Value Adding for Squid Processing in the Geelong Region

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Existing squid industry
Australia produces some 1500-3000 tonnes of squid per year, with the main production coming from Bass Strait. This resource is underutilised, and is capable of sustaining considerably higher catches. Despite this, Australia is a net importer of squid (7968 tonnes). Imports come in a variety of forms, from whole squid for onprocessing, to squid tubes competing directly with local tubes, and a range of value added squid products.

Economics of squid processing
Economic analysis showed that local processing is efficient, and at 25% of total costs was not a major source of cost. Cost is dominated by the purchase cost of squid itself (75% of total costs). Consequently the local industry can make significant improvements in its competitive position by either

- value adding its existing output, or
- reducing the price paid to squid fishing sector, however, any reduction in price paid to fishermen without an effective structural change would see a reduction in fishing effort.

Major processors exist at Geelong and Portland, producing squid tubes and crumbed products. Little other value adding occurs. Processing is characterised by a low yield of tubes (circa 30%). Offcuts (30-40%) comprised of wings and tentacles, are not suited to existing mechanical processing methods, are currently sold for a low price and little profit.

Value adding squid offcuts by enzymic skin removal
A literature review of enzyme technology in fish processing indicated mixed results for enzymic removal of squid skin. Most of the work was conducted in the northern hemisphere, (Norway) with *Loligo* species, although New Zealand also had researched the subject using *Notodarus gouldii*, which is fished in Bass Strait.

A range of variable exist which affect the treatment process. Two trials were conducted; the first to assess the effects of different enzymes on local offcuts, and to isolate critical variables. Satisfactory yields were achieved providing care was exercised with immersion time and temperature. Agitation was necessary to remove the delaminated skin from the offcut flesh. Enzyme activity was terminated by blanching.

Subsequent to these trials, further enzymed offcuts were produced under commercial conditions for trials and assessment by processors and their markets. These were found to be entirely acceptable for inclusion in a range of squid dishes and products, although yields dropped sharply, because of a lack of processing control. Offcut quality compared with squid tubes was deemed to be good.

Markets for enzymed squid offcuts
Markets for enzymed squid offcuts were identified. Wings were ideal as a raw material for further processing;-being well suited to mincing and re-

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forming, and for canning. Products in which enzymed wings could be incorporated included reformed and breaded squid rings, sous vide dishes, nuggets, oriental squid balls and chips, and in canned products, most of which are currently imported from Asia. Canned enzymed squid wings have now been produced in commercial trials.

Enzyme treated tentacles, which have a high visual appeal, were suited to sale for retail consumption in their own right, and have a variety of uses. Market prospects included retail and wholesale packs, fresh and pickled products and sous vide dishes. Canned enzymed tentacles have also been despatched to the NSC board.

The economics of enzyme processing highlighted significant potential benefits for the industry. It was found that at prices of between $2.50 (wings)-$3.50 per kg (tentacles) the returns for enzymic skin removal may improve the competitive position of local squid processing by up to 15-30 per cent, providing it remains cost effective at a commercial scale.;- The economics of this process may be further improved by improving yield/recoveries. In turn will come with better enzyme use, and more precise control over enzyme activity.

Value adding squid products

A range of products were canvassed as for value adding. These included

- sous vide dishes and fresh squid pieces for the foodservice sector
- reconstituted squid rings, oriental squid balls and squid chips

Sous vide dishes were favoured because direct imports of sous vide is not possible. Caterers indicated that sous vide squid products of this type would be looked on favourably for "major events" catering and for the supermarket deli and prepared food sector. Enzyme tentacles (and wings) were included with squid rings in these dishes, to improve their visual appeal. While sous vide dishes met with approval from caterers, but experienced some marketing difficulties. This was attributed to the absence of an appropriate distributor rather than inherent problems with the dishes themselves.

Enzymed offcuts were well suited to inclusion in a range of other secondary processed products, improving visual appeal and reducing cost, but without any reduction in quality (eg sous vide and pickled and fresh squid mixes). Other products (eg oriental squid ball, chips, and possibly nuggets) are currently being developed in Geelong.

Enzyme technology has been employed to value add squid offcuts. This can now be commercialised, and further uses for offcuts as a competitively priced raw material now need to be developed in order to maximise the advantage that this process introduces.

Objectives

The overall objective of this project is to develop and produce, on a commercial pilot scale a range of value added products for the Geelong squid processing industry. This will involve development in the following areas;-

- Formulation and further processing of squid products
- Chemical pretreatment of squid flaps to provide basic raw materials for further processing
- use of advanced packaging systems for the presentation of value added heat processed squid products
- use of minimal processing techniques and HACCP control for the manufacture of extended shelf-life high quality products

The project has three specific objectives

- To develop an a list of likely squid based value added products, and to scrutinise the short list by applying a directional policy matrix applying criteria of market appeal, cost of production, regional industry strengths
- to produce as short list of products. and to produce these in sufficient quantities to allow a true assessment of production methods and market appeal,
- to integrate the outcomes of the program on a regional value added network, to ensure a regional commercial success.

1. Squid processing opportunities in the Geelong Region

1.1 BACKGROUND

This project was commissioned to develop a range of secondary processing opportunities for existing seafood processors in the Geelong region. It is a component of a regional strategy developed with local aquaculture and processing industry in concert with local government and State Government support. This strategy is the product of some 18 months of work and discussion and of a series of commissioned studies in the areas of aquaculture, economics and seafood processing technology.

The Geelong region is an important centre for seafood in Victoria, being the centre of the Victorian scallop processing industry, servicing fishing boats operating in both Port Phillip Bay and Bass Strait. It is also the state's largest processor of squid, sourced from Bass Strait and squid imports. Similarly, the region is home to the mussel industry, which is Victoria's only marine aquaculture industry. Regional processors also fillet fish and are involved in a range of retail and wholesale distribution activities.

In recent years, the region's seafood sectors have been threatened by a number of adverse developments:-in particular

- Scallop fishing in Port Phillip Bay has been banned

  The Victorian Government has announced a ban on the dredging of scallops in Port Phillip Bay. In Geelong, the supply of Port Phillip Bay scallops is an important component of the local raw material on which local processors depend, comprising up to fifty per cent of some processors supply of scallops.
  The remaining scallop resource is frequently tied by commercial links to processing sheds which makes access to the remaining resource difficult. Also, much of the remaining catch is landed in Lakes Entrance, where for simple geographical reasons Geelong processors have less capacity to procure scallops from fishermen.

  The loss of PPB scallops will therefore impact heavily on the Geelong processors, exacerbating an existing problem of discontinuous supply.

- The existing mussel industry has experienced a range of difficulties, many of which are long term in nature;-in particular the increasing incidence of bitter tasting algal blooms has brought into question the viability of this sector.

These setbacks have had a significant and detrimental effect on the viability of the regional processing sector and aquaculture.
As a result of this, a number of initiatives were developed:-

- The Geelong Aquaculture Task Force was created to oversee the resolution of these issues. The membership of the Taskforce is drawn from aquaculture, the Geelong Economic Development Board, the City of Greater Geelong, Fisheries, the Geelong processing sector, Deakin University and the Gordon Institute of TAFE. It was created under the auspices of the City of Greater Geelong, with support services from their Economic Development Unit.

- The task force role was expanded to cover the needs of the seafood processing sector when it became evident that problems and opportunities for the region required support.
- The City of Greater Geelong commissioned a Background Study[i]- an inventory of you like- of the fisheries, aquaculture and processing resources in the Geelong region.
- The mussel growers, in conjunction with the City, and the Geelong Economic Development Board and the Dept of Business and Employment, commissioned a study into aquaculture options for the region[ii].
- A seafood strategy, which was commissioned to build on core strengths of the region-and on the outcomes of the region's aquaculture study, to address the region's impediments and opportunities in a planned and integrated way[iii]. This study was funded by the City of Greater Geelong.

In the conduct of these studies, the consultants have met with both producers and processors both as individuals and in working groups, and have conducted workshops on particular issues. Emphasis has been given to value adding existing products, notably squid. Also, strategies are being developed to co-ordinate secondary processing in Geelong, so that over-capitalisation and duplication are avoided during development and marketing. These strategies are detailed in a separate report[iv].
In relation to potential product development, a range of marketing entities have been involved, in both the Foodservice sector (eg the Spotless group) and the retail sector (eg Safeways) with a view to further involvement in product development and marketing.

It is our belief that this is the only example of industry and local government developing a regionally focussed seafood strategy of this type. The regional strategy is specific and prescriptive, with identifiable aims and achievable objectives. In developing these objectives emphasis was placed on the ranking opportunities in relation to their likely success and their return on the investment dollar (whether this is spent in capital equipment or R&D) and on the timetable for success.

The Task Force remains active, and is committed to implementing the findings and recommendations of the regional strategic development plan.

1.2 Seafood Processing Activities in Geelong

Both scallops and squid processed in Geelong undergo primary processing only, and are sold into the export market and/or into the hotel and restaurant sector, with lesser quantities being directed to the domestic retail outlets. Apart from Austrimi Pty Ltd, which is a significant processor of surimi based products from (imported) fish fillets, little secondary processing of fish or seafood occurs apart from some crumbing of squid rings and scallops.

1.3 Development of the processing sector.

The major constraints to the further development of the processing sector in Geelong were seen as limited and discontinuous supply of raw material, and an absence of value adding and/or secondary processing and marketing. The approach to these twin problems was to develop a separate strategy to address supply and the development of post primary processing and value adding, and marketing

1.3.1 Supply of raw materials

1.3.1.1 Wild catch fisheries

Sources of fish within the region and available to the region from other areas and countries have been reviewed. Existing supplies of fish from traditional sources such as the Southeastern trawl at Portland, are not likely to provide the raw material to develop a processing sector based on scale fish because of their long term relationship with the Melbourne Wholesale Fish Market and other outlets.
Scallop resources are in strong demand and are tightly held, with little prospect of additional scallops being available to replace those lost through the cessation of scallop fishing in PPB.

Squid was the only wildcatch fishery (other than pilchards) that was able to be developed in the short term. Squid fishing effort has increased substantially over the past year and increases in volumes emanating from Bass Strait are likely. Production statistics (Table 1) have been scant and unreliable, although it is generally agreed by industry and AFMA that until 1994/95 only fifteen boats have been working. Current estimates of active boats is higher-probably in the order of 30 boats, mostly operating in Bass Strait between Queenscliff and Portland.

Table 1: Squid Production And Imports, 1994/95-1996/97 (t)

YEAR	94-95	95-96	96-97
C/Wealth	79	57	91
NSW*	892	878	783
S Aust	337	382	350
W A	378	397	44
Qld	119	151	194
N T	4	21	48
Victoria	1317	1500*	1500*
TOTAL Aust	3126	3386	3016
IMPORTS	7641	8404	7968
TOTAL	10761	11790	10984

Source: Australian Fisheries Statistics, AFMA,

* squid and octopus ** industry estimates (AFS 94t & 75 t respectively)

1.4 Processing opportunities for squid

1.4.1 Primary processing

Additional opportunities for Bass Strait squid processing are likely as imports of squid and processed squid products continue to rise. Fortuitously production from the Bass Strait fishery is also likely to increase (Table 1). AFMA's view is that the Bass Strait fishery is capable of a sustainable yield of circa 10000 tonnes per annum c/f current harvest of 1200 tonnes, representing an eight fold increase in production.

1.4.2 Secondary processing of squid

Squid processing in Geelong is mostly restricted to primary processing, and to date a number of factors have mitigated against the development of secondary processing. These factors included inadequate supply and the seasonal nature of local squid, and a lack of knowledge of secondary processing techniques, and uncertainty over demand. Many of these problems are now disappearing, and primary processing of squid is increasing, and secondary processing will become more attractive.

1.5 Product development opportunities for Squid

The market opportunity for value added squid products is significant;- Australia is a substantial net importer of squid products, many imports are in highly value added forms (Table 2) indicating that numerous opportunities for further processing Australian squid exist provided the industry is cost competitive.

Table 2: Australian squid imports by Source and Value; 1996/97

	tonnes	$'000	$/kg
NZ	2027	8374	4.13
Other	3131	13031	4.16
Thailand	1592	4997	3.13
USA	689	794	1.15
Singapore	46	258	5.60
Hong Kong	135	596	4.41
India	196	496	2.53
Japan	153	295	1.93
Total	7969	28841	3.62

Source Australian Fisheries Statistics 1997

Processing involves a range of activities, depending on the source of squid. Local squid are usually delivered chilled, and require complete processing, while imported squid has usually been partially processed and frozen prior to shipment. Often, for imported squid, this early processing (eg evisceration) takes place at sea.

2. Current Squid Processing: Primary Processing

2.1 Current practice

Squid processing in Victoria is largely restricted to primary processing;-that is, isolating the high value squid tube from the balance of the squid body for sale as squid tubes into the Food Service and the retail sectors. Offcuts (the flaps and the tentacles) are bulk packed and mostly exported to Asia, at relatively low prices.

While primary processing is notionally simple, a surprising number of operations required (see Figure 1 below).
The process is labour intensive, but requires the use of specialised machinery to remove the tough outer skin, and the peritoneal sac. This machinery does not effectively (or cost effectively) remove the skin from offcuts. The tube is trimmed, the head and viscera are removed manually.

Primary processing is divided into:-Evisceration and dismemberment (Table 3) during which

the tube is detached from the head.
tentacles are removed from the head,
the beak is removed from tentacles.
The head and eyes are discarded,
tentacles and flaps (the offcuts) are washed, and frozen into 10-20 kg blocks for export as a commodity.

Table 3: Evisceration and dismemberment

Activity	Labour Requirement
remove head from tube	one person
remove tentacles from head tentacles for cleaning head to waste bin	one person
debeak tentacles wash tentacles beak to waste bin tentacles: immerse in water (chlorinated) drain pack into 10 kg blocks blast freeze export	one person
manage raw material supply, remove rubbish etc	one person
Capacity 30 bins by 32 kg per hour	=1000 kg for 4 manhours =250 kg raw material per manhour =1000 kg for 3 manhours processing, 1000 kg/manhour cleanup

Tube processing (Table 4)

tubes are conveyed to a second line for further processing

offcuts are trimmed from the tube,

tubes are then mechanically reamed , removing the viscera and scouring the peritoneal sac,

the tube's outer skin is removed by mechanical skinning machinery.

Tubes are graded using visual assessment and weight, washed, then soaked for four -(24?) hours, drained and finally packed in 10 kg cartons for blast freezing and despatch.

Table 4: Tube processing		
	Activity	Labour Requirement
	tube is deskinned-by machine tube is reamed-machine wastes from tube processing are collected, binned and truck loaded tubes in chilled water o/nite tubes layer packed and blast frozen	one person one person one person
Capacity	25 bins/hr @ 32 kg 800 kg per hour=200 kg per manhour	=800 kg in 3 manhours, plus cleanup/service 800 kg /manhr
Water requirement	30000-40000 litres per day for 300 bins (10 tonnes)	

2.2 Yield

The yield of squid tubes and the quantity of waste varies , depending on the level of previous processing that has taken place. Imported squid can be in a number of differing configurations from whole to tubes and partially processed intermediate categories, with differing yields etc.

	local squid
tubes,	30 %
tentacles,	30 %
flaps	8%
viscera etc,	30 %
fluid loss	2-5%

Squid offcuts (flaps and wings) were also identified as a major opportunity for value adding. These offcuts are difficult to skin using conventional skinning equipment, and are currently exported block frozen to Hong Kong. Volumes of offcuts are circa 400 tonnes per year, and no doubt equivalent volume (probably in the order of 100 tonnes) also exist in Portland. Squid wings are sold at circa $1-$1.40 per kg ex factory, tentacles were circa $1.90/kg. Levels of offcuts are forecast to rise to 1000 tonnes by 1998.

2.3 Processing costs

The physical process of processing squid was examined in detail, the production costs were determined (Table 5) and expressed as a percentage of the sales dollar (Table 6).

Table 5: Cost of Production	Prime costs	cost / kg output
Raw material (yield 33%)	1.20/kg fis	3.60
Labour		
Stage 1		
detach tube from head one person		
remove tentacles from head one person		0.04
remove beak from tentacles one person		
Stage 2		
offcuts trimmed one person		
tubes graded		
reams tube- one person		
removes viscera and peritoneal sac		
mechanical deskinning (outer) one person		0.06
Support supply, store, clean up, etc		
Stage 1 one person		
Stage 2 one person		0.03
Packaging		0.10
Power and water costs (direct)		0.05
Miscellaneous (detergents etc)		0.02
Cleaning bins factory, truck, etc		0.06
Waste disposal charge		0.03
Machinery costs reamers and skinners *3 valued at $60000, i=13%, n=6yrs,1000 tonnes /p.a.	$17058 pa,	0.017
Plant depreciation	$60000 @	0.03
Total		$4.00

The major cost in processing is that of the raw material itself;-squid comprises circa 90 per cent of the total costs of production. Also, because of the low yield of tubes, (30 per cent) overall processing costs are very sensitive to minor fluctuations in squid price.

The labour cost of squid processing *per se* (10 cents per kg) is an insignificant component of overall cost, as is the annualised cost of machinery. Increases in value for the squid industry derived from improving processing efficiencies or in additional capital investment in processing would be consequently only marginal. Any change in method of primary processing would have to be based on non cost benefits, such as a higher quality product, or the development of a wider product range etc, based on different handling characteristics.

Table 6: Squid processing costs:_% of operating costs		
Cost of production	cost	%
Raw material	3.60	90.0
Labour		
Stage 1	0.04	1.00
Stage 2	0.06	1.50
Support	0.03	0.75
Packaging	0.10	2.50
Power and water (direct)	0.05	1.25
Cleanup, bins, factory truck	0.03	0.75
Waste disposal	0.03	0.75
Machinery: Annualised cost	0.02	0.50
Machinery: Depreciation	0.03	0.75
Total	3.99	100%

2.4 Competition from Imports

In summary, the above cost analysis shows that

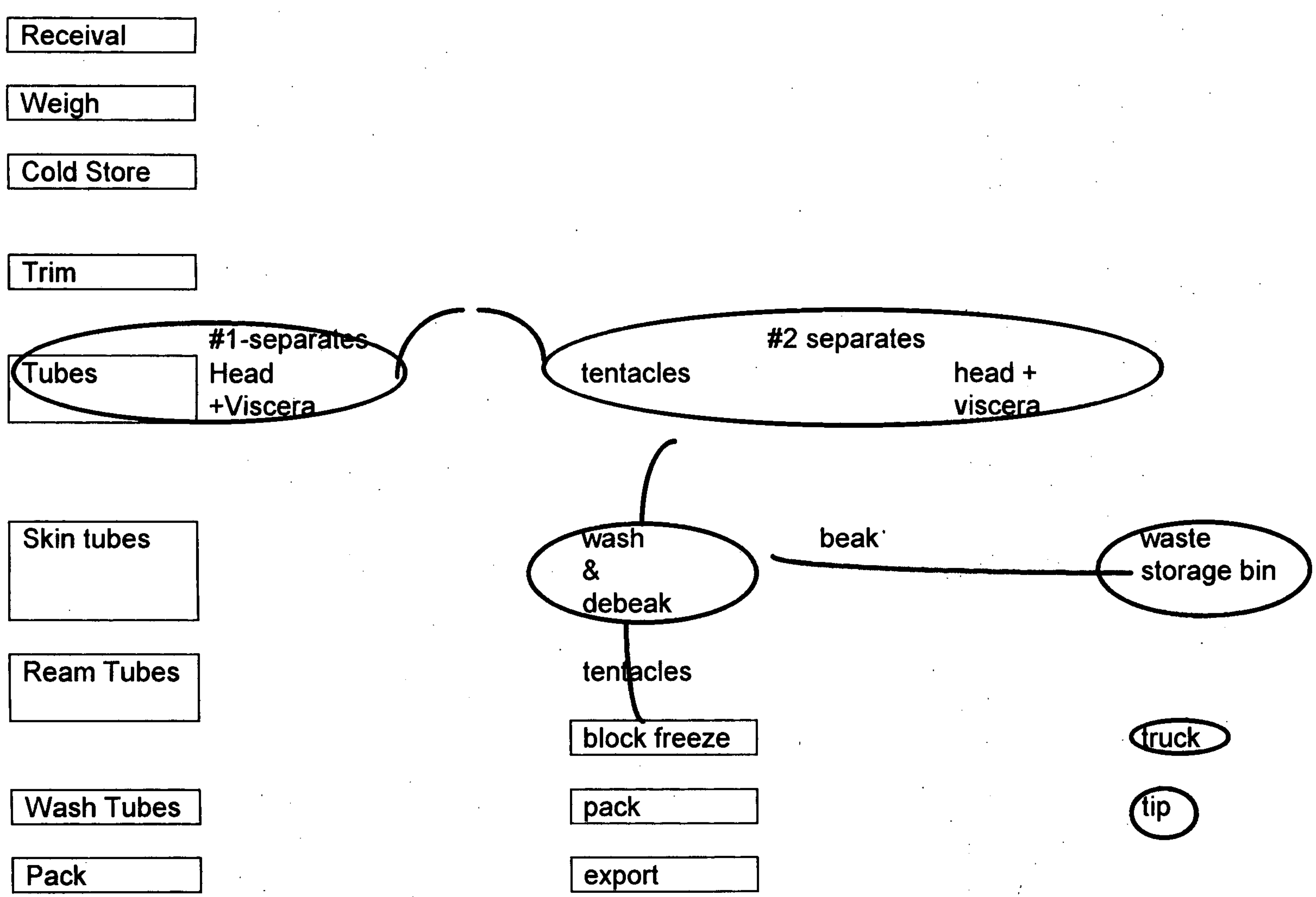
- labour is not a large component of squid processing costs,
- The overwhelming feature of the cost profile is the high cost of the raw material-whole Australian squid. This indicates that either the fishery is able to charge excessive prices for its catch by virtue of collusive practices (highly unlikely) or there are structural or other economic problems with the fishery, which build in a high cost of production (more likely to be the case). Such problems might include low or unpredictable catch rates, the highly seasonal nature of the fishery in Bass Strait, as it is currently fished. It may reflect inappropriate size and range of the existing fleet-most of which are multiple endorsement vessels, of a size which limits storage capacities and therefore range, increasing cost of the fishery, and perpetuating the short season.
- The significant production of low value offcuts, offers a means of increasing the competitive position of squid processing relative to cheaper imports, providing these can be value added in some way. This approach may allow an increase in competitive position without a reduction in price paid for whole squid.

The basic strategy for the product development in this project is to examine two separate "value -adds" for existing products

(a) high value products (ie tubes, etc) and

(b) offcuts, -to create a more valuable raw material from existing offcuts, and/or to incorporate these processed offcuts into high value products.

Figure 1: Squid Processing Flow Diagram.



3. Secondary Processing

3.1 Product Selection

Over a number of meetings, the steering committee and the project managers discussed a range of value add opportunities that they believed showed prospects, and that were capable of being produced in Geelong. This list included products previously developed by the RMIT (under a FIRTA grant) and "new" products targeted both the food service sector and the retail sector, requiring a wide range of processing methodologies/technologies. (Refer Initial Products;- Section 3.3 below).

Consideration was also given to the collective skills and attributes within the regional processing sector

3.2 Short Listed Products

Five areas of the market were seen as opportunities for value adding:-

1. Existing battered / breaded products-where a competitive edge in the cost of production should be gained by the use of squid offcuts as a raw material. (eg crumbed squid rings, squid balls, nuggets, bites etc). Preliminary costings indicated that this approach resulted in a considerable saving in raw material costs for the production of an existing surimi based product, by using a cheaper and more authentic raw material.

2. Wet dishes;-increasing demand for pre-prepared dishes is an increasing trend in both the retail and FSI sectors of the market. The retail demand emanates from less domestic time (two jobs/household), demand from the FSI relates more to outsourcing labour and costs from the kitchen. This sector of the market has grown strongly in recent years, but to date the squid industry (and perhaps the seafood industry as a whole) have yet to fully capitalise on it. It was also seen as a market where local (as distinct from New Zealand and other imports) had the competitive advantage.

3. New Retail packs: Existing squid available to the domestic market include only thawed squid tubes and rings, and whole fresh squid. Both products have presentation problems;-they are uninviting, and lack visual appeal, are of limited shelf life. Cleaning and skinning fresh squid is not a task relished by domestic consumers. Opportunity exists therefore to develop a more appealing user friendly retail pack for tubes, based on improved presentation for both tubes, and possibly rings, using evacuated blister packaging and "prestige" mounting boards, etc. Products of this type can be either frozen, or thermally treated and chilled. Similarly, squid steaks: ranging from butterflied tubes to reconstituted offcuts, were also seen as being a valuable addition to both the foodservice sector and the retail sector.

4. Given the products' similarities and the time and resources required to access supermarket shelf space, the committee felt that it was premature to try to develop the retail products at this stage and that the current focus should be kept on the enzyme processed offcuts. Developing products and meals incorporating sous vide squid offcuts approach to the supermarkets would be left to the processors at a later date.

5. Canned squid products:-These products emerged out of the trials with squid offcuts and "selected themselves". Discussions with a number of seafood processors with canning lines (in particular abalone canners) with existing export markets in Asia, revealed strong interest in trialing the tentacles and wings for canning purposes.

6. Smoked squid lines:-whole smoked squid and smoked squid pieces in oil were produced, but were discarded early in the project.

These products were then developed and produced on a small "lab" scale for assessment by the steering committee, in consultation with experienced seafood marketers from both the foodservice sector and the retail sector and supermarkets. The list was consequently narrowed down to a short list for pilot trials and market assessment.

Pilot production runs for these products were manufactured under commercial conditions at Austrimi (breaded and crumbed products) Mantzaris Fisheries P/L (enzymed offcuts) and at the Com Group P/L (sous vide dishes).

At the end of this process the short list had developed two main streams likely to achieve commercial success.

treated offcuts
sous vide squid dishes.

The third group of products for development were dependant on the successful (and economic) production of enzymed offcuts as a raw material. This group of products are being developed by the participating processors using in house technologies.

The initial listing process and the criteria for culling /retaining products is illustrated in following sheets

3.3 Product Development: Initial products considered

Product type	**Battered and crumbed squid products**
products	• Reformed squid rings squid schnitzel squid croquettes & hamburgers squid nuggets & sausages squid won tons Fisherman's basket (component) • product variations addition of flavours (Cajun crumb, smoked crumb & oils etc) sauces, other seafood (prawns, scallops, mussel meat etc).
Product development	• industrial recipe formulation • costing
source material	• squid tubes • squid tentacles and wings • assumes enzymic removal of skin from offcuts is successful.
availability	• wings-estimated 100-150 tonnes p. a. in Geelong region • use of starch and water during re-constitution will increase yield substantially. • Tubes all year supply (Australian and imported supplies). • Smaller imported tubes which are cheaper are OK-only 20 tonnes in all of local smalls are available-insufficient at one time for processing.
Processing treatment	• re-forming squid meat from prime (tubes) and secondary sources (wings, tentacles etc) • reconstitution rather than using "natural" squid tubes is preferred because of tubes' propensity for curling during cooking and crumbing. • using existing Austrimi technology and equipment
Market	fast food outlets FSI,
Packaging	glass L/P shatterpack cryobags etc.

Product type	**"Wet" Products-Delicatessen lines and Sous Vide Corporate Catering products**	
products	1. squid salad 2. squid stir fry 3. marinated (soused) squid 4. smoked squid in oil 5. vacuum packed smoked whole squid	
Source material	primarily squid tubes (80%-100%) some "pieces"-wings and tentacles (0-20%?)	
Availability	tubes/rings OK tentacles & wings subject to successful enzymic skin removal	
Processing treatment and Packaging	1. squid salad	grilled & grilled vegetables etc heat treated / pasteurised, plastic bags various sizes.
	2. squid stir fry	heat treated / pasteurised, plastic bags various sizes
	3. soused squid	soused in acid/vinegar, plastic tubs
	4. smoked squid	immersed in oil, pasteurised, packed in glass
Market	Supermarket deli Hotel restaurant trade	

Product type	**Retail Squid Tube Pack**
Source material	squid tubes and rings {squid steaks (opened and flattened tubes)} deskinned tentacles and offcuts (if process is satisfactory)
Availability	local stocks
Processing treatment	skin pack evacuated blister packaging minimal heat treatment
Packaging	blister packaging product mounted on a gold foiled cardboard backing board high visual appeal, low household handling/preparation perhaps recipes-cooking suggestions
Market	Retail outlets only-no similar product appears in the retail market at present frozen fish cabinet-(possibly chilled?) Demand for this type of product is likely to be good, because of the house wife's distaste for cleaning squid and the lack of knowledge re cleaning and eviscerating fresh squid. (Existing supplies of squid are primarily tailored to suit the needs of the food service sector-shatter packs of frozen squid tubes, with little (final) consumer appeal per se.)

Product type	**Squid Steaks (butterfly squid tubes)**
Source material	squid tubes
Availability	local stocks
Processing primary	In addition to normal production of squid tubes, the production of steaks requires tubes be split-or "butterflied"-to open out the tube. This allows the membrane on the inner tube (the tunic) to be removed by either the mechanical skinning -rather than by reaming-which is less effective, and should allow a better steak, less subject to curling on cooking.
Processing treatment-retail	(par char grilled?) skin pack evacuated blister packaging minimal heat treatment
Packaging	blister packaging product mounted on a gold foiled cardboard backing board high visual appeal, low household handling/preparation perhaps recipes-cooking suggestions
Market	Retail outlets frozen fish cabinet-(possibly chilled?) Demand for this type of product is likely to be good, because of the house wife's distaste for cleaning squid and the lack of knowledge re cleaning and eviscerating fresh squid. Existing supplies of squid are tailored to suit the needs of the food service sector-shatter packs of frozen squid tubes, with little (final) consumer appeal per se. FSI -suits char grilled squid dishes, and reduces in-house kitchen labour. shatter pack OK

4. Value Adding Offcuts

The current program is in part designed to assess the prospects of removing the skin from offcuts in a way that is both cost effective, and which results in a satisfactory yield of meat. Given the high percentage of offcuts in squid processing, this could result in the doubling of existing yield from squid processing and have a radical effect on the competitive position of Australian squid processing costs vis a vis imports.

Wings and tentacles are trimmed because of difficulties in removing tough skin from flesh, and the resultant low yield of flesh. These offcuts are of significant volume, amounting to approximately 38 per cent (wings 8%, tentacles 30%) of the entire weight c/f tubes which comprise 30 per cent, and viscera accounts for the remaining 30 per cent.

Tube end trims are for the sake of uniformity and appearance, and result in only very minor losses and/costs.

Offcuts are block frozen and mostly exported at a low value;-

Wings	circa $1.40 CNF ($0.90 ex store)
Tentacles	circa $2.30 CNF ($1.40 ex store)

These prices are generally regarded as approximating to the costs of handling and processing, rather than a profit item in their own right.

The low value and high volume of offcuts (30 per cent of total weight) indicate that although significant reduction in overall cost cannot be made, a substantial opportunity exists to increase revenue, and thereby increasing profit and competitive position vis a vis imports, if existing offcuts (and squid tubes) can be value added in some way. This required the development of offcuts as a raw material for other secondary processing/value adding activities. This required a more effective means of removing the tough skin from the offcuts. This was achieved by using enzyme technology.

4.1 Enzymic removal of skin

4.1.1 Processing: literature review

Auseas (National Seafood Centre) was commissioned to conduct a review of literature and applied uses for enzymatic skin removal This indicated that relevant expertise and experience in enzymatic skin removal existed in Norway and New Zealand. Salient features of the work were the variable nature of responses to enzymes and operating temperature, resulted in variable outcomes, in relation to yield texture, tenderness and colour. Enzyme technology under these circumstances was not likely to displace existing practices in totality, but showed sufficient promise to trial it with offcuts, particularly as the resulting product is itself a raw material rather than a finished product .

Also, direct contact has been made with Professor Jan Raa of the Norwegian Fisheries Institute at Tromsoe. Enzymic skin removal is certainly possible now, but the results are variable, and the costs are not dissimilar to those for mechanical skinning of squid tubes. However, enzymes do offer the prospect of skin removal for the more intractable offcuts, which cannot be skun mechanically. This should be effective enough to convert offcuts into a raw material for further processing at a higher value than they currently obtain. The trials aimed to determine the cost effectiveness of the process. The extent of the value add is also influenced by the price differential for squid tentacles and flaps and tubes.

Typically, the literature reported that enzymed products vary in texture, and are therefore not well suited to all value added applications, although it is likely that they will be suitable for pickling, and as a raw material for squid based surimi products, and for other re-formed squid products.[v vi]

4.1.2 Experimental enzymic skin removal

Following the Auseas Literature Review, the Australian Food Industry Science Centre (AFISC) at Werribee was commissioned to conduct an exploratory trial on a lab scale using a range of five enzymes, and a range of treatments.

The treatments included

- enzyme type five enzymes were chosen for comparative assessment
- time 10-15-20 minutes
- temperature 20, 30, 40 ^{0}C
- post treatment blanching +/- blanching 5-10 seconds @ 80-90 ^{0}C
- post blanch in an ice slurry +/- peroxide.

An optimum pH (of 6) and agitation during enzyme treatment are assumed to be needed.

Details of this trial are recorded in Section 4.2 below.

4.2 Enzymic Squid Skinning- Preliminary Trial

4.2.1 Introduction

Geelong seafood processors process c. 300 t of local squid. Their main products are traditional squid tubes and / or rings.

The processing consists of evisceration of the squid, dismemberment and finally the removal of skin from the squid mantle (or tube) Skin removal is difficult and is done mechanically by these companies. The process also results in the production of 300 t per annum, of squid wings and tentacles as by-products which are not well suited to mechanical de-skinning. Currently wings and tentacles are block frozen and exported to Asia for a very low economic return (only just covering the cost of processing, packing, etc.)

There is considerable interest in enzymic removal of skin from these off-cuts, so that they can be converted to a base product for further processing, for example in surimi-type products. The Geelong regional processors are well placed to capitalise on such a development, as they have between them a variety of processing equipment suitable for the production of value-added, squid-based processed foods.

Information gathered including a literature review conducted by AUSEAS, indicated that the approach taken in some recent enzymic skinning trials of squid conducted in New Zealand by Scott et al. (DSIR Fish Processing Report, March 1985) would provide a suitable starting point for the evaluation of this process in a local context.

4.2.2 Project Aim

The objective of this project is to investigate the feasibility of using five commercial enzymes for skin removal from local squid at laboratory scale.

4.2.3 Methods

The type of enzymes selected for this experiment were bacterial proteases due to the following reasons:

- readily available in commercial quantities
- ideal for collagen hydrolysis
- produced by controlled fermentation of Bacillus and Aspergillus species
- generally recognised as safe for human consumption
- food grade enzymes
- enhance industrial use due to low cost
- readily water soluble
- available as a standardised product
- effective over a broad range of pH and temperature conditions.
- versatile and robust

The following enzymes were used in the investigation:

Type 1. HT Proteolytic L-500 supplied by Enzyme Solutions
Type 2 Esperase 7.5 L FG supplied by Novo Nordisk
Type 3. Alcalase 2.4 L FG supplied by Novo Nordisk
Type 4. Fungal Protease supplied by Enzyme Solutions.
Type 5. Multifect P-3000 supplied by Enzyme Solutions

All enzyme solutions were prepared in tap water at ambient temperature. The concentrations of the enzymes were selected on the basis of the supplier's recommended levels. HT Proteolytic L-500 was used at 0.03% and all other enzymes were used at 0.05%. The pH of the enzyme solutions was recorded before and after each treatment. The pH of the enzyme solutions was not adjusted to any preferred pH as it fell between the active optimum pH ranges recommended by the suppliers. Description of each enzyme treatment is shown in Table.

The following processing parameters were evaluated during the experiment.

- Length of time exposure to enzyme.
- Concentration of the enzyme.
- Processing temperature.
- Processing pH.
- Type of enzyme

For the development work wings and tentacles were used. The frozen squid wings and tentacles were thawed in running tap water for one hour and drained before use. At least three wings and one tentacle were used per enzyme treatment. They were weighed and kept in the refrigerator until being added to enzyme solutions in the ratio 1 part of tentacle to 3 parts of solution, by weight. Treatment was done in glass beakers and the solution agitated. The enzyme solutions were heated under agitation to the pre-determined temperatures using infra-red lamps. The squid wings and tentacles were put into the solutions and held at that constant temperature for the pre-determined treatment times. During the treatment time the solutions were agitated to ensure uniform contact of the enzymes with the surface skin.

The temperature of the wings and tentacles before adding to enzyme solutions were approximately between 10-13 °C, causing an initial drop in temperature when the squid wings and tentacles were added. The treatment time was taken as the time the wings and tentacles were in the solution.

Following the enzymic treatment a blanching process was carried out in order to remove surface enzymes and to inactivate residual enzymes. This was done by dipping the squid in water at 80 °C for 5 seconds. The blanched materials were put into an ice slurry for 10 minutes to retard further cooking to prevent flesh from softening by further cooking. The remaining pieces of skin were pulled and cleaned under tap water and drained for 15 minutes. The final weights were recorded to determine the weight losses. The weight changes in each enzyme treatments are shown in Table 8. Squid wings and tentacles were visually assessed for degree of skin removal, colour and texture and the results are shown in Table 9.

4.2.4 Results And Discussion

Table 7: Description of Enzyme Treatments

Sample Code	Enzyme Type	Enzyme Concentration (%)	Temp (°C)	Exposure Time (min)	Initial pH	Final pH
A	Type 1	0.03	50	30	7.10	6.05
B	Type 1	0.03	43	15	7.10	6.08
C	Type 1	0.03	45	30	7.10	6.30
D	Type 2	0.05	50	20	8.05	6.22
E	Type 3	0.05	50	20	7.33	6.20
F	Type 4	0,05	50	20	7.00	6.22
G	Type 5	0.05	50	20	7.22	6.19
H	Type 2	0.05	50	30	8.42	6.30
I	Type 3	0.05	50	30	8.17	6.40
J	Type 4	0.05	50	30	7.92	6.37
K	Type 5	0.05	50	30	7.64	6.28

The initial pH of the enzyme solutions varied each time when freshly prepared. Only HT PROTEOLYTIC L 500 gave the same pH reading at all times. However the results indicated that the final pH between the commercial enzymes at various time / temperature combinations fluctuated between 6.05 to 6.40. The changes in pH during the enzymic skinning process have not been monitored in order to determine the changes over digestion time. Any benefits from maintaining the original pH were not been studied at this stage.

Table 8: Weight changes in each enzyme treatment -

Sample Code	Initial Weight (gram)	Final Weight (gram)	Percentage Loss (%)
A	513.00	391.90	23.6
B	376.00	352.13	6.35
C	393.00	335.18	14.7
D	373.70	365.30	2.25
E	360.40	351.05	2.59
F	340.20	328.60	3.41
G	375.20	358.32	4.50
H	385.10	334.80	13.10
I	366.70	268.30	26.80
J	392.70	340.30	13.30
K	429.70	384.50	10.50

There is a significant difference in respect of the efficiency to digest the skin of tentacles and wings among the enzymes. The treatment A had a high percentage weight loss compared to B and C. This may be due to changes in protein to a more soluble form at 50 °C, causing substantial protein loss. When the temperature was reduced to 43 °C, the digestion of skin was incomplete and the skin was found still intact and difficult to remove manually. In A, B and C the Type 1 enzyme at 0.03% concentration had significant difference in efficiency of squid skinning at three different time/temperature combinations. With Type 1 enzyme skinning at 43 °C was considerably slower and less effective than at 45 °C. The treatment of 45 °C for 30 minutes at initial pH 7.1 showed the best texture and percentage loss of skin. When comparing the percentage losses in experiment D, E, F and G with H, I, J and K respectively, the activity of all four commercial enzymes were increased necessitating increased digestion time from 20 minutes to 30 minutes. From the results there is no significant difference in percentage losses between the treatments H and J. In all treatments there were traces of skin attached to the flesh. This can be easily removed by abrasion. In treatments C, H, J and K the amount of skin intact was comparatively less.

Table 9: Visual Assessment of Enzyme Treated Squid Offcuts-

Sample Code	Visual Appearance
A	Skin completely removed. Clean white appearance. Slimy and mealy
B	Skin partially attached. Difficult to remove manually. Slightly pink in colour. Very slight changes to the texture.
C	Skin not attached. Tentacles were white. Wings were slightly pink. No significant changes in texture compared to fresh squid tentacles and wings. Slimy.
D	Skin attached but can be removed with abrasion. Similar to the fresh colour. Slimy.
E	Skin attached but can be removed with lots of scrubbing. No changes in colour and texture.
F	Skin still intact. Difficult to remove. No changes in colour and texture.
G	Skin still attached and can be removed with lots of scrubbing. Texture was firm. The colour was similar to the fresh state as the skin was still partially attached to flesh.
H	Skin completely removed from tentacles. Traces of skin found on wings. Easily removed by abrasion. Wings were slightly pink. Texture is firm.
I	Flesh became hard as if over-cooked. Majority of skin still attached. Slightly pink in colour.
J	Similar to sample H but much cleaner. Less pink in colour. Firm texture.
K	Traces of skin left on tentacles which is difficult to remove. Skin from the wings peeled off from the edges and curled towards the centre and remained attached to the flesh. Harder to remove. Firm texture. Slightly pink in colour.

In most cases the scrubbing or abrasion was required to remove completely the skin from squid tentacles and wings. With treatments C, H and J the traces of skin were removed easily with blanching and washing after enzyme treatment. As shown in Table 9, in certain trials the enzyme treated wings and tentacles developed a pink colour. The intensity varied and was more pronounced at higher enzyme concentrations and exposure time. The reason for discolouration is unknown.

Samples D, E, F and G were very similar to fresh samples and had almost all the skin left intact. With treatments H, I, J, and K the skin had been removed but the texture was very firm compared to the treatments with Type 1 enzyme.

4.2.5 Conclusions

The following conclusions are made on the results of the preliminary laboratory trial carried out at Afisc:

- Enzymic skinning of squid tentacles and wings is feasible under certain conditions.
- The factors such as enzyme concentration, exposure time, and processing temperature have significant effect on removal of skin from squid.
- There is a significant difference between the enzymes in respect of the efficiency to digest the skin of squid tentacles and wings.
- In most cases rubbing was necessary to remove completely the skin from flesh.
- Heat treatment is required for skinning of squid but has to be controlled to minimise denaturation of the proteins, loss of flavour and nutrients.
- HT PROTEOLYTIC L 500 obtained from Enzyme Solutions was found the most effective enzyme when used at 45 °C for 30 minutes and produced a satisfactory quality skinned end product. and caused minimum changes to the squid muscle.
- At 0.03% concentration HT PROTEOLYTIC L 500 enzyme was more effective for digestion than all other commercial enzymes at 0.05% concentration.

4.2.6 Recommendations

Based on the findings of the laboratory scale trials, further trials and investigations are required in the following areas are needed in order to commercialise this methodology;-

- A scale-up trial on squid skinning should be carried out under normal conditions at the client's manufacturing plant to evaluate the variability of results. The most promising enzyme HT PROTEOLYTIC L500 should be used for the scale-up trial.
- At the time of the scale-up trial, suitability of available equipment including the method of agitation should be evaluated.

- The effect of HT PROTEOLYTIC L 500 enzyme at different time/temperature combinations should be reviewed at the time of the scale-up trial.
- As blanching may make the flesh unsuitable for some end use, other methods such as use of acid or peroxide solutions should be evaluated to inactivate enzymes.
- To prevent softening of flesh during enzyme treatment, use of salt, calcium carbonate or other firming agents should be assessed.

Once the processing parameters such as pH, concentration, time and temperature including the enzyme inactivation process are established at the scale-up trials, residual enzyme levels should be determined to ensure the product is suitable for human consumption.

4.3 Enzymic Squid Skinning Pilot Trial

4.3.1 Introduction

The initial laboratory trials showed up one particular enzyme (HT Proteolytic L 500) as a better initial choice than the others, and gave a good guide as to the treatment scales, and the results that might be expected. This was now followed up using the enzyme of preference, to produce sufficient enzyme treated offcuts to gain further experience in the use of the enzyme technology on a larger scale, and to produce samples for potential clientele.

4.3.2 Project Aim

1. To conduct a pilot factory scale trial on squid skinning using the most promising findings from the laboratory scale trial conducted by Australian Food Industry Science Centre. (Afisc).

2. To evaluate the effect of HT Proteolytic L-500 enzymic treatment on the quality and yields of squid wings and tentacles on a larger scale trial.

4.3.3 Method

Following the laboratory scale trial on enzymic skinning treatments, the preliminary pilot scale trials, as described in the experiments below, were conducted in the Afisc pilot factory to evaluate the effect of the most promising enzyme HT Proteolytic L-500, at a larger scale operation of squid skinning. Simultaneously the effect of enzymic skinning treatment on the quality and yields of squid wings and tentacles was evaluated.

For each experiment ten kilogram of tentacles and ten kilograms of wings were used. The frozen blocks of these squid wing and tentacles were thawed overnight at room temperature prior to use in the experiments. Based on the findings from the bench scale evaluation of the squid skinning project the concentration of the enzyme solution was used as 0.03% and the ratio between enzyme solution and squid tentacles/wings as 3:1. The enzyme used in the experiment HT Proteolytic L-500 was prepared with tap water at ambient temperature.

With each enzymic treatment experiment, an initial drop in temperature of the enzyme solution was noted when squid tentacles/wings added. Treatment time was taken as the time the tentacles and wings were in the solution.

Experiment 1:

The thawed squid wings and tentacles were washed separately in running tap water for ten minutes and drained off prior to being dipped in the enzyme solution for 30 minutes at 45 °C with gentle stirring using a hand operated paddle. The temperature of the wings and tentacles before adding to the enzyme solution were approximately 10 °C.

Following the enzyme treatment a blanching process was carried out by dipping the squid wings/tentacles in water at 80 °C for 5 seconds. The blanched material was put into an ice slurry for 15 minutes.

Experiment 2:
The thawed squid tentacles and wings were washed in luke warm water for 5 minutes when their initial temperature was adjusted to approximately 20 °C before use in the experiment. This minimised the initial temperature drop when squid tentacles and wings were added to the warm enzyme solution.

The enzyme treatment was conducted at 45 °C for 15 minutes under gentle agitation using a hand operated paddle. The blanching and cooling process was similar to experiment 1.

Experiment 3:
This was similar to Experiment 2 except the cooling step following the blanching process was conducted using an ice slurry with hydrogen peroxide at 0.5% (w/w).

Experiment 4:
The treatment involved was similar to experiment 3 except the blanching process was completely eliminated. The squid tentacles and wings were dipped into an ice slurry with hydrogen peroxide immediately following the enzymic treatment.

With all the experiments 1 to 4, the end product which is the skinned wings and tentacles were washed separately in tap water to remove the remaining pieces of skin attached to the flesh. Then the products were drained well and the final weights were recorded to determine the weight losses.

Results
The weight losses in the experiments are shown below in Table 10.

Table 10: Weight Losses for enzyme treated offcuts

Experiment code	Material Treated	Initial Weight (gram)	Final Weight (gram)	Loss (%)
1	wings	10,000	6,800	32.00
1	tentacles	10,000	5,500	45.00
2	wings	10,000	8,900	11.00
2	tentacles	9,500	8,149	14.22
3	wings	9,890	8,837	10.65
3	tentacles	9,385	7,560	19.45
4	wings	9,940	9,459	4.80
4	tentacles	9,390	8,578	8.60

The skinned squid wings and tentacles were visually assessed for degree of skin removal, colour and texture and the results are shown in Table 11.

Table 11: Visual assessment of enzymic treated squid offcuts.

Treatment	Material Treated	Visual Observation
1	Wings and Tentacles	Skin completely removed except in some pieces the skin was still attached. Texture slightly stiff. Slimy. Tentacles and wings were slightly pink in colour.
2	Wings and Tentacles	Skin removed. Tentacles white and wings slightly pink. No changes in texture.
3	Wings and Tentacles	Skin removed. tentacles white and wings slightly pink. No changes in texture.
4	Wings and Tentacles	Skin attached cannot be removed with abrasion. Slimy. No changes in texture. Wings and tentacles are slightly pink.

Treatments and responses are summarised in Table 12.

Table 12: Summary of enzyme treatment and responses

	Treatment 1	**Treatment 2**	**Treatment 3**	**Treatment 4**
Pretreatment	thawed washed drained temp=10^{0}C	thawed washed-warm water drained temp =20^{0}C	thawed washed-warm water drained temp =20^{0}C	thawed washed-warm water drained temp =20^{0}C
Enzyme Treatment	30 minutes temp = 45^{0}C agitation	15 minutes temp = 45^{0}C agitation	15 minutes temp = 45^{0}C agitation	15 minutes temp = 45^{0}C agitation
Post treatment	blanch 80^{0}C 5 seconds final wash remove skin & debris drain pack/process	blanch 80^{0}C 5 seconds final wash remove skin & debris drain pack/process	blanch 80^{0}C 5 seconds final wash remove skin & debris drain pack/process	nil blanch final wash remove skin & debris drain pack/process
Yield (loss) % wings tentacles	 68% (32%) 55% (45%)	 89% (11%) 86% (14%)	 90% (10% 89% (19%)	 95% (5%) 91% (9%)
Product assessment	most skin removed texture stiff tentacles-pink wings pink slimy	all skin removed texture OK tentacles white wings pale pink	all skin removed texture OK tentacles white wings pale pink	skin strongly attached texture OK tentacles wings pink slimy

The best combination was Treatment 2:-ie

- Prewarm — frozen offcuts were brought to ambient temperature (20^0C) prior to treatment
- Enzyme — Proteolytic L500, @ 0.3%
- Temperature — 45^0C
- Immersion time — 30 minutes with agitation
- Blanch — 80^0C for five seconds
- Ice slurry — 15 minutes
- Final wash — fresh water for five minutes

4.3.3.1 Recovery: -yield using enzymes

As with the initial AFISC trials, yields ranged from 89% down to 80%. It was found that prolonged immersion in the enzyme bath lead to rapid reductions in yield.

4.3.3.2 Appearance

Appearances were consistent with the earlier trials; generally highly satisfactory

wings — slight pink discolouration,
tentacles — bright white colour;-no discolouration

although agitation during blanching and subsequent treatments was also important.

4.3.3.3 Taste and texture,

as assessed by the processors and their families were deemed to be excellent.

4.3.3.4 Toughness:

The characteristic toughness of unskinned wings and tentacles was completely removed. Tentacles and wings both had the texture and tenderness of a mechanically skinned squid tube.

4.3.3.5 Touch

It was found that treated offcuts were sometimes felt a little soapy to touch. This was probably related to the temperature of the enzyme solution (45^{0}C), as research results indicate that proteolytic enzymes convert collagen to gelatin at temperatures over 40^{0}C, but not at temperatures of less than 30^{0}C. This may also explain the differences in yield

4.3.4 Conclusions

The investigation shows that the treatment time and the initial temperature of the squid wings and tentacles have significant effect on yield and quality of the end product. The colour cannot be improved by using hydrogen peroxide at 0.5%. Hydrogen peroxide may be inactivating the enzyme but this has not been tested in this experiment. Hydrogen peroxide only adds expense to the processing but this can be offset if the end colour is improved.

Blanching enhanced the skin removal and inactivated the enzymes at the same time. The amount of enzyme and hydrogen peroxide that would diffuse into the squid muscle from the areas where the skin is cracked, has not been tested.

The better yield obtained from the Experiment 2 without the use of other chemicals is certainly of value and may be the preferred treatment.

5. Treated Offcuts as a Raw Material

Offcuts appeared to have the appeal of being a ready and legitimate substitute for existing (costly) raw materials over a wide range of products in the market. This brings the twin benefits of ready market acceptance, linked with more competitive pricing and greater profit margins.

Products where treated offcuts could be gainfully used included

canning
breaded and battered squid products
surimi based products
sous vide products
retail squid packages
pickled squid
packs of cleaned enzyme-skun fresh squid the restaurant and retail sectors.

However this scenario presupposes that commercial processors find enzymed offcuts an acceptable raw material. Five batches of 20 kg were processed for distribution to secondary processors.

5.1 Commercial Assessment of Enzyme Processed Squid Products

Samples produced in the second trial and the pilot commercial production were then sent to a number of different processors for assessment. These included

- Abalone canneries. As a raw material for canning

Abalone canners are export oriented processors and marketers, with high capital investments in canning lines, but with a low volume (albeit high value) product. Thus they have surplus canning capacity and are in touch with a market that is accustomed to consuming squid products as a staple item.

- Surimi manufacturers: As a raw material for manufacturing Kalamari® rings, squid balls for the domestic Asian market, re-formed squid rings and similar products. These are currently based on surimi and imported squid tubes as a raw material.
  - Existing Hong Kong importer of squid offcuts. The intention here was to offer to an existing user, a better product, akin to their existing line.

- Catering Trade
  As a component of prepared dishes for the catering trade. This should reduce the cost and improve the visual appeal of squid dishes, thereby expanding demand.
  Dishes were prepared using tubes and untreated offcuts, and tubes with treated offcuts.

Responses

Abalone canners were particularly keen on developing canned products from offcuts. However, a lack of product experience caused initial production problems. The first batch of cans were overcooked (using retort times for canned abalone) but canners were sufficiently encouraged to proceed further. They have had discussions with overseas buyers, and believe that they will establish a market for the product relatively easily. A range of recipe options were being considered.

Secondary processors had difficulty with the continued presence in the wings of the end of the quill, but otherwise found the product satisfactory for use in re-constituted squid products. Price for the product will dictate its use in these products.
Hong Kong importers had not responded at the time of writing, but had expressed strong interest. For this market price will be a key issue, rather than product appeal. AFISC research workers held a strong belief that the product would find a market in the Asian markets, both within Australia and in Asia, replacing existing lines of untreated canned offcuts.

5.2 Commercial production

The strong interest shown in the initial samples encouraged one processor to produce more samples under commercial conditions for additional evaluation by his customers. A larger production line was assembled from plant and equipment within the region, and an additional tonne of enzyme treated offcuts was produced, in batches of 25-75 kg. This “commercial” production trial revealed a number of problems which would need to be addressed before consistent and viable production became a reality. In particular, yields fluctuated widely because of poor temperature control. This third production run indicated the need to effectively control temperature and time in both enzyme bath, and especially in the subsequent blanching process.

To develop this process to the point where it is a viable commercial production line, requires input from a food processing engineer, and the investment of significant capital investment.

5.2.1.1 Costs of enzyme processing of offcuts

Economic modelling of the primary processing indicate that the existing processing costs are low and therefore present little opportunity for cutting costs.. The major cost is still the prime cost of squid itself, and this cannot be directly influenced by the processors. Few other costs appear to be easily reduced by any significant amount. The one area that does offer an opportunity to offset the cost is by increasing the value of the existing offcuts. Estimates of cost movements brought about by value adding offcuts are recorded in Table 13. A range of products can be developed, but this depends on the cost effectiveness of a successful development of a process to remove squid skin and membranes from flaps and tentacles. If this is successful, it radically changes the economics of processing, and improves the competitive position relative to the (cheaper) imported products.

5.2.1.2 Effects on competitive position

The use of enzyme technology, linked with market prices for deskinned offcuts results in a value add of between 10-46 cents per kg of whole squid processed, depending on the yield achieved and price. In terms of the Geelong processors' competitive position vis a vis imported squid tubes, this means that at least in the short term, processors using this technology could either

- increase their profitability by an equivalent amount, or
- reduce the market price for processed squid tubes by an equivalent amount;- becoming more competitive with imports, while holding the prices to fishermen.

At the lower levels (low yield of 80% currently achieved in production trials, and a low price, this represents a value add of only 10 cents/kg of whole squid purchased;-translating into a 33 cent per kg margin for squid tubes.

At the higher levels-(90% yield) and assuming a price of $3.50 per kg for offcuts, the value add represents $1.50 per kg of squid tube produced from locally processed squid.

Table 13: Gross Margin Analysis for Value adding offcuts

	Wings		Tentacles			
	frozen	enzyme	frozen	enzyme		
Selling Price -ex store	$1.40	$3.00	1.90	2.50	3.00	3.500
Yield	1.00	0.80	1.00	0.80	0.80	0.800
Gross Income per kg of	$1.40	$2.40	$1.90	$2.00	$2.40	$2.80
Processing costs ($/kg)						
enzyme cost	n/a	0.02	0.00	0.02	0.02	0.02
labour	0.10	0.10	0.10	0.10	0.10	0.10
packaging	0.10	0.10	0.10	0.10	0.10	0.10
freezing	0.02	0.02	0.02	0.02	0.02	0.02
water & power	0.05	0.05	0.05	0.10	0.10	0.10
Plant annuity($100k, 7.5%,			0.10	0.10	0.10	0.10
Plant R/M (10% of capital			0.10	0.10	0.10	0.10
Total direct costs	$0.27	0.29	0.47	0.54	0.54	0.54
Gross Margin	**1.13**	**2.11**	**1.43**	**1.46**	**1.86**	**2.26**
Value added increment		0.98		0.03	0.43	0.83

Value add ($ per tonne) by enzymic treatment	**80%**	**87**	**207**	**327**
offcuts for every tonne of fresh squid	**yield**	**186**	**321**	**456**

6. Sous Vide Squid Products

6.1 Sous vide processing technology

Sous vide processing is a food preservation technology in which foods packed in hermetically sealed containers are heat treated in order to achieve a refrigerated shelf-life of up to 12 weeks, or more depending on the sensitivity of the product to heat and the barrier properties of the packaging materials. The major distinction between sous vide processed foods and conventionally sterilised (ie. "canned") low acid foods is that the former have superior sensory properties (colour, flavour and texture) as they do not suffer the destructive effects of prolonged heating at elevated temperatures. This means that when compared with cans, sous vide processed foods are typically perceived as being;

- higher quality,
- less processed,
- fresher,
- perishable (and therefore, by implication, free of the less favourable connotations that are associated with "preserved" shelf-stable foods)

It is these attributes that have driven the development and market acceptance of sous vide processed meals and meal components, primarily in the food service and institutional sector, but also in the retail sector. Examples of foods suited to sous vide processing include red meats, seafood, poultry, pork, curries and casseroles, white sauces, ready meals, soups, value-added salads containing a selected combination of rice or pasta, nuts, vegetables etc. Such is the premium image of sous vide products that some shelf-stable acid foods are marketed from chilled cabinets as "sous vide look-alike products" in order to be perceived as perishable, and fresh , even though they do not require refrigeration for microbial stability.

6.2 Sous vide processed squid products

As part of the product development phase of this study a range of prototypes was developed and (through prior arrangement) submitted for evaluation by the Spotless group, the Safeway chain and representatives of the Geelong seafood processing sector. Following a series of debriefing sessions the formulations were modified in response to the requirements of the target market, and prototype products were modified for re-submission. Corporate caterers in particular expressed interest in evaluating the proposed products in their catering outlets at the MCG and it was with this market niche in mind that three varieties of 2 kg packs were developed for test market evaluation.

6.3 Development criteria

The key criteria that were established for development of sous vide processed squid products in this phase of the R&D programme were as follows;

- the products were to be packed under vacuum in heat sealed 2 kg, 15µ polyester/100µ LLDPE bags.
- cleaned squid flaps and tubes were to be supplied frozen for further processing.
- product preparation, packaging and thermal processing took place at a commercial sous vide processing plant in Melbourne. using counterbalanced retorts. The company possessed the technical expertise and plant necessary to manufacture sous vide products without the need for any capital expenditure. Furthermore using commercial manufacturing facilities enabled cost effective development of sous vide squid products until such time that processing facilities in the Geelong region could be justified.
- retort temperatures, retort pressures and pack selection were to suit processing at, or near, 100 °C as this would not preclude manufacturers adapting the technology to basic atmospheric cookers should the market growth warrant development of a local value-added processing site in the Geelong region.
- the finished products were to have a refrigerated shelf-life of 6 weeks.
- storage temperatures were not to exceed 9 °C. throughout this time.
- the target micro-organisms to be destroyed by the thermal process were to include the psychrotrophic non-proteolytic *Clostridium botulinum* types E and B, which can grow down to 3.3 °C. Destruction of these micro-organisms would ensure destruction of all other pathogens capable of growth at refrigeration temperatures
- the products were designed to suit the brief agreed with the caterer and the net weight of the packs should be 2 kg.
- meat weight should comprise not less than 50% of the net weight.

6.4 Formulations and costings.

Initially five products were developed for tasting and review as follows;

- Grilled squid with oriental dressing
- Grilled squid with salsa dressing
- Grilled squid with red wine dressing
- Pickled squid
- Smoked squid

Following assessment by the Geelong processors and caterers, the list of products was reduced to three and in each case variations to the formulations were required. As a result, further development trials were conducted and the three products that were re-submitted for evaluation were oriental squid, squid salsa and pickled squid in which the proportion of squid was 68%, 52% and 50%, respectively. The formulations, materials and packaging for these products and the production costs for each are presented in Table 14 to Table 16.

The net profits in Table 17 are based on real commercial plant, but are indicative only, and include estimates of direct overheads for relevant plant and equipment only, running at an average speed etc. They assume 100 % cost recovery per hour against squid processing. In reality, a figure of say 70% overhead recovery might be applied, which would increase profit margins considerably. The costings that have been quoted on a gross margin basis, and do not include general or non-specific overheads.

The tables show that selling prices were $20.00/2 kg unit, $18.50/2 kg unit and $18.50/2 kg unit, for oriental squid, squid salsa and pickled squid, respectively. These costs were not considered inappropriate by representatives from the corporate catering trade, nor by marketers, experienced in the marketing and distribution of sous vide products throughout the food service trade.

Table 14: Squid Salsa Recipe And Costing

Batch size (kg)	100 kg	Pack size 2 Kg		
Brine (%)	9.14			
Vegetables (%)	38.86			
Squid tubes (%)	26.00			
Squid tentacles (%)	26.00			
Combined batch (kg)	100.00			
Raw materials				
Brine	%	kg/batch	$/kg	$/batch
Tomato paste	54.71	5.000	3.50	17.50
Vinegar white	27.35	2.500	1.20	3.00
Ultra-tex	6.56	0.600	2.20	1.32
Salt	4.38	0.400	0.64	0.26
Vegetable booster	4.38	0.400	22.00	8.81
Pepper black cracked	1.31	0.120	22.00	2.63
Sugar	1.20	0.110	0.80	0.09
Mixed herbs	0.11	0.010	8.50	0.09
	100.00	9.140	3.69	33.69
Vegetables				
Tomato chopped	45.80	17.798	1.50	26.70
Onions 50 mm	15.50	6.023	1.50	9.03
Capsicum red julienne 40 x 40 mm	12.90	5.013	6.00	30.08
Capsicum green julienne 40*40mm	12.90	5.013	3.50	17.55
Celery	12.90	5.013	2.20	11.03
	100.00	21.062	3.21	67.69
Combined mix				
Blanched squid tubes, 30 x 30 mm	26.00	26.000	5.00	130.00
Tubes adjusted for 60% yield			8.33	216.67
Blanched squid tentacles, 40 mm	26.00	26.000	3.50	91.00
Tentacles adjusted for 60% yield			5.83	151.67
Brine	9.14	9.140	3.69	33.69
Vegetable mix	38.86	38.860	3.21	124.88
Yield (%)	100.00	100.000	5.27	526.91
		$/kg	$/batch	$/unit
		5.27	526.91	10.54
Cost of raw materials				
Packaging		$/kg	$/batch	$/unit
2kg 15µ polyester and 100µ LLDPE bags		0.15	15.00	0.30
Carton (for 6 units)		0.10	10.00	0.20
Cost of packaging		0.25	25.00	0.50
Total cost of materials		5.52	551.91	11.04

Table 15 Oriental Squid Recipe And Costing

Batch size (kg)				
Brine (%)	32.00			
Vegetables (%)	-			
Squid tubes (%)	34.00			
Squid tentacles (%)	34.00			
Combined batch (kg)	100.00			
Pack size (kg)	2.00			
Raw materials				
Brine	%	kg/batch	$/kg	$/batch
Water	60.78	19.450	1.20	23.34
Hoi Sin sauce	12.50	4.000	0.80	3.20
Tomato paste	12.50	4.000	0.64	2.56
Ultra Tex	6.25	2.000	22.00	44.00
Soy Sauce	2.50	0.800	22.00	17.60
Ginger crushed	2.50	0.800	22.00	17.60
Garlic crushed	1.88	0.602	0.80	0.48
Sesame seeds	0.62	0.198	0.64	0.13
Chilli flake	0.47	0.150	22.00	3.31
	100.00	32.000	3.51	112.22
Combined mix				
Blanched squid tubes, 30 x 30 mm	34.00	34.000	5.00	170.00
Tubes adjusted for 60% yield			8.33	283.33
Blanched squid tentacles, 40 mm	34.00	34.000	3.50	119.00
Tentacles adjusted for 60% yield			5.83	198.33
Brine	32.00	32.000	3.51	112.22
	100.00	100.000 5.94		593.88
yield 100%				

	$/kg	$/batch	$/unit
Cost of raw materials	5.94	593.88	11.88
Packaging	$/kg	$/batch	$/unit
2 kg 15μ polyester and 100μ LLDPE bags	0.15	15.00	0.30
Carton (for 6 units)	0.10	10.00	0.20
Cost of packaging	0.25	25.00	0.50
Total cost of materials	6.19	618.88	12.38

Table 16: Pickled Squid Recipe And Costing

Batch size (kg)	
Brine (%)	15.00
Vegetables (%)	35.00
Squid tubes (%)	25.00
Squid tentacles (%)	25.00
Combined batch (kg)	100.00
Pack size (kg)	2.00

Raw materials				
Brine	%	kg/batch	$/kg	$/batch
Vinegar white	81.43	12.215	1.20	14.66
Sugar	16.28	2.442	0.80	1.95
Salt	1.95	0.293	0.64	0.19
Peppercorn black	0.34	0.051	22.00	1.12
	100.00	15.000	1.19	17.92
Vegetables				
Onions small	37.50	13.125	1.60	21.00
Capsicum red julienne 40*5 *5mm	25.00	8.750	6.00	52.50
Capsicum green julienne 40 *5*5	25.00	8.750	3.50	30.63
Garlic whole	12.50	4.375	8.00	35.00
	100.00	35.000	3.98	139.13
Combined mix				
Blanched squid tubes, 30 x 30 mm	25.00	25.000	5.00	125.00
Tubes adjusted for 60% yield			8.33	208.33
Blanched squid tentacles, 40 mm	25.00	25.000	3.50	87.50
Tentacles adjusted for 60% yield			5.83	145.83
Brine	15.00	15.000	1.19	17.92
Vegetable mix	35.00	35.000	3.98	139.13
	100.00	100.000	5.11	511.21

	$/kg	$/batch	$/unit
Cost of raw materials	5.11	511.21	10.22
Packaging	$/kg	$/batch	$/unit
2 kg 15μ polyester and 100μ LLDPE bags	0.15	15.00	0.30
Carton (for 6 units)	0.10	10.00	0.20
Cost of packaging	0.25	25.00	0.50
Total cost of materials	5.36	536.21	10.72

Table 17: Sous vide: line processing costs and returns			
	Squid Salsa	Pickled Squid	Oriental Squid
Selling Price /Kg	9.25	9.25	10
Raw Material	5.74	5.55	6.46
Packaging	0.28	0.27	0.27
Labour	0.47	0.28	0.28
Operating Costs	6.49	6.10	7.01
Gross Margin	2.76	3.15	2.99
Plant Overhead	1.25 (0.89-2.08)	1.25 (0.89-2.08)	1.25 (0.89-2.08)
Net profit/kg	1.51 (0.68-1.87)	1.90 (1.08-2.26)	1.65 (0.73-2.10)

6.5 Market response

Initial product selection

A range of short listed dishes (later used for sous vide processing) was prepared and evaluated by a major catering outlet, catering for both corporate and mass meal demand at the Melbourne Cricket Ground. Five chefs, including the executive chef for corporate catering and "major events" catering, were included. Dishes included squid salsa, oriental squid and pickled squid.

The joint opinion was that

- the inclusion of offcuts improved the visual appeal of the dishes,
- *untreated* offcuts were too tough, even with prolonged cooking,
- the texture and tenderness of *treated* offcuts was acceptable.

Subsequent Response

The chefs' opinion of the three sous vide prepared dishes was that they were suitable for general catering purposes, but they were not yet distinctive enough for the Corporate Catering sector of the market. Discussions indicated that a more appropriate approach might be to produce a very bland sous-vide dish to which individual chefs can add their own imprimatur. While this is relatively easy to do, and is likely to find a market demand, it in part negated the appeal of sous vide, in that it meant that the dish is not ready to serve. This is important as the original strategy was to prepare sous vide dishes for major catering events, such as the Grand Prix or for Corporate boxes at the MCG. These dishes are required to be of a high culinary standard, and still require little or no preparation, and need to be prepared quickly. While this is the main attraction of sous vide, the chefs thought that the dish had not reached the general level required, especially in relation to taste.

The view was put that the products as is are suitable for the deli section of the supermarkets and similar outlets, mass catering sectors, and for the lunchtime trade etc.

The cost estimates for producing these dishes are competitive, and in this market segment, where volume production is likely, the costs of production fall rapidly as the overhead component of the overall cost is amortised.

At the time of writing the responses from the trade for the products have not matched the expectations that were generated throughout the trial period, although the caterers indicated that this is not due to the concept of sous vide prepared squid products, nor the formulation, nor the proposed costs; all of which were deemed satisfactory.

The difficulty of commercialising the proposed range of sous vide squid items appears to be due more to market development and locating a suitable distributor rather than due to technical limitations of the process.

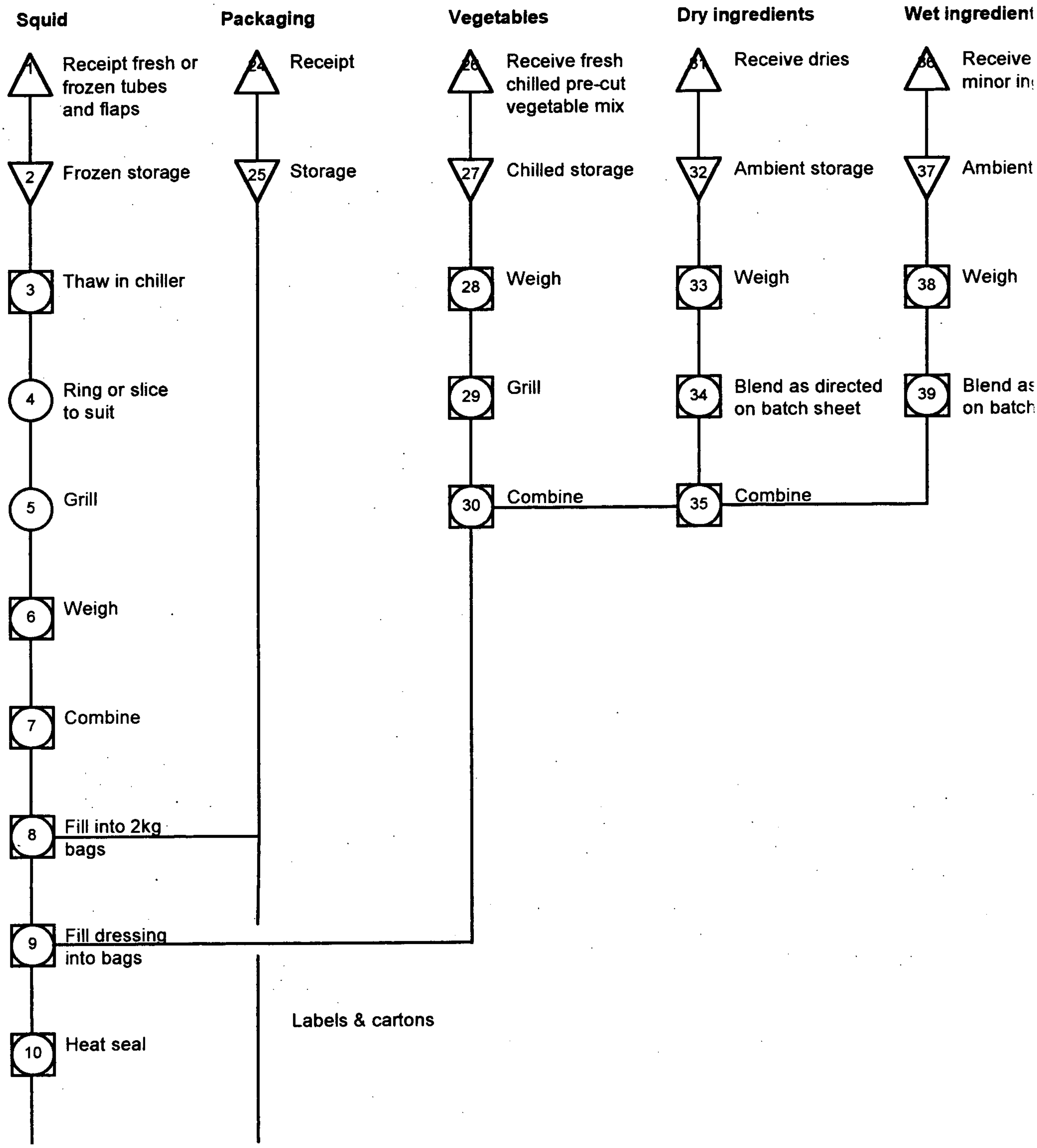
6.5 Manufacturing procedure

The manufacturing procedures for the three sous vide squid products were similar as in all instances the only differences were due to formulation. The preferred technique that is widely used to describe and specify food manufacturing operations is to make use of Process Flow Diagrams (PFDs) in which all key operations and the sequence of combining various raw material streams are shown. In addition PFDs provide an ideal plan with which to conduct a hazard analysis of the prescribed manufacturing operation. Hazard analysis of food manufacturing operations is now a regulatory requirement and this is formally conducted via implementation of the, so called, Hazard Analysis Critical Control Point Concept (HACCP).

A generic PFD for the manufacture of the three squid products is shown on the following page after which is shown the corresponding HACCP Plan form which indicates the following;

- Critical Control Points (CCPs) in the process.
- The steps at which CCPs occur.
- The Hazards that occur at each of the CCPs.
- The control measures that are to be implemented at each CCP.
- The critical limits that apply at each CCP.
- The monitoring procedures at each CCP.
- The corrective action that may be taken at each CCP.
- The records that apply for each CCP.

6.6 Generic Process Flow Diagram for Sous Vide squid products



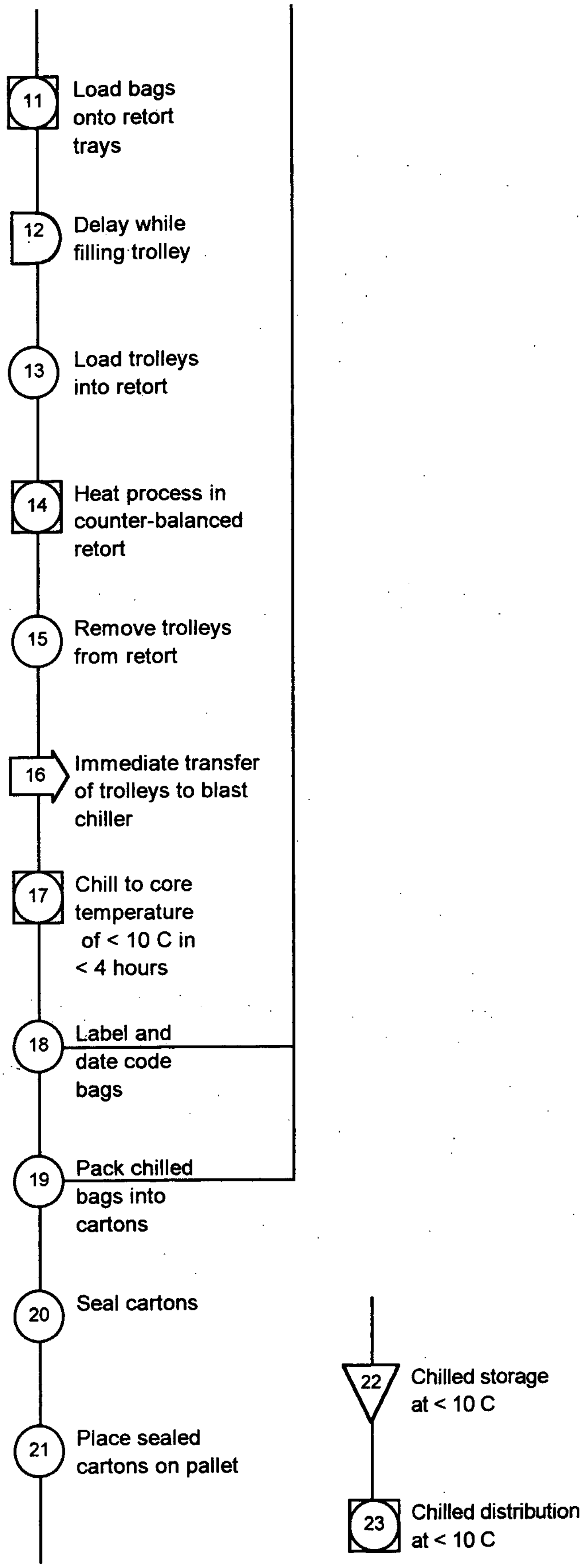

11
Load bags onto retort trays
12
Delay while filling trolley
13
Load trolleys into retort
14
Heat process in counter-balanced retort
15
Remove trolleys from retort
16
Immediate transfer of trolleys to blast chiller
17
Chill to core temperature of < 10 C in < 4 hours
18
Label and date code bags
19
Pack chilled bags into cartons
20
Seal cartons
21
Place sealed cartons on pallet
22
Chilled storage at < 10 C
23
Chilled distribution at < 10 C

Table 18: HACCP Plan form for Sous Vide squid products

Critical Control Point (CCP)	Significant Hazards	Critical Limits for each Preventive Measure	Monitoring				Corrective Action	Records
			What	How	Frequency	Who		
Step 8: Filling squid portions into bags	Target micro-organisms surviving thermal process	Weight of squid not to exceed specified value	Fill weight	Weigh	Each pack	Operator	Repack when weight out of specification	Filling station log
Step 9: Filling dressing into bags	Target micro-organisms surviving thermal process	Weight of dressing not to be less than specified value	Fill weight	Weigh	Each pack	Operator	Repack when weight out of specification	Filling station log
Step 10: Heat sealing bags	PPLC[1] as pathogenic bacteria gain entry through faulty seals	Formation of hermetic seal	Seal formation	Visual	Each pack	Operator	Discard suspect seals and re-pack	Sealing station log
Step 11. Loading bags onto retort trays	Target micro-organisms surviving thermal process	Stacking patterns to follow template	Number and arrangement of bags on trays	Visual	Every tray	Operator	Re-stack tray when not as specified	Loading station log
Step 14. Heat processing	Target micro-organisms surviving thermal process	Initial pro temp (IT) and retorting conditions to match scheduled values	IT & retort temperature & pressure, & process time	Measure IT & read charts, pressure gauges & thermometers	Measure IT & retorting conditions every cycle	Retort operator	Isolate batch and hold awaiting QA manager	Retort log

HACCP Plan form for Sous Vide squid products (Table 18 continued)

Critical Control Point (CCP)	Significant Hazards	Critical Limits for each Preventive Measure	Monitoring				Corrective Action	Records
			What	How	Frequency	Who		
Steps 17: Rapid chilling	Growth of heat bacteria which survive thermal process	Core temperature at < 10°C in < 4hr	Core temperatur e	Check temperature at SHP[2]	Two samples from every tray	Packing supervisor	Isolate batch and hold awaiting QA manager	Cooling rate log
Step 22: Chilled storage	Growth of heat bacteria which survive thermal process	Core temperature to be maintained at < 10°C	Temperatur e of chiller	Read recording charts	Daily	Packing supervisor	Check core temperature and alert Factory Supervisor and QA Manager	Chiller temperatu re log

Notes.

1. PPLC signifies post process leaker contamination due to formation of faulty seals and/or poor post process hygiene and/or seal damage after processing.

2. SHP signifies the slowest heating point of the pack which shall be determined experimentally through at least six replicate trials.

7. Other Market Opportunities

The basic preparations for squid and squid offcuts created a number of niche opportunities that were not examined closely, but which have obvious market demand. These include

Canned enzymed squid products
Canned enzymed squid tentacles have now been trialed and are likely to be developed commercially; creating a new market segment for an existing product, canned un-enzymed, skin on tentacles. However, the enzymed product is merely preserved in brine. Numerous variations on this theme are possibilities;-brine with citric acid, is one. Tentacles with tomato sauce is another, which creates a higher quality segment for an existing market.

Enzymed flaps
Enzymed flaps are being developed for use as a raw material for a Geelong processor as a substitute in manufacturing reconstituted squid rings. There is no reason why the use of enzymed flaps will not be extended to a range of other products currently based on the processing of squid tubes.

Pickled squid
Pickled squid is currently imported in retail tubs, with no bulk pack available for catering purposes. Also, this product will directly substitute for pickled octopus, which is more expensive. Pickled products are shelf stable at ambient temperatures and can be produced without expensive equipment.

Retail packs
Vacuum packaging linked with tubes, tentacles and flaps, offer a more attractive pre-prepared squid product for consumers than anything currently on the market. Th e savings created by the use of offcuts should allow this sort of product to compete on price alone. The visual appeal of tentacles and rings together will also assist.

There is also a market for squid steaks and schnitzels (butterflied squid tubes) provided the presentation is good.

Sous Vide squid mix
A pre-prepared mix of tubes, rings and offcuts bulk packed for the hotel restaurant trade. This product can be readily prepared using the enzyme skin removal and sous vide technology, to give a raw material for the hotel/restaurant trade in a bulk pack. This product is likely to be very price competitive, and will remove considerable preparation work from the restaurant kitchen. It would be readily marketed through providores and wholesalers and distributors.

There is likely to be a good market for fresh tenderised squid tentacles and offcuts for the hotel and restaurant trade. This market would require constant production and packaging for sale and distribution through market providores and distributors.

8. Network

The Australian Federal government has until recently run a Business Networking program, under the Ausindustry Program. The concept of networking is to create a situation whereby participating companies (a minimum of three is required) gain from aggregating resources to create a competitive advantage and an increased profit. The network may be a partnership, or a new company may be formed, for a joint marketing program, or for an integrated production or R&D program beyond the resources of the individual companies concerned. Networks are an appropriate tool for small to medium size enterprises. Under the Ausindustry Networking program, considerable financial assistance is offered for setting up the network in the first instance, and for implementing its aims. (Assistance is matched dollar for dollar.)

The establishment of a Business Network to oversee the project and to optimise the use of project results in a coordinated regional manner was discussed in development of this submission for the National Seafood Centre and in fact was a prime objective of the project. The intent of this was to ensure that capital investment, and other resources were not duplicated in the region as industry increased its focus on value adding.

8.1 Intellectual property rights

The original submission to the National Seafood Centre included an agreement that the intellectual property rights attaching to the project would be allocated to a "Geelong seafood Network" for a given period, prior to the public release of the report. This was in recognition of the substantial industry commitment to the project;- in both time and resources. This would give the regional seafood processors in the network sufficient time to develop the value adding of squid prior to the report's release.

The industry steering committee, which consisted of the three major seafood processing companies in the region, was intended to make up the network. The group met frequently during the course of the project, to oversee the project direction etc. During this time, it grappled a number of times with the proposal to form a network, but was unable to agree on a formal network format, and the proposal was put to one side.

As the project progressed, one company in particular, Mantzaris Seafood, became deeply involved in the development of the enzyme treatment process. Since the project's completion, Mantzaris has further developed the enzyme technology, and is now actively commercialising the process. Under the circumstances, the other two companies have agreed that the property rights should be allocated to Mantzaris Fisheries.

9. Summary and Conclusions

9.1 Existing squid industry

Australia produces some 1500-3000 tonnes of squid per year, with the main production coming from the Bass Strait fishery. The fishery is characterised by seasonal supply, and is serviced by multi-purpose boats of limited offshore range, which usually fish for scallops in the off season. The squid resource is underutilised, and is capable of sustaining considerably higher catches. Despite this, Australia is a net importer of squid. (Australian production in 1997 was 3016 tonnes, c/f imports of 7968 tonnes) Imports come in a variety of forms, from whole squid for onprocessing, to squid tubes competing directly with local tubes, and a range of value added squid products.

Major processors exist at Geelong and Portland, producing squid tubes and crumbed products. Little other value adding occurs. Processing is characterised by a low yield of tubes (circa 30%) Offcuts (30-40%) comprised of wings and tentacles are not suited to existing mechanical processing methods. Offcuts are currently sold for a low price, and are generally held to be revenue neutral.

9.2 Economics of squid processing

Economic analysis showed that processing is efficient, and at 25% of total costs was not a major source of cost. Existing methods of skinning and reaming squid tubes were cost effective, and the labour content was also small. Cost is dominated by the purchase cost of squid itself (75% of total costs). Consequently the only means by which the local industry can make significant improvements in its competitive position is by either

value adding its existing output, or
reducing the price paid to squid fishing sector.

Adoption of this latter approach assumes that the fishery would achieve higher catches and longer seasons if it moves to larger boats, and longer cruises. The success of this approach is by no means certain, and it is outside the Terms of Reference for the current project. Any reduction in price paid to fishermen without an effective structural change would see a reduction in fishing effort.

9.3 Value adding squid offcuts

Offcuts are tough to eat, by virtue of their skin; which is not removed by mechanical means. Consequently they are of little value. A literature review of enzyme technology in the fish processing indicated a variety of methods and differences in methodology, and mixed results for enzymic removal of squid skin. Most of the work was conducted in the northern hemisphere, (Norway) with *Loligo* species, although New Zealand also had researched the subject using *Notodarus gouldii*, which is fished in Bass Strait.

A range of variable exist which affect the treatment process;-temperature, enzyme type and concentration, immersion time, agitation, blanching and peroxide treatment (to deactivate enzymes). Two trials were conducted; the first to assess the effects of enzymes on local offcuts, and to isolate critical variables. The second trial used the best enzyme with the optimum treatment combination. The output of this trial was used as a raw material for product development, and to determine yield and other characteristics under more commercial conditions.

Yields of circa 82-86 per cent were experienced providing care was exercised with immersion time, and the use of both blanching and ice slurry to terminate enzyme activity and cooking effects. Agitation was necessary to remove the delaminated skin from the offcut flesh. Final skin removal was effected by further agitation during washing in an ice slurry.

Subsequent to these trials, further enzymed offcuts were produced under commercial conditions. These commercial products were given to a number of end users and onprocessors for assessment. They were found to be entirely acceptable for inclusion in a range of squid dishes and products., although yields dropped sharply, because of a lack of processing control. Offcut quality was deemed to be good c/f processed tubes.

The economics of enzyme processing of offcuts was analysed. It was found that at prices of between $2.50 (wings)-3.50 per kilogram (tentacles), the returns for enzymic skin removal may improve the competitive position of local squid processing by up to 30 per cent, providing the plant and equipment was not overcapitalised. This has yet to be developed, and the cost effectiveness of this process therefore remains an open question. If proven this translates to a significant benefit for the industry;-the Bass Strait harvest in 1998 will be in the order of 2500 tonnes, producing 750 tonnes of squid tubes and 950 tonnes of offcuts. If the offcuts are enzyme-processed at a marginal return of $290 per tonne, this results in an additional $280,000, a net gain of 10% to the local processing industry.

The economics of this process may be further improved by improving yield/recoveries. In turn will come with better enzyme use, and more precise control over enzyme activity.

9.4 Markets for enzymed squid offcuts

Markets for enzymed squid offcuts were identified. Wings were ideal as a raw material for further processing;-being well suited to mincing and re-forming, and for canning. Canned enzymed squid wings have now been produced in commercial trials (and have also been despatched to the NSC board). Products in which enzymed wings could be incorporated included reformed and breaded squid rings, nuggets, and oriental squid balls, and in canned products that are currently imported from Asia, and as a raw material in sous vide dishes.

Enzyme treated tentacles, which have a high visual appeal, were suited to sale for retail consumption in their own right, and have a variety of uses. Market prospects included retail and wholesale packs, fresh and pickled products and sous vide dishes.

9.5 Value adding squid products

A range of products were canvassed as candidates for value adding. These included

sous vide dishes, and retail products such as oriental squid balls, reconstituted squid rings and
oriental squid balls and squid chips.

Sous vide dishes were favoured because imports are not suitable for this type of preparation. Also, major caterers indicated that sous vide squid products of this type would be looked on favourably for "major events" catering and for the supermarket deli and prepared food sector. Sous vide dishes have a high quality fresh image, and after minimal heat treatment and can be stored chilled (rather than frozen). Three squid dishes, oriental squid, squid salsa and pickled squid were prepared in this manner. Enzyme tentacles were included with squid rings in these dishes, to improve their visual appeal.

These dishes met with approval from the catering group involved, but at the same time experienced some marketing difficulties which precluded their commercial development within the life of this project. This was attributed to the absence of an appropriate distributor rather than inherent problems with the dishes themselves.

Enzymed offcuts were well suited to inclusion in a range of other secondary processed products. Some of these products are currently being developed at Geelong (eg oriental squid ball, chips, and possibly nuggets. These are still in developmental stages, and are expected to reach the market in late 1998.

Enzymed offcuts were well suited to inclusion in these secondary processed products, such as sous vide and pickled and fresh squid mixes. Accordingly in manufacturing these products, it is anticipated that significant cost reductions could be achieved, with improved visual appeal, but without any reduction in quality.

9.6 Conclusion

Australia is a net importer of squid and squid products, despite having an underutilised squid resource in Bass Strait. The local industry faces strong import competition from NZ and other countries. For the local industry to increase production and develop the resource, it needs to be more price competitive, and/or needs to develop value added products for the existing industry. The Australian squid industry could expand and improve its competitive position if the cost of squid is reduced. This is not likely unless structural changes occur in the fishing sector. The prospects for this depend on whether structural changes (larger boats, extended fishing times and seasons etc) is effective, and further study of the viability and nature of the squid fishery is needed.

Production costs in general are low, and further cost savings from changes in processing technology will result in only a marginal reduction in overall costs.

Value adding, especially for the significant volumes of offcuts, is the only ready option by which the competitive position of the squid industry can be improved. Enzymic removal of skin from squid offcuts was identified as a successful means of increasing profitability within the existing processing sector, and opened the way for use of enzymed offcuts in a variety of value added products, at reduced costs.

A pilot scale commercial enzyme processing line was established, and commercially viable products based on enzyme processed offcuts were identified and test marketed. Other products were also identified, but additional product development is required to introduce these to the market.

The key to successfully commercialising this will be to develop cost effective enzyme processing plant, to control the key processing variables, notably temperature and time, and the termination of enzyme activity.

10. References

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