

Report on Description & Processing of Ingredients used in the Manufacture of Prawn Feeds

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Executive Summary

The majority of prawn feed usage is divided between the states of Queensland, New South Wales and the Northern Territory. For the year 1996/97, Queensland, by far the largest consumer of feeds, used 2739 Tonnes of feed representing 79.5% of total feed used. New South Wales used 610 Tonnes representing 17.7% and the Northern Territory used approximately 100 Tonnes, representing 2.8% of total feed used.

These figures represent that approximately 155 Tonnes of crustacean meal, as incorporated product in finished feeds for prawns, entered Australia and approximately 55 Tonnes of crustacean meal as unincorporated product destined for prawn feed manufacture entered Australia. Other small amounts of crustacean meals were imported into Australia for other feeds including marine fish and pet feeds.

Two major forms of feed are used in the Australian prawn feed industry, steam pelleted and extruded. For the year 1996/97, 722 Tonnes of extruded feeds were used and 2772 Tonnes of steam pelleted feeds were used. A small amount of feed products, less than one tonne was used in Australia that were manufactured by other means including, flaking, cold pressing and micro-particulate encapsulation.

The supply of prawn feeds come from a variety of sources and the majority of that supply originates from the South East Asian region, with the remaining smaller component of supply originating from domestic supply.

It is important to note that the country of origin of the finished feed does not usually indicate the source of supply of the crustacean meal used in that feed. A significant amount of inter-country trade exists in crustacean meals due to supply and economic influences and the elucidation of these pathways is extremely difficult to ascertain, as this intellectual property is considered proprietary by most aquaculture feed millers.

The contribution to supply from individual countries has changed over the immediate past due mainly to farmer preference. In 1996/97 major suppliers of feed from South East Asia were Thailand 38%; Taiwan 30% and Indonesia 12% of the total feed used. The remaining 12% was produced domestically.

The factors currently influencing choice of feed in the Australian industry are essentially economic and supply considerations. Outside of any potential future restrictions to supply of imported prawn feeds these two factors will remain the predominate deciders of choice in supply of feed into the Australian industry.

A number of different species are utilised to produce crustacean meal for incorporation into prawn feeds. In consideration of the terms of reference of this program of investigation to review material

pertaining to penaeid and metapenaeid species, further investigations were also conducted to elucidate other species utilised in the production of crustacean meals with the ultimate goal of incorporation into prawn feeds. A number of other crustacean species were identified including *Euphasid* species; *Carid* species and *Squilla* species.

Given that crustacean meals are seldom exclusively sourced from within the country or region that is producing prawn feed, this investigation concentrated on those areas actually supplying crustacean meal for later incorporation into prawn feeds. The South East Asian region predominates in the supply of crustacean meals. These products are generally referred to as “Shrimp Head/Shell Meal” and “Shrimp Shell Meal”. The United States of America is also a supplier of this type of product as are a number of South American Countries. Also from the South American region is the supply of products generally referred to as “Krill Meal” and “Langostine Meal”.

The growth history of the crustacea that are utilised in the production of commercial meals falls into two broad categories, cultured and wild caught. It has often been proposed that the use of wild caught crustacea for the production of meals will overcome any potential disease threats. This is however not the case, although cultured stock has shown greater incidences of point source, identified disease outbreaks, the use of wild caught in the production of meals does not preclude the incidence of potential disease vectors.

IHHNV infections (not clinical) have been identified in wild penaeids in Ecuador, western Panama and western Mexico (Lightner, 1996). TSV has been documented in wild *P. vannamei* from Ecuador, El Salvador and Mexico (Lightner, 1996). WSSV has been identified using nested polymerase chain reaction (nPCR) in wild caught; *P. monodon*, *P. japonicus*, *P. semisulcatus*, *P. penicillatus* and crabs *Charybdis feriatus*, *Portunus pelagicus*, *Portunus sanguinolentus* (Lo et al. 1996b)

Viral diseases that have not been reported in Australia and are of economic significance to prawn farming industries in other countries include:

Infectious Hypodermal and haematopoietic Necrosis

White Spot Syndrome

Baculovirus Penaei Disease

Hepatopancreas Parvovirus Disease

Taura Syndrome

Yellow Head Disease

The common methods of sun drying and furnace drying are probably insufficient to inactivate a number of potential disease agents irrespective of whether the source material is cultured or wild caught. The much higher temperatures (90-140°C) and the extended processing duration (2-10Hr) of the steam drying and drum drying methods provide protection against significant disease agents such as IHHNV and WSSV.

The use of HACCP principles in the production of prawn feeds is rarely used. It should be pointed out that most competent feed millers have in place, most of the components of a HACCP system for Quality Assurance, however the systematic application of these components into a HACCP program is rare. It is also an extremely uncommon practice for producers of crustacean meals. Some producers from the South American region do have protocols in place as an artifact of their fishmeal production systems. However, it should be noted that the use of HACCP principles are rarely used in the production of most raw ingredients used in the production of prawn feeds and especially crustacean meals.

Terms of Reference

1. Describe the volume, nature and source of imported crustacean feed products containing material derived from prawns used in Australia including patterns of use. Information should be provided on any economic or other trends which might influence patterns of importation and usage in the future.
2. Report on the nature of raw materials used in the manufacture of crustacean feeds containing material derived from prawns. For such prawn derived materials, information should be provided on the species, their source (geographic location / husbandry etc.) And where relevant, their health status.
3. Provide details of the manufacturing of crustacean feeds containing material derived from prawns in Australia and overseas (in particular those procedures likely to reduce or enhance survival of microorganisms in the product). In this context, manufacturing includes the process used to produce the 'final product' and the conditions of subsequent storage and transport. The application of quality assurance systems such as 'hazard analysis and critical control point' (HACCP) should be included in the report. Details of any government controls, legislative or commercial requirements should be provided.

Project Personnel

Dr. **Hann-Jin Haung**. B.Sc., M.Sc., PhD. Associate Consultant, AquaTactics Pty Ltd

Dr. **Kirsten Spann**. B.Sc. (Hons), PhD. Associate Consultant, AquaTactics Pty Ltd

Dr. **Alistair Brown**. B. V Sc. MRCVSc Associate Consultant, AquaTactics Pty Ltd

Mr. **Peter Krogh**. B.Sc., M. App. Sci. Principal Consultant, AquaTactics Pty Ltd

The contact person in AQIS throughout the project was Mr. Warren Vant.

Methodology

TOR 1.

- Published and unpublished sources were reviewed in conjunction with direct interview of feed importers, recognised industry representative groups and relevant state and commonwealth fisheries departments. In addition, direct contact with supply companies of crustacean meals overseas was conducted.

TOR 2.

- Direct contact with supply companies of crustacean meals overseas was conducted. Contiguous with this process information was sought from domestic aquaculture feed processors. Evaluation of health status was conducted and collated by project team members

TOR 3.

- Information was presented from published documents as well as the in-house experience of project team members. A review of quality control systems was incorporated into the collection and collation of crustacean meal producers.

1.0 Description of Prawn Feed Market in Australia.

1.1 Volume of Imported and Local Feed Products

The majority of prawn feed usage in Australia is divided between the 3 states of Queensland, New South Wales and the Northern Territory

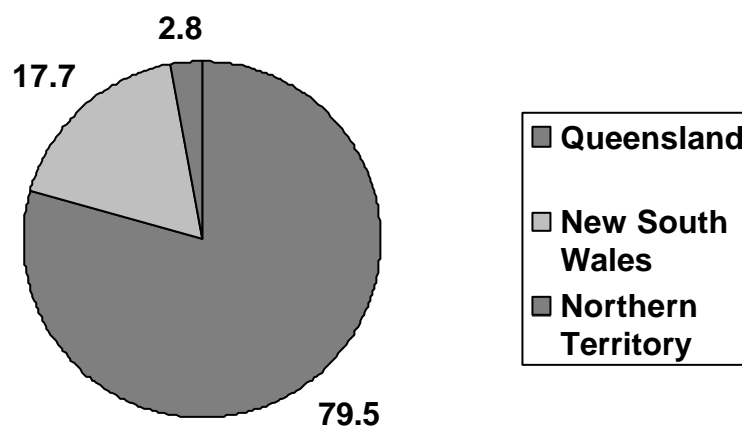
Farmers in the state of Queensland are the largest users of imported and locally produced prawn feeds by volume. In the 1996/97 year 79.5 % of feed used in Australia was in the state of Queensland representing 2739 Tonnes of prawn feed for all species. The state of New South Wales is the next largest user of prawn feed. The amounts of feed used in this state using again the 1996/97 figures were much smaller in tonnage and percentage terms than users in Queensland. Only 17.7% of total feed usage were utilised in this state representing 610 Tonnes of feed for all species (Lobegiger, 1997).

The remainder of feed usage 2.8% was consumed in the Northern Territory, Which has a small but developing industry. This percentage represents approximately 100 tonnes of feed.

(Source: N.T.D.P.I)

Figure 1.1

Volume of Feed Expressed as a Percentage



By State Usage 1996/97

Table 1.1.1
Feed Usage by Tonnes all States and all Species

	Queensland	New South Wales	Northern Territory	Total
1993/94	2487	ND	ND	2,487
1994/95	2924	ND	ND	2924
1995/96	2804	ND	ND	2804
1996/97	2739	610	100	3449
1997/98	5407*	755*	100*	6162

(Source: Lobegiger, 1997)

*- Predicted usage

ND - No Data Available

The figures cover the two main species cultivated and the feeds used to cultivate *P. monodon* & *P. japonicus*. Experimental production of *P. esculentus* has been conducted by research institutes (C.S.I.R.O.), however production levels are extremely low (< 1.0 tonne harvest weight, D. Smith *Pers Comm.*), existing *P. monodon* feeds have been used in this trialing

These figures cover both imported and domestically produced feeds using prawn based ingredients

For the year 96/97 the total amounts of feed used was 3449 Tonnes with approximately 908 Tonnes produced domestically and 2586 Tonnes imported. Given that prawn feed has an average of 6% of its ingredients that are produced from prawn derived material. Approximately 54.4 Tonnes of unincorporated prawn meal was imported destined for domestic prawn feed production. That leaves approximately 155.1 Tonnes of prawn derived material imported as a processed integrated material within imported feeds.

The year 97/98 total expected feed usage is 6262 Tonnes which given previous purchase patterns of the industry would be approximately 1232 Tonnes produced domestically and 4930 Tonnes imported. Given an average of 6% of product consists of prawn derived material that is approximately 74Tonnes of unincorporated prawn meal imported destined for domestic prawn feed production. That leaves approximately 295 Tonnes of prawn derived material imported as processed integrated material.

Table 1.1.2**Total Feed Usage Including Imported and Domestic Production by Tonnage
Years 1996 - 1998**

	Total Feed: Usage (Tonnes)	Total Feed: Imported (Tonnes)	Total Feed: Domestic Production (Tonnes)
1996/97	3494	2586	908
1997/98	6162	4930	1232

Table 1.1.3**Total Feed Usage Including Imported and Domestic Production by Percentage
Years 1996 - 1998**

	Total Feed: Usage (Percentage %)	Total Feed: Imported (Percentage %)	Total Feed: Domestic Production (Percentage %)
1996/97	100	74.1	25.9
1997/98	100	80.1	19.9

Table 1.1.4
Total Feed Tonnage Imported and Produced Domestically Years 1996-1998 Including Estimated Quantities of Prawn Derived Ingredients.

	Total Feed: Used (Tonnes)	Total Feed: Imported (Tonnes)	Total Incorporated Prawn Ingredient (Tonnes)	Total Feed: Domestic Production (Tonnes)	Total Unincorporated Prawn Ingredient (Tonnes)
1996/97	3494	2586	155.1	908	54.4
1997/98	6162	4930	295	1232	74

Note: section 2.1 details the level of inclusion of crustacean meal.

Table 1.1.5
Total Feed Tonnage Expressed as a Percentage of Imported and Produced Domestically Years 1996-1998 Including Estimated Quantities of Prawn Derived Ingredients.

	Total Feed: Used (Percentage %)	Total Feed: Imported (Percentage %)	Total Incorporated Prawn Ingredient (Percentage %)	Total Feed: Domestic Production (Percentage %)	Total Unincorporated Prawn Ingredient (Percentage %)
1996/97	100	74.1	6	25.9	6
1997/98	100	80.1	6	19.9	6

Note: section 2.1 details the level of inclusion of crustacean meal.

Note this does not account for all the imported prawn and crustacean meals as they are entering

other industries and are utilised in alternate feeds including fish and pet feeds.

1.2 Nature of Imported and Local Feed Products

Two major forms of feed, steam pelleted and extruded are loosely discriminated by their intended culture species.

P. monodon feeds are almost uniformly produced by the steam pelleting process for both imported and domestically produced products. Some *P. monodon* feeds are produced by the steam extrusion method but are not imported into Australia.

P. japonicus feeds are almost all produced by the steam extrusion method. All are imported as no local production exists. Some *P. japonicus* feeds are produced by the steam pellet methods but as is the case of extruded monodon feeds not currently imported into Australia.

Microencapsulation and suspension type feeds, (that are a homogenisation of ingredients, which is added to the larval rearing water) are feeds that are destined for the larval rearing stage of both species. The volume of these feed types while not significant, has potential as a disease vector due to the low temperatures used in the manufacture of these products and the presence of crustacean derived material in their formulations.

Flaked foods, are also used in small volumes, however the potential risks associated with this feed type is reduced due to the high temperatures used in their manufacture >100 C.. Time of exposure to these production temperatures is variable, pertinent to the formulation and is difficult to determine as this information is considered commercially sensitive information.

Detail of the techniques used for the production of these novel feeds is specified in Section 3.2.

Table 1.2.1

Feed Type by Production Method and Species by Tonnage

	Extrusion Tonnes of Feed Used (<i>P. japonicus</i>)	Steam Pelleting Tonnes of Feed Used (<i>P. monodon</i>)	Other * (<i>P. japonicus</i> <i>P. monodon</i>)
96/97	722	2772	<1Tonne
97/98 [#]	884	5278	<1 Tonne

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* Combining Micro-encapsulation, Homogenisation and Flaking.

Projected Figures : (source: industry survey)

Table 1.2.2

Feed Type by Production Method and Species by Percentage

	Extrusion Tonnes of Feed Used (<i>P. japonicus</i>) as percentage	Steam Pelleting Tonnes of Feed Used (<i>P. monodon</i>) as percentage	Other * (<i>P. japonicus</i> <i>P. monodon</i>) as percentage
96/97	20.6%	79.35	<0.1%
97/98 [#]	14.3%	85.6%	<0.1%

* Combining Micro-encapsulation, Homogenisation and Flaking.

Projected Figures : (Source: industry survey)

Figure 1.2

1996/97
Feed Type by Production Method

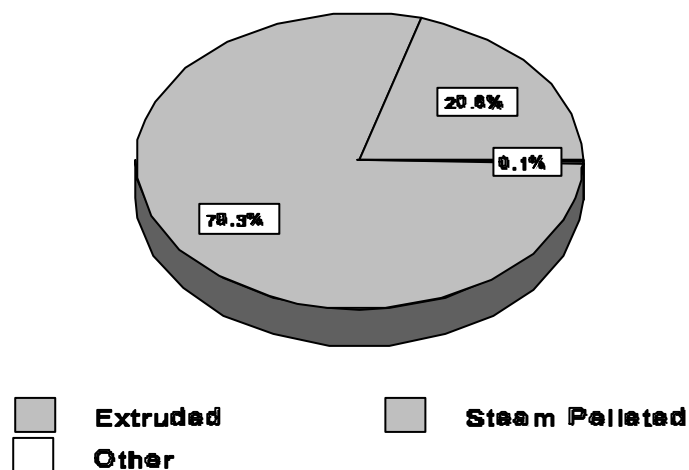
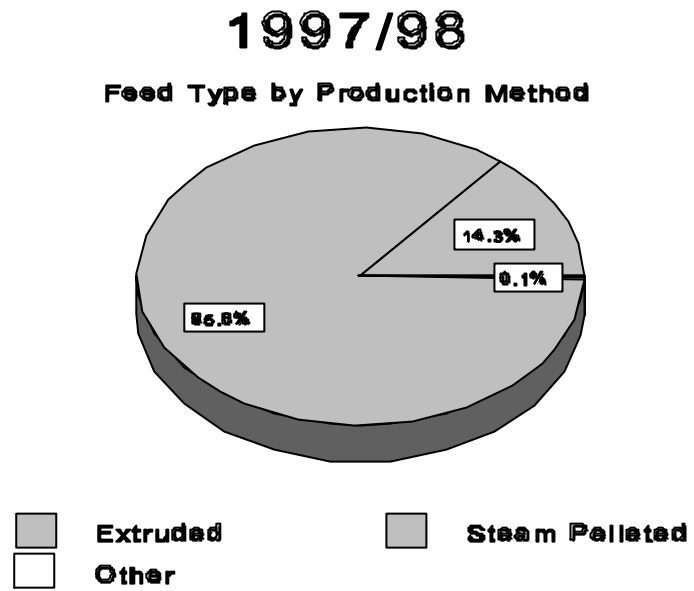


Figure 1.2.2



1.3 Source of Imported and Local Feed Products

This section details the source of supply of the finished products which is not necessarily the original point of origin of the prawn ingredients used in the manufacture of the finished prawn feeds.

There is however a commonality of source of supply across the geographic areas of use within Australia. Countries of origin for the finished feeds include Thailand, Taiwan, Indonesia and domestic production.

In Australia for the years 1993 to 1997 a small increase in the amount of feed has occurred in response to increasing area of pondage and increasing knowledge of farm management. Table 1.3.1 depicts the feed usage for Queensland as a percentage of total tonnes expressed as source of country of manufacture of the feed. Graphical representation of these figures is also presented in Figure 1.3.1.

A large increase in the forecasted usage of feed in Queensland for the year 1997/98 is incongruous with the preceding patterns of usage and should be viewed with some caution though. Of note in the Table 1.3.1 is the small, but actual decline in overall usage of feed in the 1996/97 season which has been attributed to factors including declining feed requirement due to disease problems and lowered feed conversion rates in response to improving management techniques

The pattern observed in Queensland, is however, not as predominant in the New South Wales data. A slight increase in feed requirement is noted, likely due to improving farm management techniques enabling improved stocking densities and hence slightly increased feed requirements. Table 1.3.2 and Figure 1.3.3 and 1.3.4 allude to these changes observed.

Table 1.3.1**Feed Usage by Country Source: Queensland Percentage and Total Tonnes
Years 1993 - 1998**

	Thailand (%)	Taiwan (%)	Australia (%)	Indonesia (%)	Total Tonnes
1993/94	34	51	11	4	2342
1994/95	37	31	16	16	2595
1995/96	31	33	9	9	2328
1996/97	38	30	12	12	2072
1997/98	ND	ND	ND	ND	4703*

* Predicted Usage (Lobbeiger, 1997).

Figure 1.3.1
Prawn Feed Usage by Country Source: Percentage of Total Queensland

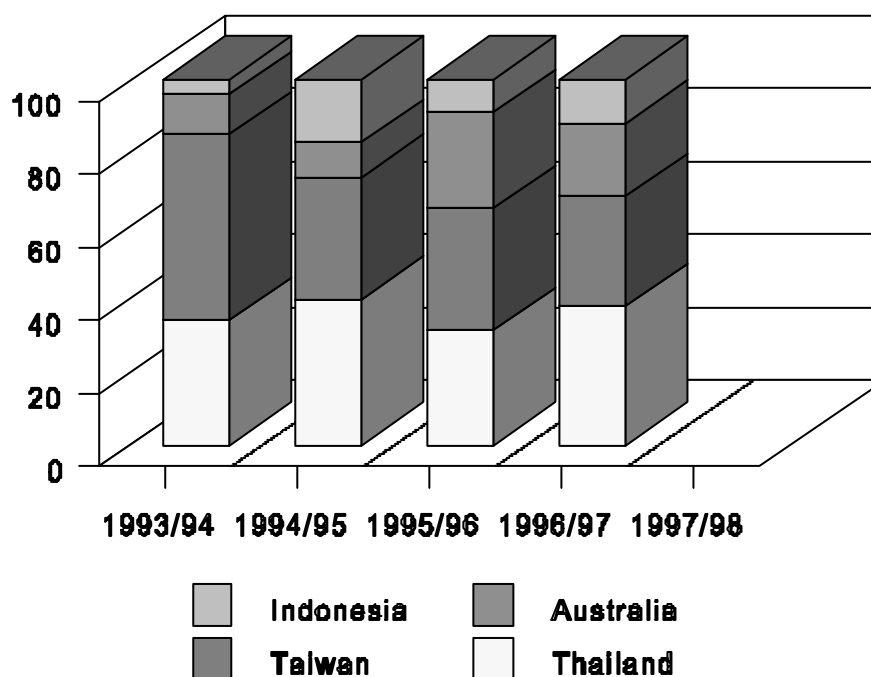
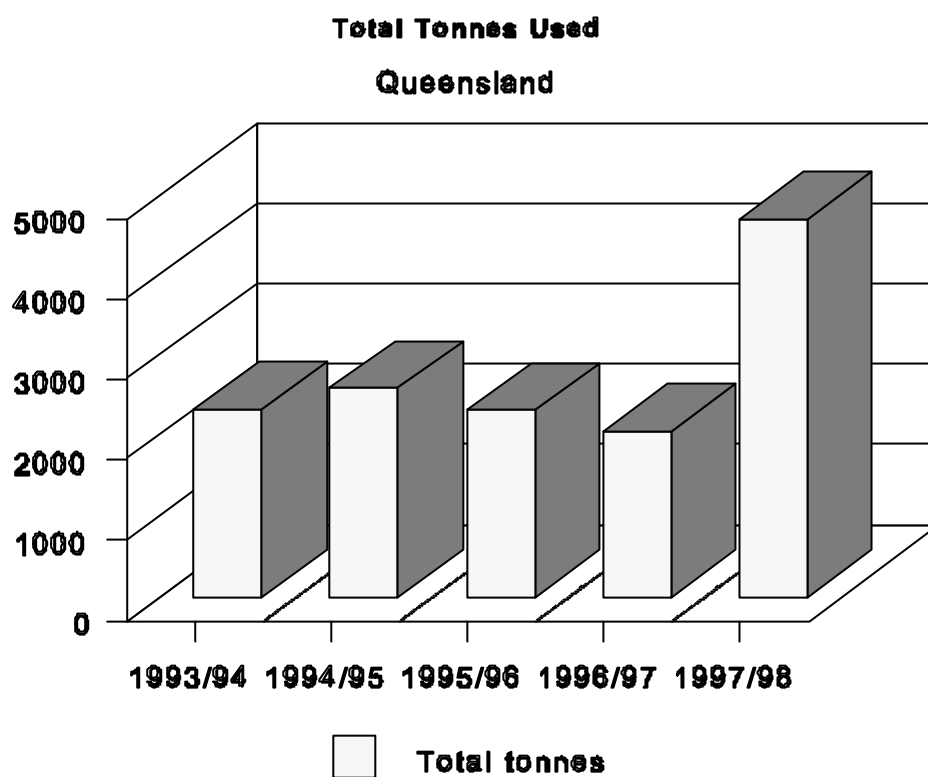


Figure 1.3.2**Table 1.3.2**

**Feed Usage by Country Source: New South Wales Percentage and Total Tonnes
Years 1996 - 1998 ***

	Taiwan (%)	Indonesia (%)	Total Tonnage
1996/97	80	20	600
1997/98	74	26	755

* (source: industry survey)

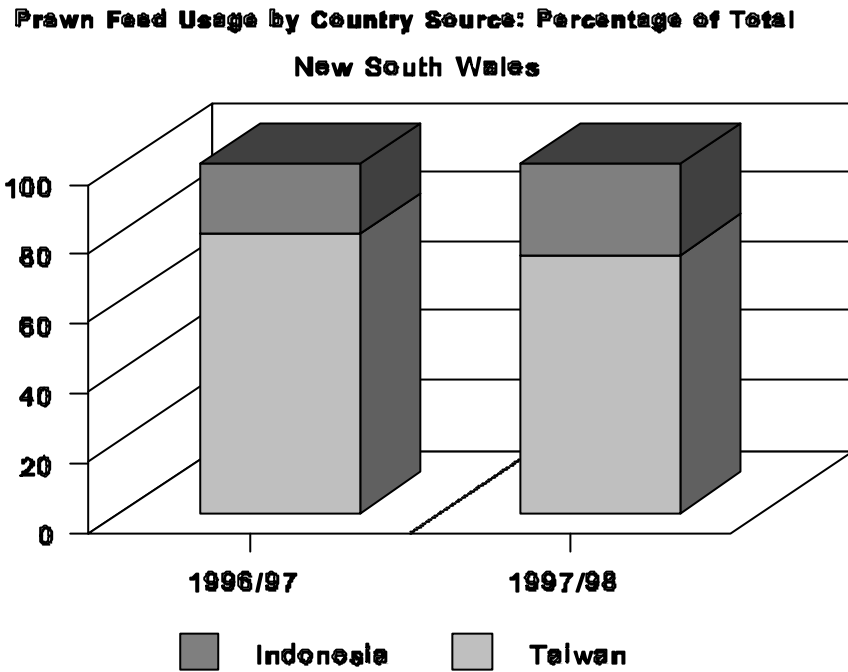
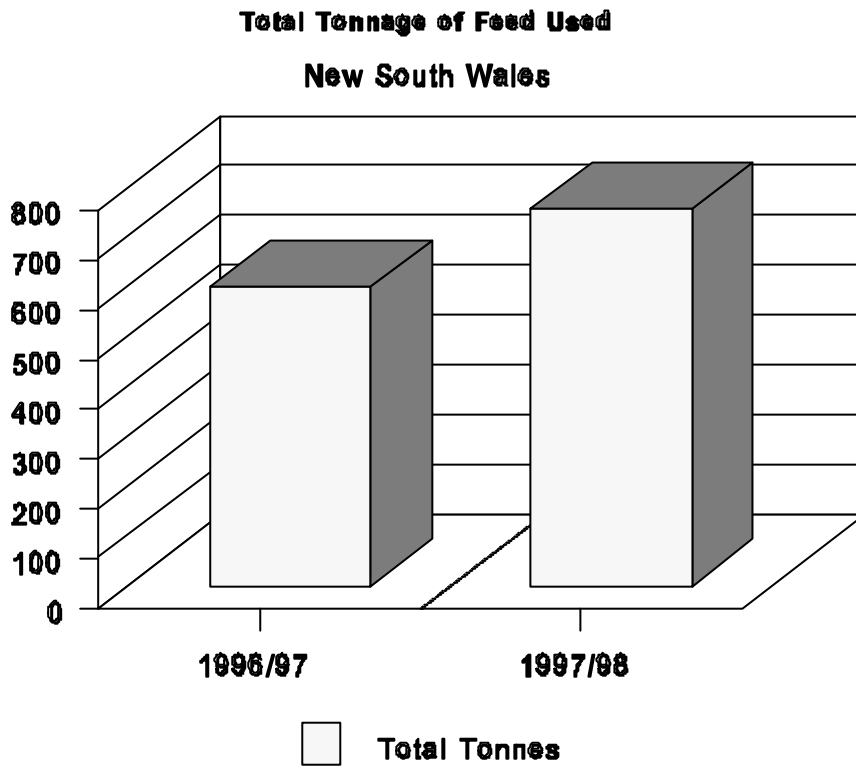
Figure 1.3.3

Figure 1.3.4



1.4 Patterns of Use

Usage of any particular feed type whether pelleted, extruded or from the other classifications relies on the type of that feed and generally the species to which it was intended.

The identification of geographical patterns of use within Australia of finished feed or unprocessed raw material is difficult due to translocation of goods. The tracing of imports relies on port of entry only, not internal movements within Australia.

A further complication is that feed intended for use in the feeding of prawns can be imported under a number of classifications and the true quantities are difficult to determine.

This is also the case in relation to the importation of unincorporated crustacean meals. They can also be imported into Australia under different descriptive categories determined by the stated final use of these products i.e.: pet feeds.

Reliance on non-audited, survey responses supplied by the farming industry is currently the only source of information concerning the distribution and use of complete feeds. No system however, exists for the tracing of unincorporated raw materials.

Crustacean meal is imported into Australia, in most cases, as a bagged product in standard shipping container loads. The meal itself is usually packed in unlined, single walled woven polypropylene sacks containing 40-50 Kilograms of meal. The storage time of this meal is usually a number of months but can be for a number of years dependent on usage rates of the manufacturer.

As the product is usually supplied in sacks, these are palletised and stored in normal warehouse conditions. This can be achieved due to the relatively low overall moisture level of the meal, which is usually between 5 – 12 %.

Finished feed that is imported is also supplied in sacks in container loads. However the style of packaging for feeds is somewhat different to that used in the transport of meals. The sacks used for finished feeds are usually multi walled paper sacks, often referred to as “Kraft” type sacks. These sacks are usually constructed of 3 to 4 layers of heavy paper with impervious sheets of polyethylene sheet bonded between the paper layers. Local manufactures almost always opt for the use of woven polyethylene sacks. This is mostly due to the high cost of the “Kraft” type sacks in Australia, which are used primarily for the packaging of foods graded as fit for human consumption.

The use of bulk feeds for supply to prawn farms is not common in Australia, possibly due to the high proportion of imported feeds in the Australian market, which are supplied in bag form only. In addition, the great distances between farms and local manufactures, tends to negate the cost benefits accrued through bulk transport.

Finished prawn feeds, whether imported or locally produced are reasonably uniform in their gross

proximate analysis. In regard to the storage conditions required, there are no different requirements between these feeds. Recommended storage conditions include a cool (equal to or less than 25°C), dark and dry storage areas free from rodents and insect pests. Storage conditions can vary widely on farms, dependent on the individual farms' ability or desire to meet these general recommendations.

Commonly, a number of different feed types are used in the production of a crop of prawns. There exist three major feed categories, broadly referred to as starter, grower and finisher. The major differences between these feeds are the size of the feed. Minor formulation differences are made between these feed types.

The starter type feeds are either in the form of a small pellet or a "crumble" which has been produced by passing already prepared pellets through machinery that physically cracks the pellets into smaller particles. The "crumbled" feed is then graded into different size fractions for different size prawns.

The grower and finisher type feeds are in pellet form only. Again the major difference is size of the pellets, with the finisher pellets being somewhat larger than the grower pellets.

Formulation changes between the major classes of prawn feeds are subtle, minor differences are made to achieve changes in the gross proximate analysis between the different feed types. This is usually achieved by the manipulation of protein rich ingredients such as fish meal and squid meal. Levels of crustacean meals usually remain reasonably constant through feed categories produced by individual manufactures.

As all feeds are essentially produced from a common, physical form i.e. a standard pellet. The processing requirements are therefore common for the three major feed types. These pellets may under go further processing to achieve size reduction but the processing techniques are common throughout the classes of feed.

In addition, as the feeds are all from a common production system the packaging and storage of feeds is also common to the major classes.

1.5 Other Influences Affecting Future Importation, Local Manufacture and Usage.

It has been suggested that the limitations to the supply of commercial feeds for prawns in Australia is predominantly economic, (Evans, 1991). This is possibly a function of a number of factors including the relatively small size of the Australian industry in comparison to the global industry. This situation inhibits feed suppliers both local and international from becoming more involved with servicing the local industry.

The issue of import restrictions currently does not present any impedance to importation of feeds other than the current requirements under the system for importation of biological material (Quarantine Act 1908).

The profile of crustacean feed types used in Australia has in recent years and possibly in the future will change as the industry investigates new species for culture. The nutritional requirements of these species are the prime determinate of ingredient selection and formulation. This will possibly affect the required addition of crustacean meals into these diets and the subsequent flow of these materials into Australia either as an incorporated ingredient in the finished feeds or as an unprocessed, separate imported item.

The large proportion of prawn feeds currently used in Australia is from imported sources. This situation may reflect the availability of feeds at the emergence of prawn farming in Australia. As no locally produced feeds were available at this time, the consequence was that feed had to be imported to ensure the continued development of the industry. As the system of importing feed became conventional, the desire to move from an established and reliable system of supply became less appealing. Also feeds from established producers with long histories of involvement in prawn feed supply overseas were considered reliable both in ability to supply as well as technical competence. The inference that overseas suppliers are more technically adept at the production of specialised feeds such as prawn feeds, because of an extended period of time supplying their local markets is possibly still prevalent in the local Australian market to some degree.

The extent to which local suppliers are able to replace the proportion of imported feeds at existing consumption levels as well as at increased levels, due to industry expansion, will be predominately driven by evaluation by farmers as the end users of these products. The farmers will have to have a level of confidence in locally produced feeds in terms of performance and safety of use equal to or exceeding that of the imported feeds.

It is a commonly held belief that locally produced feeds are substantially or should be, cheaper to produce than those that are imported. As the great proportion of ingredients needed to locally manufacture high quality feeds have to be imported the cost benefits of locally producing feeds is greatly restricted. Therefore the reliability and performance of locally produced feeds rather than cost of these feeds is a major determinate of the success of these feeds in the market.

Recent fluctuations in world economic markets and more importantly within the Asian region, which

supplies the greatest proportion of prawn feeds to Australia has had minor effect on supply of feeds into Australia. This is possibly attributable to the fact that feeds supplied from Asian countries are net exports for these suppliers from goods that are sourced locally. Ingredients available domestically are purchased in that country's local currency and the finished products, prawn feeds are usually always sold in United States dollars (USD). As the relative strength of the United States dollar to local Asian currencies has been increasing the benefit of exporting products has also been increasing at a proportional rate.

The increased cost of importing some ingredients is often offset simply by this currency exchange system and the gains made by using locally available materials. This situation has enabled many producers in the Asian area, that are net exporters, to remain relatively price stable in regard to cost of production of prawn feeds. This situation of overall stability has therefore had little impact on the quality requirements of ingredients sought by Asian based manufactures.

Any reflections on price fluctuations at point of sale of feed in the Australian market are possibly due to other influences other than those associated with cost of production and are not considered within the terms of reference for this report.

2.0 Description of Raw Materials Used in the Manufacture of Crustacean Feeds

2.1 Species Used in Preparation of Ingredients

A number of biological and non-biological materials are used in the manufacture of prawn diets. Evans, (1991); Kanazawa, (1991), list proposed commercial mixes for penaeid prawns that have varying degrees of ingredient substitution. The levels of crustacean meals proposed by these researchers is somewhat higher than the industry accepted 6-10%. As the information of the constituent ingredients used in the manufacture of prawn feeds and their levels is of a "commercial in confidence" nature, reputable and reliable published information is not available. Two members of the project team are experienced and respected commercial shrimp feed formulators and state that the use of the levels of 6-10% of crustacean meal in the production of feed for *P. monodon* and *P. japonicus* is common. The level of 6% is the most common inclusion of crustacean meals for commercial *P. monodon* feeds and up to 10% for commercial *P. japonicus* feeds. Independent advice was also sought regarding levels and advice was received that these levels were correct for commercial formulations (D. Smith, C.S.I.R.O. Div. Fisheries *Pers comm.*). However it is recognised that levels of crustacean meals can reach those indicated in Table 2.1.1 but usually only in experimental diets that are published.

Table 2.1.1**Ingredients used in Formulation of Commercial Crustacean Feeds.**

Ingredient	Percentage Inclusion *	Percentage Inclusion #
Wheat	4.5	8.0
Wheat Flour	18.0	8.0
Soybean Meal	20.0	6.0
Meat Meal	7.5	0.0
Fish Meal	20.0	20.0
Shrimp Meal	15.0	18.0
Squid Meal	10.0	20.0
Oil	1.0	4.0
Additives	4.0	10.0

* Evans, 1991. # Kanazawa, 1991.

Crustacean meals that are used in the production of prawn feeds are predominantly produced from penaeid species. Also involved in the production of these crustacean meals is the metapenaeid species. The choice of species is somewhat arbitrary and is dependent on what is available geographically and or economically. In areas where the processing of prawns for human consumption is undertaken then the waste stream (heads and shells) are often used in the production of crustacean meals destined for incorporation into prawn feeds. As the dominant species that is grown for processing in countries in the Asian region is *P. monodon*, this species account for the majority of crustacean meals produced in this area.

Other crustacean meals used in the production of prawn feeds include “Krill Meal” and “Langostine Meal” produced from a range of cold deep-water species from both the Atlantic and Pacific oceans. These meals are in relatively limited supply in comparison to traditional “Shrimp Head/Shell Meal” and “Shell Meal”. As they are often purchased on specifications additional to those used for the more traditional meals they command a higher price and their use is often confined to specialist markets. The most significant additional specifications used for “Krill Meal” and “Langostine Meal” are high levels of carotinoid pigments. The carotinoid pigments are a sought after component of feeds that assist in the colouration of marine organisms as well as some proposed disease related prophylactic effects. These meals are also often incorporated into fish diets whereas more traditional crustacean meals would not be.

The use of a finished prawn feed, whether it is to be used for the hatchery stage or the final growout stage of the crop is the major determinate of what type of crustacean meal is usually incorporated, rather than the geographical location of the feed milling plant and its location to locally produced meals.

Feeds that are destined for the feeding of animals in a hatchery situation (micro-encapsulated, suspension and flake) are less price sensitive than the large volumes of feeds used for the growing out animals and the incorporation of higher cost meals is the norm in these hatchery feeds. The use of meals that are produced from cold deep-water species that are rich in carotenoid pigments is the usual option for these types of feeds. Irrespective of the geographical location of the feed hatchery feed producer either in Europe, the Americas or from the Asian region it is not unusual for these manufactures to use crustacean meals produced from cold water species of the Pacific and Atlantic oceans. It is uncommon for these producers to use meal produced from tropical species such as *P. monodon*.

The greatest proportion of feeds that is produced is for the growout of prawns. Irrespective of the site of manufacture of these feeds, the more traditional crustacean meals (Shrimp Head/ Shell Meal and Shell Meal) are used in these feeds.

Also of note is that in some prawn feed producing areas “Crab Meal” is often substituted on an economic and supply basis when supplies of “Shrimp Head/Shell” or “Shrimp Shell Meal” become limiting. It is important to note that meals produced from sources other than penaeid or metapenaeid species may contain disease agents of significance to prawns and other crustaceans.

The use of emergency harvested prawns i.e. those that are removed from the ponds due to potential or actual catastrophic loss situations, for the production of crustacean meals is an area of concern. Animals suffering a disease event that are used to produce crustacean meals possibly have a potential for the transmission of that disease through the meal. The practice, although recognised as probably occurring can not be verified (T. Flegel: Mahidol University, Thailand *Pers comm.*) independently with veracity. In addition however, tests of meals suspected of having been produced from emergency harvested prawns for WSSV were unable to identify this agent.

The production of Crustacean meals is a reasonably simple process irrespective of the actual methodologies used by different manufactures. The usual source of supply of the raw material, shrimp heads and shells is from the waste stream of food processing plants. In some cases whole shrimp are sometimes used. The heads and shells are dried to a level of 8-12% (with the exception of sun drying where moisture levels are usually between 14-20%) moisture to facilitate storage and reduce the affect of spoilage. Once a suitable moisture level has been reached the dried heads and shells are either packed directly into sacks for dispatch or undergo a grinding stage to produce a more uniform product. Most meals produced by sun drying are not ground after the drying stage. This is a reflection of the low infrastructure that is involved in this style of production. The infrastructure for grinding is usually not available in these situations. Most of the meals produced by

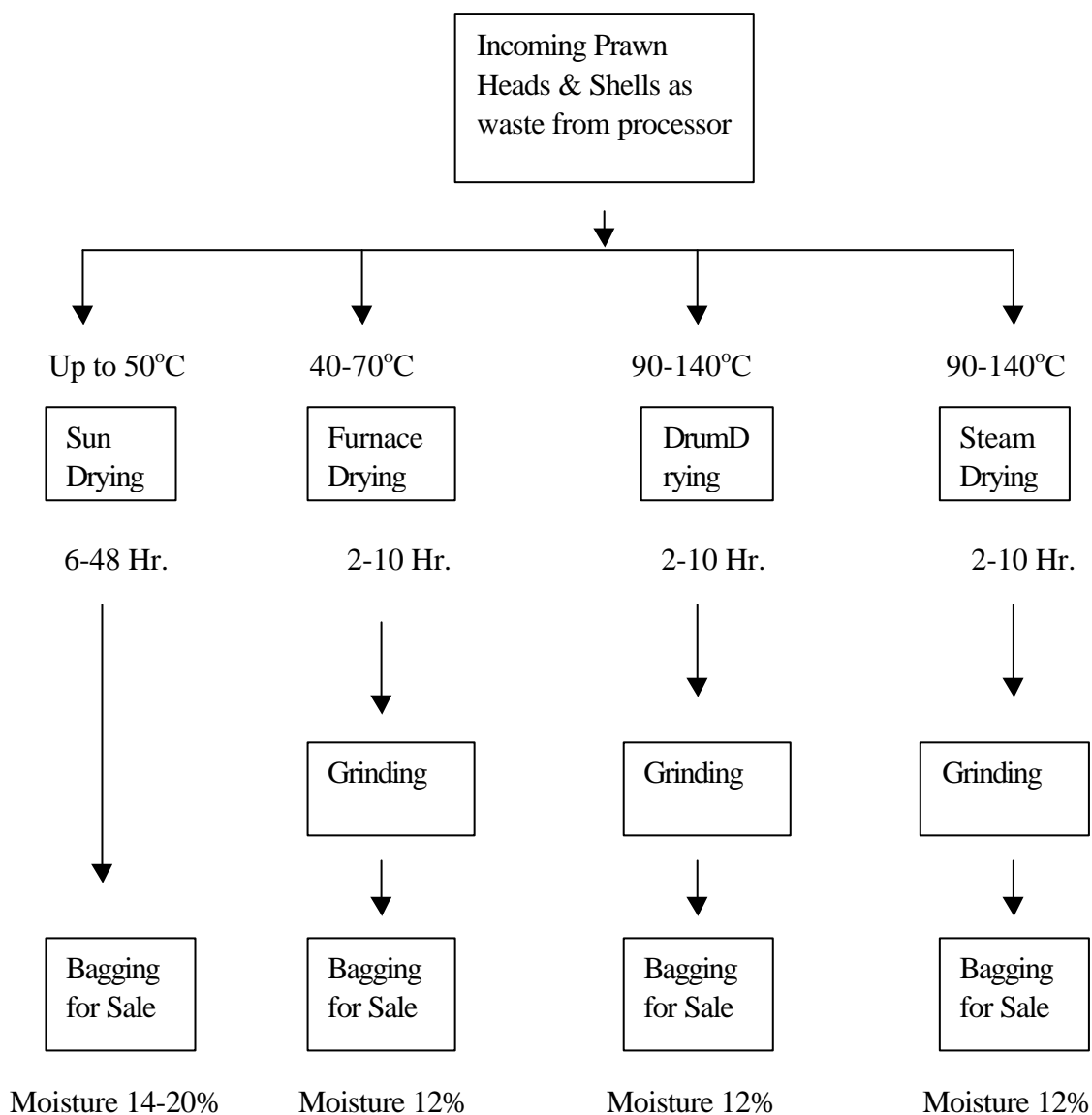
the other three major techniques, furnace, drum and steam drying do go through a grinding process as these meals are produced in plants that have a reasonable level of sophistication and grinding facilities are usually available. However it should be noted that some meals produced by these methods are sold not ground due to client specifications.

The furnace drying method usually uses a large slowly moving metal bed, which is heated by gas flames. The bed is usually encased in an outer shell to protect the flame of the gas burners. The belt can also be slowly moving, which gives a semi-automated system. The product is dried slowly as the heat of the gas flames drives off the moisture. The drum drying system uses the same principal of gas flames but the shrimp heads and meals are placed in a slowly rotating drum. This is a preferred system for manufactures as the product is moved and this feature accelerates the removal of moisture.

Steam drying also uses the same principal of moisture removal by the use of heat but in this process, rather than use direct flame as the drying agent, indirect steam is used as the heating medium. Sun drying is a common method for the preservation of products from spoilage in agrarian communities. Racks are made that are elevated from the ground and the shrimp heads and shells are placed on these for drying. As the heat penetration is not great in this system high levels of moisture are still to be found in the carapace of the prawn. In addition as grinding or crushing facilities are seldom available the opening of the carapace for exposure to drying by the sun, high moisture inside the carapace is a characteristic of this meal.

The length of time in drying shrimp heads and shell varies greatly with the incoming product. And times required between batches may vary from 2 to 10 hours. Producers of crustacean meals have little control over the characteristics of their incoming product, as it is the waste stream of other processing plants.

The large differences are due mostly to the size of the shrimp head and shells used. If small heads are used then heat penetration is good and drying time is reduced, if however large heads are used, heat penetration is not as good and drying time is greatly increased. These changes may occur on a daily basis due to the variability of the product supplied by prawn processors.

Figure 2.1.1**Flow Chart of Methods Used to Produce Crustacean Meals****2.2 Geographic Location of Original source Stock Material**

A significant factor in the supply of “Shrimp Head/Shell Meal” and “Shrimp Shell Meal” is that the site of sale is rarely an indication of the original source of that crustacean meal or the raw materials used to manufacture it. Table 2.2.1 identifies the geographic sources of original crustacean material used for the production of these meals. However, the identification of the supply pathways of the processed meal is extremely difficult due to complex trading arrangements within this sector of the

ingredient industry. This complexity is a result of a high level of inter-agency and inter-country trading of these and other specific aquaculture meals such as squid meal.

Table 2.2.1

Geographic Location of Original Source Stock Material

Geographic Area	Product Description	Species Involved
South America Inc. Chile Ecuador Peru	Krill Meal Langostine Meal Shrimp Head/Shell Meal	Euphasia species Penaeid & metapenaeid Species
Denmark	Danish Shrimp Meal	Various species
Indonesia	Whole Shrimp Meal “Hempi” Shrimp Head/Shell Meal	Penaeid Species Metapenaeid Species
Malaysia	Whole Shrimp Meal Shrimp Head/Shell Meal	Penaeid Species Metapenaeid Species
China (Peoples Republic of China)	Shrimp Head/Shell Meal	Penaeid Metapenaeid
Thailand	Shrimp Head/Shell Meal Shrimp Head/Shell Fresh	Penaeid Metapenaeid
Taiwan (Republic of China)	Shrimp Head/Shell Meal	Penaeid
Vietnam	Shrimp Head/Shell Meal	Penaeid Metapenaeid
India	Shrimp Head/Shell Meal	Penaeid Meta Penaeid
United States of America	Shrimp Head/Shell Meal	Penaeid

2.3 Status of Growth History

For the purpose of this investigation two distinct delineations are used to classify the growth history of penaeid and metapenaeid prawns.

“Wild Stock” is classified as possessing a growth cycle with no human intervention other than

capture. “Cultured Stock” is determined by having either some or all of the growth cycle manipulated or controlled in some manner through human intervention other than the capture cycle.

The delineation of a source stock as simply being “wild” or “cultured” does not provide an indication of presence or absence of potential disease.

Table 2.3.1 depicts the major geographical areas that supply crustacean meals and the growth history of the source material.

Table 2.3.1

Growth Status and Geographical Areas of Supply of Crustacean Raw Ingredient

Geographical Area of Supply	Wild Caught Product used in Manufacture of Crustacean Meal	Cultured Product used in Manufacture of Crustacean Meal
Europe including Denmark	Yes	No
South America “Krill Meal” “Langostine Meal”	Yes	No
Chile Other Species	Yes	No
Ecuador	No	Yes
USA	Yes	Yes
Taiwan	Yes	Yes
Thailand	Yes	Yes
Malaysia	Yes	No
Indonesia	Yes	Yes
Vietnam	Yes	Yes
China	Yes	Yes
India	Yes	Yes

2.4 Health Status of Original Source Stock

With rapid expansion of the cultured prawn industry, good husbandry and environmental management has often been neglected. Consequently, disease problems developed as prawns were

stressed and weakened under adverse environmental conditions. According to Sano et al (1997), these diseases can be divided into viral, rickettsial, chlamydial, bacterial, protozoan and fungal diseases; epicommissal and parasitic noninfectious diseases; and nutritional, environmental, and toxic non-biological diseases. Infectious agents tend to cause peracute or acute epizootics, resulting in a severe socio-economic problem. Infectious diseases affecting wild and farmed prawns can be seen in Tables 2.4.1; 2.4.2 and 2.4.3.

Viral diseases have become an important limiting factor for prawn production. Yellow head virus (YHV), although only recently recognized and described in Thailand in 1992, is thought to have been associated with the collapse of the Taiwanese *Penaeus monodon* farming industry in 1986 - 1987. The industry collapsed from 80 000 to 20 000 tonnes per annum (Lin, 1989). At the time, no definitive explanation for the collapse was produced. However, it is widely accepted that it was the result of environmental deterioration and disease problems (Turnbull et al, 1994). YHV is believed to have cost the Thai industry US \$ 600 million in 1994 (CSIRO, 1998). YHV can cause up to 100 % cumulative mortalities within 3 - 5 days of the onset of clinical signs. Part of the control regime is early detection followed by emergency harvest (Nash et al, 1993).

Gill associated virus (GAV), found in Queensland, is a highly pathogenic virus of *P. monodon* and is closely related to YHV (Spann, et al, 1997).

Since its appearance in 1992-1993 in north-east Asia, white spot syndrome baculovirus (WSSV) has been associated with high mortalities throughout Asia and the Indo-pacific (Durand et al., 1997, Lightner, 1996). This disease can cause cumulative mortalities reaching 100% within 3 - 10 days from the onset of clinical signs. Generally, infected prawns do not survive to become carriers.

Taura syndrome was first recognized as a unique disease in 1992 in Ecuador, although it is likely that it was present before that time (Lightner, 1996). Since 1992, the disease has spread to other prawn growing regions of the Americas. Epizootics can cause cumulative mortalities of 80 -95%, particularly in the nursery phase.

Infectious haemopoietic and hypodermal necrosis virus (IHHNV) is considered highly contagious to many penaeids (Bower, 1996). The disease is particularly severe amongst juveniles in high-density tanks and raceway culture, and can cause cumulative mortalities of 80 -90%. Survivors of an epizootic can act as carriers and the disease can spread horizontally and vertically. Although, IHHNV is widely distributed throughout the Americas and Asia, it is now considered a mild problem in these areas (Flegel et al., 1995; Lightner, 1996), as the effect of this virus has been overshadowed by Taura syndrome virus, yellow head virus and white spot syndrome virus. However, epidemics do still occur.

Epizootics are now rare in *P. stylirostris* as the highly susceptible wild stocks have been selected out of the population. A domesticated line of IHHNV-resistant *P. stylirostris* has been bred and marketed as SUPER SHRIMP. These shrimp are being cultured in Mexico and some parts of Latin America (Lightner, pers. comm., 1998). A line of IHHNV-resistant *P. stylirostris* has also been

developed in Tahiti (LeGroumellec et al., 1996). It should be stressed that these shrimp are IHHNV-resistant, not IHHNV-free and are asymptomatic carriers of IHHNV. Other lines of High Health *P. stylirostris* are being cultured in New Caledonia (Mermoud et al., 1996) Tahiti and Hawaii. These shrimp are certified as IHHNV-free when they are stocked onto farms. However, they may become infected during grow-out. High Health *P. vannamei* are being farmed in the USA, Mexico and Central America (Lightner, pers. comm., 1998).

In Thailand, viruses such as monodon baculovirus (MBV) and hepatopancreatic parvo-like virus (HPV) were reported in 1991 (Supamattaya et al., 1998). MBV is most severe in post-larval stages, where cumulative mortalities can reach over 90% (Lightner, 1996). It has caused heavy mortalities (70% of all stages of *P. monodon* in the Philippines and 90% of postlarval *P. monodon* in Madras, India), and is considered partially responsible for the collapse of the shrimp culture industry in Taiwan in the late 1980s. Usually juvenile and adult *P. monodon* are more resistant to MBV than larval shrimp. Mortalities due to HPV are difficult to document because HPV is seldom observed alone in epizootics with high mortalities. Thus, the significance of HPV in causing epizootics and economic losses is not fully understood. In such cases of multiple agent epizootics, the mortality rates may be high in early juvenile stages with cumulative mortalities of 50 - 100% within 4 weeks of the onset of clinical signs.

Baculoviral midgut-gland necrosis virus (BMNV) has been reported to cause serious peracute epizootics in hatchery reared *Penaeus japonicus* in southern Japan (Lightner, 1996). BMN is characterised by a sudden onset and a high mortality rate and it is most severe in post-larvae up to PL 9-10. The source of infection is documented to be wild-caught female spawners (Bower, 1996). Cumulative mortalities can reach up to 98%.

Baculovirus penaei (BP) can cause serious epizootics in larvae, post-larvae and juveniles in a number of species, with cumulative mortalities in excess of 90 % (Lightner, 1996). However, presence of virus does not always result in disease (Bower, 1996).

Reo-like virus infections have only been described from prawns with multiple pathogen infections, therefore the significance of these viruses is speculative (Lightner, 1996).

Lymphoidal parvo-like virus has only been observed in Australia, however, it is likely that it occurs elsewhere in Indo-pacific or Southeast Asia (Lightner, 1996). It has not been associated with significant mortalities (Owens et al. 1991).

Lymphoidal organ vacuolization virus occurs in the American penaeid *P. vannamei* and doesn't appear to cause serious disease (Lightner, 1996). It is not known if the disease occurs in Asian penaeids.

Rhabdovirus of the penaeid shrimp (RPS) is a poorly understood virus and it is not known if it is a true pathogen of penaeids (Lightner, 1996).

According to the CSIRO (1998), the diseases of greatest concern to Australian prawn aquaculture are White spot syndrome syndrome, infectious hypodermal and haematopoietic necrosis, yellow-head disease and Taura syndrome. As there is no treatment for viral diseases, the best method of prevention is avoidance.

Many bacteria that affect the cultured penaeid industry have a worldwide distribution. Species of *Vibrio* are amongst the most important bacterial agents in the industry. They are typically part of the normal penaeid microflora (Lightner et al 1992). They become opportunistic pathogens when adverse environmental conditions favour their growth at the expense of their host. Between November 1988 and October 1990, in the Central area of Thailand, a bacteriological survey was conducted on moribund shrimp (Nash et al 1992). Of the bacteria isolated, 94.9% were found to be *Vibrio* spp., 4.9% were *Aeromonas* spp. And 2.2% were *Pseudomonas* spp.. In Thailand, vibriosis outbreaks have become more frequent since 1990, and have resulted in mortalities up to 100%. Attempts to treat disease have been made using various antibiotics, often without prescription and little control over treatment regimes (Chanratchakool, 1995). Recently, the efficacy of antibiotic therapy has decreased in many areas, even at high dose rates. This may be associated with excessive usage of sub-therapeutic doses and resultant development of resistant bacteria.

Mycobacteriosis is ubiquitous and is potentially infectious to all penaeids. Mycobacteria are seldom seen as prawn pathogens, and are considered more of a marketing problem due to lesions in the muscle or on the shell (Lightner, 1996).

Fusarium spp. are also ubiquitous and all penaeids are potentially susceptible, however, susceptibility varies between the different penaeid species (Lightner, 1996). *Fusarium solani* is an opportunistic pathogen, only capable of establishing an infection in a prawn compromised by physical damage or by another infectious disease (Brock & Lightner, 1990).

Microsporidian disease has been observed from nearly everywhere that penaeid shrimp are cultured. Although they occasionally cause serious epizootics in penaeid aquaculture, for the most part, significant disease is rare (Lightner, 1996).

Haplosporidiosis has been observed in cultured and/or wild penaeid prawns in Cuba, Nicaragua, Mexico, Indonesia and Philippines. Affects on host have not been documented (Bower, 1996)

Fouling diseases are caused by filamentous bacteria, other bacteria, ciliates and flagellates. These organisms have a ubiquitous distribution and are considered opportunistic pathogens. Severity of infection can vary from subclinical to lethal (Brock & Lightner, 1990).

Gregarines have been observed in cultured and/or wild penaeids in virtually every continent. Unless the animals are very heavily infected, it is difficult to distinguish infected from uninfected prawns (Lightner, 1996).

Although the economic importance of Rickettsial and Chlamydial diseases remains relatively unknown, they are appearing more frequently in the literature (Lightner et al, 1992). Rickettsia and

rickettsia-like organisms have been reported from cultured and wild penaeids in diverse geographic locations, such as Singapore, Mexico, Hawaii, Texas, Malaysia and Indonesia. Infections in *P. monodon* have occurred concurrently with other biotic agents including Gram negative bacterial, MBV, and Reo-like virus (Bower, 1996). Mortalities are often associated with infections in cultured *P. monodon*, but not other species. Chlamydial diseases are referred to in farmed prawns in Singapore, (Chong & Loh, 1984).

Necrotizing Hepatopancreatitis (NHP) was first recognised in Texas in 1992 (Frelieret al., 1992). Similar, if not identical NHP bacteria have been associated with serious epizootic diseases in prawn farms in Peru, Ecuador, Venezuela, Brazil, Panama and Costa Rica (Lightner, 1996). Elevated mortality rates may approach more than 90% within 30 days of the onset of clinical signs if left untreated (Bower, 1996).

Table 2.4.1**Viral Prawn Disease and Geographic Location**

Viral Diseases of Prawns	Location
Baculovirus penaei disease (BP)	wide spread in cultured and wild penaeids in the Americas. central Brazil to Gulf of Mexico; and from Peru.
Monodon baculovirus disease (MBV)	Widely distributed in cultured shrimp in China, Taiwan, Indonesia, Philippines Malaysia, Thailand, Sri Lanka, India, Singapore, Oman, Italy, Kenya, Gambia, Australia Israel, Kuwait,
Baculoviral midgut-gland necrosis (BMN)	South Japan, Korea, East and South East Asia.
White spot syndrome baculovirus complex	Widely spread through out Asia and Indo-Pacific: China, Japan, Korea, Malaysia, India, U.S.A. (Texas) Thailand, Indonesia, Taiwan, Vietnam, Malaysia, India, Southern Texas
Infectious hypodermal and haematopoietic necrosis (IHHNV)	Enzootic in Taiwan, Singapore, Malaysia, Thailand, Indonesia, and Philippines, Ecuador, Peru, Brazil, Mexico & Central America. Thought to be Widely distributed in cultured penaeids in South eastern USA, Caribbean, Brazil, Hawaii, Guam, Tahiti, New Caledonia & Israel.
Hepatopancreatic parvovirus (HPVD) disease	Enzootic in Korea, Yellow Sea area of China, Taiwan, Philippines, Indonesia Malaysia, Singapore, Australia, Kenya, Israel, Kuwait, Mexico. Introduced to South America with imported cultures Asian prawns, now Found along Pacific coast of west Mexico, El Salvador and Brazil

Lymphoidal parvo-like virus disease (LPVD)	Observed only in Australia, likely to occur in SE Asia or Indo-Pacific
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Table 2.4.1 Cont.**Viral Prawn Disease and Geographic Location**

Lymphoidal organ vacuolization virus (LOVD)	Presumed LOVD has been observed everywhere that <i>Penaeus vannamei</i> is cultured in the Americas & Hawaii *
Reo -like virus disease (REO)	REO III – Japan, Hawaii, France, Malaysia, Mississippi, Ecuador REO IV – Yellow Sea region of north east Asia
Taura syndrome virus	Limited to regions of Americas - Ecuador, both coasts of Columbia, Peru, Gulf of Fonseca region of Honduras and El Salvador, Guatemala, NE Brazil Nicaragua, Mexican states of Sonora, Chiapas and
Rhabdovirus of American penaeids	Hawaii and Ecuador
Yellow-head disease	Diagnosed in Thailand but may be distributed wider in SE Asia and Indo-Pacific, as there have been unconfirmed reports of outbreaks in Malaysia, Sri Lanka, Philippines, China, Taiwan, Indonesia, India. A similar virus, Gill associated virus (GAV) was found in Australia

* Lightner, 1996

Table 2.4.2**Classification of the Viral Pathogens of Prawns**

Classification	Pathogen
Baculoviridae	Baculovirus penaei (BP) Monodon baculovirus virus (MBV) Baculoviral midgut-gland necrosis virus (BMN)
Parvoviridae	Infectious hypodermal and haematopoietic necrosis virus (IHHNV) Lymphoidal parvo-like virus (LPV) Spawner mortality virus (SMV)
Togaviridae	Lymphoidal organ vacuolization virus (LOVV)
Picornaviridae	Taura syndrome virus* (TSV)
Reoviridae	Reo-like virus types III & IV (REO)
Rhabdoviridae	Rhabdovirus of American penaeids (RPS)
Coronaviridae	Gill associated virus (GAV) Yellow-head virus (YHV)
Unclassified Bacilli form viruses	White spot syndrome virus (WSSV)

* - tentative classification

Table 2.4.3**Other Diseases of Juvenile to Adult Prawns**

Bacterial Infection	<p>Vibriosis caused by numerous <i>vibrio</i> spp.</p> <p>Bacterial septicaemias caused by <i>Vibrio</i> spp., <i>Aeromonas</i> sp., <i>Pseudomonas</i> sp.</p> <p>Chitinolytic bacterial shell disease, caused by e.g. <i>Vibrio</i>, <i>Aeromonas</i></p> <p>Filamentous bacterial disease caused by e.g. <i>Cytophaga</i>, <i>Flexibacter</i>, <i>Leucothrix</i></p> <p>Mycobacteriosis</p> <p>Necrotizing hepatopancreatitis caused by Proteobacterium</p> <p>Red Disease - associated with G+ve cocci</p> <p>Chlamydial Infection</p> <p>Rickettsial Infection</p>
Fungal disease	<p>Fusarium disease</p> <p><i>Helminthosporium</i></p> <p><i>Aspergillus pulvinus</i></p>
Protozoan disease	<p>Microsporidiosis (Cotton shrimp disease) caused by e.g. <i>Pleistophora</i>, <i>Agmasoma</i>, <i>Ameson</i> spp.</p> <p>Protozoan fouling caused by Ciliates Flagellates</p> <p>Haplosporidiosis</p> <p>Gregarine disease (Apicomplexa)</p>

After Lightner, 1996

Table 2.4.4**Viral Pathogens Present in Countries Which Produce Prawn Meal***

Prawn Meal Producing Country	Documented Viruses
Denmark	no reports of viruses
Indonesia	MBV,BMNV,WSSV,IHHNV,HPV,YHV
Malaysia	MBV,BMNV,WSSV,IHHNV,HPV,RPS,YHV
China	MBV,WSSV,HPV,RPS,YHV
Taiwan	MBV,WSSV,IHHNV,HPV,YHV
Thailand	MBV,WS,IHHN,YHV,HPV
USA	BP,WSSV,IHHNV,TSV (Texas, Hawaii, Florida), MBV(Hawaii)
Vietnam	WSSV
Ecuador	BP, MBV,IHHNV,RPS,TSV,REO
India	MBV,WSSV,YHV

Note: Information collated from published sources, all others have been considered supposition and have not been included.

MBV = Monodon baculovirus

BMNV = Baculoviral midgut gland necrosis

WSSV = White spot syndrome baculovirus complex

IHHNV = Infectious hypodermal and haematopoietic necrosis virus

HPV = Hepatopancreatic parvovirus

REO = Reo- like virus disease

YHV = Yellow head virus

BP = Baculovirus Penaei Disease

TSV = Taura syndrome virus

RPS = Rhabdovirus of American penaeids

3.0 Methods of Manufacture of Prawn Feeds

3.1 Common Methods of Manufacture of Prawn Feeds.

The manufacture of aquaculture feeds is the process of combining ingredients to form a mixture designed to provide a variety of nutrients and non-nutrient compounds in a practical form to farmed aquatic animals. Non nutrient components include fillers such as limestone and pellet binders that offer no nutritional contribution to the integrated components.

The levels of nutrients and non-nutrient compounds present in the mixture can be predicted from the levels of these compounds in the starting ingredients. The overall balance of the nutrients and the non-nutrient compounds in the feed mixture is determined by the nutritional requirements of the species being fed and by the specific goal for which the mixture was designed.

Feeds can be designed to meet a number of goals, including rapid growth for market, cost effective growth parameters, successful reproduction or low pollution.

Feeds can also be formulated and produced to meet the goals of research needs, such as investigation of vitamin or protein requirements.

The methods used for the production of prawn feeds do not vary greatly between the major prawn feed producing countries. Commercial prawn feeds are almost identical in form irrespective of the country of origin. As would be expected for the production of similar products the use of similar techniques and equipment has been standardised.

3.1.1 Steam Pellet Pressing

Steam pelleting through the process of compression produces dense pellets that sink in the water. This process involves the use of moisture, heat and pressure to bind together the small ground particles into pellets. Steam is added to the ground mixture to partially cook the starches found in the ingredients. This steam addition also adds an amount of water that assists in the cooking process.

During the process of steam pelleting temperatures in the feed ingredients may rise to 90°C which necessitates a cooling process.

Major ingredients are usually bulk stored in a silo system and minor ingredients including vitamins, probiotics, antibiotics are added immediately prior to mixing.

From this point the ingredients are transferred to the grinding system for size reduction. After this stage the ground meal is transferred into the conditioning system. This is the point for the addition of

water and steam. The conditioning system is a sealed system where the ground ingredients are agitated with radial mixers under the influence of moisture and temperature supplied by steam at varying pressure and moisture relationships. This is dependent on the specific equipment used in the downstream stage of the process i.e.: pellet press type. Temperatures often reach 90°C and are held in this system for a time period that varies from manufacturer to manufacturer. However normally retention time in this system is between 5 to 60 seconds.

From stage the hot conditioned meal is introduced into the pellet mills where the hot moist mash is compressed through the pellet dies. These pellet dies shape the mash into pellets, which are cut off to length at the face of the pellet die.

These hot pellets are then transferred to a cooling system where ambient air is blown over the pellets to cool and reduce the moisture level. From this point the cool pellets are transferred to the bulk storage silos as a finished product for packing into bags for storage and final dispatch. Storage of finished feed is either in multi-walled paper bags (imported feed) or woven polypropylene bags usually of 20 kilogram nett weight. Transport is usually either in palletised form or containerised form using rail or road transport.

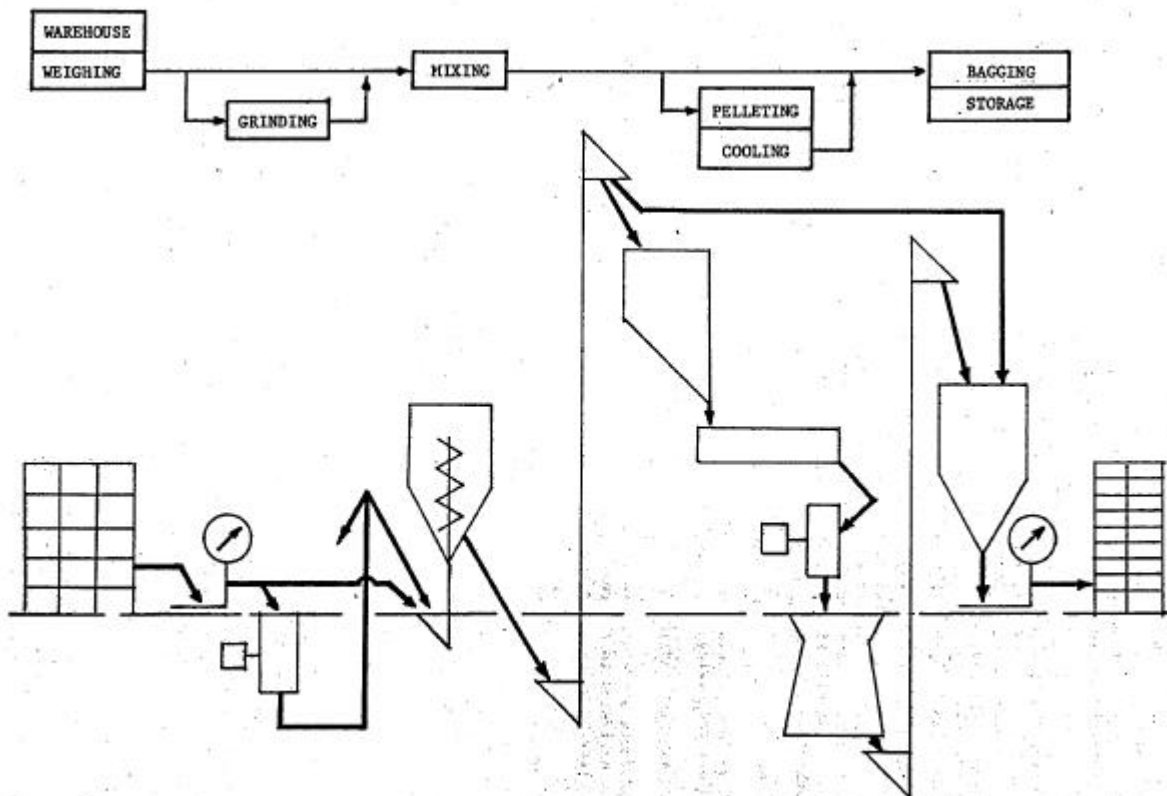
Fig 3.1.1

Schematic of Prawn Feed Milling Plant

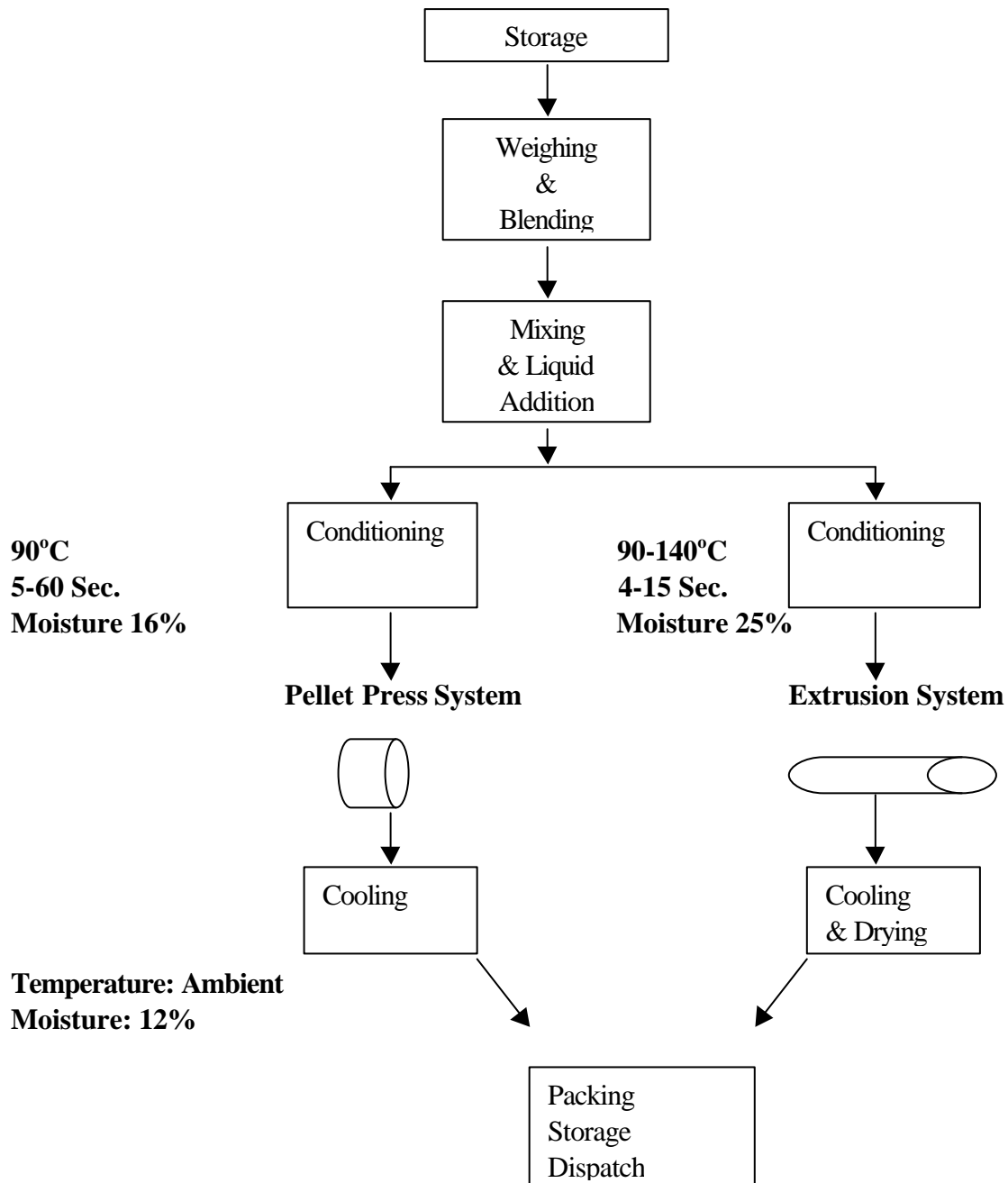
3.1.2 Steam Extrusion Methods

The process of manufacturing prawn feeds by the extrusion method is similar to the process of steam pelleting involving mixing, grinding and conditioning of ingredients. However once the conditioned mash of ingredients is about to be pelleted it enters the extrusion barrel where it is subjected to extremely high pressures and temperature for a short period of time. Temperatures are in excess of 100°C sometimes up to 140°C, however retention times in the extruder barrel are only of the order of 4 to 15 seconds.

All other components of the process are similar to the steam pelleting methods already described. With the exception that moisture is reduced in a drying system to a level of 8-12% on an “as fed basis”. Commercially, moisture levels do not fall outside of this range for either extruded or pelleted



feeds.

Figure 3.1.2**Flow Chart of Production Techniques used in the Manufacture of Prawn Feeds**

3.2 Novel Methods of Manufacture of Prawn Feeds Containing Crustacean Derived Material.

3.2.1 Cold Pressing

This method of manufacture of prawn feeds is not universally considered to be a commercial process. It is however used in the production of certain fish feeds, which at this point in time are not imported into Australia. It is however commonly used as a process for the production of research based and semi-purified diets. Quantities of feed, usually less than 5 kilograms at one time are produced.

The process involves the mixing of ingredients with a liquid, usually water until a stiff dough like consistency is achieved. The mix is then formed into pellets by extruding through a die plate. This is achieved under normal room temperatures and the feed mix does not rise above this temperature, NRC, (1983)

3.2.2 Agrommalation

This process of manufacturing method is that finely ground ingredients are mixed with a water-activated binder. This mix is then introduced onto an angled spinning disk and the moist mash is agrommalated into small spheres. No heating is involved in this process. The pellets can be either in the “dry” form with moisture of approximately 10% or a “semi-moist” pellet with moisture content of 25%.

3.2.3 Flaking

Flaking is the process where the feed ingredients are mixed with water to form a slurry mixture. The most common form of production is the introduction as a thin film onto a slowly revolving heated drum. Due to the thickness of the slurry the mixture quickly dries and is scrapped off the drum before the next full rotation and addition of more slurry. The drums are usually heated by steam and have a temperature equal or in excess of 100°C. Other methods include the use of freeze-drying or oven drying. It is recognized that the drying temperatures affect the nutritional value of the product, Gabaudan et al., (1980); Teshima and Kanazawa, (1983). Appropriate binders have included agar, gelatin, carrageenin and alginates, Teshima et al., (1982); Levine et al., (1983).

3.2.4 Micro encapsulation

Micro encapsulation is the process whereby small packets of feed ingredients are encapsulated in a encasing matrix. The membranes are non-toxic, impermeable and are digestible once entering the gut of the target species. The reason for this is to slow the leaching of nutrients into the water column. Heating of ingredients is not an obligatory step in the manufacture of these feed types and ingredients may have not undergone any heat treatment at all before Micro encapsulation. After Micro encapsulation no heat treatment is carried out.

Membrane material has included nylon-protein, Change et al., (1966); gelatin acacia, Jones and

Gabbot, (1976); lipid, Langdon and Waldock, (1981); chitosan, Langdon and Seigfried, (1984); glycopeptide Gabbot et al., (1975); and whole egg, Chow, (1980).

3.3 Effect of Processing Methods on Survival of Potential Pathogens

The processing methods used by the prawn meal producing countries can be seen in Table 3.3.2. The viral diseases present in these countries are represented in Table 3.3.3. The method used will influence the survival of potential pathogens in the prawn meal. Heat inactivates viruses by denaturing the capsid protein or nucleic acids (Gardner & Peel, 1991). This inactivation is strongly influenced by moisture. Bacterial spores are killed rapidly at 121°C in saturated steam but the temperature must be raised to 160 °C for a comparable death rate in dry conditions. In general terms, Gardner & Peel (1991) stated that most viruses and fungi are killed at temperatures in the range 65 - 100°C. Little information is available concerning the effect of heat and desiccation on prawn virus particles protected by organic matter as most studies have been conducted using virus purified from cell culture.

IHHNV is considered to be a tentative member of the *Parvoviridae* and the genus *Parvovirus* (Bonami et al., 1990). Other members of this genus are bovine parvovirus, porcine parvovirus and canine parvovirus (Berns et al., 1995).

Parvoviruses are considered to be highly resistant to heat (Siegl, 1976). Studies of canine parvovirus have shown that this virus remains infectious in solution after 7 h at 80°C and 72 h at 56°C. Boiling (100°C), however, inactivates the virus within a few minutes (McGavin, 1987). Bovine parvovirus remains infectious in moist conditions when treated for 24 h and 3 to 4 days with 55°C and 35°C respectively coupled with the action of anaerobic digestion (Monteith et al., 1986). Porcine parvovirus requires at least 5 days to be inactivated at 55°C when moist (Lund et al., 1996). The survival of IHHNV after exposure to heat is not known. However, considering the data for other parvoviruses, it can be proposed that IHHNV would survive sun drying and furnace drying of crustacean meals as desiccation is not complete and drying may occur at a temperature as low as 50°C for only 2 hours. Processing methods, which reach 100°C or more, such as steam and drum drying, would be adequate to inactivate IHHNV if sustained for a few hours.

WSSV, is inactivated by heating at 50°C for 20 minutes when suspended in seawater (Maeda et al. In press) and for 60 minutes as a tissue homogenate (Nakano et al., 1998). Furnace drying may inactivate WSSV if at least 50 °C is reached throughout the meal and is maintained for at least 90 minutes. Maeda, et al., 1998, states that WSSV is inactivated by total desiccation for 1 hour at 30 °C. These results were obtained using a filtered homogenate of prawn tissue rather than purified virus and indicate that at this low temperature the complete drying (to 0.0 % moisture, which is not commercially practiced) of the crustacean meal for at least 1 hour is required to inactivate WSSV.

Momoyama (1989) demonstrated that BMN virus was inactivated by the following - sun light exposure within 3 hours at 30 °C; heating at 45 °C for 120 minutes, heating at 50 and 55 °C for 30 minutes, heating at 60 °C for 5 minutes; drying virus onto filter paper for 90 minutes at about 30 °C.

Crustacean meals that are sun dried for as little as 6 hours are unlikely to be completely dried in this time or reach adequately high temperatures. The risk of baculoviruses surviving in meals processed in this manner is high. It is highly unlikely that baculoviruses would survive heating beyond 100°C for a few hours.

Vibrio species isolated from diseased black tiger shrimp (*P.monodon*) could be cultured at 40°C (Ruangpan, L.& Kitao, T., 1991). This would indicate that the methods of furnace drying and sun drying would have limited effect on pathogenic contaminants. Although *Vibrio* species have a ubiquitous distribution, the risk of importing antibiotic resistant strains will always need to be considered.

Table 3.3.1

Viruses Present in Countries Which Produce Prawn Meal

Prawn Meal Producing Country	Documented Viral Outbreaks
Denmark	no reports
Indonesia	MBV,BMNV,WSSV,IHHNV,HPV,
Malaysia	MBV,BMN,WSSV,IHHN,HPV,RPS,YHV
Chile	no reports
China	MBV,WSSV,HPV,RPS,YHV
Taiwan	MBV,WSSV,IHHNV,HPV,YHV
Thailand	MBV,WS,IHHN,YHD
USA	BP,WSSV,IHHNV,TSV (Texas, Hawaii, Florida), MBV(Hawaii)
Vietnam	WSSV
Ecuador	BP, MBV,IHHNV,RPS,TSV,REO
India	MBV,WSSV

MBV = Monodon baculovirus

BMNV = Baculoviral midgut gland necrosis

WSSV = White spot syndrome baculovirus complex

IHHNV = Infectious hypodermal and haematopoietic necrosis virus

HPV = Hepatopancreatic parvovirus

REO = Reo- like virus disease

YHV = Yellow head virus

BP = Baculovirus Penaei Disease

TSV = Taura syndrome virus

RPS = Rhabdovirus of American penaeids

Table 3.3.2**Details of the Processing Methods for the Production of Crustacean Meals**

Processing Method	Processing Temperature (°C)	Processing Duration (hr)	Product Moisture (%)
Steam Dried	90 – 140	2 - 10	12 maximum
Drum Dried	90 – 140	2 - 10	12 maximum
Furnace Dried	40 – 70	2 - 10	12 maximum
Sun Dried	Up to 50	6 - 48	14 - 20

Table 3.3.3

Suggested Probability (based on published or known literature concerning reported outbreaks of IHNV and WSSV, incidence in wild and cultured penaeids and the effectiveness of various processing methods to inactivate IHNV and WSSV)

- = no probability + = low probability ++ = moderate probability +++ = high probability

country source	meal type	processing method	level of risk		
			IHNV	WSSV	
Denmark	wild caught	shrimp meal	steam	-	-
South America	wild caught	krill	steam	-	-
Chile	wild	head/shell	sun	-	-
		head/shell	drum	-	-
Ecuador	cultured	head/shell	sun	+++	-
USA	wild	head/shell	sun	+	+
		head/shell	drum	-	-
Taiwan	wild caught	head	drum	+	+
Thailand	cultured	head/shell	furnace	+++	++
	wild	head/shell	furnace	+	++
	cultured	head/shell	sun	+++	+++
	cultured	head/shell	fresh (no drying)	+++	+++
Malaysia	wild	whole shrimp	sun	+++	+++
	wild	head/shell	furnace	+++	++
Indonesia	cultured	head/shell	sun	+++	+++
		head/shell	furnace	+++	++
	wild	whole	sun	+++	+++
Vietnam	wild	head/shell	sun/furnace	+	+++/++
		head/shell	drum	+	+
	cultured	head/shell	sun/furnace	+	+++/++
		head/shell	drum	+	+

Table 3.3.3 Cont.

Suggested Probability (based on published or known literature concerning reported outbreaks of IHHNV and WSSV, incidence in wild and cultured penaeids and the effectiveness of various processing methods to inactivate IHHNV and WSSV)

- = no probability + = low probability ++ = moderate probability +++ = high probability

country source	meal type	processing method	level of risk		
			IHHNV	WSSV	
China	wild	head/shell	sun	+	+++
	cultured	head/shell	drum	+	+
India	cultured	head/shell	sun	+	+++
		head/shell	drum	+	+

* On the basis of distribution of IHHNV and WSSV and the use of wild stocks for production of meals some countries are classified as no risk. Other classifications are rated on the suitability of processing techniques combined with source stock of original material.

up to 90% mortality within a few weeks of onset of infection (Bell and Lightner, 1984). In other species, such as *P. vannamei*, IHHNV is a chronic disease which causes runt deformity syndrome in juveniles (Kalagayan et al., 1991). Shrimp which have survived infection apparently carry the virus for life (Lightner, 1996).

IHHNV histopathology

IHHNV is an unenveloped, icosahedral virus which replicates in cells of ectodermal and mesodermal origin (Lightner et al., 1983). This includes: epidermis, fore and hind gut, antennal gland, neurons, haematopoietic tissue, haemocytes, striated muscle, heart, lymphoid organ and connective tissues. IHHNV may cause a white to buff mottling of the shell (Bell and Lightner, 1984). Although IHHNV does not directly invade the calcareous shell, fragments of epidermis may remain on the shell and be incorporated into shell meal.

Inactivation

IHHNV is considered to be a tentative member of the *Parvoviridae* and the genus *Parvovirus* (Bonami et al., 1990). Other members of this genus are bovine parvovirus, porcine parvovirus and canine parvovirus (Berns et al., 1995).

Heat inactivates viruses by denaturing the capsid protein. Viral inactivation by heat is decreased by the presence of salts, protein and sulphides, which stabilize the viral protein structure. Little information is available concerning the effect of heat and desiccation on parvovirus particles protected by organic matter as most studies have been conducted using virus purified from cell culture.

Parvoviruses are considered to be highly resistant to heat (Siegl, 1976). Studies of canine parvovirus have shown that this virus remains infectious after 7 h at 80°C and 72 h at 56°C. Boiling (100°C), however, inactivates the virus within a few minutes (McGavin, 1987). Bovine parvovirus remains infectious for 24 h and 3 to 4 days when treated with 55°C and 35°C respectively coupled with the action of anaerobic digestion (Monteith et al., 1986).

Porcine parvovirus requires at least 5 days to be inactivated at 55°C (Lund et al., 1996). The survival of IHHNV after exposure to heat is not known. However, considering the data for other parvoviruses, it can be proposed that IHHNV would survive sun drying and furnace drying of feed pellets. Processing methods which reach 100°C or more, such as steam and drum drying, would be adequate to inactivate IHHNV.

White Spot Syndrome Virus (or White Spot Baculovirus Complex)

Host range

Natural infections have been reported in the following cultured penaeid species:

<i>P. monodon</i>	<i>P. japonicus</i>
<i>P. chinensis</i>	<i>P. indicus</i>
<i>P. merguensis</i>	<i>P. setiferus</i>
<i>P. semisulcatus</i> (also wild from Taiwan)	<i>P. penicillatus</i>

(Lightner, 1996)

Given the propensity of WSSV to survive in numerous wild crustacean species, the possibility that the virus occurs in wild populations of the above species, located near shrimp culture areas, cannot be ignored.

Other penaeids, which have been infected experimentally, include:

<i>P. vannemei</i>	<i>P. stylirostris</i>
<i>P. aztecus</i>	<i>P. dourarum</i>
<i>P. setiferus</i>	

(Lightner, 1996)

Recent experiments and surveys have shown that approximately forty species of penaeids, crabs, lobsters and *Macrobrachium* spp. can act as carriers of WSSV. Copepods and insects have also been identified as possible carriers (Chou et al., 1996; Lo et al., 1996b; Flegel et al., 1997; Maeda et al., 1997, Supamattaya et al., 1998). Specific crustaceans, which have been reported as susceptible to WSSV, include:

From Taiwan:

<i>Parapenaepsis</i> spp.	<i>Metapenaeus ensis</i>
<i>Macrobrachium</i> spp.	<i>Trachypenaeus curvirostris</i>

From Thailand:

<i>Macrobrachium rosenbergii</i>	<i>Portunus pelagicus</i> (crab)
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<i>Acetes</i> sp. (wild krill)	<i>Scylla Serrata</i> (crab)
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Resistance to WSSV has not been reported for any penaeid species. WSSV continues to cause significant stock losses throughout Asia.

Life stages infected

WSSV causes disease in juvenile and adult prawns. Cumulative mortalities in infected populations

may reach 100% within a few days of the onset of disease (Chou et al., 1995). Generally, infected prawns do not survive to become carriers.

Histopathology

Prawns infected with WSSV may have a loose cuticle and display white spots caused by abnormal deposits of calcium, the accumulation of vacuoles and lysed debris and the necrosis of cuticular pore canals (Wang et al., 1995). Not all infected prawns display these white spots on the carapace (Lightner, 1996). Moribund prawns may also display pink to red colouration of the body and appendages (Takahashi et al., 1994; Wang et al., 1995). WSSV infects cells of mesodermal and ectodermal origin, including the subcuticular epithelium, haemocytes, haematopoietic tissue, lymphoid organ, stomach cuticular epidermis and connective tissue. Crustacean meals contain shell, cuticular epithelium and subcuticular connective tissues, muscle and a variety of other soft tissues. These tissues are likely to harbour WSSV in living, infected prawns.

Inactivation

WSSV, suspended in seawater, is inactivated by heating at 50°C or more for 20 min (Maeda et al., in press). WSSV would survive at 50°C for much longer than 20 min in shrimp feed pellets, due to the protection of proteins, salts and other compounds. No information concerning the inactivation of WSSV when protected by organic matter is available.

WSSV has been tentatively classified as a bacilliform virus (Takahashi et al., 1994). Bacilliform viruses formerly belonged to the *Nudibaculovirinae* (non-occluded baculoviruses) subfamily of the *Baculoviridae*, however this subfamily was dissolved (Volkman et al., 1995). Little information concerning the effect of heat, desiccation and sunlight on non-occluded baculoviruses is available. *Baculovirus heliothis* (HzSNPV) is a singly embedded, or occluded, nuclear polyhedrosis virus, with each individual virion protected by a polyhedrin body. In the presence of water, this virus is not completely inactivated by simulated sunlight after exposure for 24 h at temperatures ranging from 10 to 50°C (Ignoffo and Garcia, 1992). Non-occluded virions of the same virus, derived from tissue culture or alkali-released from inclusion bodies, were exposed to simulated sunlight-UV for 32 and 64 h at 20°C (Ignoffo et al., 1989). Although infectivity of the virus following this treatment was low, viable virus was still present. WSSV particles are not protected by polyhedrin, but would be protected by the organic matter present in feed pellets. These data for a related virus, indicate that it is highly likely WSSV, present in feed pellets, would survive exposure to sunlight at 50°C for 24 h.

Shrimp meal may be sun dried for as little as 6 h. The risk of WSSV surviving in meals processed in this manner is high. The efficacy of furnace drying to inactivate WSSV is unclear. It is highly unlikely WSSV would survive heating to 100°C.

3.4 Quality Assurance Systems used in the Manufacture of Prawn Feeds.

Production of prawn feed must be divided into several discrete steps to apply HACCP principles to identify the hazards or risks associated with the process. These steps are (1) feed ingredient quality; (2) feed formulation; (3) feed manufacture; (4) feed shipment and storage.

It is generally accepted that a HACCP program can be defined as a systematic approach to minimize the risk of production of defective products. The steps usually involved in a generalised HACCP program include; hazard analysis; identification of critical control points; establishment of critical control point criteria; monitoring of critical control points; establishment of protocols for critical control point deviation and verification.

The individual steps associated with a generalised description of a HACCP program and more specific application to prawn feed production are steps that are often already performed by many feedmillers. The four major steps that have the potential of being incorporated into a functional HACCP system include:

(1) Feed Ingredient Quality

In the production of prawn feeds a limited number of ingredients are used in the feed formulations. Quality control of these individual ingredients is confined to which ingredients are most likely to vary in quality, commonly measured as the nutritional profile of the ingredient. The next step is the evaluation of this variability in the individual ingredient and its consequence on the manufacturing process.

(2) Feed Formulation

The successful formulation of all compounded feeds, including prawn feeds, requires the proximate and nutritional profile of each ingredient. In addition, the cost of each ingredient, maximum and minimum incorporation levels determined by manufacturing constraints, palatability and potential anti-nutritional effects of individual ingredients is required. Furthermore, the desired proximate and nutritional profile of the finished feed is also essential.

The complete nutrient requirements of most species of commercially grown prawns is not fully understood and formulation of feeds is often estimated from what imperical knowledge of particular species is known and also extrapolated from other species, often not closely related.

Quality issues within this area of feed milling concentrate on attempting to ensure that proximate and nutritional composition profiles of ingredients are accurate and the correct minimum and maximum levels are used in the feeds. The use of incorrect essential nutrient requirements of targeted species is also an area often reviewed as a quality issue.

(3) Feed Manufacture

The emphasis of quality control in the manufacture of compounded animal feeds is the prevention of incorrect feed mixes being produced and the production of inferior pellets or products not reaching particular physical characteristics sought by the market.

Incorrect pellet identification is a minor problem, but still possible, particularly with medicated feeds.

(4) Feed shipment and storage

Quality control in this area of feed manufacture is predominantly the anticipation of potential risks. This is a result of the feed being outside the direct control of the feed miller. Usually the areas of concern are overcoming the issues of rough handling during transport and storage of the feeds so that physical characteristics required by their markets are retained as much as possible.

However, it should be strongly stressed that even though the components of a functional HACCP system often exist in plants that produce compounded animal feeds. The individual components are rarely integrated into an overall systematic approach that would result in a recognisable HACCP program, (Hardy, 1991).

The use of quality assurance systems in prawn feed manufacture is orientated towards physical product quality. This is evident in the assessment of ingredients that are used to produce these compounded feeds. Even at this preliminary stage of risk management, the assessment of disease potential is not incorporated into quality assurance systems. Hardy (1991), describes the common ingredients and tests used for quality control in the production of aquaculture feeds, Table 3.4.1. This approach to quality control is widespread in the production of aquaculture feeds and focuses on the chemical composition of feeds and the effect of these attributes on manufacturing efficiency. Customer perception of physical attributes, such as stability of the pellets in water, is the major quality issue in commercial production of prawn feeds. The determination of quality in regard to disease vectors is not common in the commercial production of prawn feeds.

As stated, a systematic approach to HACCP principles is not common practice in the manufacture of prawn feeds and is not used in the production of most crustacean meals. The exception to this are Danish and some South American firms that incorporate the same quality assurance and HACCP systems that are used in the production of their fish meals. The areas of particular interest for these firms are the quality of the raw ingredient in terms of the storage temperature of freshly caught fish and the production times of meals. These important characteristics directly effect the value of the meal due to degradation of nutritional aspects of the final meal product. Fish that is stored at low temperatures (commonly 0-4° C) and is processed within specific commercial parameters of controlled time and temperature, produce fish meals that command significantly higher prices than meals that have not been produced following these practices.

Typical methodology used for the production of high quality marine meals generally classed as “*Aquaculture Grade*” is rigorously controlled through each step of production. The procedures involved in production include the heating of raw fish to 95°C for 30 minutes. The meal is then pressed at 85°C for 30 minutes to remove oil and water soluble fraction leaving a press cake. The

oil and water-soluble fraction is then heated to 90°C to reduce the water fraction, where it is either reincorporated with the original press cake or diverted for further processing into separate oil and water soluble fractions. The most common method however is for the oil and soluble fractions to be reincorporated with the press cake. The recombined meal is then dried in an air dryer for approximately 30 minutes at a temperature of 85°C. Figure 3.4.1 describes a flow chart representation of this process.

In light of these findings it is suggested that the areas that are of particular interest in the production of prawn feeds and the potential of these products as disease vectors are the selection of raw materials and the transport and storage of these products.

The supply of ingredients for the production of prawn feeds with little potential for transfer of disease is a critically important first step in the lowering of the potential for disease transfer. In addition the geographical origin of the raw material is not as important as the processing techniques used in the manufacture of these ingredients.

Secondly the storage of finished products within the milling environment other than in separate, dedicated storage facilities is also an area that has the potential of increasing the risk of disease transfer. Physical transfer of infected material can contaminate feed that has been adequately prepared in relation to ingredient supply and milling techniques. Aerosol particles of unprocessed crustacean meal, have the potential of becoming a significant disease vector by contaminating finished processed feed that is stored in close proximity to the milling environment.

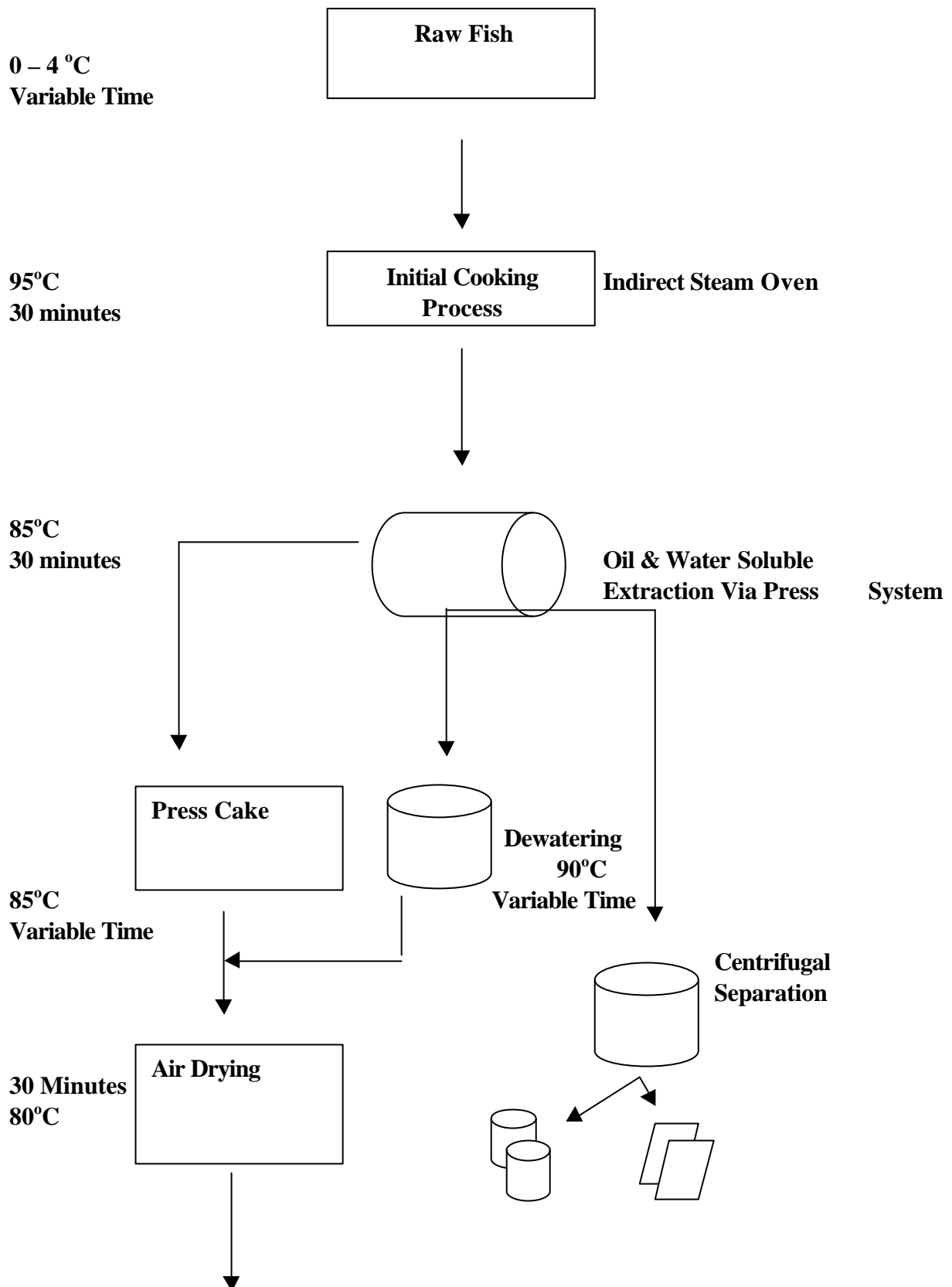
Table 3.4.1

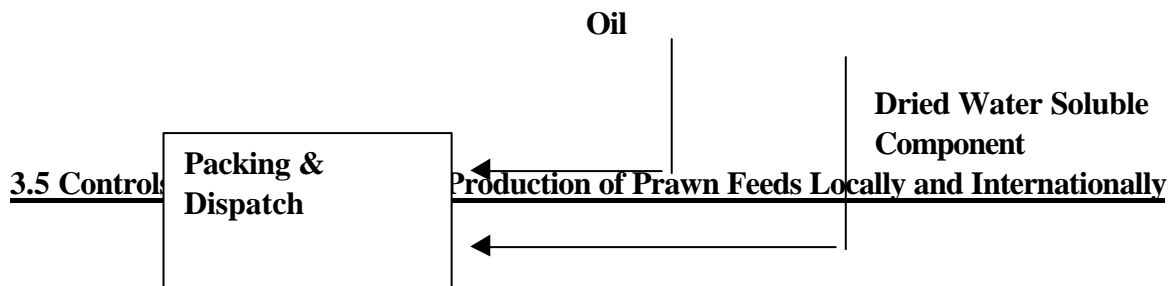
Common Ingredients used in Aquaculture Feeds and Factors Affecting Quality.

Ingredient	Quality Factor
Fish Meal	Proximate Composition Freshness of Raw Material Manufacturing Conditions
Fish Oil	Oxidative Rancidity
Blood Meal	Digestibility
Poultry By-Product Meal	Ash Level
Feather Meal	Digestibility
Meat & Bone Meal	Ash Level
Crustacean Meal	Manufacturing Conditions
Squid Meal	Manufacturing Conditions
Soybean Meal	Trypsin Inhibitor Level
Cereal Meal & By-Products	Mould

(After Hardy, 1991)

Figure 3.4.1
Flow Chart of Fish Meal Processing Techniques.





Currently import requirements centre around the fulfillment of criteria required under “Australia’s Import Conditions for Feeds for Aquatic Animals”.

Contiguous with this, particularly in relation to domestic production a number of locally based pollution controls dealing with solid waste, air and liquid waste streams are the only other requirements for the production of prawn feeds.

Also of note for domestic production if required is regulations relating to the control of S4 registered substances. This is relevant for the production of medicated feeds containing particularly antibiotics and other medicants. Control of these substances is administered on a state by state basis through state health departments.

4.0 Other Identified Feeds Containing Prawn Derived Ingredients

4.1 Feeds Identified and Current Use

Currently there exist two other major uses of crustacean meal in Australia other than the production of prawn feed. The feeding of Southern Blue Fin Tuna in Port Lincoln, South Australia currently relies on the supply of frozen baitfish. Efforts are currently underway from a number of interested parties to develop a formulated feed to replace these local and imported frozen baitfish. A commercial feed company is currently producing a moist pellet that utilises a crustacean meal as a component.

The crustacean meal was identified through the industry survey as “Krill Meal” sourced through Chile. As the level of incorporation is proprietary knowledge the amounts of crustacean meal used in this market sector is unknown. However the particular crustacean meal that is being utilised is sourced from suppliers in South America using steam processing techniques that render the meal in a low risk category regarding the potential as a disease vector.

Another area of crustacean meal use is small amounts that are being utilised in the production of pet feeds. “Shrimp Head/Shell Meal” and probably “Shrimp Shell Meal” are used as a small component in some pet feeds. Source of origin for this product is various. Quantities used are also currently unknown.

Other products that contain crustacean meals include aquarium fish feeds in flake and extruded pellet form as well as larval fish feeds in flake and micro-encapsulated form. See sections 3.2.3 and 3.2.4 for full description of processing descriptions. Quantities used in these feeds vary greatly and the actual amounts are “commercial in confidence” and are not required to be identified for distribution within Australia.

5.0 Survey of Aquaculture Feed Production Facilities.

A survey of major Australian aquaculture feed manufacturers was conducted as an integral part of this investigation to obtain an understanding of the use of crustacean meal as an ingredient in Australian aquaculture feed milling. This is seen as an adjunct to the investigation of imported feeds having crustacean meals as an incorporated component. All major suppliers of aquaculture feeds were contacted irrespective of their specific involvement in the supply of feeds to the prawn farming industry. In addition, all feed millers surveyed were invited to comment on the investigation as well as assisting that investigation by the supply of information pertaining to the use of crustacean meals.

As the information supplied is usually considered commercial-in-confidence, the willingness of the respondents to assist in the process is highly commendable and their actions are acknowledged.

All aquaculture feed supplier groups were able to respond with the exception of one group, which declined.

Of all those surveyed only one group indicated that crustacean meal was used in their feeds and the end use was for fish, specifically Southern Blue-Fin Tuna. The material used in this feed was Krill Meal sourced through Chile. Quantities of meal were not available as this is considered proprietary intellectual property.

The only domestic supplier of prawn feeds declined to become involved in the survey or comment phases of the project.

Attached in appendix 1 is a pro-forma of the survey forms sent to the feed milling groups.

Table 5.1 summarises the detail obtained from the respondents, appendix 2 contains responses obtained from those major aquaculture feed producers that responded.

Table 5.1**Major Domestic Aquaculture Feed Producers Surveyed**

Feed Producer	Contact	Crustacean Meal Used	Target Species Intended	Country of Origin of Crustacean Meal
Gibson's Ltd	Dr. C. Foster	Yes (Krill)	Southern Blue Fin Tuna	South America
Ridley Agriproducts (Narangba, Qld)	Mr. K. Smyth	Failed to Respond	ND	ND
Ridley Agriproducts (Corowa, NSW)	Mr. D. Grey	Failed to Respond	ND	ND
Kinta Feeds P/L	Mr. B. Wiadrowski	No	-----	-----
Feed Producer	Contact	Crustacean Meal Used	Target Species Intended	Country of Origin of Crustacean Meal
Lauke Feeds P/L	Mr. P. Hawkins.	No	----	----

ND= No Data available

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Appendix 1

Proforma of Survey Forms Sent to Major Aquaculture Feed Producers.

Company: xxxxxxxxxxxxxxxxxxxxxxxx

(1) Do you use prawn / shrimp meal in the production of feed for penaeid
prawns_____

(2) Are these feeds

(I) Steam Pelleted Y/N

(ii) Extruded Y/N

(iii) Other Y/N Please describe_____

(3) Do you use other shrimp based products (ie: liquid solubles or
pastes)_____

(4) Do you use prawn / shrimp meal in the production of feeds for any other
animals?_____

(a)Please specify the species that the feed is produced for

(b) Are these feeds

(I) Steam Pelleted Y/N

(ii) Extruded Y/N

(iii) Other Y/N Please describe_____

(5) Are the feeds you have described considered to be experimental or commercial?

(6) What are the countries of origin of the prawn / shrimp ingredients ?

Thank you for your time, this completed form can be returned to the address indicated below or by faxing to **07 3202 6942**

AquaTactics Pty Ltd
12 Sweetgum St.
Bellbowrie
Qld. 4070
Australia

Dear xxxxxxxx,

The Australian Quarantine & Inspection Service (AQIS) is currently conducting a series of evaluations of disease threats to the Australian prawn farming industry. Aquatactics has been appointed by AQIS to carry out an evaluation of processing and ingredients used in the manufacture of prawn feeds.

As a component of that evaluation, we are compiling information on the use of prawn derived ingredients used in the manufacture of feeds in Australia. As you would be aware, the outcomes of this evaluation could have significant effects on the use of these products within this country as well as the importation of feeds that contain them. It is because of this that your valuable contribution to this process is sought.

Attached you will find a survey form addressing the issues of use of prawn meal and prawn derived ingredients, could you please complete this form and return it either by post or by faxing to the nominated number.

We would also be pleased to receive any comments or remarks from your firm concerning this matter that may be used in the evaluation of this issue.

I thank you in anticipation

Yours Sincerely

Peter Krogh
Principal Consultant

Appendix 2

Responses to Survey Forms Returned from Major Aquaculture Feed Producers.