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Laboratory Evaluation of some Marine Plants on South Australian Beaches

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ABSTRACT

In the first experiment, twelve species of the most plentiful and fresh seaweeds and one species of seagrass from the beach were collected at Kingston, South Australia. All species were then separately sun-and oven-dried and ground. The ground samples were analysed for dry matter, ash, organic matter, crude protein, crude fibers, ether extract and digestibility *in vitro.* The digestible and metabolisable energy of the samples were estimated by calculation. The results showed that all seaweeds and seagrasses contained a very high ash content, ranging from 19.5 - 40 per cent. The crude protein content of the samples was low and ranged from 4.4 - 7.3 per cent. The crude fiber in seagrass was considerably greater than in seaweed species (34.4 % vs 3.7 -10.1 %). The dry matter digestibility of samples ranged from 34.1 to 51.5, while the data also showed that the values for digestible and metabolisable energy of aquatic plants were very low as compared with lucerne (the control). From the first experiment it was concluded that, amongst marine plants available in South Australia, the seagrass *Posidonia australis,* because of its ready availability in great quantities and the environmental problems for residents, may be regarded as a potential alternative animal feedstuff. In the second experiment, samples of four different physical forms of seagrass, *Posidonia australis* green and fresh *(from* the water, and washed and un-washed from on the beach) were examined and compared for their chemical composition, including nonstarch-polysaccharides, uronic acids, neutral detergent fiber, acid detergent fiber and lignin, amino acids, crude protein, tannin, ether extract, soluble and insoluble ash. The results from this experiment showed that there were no significant differences between the four different physical forms of seagrass collected in terms of their most important chemical constituents.

Keywords: Australia, Evaluation, Marine, Plants, Seaweeds.

INTRODUCTION

A major characteristic of sheep husbandry in Australia is its dependence on pasture land (Squires, 1981). It is well documented that annual pastures have declined in productivity and quality in recent years in southern Australia, primarily owing to loss of legumes (Carter, 1982; Gillespie, 1983; Dear and Loveland, 1985). In order to reduce the dramatic effects of over-grazing during the dry season on pasture deterioration and soil erosion, declining sheep bodyweight and wool production, and high death rates, the use of supplementary protein and energy sources should be considered. One of the alternative protein and energy sources that can be seriously considered, especially in Australia, is marine plant life.

The saline waters which cover about 71% of our planet's surface support many different kinds of plants. These include the various types of large algae, popularly known as seaweeds, which grow freely in shallow waters throughout the world. Also conspicuous on many coasts are the marine angiosperms, comprising seagrasses and saltmarsh plants, and to lesser extent the marine lichens

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(Price, 1980). Throughout the world, including Australia, marine flora is dominated by algae and seagrasses (King, 1980).

There are about 8000 known species of seaweed along the world's coast lines, and they may extend out to water as deep as 270 meters (Wornersley, 1980). The annual global seaweed harvest amounts to about $3x10^6$ tonnes of algal fresh weight (Blunden *et al*., 1975). Marine angiosperm, seagrasses, are without doubt, the most productive plants on the earth (Westlake, 1963). The primary productivity of seagrass may be considerably higher than pasture growth rate, at some five tonnes per hectare annually in Southeast Australia with 430mm annual rainfall (Ransom, 1991).

The purpose of the experiments described in this article was two-fold: (i) estimation and comparison of the possible nutritive value of widely available aquatic plants in South Australia; and (ii) the screening of one appropriate species for further evaluation in sheep nutrition studies and, ultimately, for use in commercial sheep production.

MATERIALS AND METHODS

Experiment 1

Plants: Twelve species of fresh seaweeds from the water and one species of seagrass from the beach were collected at Kingston, South Australia. The genera and species of the marine plants collected were identified by the Department of Botany, the University of Adelaide as follows:

(i) Seaweeds: *Acrocarpia panicuata* (AP), *Cystophora platylobium* (CP), *Cystophora moniliformis* (CM), *Cystophora retorta* (CR), *Cystophora subfarcinata* (CS), *Ecklonia radiata* (ER), *Seirococcus anillaris* (SA), *Sargassum bracteolosum* (SB), *Sargassum dicipens* (SD), *Sargassum lineafolium* (SL) *and Sargassum varians* (SVa).

(ii) Seagrass: *Posidonia australis* (PA).

Lucerne *(medicago sativa)* chaff, obtained from stocks at the Waite Institute, was used as a control.

Sample Preparation: After collection and identification, all fresh aquatic plants were separately sun-dried for 24 hrs and then further dried in a force-dried oven at 60^0C for 24 hrs. They were then allowed to reach equilibrium with the moisture levels in room air. About 500g of each dried plant was ground through a 1mm screen, further mixed and then a 200g sub-sample was placed in an air-tight plastic container for later chemical analysis.

Analytical Techniques: Ground samples were analysed for dry matter (DM), ash, organic matter (OM), crude protein (CP), crude fiber (CF) and ether extracts (EE) using proximate analysis (A 0 A C, 1984). A modification of Tilley and Terry's two-stage technique (1963) was used for the determination of dry matter and organic matter digestion *in vitro.* In order to estimate digestible and metabolisable energy, the equations set out by Heaney and Pigden (1963) and ADAS (1984) were used respectively.

Statistical Analysis: Data obtained for each plant variety were compared using Fisher's protected LSD method at the 0.05 probability level or below.

Experiment 2

Plant: Four different physical forms of seagrass, *Posidonia australis,* were collected from the same area of beach at Kingston, South Australia in mid-summer including: (i) *Posidonia australis* (GP) that was green in color, collected from the sea at a maximum depth of one meter; (ii) fresh *Posidonia australis* (FP) collected from the edge of beach, as near as possible to the water, that seemed to have been a massed very recently by wave action and the color of which was mostly brown; (iii) dry and washed *Posidonia australis* (DWP) collected on the beach above the water-line and had probably been exposed to the weather for a long time-collected plants were washed three times in tap water the day after collection in order to remove surface sand, dirt and other contaminants; and (iv) dry but unwashed *Posi-*

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donia australia (DUP) which was just as collected, i.e. as (iii) but without washing.

All samples were prepared for analysis as in experiment 1.

Analytical Techniques: Ground samples were analysed for non-starch polysaccharides (NSP) and uronic acids (UA) using the modified method of Englyst *et al.* (1982) and Blumenkrantz and Asbe-Haansen (1973) respectively. Neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were analysed according to Van Soest (1971). Cellulose and hemicellulose were calculated using the values obtained for NDF, ADF and ADL (Cellulose= ADF-ADL; Hemicellulose= NDF-ADF). The amino acid content was determined at the South Australia Research and Development Institute (SARDI) following the successive stage at pre-oxidation of the sample by hydrolysis and separation of the amino acids using chromatography (Mackenzie, 1987). All the samples were well prepared and all internal standards fell within normal limits (+0.025 of the batch mean). The tannin content of the samples was determined using the vanillin /HC1 method of Burns, (1963). The crude protein (CP), ether extract (EE) and total ash content of the samples were determined using procedures described in experiment 1. Soluble ash was calculated using the value obtained for the total, experiment 1 and insoluble ash (= total ash - insoluble ash) (Faichney and White 1991).

RESULTS

Experiment 1

Table 1 shows the chemical composition of various seaweeds and seagrass. It is evident that there were wide variations in chemical composition amongst the various aquatic plants. The crude protein content of the seaweeds and seagrass is low and ranged from 4.4% to 7.3% and is much lower than that of lucerne chaff hay which contains 17.9% protein and is thus significantly greater. The crude fiber content in the seagrass *Posidonia australis* (34.4%) is consid-

Table l. Approximate chemical composition of 12 species of seaweeds and one species of seagrass in comparison with lucerne chaff hay (%DM).

Plant samples	Ash	Organic matter	Crude protein	Crude fiber	Ether extract	Nitrogen free extract
Seaweeds:						
AP	33.0	67.0	7.3	8.8	1.1	49.8
CD	24.7	75.3	4.8	8.9	1.7	59.9
CM	19.1	80.9	5.1	10.1	1.6	64.1
CR	23.8	76.2	6.5	3.7	1.1	64.9
CS	20.5	79.5	503	4.9	1.7	67.5
ER	28.6	71.4	5.6	5.8	1.2	58.7
SA	19.5	80.5	4.4	7.7	1.1	67.3
SB	28.3	71.7	4.8	7.8	1.2	58.0
SD	31.5	68.5	5.4	6.6	1.7	54.8
SL	40.0	60.0	505	6.4	1.3	64.7
Sva	28.3	71.7	4.6	5.9	1.5	59.7
Sve	34.3	65.7	6.0	6.2	1.1	52.4
Seagrass:						
PA	19.8	80.2	5.5	34.4	1.1	39.2
Legume:						
Luc.	8.3	91.7	17.9	29.8	2.0	42.0
1% LSD	3.5	3.5	1.2	2.5	0.3	4.7
5%	2.6	2.6	0.9	1.8	0.2	3.5

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erably greater than in all of the seaweed species and in lucerne (29.8%). The ether extract content of both seaweeds and seagrass was very low ranging in seaweeds from 1.1% to 1.7% and in seagrass at 1.1%. The crude protein, crude fiber and ether extract contents of lucerne were higher than those of seaweeds and seagrass. The ash content of all the seaweeds and seagrass was significantly higher than of lucerne (8.3%).

The dry and organic matter digestibility (DMD and OMD) and the digestible and metabolisable energy of the experimental plants are shown in Table 2. The DMD and OMD of seaweeds ranged from 34.1% to 51.5% and from 21.8 to 40.3% repectively and, for seagrass, were 34.7% and 20.1% respectively. The DMD and OMD of lucerne chaff were substantially higher than for the aquatic plants (at 67.7% and 64.9%). The data in Table 2 also show that the values for digestilde energy (DE) and metabolizable energy (ME) of aquatic plants are very low compared with lucerne. The minimum values of DE and ME are 6.0 and 4.9 MJ/Kg dry matter in *Cystophara moniljformis* respectively and the maximum values are 9.4 and 7.6 repectively in *Ecklonia radiata.* Seagrass had values of 6.1 and 5.0 MJ/Kg dry matter.

In all the forms of seagrass collected, glucose, galactose and mannose were the dominant sugars in the soluble fraction of NSP (more than 1% of dry matter), while ribose and rhamnose were present in the lowest quantities (Table 3). The contents of insoluble constituents of NSP were dramatically greater than those of soluble NSP constituents. Among them, glucose and rhamnose revealed the highest and lowest values, respectively. All insoluble NSP constituents of the four different collections were significantly different from each other (P<0.01).

The total soluble NSP content of GP, DWP and DUP was less (at P<0.01) than that of FP (Table 4). Total soluble NSP for all the samples was less than 6% of the dry matter content. Compared with soluble NSP, the overall insoluble NSP in samples was high at >20% as opposed to <6%. Among the different samples, dry, unwashed *Posidonia* (DUP) contained less insoluble NSP than the other forms (p< 0.01).

Although, both dry forms contained more uronic acid than the green and fresh forms, there were no significant differences overall

Table 2. *In vitro* digestiblity of the dry matter (DMD) and organic matter (OMD), estimated digestible energy (DE) and metabolizable energy (ME) content of experimental plants(%DM).

Sample	DMD[a] (%)	OMD[a] (%)	DE[b] (MJ/KgDM)	ME[b] (MJ/KgDM)
AP	48.1	30.1	8.7	7.1
CD	34.7	21.8	6.1	5.0
CM	34.1	24.1	6.0	4.9
CR	38.8	33.2	6.9	5.6
CS	36.5	25.0	6.5	5.2
ER	51.5	40.3	9.4	7.6
SA	37.2	3107	6.6	5.4
SB	42.6	25.0	7.7	6.2
SD	45.8	28.1	8.3	6.7
SL	50.0	31.9	9.0	7.4
Sva	41.8	29.8	7.5	6.1
Sve	41.2	24.4	7.4	6.0
PA	34.7	20.1	6.1	5.1
Luc	67.7	64.9	12.6	10.2
0.05 LSD	3.4	4.1	0.7	0.5
0.05	2.6	3.1	0.5	0.4

[a] Tilley and Terry's two-stage technique (1963).
[b] Estimated according to Heaney and Pigeden (1963) and ADAS (1984).

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Table 3: NSP constituents of four collections of *Posidonia australis* using the Englyst method (1982) (mean and SE; n=3).

Constituent	Different collections of Posidonia [a]				LSD [b] (P<0.01)
	GP	FP	DWP	DUP	
Soluble:					
Xylose	0.49±0.01	0.53±0.02	0.80±0.00	0.63±0.001	0.05
Mannose	1.39±0.01	1.71±0.01	1.39±0.05	1.99±0.01	0.1
Galactose	1.01±0.03	1.05±0.09	0.15 ±0.00	0.09±0.02	0.2
Glucose	1.42± 0.19	1.14±0.01	1.71±0.01	1.33±0.01	0.4
Rhamnose	0.08±0.00	0.32±0.02	0.15±0.01	0.12±0.01	0.5
Fucose	0.12 ± 0.01	0.14± 0.00	0.18± 0.02	0.14±0.01	0.04
Ribose	0.03±0.00	0.11±0.07	0.24±0.19	0.02 ± 0.00	0.4
Arabinose	0.17±0.00	0.17±0.01	0.27±0.02	0.19±0.01	20.05
Insoluble:					
Xylose	5.75±0.05	5.94 ± 0.09	5.31±0.08	4.13±0.01	0.49
Mannose	0.52±0.03	0.55±0.08	0.42±0.06	0.71±0.01	0.23
Galactose	0.71±0.04	1.09 ±0.19	0.39±0.07	0.67±0.03	0.46
Glucose	15.70±1.54	15.06 ±0.10	14.03±0.66	12.20 ±0.06	2.6
Rhamnose	0.22±0.01	0.20±0.01	0.14±0.00	0.16±0.00	0.3
Fucose	0.36±0.01	0.30± 0.00	0.33±0.01	0.30±0.01	0.4
Ribose	0.33±0.01	0.32 ±0.00	0.26 ±0.01	0.25±0.00	0.3
Arabinose	0.47±0.01	0.37±0.01	0.30±0.01	0.50±0.01	0.4

[a]: Green *Posidonia australis(GP), fresh Posidonia australis(FP),* dry and washed *Posidonia australis(DWP), and* dry but unwashed *posidonia australia (DUP).*
[b]: Least significant difference.

Table 4: Cell- wall constituents of four collection forms Samples *of Posidonia australis* (%DM)

	Samples				LSD
	GP	FP	DWP	DUP	*(P<0.01)*
Soluble NSP	4.7	5.1	4.7	4.5	0.5
Insoluble NSP	24.0	23.8	21.0	18.9	2.3
Total NSP	28.8	28.7	26.9	24.4	4.5
Uronic acid	17.2	17.7	18.4	18.6	1.5
Tannin	1.74	1.74	1.85	1.82	-
NDF	46.8	46.5	47.3	45.2	1.5
ADF	35.1	35.3	35.9	33.5	0.4
ADL	14.9	15.4	15.1	14.5	1.6
cellulose	20.2	19.9	20.9	19.0	2.4
Hemicellulose	11.7	11.2	11.4	11.7	1.1
Soluble ash	9.8	9.4	10.2	14.6	-
Insoluble ash	5.5	5.7	5.4	5.4	-
Total ash	15.3	15.1	15.6	20.0	-

among the different samples in this regard (Table 4). The tannin content of the samples ranged between 1.74% and 1.85% of DM. Although the total ash content of dry, unwashed *Posidonia* (DUP) is highest (20% of DM), it's insoluble ash content is not different from that of the other forms collected (P< 0.01).

The NDF content for DUP was less than that of the other samples (P<0.01), but there were no significant differences amongst the other samples. The cellulose, hemicellulose and lignin contents of the samples varied between 19 to 20.9%, 11.2 to 11.7 and 14.5 to 15.4% respectively. It is evident that the major constituents of the *Posidonia* cell wall are cellulose and lignin.

Table 5 shows the amino acids and crude

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Table 5*:* Amino acid and crude protein content of four samples of *Posidonia australis(DM* basis). Data show the mean and SE, while n=3.

Costituenst	GP	FP	DWP	DUP
Alanine (g/kg)	3.06±0.30	2.93±0.19	2.31±0.14	2.50 ±0.01
Arginine	3.13±0.13	2.76±0.43	2.47±0.09	2.25 ±0.07
Aspartic acid	7.08±2.06	5.72±0.39	4.16±0.20	1.49 ±0.18
Cystein	1.62±0.00	1.16±0.00	0.98±0.00	1.23 ±0.00
Glutamic acid	7.43±1.02	7.01±1.36	4.86±0.27	5.08 ±0.16
Glycine	3.70±0.29	3.64±0.19	2.78±0.16	0.03 ±0.04
Histidine	0.82±0.00	0.84±0.00	0.64±0.00	0.65 ±0.00
Iisoleucine	2.84±0.33	2.65±0.25	2.00±0.00	1.95 ±0.07
Leucine	4.06±0.33	3.65±0.31	2.80±0.06	2.90 ±0.10
Lysine	2.50±0.49	2.38±0.33	1.80±0.09	1.88 ±0.09
Methionine	1.02±0.00	0.78±0.00	0.72±0.00	0.66 ±0.00
Phenylalanine	2.38±0.00	2.49±0.00	2.00±0.00	2.06 ±0.00
Proline	2.83±0.03	2.55±0.19	2.05±012	2.08 ±0.06
Derine	3.50±0.32	2.77±0.16	2.10±0.06	2.32 ±0.04
Threonine	2.79±0.23	2.39±0.17	2.05±0.06	2.16 ±0.04
Tyrosine	1.03 ±0.00	0.89±0.00	0.88±0.00	0.99 ±0.00
Valine	3.38± 0.55	4.64±1.78	2.49±0.06	2.49 ±0.02
Total of amino acids (%)	5.3± 0.55	4.9±0.57	3.7±0.14	3.9 0±.07
Crude protein (%)	6.1	5.4	4.8	6.6

DUP= Dry Unwashed *Posidonia;* FP= Fresh *Posidonia*; DwD= Dry and washed *Posidonia;* GP = Green *Posidonia.*

protein content of the samples. The glutamic acid, aspartic acid, leucine, serine, valine and arginine contents were highest, while the histidine, methionine, tyrosine and cystein contents were lowest.

DISCUSSION

The results of chemical analysis of the composition of the thirteen marine plants examined showed that all seaweeds and seagrass contain a very high ash content. This result is in agreement with Black (1955) and Durako and Dawes (1980), the latter reporting the ash content of marine plants at 35 %.

It was found that the protein content of both seaweeds and seagrass is so low that they can not realistically be regarded as a significant source of dietary protein, although there are some species of aquatic plants that contain high protein levels. The literature indicated that seaweeds and seagrasses are mostly low in protein content (Harrison and Mann, 1975; Suberkropp *et al*., 1976, Augier *et al.,* 1982, and Price, 1985). The apparent *in vitro* dry matter and organic matter digestibility and the estimated digestible and metabolisable energy contents of seaweeds and seagrass are very low in comparison with those of lucerne.

Amongst the aquatic species of seagrass, *Posidonia australis* was selected for further study as a possible foodstuff because of its lower content of ash and its accessibility. In southern Australia, hundreds, even thousands, of tonnes of the seagrass *Posidonia australis* are accumulated on beaches each year by the action of water on the beaches and this causes environmental problems in some areas. However, the harvesting of aquatic plants from sea water entails such large costs, that its utilisation as a feed for animals may never be economic.

In addition, the data show that the crude fiber content of seagrass is about three times greater than in the seaweed species. Seagrass can thus be regarded as a potentially rich source of polysaccharide carbohydrates for ruminants.

Various factors influence the quality of animal feed, but crude fiber is undoubtedly one of the most important factors (Van Soest, 1981). Several methods are available

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for determination of dietary fiber. Defining dietary fiber as proposed by Englyst *et al*., (1982), gives the best index of the plant cell-wall polysaccharides being is chemically precise and in keeping with the original concept of dietary fiber. In the second experiment, the soluble NSP contents of all four samples were the same ranging between 4.5 - 4.7% of dry matter. This concentration of souble NSP is roughly similar to the results reported by Pirc (1989). The insoluble NSP content of two samples of GP and FP was slightly different from those of DWP and DUP, but this is probably due to the higher content of soluble ash in DWP and DUP which, in turn, affects the proportion of total insoluble NSP. The total content of the cell wall (ADL) ranged from 14.5 in DUP to 15.4% DM in FP. This level of lignin in seagrass seems to be very high when compared with traditional lignocellulosic foodstuffs. The high proportion of fibers especially lignin 'in seagrass samples is in agreement with Bjornedal (1990).

In the second experiment, 17 amino acids were also identified in the four collected samples. The amino acid analyses show differences with the results reported by other researchers such as Augier *et al.,* (1982), but these variations could be due to many factors, such as the place and depth where the Posidonia was collected, the degree of development of the plants, seasonal variations etc.

Tannin is one of the important constituents because of its high levels in the experimental samples used and its adverse effects on animal nutrition, when compared with other grasses. Therfore the associated effects of tannin on protein /carbohydrate digestion could be important as well. In this experiment, the tannin content of different collected forms of *Posidonia* was similar. These results are in contrast with O'Donovan's, (1992) statement that the level of tannin is higher in plants growing in the sun than in the shade. The explanation for this contrast might be that of the limitations associated with total tannin measurements. Although the same total results were obtained for different collected forms, this could be due to possible oxidation reactions occurring in the different forms of tannin in the *Posidonia* collected on the beaches (Minson, 1981).

In summary, the substantial variations in nutrient contents between species of marine plants and also within any one of the species could be due to their different origins, the time of the year and their stage of growth. All four different forms of *Posidonia australis* can be characterised as being high in fiber content, including both cellulose and lignin, and low in protein content. They can thus be listed in the general category of lignocellulosic feedstuffs, most of which are also poor in protein.

Generally, the results from this experiment show that there are no significant differences among the four different collected physical forms of seagrass (GP,FP,DWP and DUP) in terms of their most important chemical constituents. The dry, unwashed seagrass which is readily available in large quantities and easily harvested has the potential as a foodstuff for ruminant animals.

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ارزشیابی آزمایشگاهی برخی از گیاهان دریایی در سواحل استرالیای جنوبی

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چکیده

هفتاد و یک درصد از سطح کره زمین را آبهای شور می‌پوشانند که گیاهان زیادی را درخود پرورش داده و می‌توانند بعنوان یکی از مهمترین منابع غیرموسوم غذایی در جهان مورد توجه قرار گیرند. در آزمایش اول ۱۲ گونه گیاه دریایی از خانواده جلبکهای ماکروسکپی و یک گونه گیاه دریایی از خانواده علف دریایی که نسبت به سایر گونه‌ها در سواحل استرالیای جنوبی از تراکم بیشتری برخوردار بودند به صورت تازه جمع‌آوری شدند. گونه‌های جمع‌آوری شده به صورت جداگانه به ترتیب در آفتاب و خشک‌کن الکتریکی خشک و سپس خرد گردیدند. نمونه‌های خرد شده به منظور اندازه‌گیری ماده خشک، خاکستر، ماده آلی، پروتئین خام، فیبر خام، چربی و قابلیت هضم به روش آزمایشگاهی مورد تجزیه قرار گرفتند. نتایج نشان داد که جلبکهای ماکروسکپی و علف دریایی مورد آزمایش از مقدار زیادی خاکستر (بین ٤٠-١٩/٥ ردصد) تشکیل شدند. میزان پروتئین خام نمونه‌ها از ٤/٤ تا ٧/٣ درصد متغیر بود و میزان فیبر خام در علف دریایی به طور چشمگیری بیشتر از جلبکهای ماکروسکپی بود (٣٤/٤ در مقابل ١٠/١ تا ٣٠/٧ درصد)، میزان قابلیت هضم ماده خشک نمونه‌ها بین ٣٤/١ تا ٥١/٥ درصد متغیر بود. همچنین نتایج نشان دادکه میزان انرژی هضمی ومتابولیسمی گیاهان دریایی درمقایسه با یونجه بسیارپایین بود. به طورکلی نتایج آزمایش اول نشان می‌دهدکه درمیان گیاهان دریایی آزمایشی گونه Posidonia australis به دلیل سهولت دسترسی و میزان بالای تولید و مسائل محیط زیستی که برای ساکنین سواحل استرالیای جنوبی بوجود می‌آورند می‌تواند بعنوان ماده خوراکی بالقوه برای تغذیه دام مورد توجه قرار گیرد. در آزمایش دوم، نمونه‌هایی از چهار حالت فیزیکی Posidonia australis شامل دو حالت سبز و تازه از داخل دریا و دو حالت شسته شده و شسته نشده از ساحل برای مقایسه با یکدیگر و به منظور اندازه‌گیری ترکیبات شیمیایی شامل پلی ساکاریدهای غیرنشاسته‌ای، اسیداورونیک، ADF, NDF ، لیگنین، اسیدهای آمینه، پروتئین خام، تاتن، چربی و خاکستر محلول و غیرمحلول مورد تجزیه شیمیایی

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قرار گرفتند. نتایج این آزمایش نشان داد که اختلاف معنی‌داری بین ترکیبات شیمیایی چار حالت مختلف فیزیکی گونه دریایی Posidonia australis وجود نداشت.

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