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Comparison of three systems for concurrent production of lamb meat and wool

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Abstract

An innovative lamb-feeding facility with a raised-slatted floor (RF) was designed and built for the purposes of concurrently producing high-quality, high-value wool and large, lean lamb carcasses. A ration was formulated to provide a low rate of gain in order that lambs attained slaughter weight (59 kg) when they were approximately 12 month of age because a 12-month fleece is a prerequisite for high value in the targeted hand spinning niche wool market. A study was conducted to compare production and quality of wool and meat and associated economics of feeding lambs housed in the RF system versus two conventional systems, a feedlot (FL) and supplementation on pasture (P). For this purpose, 143 5-month-old, male, castrated Rambouillet lambs were obtained and assigned to a production system. Half of the lambs in the RF and FL systems were fitted with protective coats. As planned, daily gain was greater and days to slaughter were less in the FL versus the RF system, with P being intermediate. Final shorn bodyweights were similar in each system, but RF dressing percentage was considerably lower than those in the FL and P systems. This anomaly was likely due to the greater gut fill of RF lambs compared to those in the other two systems. Leaner carcasses were produced in the RF and P systems compared to the FL system. The RF fleeces were heavier than those produced in the FL system with P fleeces being intermediate. Average fiber diameter and variability did not differ among treatments. Though considerably longer than FL staples, wool produced in the RF system was more uniform (CV%) in terms of fiber diameter measured along the staple length. Importantly, coats did not affect rates of gain in either the FL or RF system and had minimal effects on other measured properties. Coated fleeces were only arithmetically higher yielding than uncoated fleeces (55.2% versus 53.4%), but the coated fleeces were visually cleaner and brighter than uncoated fleeces, which is very important for the targeted niche market. Price obtained for coated RF wool sold into a niche market was five times higher than conventionally marketed FL and P wool prices. Net income per head was negative for all three systems (−US$ 0.11, −US$ 2.20, and −US$ 5.57 per head for FL, P, and RF, respectively). In this study, the substantially higher returns from the niche wool market did not compensate fully for the extra cost of production and the extra effort required for niche marketing.

Keywords: Lamb meat; Niche market; Production system; Rambouillet lambs; Wool

1. Introduction

Low wool prices, production of over-fat lambs, and unpredictable, erratic prices for lamb meat are some of the problems faced by U.S. sheep producers. Because wool is an international commodity dominated by the

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major producing countries, Australia and New Zealand, a U.S. wool producer has only limited influence on the value of his clip unless he is able to grow a specialty product and sell into a niche market. To maximize income from wool, a producer would normally raise a fine-wool breed of sheep such as the Merino or Rambouillet. In the United States, the Rambouillet is the dominant fine-wool, dual-purpose breed. Some exceptionally high-value, ultra-fine wool is being produced in Australia by Merino wethers fed maintenance rations and held permanently indoors. This production system was studied by Cottle (1986) and described by Scarlett (1991). In 2004, one bale of this type of extremely fine wool sold for more than US$ 5500 kg^{-1}, clean (Byrns, 2004). After evaluating the economics of this type of production system in a U.S. environment, we decided instead to investigate a system that utilized fine-wool lambs from which three products (rather than one) would be available by the time the animals attained 1 year of age: high quality wool, skins, and lean lamb meat. When fine-wool lambs are fed to slaughter weight in a traditional feedlot, the value of the wool is invariably low due to excessive dirt content and short staple length. Feedlot rations are designed to maximize rate of growth and minimize the number of days on feed. Rarely is consideration given to nutritional effects on fiber quality (average fineness and uniformity, for example). Much has been studied and documented concerning the feeding of lambs (NRC, 1985) and feeding systems for lambs (Kemp et al., 1981) but the search for a cost-effective method to consistently produce large, lean, slaughter lambs continues (Borton et al., 2005). Theoretically, if wool from feedlot lambs could be kept clean and allowed time to grow to ∼9 cm in length, its value would be similar to or even greater than wool from adult sheep maintained traditionally on rangeland. This article describes a study with lambs in which we compared wool and meat production and their quality attributes when lambs were fed in a raised-floor (RF) facility with more conventional production in a feedlot (FL) and supplementation on pasture (P). A spreadsheet was developed to facilitate economic comparisons among the three production systems, and a web site was established to advertise and sell the high-quality wool produced in the RF system.

1.1. High-quality wool

"High-quality" is a vague term that is defined here in terms of measurable (objective) and subjective characteristics of wool. The term implies high yielding (>60%), long staple (>90 mm), vegetation free (<0.3%), white wool containing no weak points in the staple (strength > 30 N/ktex) and having very clear crimp definition. It also implies fine (<23 μm), uniform (particularly in terms of fiber diameter and staple length) wool.

1.2. High-quality lamb meat

Marketing surveys of U.S. lamb consumers have shown that most favor a large, rather than a small lamb chop. Though ribeye area is quite variable even within a breed and within a narrow weight range, we selected a target slaughter weight of 59 kg in an attempt to ensure adequate sized market cuts. The challenge was to produce a lamb of this size that was not too fat. Other target specifications were ≥29.5 kg carcass weight, ≤5 mm back fat thickness, and ≤2.0 yield grade.

1.3. Systems

Each of the three systems being compared in this study include the facilities in which the lambs were fed (3), the diets (3), the methods used to sell wool (2), and the methods used to sell hides (1) and meat (1).

2. Materials and methods

2.1. Feeding facilities

A native pasture in West Texas and a drylot were used to feed two groups of lambs. As one component of our attempt to produce high quality wool and lean lamb, a 168 m^2 facility was designed and constructed that consisted of an open-sided, covered shed with a raised, wooden, slatted floor constructed over a concrete slab. This provided adequate space to feed 200 lambs. The slatted floor was designed to release fecal material and urine and was constructed 1.2 m above ground to facilitate removal of manure and provide adequate ventilation. Feeding and watering systems were custom designed to provide adequate access to the livestock while preventing them from contaminating the feed and water with fecal material and urine. An automated feed system was designed to deliver feed by auger into a central feed bunk from an adjacent bulk feed tank. The facility was designed to have a low labor requirement. One person can operate the system for 10 min delivering enough feed for 2 days. In order to evaluate available genetics and develop management practices necessary to produce uniformly fine, strong, and clean fleeces and large, lean carcasses from lambs fed a low-energy diet, several feeding studies (Lupton et al., 1998, 1999, 2000) were conducted in this facility over a 3-year period prior to initiating the study described here.

2.2. Experimental design

Recently weaned, unshorn Rambouillet male castrated lambs ($n = 143$, age = ∼5 months) were vaccinated for entero-

Table 1
Percentages of ingredients and diet nutrient summaries in the feed lot diets, pasture supplements, and raised floor diet

	Diet (time fed, day)			
Feedlot	1 (7)	2 (101)		
Pasture	1 (7)	2 (21)	3 (109)	
Raised floor	1 (0)	2 (0)	3 (0)	4 (167)
Ingredient composition (DM basis)				
Sorghum grain (milo)	65.7	68.0	60.1	0
Dehydrated alfalfa meal, 17%	10.1	5.1	10.1	0
Cottonseed hulls	10.1	10.1	0	0
Cottonseed meal, 41%	10.2	12.1	10.1	0
Soybean meal, 47.5%	0	0	10.1	0
Oat hay	0	0	0	87.0
Barley grain	0	0	0	7.4
Molasses	2.2	2.2	3.0	5.6
Urea	0	0.5	0.5	0
Ammonium chloride	0.6	0.6	0	0
Salt, mixing	0	0	4.5	0
Calcium carbonate	0.6	1.1	0	0
Monodicalcium phosphate	0	0	1.1	0
Vitamin–mineral–antibiotic pre-mix	0.5	0.3	0.5	0
Totals	100.0	100.0	100.0	100.0
Chemical composition and nutritive value[a]				
Crude protein (%)	15.5	17.3	20.5	9.6
Digestible intake protein (% of DM)	8.7	10.4	12.4	6.6
NE_m (mcal/kg)	1.6	1.6	1.7	1.2
NE_g (mcal/kg)	1.0	1.0	1.1	0.6
eNDF (% of DM)	13.1	13.2	4.3	54.2
Ca (%)	0.5	0.6	0.4	0.3
P (%)	0.4	0.4	0.7	0.3

[a] Calculated using the Texas Tech University Beef Cattle Diet Formulation Program using dietary ingredient composition values from NRC (1996).

toxemia (Clostridium perfringens type C and D toxoid, a product of Boehringer Ingelheim Vetmedica, Inc., St. Joseph, MO 64506, USA. Dosage rate: 5 ml/head) and fed a common ration (Diet 1, Table 1) during a 3-week adjustment period at which time an anthelmintic was administered (Ivermectin – Ivomec, a product of Merck and Co., Rahway, NJ 07065, USA. Dosage rate: 3 ml/11.8 kg). Subsequently, the lambs were assigned to treatment (blocked by weight, 37.3 ± 3.0 kg) and the experiment was initiated on 9/1/2000. By design, the effects of physical environment, nutrition, and marketing method for the products were confounded because they were different for each system. Hence, we compared whole systems not individual components within the systems. Animals in the RF system were fed a pelleted mixture of 85% oat hay, 7.5% barley, and 7.5% molasses (as fed basis). This diet was designed to produce a relatively slow rate of gain so that wool longer than 95 mm could be produced before the animals attained slaughter weight at ~12 month of age. The ration was also designed to produce a lean carcass. Lambs in the feedlot were provided with typical step-up rations (Table 1, Diet 2) that were designed to produce relatively fast rates of gain. Lambs in the P system received a salt-limiting supplement (Table 1, Diet 3) after a month in the pasture. In each system, diets were available to lambs on an ad libitum basis and salt blocks were also accessible. It was planned for the P lambs to gain at a similar rate to the RF lambs. Half the lambs in the FL and RF systems were fitted with fleece-protecting coats. The FL lambs were shorn on 11/14/2000 allowing 34 days for wool re-growth prior to slaughter on 12/18/2000 (108 days on feed) when the target slaughter weight had been attained. The P lambs were shorn on 12/14/2000 allowing 33 days for re-growth prior to slaughter on 1/16/2001 (137 days supplemented in the pasture). The RF lambs were shorn on 1/25/2001 allowing 3 weeks for re-growth prior to slaughter on 2/15/2001 (167 days on feed). Marketing of the FL and P lamb wool was achieved in the traditional manner through a commercial Texas warehouse. The RF wool was sold through a specially designed web site. Marketing of the carcasses was also achieved through normal commercial channels.

2.3. Carcass measurements

All lambs were slaughtered and carcasses were evaluated at Ranchers' Lamb of Texas, Inc., San Angelo. Most carcass measurements (hot carcass weight excluded) were made after the carcasses had been in the cooler for 24 h. These included back fat thickness (measured between the 12th and 13th ribs) at the midpoint of the ribeye and body wall thickness measured from the inside of the rib to the outside fat about 10 cm below the rib eye. In addition, hind leg circumference (thickest point) and carcass length (from hock to shoulder) measurements were made. USDA quality and yield grades (USDA, 1992) were assigned by USDA meat graders at the plant. Yield grades were also calculated (CYG) using the formula:

$$\text{CYG} = 0.4 + (10 \times \text{fat thickness measured to the nearest one hundredth of an inch})$$

Dressing percentage was calculated by dividing the hot carcass weight by shorn final weight and multiplying by 100.

2.4. Fleece and fiber measurements

Fleece and fiber measurements were made at the Texas Agricultural Experiment Station's Wool and Mohair Research Lab, San Angelo. At shearing, fleeces from individual sheep were bagged separately. After a grease weight had been obtained, staples (10) were removed from random positions in the fleece for length and strength measurements. The remainder of the fleece was pressure cored (32 mm × 13 mm cores, Johnson and Larsen, 1978) to obtain a 50 g random sample of the fleece. Two 25 g sub-samples were used to determine lab scoured yield (ASTM, 2004a). One of the washed and dried duplicates was mini-cored (ASTM, 2001) to obtain a few milligrams of 2 mm snippets that were representative of the whole fleece. These snippets were washed in a Buchner funnel with 1,1,1-trichloroethane (10 ml) and acetone (10 ml), dried at 105 °C for 1 h and cooled and conditioned for 12 h in a standard atmosphere of 21 ± 1 °C and 65 ± 2% rh (ASTM, 2004c). The conditioned snippets were then spread onto microscope slides (7 cm × 7 cm) and measured for fiber diameter distribution (mean, S.D. and CV), comfort factor (%fibers < 30 μm), along-fiber average fiber diameter, S.D. and CV and average fiber curvature, S.D. and CV, using an OFDA 100 (BSC Electronics, Andross, Western Australia; Baxter et al., 1992; ASTM, 2001). Ten staples were measured to determine staple length, S.D. and CV (ASTM, 2004b) and staple strength, S.D. and CV and position of break in the staple (Agritest et al., 1988).

2.5. Statistical analysis

Due to resource limitations, individual animals were used as experimental units in this case study. Because independent replicates were not available, effects of system were determined on the basis of non-overlapping confidence limits. Ninety five percent confidence intervals (alpha = 0.05) were calculated for each characteristic measured in each system and for the coated and uncoated groups separately.

3. Results

3.1. Effects of system on growth and carcass characteristics

The effects of system on growth and carcass characteristics are summarized in Table 2. Not listed is average daily consumption of feed by lambs in the FL, P, and RF systems, which was 1.78, 1.68, and 1.09 kg/head, respectively. As planned, FL lambs gained at a higher rate than P and RF lambs. The summer, fall, and winter seasons of 2000 were very dry in western Texas and little vegetation was produced on the range. Consequently, a high proportion of the diet consumed by the P lambs consisted of the "supplement" that was supplied to them. Shorn final weights of FL, P, and RF lambs were similar. Carcass weights of FL and P were arithmetically >RF. Inspection

Table 2
Effects of system on growth and carcass properties (mean ± 95% confidence limit)

Item	System		
	Feedlot	Pasture	Raised floor
n	27	28	88
Initial weight (kg)	37.4 ± 1.2	37.3 ± 2.7	37.4 ± 0.6
Shorn final weight (kg)	59.2 ± 2.3	59.4 ± 2.0	60.8 ± 1.1
Average daily gain (kg/day)	0.23 ± 0.02	0.18 ± 0.01	0.16 ± 0.01
Days to slaughter	108	137	167
Carcass weight (kg)	30.5 ± 1.1	30.9 ± 1.1	28.9 ± 0.5
Dressing percentage	51.7 ± 0.8	52.0 ± 0.6	47.6 ± 0.4
Back fat thickness (mm)	7.3 ± 0.7	5.5 ± 0.8	5.0 ± 0.4
Body wall thickness (mm)	32.0 ± 1.4	29.0 ± 1.5	28.3 ± 0.8
Hind leg circumference (cm)	69.9 ± 0.8	71.9 ± 0.8	70.9 ± 0.4
Carcass length (cm)	116.2 ± 1.5	117.9 ± 1.2	118.4 ± 0.7
USDA quality grade[a]	1P, 26C	28C	2P, 86C
USDA yield grade	2.11 ± 0.13	2.32 ± 0.21	2.08 ± 0.07
Calculated yield grade	3.26 ± 0.27	2.55 ± 0.32	2.37 ± 0.16

[a] C, choice; G, good; P, prime.

Table 3
Effects of system on wool growth and properties (mean ± 95% confidence limit)

Item	Treatment		
	Feedlot	Pasture	Raised floor
n	27	28	88
Grease fleece weight (kg)	2.67 ± 0.15	3.03 ± 0.18	4.09 ± 0.14
Clean yield (%)	54.5 ± 1.8	52.3 ± 1.6	54.6 ± 0.81
Clean fleece weight (kg)	1.45 ± 0.08	1.58 ± 0.09	2.23 ± 0.09
Average fiber diameter (μm)	20.2 ± 0.6	19.4 ± 0.5	19.6 ± 0.4
Coefficient of variation of fiber diameter (%)	21.4 ± 0.7	20.7 ± 0.8	22.1 ± 0.7
Comfort factor (% fibers <30 μm)	98.2 ± 0.7	99.1 ± 0.3	98.7 ± 0.3
Along-fiber average fiber diameter (μm)	20.30 ± 0.60	19.37 ± 0.48	19.55 ± 0.36
Coefficient of variation of along-fiber diameter (%)	4.44 ± 0.13	4.27 ± 0.11	4.07 ± 0.06
Average fiber curvature (degree/mm)	97.9 ± 3.9	95.1 ± 4.2	97.8 ± 2.3
Coefficient of variation of fiber curvature (%)	65.8 ± 1.0	67.4 ± 1.1	65.5 ± 0.7
Average staple length (cm)	6.3 ± 0.3	7.3 ± 0.3	8.7 ± 0.2
Coefficient of variation of staple length (%)	8.0 ± 1.1	8.5 ± 1.3	6.9 ± 0.4
Average staple strength (N/ktex)	32.9 ± 4.1	34.8 ± 5.2	33.8 ± 2.4
Coefficient of variation of staple strength (%)	24.3 ± 3.9	29.6 ± 3.7	20.8 ± 1.4
Position of break (0–1)	0.37 ± 0.05	0.38 ± 0.06	0.39 ± 0.02

of the dressing percentages indicates the RF lambs probably had higher gut fill prior to slaughter compared to the P and FL lambs. This observation was consistent with previous experience (Lupton et al., 2000). The back fat thickness of the FL lambs was >*P* = RF. Body wall thickness measurements exhibited the same trend as back fat thickness and average daily gain. Interestingly, hind leg circumference showed a different trend with P lambs showing the greatest development. This may be related to the relatively long distances walked by the P lambs each day compared to lambs in the other systems. Carcass length was similar among systems. Most of the lambs in this experiment graded choice (C) except for 3 prime (P) (2 in the RF group and one in the FL group). The subjectively determined USDA yield grades were not different among systems. When assessing USDA yield grades, a USDA grader takes into account the condition of the whole carcass. Calculated yield grade (CYG) on the other hand uses only back fat thickness in the formula. Consequently, it should not be surprising when these two estimates of yield differ. In this case, FL carcasses had higher average CYG (3.26) compared to P and RF (2.55 and 2.37, respectively). Average days to slaughter were 108 (FL), 137 (P) and 167 (RF). Interpreted in a positive manner, we were able to hold the lambs on the raised floor for this extended period of time (necessary to produce a fleece having adequate staple length) without producing any carcasses that did not "break" (i.e., the spool joints of younger sheep break easily. In the current U.S. marketing system, a substantial discount is applied to carcasses in which the spool joints do not break). Interpreted negatively, the longer time to slaughter resulted in greater feed consumption in the RF and P systems versus FL.

3.2. *Effects of system on fiber production and properties*

Table 3 summarizes effects of system on wool growth and properties. As planned, grease and clean wool production of RF lambs >FL and P. Clean yield did not differ among systems. The level of 54.5% is high for FL lambs but was in fact identical to that reported previously (Lupton et al., 2000) for a different set of lambs. Average fiber diameters (AFD), CV, and comfort factor (CF), did not differ among systems. A potential downside of producing longer wool is that a longer period is available in which to produce changes in fiber diameter. One way to investigate this property (uniformity of fiber diameter along the length of the fiber) is to make multiple measurements on the same fiber and calculate variability (CV). This is reported as along-fiber AFDCV. Table 3 indicates that along-fiber AFD's are almost identical to those obtained when a random sample was measured. However, the CV's of along-fiber diameter indicate that RF fleeces are more uniform than P and FL fibers. Although the differences are small, they are important in terms of the original objective for developing the RF system, i.e., to produce high quality (meaning more uniform) wool. The RF lambs produced longer wool than *P* > FL corresponding to the different periods of wool growth (birth to 1 month before slaughter). The variability of staple length (CV) did not differ among systems. Average staple strength and position of break were not different among systems, a noteworthy result for the RF lambs that produced wool over a longer period of time.

3.3. Effects of coats on growth and carcass characteristics

In previous experiments, coats had soon become torn and non-functional when placed on lambs in the P system. Consequently, coats were not used on the P lambs in this study. In the extreme heat of the Texas summer, we had anticipated that wearing a coat might slow down the rate of growth. This proved not to be the case. Importantly, coats had no effect on any of the growth and carcass traits measured.

3.4. Effects of coats on wool growth and properties

As expected, coated fleeces (C) tended to be higher yielding than uncoated (U) fleeces (55.2% versus 53.4%) but the difference was not significant. However, the C fleeces were visually cleaner and whiter, thus being more appealing to hand spinners. Analyses were conducted for the effects of coat within system and overall. The coats produced no differences in any of the fiber characteristics measured.

4. Discussion

4.1. The raised floor system

Table 4 summarizes the results obtained using the RF system and coats with respect to the original targets for the major growth, carcass, and fiber characteristics. It is emphasized that the RF system produced leaner carcasses and heavier fleeces that were more uniform than the other two systems in terms of fiber diameter along the staple length, longer, and visually cleaner and most acceptable to hand spinning requirements. Table 4 also indicates the fleece properties still requiring improvement. These are clean yield (needs to be higher); fiber diameter (needs to be lower); and, staple length (needs to be longer). These requirements will likely only be met by using alternative genetics, for example, finer Merinos. Unfortunately, this approach might undermine the carcass traits (Snowder et al., 1997).

Table 4
Summary of progress in the raised-floor system

Property	Target	Actual	Status
Age at slaughter (month)	12	12–13	OK
Final shorn weight (kg)	59.0	60.8	OK
ADG (kg/day)	0.14	0.16	OK
Carcass weight (kg)	29.5	28.8	OK
Back fat thickness (mm)	5.0	5.0	OK
USDA quality grade[a]	P, C	P, C	OK
USDA yield grade	2.0	2.1	OK
Grease fleece weight (kg)	>3.6	4.1	OK
Yield (%)	>60	54.6	X (genetic)
Vegetable matter (%)	<0.3	<0.3	OK
Fiber diameter (μm)	<19.0	19.6	X (genetic)
Staple length (cm)	>9.4	8.6	X (genetic)
Staple strength (N/ktex)	Sound (>30)	33.8	OK

[a] C, choice, P, prime.

4.2. Miscellaneous observations

The wooden slatted floor did not self-clean as efficiently as we had planned. The relatively soft, sticky fecal pellet produced by the RF diet did not fall easily between the slats and was more typically squashed and forced through the spaces by foot action. We later replaced this wooden floor with a woven steel wire floor that has worked very well.

Another deficiency of the wooden floor is also worth mentioning. A fourth (but previously unreported) product of this feeding system is seed-free manure, much favored by home gardeners. However, they have a preference for distinct pellets versus disintegrated feces since this clearly distinguishes the sheep product (superior product in the opinion of gardeners) from that which is available from the cattle feedlots. Changing to a woven wire floor produced the preferred manure texture.

One further aspect of the RF system deserves mention. Lambs fed in this system appeared to be exceptionally content. A high percentage of their time was spent simply sitting down. No wool biting or fighting for dominance was ever observed in this group. This behavior initially made us think the lambs might become excessively fat due to lack of exercise. However, carcass data indicated this was not the case.

5. Financial considerations

A budget scenario (Table 5) was developed for the three lamb feeding systems that took into account the cost of building a feedlot pen, leasing pasture, and building a raised-floor barn, in addition to other variables. The budget scenario was made available to the public in 2001 in spreadsheet format so that an individual could enter his own values and the program would automatically recalculate the “bottom line,” i.e., net income per head.

Using our own Texas Agricultural Experiment Station web site (http://sanangelo.tamu.edu/wmrl/handspin.htm), we were able to list and subsequently

Table 5
Budget scenario for feedlot, pasture, and raised-floor feeding systems 200 lambs/system

	Feedlot	Pasture	Raised floor
Assumptions			
Death loss (%)	3.00	3.00	1.00
Labor (h/day)	1	1	0.25
Mileage (km/day)	0.8	14.5	0.8
Lease property (US$/year)	0	2000.00	0
Carcass prices received (US$/kg)	3.31	3.31	3.46
Lamb prices paid (US$/kg)	1.87	1.87	1.87
Income (US$/head)			
Meat[a]	100.95	102.15	99.85
Wool[b]	0.77	3.96	32.85
Offal[b]	0.80	0.80	0.80
Pelt[b]	7.00	7.00	9.00
Total income per head	110.52	113.91	142.50
Expenses (US$/head)			
Purchase cost[c]	62.90	62.56	62.56
Death loss[d]	3.32	3.42	1.43
Feed cost[e]	24.65	20.12	44.57
Lease property (annual)	0.00	10.00[f]	0.00
Shearing cost	1.85	1.85	1.85
Fleece testing	0.00	0.00	3.00
Cost of packaging wool	0.30	0.30	1.95[g]
Wool marketing commission	0.12[h]	0.28[h]	0.00
Coat cost	0.00	0.00	2.00[i]
Vet/medication costs	1.00	1.00	0.50
Slaughter cost	9.00	.00	9.00
Labor[j]	4.05	6.60	1.52
Fuel cost[k]	0.03	0.99	0.05
Structure cost[l]	3.41	0.00	19.64
Total expenses per head	110.63	116.11	148.07
Net income per head[m]	−0.11	−2.20	−5.57

Adjusted to 2/20/2001 prices.
[a] Actual carcass weight × average carcass price.
[b] Actual prices received.
[c] Weight at purchase × $1.87/kg.
[d] Death loss% × 200 × total income/head/200 × 100.
[e] Actual total kg fed × actual cost of feed per kg/200.
[f] 162 ha × US$ 12.35 per ha/200.
[g] 15 min labor × $6.00/h + $0.10 per bag × 4.5 bags for RF.
[h] 7% of wool value when sold through commercial channels.
[i] US$ 6.00 per coat with a 3 year expected coat life.
[j] Labor h/day × days to slaughter × $6.00/h/200.
[k] km traveled × days to slaughter/6.3 km/l × US$ 0.40/l/200.
[l] Annual payment/200. Initial cost of US$ 4479.80 for Feedlot and US$ 28,539.94 for raised floor facility amortized over 10 years at 9% interest.
[m] Total income per head–total expenses per head.

sell most of the coated RF fleeces (after thorough skirting) at a price of US$ 11.00/greasy kg. The FL and P wool was sold by a commercial warehouse. The lower prices received for FL and P wool are listed in the spreadsheet (Table 5). In 2001, carcass prices varied with slaughter time across the three treatments. However, these differences were not related to carcass quality, so for the example in Table 5, prices received at a specific time were used across systems.

Inspection of the budget scenario reveals the potential advantage and the downside of the RF system, i.e., increased wool income and cost of feed and structure, respectively. What is not so obvious are some of the actual and potential (future) advantages, e.g., healthier sheep (reflected in death loss rates), less labor, and perhaps at some point in the future, higher prices for leaner carcasses, as well as the potential for “organic” production of wool and lamb meat. Prices greater than US$ 11.00/kg would be required to make the RF/C system profitable. This may be possible as a reputation for high quality hand spinning-type wools became established. However, prior to that point, making multiple sales of small quantities of wool into this niche market is a “high maintenance,” time consuming enterprise. The initial cost of the structure and the relatively high cost of the pelleted, high-roughage diet obviously makes the system cost prohibitive unless these exceptionally high wool prices or/and better prices for lean carcasses can be obtained. An alternative approach is also worth consideration. If exceptionally strong, tear-resistant coats can be sourced, capable of withstanding rugged pasture conditions, then it should be possible to produce staple length, clean, uniform, high quality wool concurrently with lean carcasses under pasture conditions. This P/C lamb feeding system could be profitable assuming the wool could be sold into high value niche markets.

In summary, the following requirements should be present for any degree of success with the RF system of lamb feeding: an initial substantial investment in the facility; the correct sheep genetics; a desire to work with wool and (primarily) hand-spinners in order to obtain wool prices > US$ 11.00/kg for fully skirted fleeces; recognition that the size of this market is limited and that competition is keen; a lamb carcass market that fully rewards leanness; and, patience, because earlier points will not occur overnight. It will take time to identify or develop the correct genetics, build a good reputation with the hand-spinner clients, and to convince lamb buyers that one should be paid more for lean lambs than for fat lambs.

6. Conclusions

Most of the anticipated advantages (Table 6) of the open-sided raised, slatted-floor barn system were realized. The combination of diet, raised-floor environment, and coats resulted in lean, desirable carcasses and visually attractive, relatively long and uniform wool.

Table 6
Advantages of open-sided, raised and slatted floor barn system

• Clean, healthy environment
• Reduced exposure to internal parasites
• Protection from predation
• Reduction in energy expenditure of animals
• Improved comfort, cooler in summer, warmer in winter
• Visually cleaner fleeces
• More uniform fibers (fiber diameter)
• More consistent products (fibers, pelts, and meat)
• Seed-free, consistent quality manure, improved disposal
• Applicable to most U.S. environments

A market for this type of wool was accessed in which prices received were more than five times commercial levels for comparable wool. Higher meat and wool prices or lower facility and feed prices are required to make this system profitable. Different genetics are required to produce more valuable wool. The comparison of these three systems of producing animal fibers and meat will provide sheep producers with technical and economic data with which to make more informed production decisions while possibly alerting them to new technological and marketing options.

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