaeggi J.J , S. Govindasamy-Lucey, Y.M. Berger, M.E. Johnson, B.C. McKusick, D.L. Thomas,

and W.L. Wendorff. 2003. Hard ewe's milk cheese manufactured from milk of three different groups of somatic cell counts. J. Dairy Sci. 86:3082-3089.
McKusick, B. C., D. L. Thomas, and Y. M. Berger. 2003. Effect of omission of machine stripping on milk production and parlor throughput in East Friesian dairy ewes. J. Dairy Sci. 86:680-687.
Paape, M.J., G.R. Wiggans, D.D. Bannerman, D.L. Thomas, A.H. Sanders, A. Contreras, P. Moroni, and R.H. Miller. 2007. Monitoring goat and sheep milk somatic cell counts. Small Ruminant Res. 68:114-125.

2004
Berger, Y.M. 2004. Breeds of sheep for commercial milk production. Proc. 10th Great lakes Dairy Sheep Symp., Hudson, Wisconsin. University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 14-20.
Berger, Y. M. and D. L. Thomas. 2004. Milk testing, calculations of milk production, and adjustment factors. Proc. 10th Great lakes Dairy Sheep Symp., Hudson, Wisconsin. University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 55-62.
Caja, G., D. L. Thomas, M. Rovai, M. Hernandez-Jover, Y.M. Berger, and T. A. Taylor. 2004. Using different rumen boluses for the electronic identification and milk recording of dairy sheep. Proc. of the International Symposium on the Future of the Sheep and Goat Dairy Sectors, Zaragoza, Spain. Special issue 200501, Part 3:194. Int. Dairy Fed. (Only available in electronic format: http://www.fil-idf.org/content/default.asp?PageID=314).
Jaeggi, J., W. Wendorff, M.E. Johnson, J. Romero, and Y. Berger. 2004. Milk composition and cheese yield from hard and soft cheese manufactured from sheep milk. Proc. 10th Great lakes Dairy Sheep Symp., Hudson, Wisconsin. University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 132-142.
Rovai, M., D. L. Thomas, Y. M. Berger and G. Caja. 2004. Udder morphology and effects on milk production and ease of milking in dairy sheep. Proc. 10th Great lakes Dairy Sheep Symp., Hudson, Wisconsin. University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 79-114.
Thomas, D. L. 2004. Overview of the dairy sheep sector in Canada and the United States. Proc. 10th Great Lakes Dairy Sheep Symp., Hudson, Wisconsin. University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 166-180.
Thomas, D. L., Y. M. Berger, R. G. Gottfredson, and T. A. Taylor. 2004. Comparison of East Friesian and Lacaune breeds for dairy sheep production in North America. Proc. 10th Great lakes Dairy Sheep Symp., Hudson, Wisconsin. University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 115-123.

2005
Berger, Y.M. 2005. Evolution of the milk production at the Spooner Agricultural Research Station between 1996 and 2004. Proc. 11th Great lakes Dairy Sheep Symp., Burlington, Vermont. University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 6-13.
Jaeggi, J.J., W.L. Wendorff, J. Romero, Y. M. Berger, and M. E. Johnson. 2005. Impact of seasonal changes in ovine milk on composition and yield of a hard-pressed cheese. J. Dairy Sci. 88:1358–1363
Thomas, D. L. and G. F. W. Haenlein. 2005. Panorama of the goat and sheep dairy sectors in North America. Proc. of the International Symposium on the Future of the Sheep and Goat

Dairy Sectors, Zaragoza, Spain. Special issue 200501, Part 1:23-28. Int. Dairy Fed. (Only available in electronic format: http://www.fil-idf.org/content/default.asp?PageID=314).

2006

Berger, Y.M. 2006. Accuracy of the PORTASCC milk test for the detection of somatic cells in sheep milk. Proc. 12th Great Lakes Dairy Sheep Symp., La Crosse, Wisconsin. University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 93-96.

Mikolayunas, C. and S. Eckerman. 2006. Estimating pasture forage availability. Proc. 52nd Biennial Spooner Sheep Day, Dept. Animal Sci., Univ. of Wisconsin-Madison. pp. 26-27.

Mikolayunas, C.M., D.L. Thomas, K.A. Albrecht, D.K. Combs, and Y. M. Berger. 2006. Effect of supplementation and stage of lactation on performance of grazing dairy ewes. Proc. 12th Great Lakes Dairy Sheep Symp., La Crosse, Wisconsin. University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 56-71.

Mikolayunas, C.M., D.L. Thomas, Y. M. Berger, T.F. Gressley, and G.E. Dahl. 2006. Effect of prepartum photoperiod on prolactin and milk production of dairy ewes. Proc. 12th Great Lakes Dairy Sheep Symp., La Crosse, Wisconsin. University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 72-81.

Thomas, D.L., M. Hernandez-Jover, M. Rovai, M. Bishop, G. Caja, Y.M. Berger, T.A. Taylor, B. Bishop, L. Taylor, R.G. Gottfredson, M. Frank, R. Schlapper, B. Bolan, and W. Keough. 2006. Variable effectiveness of radio frequency ear tags and rumen boluses for electronic identification of sheep. Proc. 52nd Biennial Spooner Sheep Day, Dept. Animal Sci., Univ. of Wisconsin-Madison. pp. 11-21.

2007

Berger, Y.M. 2007. Realistic expectations for milk yield and price of milk. Proc. 13th Great Lakes Dairy Sheep Symp., Guelph, Ontario. University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 15-28.

Berger, Y.M. 2007. The East Friesian breed of sheep in North America. Proc. 3rd Biennial Spooner Dairy Sheep Day, Dept. Animal Sci., Univ. of Wisconsin-Madison. pp. 10-16.

Mikolayunas, C. M., D. L. Thomas, Y. M. Berger, K. A. Albrecht, D. K. Combs, and S. R. Eckerman. 2007. Effect of supplementation on milk production of dairy ewes. Proc. 3rd Biennial Spooner Dairy Sheep Day, Dept. Animal Sci., Univ. of Wisconsin-Madison. pp. 2-9.

Mikolayunas, C. M., D. L. Thomas, Y. M. Berger, T. F. Gressley, and G. E. Dahl. 2007. Effect of prepartum photoperiod on milk production of dairy ewes. Proc. 3rd Biennial Spooner Dairy Sheep Day, Dept. Animal Sci., Univ. of Wisconsin-Madison. pp. 25-31.

Thomas, D. L. and Y. M. Berger. 2007. Progress report: Effects of prepubertal growth rate of ewe lambs on their subsequent lamb and milk production. Proc. 3rd Biennial Spooner Dairy Sheep Day, Dept. Animal Sci., Univ. of Wisconsin-Madison. pp. 32-39.

Thomas, D. L. and Y. M. Berger. 2007. Katahdin hair sheep at the Spooner Agricultural Research Station. Proc. 3rd Biennial Spooner Dairy Sheep Day, Dept. Animal Sci., Univ. of Wisconsin-Madison. p. 42.

2008

Berger, Y. M. and D. L. Thomas. 2008. Evolution of ewe milk production at the Spooner Agricultural Research Station from 1996 through 2006. In: Proc. The Challenge to Sheep and

Goats Milk Sectors – An International Symposium. Alghero, Sardinia, Italy, April 18-20, 2007. Special Issue of the International Dairy Federation 0801/Part 1, I-P008:21-22. Online: http://www.fil-idf.org/WebsiteDocuments/0801Part1.pdf.

Casellas, J., D. L. Thomas, and Y. M. Berger. 2008. Estimates of genetic parameters for milk production traits and litter size of U.S. dairy ewes. In: Proc. The Challenge to Sheep and Goats Milk Sectors – An International Symposium. Alghero, Sardinia, Italy, April 18-20, 2007. Special Issue of the International Dairy Federation 0801/Part 2, I-P094:206-208. Online: http://www.fil-idf.org/WebsiteDocuments/0801Part2.pdf.

Mikolayunas, C. M., D. L. Thomas, K. A. Albrecht, D. K. Combs, Y. M. Berger, and S. R. Eckerman. 2008. Effects of supplementation and stage of lactation on performance of grazing dairy ewes. J. Dairy Sci. 91:1477-1485.

Mikolayunas, C. M., D. L. Thomas, Y. M. Berger, T. F. Gressley, and G. E. Dahl. 2008. Effect of prepartum photoperiod on milk production of dairy ewes. In: Proc. The Challenge to Sheep and Goats Milk Sectors – An International Symposium. Alghero, Sardinia, Italy, April 18-20, 2007. Special Issue of the International Dairy Federation 0801/Part 2, I-P063:144-146. Online: http://www.fil-idf.org/WebsiteDocuments/0801Part2.pdf.

Mikolayunas, C. M., D. L. Thomas, G. E. Dahl, T. F. Gressley, and Y.M. Berger. 2008. Effect of prepartum photoperiod on milk production and prolactin concentration of dairy ewes. J. Dairy Sci. 91:85-90.

Spanu, C., Y.M. Berger, D.L. Thomas, and P.L. Ruegg. 2008. Effect of dry treatment on mastitis in dairy sheep. Proc. 14th Great Lakes Dairy Sheep Symp., Maryville, Tennessee. University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 56-63.

Wendorff, W.L., M.A. Dufek, J.J. Jaeggi, Y. Peng, Y.M. Berger, and J.A. Lucey. 2008. Impact of handling and thawing on cheesemaking properties of frozen sheep milk. Proc. 14th Great Lakes Dairy Sheep Symp., Maryville, Tennessee. University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 35-44.

<u>2009</u>

Berger, Y.M. 2009. Update on the crossbreeding trial between the Katahdin and Lacaune breeds. Proc. 4th Biennial Spooner Dairy Sheep Day, Dept. Animal Sci., Univ. of Wisconsin-Madison. pp. 43-47.

Berger, Y.M. 2009. Economics of dairy sheep operations. Proc. 4th Biennial Spooner Dairy Sheep Day, Dept. Animal Sci., Univ. of Wisconsin-Madison. pp. 4-10.

Berger, Y.M. 2009. Economics of dairy sheep operations. 15th Annual Great Lakes Dairy Sheep Symp., Albany, New York. University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 119-125.

Mikolayunas-Sandrock, C., L.E. Armentano, D.L. Thomas, and Y.M. Berger. 2009. Effect of protein degradability on milk production of dairy ewes. J. Dairy Sci. 92:4507-4513.

Mikolayunas, C.M., D.L. Thomas, and Y.M. Berger. 2009. Protein utilization in lactating dairy ewes. Proc. 15th Annual Great Lakes Dairy Sheep Symp., Albany, New York. University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 59-77.

Sandrock, Claire M., D.L. Thomas, and Y. M. Berger. 2009. Protein utilization in lactating dairy ewes. Proc. 4th Biennial Spooner Dairy Sheep Day, Dept. Animal Sci., Univ. of Wisconsin-Madison. pp. 11-29.

Thomas, D.L. and Y.M. Berger. 2009. Effects of prepubertal growth rate of ewe lambs on their subsequent lamb and milk production. Proc. 15th Annual Great Lakes Dairy Sheep Symp., Albany, New York. University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 78-85.

Thomas, D.L. and Y. M. Berger. 2009. Effects of prepubertal growth rate of ewe lambs on their subsequent lamb and milk production. Proc. 4th Biennial Spooner Dairy Sheep Day, Dept. Animal Sci., Univ. of Wisconsin-Madison. pp. 35-42.

2010

Mikolayunas, C. 2010. Dairy sheep feeding 101. Proc. 16th Annual Great Lakes Dairy Sheep Symp., Eau Claire, Wisconsin. University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 12-16.

Ruegg, P.L. 2010. Mastitis in dairy sheep. Proc. 16th Annual Great Lakes Dairy Sheep Symp., Eau Claire, Wisconsin. University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 32-39.

Thomas, D.L. and Y.M. Berger. 2010. Milk recording and genetic improvement. Proc. 16th Annual Great Lakes Dairy Sheep Symp., Eau Claire, Wisconsin. University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 56-66.

Wendorff, W.L. 2010. Milk quality for cheesemaking. Proc. 16th Annual Great Lakes Dairy Sheep Symp., Eau Claire, Wisconsin. University of Wisconsin-Madison, Dept. of Anim. Sci. pp. 79-94.

2011

Mikolayunas, C., D.L. Thomas, L.E. Armentano, and Y.M. Berger. 2011. Effect of rumen undegradable protein supplementation and fresh forage composition on nitrogen utilization of dairy ewes. J. Dairy Sci. 94:416-425.

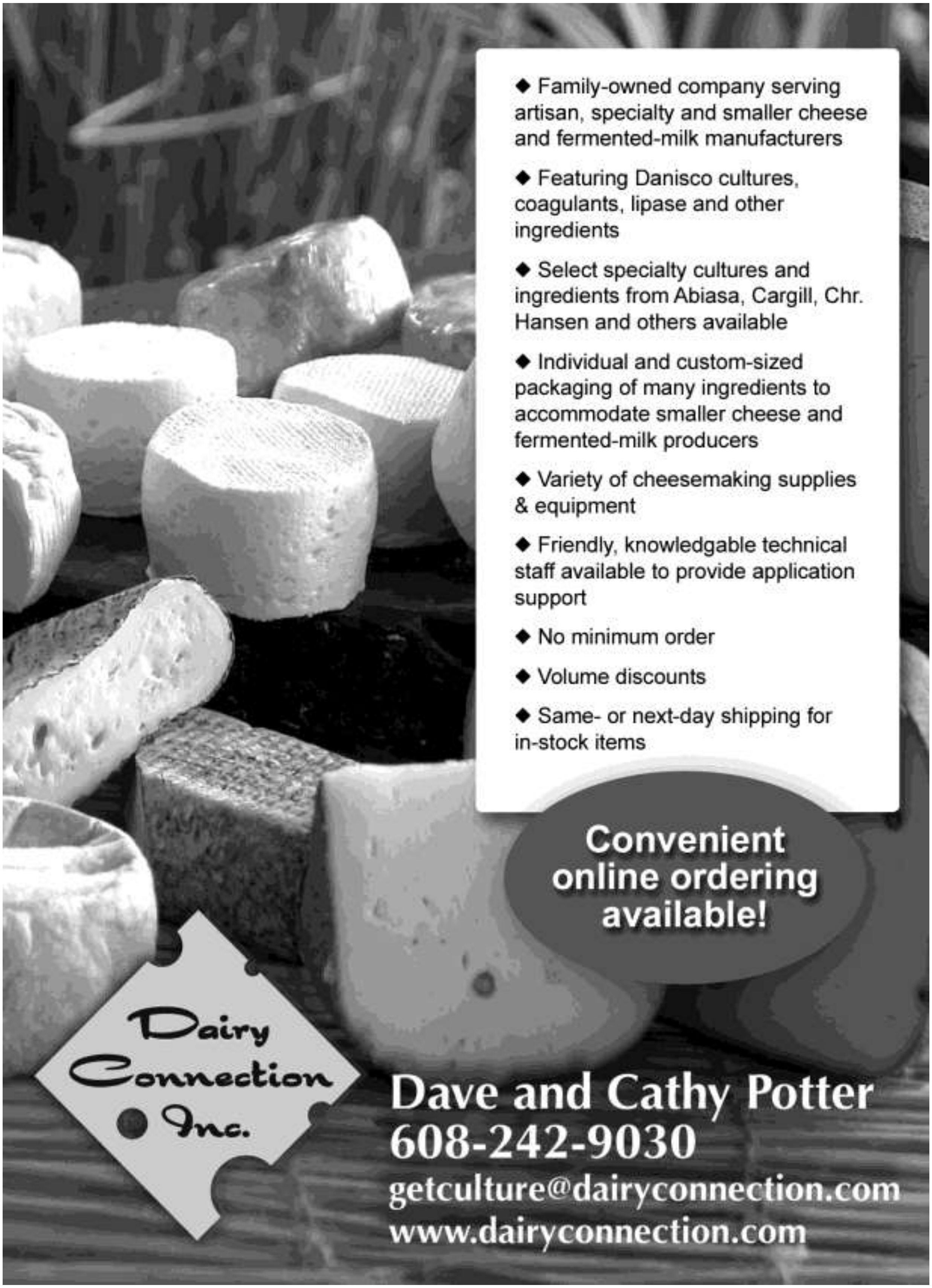
Spanu, C., Y.M. Berger, D.L. Thomas, and P.L. Ruegg. 2011. Impact of intramammary antimicrobial dry treatment and teat sanitation on somatic cell count and intramammary infection in dairy ewes. Small Ruminant Res. 97:139-145.

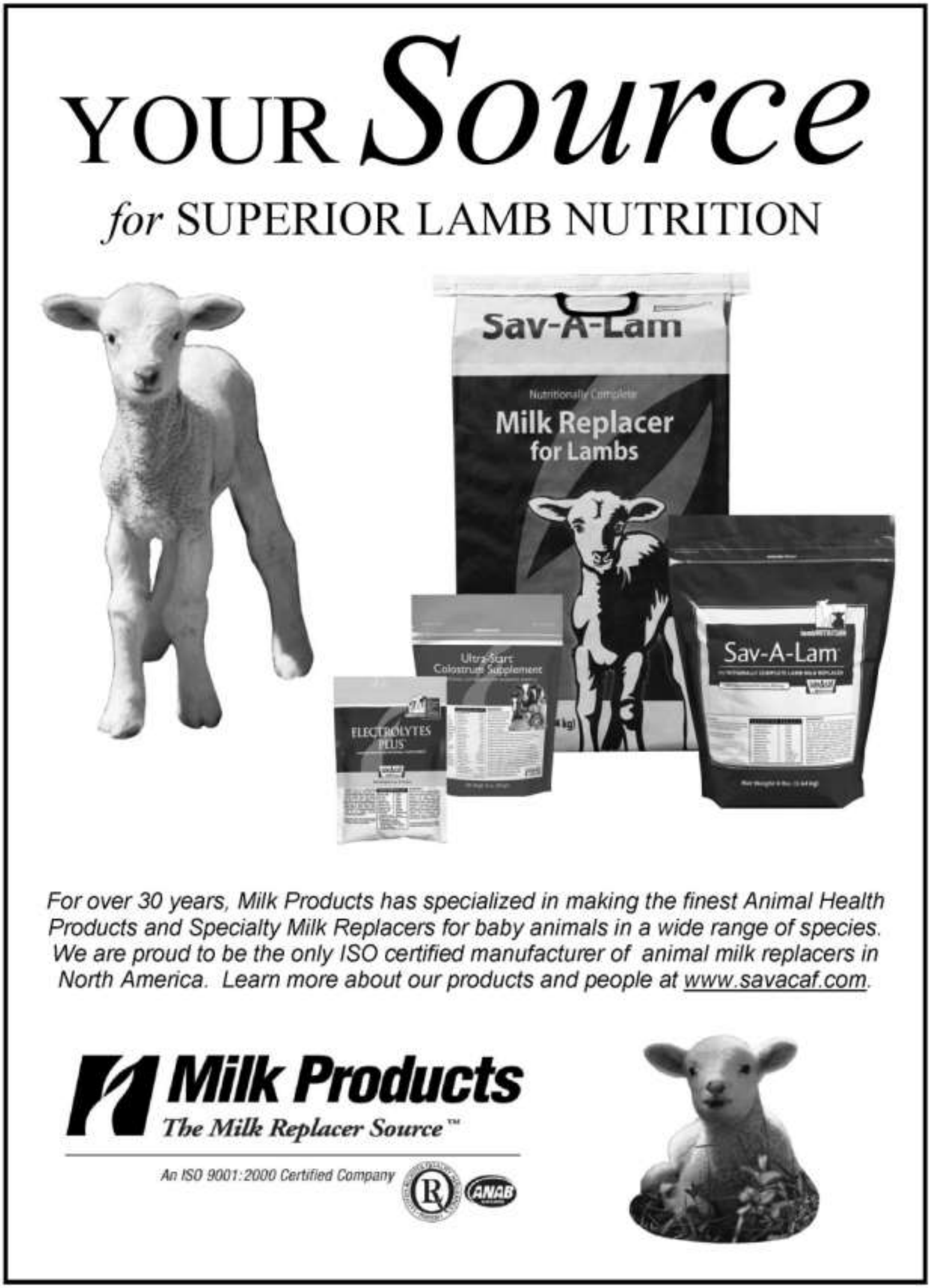
Recipients of the William J. Boylan Distinguished Service Award (Formerly the DSANA Distinguished Service Award)

2003 – David Thomas, Madison, Wisconsin, USA – Dairy sheep researcher
2004 – Daniel Guertin, Stillwater, Minnesota, USA – Dairy sheep producer
2005 –
2006 – Pat Elliot, Rapidan, Virginia, USA – Dairy sheep producer and artisan cheese maker
2007 – Tom and Nancy Clark, Old Chatham, New York, USA – Dairy sheep producers and sheep milk processors
2008 – William Wendorff, Cross Plains, Wisconsin, USA – Sheep milk processing researcher
2009 – Yves Berger, Spooner, Wisconsin, USA – Dairy sheep researcher
2010 – Eric Bzikot, Conn, Ontario, Canada – Dairy sheep producer and sheep milk processor

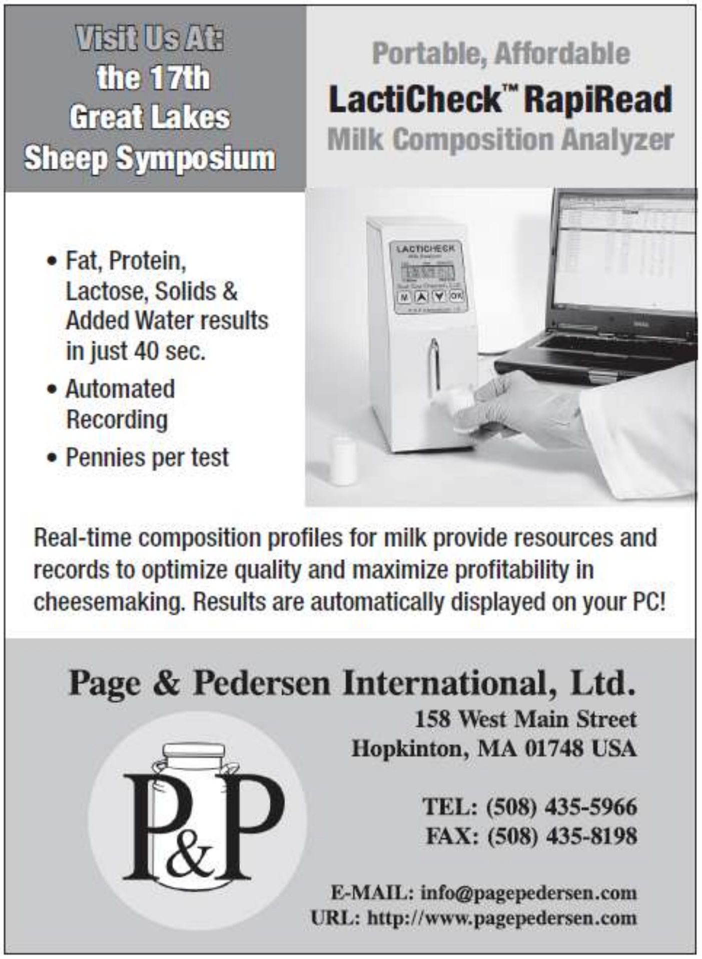
Locations and Chairs of the Organizing Committees of Previous Symposia

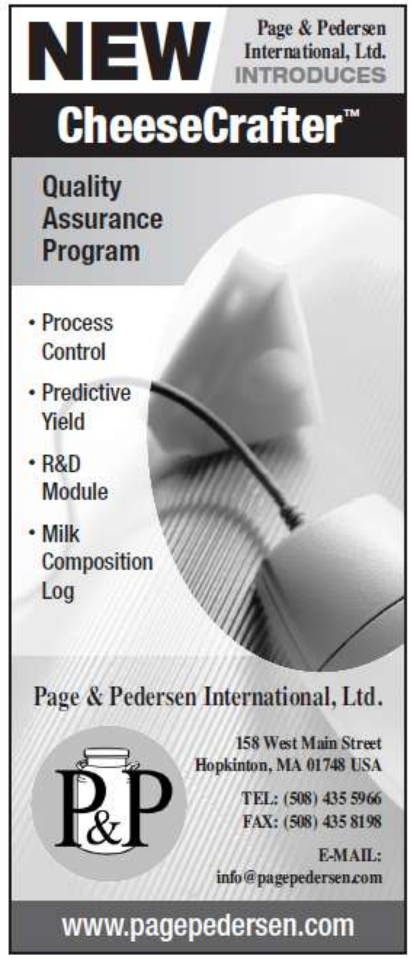
1995 – 1st Great Lakes Dairy Sheep Symposium – Madison, Wisconsin, USA
Yves Berger – Chair
1996 – 2nd Great Lakes Dairy Sheep Symposium – Madison, Wisconsin, USA
Yves Berger - Chair
1997 – 3rd Great Lakes Dairy Sheep Symposium – Madison, Wisconsin, USA
Yves Berger – Chair
1998 – 4th Great Lakes Dairy Sheep Symposium – Madison, Wisconsin, USA
Yves Berger – Chair
1999 – 5th Great Lakes Dairy Sheep Symposium – Brattleboro, Vermont, USA
Carol Delaney - Chair
2000 – 6th Great Lakes Dairy Sheep Symposium – Guelph, Ontario, Canada
Axel Meister - Chair
2001 – 7th Great Lakes Dairy Sheep Symposium – Eau Claire, Wisconsin, USA
Yves Berger - Chair
2002 – 8th Great Lakes Dairy Sheep Symposium – Ithaca, New York, USA
Michael Thonney - Chair
2003 – 9th Great Lakes Dairy Sheep Symposium – Québec, Québec, Canada
Lucille Giroux - Chair
2004 – 10th Great Lakes Dairy Sheep Symposium – Hudson, Wisconsin, USA
Yves Berger - Chair
2005 – 11th Great Lakes Dairy Sheep Symposium – Burlington, Vermont, USA
Carol Delaney - Chair
2006 – 12th Great Lakes Dairy Sheep Symposium – La Crosse, Wisconsin, USA
Yves Berger - Chair
2007 – 13th Great Lakes Dairy Sheep Symposium – Guelph, Ontario, Canada
Eric Bzikot - Chair
2008 – 14th Great Lakes Dairy Sheep Symposium – Maryville, Tennessee, USA
Claire Mikolayunas - Chair
2009 – 15th Great Lakes Dairy Sheep Symposium – Albany, New York, USA
Claire Mikolayunas - Chair
2010 – 16th Great Lakes Dairy Sheep Symposium – Eau Claire, Wisconsin, USA
Claire Mikolayunas - Chair
2011 – 17th Great Lakes Dairy Sheep Symposium – Petaluma, California, USA
Cynthia Callahan - Chair


◆ Family-owned company serving artisan, specialty and smaller cheese and fermented-milk manufacturers
◆ Featuring Danisco cultures, coagulants, lipase and other ingredients
◆ Select specialty cultures and ingredients from Abiasa, Cargill, Chr. Hansen and others available
◆ Individual and custom-sized packaging of many ingredients to accommodate smaller cheese and fermented-milk producers
◆ Variety of cheesemaking supplies & equipment
◆ Friendly, knowledgable technical staff available to provide application support
◆ No minimum order
◆ Volume discounts
◆ Same- or next-day shipping for in-stock items
Convenient online ordering available!
Dairy Connection Inc.
Dave and Cathy Potter
608-242-9030
getculture@dairyconnection.com
www.dairyconnection.com

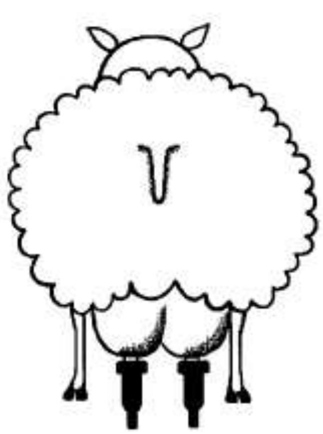

YOUR Source
for SUPERIOR LAMB NUTRITION
Sav-A-Lam
Nutritionally Complete
Milk Replacer
for Lambs
Ultra-Start
Colostrum Supplement
ELECTROLYTES PLUS
Sav-A-Lam
For over 30 years, Milk Products has specialized in making the finest Animal Health Products and Specialty Milk Replacers for baby animals in a wide range of species. We are proud to be the only ISO certified manufacturer of animal milk replacers in North America. Learn more about our products and people at www.savacaf.com.
Milk Products
The Milk Replacer Source™
An ISO 9001:2000 Certified Company
ANAB


COUNTING SHEEP shouldn't KEEP YOU UP AT NIGHT
WHEN 1 OUT OF 10 LAMBS DIE OF STARVATION it's comforting to know you have the advanced nutrition and technology of
Ultra Fresh
NEW & IMPROVED FORMULA
lamb milk replacer
LAND O LAKES
WWW.LOLMILKREPLACER.COM
Plan ahead to have Ultra Fresh® Lamb Milk Replacer ready for your lambs. Ultra Fresh is even better now, thanks to the new and improved formula that includes complex carbohydrate Beta glucan, which promotes improved gut health and stronger immunity protection for your lambs. Now you can rest easy.


Visit Us At:
the 17th
Great Lakes
Sheep Symposium
Portable, Affordable
LactiCheck™ RapiRead
Milk Composition Analyzer
• Fat, Protein, Lactose, Solids & Added Water results in just 40 sec.
• Automated Recording
• Pennies per test
Real-time composition profiles for milk provide resources and records to optimize quality and maximize profitability in cheesemaking. Results are automatically displayed on your PC!
Page & Pedersen International, Ltd.
158 West Main Street
Hopkinton, MA 01748 USA
TEL: (508) 435-5966
FAX: (508) 435-8198
E-MAIL: info@pagepedersen.com
URL: http://www.pagepedersen.com


NEW
Page & Pedersen International, Ltd.
INTRODUCES
CheeseCrafter™
Quality Assurance Program
• Process Control
• Predictive Yield
• R&D Module
• Milk Composition Log
Page & Pedersen International, Ltd.
158 West Main Street
Hopkinton, MA 01748 USA
TEL: (508) 435 5966
FAX: (508) 435 8198
E-MAIL:
info@pagepedersen.com
www.pagepedersen.com


GROBER NUTRITION
LambGro Milk Replacer
NEW
•LambGro 22/28
•Dairy LambGro 24/35
➤ Replacement feeding of multiple birth lambs
➤ Rearing orphaned lambs
➤ Formulated to match nutritional profile of Ewe's milk
➤ Automatic lamb feeding machines
(800) 265-7863 x210
(866) 234-7281 fax
orders@grober.com
www.grobernutrition.com/usa/



Dairy Connection Inc.

The Babcock Institute
for International Dairy Research and Development

GEA

GEA Farm Technologies

Milk Products
The Milk Replacer Source™
An ISO 9001:2000 Certified Company

LAND O LAKES
ANIMAL MILK PRODUCTS CO.

WSDC
wisconsin sheep dairy cooperative

EVERONA
Sheep's Milk Cheese

NATIONAL LIVESTOCK PRODUCERS ASSOCIATION
SHEEP & GOAT FUND