Dairy Sheep

Section 1: Commercial Scale Management & Breeding Procedures

Section 2: Production of Sheepmilk Powder

A report for the Rural Industries Research and Development Corporation

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Management and Breeding Procedures

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Foreword

Sheep dairying is a new Australian livestock industry. Industry participants have recognised expanding domestic and export markets for speciality cheeses that are the major products manufactured from sheep milk. It has been estimated that Australia imports approximately 2,000 tonnes of sheep milk cheeses annually, valued at around $20 million.

This publication reports the outcomes of a series of investigations by AWASSI (Aust) Pty Ltd, Australia’s largest sheep dairy, in which they investigated commercial scale feeding and management systems for the highly productive dairy sheep breed, the Awassi, which the company imported from Israel in 1995.

Sheep dairying is a new Australian rural industry supported under the New Animal Products sub-program of RIRDC.

This project was funded from RIRDC Core Funds which are provided by the Federal Government.

This report, a new addition to RIRDC’s diverse range of over 600 research publications, forms part of our New Animal Products R&D program, which aims to accelerate the development of viable new animal industries.

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- downloads at www.rirdc.gov.au/reports/Index.htm
- purchases at www.rirdc.gov.au/eshop

Peter Core
Managing Director
Rural Industries Research and Development Corporation
Executive Summary

Australia’s largest sheep dairy has been successfully operated by AWASSI (Aust) Pty Ltd at Cowra, NSW for four years. Up to 1,000 ewes, based on the imported AWASSI sheep breed, are milked twice daily in facilities and management systems that reflect world’s best practice.

Up to 12,000 litres of milk have been produced per week. A predictable regular market has existed for 5,000 to 7,000 litres / week – primarily for the production of speciality cheeses. This market has paid $1.15 to $1.20 / litre. We estimate cost of production (not including finance costs and drawings) of approximately $1.05/litre.

Other markets for sheep milk (for production of cheese, milk powder, yoghurt) have been investigated.

In conjunction with the Rural Industries Research and Development Corporation, AWASSI (Aust) Pty Ltd have conducted applied research to investigate the feasibility of this new Australian industry.

Key outcomes of the research conducted under this project include:

- Fully housed lactating ewes consume approximately 5kg fresh (2kg dry matter) of a diet based on pasture (grass / legume) silage, cereal grain (triticale) and a high protein source (whole lupins, cotton seed meal or soybean meal) in approximate proportions of 68% : 27% : 5% on a dry matter basis.

- Increasing the high protein source component of the diet from 5% to 10% (dietary crude protein increased from 16.5% to 17.5%) increased milk yields by about 15% and milk fat content by about 10%.

- Average milk quality parameters are : Fat – 4.6% to 5.2%, Protein – 4.7% to 5.0%, Total Solids – 14.9% to 15.8%.

- A low cost system of rearing lambs (that are removed from their dams within one day after birth) has been developed, based on multiple suckling of lambs by lower production / late lactation ewes.

- In a 84 day lactation monitoring trail, 75% AWASSI ewes peaked at 2.9 litres of milk / day at about day 20 after commencement of lactation, and averaged 2.3 litres / day over the trial period. 50% AWASSI ewes peaked at 2.4 litres / day at about day 20 and averaged 1.9 litres / day over the trial period. Ewes are “dried off” at approximately 0.8L/day – lactation lengths have averaged 150 to 175 days.

- A trial of contemporary lactating ewes run in either a fully housed and lot fed system or at pasture with supplementary feeding (same ration as housed sheep) produced the following results:
  - Housed ewes produced approximately 30% more milk.
  - Unhoused ewes with some access to pasture consumed approximately 15% less of the silage : grain : protein feed mix.
  - Ewes run out of the shed for part of their lactation had a 60 day shorter “dry” period until the subsequent lactation, than ewes fully housed (in artificial light conditions) during lactation. It is hypothesised that this is a response to shorter day length when removed from the ewe housing, leading to earlier resumption of oestrus cycling during lactation.

- An unresolved management problem has been the apparently high susceptibility of Awassi sheep to feet infections (foot abscess, foot rot) in temperate climates.

- A system of computer based recording of ewe genotype, lactation length and lactation yields has been developed.
1. Introduction

AWASSI (Aust) Pty Ltd was registered in NSW in 1990 and its principal activities to date have been the importation of Awassi sheep from Israel to Australia (via quarantine in New Zealand) and the conduct of a sheep dairying operation at Cowra NSW, based on those sheep.

The company has invested approximately $2.4 million of shareholders’ funds to date in the importation of the Awassi sheep and in the establishment of facilities for sheep breeding, management and milking at its base near Cowra, in Central West NSW. The Rural Industries Research and Development Corporation (RIRDC) and AWASSI (Aust) Pty Ltd have jointly invested in the development on the grounds that both are committed to the development of new Australian rural industries based on the unique characteristics of the Awassi sheep.

The first phase of the project (1991 - 1995) supported the importation of a new breed of sheep to Australia - the Awassi. The purpose for the importation was to stimulate the development of a new rural industry in this country - sheep dairying. The project was successful in that 64 purebred Awassi sheep and 292 crossbreds (½ and ¾ Awassi) were imported to Australia in March 1995, having been through a 4 year quarantine period in New Zealand. The sheep were then managed and multiplied in number on a property near Cowra, NSW, where the first milking of ewes commenced in August 1996.

During the period of quarantine in NZ, the foundation Awassi sheep (imported to NZ quarantine as frozen embryos from Israel) were both naturally and artificially bred to increase the population size. Some of the offspring were evaluated for various production traits. In one evaluation, Awassi sired lambs out of Romney and Dorset dams were compared with Texel sired lambs out of comparable dams. There were no significant differences in the birth weights of the two sire groups. Pre and post weaning growth rates of Awassi sired lambs were lower than those of Texel sired lambs. The fleeces of Awassi cross lambs were similar in weight and fibre diameter, higher yielding, longer staple length, lower bulk, more coloured and lower staple strength, than the fleeces of Texel cross lambs.

Due to the absence of sheep milking facilities in the quarantine station in New Zealand, no evaluation of milk traits was possible during the course of the first phase of the project. A small number of ½ bred Awassi ewes were test-milked on arrival in Australia. Early lactation yields were 2 to 4 litres per head per day and cumulative lactation yields, 120 days after commencement of lactation, were 200 to 400 litres per head. These figures compared favourably with previously published figures of lactation yields for Australian bred (Merino x Dorset, Merino x Border Leicester) ewes of 30 to 120 litres per head over 90 to 100 day lactation periods. Preliminary conclusions from these data confirmed existing data from the Israeli flock from which the Awassi sheep were originally selected for importation - that the Awassi sheep had the potential to more than double daily milk yields and increase lactation periods by 50 to 100 per cent, compared to existing Australian sheep breeds.

The development of a viable commercial sheep dairy industry, based on the Awassi sheep, would then be pursued by AWASSI (Aust) Pty Ltd in the next phase. A Business Plan was developed by the company for production and marketing of both sheep dairy and sheep meat products by AWASSI (Aust) Pty Ltd and other commercial industry partners.

This report covers the second phase of the development from 1996 to mid 2000.
2. Objectives

2.1 Broad Aim

By June 2000, to have the information, technology and high quality genetics required for an expansion in the sheep dairy industry in Australia.

2.2 Detailed Objectives

1. Install in-line milk recording equipment and electronic animal identification systems (funded by University of Sydney collaborative project) - October 1997. This would allow Awassi to begin to collect the following data.

- Variation within and between contemporaneously managed groups of 50%, 75% and 87.5% Awassi ewes in milk production and quality.
- Changes over the full lactation duration in milk production and quality for these ewe genotypes.

The need for such studies at a commercial scale had been clearly identified by the UWA project supported by RIRDC and would allow us to ultimately answer the important question - what is an ideal genetic make up for the Australian commercial dairy sheep?

2. With 3 belt line feeders installed in the main sheep house for lactating ewes, there was the capacity to study, in a relatively controlled design, the response (in milk yields and quality) to variations in diet. There were 3 specific experiments proposed in the first two years of the project. Each experiment would involve two nutrition treatments, imposed at a belt line feeder level (up to 350 ewes per treatment), with milk production and quality from each group monitored for 90 days. Ewe genotype and stage of lactation would be stratified to ensure treatment groups did not differ for these characteristics. Basal diets were silage plus cereal grain. Treatments to be evaluated were likely to be:

- Soybean meal versus cotton seed meal as a protein source in a silage/cereal grain based diet. Soybean meal is the major protein source evaluated in overseas sheep dairy research to date. However, cotton seed meal is less expensive in Australia.
- Cotton seed meal versus whole cotton seed. Whole cotton seed is less expensive but higher oil content may have milk quality and management implications.
- The best (most cost effective) protein source identified in the above two studies versus commercially available protected protein meals.

Data would be collected on milk production (daily); milk composition (weekly) for protein, fat, lactose; ewe body weight (weekly) and fat score. Total feed intake would be recorded and rations analysed for energy, protein, minerals and other key nutritional indicators.

The outcome of these experiments would be recommendations on the most cost effective diet for commercial dairy sheep. Further diet studies were also foreshadowed, including investigation of appropriate feeding level and diet composition for ewes at different stages of lactation. Awassi (Aust) were already conducting preliminary investigations of these issues - practical experience has indicated that over-feeding leading to over-fatness of ewes in late lactation may not only be costly but also have deleterious effects on subsequent lactation performance. In addition to the large scale (feed belt line) nutrition studies proposed, Awassi (Aust) had the capacity to simultaneously evaluate up to 3 feed treatments with small pens of sheep (10 sheep/group).
3. While the Awassi (Aust) Pty Ltd sheep dairy is currently based on fully housed ewes, Mr Grant of Awassi (Aust) and from the property interests near Cowra intended to investigate the management and nutrition implications of running a group of lactating ewes in an unhoused environment. Successful management of lactating ewes in this way would demonstrate to new commercial sheep dairy operators whether the high cost of sheep housing can be, at least in part, avoided. Contemporaneous groups of ewes would be fed identical diets in either housed or unhoused conditions, and milk production, milk quality measured, labour and feed costs recorded and animal health parameters monitored.

4. Based on data on individual ewe milk yields and quality and on individual animal pedigree records, Awassi (Aust) Pty Ltd would consult with a geneticist to develop a performance recording system for the “Australian Milking Sheep”. Questions to be answered include:

- What is the optimum proportion of Awassi genes in commercial milking sheep?
- What is the most effective structure for this parent flock (open nucleus, tiered stud and commercial flocks)?
- Can DNA marker assisted selection (University of Sydney project) improve upon estimated breeding values for sires for milk production based on daughter and dam production records?

It is intended that the breeding and performance recording system would be designed with an expanding commercial sheep dairy industry in mind - so that performance data in commercial dairy flocks can be fed back to a centralised recording system.

5. Awassi (Aust) recognised the importance of sheep milk processing studies to enhance the demand for sheep milk by Australian processors supplying domestic and/or export markets. Our project reference group includes Dr Roberta Bencini (UWA) and Dr Allan Nichols (CSU - Wagga), both of whom have research activities in sheep milk processing and product development. Other contacts have been established with commercial processors and dairy product research groups elsewhere. Awassi (Aust) undertook to collaborate with such research and development groups, including supply of sheep milk for research purposes.
3. Methodology

3.1 Milk Recording Equipment and Animal Identification

Under a related project with the University of Sydney (Orange Ag College), an integrated in-line milk recording and electronic animal identification system was planned to be installed in the AWASSI (Aust) Pty Ltd sheep dairy by late 1997. The automatic, digital milk recording system was installed in the dairy in March 1998 and after several months of testing, was found to be satisfactory for recording individual ewe milk volumes. The University of Sydney supplied 1,000 transponders for individual ewe identification and it was planned to fix these to the rear leg of lactating ewes to allow electronic interrogation of the transponder during milking in the pit, herringbone milking parlour. However, the reader for these transponders could not operate reliably and AWASSI (Aust) Pty Ltd proceeded with normal, physical leg tags which were visually recorded for the duration of lactation trials.

3.2 Evaluation of a range of sources and proportions of protein in the diets of lactating ewes.

On 3 January 1998, approximately 700 lactating ewes were stratified according to stage of lactation and genotype and allocated to 5 pens within the dairy shed at the Cowra farm.

Pen 1 - 160 mid to late lactation ewes
Pen 2 - 120 early lactation ewes
Pen 3 - 160 mid to late lactation ewes
Pen 4 - 120 early lactation ewes
Pen 5 - 133 early to mid lactation ewes

Pens 1 & 2 had access to a common feeding source, Pens 3 & 4 had access to a separate common feeding source. Pen 5 had access to a third feeding source.

In the period 3 January 1998 to 29 January 1998, all pens had access to the same feed supply. This was a silage (ryegrass/clover), grain (triticale) and cotton seed meal mix in the following proportions on a dry matter basis - 68%:27%:5%.

Nutritional analysis of the diet ingredients were:

Silage -
12.2% crude protein
71.5% digestibility
10.2 MJ/kg dm energy

Triticale -
9.5% crude protein
13 MJ/kg dm energy

The feed mix was fed at the rate of approximately 5kg/ewe/day (2kg dry matter).

On 30 January 1998 Pens 1 & 2 (on a common feeding source) had their 5% cotton seed meal replaced by 4% soybean meal. Pens 3 & 4 (on a common feeding source) had their 5% cotton seed meal replaced by 10% cotton seed meal. Pen 5 remained on 5% cotton seed meal. On 5 February 1998 pens 1 & 2 had their soybean meal increased to 8.2% of the mix (on a dry matter basis) - this rate of soybean meal supplied equivalent protein to the 10% cotton seed meal provided to pens 3 & 4.

Throughout the trial, data were collected on the following parameters:
Feed consumption - daily total consumption on each feeding source from 6 January 1998 to 18 March 1998.

Ewe live weights - 10 ewes per pen weighed on 5 occasions throughout the trial (16 January, 10 February, 25 February, 10 March, 21 March).

Milk yield - total milk yield per pen, recorded at each milking (morning and afternoon) from 6 January 1998 to 18 March 1998.

Milk quality - Fat %, Protein % and Total solids % recorded from samples collected on 5 occasions throughout the trial (29 January am, 11 February am, 22 February am, 10 March am, 10 March pm).

3.3 Evaluation of Milk Yields from ewes of different genotypes at different lactation stages.

40 Awassi x Dorset ewes (50% Awassi) and 40 Awassi x (Awassi x Dorset) ewes (75% Awassi) participated in the trial. All ewes were on their second or later lactation. All ewes lambed between 30 July 1998 and 25 August 1998. As is standard practice at Awassi (Aust), all ewes spend a minimum amount of time post parturition with lambs at foot to allow lambs to “harvest” colostrum (less than 24 hours). Ewes are not milked in this period. After this period, ewes were moved to the milking shed and lambs were artificially reared on milk replacer. Milk yield recording commenced on the first Monday after ewes were moved into the milking shed.

Total daily milk yield (sum of morning and afternoon milk yield) was recorded for each ewe, once per week (every Monday) for the duration of the trial – 12 weeks. A small number of ewes (8 x 50% Awassi, 4 x 75% Awassi) were removed from the trial before week 12, when their milk yield fell below 1 litre/day – as was standard practice at Awassi (Aust).

3.4 Evaluation of Milk Yields and other management issues with unhoused lactating ewes.

There are two reasons for evaluating the performance of unhoused lactating ewes:

1. New entrants to the sheep dairy industry may not wish (or have the capital required) to maintain lactating ewes in a fully housed, lot fed environment. This trial would identify any management or animal health implications of running ewes at pasture with appropriate supplementary feeding, and bringing them into the dairy shed only for twice daily milking.

2. Under the fully housed management regime, lactating ewes are subject to a constant 16 hours of light per day. This regime overrides the normal oestrous cycling trends which are influenced by seasonal increases and decreases in day length. The outcome is that ewes (which may be in lactation for 125 – 150 days) generally do not cycle during lactation. Experience has shown that they cycle about 40 days after removal from the shed (into shorter day length) at the end of lactation. If successfully mated immediately, the ewes will only lamb at about 12 month intervals. The hypothesis is that if we could induce cycling in lactating ewes (by controlling the light regime in shed or by running them outside the shed under natural daylight conditions for at least a portion of their lactation) and mate them prior to the end of their lactation, we could reduce lambing intervals to about 8 months – increasing the annual milk production per ewe dramatically.

Two groups of ewes, balanced as close as practically possible for stage of lactation and ewe genotype, were involved in the trial.
<table>
<thead>
<tr>
<th>Treatment Group</th>
<th>Number in group</th>
<th>Ewe Genotype</th>
<th>Ave stage of lactation*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Housed</td>
<td>87</td>
<td>15, 75% AWASSI; 72, 50% AWASSI</td>
<td>42 days</td>
</tr>
<tr>
<td>Unhoused</td>
<td>88</td>
<td>10, 75% AWASSI; 78, 50% AWASSI</td>
<td>50 days</td>
</tr>
</tbody>
</table>

* At date when unhoused group of ewes was moved outside (19 May 1999)

Ewes in the unhoused group, had on average spent the first 50 days of their lactation in the shed (range 20 days to 80 days). The unhoused group were moved to a small grazing paddock adjacent to the milking shed after milking on 19 May 1999.

Both housed and unhoused groups were offered similar daily quantities of a silage (pasture), grain (triticale), cotton seed meal, lupin, mineral mix in the following proportions on a dry matter basis – 62% : 28% : 5% : 4% : 1%.

The unhoused ewes also had access to an annual grass / cape weed based pasture.

Ewes in both groups were milked twice daily. Milk yields of individual ewes in each group were recorded fortnightly at a morning milking from commencement of lactation. Total daily milk yield was estimated by multiplying morning milk yield by a factor which accounted for the proportion of total daily yield produced at the morning milking. This factor was established by periodic recording of both morning and afternoon yields. Teaser rams were run with both groups of ewes to allow observation of oestrous cycling activity.

A sample of ewes in each group were body weighed periodically.

### 3.5 Evaluation of alternative sources of protein in the diet of lactating ewes

Feed costs are a significant proportion of the operating costs of an intensive sheep dairy enterprise – estimated at approximately 10c/litre of milk produced. This project has previously evaluated the impact on milk yield and quality of alternative protein sources in a silage / cereal grain based diet for lactating ewes (soybean meal versus cotton seed meal) and of varying the level of cotton seed meal from 5% to 10% of the diet. In this trial we evaluated the provision of an additional protein source, whole lupins, in the diet of lactating ewes.

Two groups of 320 mid to late lactation ewes, balanced as closely as practically possible for stage of lactation and ewe genotype, were involved in the trial, commencing on 1 February 1999. For 2 weeks, both groups of ewes were fed a base ration in the dairy shed, comprising triticale grain, legume / grass pasture silage, cotton seed meal and minerals in the following proportions on a dry matter basis – 28% : 66% : 5% : 1%. The estimated crude protein content of this base diet mix was 16.5%. On 16 February 1999, one group of ewes were introduced to a new diet comprising triticale grain, legume / grass pasture silage, cotton seed meal, whole lupins and minerals in the following proportions on a dry matter basis – 28% : 62% : 5% : 4% : 1%. The estimated crude protein content of this trial diet was 17.3%.

Both groups of ewes were offered the same quantity of feed daily. Average daily feed consumption per ewe was estimated by weighing daily residuals.

Average daily milk yield per ewe was measured once per week.
The trial continued for 10 weeks after the introduction of the trial diet for one of the groups and concluded on 26 April 1999.

### 3.6 Evaluation of appropriate feeding level and diet composition for ewes at different stages of lactation

Understanding the lactation curves and other indicators of physiological state such as body weight and condition score of milking animals, is important from several perspectives:
- As a selection tool for identifying superior performing animals for breeding;
- As a management tool to adjust, where possible, quantity and quality of diet to optimise productivity and profitability.

Data have been collected on milk yields, milk quality, feed consumption and liveweight changes of ewes throughout several lactations.
4. Results

4.1 Performance Recording

Limited progress has been made during the course of the project towards implementing a structured performance recording system. A sheep diary recording software package developed in Europe, “Sheep Milk Parlour”, has been trialed. Ewe identity, genotype (% Awassi), ewe age, date of start and finish of lactation, daily milk yields and some other scored information has been recorded on the system.

4.2 Evaluation of a range of sources and proportions of protein in the diets of lactating ewes.

4.2.1 Feed Consumption

Total feed consumption by the different treatment groups from 30 January 1998 to 18 March 1998 was as follows:

Pens 1 & 2 (8.2% soybean meal) - 67.4 tonnes. Approximately 5.0kg/ewe/day (2kg dm).

Pens 2 & 3 (10% cotton seed meal) - 66.3 tonnes. Approximately 4.9kg/ewe/day (2kg dm)

Feed consumption could not be recorded in pen 5 because sheep in that pen had access to a feed source also accessed by another group of ewes which varied in number throughout the course of the trial.

4.2.2 Ewe live weights

Average live weights of a sample of 10 ewes from each pen at the start and end of the trial were as follows.

<table>
<thead>
<tr>
<th>Pen</th>
<th>Treatment</th>
<th>Start (16/1)</th>
<th>Finish (21/3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8.2% soybean</td>
<td>80.8 kg</td>
<td>82.4 kg</td>
</tr>
<tr>
<td>2</td>
<td>8.2% soybean</td>
<td>68.2 kg</td>
<td>69.6 kg</td>
</tr>
<tr>
<td>3</td>
<td>10% cotton seed</td>
<td>82.0 kg</td>
<td>84.7 kg</td>
</tr>
<tr>
<td>4</td>
<td>10% cotton seed</td>
<td>69.0 kg</td>
<td>70.5 kg</td>
</tr>
<tr>
<td>5</td>
<td>5% cotton seed</td>
<td>65.4 kg</td>
<td>67.5 kg</td>
</tr>
</tbody>
</table>

There appear to have been no significant differences between groups in live weight and live weight change. All ewe groups gained 1.5 to 2.5kg live weight over the 9 weeks of lactation in which measurements were recorded.
4.2.3 Milk Yields

Total milk yields measured at each milking for each pen were divided by the number of ewes in each pen to estimate an average daily milk yield/ewe in each pen. For the period in which the different protein meal treatments were imposed (31/1/98 to 18/3/98) the estimated daily milk production/ewe in each pen/treatment were as follows:

<table>
<thead>
<tr>
<th>Period</th>
<th>Pens</th>
<th>Treatment</th>
<th>Av Daily Milk Yield/Ewe (litres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>31/1-6/2</td>
<td>1,2</td>
<td>8.2% soybean</td>
<td>1.32</td>
</tr>
<tr>
<td></td>
<td>3,4</td>
<td>10% cotton seed</td>
<td>1.35</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>5% cotton seed</td>
<td>1.15</td>
</tr>
<tr>
<td>7/2 - 13/2</td>
<td>1,2</td>
<td>8.2% soybean</td>
<td>1.22</td>
</tr>
<tr>
<td></td>
<td>3,4</td>
<td>10% cotton seed</td>
<td>1.06</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>5% cotton seed</td>
<td>1.05</td>
</tr>
<tr>
<td>14/2 - 20/2</td>
<td>1,2</td>
<td>8.2% soybean</td>
<td>1.12</td>
</tr>
<tr>
<td></td>
<td>3,4</td>
<td>10% cotton seed</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>5% cotton seed</td>
<td>1.00</td>
</tr>
<tr>
<td>21/2 - 27/2</td>
<td>1,2</td>
<td>8.2% soybean</td>
<td>1.04</td>
</tr>
<tr>
<td></td>
<td>3,4</td>
<td>10% cotton seed</td>
<td>1.06</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>5% cotton seed</td>
<td>0.95</td>
</tr>
<tr>
<td>28/2 - 6/3</td>
<td>1,2</td>
<td>8.2% soybean</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>3,4</td>
<td>10% cotton seed</td>
<td>1.03</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>5% cotton seed</td>
<td>0.91</td>
</tr>
<tr>
<td>7/3 - 13/3</td>
<td>1,2</td>
<td>8.2% soybean</td>
<td>0.93</td>
</tr>
<tr>
<td></td>
<td>3,4</td>
<td>10% cotton seed</td>
<td>0.96</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>5% cotton seed</td>
<td>0.83</td>
</tr>
<tr>
<td>14/3 - 18/3</td>
<td>1,2</td>
<td>8.2% soybean</td>
<td>0.89</td>
</tr>
<tr>
<td></td>
<td>3,4</td>
<td>10% cotton seed</td>
<td>0.95</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>5% cotton seed</td>
<td>0.81</td>
</tr>
<tr>
<td>Total Period</td>
<td>1,2</td>
<td>8.2% soybean</td>
<td>1.08</td>
</tr>
<tr>
<td></td>
<td>3,4</td>
<td>10% cotton seed</td>
<td>1.11</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>5% cotton seed</td>
<td>0.96</td>
</tr>
</tbody>
</table>

There appeared to be no significant differences in milk yields between the soybean meal and high cotton seed meal diets. Although the ewes receiving the low cotton seed meal were not strictly a control (ewes were on average at a slightly different stage of lactation), they produced approximately 12% lower milk yields over the whole trial period than the other two treatments.

4.2.4 Milk Quality

The average of milk quality parameters for milk samples taken from each pen/treatment on 4 occasions are shown in the following table. Note, measurements taken on samples collected at the fifth sampling time were deleted from these analyses because the sample was taken at the afternoon milking whereas all other samples were taken at the morning milking.

<table>
<thead>
<tr>
<th>Pens</th>
<th>Treatment</th>
<th>% Fat</th>
<th>% Protein</th>
<th>% Total Solids</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,2</td>
<td>8.2% soybean</td>
<td>5.2</td>
<td>5.0</td>
<td>15.8</td>
</tr>
<tr>
<td>3,4</td>
<td>10% cotton seed</td>
<td>5.1</td>
<td>5.0</td>
<td>15.8</td>
</tr>
<tr>
<td>5</td>
<td>5% cotton seed</td>
<td>4.6</td>
<td>4.7</td>
<td>14.9</td>
</tr>
</tbody>
</table>
There appeared to be no significant milk quality differences between milk sampled from ewes consuming soybean meal or high cotton seed meal. Milk collected from ewes consuming a diet with lower levels of cotton seed meal contained 10% less fat, 6% less protein and 6% less total solids.

4.3 Evaluation of Milk Yields from ewes of different genotypes at different lactation stages

Average daily milk yields for the 50% Awassi ewes peaked at 2.4 litres in week 3, averaged 1.9 litres per day over the 12 weeks of the trial, and had declined to 1.5 litres per day in week 12.

Average daily milk yields for the 75% Awassi ewes peaked at 2.9 litres in week 3, averaged 2.3 litres per day over the 12 weeks of the trial, and had declined to 1.6 litres per day in week 12.

It was interesting to note that there were some 50% Awassi ewes which had daily milk yields as high as the highest yielding 75% Awassi ewes. The highest yielding in the trial was a 50% Awassi ewe which averaged 3.4 litres/day – an estimated total yield over the 12 week trial of 284 litres.

On average, the 50% Awassi ewes yielded a total of 153 litres over the 12 week trial period, while the 75% Awassi ewes yielded 182 litres.

Figure 1 shows the higher peak yield of the 75% Awassi ewes. It also shows that both genotypes had declined to a similar level of daily production by the end of the trial. The histograms in figure 1 show the daily production figure for each genotype in each week, expressed as a % of week 12 yield. For example, in week 3 – the peak yield period for both genotypes – the 75% Awassi ewes were producing 183% of their final daily yield, and the 50% Awassi ewes were producing 156% of their final daily yield.

Figure 1
Figure 2 shows the variation in estimated total (12 week) milk yield for individual ewes of each genotype. There is obviously a wide range of yields within each genotype, with a skewness of yields by 75% Awassi ewes towards the upper end of the yield distribution.

**Figure 2**

![Distribution of Milk Yields](image)

**4.4 Evaluation of Milk Yields and other Management issues with unhoused lactating ewes**

**4.4.1 Milk Yields**

The estimated daily milk yield of housed and unhoused groups of ewes are shown in Figure 3. The reasonably balanced nature of both groups is shown in the similarity of the average daily milk yields of both groups to week 12, when the unhoused group was moved out of the milk shed. Peak average daily yields in weeks 2 to 4 of lactation of 2.5 to 2.7 litres/day for both groups are consistent with earlier data from this project. Both groups were producing about 1.6 litres per day at week 12, at which point the unhoused group were moved out of the dairy shed and onto pasture.

After 4 weeks outside the dairy shed, the daily milk yields of that group had declined to 1.1 litres/day. At the same stage, the contemporary housed group produced 1.4 litres/day, 29% more than the unhoused group. Over the ensuing 4 weeks until the termination of the trial on 14 July 1999, both groups maintained relatively stable daily milk yields (unhoused 1.2 litres/day; housed 1.6 litres/day).
4.4.2 Feed Intake

Estimated daily feed mix intake of both groups of ewes, were as follows:

Housed : 4.8kg/ewe/day (1.9kg d.m.)
Unhoused : 4.1kg/ewe/day (1.6kg d.m.)

4.4.3 Live weight

The data on liveweight are not comprehensive. Phillip Grant, dairy manager, estimates that the unhoused group of ewes lost an average of 2kg liveweight after about 4 weeks outside the dairy shed. The contemporary housed group lost an average of 0.5kg liveweight over the same period.

4.4.4 Oestrous Cycling Activity

Four ewes in the unhoused group and three in the housed group were marked by teasers. Unfortunately, management constraints precluded further collection of oestrous cycling data.

The trial of unhoused versus housed lactating ewes was extended in late 1999 and the results are summarised below.

1. The lactation curves of 50% AWASSI and 75% AWASSI ewes run either entirely in a shedded environment (inside) or run outside the shed for the majority of their lactation (moved outside usually 4 to 6 weeks after commencing lactation) are shown in the following figure (Figure 4).
Features of this figure are:

- Fully shedded (inside) ewes generally yielded about 0.4 litres / day more milk than their counterparts that were run outside the shed. This approximate 27% yield advantage to the shedded ewes was similar to that reported in the preliminary trial results (29% yield advantage to shedded ewes in that trial).

- The lactation curves for both shedded and outside ewes showed similar patterns (at least up to week 16 of lactation).

2. The computerised performance recording system (see 4.1) allows us to review the lambing interval of ewes. We have contrasted the interval between “dry off” and re-entry to the milking shed of ewes that had been exposed to a period outside the shed during the previous lactation with that for ewes which were shedded for the entire lactation.

In the database at that stage, there were records for 141 ewes that have been recorded for more than 1 lactation. Of these, 128 had been shedded for their entire first recorded lactation, while 13 had spent at least part of their first recorded lactation outdoors. Although the numbers are small, an interesting difference in lactation interval between these groups of ewes was recorded.

**Ewes shedded during lactation:**
Average interval between “dry off” and recommencement of lactation – 173 days (range 80 to 250 days)

**Ewes run outside the shed for part of lactation:**
Average interval between “dry off” and recommencement of lactation – 110 days (range 43 to 132 days)
4.5 Evaluation of alternative sources of protein in the diet of lactating ewes

Average daily feed consumption / ewe (on a fresh weight basis) in each of the 2 groups is shown in the following Figure (Figure 5). Week 4 corresponds to the first week in which the lupins were added to the diet mix of the treatment group. Average daily feed intake of the control group over the 10 week trial period, was 4.39kg/day (1.65kg d.m.), while in the lupin treatment group it was 4.53kg/day (1.75kg d.m.) – 6% higher on a dry matter basis.

**Figure 5**

![Feed Consumption - control & lupin based groups](image)

Average daily milk yield / ewe in each of the 2 groups is shown in the next figure (Figure 6). Average daily milk yield of the control group in the period week 4 to week 13 inclusive was 1.22 litres/ewe/day, while in the lupin treatment group it was 1.38 litres/ewe/day – an increase of 13%.

**Figure 6**

![Milk Yield - control & lupin based groups](image)
4.6 Evaluation of appropriate feeding levels and diet composition for ewes at different stages of lactation

4.6.1 Milk Yield

Figures 7 and 8 indicate the lactation curves (daily milk yield) for different groups of ewes over two 12 week monitoring periods. In figure 7, the daily yields of two different ewe genotypes are plotted, commencing at one week after lactation commenced (lambing) and continuing to week 12 (mid lactation). Figure 8 shows a plot of the daily yields of two groups of ewes (mixed genotypes; mixed stage of lactation, but averaging mid lactation at the commencement of the monitoring period) fed different diets over a 13 week period to late lactation. One diet (control) contained triticale grain, legume / grass pasture silage, cotton seed meal and minerals in a 28% : 66% : 5% : 1% mix (dry matter basis). The other diet contained triticale grain, legume / grass pasture silage, cotton seed meal, whole lupins and minerals in a 28% : 62% : 5% : 4% : 1% mix.

Figure 7

![Awassi Average Daily Milk Yields](image-url)
4.6.2 Milk Quality

Milk quality data is relatively limited at this stage. More extensive data will be available when results from regular (fortnightly) group sampling over a 6 month period are received from Charles Sturt University and from individual animal sampling over a full lactation are received from Sydney University. The table below presents information on 3 key milk quality parameters measured on samples collected over a 7 week period from groups of mid lactation ewes fed 3 different diets containing varying levels, and different types, of protein meal.

Milk quality changes through lactation on 3 diets

<table>
<thead>
<tr>
<th>Diet</th>
<th>Sampling Time</th>
<th>% Fat</th>
<th>% Protein</th>
<th>% Total Solids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Triticale grain, pasture silage + 8% soybean meal.</td>
<td>Week 1</td>
<td>5.45</td>
<td>4.61</td>
<td>15.70</td>
</tr>
<tr>
<td></td>
<td>Week 3</td>
<td>5.81</td>
<td>5.04</td>
<td>16.38</td>
</tr>
<tr>
<td></td>
<td>Week 5</td>
<td>5.76</td>
<td>4.98</td>
<td>16.62</td>
</tr>
<tr>
<td></td>
<td>Week 7</td>
<td>4.31</td>
<td>5.39</td>
<td>15.10</td>
</tr>
<tr>
<td>Triticale grain, pasture silage + 5% cotton seed meal.</td>
<td>Week 1</td>
<td>5.09</td>
<td>4.53</td>
<td>15.09</td>
</tr>
<tr>
<td></td>
<td>Week 3</td>
<td>4.92</td>
<td>4.71</td>
<td>15.13</td>
</tr>
<tr>
<td></td>
<td>Week 5</td>
<td>4.78</td>
<td>4.68</td>
<td>15.13</td>
</tr>
<tr>
<td></td>
<td>Week 7</td>
<td>3.92</td>
<td>5.09</td>
<td>14.95</td>
</tr>
<tr>
<td>Triticale grain, pasture silage + 10% cotton seed meal.</td>
<td>Week 1</td>
<td>5.63</td>
<td>4.69</td>
<td>16.11</td>
</tr>
<tr>
<td></td>
<td>Week 3</td>
<td>5.48</td>
<td>5.12</td>
<td>16.36</td>
</tr>
<tr>
<td></td>
<td>Week 5</td>
<td>5.31</td>
<td>5.03</td>
<td>16.07</td>
</tr>
<tr>
<td></td>
<td>Week 7</td>
<td>4.79</td>
<td>5.39</td>
<td>15.72</td>
</tr>
</tbody>
</table>
4.6.3 Feed Consumption

Feed consumption by individual ewes has not been measured at any stage. However, average daily feed consumption of groups of ewes has been estimated, for example in the groups of ewes referred to in Figure 8 above (fed either a standard triticale grain, silage, cotton seed meal mix or the same mix with the addition of 4% whole lupins). Figure 9 shows the average daily fresh weight of each ration consumed by each ewe over a 13 week period from mid to late lactation.

Figure 9

In another trial, ewes (in groups of mixed lactation stages) consumed on average 4.9 to 5.0 kg fresh weight/day of rations comprising triticale grain, silage and either soybean meal or cotton seed meal.
4.6.4 Liveweight Change

Liveweight changes throughout lactation are shown in Figure 10. On average, mature ewe liveweight at the commencement of lactation is approximately 75kg (range 65 – 82kg). Ewes generally gain 1.5kg to 2.0kg liveweight in the last half of lactation.

Figure 10

![Average Awassi Ewe Liveweights](image)
5. Discussion of Results

5.1 Measuring Production and Milk Quality trends of individual ewes throughout lactation.

Milk yields vary significantly between individual ewes. Peak yields are achieved in weeks 2 to 4 of lactation at 2.4 to 2.9 litres per day. Average yields decline slowly from that point to about 1.5 litres per day after 12 weeks and to about 1.0 to 1.2 litres per day after 25 weeks. Current AWASSI (Aust) Pty Ltd management practice is to remove ewes from the dairy shed when daily yield falls to approximately 0.9 litres per day. Average lactation length is approximately 150 days.

No clear trends in milk quality over the duration of lactation have been determined, although future data analysis will clarify this. Increasing protein level in the diet from about 16.5% to 18% increased yield by about 15%, fat content of the milk by about 10%, protein content by about 5% and total solids by about 5%.

Live weight and feed intake both tend to increase marginally from mid to late lactation. Intuitively this is wasteful and costly. However, in a management situation where ewes are fed ad lib, in groups of up to 320 ewes, it has not proven practical to change or restrict rations or rates of feeding according to stage of lactation.

5.2 Feeding Trials

5.2.1 Cotton seed meal at different rates or soybean meal as protein sources in the diet.

There appear to be no differences in the milk production or milk quality of ewes fed either soybean meal or cotton seed meal at equivalent protein levels in a silage/grain based diet. Given an approximate cost of $700 to $900/tonne for soybean meal and $280 - $300/tonne for cotton seed meal, there is a significant cost: benefit advantage from substituting cotton seed meal for soybean meal in the rations for milking sheep.

The ewes fed 10% cotton seed meal in the diet produced about 15% higher milk yields than those receiving 5% cotton seed - they also produced milk with a 10% higher fat content, 6% higher protein and 6% higher total solids.

Assuming a milk price of $1.20/litre (and no premium for higher fat and solids content), the ewes receiving the higher rate of cotton seed meal were producing milk worth an extra 18 cents per ewe per day. The extra cost of the higher rate of protein meal was approximately 3 cents per ewe per day.

5.2.2 Cotton seed meal with or without lupins as protein sources in the diet.

Whole lupins are a highly palatable, high protein and energy feed source for sheep. Feed consumption increased by 6% when lupins were added to the base diet of pasture silage / cereal, grain / cotton seed meal at the rate of 4% of the diet on a dry matter basis.

The 13% increase in milk production that occurred soon after introduction of the lupins to the treatment group, and which was maintained throughout the 10 week trial period, was probably a result of 2 factors – an overall increase in feed intake and an increase in protein content of the diet from 16.5% in the base diet to 17.3% in the lupin supplemented diet.
The AFRC “Energy and Protein Requirements of Ruminants” suggests ewes require 71.9 grams of metabolisable protein per kg of milk produced. At 1.5 litres milk yield per day, ewes would require approximately 111 grams of metabolisable protein for milk, plus an estimated 70 grams of metabolisable protein for maintenance (incl. wool growth). This equates to a daily dietary crude protein requirement of about 300g. With daily feed consumption of the base diet of 1.65kg d.m. at 16.5% crude protein, the ewes were consuming about 275g of crude protein/day (about 8% below estimated requirement). With daily feed consumption of the lupin supplemented diet of 1.75kg d.m. at 17.3% crude protein, the ewes were consuming about 305g of crude protein per day (slightly above estimated requirement). This suggests that at least some of the apparent 13% increase in milk production in the lupin supplemented group was due to a protein response. In practical terms, it appears that a dietary crude protein content of about 17% is appropriate for ewes producing on average about 1.5 litres milk/day. Of course, this figure will be higher for higher producing ewes. We estimate that the daily crude protein requirement of ewes averaging 2.5 litres milk/day would be approximately 370 grams or about 18.5% protein at feed intakes similar to those in this trial.

The results of this trial are consistent with the earlier one involving feeding higher levels of cotton seed meal in the diet, where increasing dietary cotton seed meal from 5% to 10% of the diet increased milk yields by about 15%.

The increase in milk yield with added lupins was worth about 20c/day/ewe at a cost of about 3c/day/ewe in extra feed costs.

5.3 Production and animal health issues with unhoused lactating ewes

This trial has demonstrated the feasibility of running highly productive dairy ewes at pasture during lactation. There appears to be a trade off in milk production of approximately 30%. The unhoused ewes were being run on relatively poor (quality, quantity) annual pasture. They were given access to an identical (quality, quantity) feed mix as a contemporary housed group of ewes and consumed approximately 15% less of that mix. There were no apparent differences in the animal health status of both groups, although the unhoused group lost slightly more live weight. Due to management pressures, the trial was terminated prematurely, not allowing collection of extensive data on other parameters of interest (particularly oestrus cycling activity).

If the above reductions in milk yields and feed mix intake are confirmed then we estimate that unhoused ewes will return a gross margin of approximately 25% less than housed ewes. It does not take into account the capital costs associated with construction, maintenance or depreciation of the shed housing and associated infrastructure.

The conclusions could be quite different if the unhoused ewes had access to high quality, legume based pastures, although the additional cost of provision of such pastures would need to be accounted for.

In the second phase of the unhoused ewe trial, the approximate 30% reduction in milk yield of ewes run outside the shed was confirmed – approximately $55 less gross income from milk sales per lactation. The overall annual impact on total revenue is reduced if the shorter interval between lactations of the ewes spending some time outdoors is taken into account. The impact of this reduced dry period can be seen from our calculation that ewes fully housed (and with resultant longer dry periods) would average 2.6 lactations over 2 years, while those which were run outside for a period during lactation would average 3.3 lactations over 2 years.

Taking into account the 30% lower yield per lactation of the outside ewes, the annualised difference in production is only about 6% when we take into account this increased lactation frequency. On this same basis, the annual difference between housed and unhoused ewes in gross milk income reduces
to about $16/year. Reduced feed costs and reduced capital costs (for ewe housing) with unhoused ewes are likely to further reduce the difference in profitability between the fully housed and unhoused or partly unhoused management systems.

5.4 Other Outcomes of the project

5.4.1 Incorporation of DNA Markers into performance recording system.

Background

The objectives of this large research collaboration between the University of Sydney (Dr Raadsma and A/prof Frank Nicholas) and AWASSI (Aust) Pty Ltd (Tom and Phil Grant) were to identify DNA markers for milk, meat and wool production traits. The program had a particular focus to identify DNA markers for milk yield and milk composition in sheep. Application of such technologies would enable AWASSI (Aust) Pty Ltd to select superior milk production in both ewes and rams at an early age, and incorporate these selection tools in the major upgrading program proposed by AWASSI (Aust) Pty Ltd. The research was supported by an ARC-Industry grant for the period 1996-1999.

Progress

The experimental resource developed as a consequence of the collaborative research included 1000 progeny from four specifically bred Awassi x Merino crossbred sires. The progeny represent the four major foundation families imported by AWASSI (Aust) Pty Ltd, and have been created to allow expression of highly productive Awassi milk-genes in a low genetic background for milk production provided by the Merino. With the aid of DNA markers, a detailed genome analysis has been undertaken in 380 progeny from the main mapping family. Data were collected on the milking performance of all ewe progeny to their second lactation (the maiden lactation was deemed too limited in the detection of major genes). An experimental sheep dairy was built at the University of Sydney based on the design by AWASSI (Aust) Pty Ltd and can handle approximately 150 ewes per hour. Milk yield is measured at each milking (14 records/week) for the entire lactation. Milk composition was measured twice weekly for the duration of the lactation. The proposed analysis for detection of major genes and flanking DNA markers for milk performance, will be completed by early 2001.

The male progeny have been assessed for growth, meat production and feed intake. The first group of 90 male progeny have been slaughtered and all relevant carcass and body composition data obtained. (Body composition was measured by means of Computerised Aided Tomography, or CAT scan analysis). The second group of progeny are currently in a computerised feed intake facility developed at the University of Sydney to allow measurement of growth, body composition and efficiency at maturity.
5.4.2 Lamb Rearing

In 1997 we hand reared over 1,000 ewe lambs, from day olds, as replacement ewes. The cost of this exercise was over $50,000 or $50 per lamb when you include labour, pellets and milk powder.

In an attempt to cut these costs we began trying to get the poor milking ewes in the flock to rear two replacement ewe lambs instead of being milked. To get a ewe to adopt two lambs that were not her own proved to be very labour intensive and difficult with only about a 20% success rate.

We then built small pens 1 metre x 1.5 metre with a head bale that allowed the ewe to stand up or lay down. The head bale was on the outside fence of the pen so that ewe could be fed and watered outside the pen and actually had no contact with the lambs which were placed in the pen with the rest of the ewe. By preventing the ewe from being able to smell the lambs for about 4 days, the ewe then accepted the lambs when released from the head bale. When this proved successful we then tried the system using milking ewes which were past peak lactation and heading towards drying off. To date the success rate has been 100%.

Using mid to late lactation ewes to rear replacement lambs offers many advantages:

1. Huge savings when compared to hand rearing.
2. The ewes are available every day of the year instead of hoping you have a low producing ewe, lamb on the day you have 2 good ewe lambs to rear.
3. Loss in milk production is reduced to a minimum because all ewes can be milked after lambing and ewes are past peak production before they are used to rear lambs.

We already know that high producing ewes cannot be used to rear lambs. Apart from foregone milk production, the lambs cannot consume enough milk in the first two weeks of life and this leads to mastitis and “blown out” udders which end up dragging on the ground and cause the ewe to be culled.

5.4.3 Sheep Dairy R&D Project Reference Group

As foreshadowed in the original project proposal, AWASSI (Aust) Pty Ltd convened annual meetings of a project reference group to review progress with the RIRDC funded project and other initiatives in R&D for the sheep dairy industry. These meetings also made recommendations on the priorities and design of future R&D activities by AWASSI (Aust) Pty Ltd and collaborators.

A summary of the last meeting held in 1999 is as follows:

**Date:** Thursday 24 June 1999  
**Venue:** “Slievenamon”, Cowra  
**Attendance:** Tom Grant, Phillip Grant, Evan Hunt (OAC), Herman Raadsma (Uni Syd), Jim Hackett (CSU), Bob Seaman (CSU), Barry Lillywhite (CSU), Peter McInnes (RIRDC), Ian Rogan (Hassall & Associates - Chairman).

**Issues Discussed**

1. Overview of project activities at AWASSI (Aust) Pty Ltd over the past 12 months.  
   - type and rate of protein meal trial.  
   - productivity of different ewe genotypes.  
   - adding lupins to the diet.  
   - evaluation of unshedded lactating ewes.

2. Plans for Performance Recording:  
   - AWASSI (Aust) Pty Ltd plans to identify the top 200-250 ewes on milk production and quality, determine their sire pedigree by DNA testing, and then start a performance and pedigree based breeding program using these ewes to produce future sires.  
   - The percentage of AWASSI genes in this nucleus group is not likely to be important, although it is believed that 3/4 to 7/8 AWASSI will be optimum.
The electronic animal identification system is still not operational. Milk recorders working well (being recorded manually).

- OJD diagnosis in Uni flocks forced a major change of plans with this project.
- Approximately 180 back cross AWASSI x Merino ewes which are lambing mid 1999 and were to be milked at AWASSI (Aust) Pty Ltd, Cowra, will now be milked at a newly established research facility at the University property at Camden. This will create the first milk production data to correlate with DNA patterns and which will allow identification of genes responsible for milk production.
- Comparable wether animals have been subject to detailed data collection for feed intake, growth and carcass characteristics. This will allow similar identification of genes responsible for these traits.
- The University has developed an advanced technical service / consultancy on genetics and reproduction technologies.

4. Developments at Charles Sturt University
- Have developed a small cheese factory, capable of producing 20,000 to 50,000 kg of cheese / year.
- Intend to process some sheep milk (perhaps 20% of their production capacity).
- Have completed market research for sheep milk cheeses (with RIRDC support).
- A specialist cheese maker (Barry Lillywhite) has been appointed.
- Commencing trials with sheep milk.
- Unsure at this stage which sheep milk (cheese) products they will develop and market.
- Goal is to produce consistent, high quality product.

5. Other Sheep Dairy R&D Initiatives
- Project in WA completed after 3 years of RIRDC funding.
- A new project (with collaboration between UWA and CSU) has been supported by RIRDC – focusing on new product development.
- It was noted that the dairy goat industry is growing rapidly. Some joint work on specialty cheeses (from sheep and goat milk) has been done – may be potential for future joint marketing efforts.

6. Future Trials and Other Activities Proposed at AWASSI (Aust) Pty Ltd.
- Monitoring body weight change and manipulating rations according to stage of lactation of ewes.
- Changes in milk quality through different stages of lactation.
- Impact of changes in diet on milk quality.
- Extent of variation between individual ewes in major milk quality parameters.
- Updating of performance recording software to accommodate pedigree information and to produce breeding values.
- Production of advisory material for new producers (feeding, reproduction, lamb raising, basic husbandry and economics).

- Target audience: producers, educators, researchers, processors, distributors, marketeers.
- Timing: next 12 months.

8. Possible Future Project – to be submitted to RIRDC for consideration.
- Focus on product development and commercialisation.
- Increase consumer knowledge of the products.
- Develop new products.
- Achieving consistent, high product quality.
6. Implication and Recommendations

The broad aim of the project, “by June 2000, to have the information, technology and high quality genetics required for an expansion in the sheep dairy industry in Australia”, has been achieved.

Highlights of conclusions from research undertaken in this project are:

- The imported Awassi genetics have confirmed their superiority over existing Australian sheep breeds for milk production. 75% Awassi (25% Poll Dorset) ewes produced, on average, approximately 20% higher total lactation yield than 50% Awassi ewes, although individual 50% Awassi ewes had yields as high as the 75% Awassi ewes. Feet infections in high % Awassi ewes run at pasture at Cowra are a significant management problem.

- Running lactating ewes at pasture (rather than in a fully housed, lot fed situation) was proven feasible. Ewes run at pasture produced 30% less milk than housed ewes, but had 15% lower supplementary feed requirements and up to 60 day shorter “dry off” period due to earlier cycling post parturition.

- The milk yields and milk quality of fully housed, lot fed lactating ewes are highly responsive to the amount of protein in the diet. Economic optimum dietary crude protein levels were estimated at 17% of the diet for ewes producing 1.5 litres milk / day and 18.5% for ewes producing 2.5 litres / day.

- Practical, low cost systems for lamb rearing have been developed which allow highly productive ewes to commence full milking 3 days after parturition.

The Awassi (Aust) Pty Ltd sheep dairy has been Australia’s largest producer of sheep milk for the past 4 years – producing up to 12,000 litres of milk per week. Cost of production has been estimated at approximately $1.05 / litre (not including finance costs and drawings). A secure market existed for 5,000 to 7,000 litres per week, paying $1.15 to $1.20/litre. The balance of production at peak season was sold at prices below the cost of production. The future economic viability of the Awassi (Aust) Pty Ltd business and other sheep dairy producers is dependent on development of a wider demand for sheep milk from dairy processors. This in turn requires investment in product development and consumer awareness. Members of the Grant Family have formed the Cowra Cheese Company and are now manufacturing and marketing a limited range of sheep milk cheese and yoghurt products in an attempt to achieve these goals.
Section 2: Production of Sheepmilk Powder

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Sheep dairying is a new Australian livestock industry. The establishment of this industry has been driven by a recognition of significant imports of specialty cheeses derived from sheep milk, and an overall growth in domestic and export markets for specialty cheeses.

One of the features (and marketing problems) of many incipient rural industries is strong seasonality of supply of raw product. This is a result of the generally small number, scale and geographic distribution of early industry participants.

This seasonality of supply creates difficulties for producers and particularly for processors, wholesalers and retailers of fresh or short shelf life products. The production of milk powder offers a solution to this seasonality of supply and an expansion of the range of end products for this new industry.

Sheep dairying is a new Australian rural industry supported under the New Animal Products sub-program of RIRDC.

This project was funded from RIRDC Core Funds which are provided by the Federal Government.

This report, a new addition to RIRDC’s diverse range of over 600 research publications, forms part of our New Animal Products R&D program, which aims to accelerate the development of viable new animal industries

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- downloads at www.rirdc.gov.au/reports/Index.htm
- purchases at www.rirdc.gov.au/eshop

**Peter Core**  
Managing Director  
Rural Industries Research and Development Corporation
Executive Summary

Milk powder is produced from sheep milk in some European and Middle Eastern countries, where it has three main uses:

- reconstituted for drinking products;
- reconstituted for manufacture of cheese; and
- an ingredient for low allergenic infant foods.

To date, milk powder has not been produced from sheep milk in Australia.

In this project, AWASSI (Aust) Pty Ltd, Australia’s largest producer of sheep milk, and Cowra Cheese, a speciality cheese and yoghurt manufacturer, have investigated the feasibility of production of milk powder from sheep milk.

Outcomes of the project have been:

- Participation in a training course on milk evaporation and drying (University of Melbourne).
- Preliminary investigation of potential markets for sheep milk powder.
- Investigation of opportunities for utilising cows milk drying facilities to produce sheep milk powder.
- Investigation of the costs of establishment and operation of a small, commercial scale drying plant for sheep milk.
1. Introduction

AWASSI (Aust) Pty Ltd has been producing sheep milk at Cowra, NSW, since 1996, milking up to 1,000 ewes twice daily. Up to 12,000 litres of milk have been produced weekly at the peak of seasonal production (late Winter / Spring). A regular, predictable market for 5,000 to 7,000 litres / week has existed – primarily for the production of speciality cheeses.

AWASSI (Aust) Pty Ltd has had a goal of encouraging other new sheep dairy enterprises, but new entrants to the industry have faced several problems common to many new rural industries:

- Lack of sustainable demand for the raw product in the absence of a sustainable supply on which processors and marketers can develop product and market profile.
- Seasonal overproduction and lack of marketing alternatives at such times.
- Seasonal under production, exacerbating the problems of sustainable relationships with processors and marketers as outlined above.

Cowra Cheese have developed, manufactured and marketed a small range of high value fresh cheese and yoghurt products based on milk sourced from AWASSI (Aust) Pty Ltd.

In a joint initiative, Cowra Cheese and AWASSI (Aust) Pty Ltd, identified the potential to produce milk powder from sheep milk. The potential was based on the following rationale:

- there was some evidence of export market opportunities for sheep milk powder produced in Australia;
- drying milk produced at peak seasonal supply would provide an opportunity to deal with milk that was surplus to fresh milk processors’ needs; and
- sheep milk powder would be another end use for sheep milk, thus establishing a stronger, broader market for the product in Australia.

2. Objectives

The objectives of the project were to:

- Examine small scale machinery options and their operating limitations for producing sheep milk powder from fresh milk for various export markets.
- Report on the scope for these drying plant options being employed by Cowra Cheese.
- Attend the five day Evaporation and Drying Course at the University of Melbourne from 1 to 5 May 2000.

3. Methodology

Mr John Grant of Cowra Cheese consulted with a number of businesses and individuals with involvement in dairy product and other food marketing in Australia and New Zealand. These consultations led to indications of potential markets and product specifications for sheep milk powder.

Mr Grant also contacted known cow milk powder producers to identify the potential for producing powder from sheep milk using existing infrastructure.

In conjunction with Dairy and Food Machinery Pty Ltd (Cobram, VIC), Mr Grant developed specifications for an evaporator and spray dryer for sheep milk.

Finally, Mr Grant attended and successfully completed the Evaporation and Drying Autumn School course at the Gilbert Chandler Campus, Institute of Land and Food Resources, University of Melbourne.
4. Results

4.1 Outcomes of consultation with dairy food marketers and processors.

A summary of consultations undertaken and their outcomes is shown below:

(a) Mr Lloyd Higginbotham, Food Sciences Australia, Werribee.
- operates a dryer for cow milk.
- could potentially run 1,000L batches of sheep milk through dryer but too expensive ($5,000 / 1,000L) and remoteness from Cowra would make transport of raw milk expensive.

(b) Mr Peter Jackson, Scand Australia Pty Ltd, Helensburgh NSW (02 4294 2376)
- food commodity trader.
- has had an enquiry from Italy for sheep milk powder to use in infant formula manufacture.
- anecdotal evidence of demand for up to 60t/year for this market.
- believes wholesale price for sheep milk powder would be in the range of $13.80 to $15/kg.

(c) Mr George Assaf, AWASSI (NZ) Pty Ltd.
- has inquired about potential markets for sheep milk powder in the Middle East & Europe.
- no specific markets identified.

(d) Mr Allan Hibbard, sheep dairy operator in NZ.
- claimed to have a possible contract to supply 120 – 240t / year of sheep milk powder.
- was investigating access to milk drying facilities under contract.

(e) Mr Stuart Steele, milk processor, Tasmania.
- proposing to investigate markets for sheep and goat milk powder in Asia.

(f) Mr Dennis Gastin, Instate Pty Ltd, Sydney.
- food marketer into Asia.
- saw potential for markets for sheep milk powder, but need to develop a specific product such as infant formula.
- more definite markets for sheep milk cheese.

(g) Mr Campbell King, MPD – Dairy Products, Sydney.
- proposed to consult with Saudi traders re sheep milk powder demand.

(h) Mr Robin Swift, DOA Food Processors, Melbourne.
- no market for sheep milk powder because they have not had the product to sell.
- a market exists for goat milk powder.
- sees potential as an ingredient for infant formula.
- sees potential for sheep milk cheeses to be marketed in USA and the Middle East.

(i) Australian Dairy Corporation, Sydney.
- attempted to identify contracts for milk powder processors and marketing, without success.
4.2 Potential for drying sheep milk using existing infrastructure.

John Grant could not identify any technical constraints to using cow milk drying facilities to produce milk powder from sheep milk. However, the scale of most commercial milk dryers requires a throughput of approximately 2,500L/hr which would make it difficult (and expensive) to process small batches of sheep milk, with the associated clean down of the machinery before and after the sheep milk processing.

One pilot scale milk dryer (Food Sciences, Australia, Werribee) was prepared to process 1,000 litre batches of sheep milk. This would produce approximately 180kg of sheep milk powder. However, the processing expense would be prohibitive (approximately $27/kg), not including the cost of transporting raw milk to the processor.

Consultation with milk powder producers in Australia and New Zealand confirmed John Grant’s view that there were no existing commercial milk drying facilities which could operate viably at the scale required to process batches of sheep milk at volumes likely to be available in the foreseeable future.

4.3 Developing specifications for a sheep milk drying system.

Milk drying is a two stage process. Raw sheep milk is approximately 82% water. The first stage of drying involves evaporation of some of the water from the milk to produce a slurry with a water content of approximately 50%. The slurry is then spray dried to produce a powder of less than 5% moisture.

In conjunction with Dairy and Food Machinery Pty Ltd, Cobram, Victoria, specifications have been developed for an evaporator / spray dryer to process up to 900L of sheep milk / hr, producing approximately 150kg of sheep milk powder / hour.

The processor would have the following components:

- Balance tank
- Feed pump
- Feed line
- Falling film evaporator (feed rate : 167kg/hr at 18% total solids. Water removal : 107kg/hr)
- Evaporator : dryer connection
- Air inlet filter and air electric heater with air inlet ducting.
- Drying chamber with integrated fluid bed (feed rate : 60kg/hr at 50% total solids. Water removal : 30kg/hr at 200°C inlet air temp/80°C outlet air temp)
- Cyclone
- Exhaust air fan and ducting
- Instrumentation and control panel.

Capital cost for this equipment (as at July 2000) was $310,000 plus GST (ex Dandenong). This does not include installation costs.

The energy operating costs for the evaporator / dryer (assuming an electricity cost of 6 cents / kwh) were estimated at 37 cents / kg of powder produced.

John Grant has prepared the following operating cost budget for the dryer based on a throughput of 4,000 litres of sheep milk / week, producing approximately 720kg of sheep milk powder.

<table>
<thead>
<tr>
<th></th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk ($1.20/L)</td>
<td>4,800.00</td>
</tr>
<tr>
<td>Capital ($500,000 @ 8%pa)</td>
<td>800.00</td>
</tr>
<tr>
<td>Labour (24hrs @ $30/hr)</td>
<td>720.00</td>
</tr>
<tr>
<td>Power (37c/kg powder + allowance for light, packaging)</td>
<td>300.00</td>
</tr>
<tr>
<td>Packaging (25kg bags @ $5/bag)</td>
<td>150.00</td>
</tr>
<tr>
<td>TOTAL</td>
<td>$6,770 or $9.40/kg</td>
</tr>
</tbody>
</table>

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4.4 Training in milk powder production.

The Gilbert Chandler Campus at Werribee, part of the Institute of Land and Food Resources – University of Melbourne, conducted a milk evaporation and drying course in Autumn 2000. John Grant participated successfully in that course which covered the following topics:

- Concentration and drying products and technology.
- Drying principles.
- Condensed milk process outline.
- Microbiology of milk powders.
- Milk production in mammals.
- Preheating milk for powder production.
- Evaporation plant components.
- Evaporation plant: vapour recompression.
- Multiple effect evaporators.
- Evaporator final affects.
- Dryer operation.
- Spray drying plant components.
- Multi stage spray drying.
- Powder properties.
- Analysis of dried milk.
- Powder packing, handling and storage.
- Fires and explosions in spray dryers.
- Directions in the powder industry.
- Particle morphology.
5. Conclusion

This project has identified the technical feasibility of producing milk powder from sheep milk. Production costs of approximately $10/kg have been estimated and are in the “right” order of magnitude compared to potential wholesale prices of $13 to $15 per kg – based on goat milk powder prices.

A number of issues are unresolved, with respect to the viable production and marketing of sheep milk powder.

1. Firstly, there appear to be no existing evaporator / dryer facilities of an appropriate scale for cost effective drying of relatively small volumes of sheep milk. It was the conclusion of this study that a small scale, specialist evaporator / dryer would need to be constructed. A specification was developed for such a facility and it is estimated to cost approximately $350,000 to purchase and install.

2. Secondly, although one sheep dairy, AWASSI (Aust) Pty Ltd, seasonally produces up to 5,000 litres of sheep milk per week surplus to their speciality cheese manufacturer’s requirements, it is not clear that there is sufficient production of sheep milk in south eastern Australia to warrant investment in development of sheep milk powder processing capability and in development of markets for sheep milk powder.

3. Thirdly, and most importantly, there is not a proven market for sheep milk powder. Potential export markets in both Asia and Europe were identified but not confirmed in this study. It is the primary conclusion of this study, that no further investment in the production of sheep milk powder should occur prior to investment in determining the real level of demand for sheep milk powder internationally and preferably in securing supply contracts.