Evaluation of Milk Production in Western Whiteface and Navajo-Churro Ewes

Marla Faye Brindley
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EVALUATION OF MILK PRODUCTION IN WESTERN WHITEFACE AND NAVAJO-CHURRO EWES

by

Marla Faye Brindley

A thesis submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

in

Animal Science

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1995
ABSTRACT

Evaluation of Milk Production in Western Whiteface and Navajo-Churro Ewes

by

Marla F. Brindley, Master of Science
Utah State University, 1995

Major Professor: Dr. Lyle G. McNeal
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Western Whiteface and Navajo-Churro Ewes, two types of sheep present in the Intermountain West, were compared for their milk production ability. Amount of milk produced per individual and the group milk composition were analyzed for butterfat, lactose, somatic cell count, protein, calcium, and phosphorous.

Ewes were fed ad libitum alfalfa hay and had access to free-choice grain while in the milking parlor. Lambs were weaned at 35 d of age and removed to another holding area and placed on creep feed. Ewes were milked for 90 d following the weaning of the lambs.

Western Whiteface ewes had a much higher milk production level than the Navajo-Churro ewes \( (P < 0.05) \). Western Whiteface ewes were almost double in their overall level of production versus the Navajo-Churro ewes. Half of the Western Whiteface ewes completed the 90-d lactation period, producing an average of .83 kg of milk per day. Navajo-Churro ewes did not complete the full lactation period, with 100% of them ceasing milk production.
before completion of the 90-d milking period. The criterion for being considered dry consisted of completing six consecutive milkings while producing 50 ml or less of milk.

Overall production for the two groups of ewes was .83 kg/day of milk for the Western Whiteface ewes and .52 kg/day for the Navajo-Churro. The average number of days in production for the Western Whiteface ewes was 69.5 d and 50 d for the Navajo-Churro. Western Whiteface ewes consistently exhibited higher milk production levels than the Navajo-Churro ewes and they adapted well to the milking barn. Navajo-Churro ewes did not produce an adequate quantity of milk for a dairy setting.
ACKNOWLEDGMENTS

I would like to thank Dr. Lyle McNeal for giving me the opportunity to learn about sheep milking and complete the research in this thesis. I would especially like to thank my committee members, Drs. Randy Wiedmeier, Wallace Taylor, and Don Sisson, for their support and assistance throughout the entire process. I also want to thank Dr. Robert Lamb for continuing to ask “how are things going” and keeping me on track to completion, and to Phil Rodgers for his assistance and help with analysis of my data.

Thanks to my father for his help in my writing and coursework and my mother for her patience and impatience as well. I give special thanks to my family, friends, and colleagues for their support and encouragement. Without all the people listed, and others I haven’t mentioned, this thesis would not have been completed. Thanks to all of you.

Marla F. Brindley
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INTRODUCTION

Sheep milk production for human use is an alternative for the sheep industry in the United States. The United States imports millions of dollars worth of sheep milk cheeses from European countries every year. This market currently is open for United States sheep producers to become actively involved and add another source of income for their operations.

Development of a dairy sheep industry in the United States will be slow until an effort is made by universities and producers to investigate and invest in sheep dairying enterprises. Established foreign milking breeds of sheep have been developed but are not available to producers in the United States due to strict importation and health regulations.

Laws regarding importation of livestock from European countries are currently very restrictive because of Sheep Spongiform Encephalomyopathy, commonly known as Scrapie. For this reason it is essential to work on developing milking breeds from the existing United States sheep gene pool.

The three objectives of this study were to:

1. Quantitate the milking ability of Navajo-Churro and Western Whiteface that are now present in the Mountain West Region of the United States.

2. Determine the milk composition of Navajo-Churro and Western Whiteface.

3. Measure persistence of milk production for 90 days post-weaning.

The traits considered for this study were milk produced, milk composition, and ability to milk for an extended period of time.
REVIEW OF LITERATURE

Very little research has been conducted in the United States with regards to sheep dairying as a potential industry. France, Cyprus, Israel, Poland, and Spain are a few countries that have been milking sheep for many years as a commercial business (Kervina et al., 1984). Many of these countries export their sheep milk products to the United States. Development of a sheep dairy industry can provide new jobs and another source of income for sheep producers in the United States.

Sheep-milk cheeses make up about 10% of the total cheese imports into the United States, Roquefort being one of the main cheeses imported (Boylan, 1984). In 1980 sheep-milk cheese imports accounted for 22,771,000 pounds of cheese (Boylan, 1984). Research into milking techniques and suitability of United States sheep breeds for dairy production should be pursued to help maintain viability of this industry. For the sheep milk industry to thrive, three things are needed: customers, sheep milk in adequate quantities to supply the market, and manufacturers and retailers (Jordan and Boylan, 1988). Consumers already exist as is evidenced by the large volume of imported sheep-milk cheeses.

Milking Sheep Breeds

The majority of the sheep breeds recognized as having dairy capabilities are present in the Mediterranean and the Middle East. The Awassi, East Friesian, and the Lacaune are three of the more popular breeds used in sheep dairy operations. These animals maintain high milk yields, from 104 to 600 liters, over a lactation period in excess of 130 d. Table 1 displays the milk production levels of various breeds of sheep. The Spanish Churro has demonstrated the
ability to milk for 150 d, producing 151 liters (Sakul and Bradford, 1991), and is a relative of the Navajo-Churro, which is present in the United States. Unfortunately, these breeds are not available to the United States due to United States Department of Agriculture - Animal Plant Health Inspection Service importation restrictions (Sakul and Bradford, 1991).

East Friesian ewes are considered to be the top milk-producing ewe available for dairy use in the world. Lambing rates of the East Friesian are high, with an average of a 270% lambing rate and longevity up to 9 yr of age. Milk produced on average is 550-650 kg of milk per lactation. The average lactation length being 260 d. Fat content of the milk ranges from 5.5 to 6% (Kervina et al., 1984; Mills, 1989).

East Friesian ewes have improved the milking ability of every breed with which it has been crossed. East Friesian crossed with Awassi has created a breed known as Assaf. Assaf ewes have higher production than the Awassi. East Friesian has also been crossed onto lowland or down breeds of sheep and greatly improved the fertility and milking ability of the lowland

Table 1. Milk production of various breeds of sheep present in the Middle East and Mediterranean countries (Sakul and Bradford, 1991)

<table>
<thead>
<tr>
<th>Breed</th>
<th>Lactation length (Days)</th>
<th>Milk Yield (Liters)/Lactation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assaf</td>
<td>100-117</td>
<td>192-287</td>
</tr>
<tr>
<td>Awassi</td>
<td>144-260</td>
<td>104-350</td>
</tr>
<tr>
<td>Chios</td>
<td>172-197</td>
<td>161-205</td>
</tr>
<tr>
<td>Churro</td>
<td>150</td>
<td>151</td>
</tr>
<tr>
<td>East Friesian</td>
<td>153-260</td>
<td>148-600</td>
</tr>
<tr>
<td>Garfagnana</td>
<td>180-210</td>
<td>120-150</td>
</tr>
<tr>
<td>Lacaune</td>
<td>143-155</td>
<td>143-165</td>
</tr>
<tr>
<td>Lacha</td>
<td>180</td>
<td>207</td>
</tr>
<tr>
<td>Langhe</td>
<td>250</td>
<td>231</td>
</tr>
<tr>
<td>Mancha</td>
<td>150</td>
<td>135</td>
</tr>
<tr>
<td>Massa</td>
<td>180-210</td>
<td>150-160</td>
</tr>
</tbody>
</table>
cross. Friesian sheep also have been shown to be able to breed out of season, thereby allowing breeding to be staggered to the point that year-round milking is possible (Mills, 1989).

The Lacaune is the most important milking breed of sheep present in Europe for cheese production. The Lacaune is also the most profitable farm animal in France. These animals are milked for the production of Roquefort cheese (Jordan and Boylan, 1986). Producers who sell their milk for use in making this cheese receive 3.5 times more per pound than do cow milk producers. The Lacaune are known for a slow period of milk let-down and for having two distinct peaks of production in the milking cycle (Kervina et al., 1984). Selection of this breed of sheep is based on the milking properties of the udder (such as rate of let-down, udder style, and development) more than milk yield (Kervina et al., 1984).

The Awassi is distinct from the other breeds. It is a fat-tailed breed of sheep common to Africa and is thought to have originated in Syria. Awassi are particularly well suited to the harsh, arid environment of Africa and the Middle East countries including Iraq, Jordan, and Israel. Average milk production levels range in Syria from 70 - 90 kgs over a 4- to 6-mo lactation period (Kervina et al., 1984). Overall, average Awassi milk production is at 350 kg for one lactation cycle.

The Dorset, a breed present in the United States, may prove, through genetic selection, to be a suitable milking breed. These animals are quiet mannered and easy to manage. Selection currently has not been based on milk production but this is changing with the increased emphasis on milking sheep (Mills, 1989).
Compared to the Dorset, East Friesian sheep exhibit a much smaller and lighter frame, with reluctance to fatten easily. The Dorset, on the other hand, is an "easy-keeping" breed that readily puts on excess body condition, thereby making the animals quite heavy (Mills, 1989).

Reynolds and Brown (1991) examined the milking potential of Western White-faced ewes. In one experiment, 31 ewes of Targhee breeding that were suckling twins were utilized (Reynolds and Brown, 1991). Milk yield averaged 1.7 kg/day in the Targhee ewes. A second experiment used 24 ewes (Rambouillet X Finn-Dorset breeding) that were separated from their lambs at 7 wk and milked twice daily for 8 wk (Reynolds and Brown, 1991). Ewes in this experiment produced .47 kg/day.

Corbett (1968) reported a yield of approximately 80 kg/ewe over a 10-wk lactation cycle. Daily milk yield increased until a mean of 1.4 - 1.6 kg was reached about 3 wk postpartum (Corbett, 1968).

The Suffolk, Rambouillet, Polypay, Columbia, and Dorset breeds are some of the United States breeds of sheep that have been milked successfully. United States sheep breeds that have been milked have had much lower production levels than the European sheep. Due to the restrictions on importation, however, it is necessary to continue research with United States sheep breeds to attempt to develop a milking breed from the germ plasm available (Sakul and Bradford, 1991). Table 2 shows the milk production of several United States breeds of sheep.

Suffolk, Rambouillet, Polypay, and Columbia ewes were milked in a study reported by Snowder and Glimp (1991). Ewes were evaluated for milk production and composition while under range conditions. Snowder and Glimp (1991) reported no differences in milk yield and
Table 2. Milk production of several United States sheep breeds\(^a\) (Sakul and Bradford, 1991)

<table>
<thead>
<tr>
<th>Breed</th>
<th>N</th>
<th>Milk yield (liters)/Lactation Mean(^b)</th>
<th>SD(^c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dorset(D)</td>
<td>28</td>
<td>71.7(^{de})</td>
<td>32.6</td>
</tr>
<tr>
<td>Finnsheep(F)</td>
<td>31</td>
<td>66.2(^{ef})</td>
<td>47.5</td>
</tr>
<tr>
<td>Lincoln(L)</td>
<td>31</td>
<td>60.0(^{ef})</td>
<td>28.7</td>
</tr>
<tr>
<td>Rambouillet(R)</td>
<td>30</td>
<td>68.7(^{de})</td>
<td>31.7</td>
</tr>
<tr>
<td>Romanov(Ro)</td>
<td>18</td>
<td>34.8(^{g})</td>
<td>40.6</td>
</tr>
<tr>
<td>Suffolk(S)</td>
<td>32</td>
<td>83.2(^{d})</td>
<td>26.6</td>
</tr>
<tr>
<td>Targhee(T)</td>
<td>30</td>
<td>72.0(^{de})</td>
<td>27.9</td>
</tr>
<tr>
<td>Synthetic I (FxL)</td>
<td>28</td>
<td>50.8(^{fg})</td>
<td>25.9</td>
</tr>
<tr>
<td>Synthetic II (DxR)</td>
<td>26</td>
<td>76.4(^{de})</td>
<td>26.5</td>
</tr>
<tr>
<td>Synthetic III (FxL x DxR)</td>
<td>26</td>
<td>70.7(^{dc})</td>
<td>24.9</td>
</tr>
</tbody>
</table>

\(^a\)Milking 2X daily starting 30 days postpartum for about 120 days.

\(^b\)Means not having a common superscript differ significantly \((P < .05)\).

\(^c\) Standard Deviation.

composition among the Rambouillet, Suffolk, Polypay, or Columbia ewes. Suffolk ewes, however, dropped significantly in body weight during the lactation period, indicating the possibility of their unsuitability to milking under range conditions.

Selection and Development of Milking Sheep

Selection of dairy sheep is based primarily on selection of those animals that have the milk-producing capacity and udder development to fit the dairy setting. Different breeds have different characteristics that are unique to that breed. The Lacaune, for example, has a slow let-down of milk and peak twice during the milking period (Kervina et al., 1984).

When selecting sheep for the dairy use, it is ideal to have them be low on body condition in spring, begin picking up weight before breeding, and then lose again following lambing (Mills, 1989).
Use of genetic selection through data collection and evaluation is a proven method of determining milking potential of animals. To best utilize this form of selection, however, detailed records need to be kept on flock production. Reports of the estimates of heritability for milk traits vary amongst researchers. Sakul and Bradford (1991) reported heritability estimates ($h^2$) for total milk yield ranging from 0.20 - 0.41. Boylan and Sakul (1990) reported the repeatability value of total milk production per lactation to be 0.53.

Use of artificial insemination and embryo transfer are two effective means of developing a milking sheep flock. Natural reproduction with proper record keeping and selection will improve the flock productiveness over time. Introduction of artificial insemination and embryo transfer, however, can reduce the time for improvement by a little less than half. For example, natural reproduction and selection methods have been shown to improve milk production twofold in about 20 yr (Sakul and Bradford, 1991). With the use of artificial insemination this can be lowered to approximately 8 yr time for a 65% increase in production. Table 3 displays results expected from selection using natural versus artificial service methods.

Socializing of the breed of sheep being selected for the milking parlor should be considered. Breeds that are solitary by nature may tend to be uncomfortable in the confinement setting of a working dairy (Mills, 1989). Behavior problems can lead to lowered milk production and stress in the parlor setting. Ewes that are forced about in the dairy setting will have decreased production due to stress-related factors such as adrenalin in the system, which is an inhibitor of milk let-down (Mills, 1989).
Table 3. Summary of results expected from selection using natural reproduction (NR), artificial insemination (AI), and embryo transfer (ET) (Sakul and Bradford, 1991)

<table>
<thead>
<tr>
<th>Mating ratio</th>
<th>Milk yield after sel.</th>
<th>Years of selection</th>
<th>Annual genetic progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>NR 1:25</td>
<td>134.2</td>
<td>20</td>
<td>3.4</td>
</tr>
<tr>
<td>NR 1:50</td>
<td>125.0</td>
<td>13</td>
<td>4.5</td>
</tr>
<tr>
<td>AI 1:100</td>
<td>111.8</td>
<td>8</td>
<td>5.6</td>
</tr>
<tr>
<td>ET(5) 1:5</td>
<td>152.1</td>
<td>17</td>
<td>5.0</td>
</tr>
<tr>
<td>ET(5) 1:10</td>
<td>147.1</td>
<td>12</td>
<td>6.7</td>
</tr>
<tr>
<td>ET(10) 1:5</td>
<td>139.7</td>
<td>10</td>
<td>7.3</td>
</tr>
<tr>
<td>ET(10) 1:10</td>
<td>157.1</td>
<td>10</td>
<td>9.0</td>
</tr>
</tbody>
</table>

*Ram-to-ewe breeding ratio.*

*b Starting average milk yield = 67 liters.*

Figure 1 shows the social and phylogenetic relationships of some sheep breeds as reported by the American Sheep Industry (1988).

**Litter Size and Milk Production**

Snowder and Glimp (1991) investigated the influence of breed, litter size, and stage of lactation in Suffolk, Rambouillet, Columbia, and Polypay ewes. Milk yield among breeds within litter size interaction was not significant. Milk yield of Suffolk ewes with twins, however, was consistently higher than that of other ewes with twins. Among Rambouillet, Columbia, and Polypay ewes, milk yield was increased 44 to 47% over ewes with single lambs. In the Suffolk, the increase of milk yield for twins over singles was 64%. Suffolk ewes
Figure 1. Social and phylogenetic relationships of some sheep breeds (American Sheep Industry, 1988)
produced overall 13 to 17% more milk than the Rambouillet, Columbia, or Polypay ewes. Higher milk production in the Suffolk may be due to the larger body size of the ewes.

Overall, ewes suckling twins consistently produced more milk than those suckling singles. From d 70 to 98 postpartum, milk yield of ewes suckling twins was 71 to 149% higher than those with singles (Snowder and Glimp, 1991). This indicates a response to milking stimulus.

Body weight of Suffolk ewes suckling single or twin lambs decreased significantly (12 and 21% at 4 d postpartum, respectively); Columbia ewes (5 and 8%), Polypay (8 and 8%), and Rambouillet (4 and 7%) (Snowder and Glimp, 1991). Snowder and Glimp (1991) reported correlation coefficients in 118 multiparous, 3- to 7-yr-old Rambouillet, Columbia, Polypay, and Suffolk ewes between milk production and lamb growth that were positive and significant ($P < .05$) up to 56 d of age. Growth rate of single lambs correlated to milk production was higher than that of twins.

**Milk Composition**

The main constituents of sheep milk include fat, proteins, lactose, minerals and vitamins. Jordan and Boylan (1986) stated that sheep milk has twice as much fat, 40% more protein, and 30% more solids than milk from cattle or goats. Table 4 shows the comparison of sheep's milk versus cow's milk in composition. The relatively high level of fat present in sheep milk increases its value for making cheese. Production of cheese from sheep milk is based on a 4:1 ratio of milk to cheese on average (Boylan, 1984).
Table 4. Comparison between the average composition of sheep and cow milk (in percentage) (Kervina et al., 1984)

<table>
<thead>
<tr>
<th></th>
<th>Sheep Milk %</th>
<th>Cow Milk %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Matter</td>
<td>18.2</td>
<td>12.6</td>
</tr>
<tr>
<td>Fat</td>
<td>7.2</td>
<td>3.7</td>
</tr>
<tr>
<td>Protein</td>
<td>5.5</td>
<td>3.3</td>
</tr>
<tr>
<td>Lactose</td>
<td>4.6</td>
<td>4.6</td>
</tr>
<tr>
<td>Ash</td>
<td>0.9</td>
<td>0.8</td>
</tr>
</tbody>
</table>

The fat in sheep milk contains more caprylic and capric fatty acids than does cow milk. This gives the milk its unique aroma and taste (Kervina et al., 1984). Sheep milk is very high in casein, the main milk protein, and therefore is excellent for making yogurt and several cheeses. The proteins in sheep milk also are complete proteins in that they contain all of the essential amino acids in their complex. Lactose is the main sugar present in sheep milk and provides energy, as well as influencing the metabolism of calcium, promoting its absorption into the bones (Kervina et al., 1984).

All of the minerals found in the animal body are represented in milk. Nutritional value of foods has become a measuring tool for society and can determine which food products are purchased. Sheep milk products are high in vitamins and minerals that are required for a healthful diet. The minerals present in milk are also in a form that is easily absorbed by the body (Kervina et al., 1984). Table 5 shows the daily mineral requirements of humans and a comparison of those minerals provided in sheep milk to those present in cow milk (Kervina et al., 1984). Sheep milk is also an excellent source of vitamins. It is high in vitamins A and E, which are fat soluble, and also high in B-complex vitamins, namely B-12. Table 6 shows the
human vitamin requirements and a comparison of those provided in sheep and cow milk (Kervina et al., 1984).

Many factors, such as type of feed, time of milking, and health of the animal, affect the composition of sheep milk. Health care, flock maintenance, and feeding of the ewe combined with environmental factors, such as weather and cleanliness, can confound establishing milk composition of various breeds of sheep (Boylan, 1984).

Snowder and Glimp (1991) found milk composition among Suffolk, Rambouillet, Columbia, and Polypay breeds did not differ significantly ($P < .05$). Differences in composition of milk for ewes nursing twins and those with singles were also not significant. Milk fat did differ significantly, however, between ewes with singles and those with twins. Colostrum was significantly higher in levels of fat and protein, mainly gamma-globulins for a period of 2 to 3 d.

<table>
<thead>
<tr>
<th>Minerals</th>
<th>Human daily need (mg)</th>
<th>Quantity (mg/l)</th>
<th>Need covered by 1 litre of milk (percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sheep milk</td>
<td>Cow milk</td>
<td>Sheep milk</td>
</tr>
<tr>
<td>Ca</td>
<td>800</td>
<td>2030</td>
<td>1360</td>
</tr>
<tr>
<td>P</td>
<td>1000</td>
<td>1330</td>
<td>850</td>
</tr>
<tr>
<td>K</td>
<td>1500</td>
<td>1460</td>
<td>1520</td>
</tr>
<tr>
<td>Na</td>
<td>1150</td>
<td>360</td>
<td>460</td>
</tr>
<tr>
<td>Mg</td>
<td>300</td>
<td>170</td>
<td>120</td>
</tr>
<tr>
<td>Cu</td>
<td>2</td>
<td>0.34</td>
<td>0.12</td>
</tr>
<tr>
<td>Fe</td>
<td>12</td>
<td>1.05</td>
<td>0.6</td>
</tr>
<tr>
<td>Mn</td>
<td>3</td>
<td>0.05</td>
<td>0.06</td>
</tr>
<tr>
<td>Zn</td>
<td>7</td>
<td>7.42</td>
<td>3.9</td>
</tr>
</tbody>
</table>
Table 6. Daily need by man of some vitamins and their supply (in percentage) by 1 liter of sheep and cow milk, respectively (Kervina et al., 1984)

<table>
<thead>
<tr>
<th>Vitamin</th>
<th>Human daily need (mg)</th>
<th>Quantity Sheep milk (mg)</th>
<th>Quantity Cow milk (mg)</th>
<th>Need covered by 1 litre of milk (percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Sheep milk</td>
<td>Cow milk</td>
<td>Sheep milk</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>1.5</td>
<td>0.5</td>
<td>0.3</td>
<td>33</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>20</td>
<td>15.8</td>
<td>7</td>
<td>79</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>70</td>
<td>40.0</td>
<td>22</td>
<td>61</td>
</tr>
<tr>
<td>Vitamin B₁</td>
<td>1.3</td>
<td>1.2</td>
<td>0.48</td>
<td>92</td>
</tr>
<tr>
<td>Vitamin B₂</td>
<td>1.6</td>
<td>4.3</td>
<td>2.2</td>
<td>269</td>
</tr>
<tr>
<td>Vitamin B₆</td>
<td>3</td>
<td>0.7</td>
<td>0.52</td>
<td>23</td>
</tr>
<tr>
<td>Vitamin B₁₂</td>
<td>0.0035</td>
<td>0.0098</td>
<td>0.0027</td>
<td>280</td>
</tr>
<tr>
<td>Pantothenic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2c acid</td>
<td>8</td>
<td>5.3</td>
<td>3.4</td>
<td>66</td>
</tr>
<tr>
<td>Folic acid</td>
<td>0.15</td>
<td>0.054</td>
<td>0.052</td>
<td>36</td>
</tr>
<tr>
<td>Biotin</td>
<td>0.2</td>
<td>0.050</td>
<td>0.017</td>
<td>25</td>
</tr>
</tbody>
</table>

Lactose content was lower in colostrum and elevated at about 28 d postpartum. Lactose then began to decline over time (Snowder and Glimp, 1991).

Milk composition changes significantly in the presence of mastitis. When mastitis is present, lactose content, percent solids non-fat, and casein content of the milk decrease. Salt, pH, and whey proteins increase in the presence of a mastitis infection (Anderson et al., 1985). Decreases in milk production, pressure changes in the udder, and bacterial action cause the resultant changes in milk composition (Anderson et al., 1985).

Lactation Length and Milk Production

In a study conducted by Snowder and Glimp (1991), milk production decreased from d 28 to 98 by 76 and 83%, respectively, for ewes suckling singles and twins. Calcium and
phosphorous decreased gradually over time. Milk fat increased over time, providing higher energy levels in smaller amounts of milk. A lowering of milk production levels of ewes was also associated with rumen development of the lambs.

Peak milk yield was estimated to be around the third week of lactation for twins and the fourth week for singles. The largest drop in the lactation curve for singles and twins occurred during d 56 to 70, with declines of 57 and 42%, respectively (Snowder and Glimp, 1991). This drop in milk production can be attributed to the development of grazing habits of the young lambs when moved to mountain pasture under drought conditions, thus reducing the nutrient supply and suckling stimulus (Snowder and Glimp, 1991).

Nutrition

Nutrition is vital for milk production. If the nutrients are not present, milk will either not be produced, or will be produced at greatly reduced amounts. The nutrients required for milk production are drawn directly from the blood of the animal (Anderson et al., 1985). Adjustments in the nutrient intake should be made based on the response of the ewes to the nutrients provided (Treacher, 1989).

Nutritional needs of the animals, such as protein, energy, and mineral intake, change at different stages of lactation. Nutritional requirements also change significantly due to the climate of the area in which the animals are being housed and due to the genetic makeup of each animal in the production cycle. Lactation is the most demanding physiological state and the most difficult period of time in which to try and maintain ewe health. Underfeeding of ewes during the lactational period will shorten the lactation cycle and compromise the
maximum output of the ewe. Acceleration of lambing and multiple birthing increase the nutritional requirements of the standard milking ewe (Brown, 1991).

High-yielding ewes have two periods in which feeding requirements change dramatically. Figure 2 displays the nutritional needs of the ewe over the lactation curve. The first of these two periods is immediately following lambing when lactation first begins (Kervina et al., 1984). In the first 1 to 2 mo of lactation, it is nearly impossible to provide the high producing ewe with the quality and quantity of feed that is required for her production level (Kervina et al., 1984). Following that first period, the requirements for feed intake of the ewe diminish and the risk of overfeeding develops.

Figure 2. Lactation curve and feeding (Kervina et al., 1984)
Protein and energy intake are the main nutrients that influence milk production in the ewe (Treacher, 1989). Figure 3 displays the response of milk yield to changes in intake of protein and energy. The variations of production in response to changes of protein and energy were examined during the first 12 wk of lactation, concentrating on the first 6 wk of lactation (Treacher, 1989). The data collected are complicated, however, by the large shift in animal body weight in the first weeks of lactation (Treacher, 1989).

Level of energy intake dictates the amount of protein required by the animal. Any reduction in protein below that level will cause a reduction in the milk yield of the ewe (Treacher, 1989). The minimum ratio between protein and energy raises as the demand for

![Figure 3. Response of milk yield to change in intake of metabolizable energy (ME) and crude protein (CP) (Treacher, 1989)](image)
higher production is placed on the ewe (Treacher, 1989). Increasing the protein above the required level, without increasing the energy intake, will result in an increase in milk production if the ewe has not reached her full potential for production. During early lactation, ewes on a low metabolizable energy diet responded with significant increases in milk production when protein supplementation was started (Treacher, 1989).

Ability of the ewe to mobilize body reserves for milk production is also a factor in the quantity of milk produced. Thin ewes on low intakes of metabolizable energy may be limited in milk production due to a low rate of fat mobilization from body fat reserves. Different protein sources also create different responses in milk production levels. Response in milk yield is strongly related to the degradability of the protein source, and the amount of non-ammonia nitrogen (Treacher, 1989).

Animal diets that are low in selenium and vitamin E will result in increased incidence of environmental types of mastitis (Smith and Hogan, 1992).

**Machine Versus Hand-milking**

Machine milking of sheep requires larger capital expenditures for equipment and facilities. Procedures for milking with machines versus hand-milking also differ. Sanitation of milking equipment is also essential for milk harvesting. The equipment costs involved in machine milking are offset by the improved efficiency of machine milking versus hand-milking. In general, the milking machine is six times as efficient as a hand-milking system, thereby increasing the number of ewes that can be milked and therefore increasing profits (Kervina et al., 1984).
Ewes should enter the dairy parlor with as little stress placed on them as possible. The teats and udder of the ewe should be sanitized and dried before milking takes place. Cleaning of the udder stimulates release of oxytocin and assists in milk letdown. A few streams of milk should be squirted into a strip cup to check for abnormalities in the milk. Milking equipment can then be placed on the teats or hand-milking can take place (Sundburg, 1991).

**Sheep Milking Equipment**

Mechanical milking of sheep requires the use of specialized equipment developed for use with sheep as well as some nonspecialized bovine milking equipment. Renovation of used dairy cattle facilities for sheep is a viable option that can be utilized. Milking systems for cattle can be used for sheep with a few changes in the vacuum level and in the regulator setting.

The standard equipment required for machine milkings needs to accomplish two general functions. These are restraint of the ewe, and extraction of milk. Restraints should be established in a manner that allows for quick entry and exit from the dairy parlor and that also provides a way of feeding the ewes during the milking period. The four basic components of the milking machine are the vacuum, pulsator, cluster, and milk storage area (Steinkamp, 1991).

The vacuum system is the main portion of the milking equipment. It is composed of the pump, regulator, and gauge. The vacuum control regulator allows for the entry of air into the vacuum line for maintaining a consistent pressure level. The gauge tells the operator the level of vacuum present in the system and should be closely monitored. The pulsation system is mounted directly on the milking line and has two working phases. The first phase allows
atmospheric pressure change in concert with the milking vacuum and collapses the liner, thus massaging the teat. In the second phase, vacuum is applied, the liner expands outward, and the milk is drawn out of the teat with the negative pressure produced (Steinkamp, 1991).

Current dairy sheep industry recommendations for use of milking equipment are as follows (Steinkamp, 1991).

Pulsation Rate = 120 cycles per minute
Pulsator Ratio = 50:50
Vacuum Level = 11" Hg or 40 kPa

Industry standards for milking of cattle differ from those for milking of sheep. The standards for milking cattle are as follows:

Pulsation Rate = range 40-60 cycles/min
Pulsator Ratio = 50:50, 60:40, and 70:30 are all used.
Vacuum Level = 12.5-13" Hg or 50 kPa

Normal atmospheric pressure is equal to standard atmospheric pressure at sea level, which is 14.69 lb/sq in. and equal to 30" Hg, 760 mm Hg, or 100 kPa (Anderson et al., 1985). Kilopascals, abbreviated kPa, is the preferred unit of measurement used today (Anderson et al., 1985).

The pulsation rate is the number of times that air in the pulsation chamber of the teat cup is evacuated and returned to standard atmospheric pressure (30" Hg, or 100 kPa) in a minutes time. Low vacuum level combined with high pulsation rate have the effect of increasing the milking rate as compared to high pulsation with high vacuum. Pulsation rates that are too low result in inadequate massage of the teats, creating a painful milking setting and
reducing milk ejection. Pulsation ratio works directly with the pulsation rate to create the milking action. Increasing the milking ratio reduces the amount of time the teat is massaged, resulting in a longer milk flow and faster milking rate. If increased too much, however, the teat may swell and the need for stripping will increase (Anderson et al., 1985).

Vacuum level needs to be closely regulated. If the vacuum becomes too high, rupture of blood vessels can occur and bruises can develop on the inside of the teat. Vacuum set too low will result in inadequate milk withdrawal (Anderson et al., 1985).

With mechanized milking it is important to make sure that the cluster is properly attached to the udder. Care must also be taken to not leave the machine on too long. Failure to remove the unit following completion of milking will greatly increase the risk of udder damage and development of mastitis (Sundburg, 1991).

Methods of Estimation of Milk Production

Many different methods have been used for estimating the milk production capabilities of sheep. The most common of these involve the use of exogenous oxytocin therapy of the ewe and the weigh suckle weigh method used with ewes and lambs. Milk production estimates made by actual milking of sheep in a dairy setting are only now becoming more common.

Geenty (1979) used exogenous hormone therapy in the form of oxytocin injections for estimation of overall milk production in sheep. This method has been widely used in milking studies but is considered to give an overestimation of the milk production capability of the ewe.

Heap et al. (1986) researched the effectiveness of using oxytocin treatment for removal of residual milk. The mean lactation yield for the ewes prior to any injection was 293 ± 26 kg
for the milking period (Heap et al., 1986). The lactation period was 33 to 37 wk in length and ewes had an average daily milk yield of 1 to 2 kg per d. The highest ewe produced 3.7 kg per d.

Sheep that were given saline injection had milk yields that were fairly constant at both morning and evening milkings. A 9% difference was noted in overall milk production. Sheep given the oxytocin treatment had significant increases in the milk yields, 27%, as compared to the ewes treated with saline. On average, residual milk secretion accounted for 7.4% and 27.2% increases in overall milk production for ewes treated with saline and oxytocin, respectively (Heap et al., 1986).

Heap et al. (1986) established test periods that were carried out at 2-wk periods throughout the lactation cycle of the ewes between April and late September. The periods were as follows: period one and two were carried out between 3 to 10 wk postpartum, period three and four took place during mid lactation, between 10 to 17 wk postpartum, and period five took place in late lactation weeks 26 to 34. During period five ewes were only milked once a day due to low milk yields (Heap et al., 1986).

The amount of residual milk did not change significantly between the test periods with the exception of periods four and five. At this stage, ewe milk production was decreasing and milking in period five took place only once daily, which could also contribute to the change (Heap et al., 1986).

Use of low levels of oxytocin injected following regular milking and then repeating milking significantly increased milk yields on the ewes tested by increasing let-down and decreasing residual milk (Heap et al., 1986). The increase in milk yield was best observed in
test periods one, two, three, and four. Test period five did not show a significant increase in milk yield due to the naturally decreasing milk yield of the ewes as they dropped out of production and the subsequent change to once-a-day milking.

As milk secretion rate is somewhat dependent on the udder being milked out, it is felt that yields in oxytocin-treated sheep had increased values due to the more complete emptying of the alveoli and gland cistern (Heap et al., 1986). With use of saline, some milk was left in the gland and this may have limited the amount of milk produced for the following milking. The secretion rate of ewes treated with oxytocin was not significantly different between long and short milking intervals. In saline-treated sheep, however, there was a numerical difference between the periods but it was not statistically significant (Heap et al., 1986).

Overall, the daily milk yield in sheep treated with exogenous oxytocin increased 10% with a low-dose injection. The neural-hormonal release of endogenous oxytocin is the mechanism responsible for milk let-down at normal milkings (Heap et al., 1986).

**Mastitis Prevention**

Mastitis is a problem with which all dairies must deal. In establishing a dairy it is important to make sure that facilities and equipment are maintained in a manner that minimizes animal stress. Increased stress can increase the occurrence of mastitis. Proper adjustment of milking equipment, as to vacuum pressure regulation and pulsation rate, is essential for maintenance of good udder health. Also important is keeping udders clean and free of wool through use of regular shearing or flaming (burning the wool off the udder of the ewe with use
of fire). Use of pre-dips currently approved for cattle is also an important step in preventing mastitis (Smith and Hogan, 1992).

Mastitis treatment commonly involves the use of intramammary infusion of antibiotic. It is important that withholding times be observed with the use of any antibiotic treatment. It is important to note that there are currently no antibiotics licensed specifically for sheep in the dairy industry. This leads to “extra label” use of drugs currently utilized for treating dairy cattle. As this is the case, it is extremely important that any drugs used be used in conjunction with veterinary consultation and recommendations on withholding times.

Use of intramammary infusions of antibiotics for mastitis treatment have also changed to a large extent. The currently approved method of infusing an animal is to insert the applicator only part way into the teat. Partial insertion reduces the damage to the teat and the teat keratin. Care at the time of treatment can speed healing time and decrease the chance of reinfection (Belschner, 1992).
METHODS AND PROCEDURES

Methods

Twelve Navajo-Churro ewes and 12 Western Whiteface Range ewes were utilized in this study. Ewes were randomly selected based on the birthdate of their lambs, the last 12 animals to lamb being the ones selected for the study. Birthdate of lambs was used as the selection criterion in order to more closely match days in lactation of the ewes in the dairy barn. Ewes were housed at the original USU Ovine dairy. All ewes were 3 yr of age and in their second parity. There was a 1-mo difference in the lambing season of the two types of sheep utilized in the study. Western Whiteface ewes lambed in May and the Navajo-Churro ewes lambed in June. Ewes had access to ad libitum alfalfa hay in the loafing area and an 80:20 mix of rolled barley and corn grain (Table 7) while in the milking barn. Shelter was provided and ewes were bedded on clean oat straw.

Lambs were housed with ewes until weaning at 39 d of age, at which time they were moved to another holding area. Lambs ate alfalfa hay ad libitum and creep feed (Table 7). No milk replacer was provided for the lambs, only the 16.1% protein creep diet. Lambs were checked twice daily and herd health practices were maintained. Animal management, in regards to maintenance of animal health, and facilities maintenance were under the current auspices of the Institutional Animal Care and Use Committee and The Animal Welfare Act. A Utah State University clinical veterinarian monitored flock health.
Table 7. Feed analysis of alfalfa hay, grain mix, and creep feed

<table>
<thead>
<tr>
<th>Description</th>
<th>Alfalfa Hay</th>
<th>80:20 Barley/Corn</th>
<th>Creep 6-19</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>As Sampled</td>
<td>Dry Matter</td>
<td>As Sampled</td>
</tr>
<tr>
<td>Moisture %</td>
<td>6.9</td>
<td>10.3</td>
<td>100.0</td>
</tr>
<tr>
<td>DM %</td>
<td>93.1</td>
<td>100.0</td>
<td>89.7</td>
</tr>
<tr>
<td>CP %</td>
<td>15.6</td>
<td>16.8</td>
<td>11.4</td>
</tr>
<tr>
<td>ADF %</td>
<td>33.2</td>
<td>35.7</td>
<td>5.9</td>
</tr>
<tr>
<td>TDN</td>
<td>52.37</td>
<td>56.25</td>
<td></td>
</tr>
<tr>
<td>NEL Mcal/kg</td>
<td>1.17</td>
<td>1.26</td>
<td>0.78</td>
</tr>
<tr>
<td>NEM Mcal/kg</td>
<td>1.10</td>
<td>1.18</td>
<td></td>
</tr>
<tr>
<td>NEG Mcal/kg</td>
<td>0.58</td>
<td>0.62</td>
<td></td>
</tr>
<tr>
<td>Ca %</td>
<td>1.05</td>
<td>1.13</td>
<td>0.04</td>
</tr>
<tr>
<td>P %</td>
<td>0.23</td>
<td>0.25</td>
<td>0.29</td>
</tr>
</tbody>
</table>

DM - Dry Matter; CP - Crude Protein; ADF - Acid Detergent Fiber; TDN - Total Digestable Nutrients; NEL - Net Energy Lactation; NEM - Net Energy Maintenance; NEG - Net Energy Gain; Ca - Calcium; P - Phosphorous.

Procedures

Lambs were weaned at 39 d of age. Upon weaning the ewes were moved a pen near the milking barn and were milked the first time approximately 12 h following weaning. Ewes were milked twice daily at 5 am and 5 pm. Navajo-Churro and Western Whiteface ewes were brought into the milking barn separately. Milk yield was measured in milliliters produced for each ewe at each milking and composite group milk samples were taken at 2-wk intervals. Samples were analyzed by the Dairy Herd Improvement Association and the Utah State University Nutrition and Food Science Department for fat, protein, solids non-fat, lactose, and somatic cells.
Ewes were provided free choice grain mix while in the milking barn. This aided animal movement through the parlor and kept animals calmer during milking.

Ewes were milked with a portable cow vacuum pump, and bucket milking system. Milk was collected in the bucket and later cooled with use of a refrigerator freezer. Ewes were milked at 10" Hg with a pulsation rate of 120 pulsations/minute. The pulsator and teat cup liners were imported from Europe and are designed specifically for use with sheep. Equipment was cleaned following each milking using approved dairy equipment cleaning chemicals. The milking equipment was also cleaned with warm water between breed types entering the barn.

Six ewes were milked at a time with the use of a stanchion headgate system. Prior to milking, ewes udders were cleaned with a cattle dairy iodine teat dip and wiped dry using an individual, disposable towel for each. Following removal of the milking machine, each ewe was again dipped with a dairy dip.

After milking, ewes were returned to their pen and given *ad libitum* access to alfalfa hay. Clean water and shelter were provided.
RESULTS AND DISCUSSION

The idea of milking sheep has raised many questions. For example, is it possible to milk sheep and make a profit? This research was aimed at measuring the ability of Navajo-Churro and Western Whiteface sheep present in Utah.

Research into milk production of sheep in the United States has mainly been in the form of estimating milk production. Snowder and Glimp (1991) completed research that investigated the differences in milk production based on litter size. Milk estimation using this method is fine for use in a non-dairy setting, but great differences in overall production will be found in a dairy setting. Snowder and Glimp (1991) milked ewes that had their lambs present with them throughout the milking period. Lambs were removed for only a short period of time before the ewes were milked. Milk let-down was induced through the use of oxytocin, which is not practical for a dairy setting but was needed to help induce milk letdown in a stressful situation. Litter size in a dairy setting does not make a large difference in the production level of the ewes. In a dairy, ewes are milked regularly and evenly on both sides to attain the highest level of production. Single lambs cannot draw off the total amount of milk produced in a high-producing ewe and therefore her production level will decrease in a short period of time due to negative feedback from pressure in the mammary system. Twins and triplets, on the other hand, will work to keep milk production high as more lambs are able to withdraw more milk. Therefore, multiple births of lambs in a dairy setting does not greatly affect the overall milk production of the dairy ewe. Research that has been done with range ewes does demonstrate
the ability of these sheep to produce in the milking parlor. Definite differences in production
level of Navajo-Churro and Western Whiteface sheep have been demonstrated.

The two types of sheep selected were Navajo-Churro and Western Whiteface. Differences in milk production level between and within the two groups of sheep were assessed. Because the group variances were unequal, t' rather than a t-test was used to analyze the data involving breed comparisons. Western Whiteface ewes were significantly higher in milk production than the Navajo-Churro ewes at the \( P < .025 \) level. Table 8 shows the summary of statistics for the overall milk production.

Differences between the amount of milk produced in the morning versus production in the evening between Navajo-Churro and Western Whiteface sheep were also evaluated. A t-test was used to analyze milk production between AM and PM milking on individual animals. For individual subjects, the effect sizes ranged from -.07 to .38. The formula for determining

Table 8. Summary statistics of the overall milk production

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number of Cases</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Separate Variance Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM</td>
<td>am milk production</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Navajo-Churro</td>
<td>12</td>
<td>274.42</td>
<td>98.99</td>
<td>t' Degrees 2-tail Prob</td>
</tr>
<tr>
<td>Western Whiteface</td>
<td>13</td>
<td>419.54</td>
<td>187.00</td>
<td>-2.45 19 .024</td>
</tr>
<tr>
<td>PM</td>
<td>pm milk production</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Navajo-Churro</td>
<td>12</td>
<td>259.00</td>
<td>96.20</td>
<td>t' Degrees 2-tail Prob</td>
</tr>
<tr>
<td>Western Whiteface</td>
<td>13</td>
<td>399.92</td>
<td>183.78</td>
<td>-2.43 18 .026</td>
</tr>
<tr>
<td>TOT</td>
<td>total milk production</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Navajo-Churro</td>
<td>12</td>
<td>266.33</td>
<td>97.15</td>
<td>t' Degrees 2-tail Prob</td>
</tr>
<tr>
<td>Western Whiteface</td>
<td>13</td>
<td>409.31</td>
<td>185.20</td>
<td>-2.44 18 .025</td>
</tr>
</tbody>
</table>
the effect size is as follows:

\[
\text{ES} = \frac{\text{Mean AM production} - \text{Mean PM production}}{(\text{SD AM production} + \text{SD PM production})/2}
\]

The results are shown in Table 9. In addition, Figure 4 compares the average daily milk production of the Navajo-Churro and Western Whiteface ewes. There was no significant difference found between milk production in the morning and that in the evening \((P > .05)\).

Differences in milk production levels between milkers were noticed throughout the lactation cycle. Three personnel were employed in the milking parlor. It was noted that individual animals produced higher or lower quantities of milk in relation to the staff person who was milking.

Western Whiteface ewes overall outperformed the Navajo-Churro ewes. Western Whiteface ewes produced a significantly larger quantity of milk and maintained their production over a significantly longer period of time. Ewe production within groups displayed great variability in the total amount of milk produced/ewe/day.

Table 9. Statistical results for AM and PM milk production

<table>
<thead>
<tr>
<th>Variable</th>
<th># of Cases</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Standardized Mean Difference</th>
<th>t Value</th>
<th>Degrees of Freedom</th>
<th>2-tail Prob</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM</td>
<td>25</td>
<td>356.33 ml</td>
<td>166.49</td>
<td>.10</td>
<td>0.36</td>
<td>48</td>
<td>.73</td>
</tr>
<tr>
<td>PM</td>
<td>25</td>
<td>339.68 ml</td>
<td>161.78</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 4. Comparison chart of Western Whiteface ewes to Navajo-Churro ewes, based on average daily milk production.

Tables 10 and 11 display total ewe milk production, milk produced/ewe/day, and lactation length. None of the Navajo-Churro ewes completed the full milking period length of 90 d. Fifty percent of the Western Whiteface ewes reached the objective of 90 d in the milking parlor, postweaning.
Table 10. Western Whiteface milk production records

<table>
<thead>
<tr>
<th>Ewe #</th>
<th>Length (Days)</th>
<th>Lactation kg's Produced</th>
<th>Average Daily Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>9057</td>
<td>91</td>
<td>74.02</td>
<td>.81/day</td>
</tr>
<tr>
<td>9056</td>
<td>91</td>
<td>112.19</td>
<td>1.23/day</td>
</tr>
<tr>
<td>9089</td>
<td>23.5</td>
<td>18.32</td>
<td>.78/day</td>
</tr>
<tr>
<td>9050</td>
<td>90.5</td>
<td>51.40</td>
<td>.57/day</td>
</tr>
<tr>
<td>9035</td>
<td>87</td>
<td>41.07</td>
<td>.47/day</td>
</tr>
<tr>
<td>9058</td>
<td>90.5</td>
<td>80.11</td>
<td>.89/day</td>
</tr>
<tr>
<td>9093</td>
<td>42</td>
<td>37.0</td>
<td>.88/day</td>
</tr>
<tr>
<td>9074</td>
<td>91.5</td>
<td>120.38</td>
<td>1.32/day</td>
</tr>
<tr>
<td>9075</td>
<td>10.5</td>
<td>11.58</td>
<td>1.10/day</td>
</tr>
<tr>
<td>9082</td>
<td>62</td>
<td>18.01</td>
<td>.29/day</td>
</tr>
<tr>
<td>9060</td>
<td>63.5</td>
<td>22.51</td>
<td>.35/day</td>
</tr>
<tr>
<td>9029</td>
<td>91.5</td>
<td>106.56</td>
<td>1.16/day</td>
</tr>
</tbody>
</table>

Total Milk Production: 693.16 kgs  
Average Overall Production: .83 kgs/day/ewe

Table 11. Navajo-Churro milk production records

<table>
<thead>
<tr>
<th>Ewe #</th>
<th>Length (Days)</th>
<th>kg's Produced</th>
<th>Average Daily Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>9030</td>
<td>19</td>
<td>2.41</td>
<td>.13/day</td>
</tr>
<tr>
<td>9116</td>
<td>56</td>
<td>21.29</td>
<td>.38/day</td>
</tr>
<tr>
<td>9091</td>
<td>73</td>
<td>55.01</td>
<td>.75/day</td>
</tr>
<tr>
<td>9140</td>
<td>75</td>
<td>35.54</td>
<td>.47/day</td>
</tr>
<tr>
<td>9094</td>
<td>30.5</td>
<td>7.02</td>
<td>.23/day</td>
</tr>
<tr>
<td>9043</td>
<td>42.5</td>
<td>20.68</td>
<td>.49/day</td>
</tr>
<tr>
<td>9004</td>
<td>54</td>
<td>24.68</td>
<td>.46/day</td>
</tr>
<tr>
<td>9035</td>
<td>17</td>
<td>13.39</td>
<td>.79/day</td>
</tr>
<tr>
<td>9114</td>
<td>74.5</td>
<td>64.25</td>
<td>.86/day</td>
</tr>
<tr>
<td>9110</td>
<td>53</td>
<td>20.97</td>
<td>.40/day</td>
</tr>
<tr>
<td>9076</td>
<td>71.5</td>
<td>30.67</td>
<td>.43/day</td>
</tr>
<tr>
<td>9117</td>
<td>38.5</td>
<td>17.64</td>
<td>.46/day</td>
</tr>
</tbody>
</table>

Total Milk Production: 313.54 kgs  
Average Overall Production: .52 kgs/day/ewe
Milk was analyzed by the Utah Dairy Herd Improvement Association for butterfat, protein, lactose, solids, non-fat, and somatic cells. Tables 12 and 13 display the composition of milk produced by Navajo-Churro and Western Whiteface ewes.

Table 12. Milk composition of Navajo-Churro ewes

<table>
<thead>
<tr>
<th>Week #</th>
<th>% BF</th>
<th>% PRO</th>
<th>% LAC</th>
<th>% SNF</th>
<th>% SCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 am</td>
<td>4.50</td>
<td>5.61</td>
<td>4.89</td>
<td>11.46</td>
<td>4.84</td>
</tr>
<tr>
<td>pm</td>
<td>5.80</td>
<td>4.31</td>
<td>3.30</td>
<td>8.29</td>
<td>2.10</td>
</tr>
<tr>
<td>2 am</td>
<td>3.78</td>
<td>5.92</td>
<td>5.06</td>
<td>12.00</td>
<td>0.19</td>
</tr>
<tr>
<td>pm</td>
<td>4.01</td>
<td>6.10</td>
<td>5.18</td>
<td>12.33</td>
<td>0.11</td>
</tr>
<tr>
<td>3 am</td>
<td>4.57</td>
<td>6.40</td>
<td>4.90</td>
<td>12.34</td>
<td>0.39</td>
</tr>
<tr>
<td>pm</td>
<td>5.54</td>
<td>6.00</td>
<td>4.47</td>
<td>11.42</td>
<td>0.56</td>
</tr>
<tr>
<td>4 am</td>
<td>17.04a</td>
<td>4.87</td>
<td>3.85</td>
<td>9.43</td>
<td>8.42</td>
</tr>
<tr>
<td>pm</td>
<td>5.99</td>
<td>5.26</td>
<td>3.94</td>
<td>10.03</td>
<td>1.11</td>
</tr>
<tr>
<td>5 am</td>
<td>5.98</td>
<td>6.33</td>
<td>4.66</td>
<td>11.99</td>
<td>0.33</td>
</tr>
</tbody>
</table>

* DHIA analysis provided this numerical value for butterfat in the Churro ewes. Exact reasons for why this value was measured are not known.

BF - Butterfat; PRO - Protein; LAC - Lactose; SNF - Solids, Non-fat; SCC - Somatic Cells
Table 13. Milk composition of Western Whiteface ewes

<table>
<thead>
<tr>
<th>Week #</th>
<th>% BF</th>
<th>% PRO</th>
<th>% LAC</th>
<th>% SNF</th>
<th>% SCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 am</td>
<td>7.06</td>
<td>5.95</td>
<td>4.67</td>
<td>11.57</td>
<td>0.41</td>
</tr>
<tr>
<td>pm</td>
<td>9.76</td>
<td>5.74</td>
<td>4.36</td>
<td>10.98</td>
<td>0.87</td>
</tr>
<tr>
<td>2 am</td>
<td>5.34</td>
<td>5.44</td>
<td>4.84</td>
<td>11.22</td>
<td>1.13</td>
</tr>
<tr>
<td>pm</td>
<td>7.10</td>
<td>4.64</td>
<td>4.34</td>
<td>9.79</td>
<td>1.76</td>
</tr>
<tr>
<td>3 am</td>
<td>3.60</td>
<td>4.45</td>
<td>3.97</td>
<td>9.19</td>
<td>0.53</td>
</tr>
<tr>
<td>pm</td>
<td>6.52</td>
<td>5.96</td>
<td>5.31</td>
<td>12.18</td>
<td>0.96</td>
</tr>
<tr>
<td>4 am</td>
<td>5.11</td>
<td>5.09</td>
<td>4.55</td>
<td>10.52</td>
<td>0.62</td>
</tr>
<tr>
<td>pm</td>
<td>3.37</td>
<td>6.34</td>
<td>6.03</td>
<td>13.51</td>
<td>0.16</td>
</tr>
<tr>
<td>5 am</td>
<td>5.45</td>
<td>5.85</td>
<td>4.90</td>
<td>11.73</td>
<td>0.77</td>
</tr>
<tr>
<td>pm</td>
<td>5.22</td>
<td>6.01</td>
<td>5.02</td>
<td>12.04</td>
<td>0.45</td>
</tr>
<tr>
<td>6 am</td>
<td>5.48</td>
<td>5.90</td>
<td>5.02</td>
<td>11.92</td>
<td>0.82</td>
</tr>
<tr>
<td>pm</td>
<td>6.65</td>
<td>5.77</td>
<td>4.84</td>
<td>11.56</td>
<td>1.14</td>
</tr>
<tr>
<td>7 am</td>
<td>6.86</td>
<td>5.61</td>
<td>4.75</td>
<td>11.29</td>
<td>0.60</td>
</tr>
<tr>
<td>pm</td>
<td>6.52</td>
<td>4.86</td>
<td>3.32</td>
<td>8.90</td>
<td>0.75</td>
</tr>
</tbody>
</table>

BF - Butterfat; PRO - Protein; LAC - Lactose; SNF - Solids, Non-fat; SCC - Somatic Cells
Western Whiteface ewes, overall, produced larger quantities of milk and maintained a longer length of production in the dairy setting. Navajo-Churro ewes did not adjust well to the dairy setting and their milk production was low. Lactation length in the dairy setting was inadequate to provide the amount of milk necessary to support a dairy operation. Because the Navajo-Churro has not previously been in a confinement setting such as was present in the milking operation, this had a large influence on the lactation cycle of the sheep. Through proper selection of animals that are accepting of intensive handling, a milking breed could be produced. The potential for high milk production is present in this breed and the animals just need to be raised to be familiar with the dairy setting. Behavioral research should be continued.

The European Churro is a top milking sheep and the Navajo-Churro can be the same.

All animals were fed in the same manner and had *ad libitum* access to alfalfa hay while in the loafing area, and a grain mix free-choice when in the milking parlor. Composition changes between breeds in other research have generally been due to differences in environmental and genetic differences.

Lambs born to the ewes on this project were successfully weaned at 39 d of age. A milk replacer was not given and was replaced by a 16.1% protein creep feed. Growth of lambs was comparable to lambs left on related ewes lambing at the same time. No negative results were seen in the lambs that were weaned early for use in the milking project.
IMPLICATIONS

Twenty-four ewes represented by Western Whiteface Commercial range type ewes and Navajo-Churro ewes were chosen from Utah State University flocks.

Western Whiteface ewes had higher milk production levels, extended over a longer period of time than Navajo-Churro ewes. Western Whiteface ewes have the potential of being a good dairy breed for the United States. Proper selection and breeding of those animals which adjust quickly to the dairy setting and produce adequate quantities of milk may benefit the sheep dairy industry.

Navajo-Churro ewes produced large quantities of milk for their lambs but did not adjust well to an intensive dairy setting. Proper selection and training are needed to acquaint them with a dairy setting.


