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Comparison of feeding value of a treated sea plant, *Posidonia australis*, with lucerne, pasture and wheat

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Abstract

An experiment was carried out to compare the effect of feeding *posidonia australis* as a non-conventional feedstuff with cereal straw for sheep maintenance; and to compare seagrass/chicken litter with lucerne hay and pasture for sheep production on a scale such as would be applicable to lot-feeding of sheep in the area of suthern Australia in case of short term feed scarcity. To approach this target a Randomized Completely Block Design with six treatments was applied on sixty adult merino. The six experimental diets were: (A) 75% treated seagrass+25% lucerne; (B) 75% treated wheat straw+25% lucerne; (C) 75% treated wheat straw+25% chicken litter (seagrass bed+chicken manure from a 7-week broiler raising period); (D) 50% treated wheat straw+50% treated seagrass; (E) 100% treated straw; (F) Green pasture, mixture of legume and graminea. To treat seagrass and straw a solution containing 8% fertilizer grade urea, 15% sugarcane molasses and 1% calcium-diphosphate was mixed with either seagrass or straw (1 Kg/Kg DM). The mixture was stored under anaerobic conditions for 3 weeks. The total experimental period of 109 days was used to measure the effect of experimental rations on the voluntary intake, body weight gain, fat score, feed efficiency and wool growth rate of sheep. There were different DMI of diets A, B and C during the experiment but these differences were not significant. Similar results were obtained for diets D and E as well. Among sheep of groups A, B and C total body gain of the sheep in group A was significantly less than that of the other two groups. The body weight gain of sheep grazed on pasture was significantly less than that of the sheep groups B and C, more than for the sheep in groups D and E ($P<0.05$) and equal that of the to sheep group A. In general there were few statistical differences, except that sheep on diet A showed consistently lowest values for greasy and clean fleece weight, staple growth rate, length: diameter ratio and staple strength. There was not a significant difference in clean fleece growth rate between sheep grazed on pasture and sheep in diet groups B, C, D and E, but this value was higher than for sheep in group A. It can be suggested that seagrass litter can be used proportionally in a mixed diet to provide enough nutrients and energy for sheep production in time of drought or feed scarcity. Meanwhile the cheaper diets D (seagrass containing) or E (straw only) could be used with equal efficiency in a lot-feeding system.

Keywords: Sea plants; *Posidonia australis*; Lucern; pasture; Feeding value; Sheep.

Introduction

In the areas of southern Australia with a Mediterranean-type climate pasture availability is often a major limitation to sheep production during late summer and early autumn (Doyle et al. 1989; Squires and Bennett 2004). A shortfall in feed supplies during drought periods is also a common feature of the Australian sheep industry (Cottle, 1991; Wilson, 1994). Continous grazing, especially with high stocking rates, during this period make paddocks bare, causing soil erosion and pasture deterioration, mainly through the loss of annual legumes. The situation could be theoretically be relieved by new solutions including: breeding more efficient animals, breeding plants which are able to fix more than the current maximum of 3% of solar energy and finding new protein and energy resources. Among these solutions the use of many conventional resources should examined for both animal and human nutrition (Macedo et al., 2003).

One of the most important non-conventional resources that should be considered seriously throughout the world, and especially in Australia for animal nutrition, is aquatic plant. The saline waters, which cover about 71% of our planet's surface, support many different kinds of plants. Amongst these plants seaweeds and seagrasses are the important constituents of the marine vegetation (Christianson et al., 1988). There are thousands of known species of seaweeds and seagrasses (Womersley, 1980; den Hartog, 1970), which are possibly the world's most productive plants (Schopf, et al. 1978; Westlake, 1963). They can contribute both to food webs in costal waters and to terrestrial animals. Therefore the use of marine plants for animal nutrition, especially ruminant nutrition, should be placed on the agenda of world animal nutrition programs to solve world-wide feed deficiency. Nutritional studies of marine plants should be carried out based on their local availability.
Birch (1975) observed that seagrasses from the Australian tropics had energy and nutrient levels similar to those of poor pastures. The organic matter is usually in the range of 75-80% of dry weight, but may be as high as 90% in newly formed leaves. Other nutritional components vary with season, species, age and portion of the plant (Harrison and Mann 1975; Bjorndal 1980; Klumpp and Van der Valk, 1984; Pirc, 1985). Carbohydrate average 50% of the dry weight of leaves, a high proportion of which is in complex form. The proportion of organic matter as fiber and other structural components is comparatively high in seagrasses, ranging between 30 and 80%, with cellulose as the main fibrous component (50-60%) and the remainder as hemicellulose and lignin (Bjorndal 1980; Klumpp and Van der Valk, 1984). Whereas hemicellulose and cellulose can be digested and utilized by some consumers, lignin is the most refractory of fibrous components and can also further limit the digestive efficiency of consumers that are otherwise generally capable of utilizing fiber (Van Soest 1982). Seagrasses typically contain some 10 to 15% protein, some of which may be inorganic or associated with non-protein amino acids and protein complexes of unknown nutritional value (Harrison and Mann, 1975; Suberkropp et al., 1976).

The potential for *Posidonia australis* to be used as a sheep feed has been demonstrated in different *in vitro* and short term *in vivo* experiments (Torbatinejad, 1995, Morbey and Ashton, 1999). It has been shown that the low digestibility of *Posidonia australis* for sheep can be increased when the material is treated with alkali. Alkali treatment and supplementation of *Posidonia australis* was found also to increase dry matter intake. It was found that amongst various treatments and supplementation ammonia, molasses, chicken manure and lucerne were effective and practical in term of increasing digestibility and voluntary intake and consequently the nutritive value of *Posidonia australis*. Further study on the potential of treated- supplemented *Posidonia australis* can be useful to clarify whether or not it can be used more widely, as during drought and in times of pasture limitation (Torbatinejad, 1995).

The objectives of current experiment were comparing the effect of feeding *posidonia australis* as a non-conventional feedstuff with cereal straw as a conventional feedstuff for sheep maintenance; comparing seagrass/chicken litter with lucern hay and pasture for sheep production on a scale such as would be applicable to lot-feeding of sheep in the area of suthern Australia.

Materials and methods

Sheep and location of experiment

Sixty south Australian adult Merino wethers, averaging 47.8 kg body weight, were selected from the wether flock of the Faculty of Agriculture and Natural Resources Science, Roseworthy Campus, the University of Adelaide, South Australia. These were vaccinated against enterotoxaemia and drenched for internal parasites. The sixty experimental animals were divided into six groups by Randomized Completely Block Design (RCBD), as based on body weight and were allocated to each of six experimental diet treatments. Five groups of sheep were housed and one group released on the pasture with continous access to water and feed.

Statistical design and diets

A Randomized Completely Block Design (RCBD) with six treatments and ten sheep replicates for each treatment was used. The six experimental diets were: (A) 75% treated seagrass+25% lucerne; (B) 75% treated wheat straw+25% lucerne; (C) 75% treated wheat straw+25% chicken litter (seagrass bed+chicken manure from a 7-week broiler raising period); (D) 50% treated wheat straw+50% treated seagrass; (E) 100% treated straw; (F) Pasture, mixture of legume and graminea (50:50). The idea of treatments were followed some objectives of experiment inluding: (1) Comparing the feeding value of seagrass and straw; (2) comparing feeding value of treated- with chiken manure and/or lucerne- seagrass and treated straw; and (3) Comparing feeding value of tereated and untreated seagrass and straw with pasture.

A solution containing 8% fertiliser grade urea (46% N), 15% sugarcane molasses and 1% calcium-diphosphate was mixed with either seagrass or straw (1 Kg/Kg DM) using a Keenan mixer with digital balance for about 20 minutes. This time allowed for complete mixing. The mixture was then transferred into a plastic lined pit which was dug into the ground, pressed by loader, covered by plastic and stored under anaerobic conditions for 3 weeks. After this time the silage pits were uncovered and the same mixer used to prepare the experimental rations (A) to (E). These were bagged and delivered to the location of the experiment. The same procedure was done to treat wheat straw. Treated straw was mixed

Table 1. Ingredient proportions of experimental rations (%DM basis).

Rations	Seagrass (treated)	Straw (treated)	Chicken litter (seagrass)	Lucerne chaff	Pasture (legume+graminea)
A	75	0	0	25	0
B	0	75	0	25	0
C	0	75	25	0	0
D	50	50	0	0	0
E	0	100	0	0	0
F	0	0	0	0	100

with lucerne chaff (75%:25%) and chicken litter (75%:25%), to make diets B and C respectively. 100% of treated straw was used as diet E in experiment.

The summary of the ingredient proportions of the experimental rations is shown in Table 1.

Feeding technique

The total experimental period of 109 days was divided into three sub-periods of 11, 77 and 21 days respectively. During the first, adjustment period (11 days) the sheep were gradually adapted to the new location and experimental feeds. During the second period (77days) the main experimental period, the sheep were fed the experimental diets *ad libitum.* During this main period a mineral blend salt block containing major and trace elements (Olsson Industries Pty. Ltd.) was provided to the sheep. During the third period (21 days) the sheep were fed shed ration; this last period allowed for wool growth to be enough for ease of shearing under the last dye-band.

All five feeds in lot feeding (A-E) were weighed prior to feeding for each sheep every day and were offered between 7:00 and 7:30 hr. Feed residues were collected and weighed periodically during each week for determining weekly voluntary dry matter intake. Feed were sampled twice weekly throughout the experiment and were mixed at the end, when sub-samples were used in order to determine chemical composition and *in vitro* digestibility. Rumen degradable protein (RDP) were determined *in sacco*. The results of chemical composition and digestibility determinations are shown in Table 2.

Take Away and Rumnut programs were employed to estimate the minimum daily nutrient requirements at maintenance and growth levels for the five groups (A-E) of experimental sheep.

All sheep were weighed when they entered the experiment, weekly at the same time of day during the main period of the experiment, and then after 21 days (the end of third period).

Every week before weighing a fat score for all experimental sheep was determined by the method described by Jamieson 1984.

Wool growth measurements

Wool growth over experimental periods estimated by dye-banding method (Chapman and Wheeler, 1963; Williams and Chapman, 1996; Langlands and Wheeler, 1989).

Table 2. Chemical composition of experimental rations.

Nutrients*	Rations				
	A	B	C	D	E
DM (%DM)	63.3	65.4	65.8	53.7	54
OM	80.3	91.6	88.9	84.2	91.4
Ash	19.7	11	11.1	16	8.6
CP	9.6	8.8	8.8	6.3	5.7
CF	36	45	41.6	42.4	48.3
Ca	3.4	2.5	2.5	2.1	2.2
P	0.8	0.11	0.7	0.06	0.05
IVDMD	52.1	58	59	44	49
RDP	6.7	5.7	5.9	4.2	3.6
DE (MJ/KgDM)	9.5	10.7	10.9	8	8.9
ME	7.7	8.6	8.8	6.5	7.2

*DM=Dry Matter, OM=Organi Matter, CP=Crude Protein, CF=Crude Fibre, Ca=Calcium, P=Phosphorous, IVDMI=*In vitro* Dry Matter Digestibility, RDP=Rumen Degradable protein, DE = Digestible Energy, ME= Metabolisable Energy

Fat scoring technique

The Staple Length (SL) between dye bands was measured by ruler on five dye-banded staples per sheep. The mean and variation in fiber diameter of wool between the dye bands were determined using Fiber Distribution Analyzer (Lynch and Mitchie 1976) by workers at Turretfield Research Center, South Australia. Staple Strength (SS) was measured on 10 staples per sheep, taken from the whole fleece using a CSIRO measurement system (ATLAS), based on the standard Australian test for the determination of mean staple strength and staple length (AS 2810, 1985). The staple strength calculated by the ATLAS was corrected according to an adaptation of the regression equation of Kavanagh and Bow (1985).

Results

Results of DMI of the rations (A, B, C, D and E) are given in Table 3. Total DMI during about the first 6 weeks of the experiment for these rations increased weekly, while during the subsequent weeks it was nearly constant. While there were different DMI of diets A, B and C during the experiment these differences were not significant. Similar results were obtained for diets D and E as well.

Weekly body weight changes of the five groups of experimental sheep are summarized in Table 4. In all treatments (except groups D and E in week 1) sheep body weight increased steadily over the experimental period. Body weight gain in sheep on diets D and E were significantly less than of those on diets A, B and C throughout the experiment($P<0.05$). Although there were some differences in body weight gain between the sheep in groups D and E in some weeks the difference in total body gain during the entire experimental period was not significant. Between sheep of groups A, B and C total body gain of the sheep in group A was significantly less than that of the other two groups. The blok effect was not significant.

The total body gain of sheep which had been grazed on green pasture (group F) is graphically compared with that of the sheep fed with diets A, B, C, D and E in Figure 1.

Table 3. Average daily dry matter intake (g/Kg W0.75) of whole diets by sheep*.

Experimental	Experimental diets					Significance	
period (week)	A	B	C	D	E	(LSD; P<0.05)	SE
1	48.9[a]	65.2[b]	51.0[a]	48.4[a]	49.3[a]	6.2	7.1
2	62.1[b]	71.3[c]	52.4[a]	49.5[a]	51.4[a]	6.8	9.2
3	66.7[b]	74.3[c]	53.2[a]	50.7[a]	54.0[a]	7	10.2
4	75.2[c]	73.4[c]	62.7[b]	53.7[a]	55.9[ab]	7.1	9.8
5	77.5[b]	77.7[b]	73.0[b]	58.2[a]	58.6[a]	7.8	9.9
6	78.2[b]	83.4[b]	77.5[b]	60.5[a]	63.1[a]	8.6	10.1
7	79.3[b]	85.9[b]	95.2[c]	66.3[a]	68.0[a]	9.1	12.2
8	82.4[b]	87.4[bc]	95.3[c]	69.3[a]	70.1[a]	8.8	11.2
9	83.3[b]	89.9[bc]	96.8[c]	71.1[a]	70.1[a]	9.7	11.7
10	83.0[b]	90.5[bc]	96.5[c]	70.6[a]	68.6[a]	8.8	12.2
11	83.6[b]	90.4[b]	92.3[b]	71.1[a]	71.0[a]	9.4	10.2
Average	74.6[b]	80.8[b]	76.9[b]	60.8[a]	61.8[a]	7.6	9.1

*Mean within each column that share no common superscript differ significantly (P<0.05).

According to this data body weight gain of sheep grazed on pasture was significantly less than that of the sheep groups B and C, more than of the sheep in groups D and E (P<0.05) and equal that of the sheep in group A.

The mean weekly fat scores of the experimental sheep are shown in Table 5. It is clear from the data presented there that there were no significant differences between mean scores in week 0, 1, 2, 3 and 4. During the following weeks, however, significant differences (P<0.05 in weeks 5, 6, 7, 8 and 10; P<0.01 in weeks 9 and 11) in fat scores developed. The general trends of mean fat scores were similar to those of body weight gains.

Feed conversion ratios (Kg feed intake: Kg body gain) for the five diets during the experimental period are shown in Table 6. According to these results diet C (with chichen litter) showed the best feed efficiency and diet D showed the poorest.

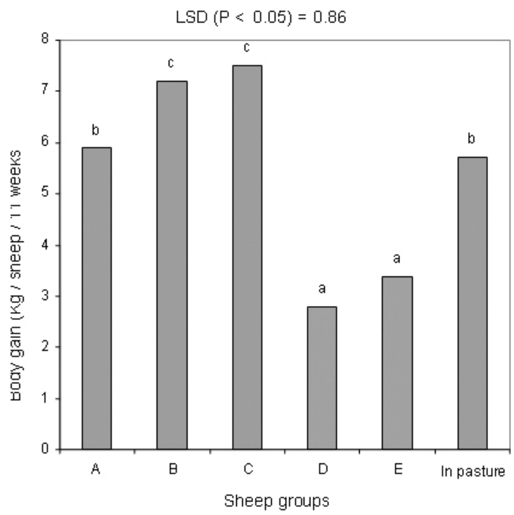

Figure 1. Total body gain comparison of experimental sheep and sheep released in green pasture.

Table 4. Body weight gain of five group sheep over the experimental periods (kg/sheep/week).

Period (week)	Groups A	B	C	D	E	LSD* (P<0.05)	SE
1	0.5 [a]	0.4 [a]	0.7 [a]	-0.7 [b]	-0.5 [b]	0.34	0.1
2	0.4 [a]	0.6 [a]	0.5 [a]	0.3 [a]	0.3 [a]	0.21	0.1
3	0.5 [a]	0.6 [a]	0.5 [a]	0.3 [b]	0.3 [b]	0.19	0.1
4	0.5 [a]	0.6 [a]	0.4 [a]	0.3 [a]	0.4 [a]	0.29	0.1
5	0.5 [a]	0.6 [a]	0.6 [a]	0.3 [b]	0.4 [b]	0.14	0.1
6	0.5 [a]	0.7 [a]	0.7 [a]	0.3 [b]	0.4 [a]	0.32	0.1
7	0.5 [a]	0.7 [a]	0.8 [a]	0.4 [a]	0.4 [a]	0.29	0.1
8	0.5 [a]	0.7 [a]	0.8 [a]	0.4 [b]	0.4 [b]	0.31	0.1
9	0.6 [a]	0.7 [a]	0.8 [a]	0.4 [b]	0.4 [b]	0.32	0.1
10	0.6 [a]	0.7 [a]	0.8 [a]	0.4 [b]	0.4 [b]	0.22	0.1
11	0.6 [a]	0.7 [a]	0.8 [a]	0.4 [b]	0.4 [b]	0.29	0.1
total	5.9 [a]	7.2 [b]	7.5 [b]	2.8 [c]	3.4 [d]	0.86	2.1

*LSD = Least Significant difference

Table 5. Average weekly fat score of experimental sheep in feed lot.

Period (week)	Groups A	B	C	D	E	(P<0.05)	SE
0	1.4	1.4	1.3	1.5	1.4	NS	0.07
1	1.6	1.4	1.3	1.5	1.4	NS	0.1
2	1.7	1.7	1.3	1.6	1.4	NS	0.1
3	1.7	1.7	1.3	1.6	1.4	NS	0.18
4	1.7	1.8	1.5	1.8	1.4	NS	0.1
5	1.9	2	1.6	1.9	1.5	*	0.2
6	2.1	2.2	1.7	2.1	1.7	*	0.2
7	2.2	2.3	1.9	2.3	1.8	*	0.2
8	2.3	2.4	2	2.5	1.9	*	0.2
9	2.4	2.6	2.1	2.6	1.9	**	0.3
10	2.5	2.6	2.1	2.6	2	*	0.2
11	2.5	2.7	2.1	2.6	2	**	0.3

NS=None signifiant; * = P<0.05; ** = P<0.01

Table 6. Feed onversion ratios in five groups of experimental sheep*.

Diet	Weight gain (Kg/sheep/77day)	DMI** (Kg/sheepp/77day)	Feed conversion ratio (Kg feed intake/Kg body gain)
A	5.9[b]	111.2[b]	19.6[a]
B	7.2[c]	122.7[b]	17.8[a]
C	7.5[c]	117.7[b]	15.7[a]
D	2.8[a]	88.0[a]	33.7[c]
E	3.4 [a]	89.7[a]	27.8[b]
LSD (P<0.05)	0.85	17.2	5.2

*Mean within each column that share no common superscript differ signifiantly (P<0.05).
**DMI = Dry matter intake.

The data obtained from wool measurements are shown in Table 7. In general there were few statistical differences, except that sheep on diet A showed consistently lowest values for greasy and clean fleece weight, staple growth rate, length: diameter ratio and staple

Table 7. Wool production comparison of experimental sheep and sheep min pasture*.

component	groups					Pasture
	A	B	C	D	E	
Greasy Fleece weight (g/sheep/9 week)	705[a]	806[ab]	864[ab]	767[ab]	863[b]	890[b]
Clean scoured yeild (%)	70.2[a]	72.0[a]	71.4[a]	74.7[a]	70.8[a]	71.2[a]
Clean fleece weight (g/sheep/9 weeks)	495[a]	579[b]	614[b]	572[b]	609[b]	634[b]
Clean fleece weight (g/sheep/d)	8.0[a]	9.3[b]	9.9[b]	9.2[b]	9.8[b]	10.2[b]
Staple length (mm)	13.0[a]	14.2[abc]	13.9[ab]	14.9[bcd]	15.8[cd]	16.8[d]
Fibre diameter (um)	20.6[a]	21.7[ab]	21.5[ab]	20.9[a]	22.4[b]	20.4[a]
Fibre diameter SD (um)	1.4[a]	1.7[ab]	1.1[a]	1.6[c]	1.9[bc]	0.6[d]
Length:diametre (um:um)	10.2[a]	10.6[ab]	10.4[a]	11.5[b]	11.4[bc]	13.4[d]
Staple strength (N/Ktex)	41.8[a]	51.1[bc]	46.5[ab]	55.9[c]	47.8[ab]	41.8[a]

*Mean within eah row that share no ommon superscript differ signifiantly ($P < 0.05$)

strength. A comparison of these characteristics of the experimental sheep and those of sheep grazed (group F) for the same time is also shown in table 7. Considerable results from this table are related to clean wool weight. There was not a significant difference in clean fleece weight between sheep grazed on pasture and sheep in diet groups B, C, D and E, but this value was higher than for sheep in group A. There was also a significant difference between sheep grazed on pasture and the experimental sheep in terms of L:FD ratio.

Discussion

The main target of the experiment was to determine weather or not farmers could use the seagrass as an alternative feedstuff for their sheep in case of short term feed scarcity or drought, for both maintenance and production. To approach this target four major criteria were examined, namely: voluntary intake, body weight gain, feed efficiency and wool growth rate. To examine the use of seagrass as a possible feedstuff in terms of commercial realities straw (a more conventional lignocellulosic feedstuff) was used as a control and seagrass containing chicken litter (diet C) was used in comparison with lucerne hay for its nutritive value (in diet A and B).

Forage supplements are already commonly fed on farms in other countries, particularly in Asia, because they are cheap relative to purchased concentrates. Result from table 3 shows that total DMI during about the first 6 weeks of the experiment for five rations (A, B, C, D, and E) increased weekly, while during the subsequent weeks it was nearly constant. This might have been because during the first weeks of the experiment the sheep were still adapting to the feedlot conditions and also were gradually getting used to ammonia-treated diets. Improvements in voluntary intake and nutritive value of poor quality roughage by green forage and chicken litter has been discussed by several researches (e.g. Jakhmola et al. 1988; Paul et al. 2003; Titgemeyer et al. 2004). The results here also indicate that seagrass can compare favorably with straw when both are treated and supplemented with ammonia and molasses. Overall it can be stated that an improved intake of seagrass by NH^3-molasses treatment and forage/chicken litter supplementation led to increase utilization of required nutrients by sheep (Quoc Viet and Duc Kien, 2001).

As was presented in Table 4, all groups of sheep gained weight over the experimental period (except groups D and E in week 1). Total body weight gains of sheep fed the different diets were quantitatively similar to their voluntary intake, except that sheep fed with chicken litter containing diet (C) showed higher body gain than sheep fed Lucerne containing diet (B) despite their lower voluntary intake. As expected sheep in groups A, B and C achieved higher body gains than sheep in groups D and E (no lucerne nor litter). Negative body gain of sheep in groups D and E in the beginning of the experiment might have been due to inadequate intake of protein and energy during the adaptation period (Prajapati et al. 2003; Salmon et al. 2004).

Feed conversion efficiency of seagrass/litter in diets formulated for production (A and C) was similar to that of the straw and lucerne containing diets (B) (Table 6). In terms of maintenance. However, seagrass (D) was less efficient than straw (E) but could nevertheless meet the requirements of sheep for more than just maintenance. Both diets of course could be adjusted for intake to meet exactly body weight maintenance. High efficiency in diets B, and C in converting feed to body gain was due to high content of metabolisable energy (Paul et al., 2003). Regarding Table 6 and Table 4 intake level of diets A and C could meet 100 g body gain requirement of sheep, which was similar to diet B.

As was presented in Figure 1 body gain of the 5 groups of sheep during the experimental period was compared with a group of sheep grazed for the same time on green pasture. In terms of body gain the nutritive value of green pasture was less than that of the diets containing straw-lucerne (B) and straw-seagrass/litter (C), equal to that of the diet containing seagrass-lucerne and more than for diets D and E, which were formulated for maintenance alone. An important point is that even in the presence of existing good quality pasture diet B and diet C (that is with seagrass/litter) in a lot-feeding system can be preferred for fattening sheep.

Quantity and quality of the wool produced by sheep is affected by the genotype, environmental and dietary factors (Brown, 1976; Allden 1979; Freer and Dove, 2002). In general, in all groups the rate of wool growth was in the range reported by Hall (1987) (3.6-15.3 per day). There was no significant difference in the clean fleece weight of sheep groups B, C, D and F. Strength, fiber diameter and length:diameter ratio in sheep on the experimental diets were similar to the differences found in clean wool growth rate. Comparison of the results of wool measurements of experimental sheep in lot-feeding with the sheep on pasture showed the latter achieved clean fleece weight growth equal to that in the feed lot, with the exception that wool growth on pasture was greater than on diet A (seagrass/lucerne), except group A had a lower wool growth than the pasture group of sheep.

In conclusion, seagrass when mixed with green forage (e.g. lucerne) can compete with straw in terms of sheep body weight gain. In addition, when seagrass is used first as a bedding material for broiler chicken the resultant litter can be used proportionally in a mixed diet to provide enough nutrients and energy for sheep production compete commercially with lucerne. In terms simply of maintenance of body weight although all 5 diets would be successful, but in time of drought or feed scarcity it is suggested that either of the cheaper diets D (seagrass containing) or E (straw only) could be used with equal efficiency in a lot-feeding system. Comparison of the result of wool measurement of experimental sheep in lot-feeding with the sheep on pasture was often greater than on diet (seagrass/lucern).

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