final report

Project code: W.LIV.0256

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Date published: November 2011

ISBN: 9781741917086

PUBLISHED BY
Meat & Livestock Australia Limited
Locked Bag 991
NORTH SYDNEY NSW 2059

Review of fodder quality and quantity in the livestock export trade

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government to support the research and development detailed in this publication.

Abstract

Current requirements for feeding livestock in preparation for and during export by ship are defined in the *Australian Standards for the Export of Livestock* (2008). However, fodder related components of these standards have not been updated for over 10 years. Key objectives of this project were to update these components by reviewing current industry practices and the most up to date published nutrient requirements for livestock. The industry was generally operating efficiently, although several recommendations were made for modifications to guidelines for shipping pellet formulation, feed provisioning, the supply of additional roughage for cattle on long haul voyages, the control of ammonia levels from pens, and the minimisation of risks from acidosis and heat stress. A revised shipping pellet formulation, suitable for all classes of commonly exported livestock is now recommended. Improved economic returns for exporters and importers and enhanced animal welfare are likely to be the key project benefits.

Executive summary

Current requirements for feeding livestock in preparation for and during export by ship are defined in the *Australian Standards for the Export of Livestock* (ASEL) version 2.2, October 2008. However, the fodder related components of these standards were developed in the 1990s and have not been substantially updated since. The key objectives of this project were to assess the suitability of fodder specifications in ASEL in terms of their ability to ensure that industry best practice continues to be delivered in terms of feeding efficiency, economic performance and animal welfare.

Using the 2007 CSIRO benchmark publication *Nutrient Requirements of Domesticated Ruminants*, and associated spreadsheet models, a review was firstly undertaken of the most recent nutrient requirement recommendations under Australian conditions for beef and dairy cattle and sheep, in accordance with typical performance levels on board live export vessels. Requirements were then compared with the supply of metabolisable energy and crude protein from currently specified minimum provisioning levels and shipping pellet nutrient levels, as in ASEL (2008).

Following these studies and a general review of industry practices, the following key recommendations are proposed:

1.) A revised shipping pellet formulation, suitable for all classes of commonly exported livestock, with main areas of change, in comparison with current ASEL pellet guidelines, being:

- Crude protein specification of shipping pellets (dry matter basis) to rise from min 9.0% to min 10.5%; maximum of 12.0% to remain
- Metabolisable energy specification of shipping pellets (dry matter basis) to rise from min 8.0 MJ/kg DM to min 9.0 MJ/kg DM.
- Total wheat, barley and corn specification removed, in lieu of maximum 20% set on starch.
- Acid detergent fibre to be minimum 25%, increased from minimum 18%.
- Revised specifications for calcium, phosphorus, sodium, chloride and ash.
- Urea maximum of 0.5%, as urea is highly rumen degradable and likely to increase ammonia levels in pens.

2.) In relation to the requirement for one (1) percent of feed as chaff and/or hay supplied to cattle shipped from ports south of latitude 26 degrees south, this standard be modified to specify:

- All dairy and beef cattle, deer and camelids exported from any Australian port.
- That this is mandatory only for long haul voyages over 10 days in duration.
- Provisions to be minimum two (2) percent of total feed as good quality cereal based chaff and/or hay, as a component of total ration offered for extra long haul voyages over 30 days

3.) In relation to long haul shipments of pregnant dairy cattle (over 10 days duration) a best practice recommendation is to allow 0.5% of body weight per head per day as good quality cereal based chaff and/or hay, as a component of the total ration offered. Substituting chaff or hay for a portion of the pellet ration can be a means of reducing the onset of premature lactation and possible mastitis in certain predisposed pregnant animals.

4.) A best practice recommendation is to include a vitamin / trace mineral premix in all pelleted rations. The inclusion of premix to be in accordance with common Australian stock feed industry best practice. Further research is required to determine the potential benefits of a premix in the live export ration.

5.) It is recommended that further work be undertaken on the development of more effective laboratory parameters for assessing “physically effective fibre” retained in shipping pellets.

6.) In order to minimise the output of urinary nitrogen and subsequent generation of ammonia from animal pens, rumen degradable protein levels should be kept moderate by restricting the use of urea to 0.5% maximum, and placing upper limits on crude protein in shipping pellets, as well as banning high protein legume hays/chaff when providing supplementary roughage on long haul cattle voyages.

7.) A further strategy to minimise the generation of ammonia is to include urinary acidifiers such as ammonium chloride and calcium chloride in pellets. However, the low palatability of acidifiers can reduce feed intakes, and returns on investment have been difficult to quantify. It is recommended that further work be conducted under actual voyage conditions to determine a likely return on investment from these additives.

8.) The potential role of the osmolytes glycerol and betaine in the live exporting process, particularly under conditions of severe heat stress, is interesting, but not clear. It is recommended that these products be further investigated by industry, with an accurate return on investment determined.

9.) Various commercial feed additive products, with possible application for the live export trade were outlined and presented with an indicative cost of inclusion per tonne of pellets. Products appearing to hold the highest potential include the rumen modifier ionophores based on salinomycin, monensin, or lasalocid. These products are claimed to aid in the prevention of digestive disorders, enhance feed conversion efficiency and reduce the incidence of coccidiosis, all for very low costs of inclusion. However, these products are presently banned in several importing countries and their future in general appears to be under some threat. Non-antibiotic products for aiding in the control of salmonellosis may have substantial benefit for the long haul sheep trade. Extracts from the *Yucca schidigera* plant may have benefit in absorbing ammonia from shipboard pens. Vitamin/trace mineral premixes may prove beneficial during and post shipping. Premix specifications for live export purposes were calculated as a component of the current study. It is recommended that several of the products examined in this report be further investigated to determine appropriate inclusion rates and likely returns on investment, together with the conditions under which greatest benefits for the live export trade can be expected.

10.) There currently appears to be insufficient data available to draw any conclusions on the cost-benefits of using in-feed electrolytes, such as potassium compounds, during shipping or to make recommendations on their use. Very little conclusive research into the use of in-feed electrolytes during actual shipping voyages has been documented.

11.) With respect to the feeding of livestock being transported by air, recommendations are that:
   a.) In addition to fresh water, stores of good quality, non-mouldy, non-dusty hay and or chaff be available at short notice at all on-route airports in amounts sufficient to meet the minimum requirements of the livestock. Note that this is purely an <u>emergency measure,</u> in the case of unexpected delays during the journey;
   b.) The minimum required quantity should be 0.5% of body weight, calculated on an as-fed basis.

An improvement in fodder related components of ASEL and recommended best practices should result in improved economic returns for Australian livestock exporters and overseas importers. This should be achieved through enhanced animal health, live weight gains and higher standards of animal welfare being maintained throughout the entire live export process. This project should further enhance Australia's current leading international reputation for best practice standards in the important live export trade.

Contents

1 Background

1.1 General introduction to project

Current requirements for feeding livestock in preparation for and during export by ship are defined in the *Australian Standards for the Export of Livestock*, version 2.2, October 2008 (ASEL, 2008), with the most relevant section being Appendix 4.2, Vessel Preparation and Loading. However, as the related components of these standards were developed in the 1990s and have not been substantially updated since, it is timely and appropriate to review these requirements to ensure that industry best practice continues to be delivered in terms of feeding efficiency, economic performance and animal welfare.

The MLA Livestock Export R&D Program is a joint initiative of MLA and LiveCorp which is funded by livestock exporters and livestock producers, with matching funds from the Australian Government. The program is committed to delivering research outcomes that improve animal welfare during transport processes within and from Australia and in overseas markets.

MLA - LiveCorp have identified a number of specific issues relating to fodder quality and quantity which need addressing across the cattle and sheep supply chains. These issues vary from specifications for cattle pellets in the long haul trade, to specialised fodder for integrated operators in the short haul cattle trade and to questions about the adequacy of the 2% allocation of fodder for sheep that have become accustomed to pellets prior to export. The MLA Livestock Export R&D Program has commissioned this project to review all guidelines relevant to fodder quality and quantity in the livestock export trade and to identify gaps in current knowledge.

1.2 Introduction to Australia's live export industry

1.2.1 Live export statistics

Australia is globally recognised as a world leader in the sustainable export of livestock. Australia is also the world's largest exporter of live sheep and cattle by sea, with 4.2 million sheep and over 900,000 cattle being shipped to foreign countries during 2008. The total value of Australia's livestock exports during 2008 was approx AUD 1.1 billion. These and other industry statistics, including major countries of destination, livestock numbers and values can be seen in Table 1 below.

The durations of live export voyages are classified by LiveCorp as either "short haul" (less than 10 days duration), or "long haul" (greater than 10 days). Although dependant on the port of embarkation, as well as destination, voyages are generally grouped as follows:

- Voyages to the Middle East generally range from 14-21 days,
- Voyages to China, Japan or Korea range from 10-14 days,
- Voyages to Indonesia, Philippines or Malaysia range from 3-7 days.

As can be appreciated from Table 1, over 99% of sheep voyages, and nearly 90% of dairy cattle voyages are classified as "long haul", and so represent key challenges with regards to animal health, performance and welfare standards on board export vessels.

Table 1. Australian live exports, by sea or air, by country of destination, year ended 2008.

By Country of Destination, Jan - Dec, 2008

BEEF CATTLE

	Top 5 Countries	Percentage of animals	Number of animals
1.)	Indonesia	74.9%	650,161
2.)	Israel	5.1%	44,109
3.)	Libya	4.4%	38,113
4.)	Russian Federation	2.3%	20,071
5.)	Japan	2.3%	19,770
	others	11.0%	96,286
	Total	100.0%	**868,510**
	Total FOB value AUD		**$ 638.0 million**

SHEEP

	Top 5 Countries	Percentage of animals	Number of animals
1.)	Kuwait	22.7%	956,276
2.)	Saudi Arabia	20.7%	873,937
3.)	Oman	17.6%	741,106
4.)	Bahrain	17.0%	716,040
5.)	Jordan	9.1%	383,943
	others	12.9%	543,687
	Total	100.0%	**4,214,989**
	Total FOB value AUD		**$ 321.2 million**

Percentage to Middle Eastern countries = 99.12%

DAIRY CATTLE

	Top 5 Countries	Percentage of animals	Number of animals
1.)	Russian Federation	34.4%	20,071
2.)	China	20.9%	12,209
3.)	Mexico	17.4%	10,131
4.)	Kuwait	6.7%	3,936
5.)	Pakistan	6.3%	3,680
	others	14.3%	8,337
	Total	100.0%	**58,364**
	Total FOB value AUD		**$ 120.1 million**

GOATS

	Top 5 Countries	Percentage of animals	Number of animals
1.)	Malaysia	84.9%	67,705
2.)	Brunei	6.7%	5,345
3.)	Singapore	4.2%	3,389
4.)	Philippines	3.5%	2,765
5.)	Thailand	0.2%	151
	others	0.5%	408
	Total	100.0%	**79,763**
	Total FOB value AUD		**$ 9.2 million**

NOTE:
Approx 80% of goats now commonly exported by air (Johnson, pers. comm., 2009).

TOTAL nos (cattle, sheep, goats)	**5,221,626**
TOTAL value (AUD million)	**1,088.5**

Source:
Adapted from Australian Bureau of Statistics.

With respect to the air-freighting of livestock from Australia, Table 2 below summarizes the proportion of all exported livestock which travel by air. Interesting to note are the very small percentages of cattle and sheep air-freighted, but the extremely high percentage of goats (96%) air-freighted during 2008. The principal reason is that goats generally have a higher risk of succumbing to injury or illness than do sheep during sea voyages, and their slightly higher value in SE Asian markets, particularly Malaysia, commonly warrants the relatively small additional cost involved in air-freighting these animals. As can be appreciated by viewing Table 1 above alongside Table 2, the great majority of air-freighted goats during 2008 were destined for Malaysia, with most of the remaining goats flying to other parts of South East Asia.

Table 2. Proportion of Australian live exports which travel by air-freight.

Proportion of Livestock Exported by Air			
Year	**Cattle**	**Sheep**	**Goats**
1998	0.5%	0.2%	18.6%
1999	0.1%	0.3%	31.9%
2000	0.3%	0.2%	57.2%
2001	0.3%	0.1%	28.3%
2002	0.2%	0.1%	11.3%
2003	0.3%	0.1%	27.1%
2004	0.2%	0.2%	40.3%
2005	0.3%	0.2%	69.3%
2006	0.1%	0.2%	64.0%
2007	0.3%	0.1%	69.4%
2008	1.2%	0.3%	96.0%
Ave	**0.35%**	**0.18%**	**43.4%**

Source: Australian Bureau of Statistics.

1.2.2 Basis for Australia's leadership in live exporting

Key factors responsible for Australia's industry leadership include:

a.) Australia's animal health status, with the country internationally recognised by the OIE as being free from all major exotic diseases of concern for livestock.

b.) Australia's diverse climatic conditions and magnitude of pastoral lands ensure that livestock can be produced in large numbers which are suited for both tropical and temperate climates.

c.) Australia has the world's highest livestock export standards, ensuring animals arrive in premium condition. A report published by Alliance Resource Economics in March 2006 concluded that Australia has world-best livestock export standards, in terms of coverage and capacity to deliver acceptable outcomes (Whan et al., 2006).

2 Project objectives

The key objectives of this project were to:

1.) Review current requirements for the feeding of livestock during the preparation and export by sea and by air, as specified in ASEL (2008). In particular, this review was to:
   a) Assess the suitability of the fodder specifications in ASEL (2008) in terms of the livestock species and the purpose for which they are being exported, and
   b) Assess the suitability of fodder specifications in terms of ensuring that animal welfare outcomes are consistent with expectations in relation to fodder quality and quantity.

2.) Deliver a comprehensive discussion paper that clearly identifies the issues considered and opportunities for improvement by industry.

3 Methodology

3.1 Desktop review of feed related current industry standards

A review was undertaken of all feed related components of the existing ASEL, version 2.2, with the most pertinent section being appendix 4.2, relating to vessel preparation and loading. Various recommendations for modifications to these standards were made following a review and calculation of updated feed and nutrient requirements (refer to section 3.2 below), and consultation with several key industry participants and advisors, including live export agents, veterinarians, nutritional consultants, and feed manufacturers. Persons consulted during this industry study are listed in the Acknowledgements section, below the Bibliography on page 66.

During this review, note was also made of practices undertaken by other prominent live exporting nations such as New Zealand, the European Union, USA and Canada.

A sizable third component of the review covered past research into feed related aspects of mortalities experienced in sheep on long haul voyages to the Middle East. Attention was also drawn to the large research effort currently being conducted through the MLA Livestock Export R&D Program to further understand and help resolve the crucial “Persistent inappetence – Salmonellosis – Inanition” (PSI) complex in live exported sheep. Finally, the role of electrolytes, osmolytes and hyperhydration supplements in the live exporting process was examined, largely from the perspective of helping to address the common threat of heat stress upon live export voyages from Australia.

3.2 Review of nutrient requirements

A review was also undertaken of the most recent nutrient requirement recommendations for beef and dairy cattle and sheep at maintenance and at low levels of body weight gain, in accordance with typical performance levels on board live export vessels. This study was conducted in close consultation with Dr Michael Freer, Principal Editor of the recent CSIRO benchmark publication *Nutrient Requirements of Domesticated Ruminants* (CSIRO, 2007). Associated with this publication were a number of EXCEL™ spreadsheets (including “ME Required” and “CP required”) available from a CSIRO website: www.pi.csiro.au/grazplan which enabled accurate calculations of the requirements for metabolisable energy, degradable and undegradable crude protein for Australian breeds of sheep and cattle.

The CSIRO models cater for an exact specification of animal breed and type categories, live weights and average daily gain (ADG) levels. Two fundamental performance scenarios were examined, the first assuming zero ADG during the voyage (maintenance of body weight only), the second assuming some degree of "significant ADG". Parameters for the latter scenario were carefully chosen to be most applicable for the majority of animals currently live exported from Australia. For 300 and 400 kg *Bos indicus* feeder steers and heifers, ADGs of 300 and 400 g/hd/day were used, while for sheep of 40 and 55 kg, ADGs of 50 g/hd/day were used in the models. Further details of parameters used are summarized in the Results and Discussion section of this report (Table 5 and Table 6, on pages 37 and 38).

When using the models, a generalised "live export stress factor" of 15% was applied to the category of "housed animals" in an attempt to best mimic the restrained conditions and various stressors commonly existing in the shipping environment. It was applied in the models as an "increase for grazing factor", this being the equivalent of imposing a need for the animals to expending an additional 15% of daily metabolisable energy intake in walking and browsing to source their feed. The notion of using the "increase for grazing factor" in such a way to simulate live exporting stress factors was agreed to in principle by the developer of the models, Dr Michael Freer. The stress factor had the effect of increasing total daily requirements for both metabolisable energy and crude protein.

A comprehensive review of the effects of stress during preparation and transportation phases of livestock marketing has previously been undertaken for MLA by Alliance Consulting (2001a). The types of stress factors involved in live exporting process may generally include the following:

- Yarding, and trucking from properties of origin to pre-embarkation feedlots (generally less than 8 hrs, but can be up to 12 hrs or more duration),
- Unloading, mixing and establishing social hierarchy during pre-embarkation feeding (generally 7 days, but can be several weeks in the event of delays related to weather or shipping lines),
- Yarding, protocol requirements and trucking to ships (up to 3 hrs),
- Loading onto ships (process taking up to 24 hrs),
- Mixing and establishing social hierarchy in shipboard pens (from 3 days to 3 weeks),
- Experiencing varying degrees of high (and sometimes low) temperatures, high humidity, excessive atmospheric ammonia, and possibly sea-sickness during shipping (3 days - 3 weeks),
- Unloading and trucking to feedlots or farms of destination (up to 3 day total process), and
- Mixing and establishing social hierarchy in the feedlots or farms of destination.

All requirements calculated from the models, under the two weight gain scenarios, were then compared with the supply of metabolisable energy and crude protein from currently specified minimum provisioning levels and shipping pellet nutrient levels, as stated in ASEL (2008). On the basis of this comparison, a set of revised recommendations were prepared for minimum ration provisioning levels, as well as new shipping pellet formulation requirements and nutrient levels, for all classes of exported livestock.

The CSIRO publication (CSIRO, 2007) also allowed the calculation of the most recently recommended allowances for macro minerals, trace elements and vitamins for sheep, beef and dairy cattle. These allowances were presented in the form of shipping pellet formulation guidelines and specifications for a vitamin / trace mineral premix which can be requested of commercial feed additive manufacturers by live exporters.

As a further component of this review, various commercial livestock feed additive products, with possible application for shipping pellets being consumed under conditions of high temperature, humidity, ammonia and general stress, were examined. These products were discussed and presented in tabular format on the basis of an inclusion cost per tonne of feed.

3.3 Report of recommendations

Following the desktop study and nutritional review, this report was produced to outline current Australian livestock export feeding practices and to describe recommendations for changes to the *Australian Standards for the Export of Livestock*, version 2.2, October 2008.

4 Results and discussion

4.1 Desktop review of current industry practices

4.1.1 Review of feed related current industry standards

All sections of the ASEL version 2.2, which specifically relate to fodder quality and quantity, are presented below in their current form, together with notes on recommendations for modifications where necessary. As stated in section 3.1 above, these recommendations are made following a review and calculation of updated feed and nutrient requirements (refer to section 4.2 on page 36) and consultation with several key industry participants and advisors.

Australian Standards for the Export of Livestock, Version 2.2 October 2008

Standard 3 — Management of livestock in registered premises

S3.7
To ensure adequate supply of feed and water:

(b) All livestock feed for use at the registered premises must be stored in a manner that maintains the integrity and nutritional value of the feed, and protects it from weather, pests and external contaminants (including chemical spray drift) and from direct access by animals.

(c) Where feeders and self-feeders are used, the feed trough allowance for sheep and goats held in paddocks at the registered premises is to be calculated on a paddock-by-paddock basis and must be:
(i) for ration feeding, no less than five (5) cm of feed trough per head;
(ii) for ad libitum feeding, no less than three (3) cm of feed trough per head;
(iii) during any or all of May, June, July, August, September and October feeding must occur from fully sheltered feed troughs, with the exception of areas of Australia north of latitude 26 degrees south.

(e) The quantity of feed available should meet at least minimum feed requirements, which are:
(i) Cattle/buffalo — two point five (2.5) per cent of their bodyweight, of a quality feed able to meet daily maintenance requirements;
Modification:

- Clarification - 2.5% BW as fed (fresh weight basis)

- Of a shipping pellet with specifications as per Table 9 on page 41.

(ii) Sheep and goats — three (3) per cent of their bodyweight per day for sheep younger than four (4) tooth and two (2) per cent of their bodyweight per day for four (4) tooth or older, of a quality feed able to meet daily maintenance requirements;

Modification:

- Sheep and goats <= 4 tooth: > 3.0% BW as fed (fresh weight basis),
- Sheep and goats > 4 tooth: > 2.75% BW as fed (fresh weight basis),
- Of a shipping pellet with specifications as per Table 9 on page 41.

(iii) Deer — two (2) per cent of their bodyweight per day of a quality feed able to meet daily maintenance requirements.

Modification:

- Deer of all ages for live export: > 3.0% BW as fed (fresh weight basis),
- Of a shipping pellet with specifications as per Table 9 on page 41.

S3.8

For preparation of sheep and goats in premises south of latitude 26 degrees south that are held:

(a) In paddocks during any or all of May, June, July, August, September and October, premises must have procedures to ensure that:
(i) Sheep and goats to be exported by sea are held at the premises for five (5) clear days (excluding the days of arrival and departure) before export;

Confirmation:

Recent expert veterinary advice (Norris, 2009) confirms that 5 days is still considered the optimum time for holding sheep in pre-embarkation feedlots prior to shipping, especially in outdoor, cool climate feedlots, in order to minimise the potential risk of infection with *Salmonella* species.

(ii) Livestock are fed ad libitum during that period; and
(iii) During the last three (3) days of that period, livestock are fed ad libitum, but only on pelletised feed equivalent to that normally used during an export journey.

(b) In paddocks during any or all of November, December, January, February, March and April, premises must have procedures to ensure that:
(i) Sheep and goats to be exported by sea are held at the premises for three (3) clear days (excluding the days of arrival and departure) before export; and
(ii) Livestock are fed ad libitum during that period and only on pelletised feed equivalent to that normally used during an export journey.

(c) In sheds during any or all months of the year, premises must have procedures to ensure that:
(i) Sheep and goats to be exported by sea are held at the premises for three (3) clear days (excluding the days of arrival and departure) before export; and
(ii) Livestock are fed ad libitum during that period and only on pelletised feed equivalent to that normally used during an export journey.

Addition:

For preparation of sheep and goats in premises north of latitude 26 degrees south that are held in paddocks during any or all months of the year, premises must have procedures to ensure that:

- (i) Sheep and goats to be exported by sea are held at the premises for three (3) clear days (excluding the days of arrival and departure) before export; and
- (ii) Livestock are fed ad libitum during that period and only on pelletised feed equivalent to that normally used during an export journey.

S3.14
All livestock accepted into the registered premises must be offered water and feed as soon as possible and no more then twelve (12) hours after arrival.

Standard 4 - Vessel Preparation and Loading

S4.13
All livestock for export must be offered feed and water as soon as possible after being loaded on the vessel, but no later than twelve (12) hours after loading.

S4.14
Supplies of feed and water:
(a) Adequate water of a quality to maintain good health and suitable feed to satisfy the energy requirements of the livestock for the duration of the voyage, and statutory reserves as specified in Appendix 4.2, must be loaded.
Modification to wording:

- and suitable feed to satisfy the nutritional requirements of the livestock in accordance with Table 9 on page 41, for the duration of the voyage

,
(b) The feed and water provisions must take into consideration the livestock species, class, age and expected weather conditions.

Appendix 4.2 - Shipboard Ration Specifications and Provisioning

General

The shipboard ration must not contain more than thirty (30) per cent by weight of wheat, barley or corn, unless the livestock have been adapted to the ration over a period of at least two (2) weeks before export.
Modification to wording:

- The shipboard ration must be of a formulation not containing more than twenty (20) percent of starch, and at least twenty five (25) percent acid detergent fibre, on a dry matter basis, irrespective of the level of adaptation to the ration prior to export.

All pelleted feed must be accompanied by a manufacturer's declaration that states it is manufactured in accordance with national pellet standards.
Addition:

- …..as specified in the Australian Code of Good Manufacturing Practice for the Feed Milling Industry, October 2002, and available for downloading from the website of the Stock Feed Manufacturer's Council of Australia, at: www.sfmca.com.au

All feed from a previous voyage that is suitable for livestock consumption may remain in a feed storage tank provided that:

- *Each tank is completely emptied at least once in every ninety (90) days;*
- *All feed that is no longer suitable for livestock consumption is emptied in its entirety before further feed is loaded; and*
- *Records are maintained of the emptying of feed storage tanks and are made available for inspection.*

Sheep and goats

Pellets used as the shipboard ration must conform to the nutritional specifications outlined in Table A4.2.1.

Modification:

- Outlined in Table 9 on page 41.

At the time of departure, there must be sufficient feed and water on the ship to meet the anticipated needs of the sheep and goats during the voyage, plus an additional twenty-five (25) per cent or three (3) days feed and water, whichever is less.

Feed and water allowances must be as follows:

- o *For young sheep and goats (up to and including four (4) permanent incisor teeth), at least three (3) per cent of liveweight of feed per head per day;*
- o *For sheep and goats with more than four (4) permanent incisor teeth, at least two (2) per cent of liveweight of feed per head per day; and*

Modification:

- Sheep and goats <= 4 tooth: > 3.0% BW as fed (fresh weight basis),
- Sheep and goats > 4 tooth: > 2.75% BW as fed (fresh weight basis),
- Of a shipping pellet with specifications as per Table 9 on page 41.

- o *For sheep and goats, at least four (4) litres of water per head per day, except for days when the ambient temperature is expected to exceed 35°C, when allowance must be made for at least six (6) litres of water per head per day.*

Table A4.2.1 Pellet specifications for sheep and goats

Pellet composition	Specification
Moisture content	< 12%
Ash[a]	< 13%
Crude protein[a]	< 12%, > 9%
Urea[a]	< 1.2%
Acid detergent fibre[a]	18–35%
Metabolisable energy	> 8.0 MJ/kg dry matter

[a] As a percentage of dry matter

Modification:

THIS TABLE TO BE DELETED AND REPLACED WITH THE RELEVANT SECTION OF Table 9 on page 41.

Cattle and buffalo

There must be sufficient water on the ship to meet the anticipated needs of the cattle and buffalo during the voyage, plus an additional three (3) days water.

There must be sufficient feed on the ship to meet the anticipated needs of the cattle and buffalo during the voyage, plus an additional twenty (20) per cent or three (3) days feed, whichever is less.

When calculating feed and water requirements, allowance must be made:

a) For at least the quantity of feed shown in Table A4.2.2;

Modification:

Reference to Table A4.2.2 replaced with:

- Cattle and buffalo < 250 kg: > 2.5% BW as fed (fresh weight basis),
- Breeding heifers <= 6 tooth: > 2.5% BW as fed (fresh weight basis),
- Pregnant cows: > 2.5% BW as fed (fresh weight basis),
- Other classes cattle and buffalo: > 2.5% BW as fed (fresh weight basis),
- Of a shipping pellet with specifications as per Table 9 on page 41.

b) For at least twelve (12) per cent of liveweight of water per head per day:

– This water allowance may be reduced to at least ten (10) per cent of liveweight per head per day if water consumption on the ship for each of the previous three (3) voyages averaged less than ten (10) per cent of liveweight per head per day.
Modification to wording:
- each of the previous three (3) voyages sailed under similar climatic conditions ….

– Allowance may be made for fresh water produced on the ship while at sea.

c) Fodder for cattle exported from an Australian port south of latitude 26 degrees south must include at least one (1) per cent of the required feed as chaff and/or hay.
MAJOR MODIFICATIONS:
- The requirement for chaff and/or hay in rations for cattle should be extended to ALL TYPES OF CATTLE, DEER and CAMELIDS shipped from ANY PORT in Australia, on LONG HAUL voyages (> 10 days duration).
- The feed should be GOOD QUALITY CEREAL BASED chaff and/or hay and the required amount should be INCREASED to a MINIMUM OF TWO (2) PERCENT of total feed required, as a component of the total ration offered for extra long haul voyages over 30 days duration.

Table A4.2.2 Feed specifications for cattle and buffalo

Class of cattle and buffalo	Minimum feed allowance/head/day (% liveweight)
Cattle and buffalo weighing less than 250 kg	2.5
Breeding heifers with six or fewer permanent incisor teeth (regardless of pregnancy status)	2.5
Pregnant cows	2.5
Other classes of cattle and buffalo	2.0

Modification:
THIS TABLE TO BE DELETED AND REPLACED WITH:
- Cattle and buffalo < 250 kg: > 2.5% BW as fed (fresh weight basis),
- Breeding heifers <= 6 tooth: > 2.5% BW as fed (fresh weight basis),
- Pregnant cows: > 2.5% BW as fed (fresh weight basis),
- Other classes cattle and buffalo: > 2.5% BW as fed (fresh weight basis),
- Of a shipping pellet with specifications as per Table 9 on page 41.

Deer

Deer must be fed no less than maintenance rations. Two (2) per cent of liveweight per head per day as good quality hay or its equivalent will usually achieve maintenance rations.

Modification:

- Deer of all ages should be fed > 3.0% BW as fed (fresh weight basis),
- Of a shipping pellet with specifications as per Table 9 on page 41.

Additional statement:
HOWEVER, should exporters wish to feed ONLY GOOD QUALITY HAY, or hay plus concentrates, they should be permitted, provided that the quality of hay or hay plus concentrate ration fed is reasonably comparable in nutritional content with the shipping pellet specifications given in Table 9 on page 41.

Where concentrates are fed, the concentrates should be included at a ratio of 1:4 with the roughage.
Modification:
This is statement is not necessary, provided the additional statement above is included.

Sufficient feed must be loaded on the ship to meet maintenance requirements for the duration of the voyage, plus:

- *An extra two (2) days for voyages up to and including twenty (20) days; and*
- *An extra three (3) days for voyages between twenty-one (21) and thirty (30) days.*

Feed requirements should be calculated on the basis of daily requirements of metabolisable energy (ME) in Tables A4.2.3 and A4.2.4.

Table A4.2.3 Seasonal nutritional requirements of mature deer

		Energy requirement (MJ ME/day)[a]		
Mature deer	Autumn	Winter	Spring	Summer
Stags				
Red	19	35	42	38
Elk x red	25	47	56	51
Elk or wapiti	34	62	71	66
Hinds				
Red	27	26	28	49
Elk x red	48	46	50	85
Elk or wapiti	64	61	67	120

[a] Metabolisable energy (ME), measured in megajoules (MJ) produced in fermentation of food, is the digestible energy of the food provided, less the energy lost in the production of methane and urine (16–20% total).
Note: This assumes that diets containing 14–16% crude protein are adequate for maintenance.

Table A4.2.4 Seasonal nutritional requirements for maintenance and growth of red deer from weaning till slaughter

	Liveweight (kg)							
	40	50	60	70	80	90	100	110
Maintenance stag requirements (MJ ME/day)								
Autumn (winter sheltered)	11.9	14.1	16.2	18.2	20.1	21.9	23.7	25.5
Winter	13.5	16.0	18.3	20.6	22.7	24.8	26.9	28.9
Spring	10.8	12.8	14.7	16.5	18.2	19.9	21.5	23.1
Summer	9.9	11.7	13.4	15.0	16.6	18.1	19.6	21.1
	Gain (g/day)							
	50	100	150	200	250	300	350	400
Extra energy needed (MJ/day)	2.7	5.3	8.0	10.6	13.3	15.9	18.6	21.2

Notes: Seasonal maintenance requirements are affected by the weather, and so may be lower when temperatures are warmer than normal and higher when temperatures are lower than normal.
Add extra energy for gain to the maintenance requirement to get total requirement.

Modification:

THESE TABLES ARE IMPRACTICAL AND SHOULD BE DELETED AND REPLACED WITH:

- Deer of all ages should be fed > 3.0% BW as fed (fresh weight basis),
- Of a shipping pellet with specifications as per Table 9 on page 41.

Camelids

There must be sufficient water on the ship to meet the anticipated needs of the camelids during the voyage, plus an additional three (3) days water.

There must be sufficient feed on the ship to meet the anticipated needs of the animals during the voyage, plus an additional twenty (20) per cent or three (3) days feed, whichever is less.

When calculating feed and water requirements allowance must be made:

o *For at least the quantity of feed shown in Table A4.2.5; and*
Modification:
Reference to Table A4.2.5 replaced with:

- Camelids < 250 kg: > 2.5% BW as fed (fresh weight basis),
- Breeding females <= 6 tooth: > 2.5% BW as fed (fresh weight basis),
- Pregnant females: > 2.5% BW as fed (fresh weight basis),
- Other classes of camelids: > 2.5% BW as fed (fresh weight basis),
- Of a shipping pellet with specifications as per Table 9 on page 41.

o *For at least twelve (12) per cent of liveweight of water per head per day:*

– This water allowance may be reduced to at least ten (10) per cent of liveweight per head per day if water consumption on the ship for each of the previous three (3) voyages averaged less than ten (10) per cent of liveweight per head per day.
Modification to wording:

- each of the previous three (3) voyages sailed under similar climatic conditions ….

- Allowance may be made for fresh water produced on the ship while at sea.

Table A4.2.5 Feed specifications for camelids

Class of camelids	Minimum feed allowance/head/day (% liveweight)
Camelids weighing less than 250 kg	2.5
Breeding females with six or fewer permanent incisor teeth (regardless of pregnancy status)	2.5
Pregnant cows	2.5
Other classes of camelids	2.0

Table A4.2.6 Pellet/cube specifications for camelids

Pellet composition	Specification
Moisture content	< 12%
Ash[a]	< 13%
Crude protein[a]	< 12%, > 9%
Urea[a]	< 1.2%
Acid detergent fibre[a]	18–35%
Metabolisable energy	> 8.0 MJ/kg dry matter

[a] As a percentage of dry matter

Modification:
THESE TWO TABLES TO BE DELETED AND REPLACED WITH:

- Camelids < 250 kg: > 2.5% BW as fed (fresh weight basis),
- Breeding females <= 6 tooth: > 2.5% BW as fed (fresh weight basis),
- Pregnant females: > 2.5% BW as fed (fresh weight basis),
- Other classes of camelids: > 2.5% BW as fed (fresh weight basis),
- Of a shipping pellet with specifications as per Table 9 on page 41.

Standard 5 - Onboard Management of Livestock

S5.4
All livestock for export must be offered feed and water as soon as possible after being loaded on the vessel, and within no more than twelve (12) hours.

S5.5
All livestock on the vessel must have access to adequate water of a quality to maintain good health and suitable feed to satisfy their energy requirements, taking into consideration any particular needs of the livestock species, class and age:

(a) There must be a contingency plan to provide satisfactory tending, feeding and watering of the livestock in the event of a malfunction of the automatic feeding or watering systems, but without compromising the safe navigation of the vessel.
(b) Adequate feed and water must be supplied to livestock waiting to be discharged, and during the discharge period.

S5.6
Livestock and livestock services on the vessel must be regularly inspected (day and night) to ensure that the health and welfare of the livestock are maintained while the livestock are on the vessel:

(a) A meeting must be held daily to discuss all issues relating to the health and welfare of the livestock.
(b) Livestock must be systematically inspected to assess their health and welfare.
(c) Feed and water supply systems must be monitored day and night and maintained in good order.

Standard 6 - Air Transport of Livestock

Special note with respect to the feeding of livestock during air-freighting

The feeding and watering of common species of livestock during air travel is generally not practiced in this country for the following reasons:

a.) The logistical difficulties of feeding out and storing large quantities of heavy and bulky feedstuffs on aircraft,
b.) The concern that feeding and watering of stock will result in an increased level of deposition of urine and manure in livestock crates, with a consequential increased risk of injury to animals and soiling and contamination of the area within the cargo bay of the aircraft,
c.) The difficulties created by the high density stacking of livestock air crates in aircraft cargo bays, which restricts the easy movement of stockmen, feed bags and watering buckets, and
d.) The fact that a high percentage of livestock flights are completed within 8-10 hours of departure, such that the time off feed and water is not contrary to animal welfare standards.

Nevertheless, ASEL (2008) do state that feed and water must be offered to livestock in transit if climatic conditions, species and class of livestock and total journey time warrant. In this case, for cattle, sheep and goats, this would normally involve manual watering with buckets and the placing of hay onto the floors of the wooden livestock crates.

Recommendations:

- In addition to fresh water, stores of good quality, non-mouldy, non-dusty hay and or chaff be available at short notice at all on-route airports in amounts sufficient to meet the minimum requirements of the livestock. Note that this is purely an emergency measure, in the case of unexpected delays during the journey;
- The minimum required quantity should be 0.5% of body weight, calculated on an as-fed basis.

4.1.2 Review of feed related live export standards in other countries

A comprehensive desktop study titled "*Comparison of World Livestock Export Standards*" was undertaken during 2006 by Ian Whan and associates from Alliance Resource Economics in Brisbane (Whan et al., 2006). This study concluded that "there are no formal systems in place in other countries that would add significantly to the effectiveness of the Australian Livestock Export Standards and from this point of view the Australian standards should be considered 'high quality' and not requiring immediate or drastic revision". The international comparison of standards revealed considerable variation in quality, ranging from "no evidence of any standards" in some countries to "proof of detailed and rigorous standards" in others.

The desktop study undertaken during the current project failed to find detailed specifications for feed provisioning or ration formulations pertaining to live export by sea in any foreign country, with the single exception of New Zealand. The Official Journal of the European Union (2005) did specify provisioning for sheep and cattle in terms of requirements for "fodder" and "concentrated feed" as separate percentages of live weight, but nutrient specifications for feed rations were not found.

New Zealand Fodder Standards

New Zealand standards for livestock export fodder, developed by the Ministry of Agriculture and Fisheries for sheep and cattle, are quite comprehensive, and are summarised in **Table 3** below.

Table 3. Feed provisioning and shipping pellet specifications for livestock in New Zealand.

BIOSECURITY NEW ZEALAND

Page last updated: **30 April 2008**

Shipping requirements for Sea Transport of Livestock, MAF Biosecurity New Zealand

	SHEEP	**CATTLE**
Feed Provisioning		
Young Sheep	AFI > 4.0% LW	
Sheep in general	AFI > 3.0% LW of good quality pellets	
Cattle in general		AFI > 2.0% LW as good hay or equiv
		Table of DMI req'ts given for 0 - 500 g ADG
Cattle, using concentrates		1 conc : 4 roughage
Provision Safety Margin		
	The lesser of 25% or 4 days One additional day for discharge	2 days (voyages up to 20 days) 3 days (voyages 21-30 days)
Nutrients in DM		
Dry Matter	> 85%	
Organic Matter	> 90%	
Crude Protein	> 10%	Adults 10%, Young growing 12%
Crude Fibre	> 14%	> 16%
or Modified ADF	> 15%	
Fibre particle length	> 0.5 cm	
Metabolisable Energy	> 9.0 MJ/kg	Table of ME req'ts given for 0 - 500 g ADG
Mineral Ash	8 - 10%	
Sodium	0.1 - 0.2%	
Ingredients		
Grain	not > 40% AF	
Macro & Micro Elements	not < Rec's of NZ Pastoral Association	

Information in Table 3 sourced from:

- o Ministry of Agriculture and Fisheries, New Zealand (2004). Standard for the Transport of Cattle by Sea from New Zealand, 30 July 2004.
- o Ministry of Agriculture and Fisheries, New Zealand (2008). Code of Recommendations and Minimum Standards for the Sea Transport of Sheep from New Zealand, 30 April 2008.

Additional statements made by the NZ Ministry:

- o Pre-embarkation feeding -

- A combination of meadow or legume hay and high fibre concentrate pellets is recommended, with increasing amounts of hay and pellets fed over at least a 7 day period during the preparation phase, finishing with full ship board rations for at least 72 hours before export.

o Feeding on ship -
  - Most cattle ships leaving New Zealand feed cattle meadow hay, with a supplement of concentrate feed in pellet form.
  - General recommendations include feeding pellets to hay at about 1:4 on a dry matter basis, depending on pellet fibre content.
  - Where cattle are fed pellets only, extra care with regard to pellet composition is necessary.

European Union Fodder Standards

Provisioning standards existing in the European Union are as in Table 4 below, from the Official Journal of the European Union (2005).

Table 4. Feed provisioning standards for live export from the EU.

Official Journal of the European Union, 2005			
Minimum daily feed and water supply on livestock vessels			
	Feed (in % LW of animals)		Fresh Water (Litres per animal) *
	Fodder	Concentrated Feed	
Cattle and Equidae	2.0	1.6	45
Sheep	2.0	1.8	4
Pigs	-	3.0	10

* May be replaced by a water supply of 10% of LW of the animals.

In the context of the 2.0% of total feed as roughage being recommended in this current report for long haul, non-slaughter cattle, it is interesting that authorities in the EU have specified the fodder requirement (that is, roughage, as opposed to concentrate) to be 2.0% of LW for all cattle, horses and sheep exported by sea.

4.1.3 Review of Australian shipping pellet manufacture

4.1.3.1 Australian manufacturers of shipping pellets and cubes

The Australian shipping pellet manufacturing industry consists of a fairly small number of commercial stock feed milling companies that have become mechanically equipped and specialised in their ability to produce the high roughage, high safety, and high durability pellet or cube formulations required for the live export trade. Key operators currently supplying the great majority of shipping pellets or cubes in this country include the following companies:

Western Australia -
- Gilmac, Mackie Hay, Perth
- Macco Feeds Australia, Williams
- Milne Feeds, Perth
- SP Hay, Paskeville
- Wellard Feeds, Wongan Hills
- Wesfeeds, Perth

Northern Territory -
- Adelaide River Grazing, Adelaide River
- Northern Feed and Cube, Katherine

South Australia -
- Johnson & Sons, Kapunda
- SP Hay, Adelaide

Victoria -
- Heywood Stockfeeds, Portland

Queensland -
- Ridley Agriproducts, Townsville
- Riverina stockfeeds, Warwick

There is a considerable range in the scale of operations across these companies, in terms of tonnages supplied to the live export trade. For example, only small tonnages are manufactured by the Queensland mills, and most ships leaving from the ports of Townsville and Karumba are generally loaded with pellets from the large mills in Western Australia, such as Wellards, Macco or Gilmac. The larger southern mills also often supply the far northern Western Australian ports of Broome, Wyndham and Port Hedland, with pellets generally being loaded on vessels in Fremantle or sometimes Geraldton. Although Northern Feed and Cube supply the great majority of the Northern Territory market, some vessels leaving Darwin are previously loaded in Fremantle with pellets from large mills closer to Perth. The large numbers of high value, long haul dairy cattle exported by Elders International from Portland in Victoria are generally supplied with pellets from either Heywood Stockfeeds near Portland, or Macco Feeds near Perth.

The majority of manufacturers produce pelleted formulations, generally 8 to 10 mm diameter (Figure 1). Of the above companies, the only operator producing a cubed formulation is Northern Feed and Cube at Katherine, Northern Territory (Figure 2). This is because the smaller diameter pelleted feeds can be more easily augured and pneumatically blown through feeding lines on vessels.

In view of the impending substantial withdrawal of cubed formulations from the Australian live export market, the remainder of this report will use the term “shipping pellets” to describe the general range of manufactured formulations for the trade.

Figure 1. Sample of shipping pellets manufactured in WA.

25 mm Oaten Hay pellet 9mm Oaten Hay pellet

Note that the 25 mm pellet style is currently outdated, as it is considered too large for modern vessels using pneumatic feed blowing systems.

Figure 2. Sample of shipping cubes, approx 20 x 20 x 40 mm, manufactured in NT.

4.1.3.2 Key principles of shipping pellet formulation

From an animal perspective it would be desirable to have unprocessed hay or chaff as a component of all shipboard rations. This option has been traditionally unfavoured by shipping agents, crew and exporters due to the substantial bulkiness of this form of fibre for storage purposes on ship, together with its inability to be augured and pneumatically blown through feeding lines. As a consequence, pelletised formulations have become the norm for live export rations, and this trend will only increase at a faster rate as ships become bigger and more sophisticated in their feeding systems.

Effective shipping pellet formulations are a significant challenge to the feed miller. There is a fundamental need for high roughage, high performance and high safety with minimal adaptation. Effective formulations involve many compromises, all to be balanced against the cost of the final product, as is outlined below.

1.) <u>High roughage content, to cater for minimal adaptation.</u>
Firstly, the feed miller must supply a pellet with sufficient roughage content to maintain the health status of ruminant animals which have had very minimal, or even zero adaptation to the formulation prior to entering pre-embarkation feedlots or the ships themselves. Although it is recommended and planned that animals are introduced to shipboard rations for at least one week prior to being loaded on ships, such plans do not always come to fruition. This may be due to factors such as changes to international shipping schedules, and local wet weather conditions which can influence the ability to muster and transport stock from properties of origin to pre-embarkation depots or shipping ports. Due to such unforeseen circumstances, there have been numerous anecdotal reports of animals being loaded onto ships with zero prior exposure to the shipboard ration. In addition to these unplanned extreme situations, it is quite common industry practice for sheep and cattle to be placed directly onto full shipping pellet rations after being trucked from properties into pre-embarkation feedlots (Jarvie, 2009).

2.) <u>High palatability and nutritional content, to maintain health and performance.</u>
Secondly, shipping pellets should be highly palatable and contain sufficient metabolisable energy, crude protein and minerals needed to boost feed intakes and enable the animals to regain the substantial weight of gut contents and body fluids lost in the pre-shipping processing and transportation phases (anecdotal reports suggest up to 10% of LW). Pellets then need to maintain or increase body weight and health status during the voyage itself, which can at times involve severe extremes of high temperatures, humidity and pen ammonia concentrations. Energy contents are most effectively boosted with cereal grains in formulations. Cereal grains can also significantly improve pellet durability and reduce dustiness. However, the intake of rapidly fermentable starch and soluble carbohydrate should be carefully controlled during live export, as rapid, excessive intakes can predispose to clinical or subclinical rumen acidosis, with consequential adverse impacts on overall feed intakes, performance and animal welfare on board.

3.) <u>High pellet durability, to reduce dustiness.</u>
Pellets need to be of sufficient durability to withstand the rigours of being trucked, augured and pneumatically blown into silos and feeding lines on vessels without developing excessive dustiness. The generation of "fines" and dustiness can depress feed intakes and predispose to respiratory illness and pink eye on board. Specific pellet binders have traditionally been of limited effectiveness, but as mentioned above, cereal grains in formulations are important for durability, due to the enhancing effect of gelatinization of the cereal starch matrix on pellet binding capacity. A reduction in particle size of hammer-milled grain and roughage also plays a key role in improving pellet strength and durability, as does increasing the degree of gelatinization, which is achieved through fine grinding and high temperature steam conditioning. Unfortunately, any manufacturing swings in this direction will always jeopardise the levels of physically effective fibre retained in pellets, with a certain (not clearly defined) length of fibre particle needed to maintain normal chewing, salivation and rumination processes in ruminant animals. It is now common for shipping pellet mills to use hammer-mill screen sizes of only around 8 mm to process straw or hay prior to conditioning and pelletising.

4.) Ideally moderate rumen degradable protein, plus methods to minimise generation of ammonia.
From an animal welfare perspective, shipping pellets should ideally be formulated to have moderate rumen degradable protein contents and possibly contain urinary acidifiers to minimise the output of urinary nitrogen and subsequent generation of potentially harmful levels of atmospheric ammonia from animal pens. It is relevant that Cole et al. (2005) demonstrated the ammonia emissions were effectively doubled over a 7 day period in steers fed an 11.5% vs. 13.0% crude protein diet. In a similar experiment, Todd et al. (2006) observed reducing crude protein in steer diets from 13.0 to 11.5% reduced mean daily ammonia emissions by 28%. Accioly et al. (2003) showed that higher protein diets, containing lucerne hay/chaff or urea, can increase total urinary nitrogen output. Interestingly, poor quality straws, as opposed to good quality cereal hays, had a similar effect (Accioly et al. 2003). Volatile ammonia is thought to be a contributing factor to respiratory problems, not only in cattle (Dewes et al. 1995), but also in humans (Luttrell, 2002).

However, dietary protein levels are generally correlated with palatability and feed intake, with crude protein levels of around 12% generally required for reasonable weight gain during voyages. The concept of lowering dietary rumen degradable to undegradable protein levels in shipping formulations to reduce ammonia is limited by the availability of reliable data on rumen degradable protein (RDP) and rumen undegradable protein (RUP) levels in local feed commodities, together with the fact that very minimal levels of the more expensive RUP (or "by-pass" protein) are required in rations for livestock during shipping. The issue is further complicated by the fact that increasing the proportion of RDP in shipping pellet formulations is a potential method of lowering the total level of CP required by the animals, however an increase in RDP is more likely to generate increased production of urinary nitrogen and atmospheric ammonia. The concept of using urinary acidifiers such as ammonium chloride or calcium chloride is certainly worth considering, however these agents can also reduce feed palatability and their return on investment for the live export trade has yet to be conclusively determined. (Refer to Table 10 on page 42 for more specific detail on this approach.)

5.) Ideally having a low "heat increment", to minimise the effects of heat stress.
The "heat increment" (or "heat of digestion") of a feedstuff is the increase in body heat experienced by an animal resulting from the consumption and utilization of that feedstuff. Energy is used for the mastication and propulsion of feed through the digestive tract and is required by rumen microorganisms for fermentation processes. The heat increment represents a net loss of productive potential and results in a slight rise in body temperature, and therefore can be particularly deleterious under conditions of heat stress. Consequently, shipping pellets should ideally be formulated to have a low heat increment, especially when fed to susceptible breeds of livestock on voyages determined from heat stress modelling to be "high risk". The heat increment is calculated as the difference between the metabolisable energy (ME) and net energy (NE) of a feedstuff. Commodities with lower heat increments include vegetable oils, high fat meals such as copra and palm kernel, lupins, and (within roughages) high quality cereal hays. High heat increment commodities include highly fibrous feeds such as crop stubbles, rice hulls, cotton hulls, peanut shells, and poor quality straws. However, the effects of reducing fibre levels to lower heat increments upon the acidosis risk posed to livestock will be of key importance, and must be weighed up against the perceived risks posed to animal welfare by the threat of heat stress.

4.1.3.3 Current shipping pellet formulations

Figure 3. Sample of a typical shipping pellet formulation.

WA Shipping Pellet Formula (example only) Analysis on DM basis

INGREDIENT	Inclusion % As Fed	Ingred DM%	Contribution Ration DM	Incl % DM basis	Ingred CP %	Contrib CP%	Ingred ME MJ/kg	Contrib MJ/kg	Ingred Starch %	Contrib Str %	Ingred ADF %	Contrib ADF%	Ingred NDF %	Contrib NDF%	Ingred Na %	Contrib Na%	Ingred Cl %	Contrib Cl%
Lupins	**12.00**	90.0	10.80	11.84	35.0	4.15	14.1	1.67	3.4	0.40	20.7	2.5	25.3	3.00	0.02	0.002	0.09	0.011
Barley	**23.00**	90.0	20.70	22.70	10.0	2.27	13.0	2.95	59.2	13.44	6.3	1.4	8.4	1.91	0.01	0.002	0.13	0.030
Cereal Hay/Straw	**52.00**	92.0	47.84	52.46	9.0	4.72	7.0	3.67	4.0	2.10	45.0	23.6	70.0	36.72	0.15	0.079	0.70	0.367
Wheat Pollard	**10.00**	90.0	9.00	9.87	15.0	1.48	11.0	1.09	23.5	2.32	16.0	1.6	42.5	4.19	0.05	0.005	0.05	0.005
Quick Lime (CaO)	**2.00**	95.0	1.90	2.08	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.0	0.0	0.00	0.00	0.000	0.00	0.000
Gypsum (CaSO4)	**1.00**	95.0	0.95	1.04	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.0	0.0	0.00	0.00	0.000	0.00	0.000
		90.0	0.00	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.0	0.0	0.00	37.00	**0.000**	60.70	**0.000**
		95.0	0.00	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.0	0.0	0.00	0.00	0.000	0.00	0.000
	100.00		**91.19**	100.00		**12.6**		**9.4**		**18.3**		**29.1**		**45.8**		**0.09**		**0.41**
					AF	11.5	AF	8.6	AF	16.7	AF	26.5	AF	41.8	AF	0.08	AF	0.38

Figure 4. Sample of a typical shipping cube formulation.

NT Shipping Cube Formula (example only) Analysis on DM basis

INGREDIENT	Inclusion % As Fed	Ingred DM%	Contribution Ration DM	Incl % DM basis	Ingred CP %	Contrib CP%	Ingred ME MJ/kg	Contrib MJ/kg	Ingred Starch %	Contrib Str %	Ingred ADF %	Contrib ADF%	Ingred NDF %	Contrib NDF%	Ingred Na %	Contrib Na%	Ingred Cl %	Contrib Cl%
Cavalcade Hay	**35.00**	90.0	31.50	34.54	10.3	3.56	7.7	2.66	10.9	3.77	44.3	15.3	58.4	20.17	0.003	0.001	0.23	0.079
Tropical NT Hay	**36.00**	92.0	33.12	36.32	11.0	4.00	8.5	3.09	7.0	2.54	45.0	16.3	62.0	22.52	0.04	0.015	0.59	0.214
Corn/Sorghum	**20.00**	90.0	13.80	15.13	10.0	1.51	14.0	2.12	72.4	10.96	2.5	0.4	10.3	1.56	0.01	0.002	0.05	0.008
Molasses	**5.00**	90.0	4.50	4.93	3.5	0.17	12.5	0.62	0.0	0.00	0.2	0.0	0.3	0.01	0.22	0.011	3.10	0.153
Bentonite	**4.00**	95.0	3.80	4.17	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.0	0.0	0.00	0.00	0.000	0.00	0.000
		95.0	0.00	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.0	0.0	0.00	0.00	0.000	0.00	0.000
		90.0	0.00	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.0	0.0	0.00	37.00	0.000	60.70	0.000
		95.0	0.00	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.0	0.0	0.00	0.00	0.000	0.00	0.000
	100.00		**86.72**	95.10		**9.2**		**8.5**		**17.3**		**32.0**		**44.3**		**0.03**		**0.45**
					AF	8.0	AF	7.4	AF	15.0	AF	27.8	AF	38.4	AF	0.02	AF	0.39

The current status of shipping pellet formulations in Australia could be described as “simple and safe, but capable of improvement”. However, it must be appreciated that commercial realities are a powerful player in the live export trade, and the fact that the feed milling companies listed previously, plus others not listed, are still in profitable operations suggest their product is generally meeting current market requirements for animal performance.

With the general exception of pellet binders to improve durability, there are on the whole very few feed additives used in shipping formulations, a situation which varies considerably from mainstream stock feed formulations used for domestic livestock species throughout the country. Examples of typical shipping pellet and cube formulations are shown in figures 3 and 4. Surprisingly, vitamin and trace mineral premixes were not commonplace in the industry, nor was the inclusion of common salt, the most significant source of the body’s two most important electrolytes, sodium and chloride. Reasons for the omission of salt probably relate to the concern that excess dietary salt can increase urinary output beyond normal levels and result in compromised animal welfare on board through excessively wet pen conditions, together with an apparent increase in atmospheric ammonia levels. Interestingly, salt has been banned from live export rations by certain shipping companies in New Zealand in the past.

Research findings from this report that indicate a need for modification of shipping pellet specifications and micro-additives are presented in section 4.2, and are also summarized in the Conclusions and Recommendations section.

4.1.4 Review of previous research into live export feed related issues

4.1.4.1 Feed related mortalities on long haul sheep voyages

As mentioned previously nearly all (99.12%) sheep exported from Australia are transported to the Middle East for slaughter. These voyages are classified “long haul” and generally take from 14 - 21 days. The great majority of sheep are exported from Fremantle in WA, but with significant numbers also exported from Adelaide and Portland in Victoria.

Mortality rates suffered by sheep during long haul voyages to the Middle East have been a persistent cause of animal welfare concern for the industry for many years. However, mortalities (mostly experienced during the voyage itself, as opposed to during loading or discharge) have fallen sharply since 1985, and have been under 1.0% since 2001 (Beatty pers comms, 2009).

The livestock export industry has previously commissioned a number of studies investigating the causes of mortalities in sheep on voyages to the Middle East. These studies have been reviewed by Norris (2005). Inappetence of sheep has been identified as a major problem for the live export industry. In many groups of sheep introduced to pre-embarkation feedlots, there appears to be a certain number that voluntarily refuse to eat. Persistent inappetence predisposes sheep to diseases such as salmonellosis, and those that do not die of that disease will eventually die of inanition. The interaction between these two factors is now known in the industry as the “Persistent inappetence – Salmonellosis – Inanition” (PSI) complex. The PSI complex continues to be identified as the primary cause of death for 60-75% of all shipboard mortalities in sheep (MLA, 2008).

The causes of inanition (failure to eat) on sheep voyages are potentially of considerable relevance to this current review of fodder requirements. However, numerous studies have already examined this phenomenon (reviewed by Norris, 2005) and four newly commenced MLA projects are currently researching related aspects (see details below).

As background information, sheep exported on ships are firstly trucked from the farm of origin, over distances generally taking 8 - 12 hours in WA, but sometimes closer to 12 hours when shipped from Victoria. They are then assembled in pre-embarkation feedlots, where they are introduced to shipping pellets over a period of approximately one week (Jarvie, 2009). They are then trucked and loaded onto the ship.

As reviewed by Norris (2005), factors having been shown to affect the risk of sheep deaths in the past have included:

a.) Level of consumption of the pelleted feed,
b.) Farm or farm group of origin,
c.) Age of sheep,
d.) Fat score,
e.) Time of year of voyage,
f.) Duration between leaving pre-embarkation feedlot and unloading in the Middle East, and
g.) Occasionally, temperature and humidity.

Although most sheep begin eating the pelleted feed in the pre-embarkation feedlot or aboard ship, a few become persistent non-feeders, and these animals are the most likely to die.

Factors for which no consistent association with mortality has been shown include:

a.) Distance trucked from farm to pre-embarkation feedlot,
b.) Time on the truck,
c.) Time off-feed from yarding on farm to unloading at the feedlot,
d.) Purchase history on the farm,
e.) Social interaction on the farm,
f.) Experience of supplementary feeding and type of feed as unweaned lambs,
g.) Experience of supplementary feeding and type of feed in the last 9 months before export,
h.) Time of shearing on the farm.

Note that the observations regarding factors f.) and g.) above, suggesting that experience of supplementary feeding prior to loading on ships is not consistently associated with mortalities, should not be regarded in any way conclusive. These observations are surprising and in fact contradict many prevailing views on the great importance for all types of livestock of prior experience in feeding from troughs and exposure to pelleted rations prior to boarding live export ships.

It is interesting that new MLA Live Export R&D projects recently approved by the Live Export R&D Management Committee or currently being undertaken include several focusing on Salmonella/inanition in sheep (and having relevance also to goats). One such project will determine whether the development of an Ovine Salmonella vaccine for the Australian industry can be justified from an economic perspective, and will also assess various animal welfare benefits.

4.1.4.2 Cause of mortalities on cattle voyages (generally non feed related)

Live cattle are exported from several ports around Australia, with the large majority leaving from Darwin, and significant numbers from Fremantle, Broome and Wyndham in WA, and Townsville in Queensland. The main destinations are shown in Table 1 on page 9, with Indonesia (3-6 day “short haul" voyage) now dominating this market, and much smaller numbers being shipped to the Middle East, on a 14-21 day voyage. The great majority of cattle exported to SE Asia are tropically-adapted *Bos indicus* beef breeds intended for slaughter following a period of feedlotting, generally 70-120 days in duration. However increasing numbers of dairy cattle have been exported in recent years, with the Russian Federation and the People's Republic of China now importing large numbers, as also shown in Table 1 previously.

As reported in the review by Norris & Norman (2006), the overall death rate among 560,000 cattle exported from Australia during 2005 was 0.14%, a slight rise from the 0.10% observed in 2004. The highest overall death rate on a regional basis was to the "long haul" destinations of the Middle East and North Africa. Exports to SE Asia (mostly Indonesia) were characterised by large numbers of small consignments on short voyages with very low death rates. However, in contrast to the causes of mortalities in sheep, the main causes of cattle mortalities to the Middle east have been shown to be heat stroke, trauma and respiratory disease (Norris et al, 2003). All of the deaths from heat stroke were in *Bos taurus* breeds and occurred in the latter half of the voyage.

In view of such findings, numerous industry supported research projects have thoroughly investigated methods of preparing for and managing heat stress during both cattle and sheep voyages, in particular those destined for Middle Eastern ports. A sophisticated risk assessment heat stress modelling program has been developed for MLA and Livecorp by Maunsell Australia Pty Ltd (Stacey and More, 2003) to assess the risk of mortality due to heat stress on long haul voyages to hot climates. The risk assessment model takes account of several factors including weather at destination and en route, animal acclimatisation, coat length, as well as the ventilation characteristics of each ship. Research into the physiology of heat stress under conditions of live export has been undertaken by several groups, including Barnes et al (2004).

4.1.4.3 Electrolyte usage during transport and shipping

The concept of electrolyte preparations being used to minimise the metabolic effects of feed and water deprivation and the generalised stress sometimes associated with certain phases of the live export process, has been touted in some commercially driven circles within the industry for many years. However, there are many differences of opinion as to the effectiveness of electrolytes and some degree of misunderstanding of their underlying physiology. In response to this, MLA has commissioned some key research groups to address this issue over recent years, and their main findings, as documented in their reports, are summarised below.

<u>Alliance Consulting (2001b): Use of electrolytes to alleviate stress: Desk top study. Final Report LIVE.104B. Meat and Livestock Australia.</u>

- There is insufficient data to draw any conclusions on the cost-benefits of electrolytes during shipping or to make any recommendations on their best use. No research into the use of electrolytes during shipping has been documented.

- The actual physiological state of cattle and sheep during shipping has not been confirmed. The literature suggests that for cattle, heat stress encountered during shipping will result in metabolic acidosis, while experience suggests that respiratory alkalosis is a significant problem. For sheep, research findings suggest that glucose supplementation may be required to treat inanition, the main cause of deaths during shipping. The current use of electrolytes by the industry is not consistent with these findings.

- Land-based studies on the benefits of electrolytes are inconclusive and do not allow any conclusions to be drawn. A general pattern of electrolyte use and industry views on the benefits of electrolytes cannot be determined due to the differences in opinion that exist in the industry.

<u>Rose, RJ and Evans, DL (2001): Desk top study of electrolyte products. Final Report LIVE.108. Meat and Livestock Australia.</u>

This study was commissioned to evaluate 5 commercially available electrolyte mixtures and determine their likely usefulness, when related to theoretical losses calculated during transport and shipping.

- A number of electrolyte solutions are recommended for cattle and sheep during transport. Unfortunately, there is little information to justify the use of such electrolyte mixtures/solutions

- Estimated losses were calculated, based on 300 kg steers with 5 and 10% dehydration levels, which is the more severe end of the dehydration spectrum. If steers drank 30 litres of any of the electrolyte solutions investigated, the amounts of electrolytes replaced in all cases represent less than 5% of the body's exchangeable electrolytes.

- Similarly, the use of electrolytes in the feed in the amounts recommended will have little effect on electrolyte balance.

- The commercial electrolyte solutions investigated are likely to be of little value for the maintenance of normal body fluid electrolytes or glucose during shipping. It seems more important to focus on the ensuring adequate water is provided, prior to further studies on determining whether cattle will drink more concentrated electrolyte solutions. Little is known about the impact on drinking behaviour of steers when different concentrations of electrolytes are added. This is important as while the potential electrolyte losses are important, in the acute situation, water is of critical importance. While it appears that much higher concentrations of electrolytes are necessary to have any effect, the addition of electrolytes to drinking water may worsen dehydration, if the steers are reluctant to drink because of the taste.

- Overall conclusions: Use of the solutions investigated would be unlikely to provide the daily requirements of electrolytes in steers during shipping. It seems unlikely that with the quantity of electrolytes provided that there is any value in providing these electrolyte solutions compared with the provision of water alone. Normal feed has significant quantities of electrolytes, and it will have a much more significant effect on the exchangeable electrolytes in the body than provision of current electrolyte mixes.

<u>Barnes, AL, Beatty, DT, Taylor, EG, Stockman, C, Maloney, SK and McCarthy, MR (2004): Physiology of heat stress in cattle and sheep. Final Report LIVE.209. Meat and Livestock Australia.</u>

- Three baseline experiments were conducted at Murdoch University, Western Australia, in climate controlled rooms, each with six cattle (two with *Bos taurus* and one with *Bos indicus*), whilst one experiment was conducted with 18 sheep. A further experiment was conducted on a commercial shipment to the Middle East, involving 80 *Bos taurus* cattle.

- An electrolyte supplement was delivered in the drinking water and contained 1.8 g $NaHCO_3$ and 3.5 g KCl per litre, giving a total of 5.3 g/L or 0.53% salts, which was more concentrated than many commercial products. Guidelines used to develop this formulation were:

a) NRC (2000) recommendations for young stressed cattle,
b) Dietary cation anion difference (DCAD) equations, and
c) Information on commercial electrolyte products used in the live export industry.

- All three experiments showed a similar result, with supplemented animals drinking more, having more alkaline urine, and showing a weight advantage.

- For cattle experiencing clinical heat stress in the climate controlled rooms, treated animals lost 5.1% of their starting body weight, while control animals lost 7.9% of starting body weight. Cattle on the commercial shipment did not exhibit clinical heat stress, but treated animals gained 2.9 ± 1.7 % more weight than the control animals ($P<0.001$).

- The electrolyte formulation used on the commercial voyage cost approximately $4.00 per head, not including infrastructure for delivery. Treated animals had a weight advantage of at least 11 kg over controls by the end of the experiment, such that even at LW sale prices of $1.00/kg, there was a clear return on investment.

- On the basis of these results, it is recommended that *Bos taurus* cattle receive appropriate electrolyte supplements in the water when shipped on long haul voyages whenever they are exposed to high heat and humidity. Although the optimal type and dose of supplement was not determined (with only one formulation type being tested), it is expected that formulations based on sodium, potassium and bicarbonate will replenish those electrolytes measured to decrease during periods of high heat and humidity. However, further work is required to determine optimal compositions and dose rates of electrolyte formulations.

- Further work should also be conducted with *Bos taurus* cattle to determine the repeatability of the weight advantage in supplemented animals, and investigate the physiological basis of this weight advantage. It appears from the increased fluid consumption by supplemented animals that the weight advantage may be largely due simply to an increased intake of fluid.

- Given the weight advantage seen with the commercial shipment of *Bos taurus* animals, despite the absence of clinical heat stress, it is the authors' recommendation that the use of electrolytes in *Bos indicus* cattle should be further examined under conditions experienced on route to the Middle East during the northern summer.

- Based on the experiment conducted with 18 sheep, there currently appears limited benefit in providing electrolytes to sheep that are eating and drinking, even if they are subject to high heat and humidity.

- However, the usefulness of supplements for sheep subject to other stressors, and in situations where they are not eating should be investigated. The issue of inanition in sheep remains very important for the live export trade, and the supplementation of drinking water with products containing glucose and electrolytes may be of some benefit in maintaining both body and rumen functions.

<u>Fitzpatrick, LA and Parker, AJ (2004): Management of pre-delivery stress in live export steers Final Report LIVE.301. Meat & Livestock Australia.</u>

- Transportation studies showed no differences in the pH of arterial blood from transported or non-transported steers, confirming that transportation stress causes no differences in the acid-base balance of transported versus non-transported ruminants.

- The primary challenge to a transported or feed- and water-deprived animal is a mild metabolic acidosis, induced by elevated plasma proteins, which may be the result of a loss of body water. In the transported animals, there was a significant decrease in plasma concentrations of potassium, however, all other electrolyte treatments did not provide significant differences between groups. This would suggest that electrolyte solutions fed post transportation would provide little benefit in correcting a steer's acid-base balance, compared to water alone.

- The studies described here clearly demonstrate that offering electrolyte solutions post transportation to *Bos indicus* cattle is unlikely to correct acid-base balance and reduce physiological stressors any more than water alone.

- The data from this project challenges the current "best practice" management protocols for transported ruminants, in particular, the efficacy of electrolyte solutions administered pre- and(or) post-transportation to minimise effects of stress.

<u>GENERAL CONCLUSION FOR LIVE EXPORTING</u>

In the light of the above inconclusive findings as to the role of in-feed electrolyte supplements in the live export process, and without further work, as suggested by Barnes et al (2004), in clarifying the most effective formulation types and dose rates, it is difficult to suggest at this point in time a likely return on investment from their inclusion in shipping pellet formulations. It is also a key consideration that feed intakes can be jeopardised by electrolytes such as potassium chloride, while potassium bicarbonate may have the effect of raising urine pH, with a resulting increase in urinary nitrogen output and pen ammonia levels.

However, work in the cattle feedlot sector has determined that increased potassium levels (often originating from in-feed molasses) can be important in maintaining feed intakes during hot weather, and so it does appear appropriate that further work on the usage of electrolytes, particularly potassium, be conducted for the live export trade.

4.1.4.4 Pre-transport dosing with osmolytes and hyperhydration supplements

<u>Fitzpatrick, LA and Parker, AJ (2004): Management of pre-delivery stress in live export steers Final Report LIVE.301. Meat & Livestock Australia.</u>

In addition to the above work, this group also evaluated the potential role of a novel orally dosed hyperhydration supplement named "SSF1" in livestock transportation processes.

- Prophylactic pre-transport dosing of cattle with the oral supplement SSF1* could have a number of significant welfare and production benefits for cattle, and a provisional patent application has been filed. Pre-transport hyperhydration with SSF1* appears capable of:

  a) Reducing the relative loss of body water during transportation,
  b) Assisting in delaying the catabolic effects of dehydration,
  c) Promoting gluconeogenesis and glycogen formation, thus aiding in the preservation of carcass protein and decreasing the incidence of dark cutting meat, and
  d) Providing immunoprotective effects by enhancing lymphocyte function in the post-transport period.

This research group has claimed that further studies are required to confirm and clearly define the potential benefits of SSF1* for the cattle transportation industry. Further studies would certainly target clarification of effects on the immune system, and would seek possible benefits for *Bos taurus*, in addition to *Bos indicus* cattle.

Parker, AJ, Dobson, GP and Fitzpatrick, LA (2007): Physiological and metabolic effects of prophylactic treatment with the osmolytes Glycerol and Betaine on Bos indicus steers during long duration transportation. J. Anim. Sci. 2007. 85: 2916-2923.

The physiological and metabolic effects of prophylactic treatment of livestock with osmolytes were investigated using 4 groups of 6 *Bos indicus* steers under conditions of feed and water deprivation for 48 hrs and trucking for 48 hrs. Treatment groups were dosed, using a nasogastric tube, with Glycerol (2 g/kg of BW), or Betaine (0.25 g/kg of BW), using the "Betafin" commercial product.

Osmolytes are low molecular weight organic compounds which maintain cellular water and ionic balance. They protect cells and body tissues from dehydration and osmotic inactivation. Betaine is a tri-methyl derivative of the amino acid, glycine.

- The glycerol group maintained a 30% greater plasma concentration of glucose than the control group, and 14% greater than the transported and betaine groups. In contrast, betaine had little effect on increasing blood glucose compared with glycerol.

- Glycerol-linked hyperhydration at 24 hrs may not only help to conserve water loss during long distance transportation, but the increased blood glucose may have an important protein-sparing effect due, in part, to greater insulin concentrations inhibiting the breakdown of muscle proteins, thus, countering the amino-acid mobilizing effect of cortisol after 24 hrs. Therefore, the osmolyte glycerol shows promise as a prophylactic treatment for attenuating the effects of long distance transportation by maintaining body water, decreasing the energy deficit, and preserving health and muscle quality.

GENERAL CONCLUSION FOR LIVE EXPORTING

In the light of the above fairly positive conclusions as to the potential role of osmolytes such as glycerol and betaine in the live export process, it is possible that a return on investment from their inclusion in shipping pellet formulations might be achieved, although possibly only under conditions of severe heat stress.

Glycerol, also commonly known as "glycerine" or "glycerin", has interesting potential as a palatable, bio-available, high energy (approx 14.8 MJ ME/kg DM) ingredient for shipping pellets. It has been used in feedlot rations in Europe and the US at up to 10% inclusion rates (Drouillard, 2008). However, the administration of glycerol (such as via nasogastric tubing) before transportation of long duration may have merit in attenuating the deleterious effects of dehydration and promoting glucose production while sparing muscle protein degradation.

Glycerol is a colourless, odourless, sweet-tasting viscous liquid of low toxicity that is widely used in pharmaceutical formulations. Until recently, synthetic glycerol has been mostly manufactured on an industrial scale from epichlorohydrin. However, glycerol is also a 10% by-product of biodiesel production (via the transesterification of vegetable oils or animal fats). Increased global interest in biodiesel has led to a recent excess of crude glycerol on the world market. Provided it can be incorporated into formulations at an economically viable cost of inclusion, and without compromising pellet durability or production throughput, glycerol may have a bright future with the live export industry. Further work with industry participants to determine likely intakes and required inclusion rates does appear warranted, as current estimates of costs of inclusion do appear high (refer to Table 10 on page 42 for likely costs of inclusion per tonne of feed).

Regarding the potential role of the pre-transportation, orally dosed hyperhydration supplement named "SSF1", this product does certainly appear well worthy of further consideration by industry, including possible incorporation into shipping pellets, if sufficiently heat stable, and if not likely to jeopardise pellet durability or milling efficiencies. It could also be interesting to investigate what achievements have been made with this product commercially since the work at James Cook University in 2004.

4.2 Review of nutrient requirements for live exported sheep and cattle

The methodology used for calculating nutrients requirements was covered in section 3.2. In summary, the spreadsheet models utilised (developed by CSIRO, 2007) cater for an exact specification of animal breed and type categories, live weights and average daily gain (ADG) levels and allow accurate calculations of the requirements for metabolisable energy, degradable and undegradable crude protein for Australian breeds of sheep and cattle.

Two fundamental performance scenarios were examined:

A.) Assuming zero ADG during the voyage. This does assume that the weight of gut contents and body fluid loss during transport and shipping is replaced, but that no net increase in empty body weight occurs. Further details of parameters used and results obtained from calculations are summarized in Table 5 below.

B.) Assuming some degree of "significant ADG". Parameters for this scenario were chosen, following discussions with key industry participants, to be appropriate for the majority of animals currently live exported from Australia. For 300 and 400 kg *Bos indicus* feeder steers and heifers, ADGs of 300 and 400 g/hd/day were used, while for sheep of 40 and 55 kg, ADGs of 50 g/hd/day were used in the models. These figures are believed to be representative of the advanced performance levels achieved by the modern day live exporting industry in Australia. Further details of parameters used and results from calculations are summarized in Table 6 below.

When using the models, a generalised "live export stress factor" of 15% was applied to the category of "housed animals" in an attempt to best mimic the restrained conditions and various stressors commonly existing in the shipping environment. The stress factor had the effect of increasing total daily requirements for both metabolisable energy and crude protein.

All requirements calculated from the models, under the two weight gain scenarios, were then compared with the supply of metabolisable energy and crude protein from currently specified minimum provisioning levels and shipping pellet nutrient levels, as stated in ASEL (2008). On the basis of this comparison, a set of revised recommendations were prepared for minimum ration provisioning levels, as well as new shipping pellet formulation requirements and nutrient levels, for all classes of exported livestock (Table 9 on page 41).

4.2.1 New provisioning and pellet specifications

Table 5 and Table 6 below show a comparison of metabolisable energy (ME) and crude protein (CP) supplied by existing shipping pellets and a newly proposed shipping pellet, with cattle, sheep and goat requirements for energy and protein under the two differing performance scenarios outlined above. Table 7 below shows a comparison of ME and CP supplied by the newly proposed shipping pellet, with the requirements that deer have for energy and protein under a weight gaining scenario.

CURRENT ASEL (2008) PELLET NUTRIENT SUPPLY vs ANIMAL REQUIREMENTS

Table 5. Analysis of nutrients supplied to livestock when fed in accordance with current ASEL (2008) minimum provisioning levels and pellet specifications. CSIRO requirements are shown by comparison.

Assuming Zero ADG during voyage

SUPPLIED ON SHIP In accordance with ASEL (2008)	Assume Pellets 90% DM			Supplied by Existing Pellet: ME > 8.0 MJ/kg DM, CP = 9-12% DM ("lower" & "upper" refers to Min & Max specs on pellets)		
	Example LW kg	AFI % LW	DMI % LW	ME MJ/day, lower	CP g/day, lower	CP g/day, upper
GROWING STRS & HFRS						
< 250 kg	240	2.50	2.25	43.2	486	648
> 250 kg	350	2.00	1.80	50.4	567	756
BREEDING HFRS < 6 tooth						
Pregnant	400	2.50	2.25	72.0	810	1,080
Non-pregnant	380	2.50	2.25	68.4	770	1,026
PREGNANT OLDER COWS	520	2.50	2.25	93.6	1,053	1,404
SHEEP & GOATS						
<= 4 tooth	40	3.00	2.70	8.6	97	130
> 4 tooth	55	2.00	1.80	7.9	89	119

Source:
ASEL (2008): Australian Standards for the Export of Livestock. Ver 2.2, Oct 2008. Department of Agriculture, Fisheries & Forestry.

Assuming Zero ADG during voyage

REQUIREMENTS, based on dietary energy concentration of 8.0 MJ/kg DM, ie, current ASEL min for Shipping Pellets In accordance with CSIRO (2009)						Dietary variables used in model	
	LW kg	ADG g/day	DMI % LW	ME MJ/day	CP g/day	ME MJ/kg DM	CP degradability
GROWING STRS & HFRS (B indicus)							
< 250 kg	240	0	1.7	32.2	338	8.00	0.70
> 250 kg	350	0	1.5	42.1	449	8.00	0.70
DAIRY							
BREEDING HFRS < 6 tooth (B.taurus)							
Pregnant #	400	209	1.7	55.6	608	8.00	0.70
Non-pregnant	380	0	1.7	51.2	551	8.00	0.70
BEEF							
PREGNANT COWS (B.indicus) #	520	183	*1.3*	*52.3*	*572*	8.00	0.70
			(suspected unresolved error in spreadsheet model)				
SHEEP & GOATS							
<= 4 tooth	40	0	2.4	7.6	145	8.00	0.70
> 4 tooth	55	0	2.2	9.5	105	8.00	0.70
# For Pregnant females, ADG here is gain in weight of conceptus only (zero maternal weight change)..							

Source:
CSIRO (2007): Nutrient Requirements of Domesticated Ruminants. M Freer, H Dove, JV Nolan (editors), CSIRO Plant Industry, Canberra.
Spreadsheets accompanying this publication were downloaded from website www.pi.csiro.au/grazplan and used to calculate requirements.

Notice that the requirements (blue section) for maintenance (zero weight gain) are adequately met by minimum feed provisioning of current pellet specifications (yellow section), but with exceptions being for crude protein requirements for both age categories of sheep and goats, and metabolisable energy requirements for older sheep and goats, where these requirements are not met.

On the other hand, notice that the requirements for significant weight gain (as shown in the blue section of Table 6 below) are not met by current minimum pellet specifications and feeding levels.

NEWLY RECOMMENDED PELLET NUTRIENT SUPPLY vs ANIMAL REQUIREMENTS

Table 6. Analysis of nutrients supplied to livestock when fed in accordance with new recommendations for minimum pellet specifications and provisioning levels following the current study. CSIRO requirements are shown by comparison, with a 15% "live export stress factor" applied.

Assuming Significant ADG during voyage

SUPPLIED ON SHIP New Recommendations	Assume Pellets 90% DM				NUTRIENTS SUPPLIED BY NEW SHIPPING PELLET (DMB) ("lower" & "upper" refers to Min & Max specs on pellets)		
	Example LW kg	Compared to ASEL	AFI % LW	DMI % LW	ME MJ/day, lower	CP g/day, lower	CP g/day, upper
GROWING STRS & HFRS							
< 250 kg	240	SAME	2.50	2.25	48.6	567	648
> 250 kg	350	INC from 2.0 AFI	2.50	2.25	70.9	827	945
DAIRY							
BREEDING HFRS < 6 tooth							
Pregnant	400	SAME	2.50	2.25	81.0	945	1,080
Non-pregnant	380	SAME	2.50	2.25	77.0	898	1,026
BEEF							
PREGNANT OLDER COWS	520	SAME	2.50	2.25	105.3	1,229	1,404
SHEEP & GOATS							
<= 4 tooth	40	SAME	3.06	2.75	9.9	116	132
> 4 tooth	55	INC from 2.0 AFI	2.78	2.50	12.4	144	165

Assuming Significant ADG during voyage

REQUIREMENTS, based on suggested new dietary energy concentration (MJ/kg DM) as shown in last column In accordance with CSIRO (2009)						Dietary variables used in model	
	LW kg	ADG g/day	DMI % LW	ME MJ/day	CP g/day	ME MJ/kg DM	CP degradability
GROWING STRS & HFRS (B indicus)							
< 250 kg	240	300	2.19	47.4	549	9.00	0.70
> 250 kg	350	400	2.15	67.6	823	9.00	0.70
DAIRY							
BREEDING HFRS < 6 tooth (B.taurus)							
Pregnant #	400	500	2.02	72.6	861	9.00	0.70
Non-pregnant	380	350	2.09	71.5	847	9.00	0.70
BEEF							
PREGNANT COWS (B.indicus) #	520	200	*1.14*	*53.5*	*594*	9.00	0.70
			(suspected unresolved error in spreadsheet model)				
SHEEP & GOATS							
<= 4 tooth	40	50	2.48	10.5	124	9.00	0.70
> 4 tooth	55	50	2.19	12.7	152	9.00	0.70
# For Pregnant females, ADG includes gain in weight of conceptus.							

Source:
CSIRO (2007): Nutrient Requirements of Domesticated Ruminants. M Freer, H Dove, JV Nolan (editors), CSIRO Plant Industry, Canberra.
Spreadsheets accompanying this publication were downloaded from website www.pi.csiro.au/grazplan and used to calculate requirements.

Notice that the requirements for "significant" weight gain are met by minimum feed provisioning of the newly recommended pellet specifications, with the exception of protein and energy requirements for both age categories of sheep and goats, which are slightly lower than the quantities supplied. However, it should be appreciated that the above comparison was based on the minimum levels of the newly recommended pellet specifications for metabolisable energy and crude protein, as shown in Table 8 on page 40 below.

NEWLY RECOMMENDED PELLET NUTRIENT SUPPLY vs REQUIREMENTS FOR DEER

Table 7. Analysis of nutrients supplied to DEER when fed in accordance with new recommendations for minimum pellet specifications and provisioning levels following the current study. CSIRO requirements for sheep and ASEL requirements for deer are shown in comparison. (A 15% "live export stress factor" was applied to CSIRO requirements.)

Assuming Significant ADG during voyage

SUPPLIED ON SHIP New Recommendations	Assume Pellets 90% DM				NUTRIENTS SUPPLIED BY NEW SHIPPING PELLET (DMB) ("lower" & "upper" refers to Min & Max specs on pellets)		
	Example LW kg	Compared to ASEL	AFI % LW	DMI % LW	ME MJ/day, lower	CP g/day, lower	CP g/day, upper
DEER							
Young Deer	60	INC from 2.0 AFI	3.06	2.75	14.9	173	198
Mature Deer	90	INC from 2.0 AFI	3.06	2.75	22.3	260	297

Assuming Significant ADG during voyage

REQUIREMENTS, based on suggested new dietary energy concentration (MJ/kg DM) as shown in last column But based on CSIRO (2009) model developed for SHEEP						Dietary variables used in model	
	LW kg	ADG g/day	DMI % LW	ME MJ/day	CP g/day	ME MJ/kg DM	CP degradability
DEER							
Young Deer	60	80	1.96	14.6	180	9.00	0.70
Mature Deer	90	150	2.06	23.9	313	9.00	0.70

Source for model (developed for Sheep):
CSIRO (2007): Nutrient Requirements of Domesticated Ruminants. M Freer, H Dove, JV Nolan (editors), CSIRO Plant Industry, Canberra.
Spreadsheets accompanying this publication were downloaded from website www.pi.csiro.au/grazplan and used to calculate requirements.

REQUIREMENTS for growth of RED DEER, based on ASEL (2008) guidelines					
	LW kg	ADG g/day	DMI % LW	ME MJ/day	CP g/day
				approx average throughout year	Not specified
RED DEER					
Young Red Deer	60	80		19.9	
Mature Red Deer	90	150		29.2	

Source:
ASEL (2008): Australian Standards for the Export of Livestock. Ver 2.2, Oct 2008. Department of Agriculture, Fisheries & Forestry.

Notice that deer requirements for the weight gains specified, when using CSIRO estimates for sheep of comparable weights, are nearly met by minimum feed provisioning of the newly recommended shipping pellet minimum specifications. Although ME requirements broadly estimated for Red Deer and outlined in ASEL (2008) are not quite met by these provisioning levels and specifications, it is excepted that if these requirements are truly accurate for the lines of deer being shipped, then these animals may gain weight at a rate slightly below that specified in this table (which would be acceptable to most exporters).

The newly recommended shipping pellet specifications for metabolisable energy and crude protein are shown in Table 8 below.

NEWLY RECOMMENDED SHIPPING PELLET

Table 8. Specifications for newly formulated shipping pellet to meet the requirements of cattle, sheep and deer which are expected to achieve significant levels of weight gain during the voyage.

Recommendation for Metabolisable Energy and Crude Protein in New Shipping Pellets, allowing for significant ADG in voyage						
	Dry Matter basis			As Fed basis, based on pellets at 90% DM		
	Min ME MJ/kg DM	Min CP % DM	Max CP % DM	Min ME MJ/kg AF	Min CP % AF	Max CP % AF
New Shipping Pellet	9.00	10.5	12.0	8.10	9.45	10.80

Note:
Specifications for the "New Shipping Pellet" have been developed to be suitable for all main livestock species commonly transported on ships from Australia - sheep and goats; beef and dairy cattle; buffalo; deer and camelids. This pellet is also suitable for horses and pigs.
`

A detailed presentation of recommended on board feed provisioning guidelines and shipping pellet specifications for stock feed mills, plus a comparison with current standards, is given in Table 9 below. Key areas of change in the proposed standards include:

- Requirement for hay and/or chaff (non legume) on all extra long haul voyages (greater than 30 day duration) with breeder cattle, deer or camelids to be minimum 2.0% of total feed, this being an increase from 1.0% of total feed.
- Crude protein specification of shipping pellets (dry matter basis) to rise from min 9.0% to min 10.5%; maximum of 12.0% to remain
- Metabolisable energy specification of shipping pellets (dry matter basis) to rise from min 8.0 MJ/kg DM to min 9.0 MJ/kg DM.
- Total wheat, barley and corn specification removed, in lieu of maximum 20% set on starch.
- Acid detergent fibre to be minimum 25%, increased from minimum 18%.
- Revised specifications for calcium, phosphorus, sodium, chloride and ash.
- Urea maximum of 0.5%, as urea is highly rumen degradable and likely to increase ammonia levels in pens.
- Recommendation for inclusion of vitamin / trace mineral premix.

The concept of specifying a minimum dry matter digestibility (DMD) of 65%, based on pepsin-cellulase digestion, was favoured by Milton (2009) and Peace (2009), however a recommendation for this may need to await further general testing for this parameter by the stock feed industry.

Table 9. Presentation of current and proposed live export feed provisioning and new shipping pellet specifications for stock feed mills.

Pellet formulation type:	CURRENT SHEEP & GOAT	PROPOSED SHEEP & GOAT	CURRENT CATTLE & BUFFALO	PROPOSED CATTLE & BUFFALO	CURRENT DAIRY HEIFER	PROPOSED DAIRY HEIFER	CURRENT DEER	PROPOSED DEER
Feed Provisioning								
Sheep & Goats <= 4 teeth	AFI > 3.0% LW	AFI > 3.0% LW						
Sheep & Goats > 4 teeth	AFI > 2.0% LW	AFI > 2.75% LW						
Cattle & Buffalo < 250 kg			AFI > 2.5% LW	AFI > 2.5% LW				
Breeding Heifers <= 6 teeth			AFI > 2.5% LW	AFI > 2.5% LW		AFI > 2.5% LW		
Pregnant Cows			AFI > 2.5% LW	AFI > 2.5% LW		AFI > 2.5% LW		
Other Cattle & Buffalo			AFI > 2.0% LW	AFI > 2.5% LW				
Camelids < 250 kg			AFI > 2.5% LW	AFI > 2.5% LW				
Breeding females <= 6 teeth			AFI > 2.5% LW	AFI > 2.5% LW		AFI > 2.5% LW		
Pregnant females			AFI > 2.5% LW	AFI > 2.5% LW		AFI > 2.5% LW		
Other classes of camelids			AFI > 2.0% LW	AFI > 2.5% LW				
Deer - general							AFI > 2.0% LW	AFI > 3.0% LW
Provisioning Safety Margin								
	The lesser of: 25% or 3 days	The lesser of: 25% or 3 days	The lesser of: 20% or 3 days	The lesser of: 20% or 3 days	The lesser of: 20% or 3 days	The lesser of: 20% or 3 days	Depends duration: 2 - 3 days	The lesser of: 20% or 3 days
Nutrients in Dry Matter								
Moisture	max 12%	max 12%	-	max 12%	-	max 12%	-	max 12%
Crude Protein	9 - 12%	10.5 - 12.0%	-	10.5 - 12.0%	-	10.5 - 12.0%	-	10.5 - 12.0%
Metabolisable Energy	min 8.0 MJ/kg	min 9.0 MJ/kg	-	min 9.0 MJ/kg	-	min 9.0 MJ/kg	ME/day only	min 9.0 MJ/kg
Acid Detergent Fibre	18 - 35%	min 25%	-	min 25%	-	min 25%	-	min 25%
Neutral Detergent Fibre	-	-	-	-	-	-	-	-
Starch	-	max 20%	-	max 20%	-	max 20%	-	max 20%
Calcium	-	min 0.55%	-	min 0.55%	-	min 0.55%	-	min 0.55%
Phosphorus	-	min 0.25%	-	min 0.25%	-	min 0.25%	-	min 0.25%
Cal : Phos ratio	-	2.0 - 6.0	-	2.0 - 6.0	-	2.0 - 6.0	-	2.0 - 6.0
Sodium	-	0.10% - 0.20%	-	0.10% - 0.20%	-	0.10% - 0.20%	-	0.10% - 0.20%
Chlorine	-	0.15% - 1.50%	-	0.15% - 1.50%	-	0.15% - 1.50%	-	0.15% - 1.50%
Mineral Ash	max 13%	max 11%	-	max 11%	-	max 11%	-	max 11%
Ingredients (% AF)								
Total Wheat, Barley, Corn	not > 30%	limit by max Starch	not > 30%	limit by max Starch	not > 30%	limit by max Starch	not > 30%	limit by max Starch
Chaff and/or Hay	-	-	min 1% feed #	min 2.0% feed **	min 1% feed #	min 2.0% feed **	-	min 2.0% feed **
Urea	max 1.2%	max 0.5%	-	max 0.5%	-	max 0.5%	-	max 0.5%
Salt	-	max 0.25%	-	max 0.25%	-	max 0.25%	-	max 0.25%
Vitamin/Trace Mineral premix	-	RECOMMENDED	-	RECOMMENDED	-	RECOMMENDED	-	RECOMMENDED
Rumen buffers	-	limit by max Na, Cl	-	limit by max Na, Cl	-	limit by max Na, Cl	-	limit by max Na, Cl
Bentonite/Pellet binders	-	commercial decision	-	commercial decision	-	commercial decision	-	commercial decision
Ionophore antibiotics	-	commercial decision	-	commercial decision	-	commercial decision	-	commercial decision
Urinary acidifiers	-	commercial decision	-	commercial decision	-	commercial decision	-	commercial decision

Only mandatory when CATTLE exported from a port south of latitude 26' S.

** Proposed for when CATTLE, DEER & CAMELIDS are exported on ALL "long haul" voyages (> 10 days).

4.2.2 Consideration of feed additives in shipping pellets

Presented in Table 10 below is an outline of various nutritional additive products which potentially could be included in shipping pellet formulations by feed mills. Many of these products are currently used by the larger commercial feed mills for a variety of reasons for several different species of ruminant and monogastric animals. Some of these have a sound basis for inclusion in shipping formulations, but for many, the likely return on investment is often highly questionable, especially for "short haul" voyages.

Notes to table below:

1.) Prior to using in export pellets any feed additives classified as veterinary medicines, it is important to:
  a.) Verify the current regulatory status of the product with the pellet manufacturer, or the Australian Pesticide & Veterinary Medicines Authority. This can be done via the APVMA website at www.apvma.gov.au . Ionophore rumen modifiers are classified as veterinary medicines.
  b.) Verify the acceptance or otherwise of the product with the country of destination for the animals concerned. This can be done by carefully checking the country's import protocols, available through the Australian Quarantine and Inspection Service (AQIS).
2.) SFMCA - Stock Feed Manufacturer's Council of Australia. The SFMCA is a National industry association, representing corporate and individual manufacturers of stock feed located throughout Australia.
3.) Acknowledgement: Feed additive prices compiled with the assistance of BEC Feed Solutions Pty Ltd, Brisbane.

Table 10. Nutritional and economic considerations for the use of various feed additives in live export shipping formulations.

FEED ADDITIVE	Considerations for inclusion in Shipping Formulations Average prices (ex GST), June 2009, based on 100 MT order: o Shipping pellets bulk FOB Fremantle - $300/T o Shipping pellets bagged FOB Broome, Wyndham - $475/T o Shipping Cubes bulk FOB Darwin - $450/T	Incl. Rates (range)	Incl. Cost $/MT June 2009
PELLET BINDERS			
Quick Lime (Burnt lime) CaO	1. Principal role is as an inexpensive pellet binder, to increase durability and reduce dustiness caused by high levels of pellet "fines". 2. Source of calcium (70%). 3. Has mild rumen buffering effect. 4. Note: Legal limit for CaO is currently 3.0%, in accordance with SFMCA's FeedSafe® quality assurance accreditation program for the stock feed manufacturing industry.	2.0%	$6.00 approx

Hydrated Lime (Slaked lime) CaOH	1. Principal role is as pellet binder. 2. Source of calcium (54%). 3. Has mild rumen buffering effect. 4. May improve digestibility & binding of straws by effecting the release of lignin (Milton, 2009). 5. Note: Legal limit for CaOH is currently 3.0%, in accordance with SFMCA's FeedSafe® QA accreditation program.	1.0 - 3.0%	$3.50- $10.50
Gypsum Calcium sulphate $CaSO_4$	1. Principal role is as pellet binder. 2. Also role as a urinary acidifier, although not a strong acidifier. Therefore can help reduce pen ammonia levels (Accioly et al. 2003). 3. Source of calcium (23%).	0.5 - 1.0%	$2.70- $5.40
Agricultural Limestone Feed grade fine lime $CaCO_3$	1. Source of calcium (37%). 2. May improve pellet binding when in fine powder form. 3. Limited rumen buffering effect due to low solubility. 4. Does not appear to lower rumen ammonia levels (Haaland and Tyrrell, 1982; Haaland et al. 1982).	0.5 - 2.0%	$0.70- $2.80
Bentonite Montmorillonite clay	1. Role is as pellet binder at 4% inclusion, although not generally regarded a powerful binder. 2. Mild rumen buffering effect, lessening the risk of acidosis. 3. Suggested lowering of rumen ammonia levels (Erlich and Davison, 1997, when feeding 4% bentonite to dairy cows).	2.0 - 4.0%	$4.00- $8.00
RUMEN BUFFERS			
Sodium bicarbonate $NaHCO_3$	1. Rumen pH raising effect, thereby minimising the risks of sub-clinical or clinical acidosis from shipboard rations which can at times be excessively high in metabolisable energy. Acidotic conditions can have significant appetite and performance limiting effects on livestock which are not sufficiently adapted to such high energy rations. 2. Source of sodium (39%). 3. However, by raising rumen pH, buffers may drive NH_3 faster across the rumen wall, thereby increasing atmospheric ammonia on board (Milton, 2009). 4. Another possible issue concerning rumen buffering is that, according to Milton (2009), it is possible that raised rumen pH levels may predispose to Salmonellosis, a vital component of the serious "Persistent inappetence – Salmonellosis – Inanition" (PSI) complex (see further discussion under "Regano" below). 5. The preferable means of controlling sub-clinical or clinical acidosis is to limit dietary starch levels and specify minimum acid detergent fibre (ADF) levels, and in some way try to ensure a level of rumen functional fibre in pellets, incorporating parameters such as particle size plus structural integrity.	0.5 - 1.0%	$2.80- $5.60

Bentonite Montmorillonite clay	1. Mild rumen buffering effect, but not as pronounced as $NaHCO_3$. 2. See further description of Bentonite in section above.	2.0 - 4.0%	$4.00 - $8.00
URINARY ACIDIFIERS	**(To minimise pen ammonia levels on board)**		
Ammonium chloride NH_4Cl	1. Role as a strong urinary acidifier, which can reduce urinary nitrogen output, and therefore atmospheric ammonia levels on board livestock ships (Accioly, et al, 2003). 2. May minimise the risk of Urinary Calculi when used at 1.0-2.0% in susceptible male sheep, goats or cattle on long haul voyages, however this condition is not generally regarded a key issue for the live export industry. 3. However, low palatability can reduce feed intakes. 4. A preferable approach to ammonia levels on board is to limit rumen degradable protein (RDP) levels and to keep these in balance with dietary fermentable carbohydrate levels. However, simple and reliable laboratory methods for determining rumen undegradable protein (RUP) and therefore RDP levels in shipping pellets are not widely available for the stockfeed industry. Also, there is a very minimal requirement for RUP in the diets of live exported animals, as they are generally not pregnant, lactating or fast growing young animals. Consequently the control of RDP levels is most practically achieved by banning the use of urea and placing upper limits on crude protein in shipping pellets, and banning high protein legume hays/chaff such as lucerne and clover when providing supplementary roughage on long haul cattle voyages.	1.0%	$10.50
Calcium chloride $CaCl_2$	1. Role as a strong urinary acidifier, which can reduce urinary nitrogen output, and therefore pen ammonia levels (Accioly, et al, 2003). 2. Source of calcium (18%), but far more expensive than limestone. 3. May minimise the risk of Urinary Calculi when used at 1.0-2.0% in susceptible male sheep, goats or cattle, however this is not highly significant for live export. 4. However, can slightly reduce feed intakes. 5. As described for NH_4Cl above, banning urea, legume hays/chaff and placing upper limits on CP in shipping pellets, are the preferable dietary approaches to controlling shipboard ammonia levels.	1.4%	$13.30
HEAT STRESS RELIEF	**(Osmolytes)**		

Betaine **"Bos Koolus"** Feedworks Australia	1. Bos Koolus™ is composed purely of the osmolyte Betaine, which helps protect the gut and internal organs from damage caused by heat stress. (Osmolytes are low molecular weight organic compounds which maintain cellular water and ionic balance. They protect cells and body tissues from dehydration and osmotic inactivation.) Betaine is a tri-methyl derivative of the amino acid, glycine. 2. The product reportedly results in an ME for maintenance sparing effect under heat stress (Loxton et al. 2007). 3. Claimed by company to maintain gut integrity, higher dry matter intakes and helps prevent the potential development of endotoxicosis under heat stress. 4. Return on investment under high heat stress conditions on board estimated by Feedworks to be 12:1.	Cattle 1.35 kg/T Sheep 0.67 kg/T	$9.50 $4.70
Glycerol Biotech Pharmaceuticals, Brisbane	1. As described back in section 4.1.4.4 on page 36, glycerol is a colourless, odourless, sweet-tasting viscous liquid of high ME value and low toxicity that is widely used in pharmaceutical formulations, and increasingly in feedlots. 2. Glycerol functions as an osmolyte (described above) which maintains cellular water and ionic balance and protects cells from dehydration, particularly under heat stress events. 3. Return on investment under high heat stress conditions on board has yet to be determined.	2.0% estimate	$17.25 approx
ELECTROLYTES	**(Acid-Base balance)**		
Salt NaCl	1. Source of sodium (37%) and chloride (61%), which with potassium are the most important electrolyte minerals required for acid-base balance, maintaining body fluid levels and many metabolic & nervous system functions. 2. However, excess dietary salt can increase water intake and urinary output beyond normal levels and result in compromised animal welfare, through excessively wet pen conditions, together with an apparent increase in atmospheric ammonia levels. Interestingly, salt has been banned from live export rations by certain shipping companies in the past.	0.25%	$0.75
Potassium chloride KCl	1. Source of potassium (52%) and chloride (48%), which with sodium are the most important electrolyte minerals required for acid-base balance, maintaining body fluid levels and many metabolic & nervous system functions. 2. However, excess potassium can increase water intake and urinary output and result in excessively wet pen conditions, together with an apparent increase in pen ammonia levels. 3. However, low palatability can reduce feed intakes if > 0.5%. 4. Probably better administered through water supply.	0.25% Depends on formula	$1.65 approx
RUMEN MODIFIERS	**(Ionophore antibiotics)**		

Rumensin 200 Monensin 200 mg/kg Elanco Animal Health	1. Ionophore rumen modifiers aid in the prevention of digestive and metabolic disturbances caused by erratic feed intake or specific feed problems including bloat and acidosis. Ionophores have the potential to aid in the control of acidosis by two distinct mechanisms. The first is to reduce lactic acid-producing strains of bacteria such as *Streptococcus bovis* and *Lactobacillus* spp. The second mechanism is through changes in eating dynamics. Subacute acidosis increases variation in intake and decreases total intake. Ionophores are largely unpalatable at high dietary concentrations, such that intakes can be regulated by using carefully controlled ionophore inclusion rates in rations. A restoration of consistent eating behaviour contributes to a reduction in digestive disorders such as acidosis, feedlot bloat and death. 2. Elanco claim improved ADG (generally around 5%) and FCE (generally 5-10%) under grazing and feedlot conditions. 3. Currently registered claims with the APVMA for improving feed efficiency, weight gain and aiding in the prevention of coccidiosis and bloat in cattle; increasing milk production and controlling bloat and ketosis in dairy cattle; and aiding in the prevention of coccidiosis in goats. <u>Not currently registered for use in sheep</u>. 4. Elanco also claim a role in reducing methane emissions by altering energy metabolic pathways. 5. However, monensin and other ionophore antibiotics are currently banned in the EU and some other countries. They also reduce feed intakes, which is probably not an appropriate on-board strategy. Although having a very low cost of inclusion, a return on investment for the live export industry is yet to be determined.	20-25 mg/kg active	$1.25-$1.57
Salindox 12 BMP Salinomycin 120 mg/kg Dox-al Australia	1. Very similar role and company claims as for Rumensin. 2. Dox-al claims for the prevention of Coccidiosis. 3. Currently registered with the APVMA for the enhancement of productivity in beef cattle. <u>Not currently registered for use in sheep or goats</u>. 4. However, salinomycin is also banned in the EU and some other countries. Although having a very low cost of inclusion, a return on investment for the live export industry has yet to be determined.	11-15 mg/kg active	$0.44-$0.59
Bovatec 20 Lasalocid 200 mg/kg Fibro Animal Health	1. Very similar role and company claims as for Rumensin and Salinodox. 2. Fibro claims for the prevention of Coccidiosis. 3. Currently registered claims with the APVMA for improving feed efficiency, weight gain and aiding in the prevention of coccidiosis in cattle; increasing milk production in dairy cattle; and aiding in the prevention of coccidiosis in sheep maintained in confinement. <u>Not currently registered for use in goats.</u> 4. However, lasalocid is also banned in the EU and some other countries. Although having a very low cost of inclusion, a	25-33 mg/kg active	$1.80-$2.40

	return on investment for the live export industry has yet to be determined.		
SALMONELLA CONTROL	**(Using non-antibiotic approaches)**		
Regano (Arabinogalactan) Feedworks Australia	1. Non-antibiotic approach to the control of infections caused by Salmonella, E. coli and certain other bacterial species. 2. Nil withholding period. 3. The "Persistent inappetence – Salmonellosis – Inanition" (PSI) complex continues to be identified as the primary cause of death for 60-75% of all shipboard mortalities in sheep (MLA, 2009). 4. Caused by consumption of feed contaminated with *Salmonella typhimurium* and/or *S. Dublin* bacteria. This is most likely to occur under conditions of over-crowded, damp, poorly cleaned or otherwise contaminated pens on ships or feedlots or in holding yards. 5. Return on investment estimated by Feedworks to be 10:1, depending on severity of disease challenge, although no peer reviewed scientific publications have been observed to date.	Sheep 350 g/T	$11.50
PROBIOTICS	**(Yeast and bacterial cultures)**		
Yea-Sacc[1026] Alltech Australia	1. Live yeast culture based on *Saccharomyces cerevisiae* strain 1026, a strain of yeast selected for its beneficial influence on animal performance. 2. Contents of the yeast cell wall are claimed to aid in the binding of non-pathogenic bacteria within the rumen, thereby reducing the risk of colonisation of detrimental bacteria, which may lead to ruminal upsets. 3. The Alltech company claim that Yea-Sacc[1026] animal performance results have been scientifically proven. They state that of the 71 peer reviewed papers published in leading scientific journals on the mode of action of yeast cultures, 42% have been based on Yea-Sacc[1026]. 4. According to a leading Australian cattle feedlot veterinarian (Sullivan, 2008), live yeast cultures have gained increasing acceptance in recent years as alternatives to ionophores in cattle feedlot rations, based on comparable effects on feed conversion efficiency, weight gain and return on investment. 5. Unlike ionophores, there is no depression of feed intakes. 6. However, a return on investment for yeast cultures in the live export industry has yet to be determined.	1.3 kg/T	$17.30
VITAMIN/MINERALS			
Vitamin/Trace Mineral Premix BEC Feed Solutions Brisbane	1. Provision of micro-nutrients which could be lacking in standard shipping pellet ingredients and which may be required at increased levels under the stresses of trucking, yarding and shipping. 2. Vitamins A, E, Selenium and Zinc may play roles in maintaining health & disease resistance on board. 3. B complex vitamins are synthesised under normal	3.0 kg/T	Cattle $6.30 Sheep $5.40

	circumstances by ruminant animals, but could be jeopardised under the stresses of the lengthy live export process. B vitamins may be involved in stimulating feed intakes on board. 4. However, a return on investment for the live export industry has yet to be determined.		
AMMONIA ADSORBANTS	**(*Yucca schidigera* plant extracts)**		
Deodorase Alltech Australia	1. In-feed source of natural product, derived from leaves of the yucca plant, which is claimed to bind ammonia, both metabolically inside the animal and in the external environment. 2. Claimed to have natural deodorizing properties. 3. Despite on-going interest by the live export industry in products of this type for many years, a clear and consistent return on investment for this application has yet to be determined. 4. Further work to clarify a likely ROI appears warranted.	60 g/T	$2.10
Desert King Yucca Feedworks Australia	Very similar function to “Deodorase”.	100 g/T	$1.60

4.2.3 Calculation of mineral, trace element and vitamin specifications

Macro-mineral, trace element and vitamin requirements for live exporting purposes were calculated from minimum requirement estimates published by CSIRO (2007) for sheep and cattle under general conditions. As acknowledged by the CSIRO editorial team (M Freer, H Dove and JV Nolan), a major uncertainty in assessing requirements is the bioavailability of a particular mineral to the animal. For these and other reasons, the following tables of requirements (

Table 11 to Table 15) should be taken as a guide only.

When extrapolating to live exporting conditions for the current report, consideration was given to the pasture base from which the majority of animals would have come, while a slight upwards adjustment of requirements was made in lieu of the various stress factors associated with the live exporting process, these having been alluded to previously in section 3.2.

Table 11. Recommended macro and trace mineral requirements for live export.

Recommended Mineral Requirements			Suggested for Live Export	
	General Requirements		Minimums in Shipping Pellet	
	Sheep	Cattle	SHEEP	CATTLE
Macro-Minerals (% DM)			% DM (as formulated)	
Calcium (Ca)	0.14 - 0.70	0.20 - 1.10	**0.50**	**0.55**
Phosphorus (P)	0.09 - 0.30	0.10 - 0.38	**0.20**	**0.25**
Chlorine (Cl)	0.03 - 0.10	0.07 - 0.24	**0.10**	**0.15**
Magnesium (Mg)	0.09 - 0.12	0.13 - 0.22	**0.10**	**0.15**
Potassium (K)	0.50	0.50	**0.50**	**0.50**
Sodium (Na)	0.07 - 0.10	0.08 - 0.12	**0.10**	**0.10**
Sulfur (S)	0.20	0.15	**0.20**	**0.15**
Trace Minerals (mg/kg DM)			mg/kg DM (added via premix)	
Cobalt (Co)	0.08 - 0.15	0.07 - 0.15	**0.15**	**0.15**
Copper (Cu)	4 - 14	4 - 14	**5.0**	**10.0**
Iodine (I)	0.5	0.5	**0.5**	**0.5**
Iron (Fe)	40	40	**40.0**	**40.0**
Manganese (Mn)	20 - 25	20 - 25	**25.0**	**25.0**
Selenium (Se) #	0.05	0.04	**0.05**	**0.04**
Zinc (Zn)	9 - 20	9 - 20	**20.0**	**20.0**

Note:
Where a range is given, the higher values are for rapidly growing, pregnant or lactating animals;
the lower values are for animals at maintenance or with a low level of production.
Source:
CSIRO (2007): Nutrient Requirements of Domesticated Ruminants.
M Freer, H Dove, JV Nolan (editors), CSIRO Plant Industry, Canberra. CSIRO Publishing.

Notes:

1. The suggested minimum levels for macro-minerals in shipping pellets should be set as minimum constraints for least-cost formulation purposes by feed mill nutritionists. In this way, the natural content of minerals in standard pellet ingredients can be taken into account and topped up where necessary with mineral additives. These nutrient constraints should be set on a 100% dry matter basis.

2. Minimum trace mineral levels should be provided in a premixed formulation, generally prepared by a specialist premix manufacturer and generally also including the required levels of vitamins A, D and E (see below). Note that the stated minimum levels of trace minerals and vitamins should be fully by the premixed formulation, and therefore should not rely on contributions from natural contents in standard pellet ingredients.

Table 12. Recommended Vitamin A requirements for live export.

Recommended Vitamin A Requirements		Suggested for Live Export
General Requirements	**Retinol Equivalents RE ug/kg LW**	**Minimums in Shipping Pellet RE ug/kg DM (added via premix)**
Sheep		**SHEEP**
Finishing lambs; Ewes at maintenance	7.7 *	Assume 40 kg dry sheep
Growing lambs	15	Assume ave 15 RE ug/kg LW
Replacement ewes, 60 kg	15	So, 600 RE ug/hd/day
Pregnant ewes, 70 kg	30	Assume DMI 2.5% LW, ie, 1.0 kg DM
Lactating ewes, 70 kg	45	Thus, 600 RE ug per 1.0 kg DM/day
Replacement rams, 80-100 kg	20 - 25	**Use: 600 RE ug/kg DM**
Cattle		**CATTLE**
Feedlot beef cattle	30	Assume 300 kg cattle
Pregnant beef heifers; Cows	45	Assume ave 30 RE ug/kg LW
Lactating beef cows; (Bulls)	67 (30)	So, 9000 RE ug/hd/day
Growing dairy cattle	24 ^	Assume DMI 2.5% LW, ie, 7.5 kg DM
Lactating dairy cows; Bulls	33 ^	Thus, 9000 RE ug per 7.5 kg DM/day
Dairy cows, dry period	33 ^	**Use: 1,200 RE ug/kg DM**

* from NRC Sheep (1975)
^ from NRC Dairy (2001)
Source (except where indicated):
CSIRO (2007): Nutrient Requirements of Domesticated Ruminants.
M Freer, H Dove, JV Nolan (editors), CSIRO Plant Industry, Canberra. CSIRO Publishing.

Additional notes (CSIRO, 2007):

Grazing animals generally do not require vitamin A supplementation, due to liver storage, although supplementation may be desirable during prolonged drought conditions, or for animals weaned during droughts onto grain and dry forage diets.

Table 13. Recommended Vitamin D requirements for live export.

Recommended Vitamin D Requirements		Suggested for Live Export
General Requirements	**International Units IU/kg LW**	**Minimums in Shipping Pellet IU/kg DM (added via premix)**
		SHEEP
Sheep		Assume 40 kg dry sheep
Lambs & growing sheep	6	Assume ave 6 IU/kg LW
Pregnant & lactating ewes	10	So, 240 IU/hd/day
		Assume DMI 2.5% LW, ie, 1.0 kg DM
		Thus, 240 IU per 1.0 kg DM/day
		Use: 240 IU/kg DM
		CATTLE
Cattle		Assume 300 kg cattle
Calves & growing cattle	6	Assume ave 6 IU/kg LW
Pregnant & lactating cows	10	So, 1800 IU/hd/day
		Assume DMI 2.5% LW, ie, 7.5 kg DM
		Thus, 1800 IU per 7.5 kg DM/day
		Use: 240 IU/kg DM

Source:
CSIRO (2007): Nutrient Requirements of Domesticated Ruminants.
M Freer, H Dove, JV Nolan (editors), CSIRO Plant Industry, Canberra. CSIRO Publishing.

Vitamin D requirements are provided by most diets, including dried forages, and by body synthesis effected by solar radiation. Body stores can supply requirements for 6 to 15 weeks.

Table 14. Recommended Vitamin E requirements for live export.

Recommended Vitamin E Requirements		Suggested for Live Export
General Requirements	**1 IU Vit E = 1 mg mg/kg DM**	**Minimums in Shipping Pellet mg/kg DM (added via premix)**
		SHEEP
Sheep		**Use: 20 IU/kg DM**
Lambs to 20 kg	15 *	
Heavier sheep; Pregnant & lactating ewes	20 *	
		CATTLE
Cattle		**Use: 40 IU/kg DM**
Beef cattle in general	15 - 60 ^	
Lactating cows	65 ^^	

* from ARC Ruminants (1980)
^ from NRC Beef (1984)
^^ from NRC Dairy (2001)
As cited by:
CSIRO (2007): Nutrient Requirements of Domesticated Ruminants.
M Freer, H Dove, JV Nolan (editors), CSIRO Plant Industry, Canberra. CSIRO Publishing.

Additional notes (CSIRO, 2007):

Animals grazing dry pasture, crop residues or grain stored for extended periods may require vitamin E supplementation. Requirements for vitamin E will be greater if dietary Selenium is low, and vice versa. Grinding and pelletising of feeds and addition of minerals and fats can affect α-tocopherol content of rations, and thereby necessitate supplementation.

Table 15. Recommended Vitamin B complex requirements for live export.

Recommended Requirements for Vitamin B complex		**Suggested for Live Export**			
		SHEEP		**CATTLE**	
General Requirements		Assume 40 kg dry sheep	**Minimums in Shipping Pellet**	Assume 300 kg feeder cattle	**Minimums in Shipping Pellet**
Sheep and Cattle	**ug/kg LW**	Assume DMI 2.5% LW, ie, 1.0 kg DM So, 1.0 kg DM/day	**mg/kg DM (added via premix)**	Assume DMI 2.5% LW, ie, 7.5 kg DM So, 7.5 kg DM/day	**mg/kg DM (added via premix)**
Thiamin (B1)	**65 - 150**	Ave 100 x 40 ug per 1.0 kg DM/day	**4.00**	Ave 100 x 300 ug per 7.5 kg DM/day	**4.00**
Riboflavin (B2)	**15 - 45**	Ave 30 x 40 ug per 1.0 kg DM/day	**1.20**	Ave 30 x 300 ug per 7.5 kg DM/day	**1.20**
Nicotinic Acid (B3)	**260**	260 x 40 ug per 1.0 kg DM/day	**10.40**	260 x 300 ug per 7.5 kg DM/day	**10.40**
Pyridoxine (B6)	**65**	65 x 40 ug per 1.0 kg DM/day	**2.60**	65 x 300 ug per 7.5 kg DM/day	**2.60**
Pantothenic Acid	**195**	195 x 40 ug per 1.0 kg DM/day	**7.80**	195 x 300 ug per 7.5 kg DM/day	**7.80**
Cyanocobalamin (B12)	**0.4 - 0.8**	Ave 0.6 x 40 ug per 1.0 kg DM/day	**0.024**	Ave 0.6 x 300 ug per 7.5 kg DM/day	**0.024**
Folic Acid	**5.0**	5.0 x 40 ug per 1.0 kg DM/day	**0.20**	5.0 x 300 ug per 7.5 kg DM/day	**0.20**
Biotin	**1.9**	1.9 x 40 ug per 1.0 kg DM/day	**0.076**	1.9 x 300 ug per 7.5 kg DM/day	**0.076**
Choline	**26,000**	26,000 x 40 ug per 1.0 kg DM/day	**1,040**	26,000 x 300 ug per 7.5 kg DM/day	**1,040**

Source:
CSIRO (2007): Nutrient Requirements of Domesticated Ruminants.
M Freer, H Dove, JV Nolan (editors), CSIRO Plant Industry, Canberra. CSIRO Publishing.

Additional notes (CSIRO, 2007):

As acknowledged by the CSIRO authors, “an active microbial population in the rumen will usually synthesise sufficient of all B complex vitamins to meet requirements”.

CSIRO also acknowledge that the stated value for Choline, based on ARC work published in 1980, may be a “substantial overestimate of requirements”. As a result of this advice, and in view of the fact that choline chloride can be very hydroscopic and aggressive towards vitamins in premixes, it was decided to remove choline from the recommended live export premix specifications, as shown below in Table 16.

SUMMARY OF PREMIX SPECIFICATIONS

Table 16. Summary of recommended live export Vitamin/Mineral Premixes.

Recommended LIVE EXPORT PREMIXES		
Levels shown are to be supplied per tonne finished PELLET (DM basis)		
	SHEEP	**CATTLE**
Trace Minerals (mg/kg DM)		
Cobalt (Co)	0.15	0.15
Copper (Cu)	5.00	10.00
Iodine (I)	0.50	0.50
Iron (Fe)	40.00	40.00
Manganese (Mn)	25.00	25.00
Selenium (Se)	0.05	0.04
Zinc (Zn)	20.00	20.00
Vitamins		
Vitamin A (RE ug/kg DM)	600	1200
Vitamin D (IU/kg DM)	240	240
Vitamin E (mg/kg DM)	20	40
Vitamin B complex (mg/kg DM)		
Thiamin (B1)	4.00	4.00
Riboflavin (B2)	1.20	1.20
Nicotinic Acid (B3)	10.40	10.40
Pyridoxine (B6)	2.60	2.60
Pantothenic Acid	7.80	7.80
Cyanocobalamin (B12)	0.024	0.024
Folic Acid	0.20	0.20
Biotin	0.076	0.076
BEC Feed Solutions quotation, June'09		
Price per kg	$1.80/kg	$2.10/kg
Inclusion rate per tonne Shipping Pellet	3.0 kg/T	3.0 kg/T
Cost of Inclusion per tonne	$5.40/T	$6.30/T

Note that in the event of ships carrying both sheep and cattle or other mixed livestock on the same voyage, it is recommended that the choice of using a “sheep” or a “cattle” premix in the New Shipping Pellet formulation be made on the basis of the numbers of animals of each type on board. Neither premix is harmful for species other than for which it was originally intended.

4.2.4 Consideration of acidosis risk from shipping pellets

As introduced previously in section 4.1.3.2, metabolisable energy contents of shipping pellet formulations are most effectively boosted through the inclusion of cereal grains in formulations. Grains commonly used by feed mills include wheat, barley, sorghum and corn. When cereal starch is gelatinized during the high temperature, pressure and moisture conditions of pelletising, these grains can also significantly improve pellet durability and reduce dustiness. However, the intake of rapidly fermentable starch and soluble carbohydrate should be carefully controlled, as rapid, excessive intakes of these components can predispose to digestive upsets such as clinical or subclinical rumen acidosis, with consequential adverse impacts on overall feed intakes, performance and animal welfare on board. The risks are greatest on long haul voyages for cattle, and when, due to unforeseen circumstances, animals do not receive an ideal length of adaptation period to the pelleted rations.

Various types of measurements can be performed on feeds in order to evaluate their “latent acidosis risk”. As outlined by Sauvant et al. (2006), feedstuffs or finished rations can be assessed in terms of parameters such as:

- Buffering capacity,
- *In vitro* fermentability or pH drop capacity,
- *In sacco* short term (4 hour) dry matter disappearance,
- Degradable starch content, and
- Cation-anion balance, in order to assess diet acidogenicity.

It is a recommendation of this current report that new shipping pellet specifications dictate a maximum 20% starch and minimum 25% ADF in formulations. This was shown in Table 9 on page 41. Table 17 below gives a guide to likely starch contents of commodities that may be available for shipping pellet formulations.

A maximum limit on starch in shipping pellets would allow high levels of ingredients such as lupins, copra or palm kernel meal, or vegetable oils that would achieve high metabolisable energy contents without predisposing to acidosis.

However, it is worthy of note that according to a researcher at the US Dairy Forage Research Centre (Hall, 2009), there is presently no officially recognised method for analysing the starch content of animal feeds. The method generally used by Australian testing laboratories is “total starch by glucoamylase digestion”, using a Megazyme test kit. According to Owens (2009), this method is not without some limitations, but these kits have been accredited by the National Association of Testing Authorities (NATA) and do make the testing more uniform across a number of laboratories.

Maximum starch and minimum ADF specifications will help minimise the risk of acidosis from shipping pellets, but unfortunately none of the parameters outlined above by Sauvant et al. (2006) incorporate a measurement of physically effective fibre retained in pelleted formulations (or “diet fibrosity”). As also alluded to previously in section 4.1.3.2, this is also a major factor of variation for the risk of acidosis. A certain (but not clearly defined) length and structural strength of fibre particle is needed to stimulate rumen papillae, maintain normal chewing and rumination and production of salivary buffers.

Table 17. Approximate starch content of common feed commodities.

STARCH CONTENT OF COMMON INGREDIENTS	
Note: Approx values given as guide only. Accurate laboratory assays are needed prior to formulation.	Starch % DM
HIGH ENERGY INGREDIENTS	
Rice Grain	**77.6**
Corn Grain	**72.4**
Sorghum Grain	**71.3**
Wheat Grain	**69.0**
Wheat Flour	**65.9**
Barley Grain	**59.2**
Rice Bran (grade 1)	**30.6**
Wheat Bran/Pollard	**23.5**
Corn Gluten Feed	**20.5**
Rice Bran (grade 4)	**12.9**
Soybean Hulls	**6.7**
Corn DDGS (Dried Distillers Grains+Solubles)	**6.2**
Molasses (sugar cane)	**0.0**
Crude Palm Oil	**0.0**
Glycerol	**0.0**
PROTEINS	
Chick Peas	**45.0**
Field Peas	**44.0**
Field Beans	**36.0**
Corn Gluten Meal	**15.7**
Canola Meal (solv extr) 34%	**6.6**
Lupins	**6.0**
Sunflower Meal (solv extr) 36%	**4.2**
Soybean Meal (solv extr) 47%	**2.3**
Cottonseed Meal (solv extr) 40%	**2.2**
Palm Kernel Cake (expeller)	**1.6**
Copra Meal/Cake (expeller)	**1.4**
Palm Kernel Meal (solv extr)	**1.0**
Urea	**0.0**
ROUGHAGES	
Forage Corn (~ 20% grain development)	**12.0**
Cavalcade Centro Hay (in flower)	**10.9**
Cereal Hays - Wheaten, Barley, Oaten	**7.0**
Lucerne or Clover Hays	**3.0**
Pineapple Waste	**1.7**
Improved Tropical Grasses	**1.5**
Forage Sorghum	**1.2**
Peanut Hulls	**1.2**
Native Tropical Grasses	**1.0**
Cereal Straws - Wheaten, Barley, Oaten	**1.0**
Corn/Sorghum Stubble	**1.0**
Rice Straw	**1.0**
Citrus Waste	**1.0**
Sugar Cane Bagasse	**1.0**
Rice Hulls	**0.2**

Sources:
1.) Premier Nutrition Products Ltd (2008): Premier Atlas 2008. UK.
2.) Commercial Feedlot Lab Analyses '95-'08.

Determinants of physically effective fibre for ruminants

Several methods have been developed in an attempt to specify dietary parameters which relate to fibre or roughage contents of feedstuffs and rations. However, the majority of these are based on wet chemistry determinations of components having been subjected to various *in vitro* digestibility procedures and give little indication of particle size, physical length or structural strength of fibre in the sample. Examples of these components include crude fibre, acid detergent fibre (ADF), neutral detergent fibre (NDF) and lignin. Similarly, ratios such as “forage NDF to total NDF” give little indication of the physical structure of a ration without accompanying particle size information.

Considerable work has been conducted at Penn State University in the USA, and other places, in order to address this dilemma, especially in the context of total mixed rations fed to intensively housed dairy cows. Chewing and rumination time are known to be accurate measurements of the roughage characteristics for ruminant diets (Sudweeks et al. 1981). Researchers have developed “physical effectiveness factors” (PEF) which can be assigned to different feedstuffs based on their ability to stimulate chewing activity (Mertens, 1997). Chewing time is strongly related to particle size, and this can be measured using a “Penn State Particle Separator” (Lammers et al. 1996), which separates particles over screens according to size (those > 19.0-mm; 19.0 - 8.0 mm; 8.0 - 1.18 mm and < 1.18 mm). For example, following such screening, long-stem hay is given a PEF value of 1.0, and rolled barley has 0.69. A “physically effective” peNDF value can then be calculated by multiplying the PEF for a feed by its chemical NDF% value. The peNDF parameter is defined as that dietary fibre source which effectively stimulates rumination and salivation. Target peNDF values for dairy cows are approximately 22% of DM, this being required to maintain a ruminal pH of 6.0 (Mertens, 1997).

Despite these significant achievements in assessing “fibrosity” in loose form total mixed rations for dairy cows, much of this work is inapplicable to pelletised feeds. The components of shipping pellets have normally undergone considerable grinding (often using screens as small as 8.0 mm diameter), as well as heating, pressurizing and softening with steam in order to produce pellets with high durability and low dust content. Unlike older style cubed hay products, modern day pelletised shipping formulations retain very few particles with any substantial length of fibre.

As has been discussed previously, there is sometimes very little opportunity for livestock to become effectively adapted to the pelletised shipping formulations, which are in a physical form far more likely to cause acidosis and other digestive upsets than loose form feedlot rations. There appears a need for the development of more effective parameters for assessing physically effective fibre levels retained in shipping pellets.

4.2.5 Increased hay/chaff on long haul voyages for breeders

As indicated previously when reviewing *Australian Standards for the Export of Livestock*, in section 4.1.1, a significant modification is recommended regarding the provision of hay and/or chaff on voyages, alongside shipping pellets.

Currently, *ASEL, v 2.2, 2008, Appendix 4.2 - Shipboard Ration Specifications and Provisioning*, specifies that:

> *Fodder for cattle exported from an Australian port south of latitude 26 degrees south must include at least one (1) per cent of the required feed as chaff and/or hay.*

It is recommended that this standard be modified to specify:

- o That this standard should apply to livestock exported from any Australian port, not just those south of latitude 26 degrees south.
- o That all types of dairy and beef cattle, deer and camelids be included. However, the standard should not exclude chaff and/or hay being fed to various classes of sheep and goats if so desired by the exporter concerned.
- o That for of dairy and beef cattle, deer and camelids, provisions should include a minimum of <u>two (2) percent of the total feed as good quality cereal based chaff and/or hay</u> (on fresh weight, or as-fed basis), as a component of the total ration offered for extra long haul voyages over 30 days duration. In the case of sheep and goats, if exporters do require chaff and/or hay to be provided, they do not need to abide by this 2.0 % minimum.
- o Note that this specification excludes lucerne, clover and other higher protein legume hays or chaffs, and also excludes straws. It has not been determined as necessary for exporters to bear the additional expense of testing hays and chaffs for protein content, nor chaffs for chop length.
- o That this is mandatory only for extra long haul voyages, that is, over 30 days in duration. However, this should not exclude short haul voyages if so desired by the exporter concerned, in which case exporters do not need to abide by the 2.0 % minimum.
- o The standard therefore generally refers to high value breeder animals, most commonly dairy heifers or cows. The basis for this stipulation is to concentrate on minimising the risk of digestive upsets on long haul voyages in higher value animals which will generally be used for long term milking or breeding purposes in their country of destination.
- o That all exporters need to load hay and/or chaff on all export ships for the purposes of feeding to animals admitted to “hospital pens”, or for outbreaks of diseases such as Salmonellosis, as a component of best practice veterinary health management on board.
- o That in relation to long haul shipments of pregnant dairy cattle (over 10 days duration) a best practice recommendation is to allow approx 0.5% of body weight per head per day as good quality cereal based chaff and/or hay, as a component of the total ration offered. Substituting chaff or hay for a portion of the pellet ration can be a means of reducing the onset of premature lactation and possible mastitis in certain predisposed pregnant animals.

This recommendation to the current standard has originated from a concern that large ruminants on long haul voyages may be at risk from clinical or subclinical rumen acidosis if fed for long periods solely on pellets which do not contain sufficient physically effective fibre components to stimulate normal rumen function. It is the author’s opinion that smaller classes of ruminant, such as sheep and goats, are not at the same level of acidotic risk from small particle size shipping pellets due to a requirement for a shorter length of fibre in comparison to larger ruminants, on the basis of their smaller scale digestive anatomy.

The recommendation that legume based hays or chaffs, such as lucerne or clover, be excluded from the new standard is based on the indication from work done by groups such as Accioly et al (2003), suggesting higher protein hays can lead to the output of excessive levels of urinary nitrogen and subsequent suboptimal levels of atmospheric ammonia from animal pens. The exclusion of straws is based on their poor nutritional value, high metabolic heat of fermentation and general performance limiting effects in animals. Straws have also been implicated with higher levels of atmospheric ammonia on board (Accioly et al. 2003).

The currently specified "*one (1) per cent of the required feed as chaff and/or hay"* would seem to be a trivial amount of roughage for a large ruminant animal. For a 400 kg dairy heifer eating 2.5% LW or 10 kg dry matter or 11 kg as fed per day, 1.0 % of this is only 110 grams of hay or chaff per day. The new recommendation for 2.0 % of feed as hay and/or chaff (for extra long haul voyages) would equate to 220 grams.

Recent discussions with key industry participants, including Morse (2009), have indicated that the levels of hay and/or chaff commonly being fed to high value animals on long haul voyages are considerably higher than the one percentage of total feed stated in the present standard. It is also worthy of note that when reporting on the risks of mortality during the live exporting of goats, More and Brightling (2003) recommended that the shipboard fodder include at least 200 grams/head/day of chaff and/or hay.

In making this recommendation, it is accepted that some exporters currently not feeding substantial levels of hay and/or chaff to long haul cattle, deer or camelids may have certain concerns regarding the additional storage space required on board for this additional roughage. However, as mentioned above, all exporters are currently required to carry hay and/or chaff on voyages for feeding to animals in hospital pens or for disease outbreaks. It should be recognized that this additional requirement is likely to in fact reduce the number of animals needing to be placed in these pens for feed related ailments. It is also possible that the additional requirement will lead to a reduction of feed related veterinary treatment costs, as well as an improved body condition score and level of general wellbeing of animals upon arrival at destination ports.

5 Success in achieving objectives

The key objectives of this project were:

5.1 Review of current feeding requirements as specified in ASEL

5.1.1 Assessment of suitability of fodder specifications for livestock performance

Requirements for metabolisable energy and crude protein

This objective was achieved by firstly conducting a review of the most recent nutrient requirement recommendations for beef and dairy cattle and sheep at maintenance and at low levels of body weight gain, in accordance with typical performance levels on board live export vessels. This study was conducted using the recent CSIRO benchmark publication *Nutrient Requirements of Domesticated Ruminants* (CSIRO, 2007), together with associated EXCEL™ spreadsheets which enabled accurate calculations of requirements.

Using the CSIRO models, two fundamental performance scenarios were examined, the first assuming zero ADG during the voyage (maintenance of body weight only), the second assuming some degree of "significant ADG". For 300 and 400 kg *Bos indicus* feeder steers and heifers, ADGs of 300 and 400 g/hd/day were used, while for sheep of 40 and 55 kg, ADGs of 50 g/hd/day were used in the models.

All requirements calculated from models were then compared with the supply of metabolisable energy and crude protein from currently specified minimum provisioning levels and shipping pellet nutrient levels, as stated in ASEL (2008). On this basis, recommendations were then made to slightly increase minimum ration provisioning levels, based on intakes of dry matter, as well as to slightly raise shipping pellet specifications for ME and CP, for all classes of exported livestock.

Requirements for vitamins, minerals and trace elements

It would appear from investigations made during this project that much of the current tonnage of shipping pellets produced do not contain vitamin / trace mineral premixes. CSIRO's publication *Nutrient Requirements of Domesticated Ruminants* was used to source updated recommendations for Australian conditions and to develop specifications for a vitamin / trace mineral premix which can be requested of commercial feed additive manufacturers by live exporters, as a best practice feeding strategy.

Modification of current feeding standards in ASEL

Following the series of calculations, a review was undertaken of all feed related components of the existing *Australian Standards for the Export of Livestock*, version 2.2, October 2008 (ASEL, 2008). Consultations were also held with several key industry participants and advisors, including live export agents, veterinarians, nutritional consultants, and feed manufacturers. Resulting from these calculations and consultations, various recommendations for modifications to ASEL standards were proposed. A detailed presentation of recommended on board feed provisioning guidelines and shipping pellet specifications, plus a comparison with current standards, was given in Table 9 on page 41. Key areas of change in the proposed standards include:

- A revised shipping pellet formulation, suitable for all classes of commonly exported livestock.
- Crude protein specification of shipping pellets (dry matter basis) to rise from min 9.0% to min 10.5%; maximum of 12.0% to remain
- Metabolisable energy specification of shipping pellets (dry matter basis) to rise from min 8.0 MJ/kg DM to min 9.0 MJ/kg DM.
- Total wheat, barley and corn specification removed, in lieu of maximum 20% set on starch.
- Acid detergent fibre to be minimum 25%, increased from minimum 18%.
- Revised specifications for calcium, phosphorus, sodium, chloride and ash.
- Urea maximum of 0.5%, as urea is highly rumen degradable and likely to increase ammonia levels in pens.
- Recommendation for inclusion of a vitamin / trace mineral premix, in accordance with common Australian stock feed industry best practice.
- Requirement for hay and/or chaff (non legume) on all extra long haul voyages (over 30 days) with breeder cattle, deer or camelids to be minimum 2.0% of total feed, this being an increase from the current 1.0% of total feed.

5.1.2 Assessment of suitability of fodder specifications for animal welfare

Fodder specifications should ideally have:

a.) No negative effect on the "Persistent inappetence – Salmonellosis – Inanition" (PSI) complex

In conducting this component of the study, a literature review was undertaken into feed related aspects of past mortalities experienced by the live export trade, in particular sheep on long haul voyages to the Middle East. Particular note was made of the large research effort currently being conducted through the MLA Livestock Export R&D Program to help resolve the crucial "Persistent inappetence – Salmonellosis – Inanition" (PSI) complex in live exported sheep. Although there remain several aspects of this condition not well understood, it does currently appear that dietary specifications play very little role, if any, in the occurrence of persistent non-eater sheep.

b.) Moderate rumen degradable protein levels to minimise atmospheric ammonia

From an animal welfare perspective, shipping pellets should ideally be formulated to have moderate rumen degradable protein levels, and possibly contain urinary acidifiers to minimise the output of urinary nitrogen and subsequent generation of potentially harmful levels of atmospheric ammonia from animal pens. Cole et al. (2005) demonstrated the ammonia emissions were effectively doubled over a 7 day period in steers fed an 11.5% vs. 13.0% crude protein diet, while Todd et al. (2006) observed reducing crude protein in steer diets from 13.0 to 11.5% reduced mean daily ammonia emissions by 28%. Accioly et al. (2003) showed that using lucerne hay/chaff or urea, can increase total urinary nitrogen output. Current fodder specifications in ASEL do specify maximum recommended crude protein levels in shipping pellets and it would appear from investigations made during this project that excessively high protein shipping pellets are not common in the live export trade. Similarly, the usage of legume hays or urea in formulations is not common practice. However, urinary acidifiers are also not commonly used, probably reflective of both the fact that lower protein rations are keeping ammonia generation under control, plus the unproven returns on investment from the use of acidifiers in shipping rations.

c.) <u>Low “heat increments”, to minimise the effects of heat stress</u>

As explained previously, shipping pellets should ideally be formulated to possess a low heat increment (or “heat of digestion”) when fed to susceptible breeds of livestock that have been determined from heat stress modelling to be “high risk”. High heat increment commodities include highly fibrous feeds, and so currently used shipping pellets which often contain close to or greater than 50% ground cereal hay or straw are not ideally formulated from this perspective. Nevertheless, the effects of formulation changes to lower heat increments upon the acidosis risk posed to livestock from lower fibre levels will be of key importance, and must be weighed up against the perceived risks posed to animal welfare by the threat of heat stress.

d.) <u>High in effective fibre to reduce risks of rumen acidosis</u>

Current fodder specifications do attempt to minimise the risks of clinical or subclinical rumen acidosis posed by pellets by stating minimum levels of acid detergent fibre and maximum inclusion rates of wheat, barley and corn. Slight improvements to the method of specifying against the risk of acidosis have been suggested in this report. However, levels of physically effective fibre in pellets are also important, although they are difficult to achieve and also to measure. Further improvements can be made in this area.

5.2 Report identifying key issues and opportunities for improvement

The current report was produced in order to meet this objective.

6 Impact on meat and livestock industry – now and in five years time

Following consultation and agreement by key industry participants as to the recommendations of this report, it is expected that the current version of the *Australian Standards for the Export of Livestock*, in particular Appendix 4.2, *Vessel Preparation and Loading*, will be updated for implementation by the live export industry.

As mentioned earlier in this report, Australia currently has the world's highest livestock export standards, in terms of coverage and capacity to deliver acceptable outcomes, as assessed by an extensive review conducted by Whan et al. (2006). With the update of all sections of ASEL relating to fodder quality and quantity, these standards should improve further.

The influence on the live export trade that these improvements in health and welfare should bring can be expected to increase in magnitude over at least the next five years. Associated with these improvements should also be a lowering of industry costs, in terms of the potential loss of live weight during voyages, veterinary and management costs associated with ill health, and potential loss of some degree of industry credibility in the event of aspects of animal welfare being compromised.

7 Conclusions and recommendations

1.) A general conclusion from this project on the current status of shipping pellet formulations in Australia is that they can be described as being "simple and safe", but slightly low in specifications for both protein and energy, and lacking controls over the levels of physically effective fibre contained, as well as controls over techniques to minimise the output of urinary nitrogen and subsequent generation of ammonia from animal pens.

2.) Following a review of the most recently published nutrient requirement recommendations for Australian livestock, using the CSIRO publication *Nutrient Requirements of Domesticated Ruminants* (CSIRO, 2007) and associated EXCEL™ spreadsheets, and examining the scenario where a small degree of weight gain was occurring (300 - 400 g/hd/day for cattle and 50 g/hd/day for sheep), the following recommendations are made for the standard shipping formulation as specified in *Australian Standards for the Export of Livestock*, version 2.2, October 2008. A revised shipping pellet formulation should be implemented by industry, with the main areas of change, in comparison with current ASEL pellet guidelines, being:

    - Crude protein specification of shipping pellets (dry matter basis) to rise from min 9.0% to min 10.5%; maximum of 12.0% to remain
    - Metabolisable energy specification of shipping pellets (dry matter basis) to rise from min 8.0 MJ/kg DM to min 9.0 MJ/kg DM.
    - Total wheat, barley and corn specification removed, in lieu of maximum 20% set on starch.
    - Acid detergent fibre to be minimum 25%, increased from minimum 18%.
    - Revised specifications for calcium, phosphorus, sodium, chloride and ash.
    - Urea maximum of 0.5%, as urea is highly rumen degradable and likely to increase ammonia levels in pens.
    - Recommendation for inclusion of a vitamin / trace mineral premix, in accordance with common Australian stock feed industry best practice.

    These parameters are detailed in Table 9 on page 41.

3.) Feed provisioning components of ASEL, 2008 were also reviewed, with recommendations as detailed in Table 9 on page 41. Only minor changes to current standards are recommended.

4.) In relation to additional loose form roughage supplied to cattle shipped from southern ports, *ASEL, Appendix 4.2 - Shipboard Ration Specifications and Provisioning*, specifies that:

Fodder for cattle exported from an Australian port south of latitude 26 degrees south must include at least one (1) per cent of the required feed as chaff and/or hay.

It is recommended that this standard be modified to specify:

- o That this standard should apply to livestock exported from any Australian port, not just those south of latitude 26 degrees south.
- o That all types of dairy and beef cattle, deer and camelids be included. However, the standard should not exclude chaff and/or hay being fed to various classes of sheep and goats if so desired by the exporter concerned.
- o That for dairy and beef cattle, deer and camelids on extra long haul voyages (greater than 30 days), provisions should include a minimum of two (2) percent of total feed as good quality cereal based chaff and/or hay, on a dry matter basis, as a component of the total ration offered. In the case of sheep and goats, if exporters do require chaff and/or hay to be provided, they do not need to abide by this 2.0 % minimum.
- o Note that this specification should be worded to exclude lucerne, clover and other higher protein legume hays or chaffs, whilst also excluding straws.
- o That this is mandatory only for extra long haul voyages, that is, over 30 days in duration. However, this should not exclude short haul voyages if so desired by the exporter concerned, in which case exporters do not need to abide by the 2.0 % minimum.
- o The standard generally refers to high value breeder animals, most commonly dairy heifers or cows. The basis for this stipulation is to concentrate on minimising the risk of digestive upsets on long haul voyages in higher value animals which will generally be used for long term milking or breeding purposes in their country of destination.

5.) In relation to long haul shipments of pregnant dairy cattle (over 10 days duration) a best practice recommendation is to allow approx 0.5% of body weight per head per day as good quality cereal based chaff and/or hay, as a component of the total ration offered. Substituting chaff or hay for a portion of the pellet ration can be a means of reducing the onset of premature lactation and possible mastitis in certain predisposed pregnant animals.

6.) Recommendation is made for an improvement to the current method of setting pellet specifications which will help reduce the risks of clinical or subclinical rumen acidosis posed by small particle size, starch containing shipping pellets when animals are not sufficiently adapted to the change of diet prior to loading . It is proposed to set a maximum of 20% on pellet starch content, and to increase the minimum on ADF from 18 to 25%.

7.) The content of "physically effective" fibre in shipping pellets is also very important in minimizing the incidence of digestive upsets, especially on long haul voyages and when, due to unforeseen circumstances, animals may not receive an ideal length of adaptation period to the pelletised rations. However, physically effective fibre is difficult to achieve when high roughage ingredients are pelletised, and it is also to measure. It is recommended that further work be undertaken on the development of more effective laboratory parameters for assessing physically effective fibre retained in shipping pellets.

8.) From an animal welfare perspective, shipping pellets should be formulated to have moderate rumen degradable protein (RDP) levels to minimise the output of urinary nitrogen and subsequent generation of potentially harmful levels of atmospheric ammonia from animal pens. The control of RDP levels is most practically achieved by restricting the use of urea and placing upper limits on crude protein in shipping pellets, and banning high protein legume hays/chaff such as lucerne and clover when providing supplementary roughage on long haul cattle voyages.

9.) An alternative strategy to minimise the generation of ammonia is to include one or more urinary acidifiers in shipping formulations. Strong urinary acidifiers that have proven capable of reducing urinary nitrogen output and pen ammonia levels under experimental conditions include ammonium chloride (with an inclusion cost of approx $10.50 per tonne of pellets) and calcium chloride (approx $13.50 inclusion cost). However, the low palatability of these acidifiers can reduce feed intakes, and returns on investment have been difficult to quantify. It is recommended that further work be conducted under actual voyage conditions to determine a likely return on investment from these additives, when all relevant animal welfare and human health and safety issues are considered.

10.) It is recommended as a best practice strategy, that shipping pellet formulations contain a premix containing the minimal levels of major vitamins and trace minerals as specified in this report. It is expected that such a premix would have a cost of inclusion per tonne of approximately $5.40 for sheep and $6.30 for cattle.

11.) The potential role of the osmolytes glycerol and betaine in the live exporting process was briefly reviewed, mostly from the perspective of helping to address the common threat of heat stress upon live export voyages from Australia. When administered as pre-transportation doses (given via nasogastric tubes), glycerol and betaine had some merit in attenuating the effects of dehydration and promoting glucose production while sparing muscle protein degradation. It is recommended that these products be further investigated by industry, especially if they can be successfully incorporated into shipping pellets. Return on investment should be determined, as the current costs of inclusion of such products do appear high. It is possible that ROI may only be achieved under conditions of severe heat stress.

12.) Various miscellaneous commercial livestock feed additive products, with possible application for the live export trade were outlined and presented with an indicative cost of inclusion per tonne of pellets, as shown in Table 10 on page 42. Products appearing to hold the highest potential include rumen modifier ionophores such as those based on salinomycin, monensin, or lasalocid. These products are claimed to aid in the prevention of digestive disorders, enhance feed conversion efficiency and reduce the incidence of coccidiosis, all for very low costs of inclusion (from approx $0.50 - 2.50 per tonne). However, these products are presently banned in several importing countries and their future in general appears to be under some threat, from a fear as to their effects within the human food chain. However, certain yeast cultures are claimed to have similar benefits, without concerns for the food chain, although they are considerably more expensive. There are also non-antibiotic products with claims for aiding in the control of salmonellosis, which may have substantial benefit for the long haul sheep trade, but which would add approximately $11.50 per tonne of feed. Absorption of ammonia from shipboard pens is claimed to be possible through using extracts from the *Yucca schidigera* plant, costing around $2.00 per tonne of feed.

It is recommended that the products mentioned above (and detailed further in the body of this report) be further investigated by industry, in collaboration with their commercial manufacturers and/or suppliers. Accurate inclusion rates in shipping pellets and likely returns on investment should be determined, together with the conditions under which greatest benefits for the live export trade are likely to be achieved.

13.) There currently appears to be insufficient data available to draw any conclusions on the cost-benefits of using in-feed electrolytes, such as potassium compounds, during shipping or to make recommendations on their use. Very little conclusive research into the use of in-feed electrolytes during actual shipping voyages has been documented, although physiological calculations of their likely benefit (either pre- or post- event) in covering for losses experienced during both trucking and shipping suggest their benefit is likely to be minimal.

14.) With respect to the feeding of livestock being transported by air, recommendations are that:

a.) In addition to fresh water, stores of good quality, non-mouldy, non-dusty hay and or chaff be available at short notice at all on-route airports in amounts sufficient to meet the minimum requirements of the livestock. Note that this is purely an <u>emergency measure</u>, in the case of unexpected delays during the journey;

b.) The minimum required quantity should be 0.5% of body weight, calculated on an as-fed basis.

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ACKNOWLEDGEMENTS

The compilation of this report was assisted through consultation with several key industry participants and stakeholders, including live export agents, nutritional consultants, veterinarians and feed manufacturers. The assistance provided by these people is gratefully acknowledged, and in particular thanks are extended to the following:

- Dr John Milton - Senior Lecturer in Veterinary Science, University of Western Australia, and Consulting Nutritionist to Macco Feeds Australia, Williams, WA.
- Dr David Jarvie - Veterinarian and Manager, Wellard Feeds Pty Ltd, Fremantle, WA.
- Dr Richard Norris - Live export Sheep Veterinarian, Dept of Agriculture & Food, WA.
- Dr Michael Freer - formerly Chief of CSIRO Division of Plant Industry, Canberra.
- Dr Ross Ainsworth - Live export Cattle Veterinarian, Darwin.
- Dr John Gaughan - Senior Lecturer in Biometeorology, School of Animal Studies, University of Queensland.
- Dr Rafat Al Jassim - Senior Lecturer in Nutrition & Biochemistry, School of Animal Studies, University of Queensland.
- Mr Scott McDouall - Systems, Logistics & Operations, Elders International Australia, Melbourne.
- Mr Jake Morse - Logistics Manager, Australian Rural Exports (Austrex), Brisbane.
- Steve & Cyndi Bakalian - Proprietors & General Managers, Northern Feed & Cube Pty Ltd, Katherine, NT.
- Mr Tony Thompson - Nutritionist, Gilmac Feeds, Perth.
- Mr Tim Johnson, Project Officer, Goat Industry Development, Dept of Agriculture & Food, WA.
- Ms Monette Swanson & Mr Steve Blake - Nutritionists, BEC Feed Solutions, Brisbane.
- Ms Elizabeth Owens - Sales & Marketing Manager, Symbio Alliance laboratories, Brisbane.
- Mr John Spragg - Executive Officer, Stockfeed Manufacturers Council of Australia.
- Mr Colin Peace - Executive Officer, Australian Fodder Industry Association.
- Mr Ian Whan - Agricultural Economist, Alliance Resource Economics, Brisbane.
- Mr John Griffin - General Manager, Pro-Beef Australia.
- Mr Ian Sawyer - Nutritionist, Feedworks Australia.
- Mr Adam Naylor - Northern Sales Manager, Alltech Australia.
- Mr Nick Nettle, Performance Probiotics.

9 Appendices

9.1 Appendix 1

Sample method of calculating feed quantities needed per voyage.

Sample Calculation of Feed Quantities Needed per Voyage

SHEEP - eg, long haul voyage to Kuwait on MV Becrux

	LW kg	DMI as % LW	DMI kg	AFI kg	No on ship	MT pels/day	Days voyage	MT pels/voy	Safety Margin MT pels/voy + 25%
A.	**40**	**2.75**	1.10	1.22	**50,000**	61.1	**26**	1,589	1,986
B.	**55**	**2.50**	1.38	1.53	**25,000**	38.2	**26**	993	1,241
				Total sheep:	**75,000**			Total MT pels:	**3,227**

CATTLE - eg, short haul voyage to Lampung, Indonesia on MV Becrux

	LW kg	DMI as % LW	DMI kg	AFI kg	No on ship	MT pels/day	Days voyage	MT pels/voy	Safety Margin MT pels/voy + 25%
A.	**240**	**2.50**	6.00	6.67	**2,500**	16.7	**5**	83	100
B.	**350**	**2.50**	8.75	9.72	**15,500**	150.7	**5**	753	904
				Total cattle:	**18,000**			Total MT pels:	**1,004**

Assume pellets 90% DM

Conversion of DMI to AFI

Assuming 90% DM Ship Pels

DMI % LW	AFI % LW
1.50	1.67
1.75	1.94
2.00	2.22
2.25	2.50
2.50	2.78
2.75	3.06
3.00	3.33

9.2 Appendix 2

FEEDSAFE® QUALITY ASSURANCE ACCREDITATION PROGRAM FOR THE AUSTRALIAN STOCK FEED INDUSTRY

The SFMCA operates FeedSafe® as the Quality Assurance Accreditation Program for the Australian stock feed industry.

All full (active manufacturer) members of the SFMCA arel be required to comply with FeedSafe® to retain their Association membership. The central aspect of FeedSafe® is a Code of Good Manufacturing Practice (GMP), which has been developed in conjunction with the Chief Veterinary Officers within each State, and the final document has Primary Industries Ministerial Council endorsement.

FeedSafe® requires feed manufacturers to meet minimum standards in relation to:

- Premises and mill buildings,
- Personnel training and qualifications,
- Plant and equipment,
- Raw material sourcing and purchasing,
- Raw material quality and storage,
- Feed formulation and manufacturing,
- Product labelling,
- Loading, transport and delivery to clients,
- Product inspection, sampling and testing,
- Customer complaint investigation.

To obtain FeedSafe® accreditation, feed manufacturers are required to undergo annual site audits, these being conducted by independent third party auditors.

FeedSafe® is a program aimed at increasing the commitment of the Australian stock feed industry to quality assurance and risk mitigation in the manufacture and use of animal feeds. The SFMCA through FeedSafe® has recognised the need for a broader industry approach to feed and food safety and is providing greater security of supply to Australia's livestock industries.

9.3 Appendix 3

AUSTRALIAN FODDER INDUSTRY ASSOCIATION

Incorporated in February 1996, the Australian Fodder Industry Association Inc (AFIA) is the peak body for Australia's hay and silage industries, and represents these industries on a national basis. Membership is open to all industry stakeholders. AFIA's key objectives are to:

1. Provide a voice for the hay and silage industries through increased communications and industry cohesion;
2. Enhance the trade of fodder through improving the objective measurement of fodder quality; and
3. Improve the competitiveness of the industry through the re-investment of funds into targeted research and development.

.<u>Fodder Testing Labs - Proficiency Program</u>

Since 2004, the AFIA has been coordinating a series of ring tests designed to test the testers of hay and silage in Australia and New Zealand. Samples of hay, silage and recently grain are currently sent as blind samples of unknown value to 17 labs throughout Australia and New Zealand. Results are compared and statistically analysed to enable labs to enhance their accuracy relative to other labs.

The AFIA aims to assist fodder producers to enhance their product and on-farm management for the benefit of their clients.

With the move to more on-farm QA, the AFIA is helping farmers meet the dairy industry QA programs with a Product Code of Practice.

This Code of Practice is a free service to AFIA members and involves an Annual Declaration by the fodder producer/supplier, certifying that conditions of product safety and quality have been met. This form will obligate the supplier to abide by the Product Code of Practice. The details of the Code have been addressed in the AFIA newsletter of December 1999. An audited HACCAP-based program will follow this non-audited Code.

Once signed, the Annual Declaration should be sent to the AFIA Secretariat for filing. AFIA will mail a certificate in return. Buyers will be able to call the Secretariat to check if particular suppliers are entitled to claim compliance. If members abide by this program, members will be entitled to use the term "Quality compliant to AFIA Product Code of Practice" when marketing their hay and silage.

The Product Code of Practice requires sellers of hay and silage to:

- Test all fodder marketed (CP, ME and DMD as a minimum),
- Test all fodder in a laboratory operating within the standardised procedures of the AFIA (currently all commercial Australian fodder labs are eligible),
- Sell all fodder by weight rather than by the bale,
- Supply a vendor declaration form with each lot of fodder,
- Sample all fodder marketed in accordance with the sampling protocol (outlined above),
- Apply any chemicals to the crop during production in accordance with the respective label and comply with any withholding periods.

9.4 Appendix 4

FURTHER DETAIL ON FEED ADDITIVES WITH POSSIBLE APPLICATION FOR THE LIVE EXPORT INDUSTRY

Information supplied by Feedworks Australia Pty Ltd

a) "Bos Koolus" Betaine for management of Heat stress

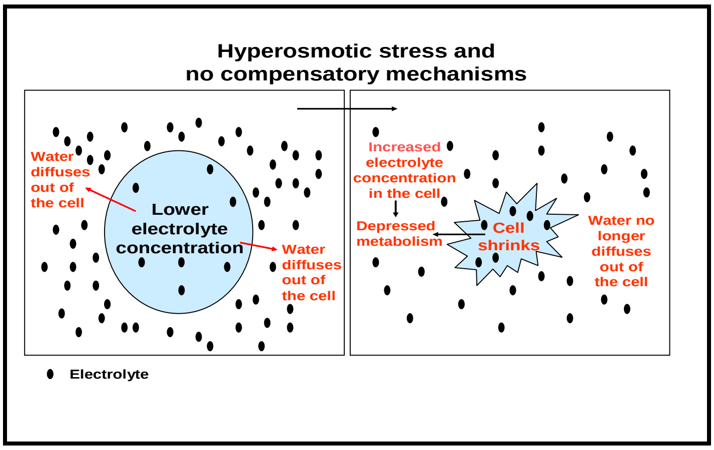
Bos Koolus is a mixture of the osmolyte Betaine and support nutrients which protect the gut and internal organs from damage caused by heat stress. (Osmolytes are low molecular weight organic compounds which maintain cellular water and ionic balance. They protect cells and body tissues from dehydration and osmotic inactivation.)

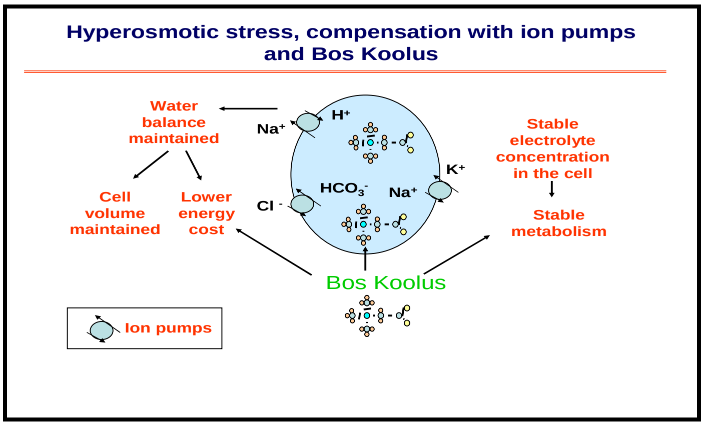
Betaine is a tri-methyl derivative of the amino acid, glycine, and is present in the cells of micro-organisms, plants and animals. In the past, it was most commonly described as either an osmolyte or a methyl-donor, but more recently has been described as a "chemical chaperone", since it repairs denatured proteins and interacts with molecular chaperones, the "heat shock" proteins. In addition to these attributes, Betaine has several other properties that make it a most attractive candidate for attenuating thermal tissue damage.

The base mode of action of Bos Koolus is to assist the ongoing hydration of core body organs in the face of a heat stress challenge, that will naturally see the movement of body fluids to the extremities. Bos Koolus does this by sparing Na/K ion transfer across cell walls of individual cells.

Two main outcomes of this in a heat stress context are:

1- <u>Sparing maintenance ME requirement:</u>
   In a thermo neutral environment this is likely to be about a 10% maintenance sparing. In heat stress situations this sparing may be greater.
   Our dairy work suggests that these animals in particular are responding with greater maintenance sparing than 10%.





2- Maintaining gut integrity, higher dry matter intake and prevention of Endotoxicosis:
The work of Pierre Cronje in particular (and more recent work also) has highlighted that a significant impact of heat stress is a breakdown in the integrity of the gut. This leads to longer periods of impact from heat stress, and decreased dry matter intakes and digestibility in short/medium term. Longer term exposure will lead to endotoxicosis and potential fatality.

Both of the above outcomes are favourable to the animal withstanding heat stress in a more positive manner, not suffering significant set back, and continuing with product growth with a more rapid recovery.

Recent dose rate work in beef, along with commercial application by leading industry consultants, suggests that a dose of **10g/head/day in beef** is likely to produce the best economic response.
This equates to a **dose of 1.35kg/t of feed and a cost about $9.50/t of feed**.

In sheep, that dose will be about 1g/head/day.
This equates to 0.67kg/t feed or about $4.70/t of feed.

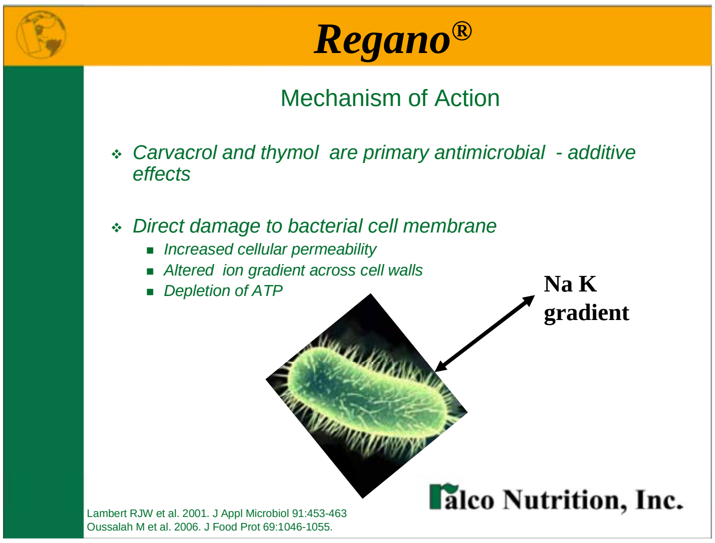
ROI on this product will be in the vicinity of 12:1.

(NB: In all heat stress situations, sub acute acidosis eminates as a continual part of the heat stress complex. “ACIDBUF” is a highly effective rumen buffer and is worthy of consideration as part of the approach to heat stress control.)

b) “Regano” management of infections caused by Salmonella, E. coli and other bacteria

This product has particular application in live sheep export. The product Regano is a highly effective product in combating Salmonella, E Coli , Clostridia, Staphylococcus and Campylobacter.

Mode of action is outlined below.



Regano has zero withholding period and significant real world exposure in the intensive live stock sector in the USA, and to a lesser degree Australia.

In Australia it has been commercially applied in Pork, calves and Feedlot lambs with good success.

It is the feedlot lamb experience that has caught the attention of the live export sector. It has shown itself to be effective **commercially in controlling Salmonella and E Coli**, and this has raised hopes that it is a safe and easily applied tool to address a major challenge on the live sheep export boats.

Personal Communications from Dr John House at Sydney University suggests that in the live sheep export industry about 70% of mortalities revolve around a interrelated Salmonella/inanition (off feed) complex.

It is hard to clearly determine wether the off feed is a result of Salmonella , or the salmonella arises following an off feed incident. Irrespective, Salmonella is a key pathogen is a high proportion of mortalities on these boats.

Regano presents as a product that is uniquely suited to this application. It has the following attributes:

- It works against the key pathogens
- It has zero withholding period, and is **not an antibiotic** that may have implications in sensitive export markets
- It is easily applied in feed or water
- It is cost effective

Regano does not present as relevant to Beef export. Its application lies in **long haul sheep export**.

Dose rate is 0.5g/head/day in sheep. That equates to 350g/t of feed.
That will cost about $11.50/t of feed.

ROI on this product will be about 10:1 based on likely reductions in mortality.

c) "Yucca Extract" (Desert King) to manage Ammonia emissions on board

Ammonia production on live export boats has impacts on health and performance of both stock and staff. The significant challenge of ammonia can be at least partially offset by the inclusion of Yucca extract.

Yucca extract has been a common inclusion into pet feeds for many years to offset odour in companion animal faeces.

It presents a product worthy of consideration for the live export industry.

Dose Rate will be 100g/t of feed.
This equates to $1.60/t of feed.

ROI is difficult to estimate, and will be dependant on the current level impact of ammonia on stock and staff.

d) "Elitox" for managing Ergovaline in rations for live sheep export out of southern Australia

The export of sheep out of Southern Australia has historically been plagued by mortalities that are related to heat stress. The logical challenge has been that stock leaving a Victorian Winter and travelling over the equator will be greatly impacted by heat stress. As such Bos Koolus Betaine has a potential application.

I would like to flag a further impact that I do not think has been considered in discussions on heat stress in these shipments out of Southern Australia....that of ergovaline.

The vast majority of feed onto boats ex Portland is manufactured at one site near Heywood Victoria. Rations are a combination of grains and ground hays. These hays are sourced from a 150 km radius.

That drawing arc will virtually ensure that large proportions of the hay that is cut from that area will contain perennial rye grass. Research on perennial rye grass in that area suggests that 80% is infected with wild endophyte fungi. These fungi produce toxins that impact on the central nervous system (Lolitrum B) or cause strong vasoconstriction (ergovaline: an ergot alkaloid).

The Qld beef sector is well aware of the impact that Dihydroergosine (DHES) from sorghum ergot can have on stock. The impact of ergovaline in the south is no less strong. Outcomes are similar.

There is plenty of work showing the wide spread presence and impact of Perennial rye grass endophyte in Southern Australia. It impacts domestic dairy beef and sheep production seasonally in Southern Australia.

As a consequence, Feedworks carried out work at Melb Uni with Dr Brian Leury. This work examined the impact of ergovaline on the physiology of sheep, and the potential to offset this impact with control products. In this case Elitox, a mycotoxin control product that is both a binder and a biological denaturing product on toxins.

The results showed strong impacts of ergovaline (as expected), but also that these impacts on physiology can be at least partially offset by Elitox. Given theses results, the use of Elitox in rations for **sheep on export boats** may be wise from both an economic and animal welfare perspective.

Dose rate is 1g/head/day in lambs. Cost is 0.6c/head/day.
Cattle dose is 10g/head/day. Cost is 6c/head/day.

Price per tonne of feed will be $8.00/t of cattle feed.
Price per tonne of feed will be $4.00/t of sheep feed.

ROI will depend on impact of heat stress on sheep, and the contribution of endophyte and mycotoxin impact.