Report on HACCP Programming and Technical Assistance for Vermont Shepherd and Farmstead Goat Cheese Production

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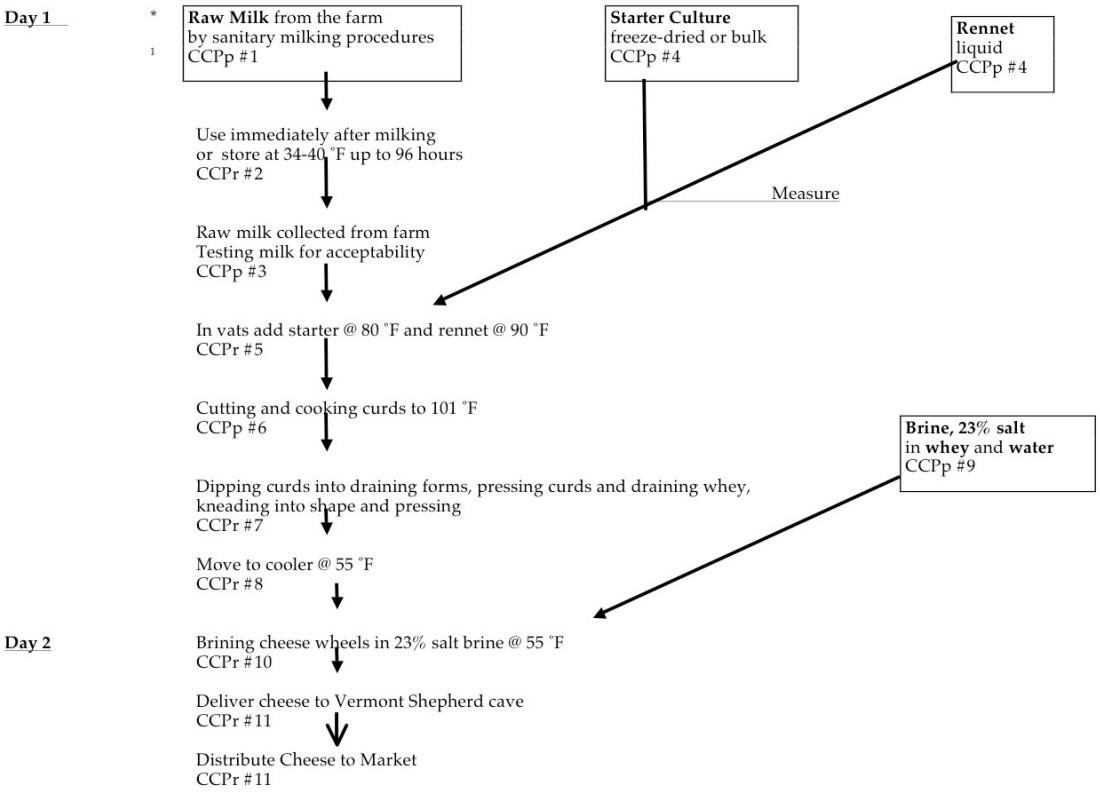
In 2000, the Small Ruminant Dairy Project at the UVM Center for Sustainable Agriculture funded me to develop a HACCP (Hazard Analysis and Critical Control Point) program for six sheep dairy farms that produce Vermont Shepherd. In addition, technical assistance was to be provided on request to Vermont's goat dairy farms about their cheesemaking technique and cheese quality.

HACCP for Vermont Shepherd Cheese

In 2000, the Vermont Shepherd Guild consisted of six separate farmstead sheep cheesemakers that made cheese on their farms and delivered brined cheeses to the cheese aging cave owned by Vermont Shepherd, LLC, in Westminster West, VT, for aging and marketing. All six Vermont Shepherd cheese producing farms were involved in the HACCP program, which consisted of creating a HACCP plan for the production of Vermont Shepherd cheese, training the producers to operate the plan, routine sampling and testing at critical control points, and providing results of raw milk and finished cheese tests to producers for monitoring the safety of their operations.

The HACCP plan was developed with eleven critical control points, starting with the health of the milking ewes and ending with the acceptance of *green* (unaged) cheese to the cave. The Vermont Shepherd business already had a grading panel to assess the cheese quality before sale. An additional control point was added at this stage: testing a representative sample of each farm's cheese for pathogens.

Figure 1. HACCP Plan for 2000 Vermont Shepherd Cheese Production: **Flow Chart**



[1] CCPp = prevents hazards CCPr = reduces, delays or minimizes hazards

HACCP PROGRAM FOR VERMONT SHEPHERD CHEESE PRODUCTION

CCP #	Hazards	CCP	Critical Limits	Action Taken if Limits Violated	Responsible Person	Record
1, 3 & 1	Antibiotic residues Dirty equipment and facilities	Milking & receiving Milking and storage	Drug residue within regulatory limits Equipment properly cleaned and sanitized Facility passed State inspection	Reject the cheese Reject the milk Clean and sanitize equipment Fix problems noted by inspect.	Laboratory tech. and Cheesemaker Milker Farmer/milker	State lab and independent lab milk tests Milk house
2	Milk not cooled properly Dirty equipment	Milk storage	Milk stored at 34-40 ˚F Equipment properly cleaned and sanitized	Fix milk cooling system to stay within limits Clean and sanitize equipment	Farmer/milker Milker	Milk house
1 & 3	Poor microbiological and physical quality pH meter not calibrated	Raw milk receiving	Total bacteria, coliform counts, and somatic cell counts within regulatory limits. Acceptable temperature, acidity, and sensory properties Calibrate pH meter	Reject the milk Troubleshoot pH meter problem; use back-up electrode	Laboratory technician and Cheesemaker	State and independent lab milk test records and Make record in cheese room
4	Improper use of starter culture	Starter culture receiving and storage	Starter culture within limits of code date at selected storage temperature	Discard starter culture Use fresh supply	Cheesemaker	Cheese room
4	Improper use of rennet	Rennet receiving and storage	Rennet within limits of code date at selected storage temperature	Discard rennet Use fresh supply	Cheesemaker	Cheese room

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5	Unsanitary equipment	Cheese vats and tools	Vats and tools clean and dry and sanitized with hot water (170 ˚F) or chemical treatment before use	Clean and sanitize before use Discard equipment that is hard to clean and sanitize	Cheesemaker	Cheese room

CCP #	Hazards	CCP	Critical Limits	Action Taken if Limits Violated	Responsible Person	Record
5	Incorrect temp. for setting milk into curd Thermometer not calibrated	Cheese vats Vat thermometer	Starter added at 77-80 ˚F; rennet added at 90 ˚F Thermometer reads 32 ˚F in ice water	Cool milk to correct temp Reduce ripening and curdling times if temp. in excess Calibrate thermometer	Cheesemaker	Make record in cheese room
6	Too high temp. cooking curds; starter failure Thermometer not calibrated	Cheese vats Vat thermometer	Temperature not > 103 ˚F Thermometer reads 32 ˚F in ice water	Cool curds and whey below 103 ˚F ASAP; monitor pH; possibly reject cheese Calibrate thermometer	Cheesemaker	Make record in cheese room
7	Unsanitary equipment Poor curd drainage	Pressing equipment, forms & cloths Cheese draining	Equipment clean and dry and sanitized; cloths boiled 5 min. Established limits for time and temperature of curd draining	Clean and sanitize before use Discard equipment that is hard to clean and sanitize Adjust to have cheese wheels with desired firmness & pH	Cheesemaker	Make record in cheese room
8	Cheese cooled too early; cooled below 55 ˚F	Cheese room pH meter and Brine area	Curd at least pH 6.35 before moving to cooler Brine area temp. not below 54 ˚F	Keep cheese wheels in cheese room until curd pH 6.35; possibly reject cheese	Cheesemaker and Cheese cave manager	Make record in cheese room and Temp. record in

CCP #	Hazards	CCP	Critical Limits	Action Taken if Limits Violated	Responsible Person	Record
8	pH meter and thermometer not calibrated	thermometer	pH meter calibrated Air thermometer agrees with a calibrated thermometer	Troubleshoot pH meter problem; use back-up electrode Calibrate air thermometer	(brine person)	brine area
9	Poor quality brine	Preparing brine	Salt quality within acceptable limits; same type for all producers Water and whey quality acceptable	Discard poor quality brine Use approved water source Make fresh brine	Cheesemaker or Brining person	Brine area
10	Insufficient brining Poor brine quality Incorrect brine technique	Brine tanks	Brine maintained at 23% salt, pH 5.1-5.2, and 54-59 ˚F Cheese brined for correct time Water from approved source and/or high quality whey used to make brine Salt on top of exposed surfaces	Adjust salt content to 23%, pH to 5.1-5.2, temp. to 54-59 ˚F Discard poor quality brine Make fresh brine Salt tops and turn wheels for even salt absorption	Cheesemaker and Laboratory technician Brining person	Brine area or cheese room Brining area
11	Insufficient aging Poor quality cheese	Cheese cave	Cheese aged for a minimum of 90 days at 54-59 ˚F Cheese shelving of high quality Temperature and humidity controlled within limits	Recall underaged cheese Discard cracked shelving Clean regularly Maintain correct temperature and humidity	Cave manager	Cheese cave

CCP #	Hazards	CCP	Critical Limits	Action Taken if Limits Violated	Responsible Person	Record
11	Poor quality cheese Unsanitary packaging Poor temperature control during transportation	Cheese grading and testing Cheese packaging and delivery	Acceptable by sensory evaluation Cheese quality in compliance with regulatory standards Use appropriate packaging materials for cheese variety Labelling in compliance Shipping containers clean and dry Cheese wheels are kept at 54-59 ˚F No physical change during transportation	Reject if cheese is poor quality Discard unsanitary packaging materials Use clean containers for shipping Check cheese temperature and quality at receipt; possibly reject cheese	Cheesemaker and Laboratory technician Packaging staff Marketing manager	Cheese cave and Office

Critical limits and target levels were set for each control point and testing was done to monitor these control points and compile records. Some of the control points were monitored for each batch of cheese produced; others were tested less frequently, based on an assessment of risk and cost. Producers paid for the costs of off-farm laboratory analyses, which were performed by the Agrimark Central Laboratory in West Springfield, MA.

Milk and cheese testing was performed to monitor the steps in the process of making cheese ready for sale as follows:

1. **pH - each batch**
    - quality of milk for cheesemaking
    - cheesemaking process up to brining
    - cheese after aging

2. **Temperature - each batch**
    - quality of the milk during storage until delivery for cheesemaking
    - cheesemaking process including brining
    - cheese upon delivery to the cave

3. **Salinity (hydrometer reading) - each batch**
    - brining and maintenance of brine quality

4. **pH and Titratable acidity - each month**
    - brining and maintenance of brine quality

5. **Microbiological testing - every 2 to 3 weeks**
    - raw milk quality

6. **Pathogen testing - 2 to 3 times per year**
    - cheese prior to sale

All participating producers and their staff were trained to implement the HACCP plan during workshops at their farms. They were responsible for testing pH, temperature, and brine salinity at the critical control points for each batch of cheese. Personnel at the Vermont Shepherd cave tested the quality, temperature, and pH of cheese delivered to the cave. The technician (myself) sampled and arranged for testing the microbiological quality of milk and cheese, received the results and provided these to the producers. The number of milk samples collected from each farm ranged from 4 to 10. This was due to the variation in the length of the milking season among farms. Five of the farms were close enough for the technician to collect samples from on a regular basis; one outlying farm either brought a milk sample on a Monday when delivering cheese to the cave or sent samples via UPS.

The regular testing of milk and cheese was very helpful to the producers. They felt that this should be continued at two-week intervals as an integral part of the HACCP program. A total of forty raw milk samples were taken from the six farms. The following tests were done:

1. **Total bacteria** - for compliance with VT state limits.
   This test was only useful in that it gave a measure of compliance with VT state standards for total bacteria in milk. Two samples were over the VT state limit (100,000 CFU/ml) during the year. We used a critical limit of <20,000 CFU/ml and a target level of <10,000 CFU/ml.

2. **Total coliforms** - indicator of level of hygiene during milking.
   This test was very useful as high coliform levels indicated poor cleaning of milking animals, i.e., an excessive amount of fecal contamination entering the milk from the teat skin. Early gassing in cheese can be attributed to high coliform counts. We used a critical limit of <100 CFU/ml and a target level of <10 CFU/ml.

3. **E. coli** - indicator of level of hygiene during milking; specifically the presence of enteric bacteria. This test was useful because it indicated the first point where disease-causing organisms could enter the cheese making process. The critical limit and target level were absence in one ml. This test was used less frequently due to the cost.

4. **Thermoduric (aerobic sporeformers) by Lab Pasteurized Count**- indicator of milking equipment sanitation and contamination from silage and soil. This test was useful because the source of high total bacteria counts could be diagnosed by using a combination of the thermoduric and coliform tests. Late gassing in cheese can be caused by high thermoduric counts. The most accurate test for predicting late gassing is the butyric sporeformer test, which was not used due to cost. The critical limit and target level were <10 CFU/ml.

5. **Psychrotrophic bacteria (PI count)** - indicator of milk keeping quality.
   It was not as useful in localizing problems since the cold-adapted bacteria, which cause high PI counts, can come from the environment and poorly cleaned animals as well as equipment. High counts usually occurred in samples having low total counts, indicating inadequate cooling of the milk. The critical limit was <50,000 CFU/ml and the target level was <20,000 CFU/ml.

6. **Somatic cells (SCC)** - for compliance with VT state limits (<750,000/ml).
   This test was a good indicator of animal health. A SCC of greater than 500,000/ml indicated the presence of mastitis or subclinical mastitis in the milking string. There seemed to be higher SCC (500,000 - 1,000,000) in the first month for most farms. Producers were able to lower high SCC by screening ewes with the CMT. This proved to be a very useful test. Two samples exceeded the state limits. The critical limit was <500,000/ml and the target level was <250,000/ml.

The most useful tests for predicting milk quality were those for coliform, E. coli, and thermoduric bacteria, and SCC. The total count was necessary for regulatory purposes. An additional test is recommended for *Staph. aureus* enumeration. This test is mandatory in the European Union for milk used in raw milk cheese manufacturing since *Staph. aureus* is the most common cause of mastitis and can produce a toxin, which will reside in the cheese. This test, like the E. coli test, can be done at any certified dairy lab for $10.

Table 1. Results of microbiological testing of sheep milk in 2000, showing critical limits and target levels used in the HACCP program.

	Total count	Coliform count	E. coli Count	Psychro-troph Count	Thermo-duric Count	Somatic cell count
No. samples	40	40	10	38	37	40
Critical limit	20,000	100	0	50,000	10	500,000
No. samples > limit	4	5	1	13	9	8
Target level	10,000	10	0	20,000	10	250,000
No. samples > level	5	16	1	19	9	18

RECOMMENDATIONS:

The total count and SCC tests should be continued because they are required by the VT State Dept. of Ag. and because they are useful for monitoring the quality of raw milk used in cheese making. The thermoduric and coliform tests should also be continued as they can help locate the source of high total counts and gassing in cheese. The cost of the bacteria test (including total count. coliform, thermoduric, and psychrotrophs, and testing milk components and SCC) is $13 per sample. A more specific thermoduric test would be for anaerobic sporeformers, e.g., butyrics, which cause late gassing in cheese. Unfortunately, this test is prohibitively expensive ($75 per sample). The method used in France for enumerating butyrics is being investigated and may prove to be less costly. The butyric test could be used on a monthly basis. The E. coli test is recommended as a safety test and can be done when coliform counts exceed the target level of 10 CFU/ml. The cost for the E. coli test is $5 per sample.

It is also recommended to use a test for *Staph. aureus*. This test is required in Europe for milk used in raw milk cheese making. Since Staph is the most common cause of mastitis the Staph test could be very useful and could be done on a monthly basis. The cost is $10 per sample.

It would be best to continue to do the total count, SCC, thermoduric, and coliform tests every two weeks. This provides timely information for producers to solve problems. The PI (for psychrotrophs) may not be necessary unless there is concern over cooling problems. The *E. coli* and *Staph. aureus* tests can be done at a frequency of once per

month to indicate the safety of the milk. The frequency of testing for the season could also be based on the average amount of milk produced per day in the following manner:

- < 220 lb./day - 3 samples
- 220-440 lb./day - 5 samples
- >440 lb./day - 7 samples

The lactofermentation test, which is described in the Fromage Fermiers cheesemaking guide by CREOM, Ordiarp, France, can be done for each batch of milk while cheese is being made to give a quicker indication of the milk quality (within 48 hours).

The following tests were done on the cheese:

1. **Salt content** - for indicating quality and safety problems. This is required for a HACCP program as a low salt cheese indicated potential for growth of pathogens. The salt testing was done at 2-3 week intervals during the season. The number of batches tested per farm varied depending on the length of the cheesemaking season. Several batches had low salt contents and there was a correlation between lower salt content and lower quality cheese; bitter flavors were noted by the judges.

2. **Pathogens (E. coli 0157, Listeria monocytogenes, Salmonella)** - indicated the safety of the cheese prior to sale. The testing was done on one batch per farm from the beginning of the season when the cheese was 3 months old. The cheeses were all negative for pathogens.

3. **pH** of the cheese was measured at the 4 month grading sessions. The cheese having pH 5.75 or greater was of lower quality.

4. **Isolating a source of contamination in gassy cheese**. One producer had a problem with early gassing in the cheese (many small pinholes). We used a private lab to isolate the contaminating microorganism. After much time and expense the result showed that it was yeast. Most of the gas holes went away after one month of aging and the flavor was not affected. Later on the producer used a faster heating time for the milk when making cheese; this seemed to reduce the number of gas holes and make them slightly larger. We also tested the water for contaminants but none were found that produced gas in cheese.

5. **Components (Fat, Total solids, and Salt contents)** - for indicating changes in cheese composition that could lead to quality and safety problems. This may be required for a HACCP program as a low salt cheese indicates potential for growth of pathogens. The components testing was done on 3 to 7 batches of cheese at 2-3 week intervals during the season. The number of batches tested per farm varied depending on the length of the cheese making season. This testing was mainly used to create standards for total solids, fat-on-dry-basis (FDB), and salt contents for young cheeses (seven days after removing from the brine).

There was considerable variation in total solids and FDB contents during the season; 55.2-59.9% and 51.0-56.1%, respectively. Some farms had minor variations during the season, while others produced cheese with wider ranges. The grading (sensory

evaluation) results showed that the low total solids/low FDB cheese was of lower quality. Several batches had very low salt contents and there was a correlation between low salt content and Shepherd's Tomme (lower quality) cheese; bitter flavors were noted by the judges.

RECOMMENDATIONS:

It is not necessary to continue the component testing now that standards for salt, total solids and FDB have been established. However, it could be useful for a producer to test any one of these components if they are concerned about batches of cheese that seem overly moist or low in salt or fat. Results from a components test may enable them to change cheese making technique to produce cheese closer to the standards. There are simple tests for salt and total solids that can be done by the cheesemaker on-site. The most effective control for low salt content is to keep the brine charged (saturated) at all times. Perhaps using a salt that dissolves easier can solve this problem.

It is important to continue pathogen testing to assure the safety of Vermont Shepherd cheese in the marketplace. The frequency of testing should be based on the average amount of milk produced per day in the following manner:

- < 220 lb./day - 3 samples per year
- 221-440 lb./day - 5 samples per year
- >441 lb./day - 7 samples per year

The cost of the testing for the three pathogens was $44 per sample.

After careful review of cheese make sheets and milk quality records the following factors that were responsible for low quality cheese were noted:

- There was one instance where poor milk quality may have been responsible for a low quality cheese.
- High moisture curds
- High pH at brining (>5.40)
- High renneting (>95 °F) and cooking temperatures (>102 °F)

The time from adding starter to moving cheese to the cave was not a factor.
Long rennet set times were not a factor.
Varying the amount of starter was not a factor

Generally speaking, producers with the most accurate and detailed make records made the smallest quantity of low quality cheese.

Cheese Composition Standards (7 days after brining)

57.0%Total solids
53.5% FDB
.60% Salt

Farmstead Goat Cheesemakers

Two goat dairies sought ongoing technical advice. This assistance with cheesemaking was delivered via telephone and email. The focus was on solving technical problems but some time was spent on developing recipes for new cheeses. The importance of acidity, temperature, and salt and moisture content control during cheesemaking was emphasized as a way to avoid problems during aging. Although this assistance didn't provide the means for milk quality testing and risk reduction techniques such as HACCP, it gave the cheesemakers a resource for technical advice. The lack of on-site visits made it harder to communicate at times, however, the consultant had previously been to the farmsteads and understood the conditions of milk and cheese production. Both recipients felt they benefited from the help and made improvements to their cheeses. One of them was able to create new varieties of cheese for their business. Both have been able to expand retail and wholesale markets for selling cheese.

CONCLUSIONS

Assurance of product safety is of paramount concern to food producers. Food safety problems and associated negative publicity threaten the viability Vermont's farmstead cheesemakers, so pro-active steps such as the development and implementation of HACCP programs are necessary.

This program was effective in that it gave the producers useful information for problem solving and quality improvement. In working to secure the quality of the raw milk first, the safety and quality of Vermont Shepherd cheese was improved. The amount of second grade cheese produced was reduced by 23% from the previous year. This clearly indicates the added economic value to a business, beyond the assurance of product safety, which a HACCP program can provide. Increased efforts to monitor the safety and quality of the cheese during aging will enable Vermont Shepherd, LLC, to continue to reduce the percentage of second grade cheese. If the program is continued, this is the direction it should take as long as it maintains the operation of HACCP programs for the individual producers.