HAL PROJECT No.: VG 06082

PROJECT TITLE: In-field Sweet Corn De-kernelling Feasibility Study

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Report Statement:
This project is to examine the feasibility of introducing an in-field kernel cutting system as an economically viable adjunct or alternative to the traditional factory-based method of corn processing.

Co-operating Organisations:

	HAL	Horticulture Australia Limited
	SAPL	Simplot Australia Pty Limited
	WRGA	Western Rivers Growers Association
Date:	15t June 2007-06-12	

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Introduction

The NSW sweet corn industry is under enormous pressure from highly competitive imported product. The largest processor of sweet corn in Australia and New South Wales, Simplot Australia, advise that unless supply and processing costs are reduced there is a real threat the processed sweet corn industry in NSW will cease and market requirements be met by imports.

This project is to examine the feasibility of introducing an in-field kernel cutting system as an economically viable adjunct or alternative to the traditional factory-based method of corn processing.

The system would be designed around mobility and could be sequentially deployed into different growing areas/seasons, providing inventory flexibility and further opportunity to reduce costs by only transporting kernel (instead of transporting whole cob weight, of which 40% is kernel) to the factory for subsequent processing.

The project is presented as an initial scoping phase only project.

Materials & Methods

The industry is aware that in-field cutting technology is being used in the mid west of USA, but none in the Australian industry has any in-depth knowledge of the specific equipment, cost or the supporting logistic and associated potential food safety/ hygiene-related issues. These need to be examined first hand to ascertain the suitability for Australian conditions.

This project will involve a high level appraisal and evaluation of the technology which is currently being used in the USA and a subsequent recommendation as to whether the project offers enough practicality and financial opportunity to be developed for more detailed analysis.

Results:

1. USA Trip Report (Authors: Steve Finn, Scott Stevenson)

In Field Sweet Corn De-Kernelling Technology Study

2nd – 13th September 2006

Abstract

Sweet corn in field de-kernelling has been proposed as a potential method of reducing costs associated with the seasonality of sweet corn production and hence processing in NSW. To investigate existing de-kernelling capabilities a study group was constructed and sent to the mid west region of the United States of America. This group consisted of two Simplot personnel and two suppliers of sweet corn. Two alternative methods of significance were presented by OXBO and Razorback farms. OXBO offered a one pass machine capable of harvesting and removing kernels on the move. Razorback farms alternative was demonstrated as a semi permanent de-kernelling facility positioned within close proximity to the sweet corn harvest operation

Introduction

Simplot Australia together with Horticulture Australia (HAL) investigated the potential of in field sweet corn de-kernelling. Simplot operate a sweetcorn processing plant situated in Bathurst NSW, Australia. Simplot utilize direct tonnage based contracts to secure the suppliers necessary to provide sweet corn to the factory for processing during a four month period January through to April. Traditionally supply has been solely sourced from NSW however, supplementary supply from QLD and VIC has been necessary to fulfill shortfalls. Hence to provide consistent year round supply Simplot are required to warehouse product due to the seasonal nature of the NSW sweet corn harvest period. Currently sweet corn requirement for the season 2006 – 2007 is 32,000 grower paid tones. Markets are generally segregated into canned and frozen. As the cost of transportation is increasing, it is in the interest of Simplot to contract the necessary supply close to the processing plant inline with the existing 4 month processing period. Firstly necessary discussion is required outlining the NSW supply situation at present. Secondly information presented for investigation into the implementation of in field processing technology. To conclude additional research will be necessary so that costs and concerns involved in the discussion are correctly quantified prior to implementation.

Results

Observations were made on two design options available for in field de-kernelling machines. OXBO International Corporation manufactured a mobile trailing machine adapted to the rear of the sweet corn picker (fig 1). Alternatively Razorback Farms operated a stationery unit in close proximity to the sweet corn harvesting operation (fig 2.) This unit is transportable to central locations within sweet corn production areas

OXBO International Corporation

OXBO international have manufactured a machine intended to trail behind the sweet corn picker. This concept provides the ability to harvest and de kernel the sweet corn on the move. Solid waste material is returned directly back to the paddock as well as 1892L of cleaning water/Hr. Sweet corn is picked and elevated into the huskers with a vibrating feeder. The trailing machine is equipped with 8 CCM automatic corn cutters with a combined capacity of 4.5t of cut kernel/hr. These corn cutters are positioned opposing i.e four on one side of the trailer and four on the other. Raw corn is distributed to the automatic kernel cutting machines by a rectangular conveyer. The cut kernel is belt shifted through two scalping machines to remove any remaining husk and silk from the cut kernel sample. The machine is able to store 2720kg of cut kernel in an on board hopper prior to unloading into a bin to be tipped for the 2nd time into a waiting truck. The kernel is required to be processed within two hrs. The de kernelling machine is hydraulically driven and powered by a 175Hp John Deere motor. The weight of the de kernelling machine alone is 26t with a length of 14.94m. When attached to a corn picker the overall length is 22.8m requiring a minimum of 18m to turn around. The general layout of the machine is shown in fig 1.

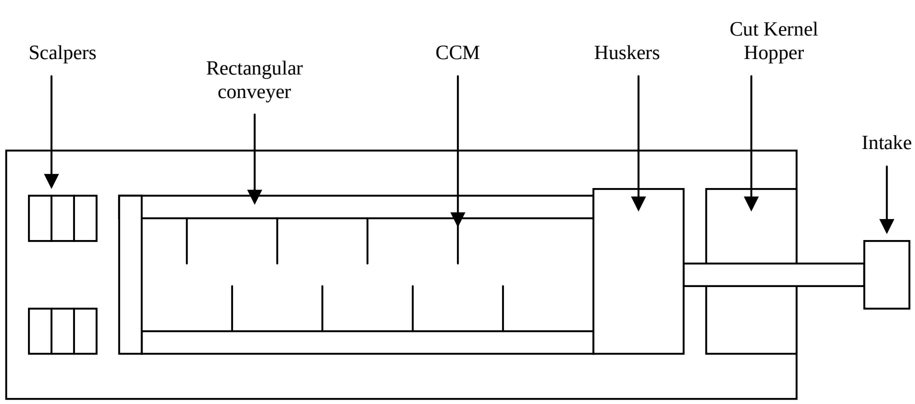

Fig 1. Aerial schematic of trailing in field de kernelling machine as shown by OXBO international

Razorback Farms

Razorback Farms operated an infield sweet corn production unit that provided chilled sweet corn kernels to processing facilities. This stationary unit requires 7 semi trailers for the processing of the sweet corn and 1 mobile workshop trailer fig 2. All trailers have the ability to be coupled to a prime mover and transported to the next centralized location

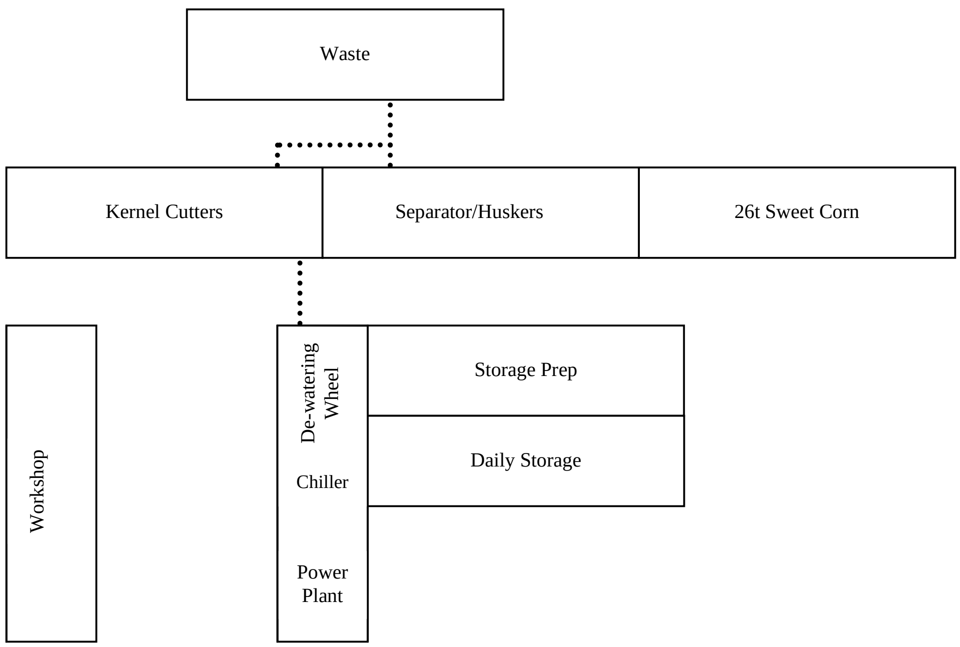

Figure 2. Aerial schematic of Razorback Farms stationary in field de-kernelling unit

Raw sweet corn is delivered to site by semi trailers equipped with walking floors. In a 14hr shift the unit is able to process eight 26t loads, hence daily sweet corn requirement is 208t, measured as field weight. The corn is elevated into separators prior to being presented to a 6 lane husker. Intake is determined by an operator positioned at the separators. Material removed from the cob in the de-husking process is elevated into a semi trailer for stock feed. Cobs are belt shifted from the husker to the cutter belt. Prior to the cutter belt there is one operator removing green ears. Nine inline individually operated hand fed kernel cutting machines remove the kernel from the cob. Spent cob is elevated to waste along with cobs rejected by the cutter operators. Cut kernel is belt shifted and then elevated to de-watering wheel for washing and final removal of EVM. Water treated by ammonium cooler applied to bring kernel temperature down to <2°C. Chilled kernel is belt shifted into plastic lined cardboard box with a cut kernel capacity of 1t.

Of the 208t of field weight sweet corn delivered to the unit 72.5t of cut kernel is produced in a standard daily 14hr shift. Therefore kernel recovery of the infield kernel cutting operation is 35%.

Razorback Farms store regular Su type sweet corn for no longer than 3 days and supersweet Sh2 type corn for no longer than 5 days in the cut and chilled form. An approximate 4% loss is incurred by the processing factory measured by weight of finished product. Hence net recovery of kernel between raw corn delivered to in field de kernelling facility and finished product at the factory is 33.5%.

A standard 14hr shift is comprised of 12.5hrs processing and 1.5hrs cleaning utilizing 19 people to operate the facility. Labor costs are $7.00/hr, meals and accommodation are provided. Well water with added chlorine is used for processing and cleaning. An average of 40,882L of water is required on a daily basis. The unit is hydraulic driven with food grade oil powered by a John Deere 225Hp motor using 606L of diesel/day. With the current configuration run by Razorback Farms 1 day is required to dissemble and 1 day required for reassembly of the in field de-kernelling facility.

Discussion

Present NSW supply to Simplot Bathurst

The 2006-2007 sweet corn requirements for the Bathurst processing plant exceeds 30,000tonnes. Of this requirement, Bathurst plant has committed to processing more than 90% from NSW grown corn. The period for processing the local NSW corn is between 2nd January and 20th April. Sweet corn from NSW scheduled for processing outside this processing period is considered unreliable. Simplot contract direct to the supplier based on tonnage delivered to the Bathurst factory. Simplot determines the type of sweet corn that is required from the supplier and construct a schedule to suit. Agronomics and nurturing of the crop is the supplier's responsibility. Once maturity is reached Simplot are responsible for the harvest of the NSW crops. Table 1 outlines the tonnage to be supplied from each NSW growing district and reliable growing periods. To minimize the cost of transport it is preferred to source corn from locations with a close proximity to the factory. However it has been necessary to venture further a field primarily due to water limitations in recent seasons.

District	Distance from Factory (km)	Tones (Grower Paid)	Optimal Harvest Period
Hillston	>500	2500(Early)	Early – 2nd-14th/Jan
		3500 (Late)	Late – 10th-20th/April
Narromine	250	3500	2nd-14th/Jan
Dubbo	200	3500	8th-26th/Jan
Cowra	130	3500 (Early)	Early - 20th/Jan – 8th/Feb
		2000 (Late)	Late – 1st-10th/April
Bathurst	<50	12000	15th/Feb – 31st/March

Table 1: Contracted tones for season 2007 and optimal harvest period for NSW growing districts

As seen in table 1 current supply is limited to optimal harvest periods for each NSW growing area. Northern Queensland has ability to produce sweet corn in the winter months i.e. out of season as sweet corn is considered a summer crop in NSW. Therefore, if in field de-kernelling were to be implemented in Australia the potential is there to supply chilled kernel to the Bathurst factory year round. However prior to adopting such technology investigations into the true costs involved in transportation of chilled kernel, production inputs and waste removal are required.

In field processing technology

In field processing provides the permanent factory with chilled kernel ready for final preparation prior to processing. Approximately 4% of the kernel delivered to the factory is lost in final preparation and processing. Once removed from the cob and chilled, Razorback farms consider the kernels to remain fit for final processing within 3 days for regular type varieties and 5 days for supersweet varieties. Within this period the kernels are able to be transported in a chilled state to the processing factory. This then provides the processing factory with the opportunity to extend their traditional localized processing periods. These traditional processing periods exist due to the costs involved with transportation from extended distances. Therefore local raw sweet corn supply to the Bathurst factory from NSW is condensed to a period between 2nd January and 20th April. Hence storage of product is necessary for a reliable year round supply to retailers.

Two successful methods of in field processing were observed. OXBO international manufactured a self contained trailing machine. This machine has the ability to remove husk and kernel from the cob in one pass.

1. *OXBO International*

OXBO have designed the mobile unit that adapted behind the corn picker as compact as possible. However the physical size and weight of the de kernelling machine in combination with the corn picker is a limiting factor. Problems associated with in field maneuverability and capability in difficult conditions requires careful consideration. It is suggested by OXBO the minimum distance required to turn the machine around would be 18 meters. Therefore operating this machine in paddocks that are watered under a flood irrigation design would not be possible. In addition the relative size of paddocks in the Bathurst growing area would not be able to accommodate the length of this machine in combination with the sweet corn picker. Unfortunately this machine was not able to be observed when in operation therefore potential problems associated with this method of in field de kernelling were not able to be monitored. However it is suggested that this machine is capable of processing 4.5t of cut kernel/hr. Removal of foreign material in the paddock is heavily reliant on two scalpers positioned prior to being elevated to the bulk hopper. It is apparent that the corn delivered to the machine is required to be of excellent quality. Hence potential issues may arise if corn delivered to the machine was of sub optimal quality. Mechanical picking and cleaning of the raw corn prior to delivery to the trailing de kernelling unit has the potential to create a localized atmosphere of dust and plant debris. In addition many property roads are unsealed, again creating dust problems and spoilage of product. These effects are potentially amplified under hot dry conditions. Therefore a risk of contamination to finished product would exist

2. *Razorback Farms*

Razorback farms operated a semi permanent unit positioned on a site within close proximity to the harvest operation. With the current configuration operated by Razorback Farms one day is necessary to dismantle the machine and allow one day for reassembly the unit once transported to next location. This unit currently supplies canning factories with chilled kernel as a supplementary to their regular supply of raw corn. Razorback farms harvesting operation is similar to the method currently used by Simplot Harvesters. Transport of the corn from the paddock to the de kernelling unit is by means of semi trailer with a walking floor configuration. Therefore instead of utilizing tipping trucks the corn is shifted out the rear of the truck when backed up to the trailer containing the separators and huskers. With the de kernelling unit close to the harvest operation one prime mover to was able to utilse three semi trailers to supply the unit. One trailer in the paddock a second in transit and the third at the site of the de kernelling machine. Once at the site of the de kernelling machine the operation appeared to be relatively straight forward. With the current configuration Razorback Farms are able to produce 72.5t of chilled kernel in standard 14hr shift. At the time of observation the in field operation had a kernel recovery of 35%. The unit required 19 operators to process the sweet corn on a daily basis. 9 of these operators are required to manage 9 individual hand fed kernel cutting machines. Potential labor savings may be made if these kernel cutting machines were to be automated. No restrictions were in place to reduce the risk of foreign material entering the finished product. Ventilation for the operators was provided by large openings, hence potential entry point’s for contamination. It is foreseen that if such an operation were to be successful in Australian conditions then measures must be taken to seal the process from the external surroundings. As a result additional, improvements to the design of the unit would be required so that the risk of contamination is minimized, whilst maintaining a comfortable working environment.

Provisions for waste management in Australia need to be fully understood. Two by-products are produced from this de kernelling process being grey water and vegetable material such as husk, core of cob. Hence 208t of raw corn is processed in a standard 14hr shift. As mentioned previously the unit was operating at a 35% kernel recovery therefore producing 135t vegetable material waste on a daily basis. In addition to the solid waste 40,882L of grey water would be produced in a standard 14hr shift.

Conclusion

Two concepts of in field de kernelling have been considered. The key potential benefit of implementing such technology would be to reduce the seasonal influence of NSW supply on the processing window of the Bathurst factory. Secondary transport benefits may also be available if cost comparisons were carefully considered. Razorback farms demonstrated the concept of preference. Corn was de kernelled at a site in close proximity to the harvest operation. Chilled kernels were delivered to the processing factories packed conveniently in plastic lined 1t cardboard boxes. However it is suggested this method of in field de kernelling will require many alterations and improvements to suit conditions that exist in Australia. Concerns discussed here would need to be researched further prior to implementation of such technology

Results cont'd

2. Cost analysis of On-site Sweet corn cutting (Authors: S.Finn & J.Yost)

Introduction:

The following costs are based on installing equipment as used in the Razorback cutting system, described in the prior report, with some modifications which were considered necessary to adapt to Australian conditions.
The main additions and/or modifications to the equipment being used by Razorback Farms were;

1. Inclusion of a Green ear eliminator (to replace labour hand sorting corn after huskers)
2. Automatic CCM cutters (instead of hand fed cutting machines, to replace labour)
3. Seal units & air condition from outside environment, to ensure sanitary, food grade processing conditions.
4. Provision of safe and hygienic working conditions, including lighting, non-slip walkways, lunch room & toilets to appropriate Australian standards.

This cost analysis is performed at a high level and is based on a best estimate of the costs expected to be incurred using the observed Razorback system of de-kernelling.
The basic assumptions which are used to develop the cost model for the production of chilled kernel are built on the observed production rates and cross-verified against (where known) demonstrated rates and factory standards for the specific equipment involved.
The costing is not meant to be absolute and could be subject to challenge in many areas. However, it will provide a 'ball park' figure which can be subsequently compared to known factory standard costs to determine whether or not the proposal, as presented, has merit as to being a potential opportunity for future cost reduction.

Cost Workings:

a) Initial Capital Cost

Section 1: Transport of crop from field to plant.		**Sub-total**
3 x semi trailers with walking floors @ $70k. (Second hand)	$210k.	
1 x prime mover @ $220k	$220k.	
		$430 K
Section 2: Power plant and cooling.		
Diesel motor and fuel tank.	$35k.	
Splitter box.	$15k.	
Hydraulic pumps motor and valves.	$60k.	
Hydraulic tank and hoses.	$25k.	
Ammonia cooling plant.	$270k	
Water storage.	$30k	
Semi trailer to mount it on (second hand).	$60k.	
		$495 K
Section 3: Intake.		
Semi trailer with walking floor (second hand).	$70k.	
Shaker conveyors & Huskers	$163k	
		$233 K

Section 4: De-kernelling room.

Semi trailer.	$ 60k	
Green Ear Eliminator	$113k	
8 CCM auto feed cutters.	$ 508k	
		<u>$681 K</u>

Section 5: Chilling and cleaning.

Semi trailer.	$60k.	
2 x rotary barrel cleaners. @ $15k.	$30k.	
1 x chilled water tank.	$10k.	
1 x box filler.	$5 k.	
7 x Conveyors @ $6k.	$42k.	
		<u>$147 K</u>

Section 6: General Issues- GMP, Food Safety & OH&S issues

Electric lighting, air conditioning, non slip floors,
Walk ways, sealing between trailers, lunch room and toilets **<u>$ 200k.</u>**

Labour – initial cost to build.
(Estimate 6 people X 2 months X $80/hr. **<u>$ 170 K</u>**

Total initial capital outlay (inc. 10% contingency) = $ 2,691 K

<u>b) Direct costs incurred in operating the system</u>

Refrigerated transport, (based on 65% of current costs)	$ 17,500 /week
1 x waste water trailer hired. (effluent sprayed back on to field).	$ 2,000 /week
Clean water to run plant 50,000 litres per day X 5 days	$ 250 /week
Truck to cart solid waste, spread to field. Hired cost	$2,000 /week
Waste water disposal to environmental standards. Potential issue	$ 1,000 /week
1 x Harvester.	$30.00 per tonne
1 x Field bin and tractor. Hired.	$7.00 per tonne

Labour costs :
Wages=14 hours/day x $45 = $600 x 14 people : $8820 per day.
Wages based on 14 hour day at $30 per hour
plus overtime + overheads @ 30% = $45/hr

The operation would require 14 people made up of the following:-
1 x harvester operator.
1 x field bin operator.
1 x delivery truck driver.

1 x intake operator.
1 x husker operator.
2 x CCM operators.
1 x chiller operator.
2 x box filler operators.
1 x TA/ general assistant.
2 x fitters.
1 x supervisor

Accommodation and meals.
14 x $100 (based on corn harvest costs NSW.) $1400/ day

c) Indirect costs
Annual cost of shifting equipment to 3-4 sites throughout year;
7 x prime mover to move gear between districts
+ labour to disassemble & re-assemble at each site . $ 60,000 p.a.

Fuel oil and consumable costs, PPE $20,000 pa

Travel cost for the crew. $10,000 pa

Annual Maintenance costs $ 40,000 pa

Overall Cost Summary:

Cost	Direct costs (weekly based)	Indirect (fixed annual costs)	Comments
Refrigerated transport	$17,500		Based on $48/kernel tonne, conservative
Waste water truck	$2,000		
Clean water	$250		Conservative
Solid waste truck	$2,000		
Environmental compliance	$1,000		Conservative allowance
Harvester	$30,000		200t Raw corn /day X 5 days
Field Bin + tractor	$7,000		
Labour	$44,100		Based on 14 people, 14 hrs/day
Accommodation/meals	$7,000		
Shifting & dis/assembly		$60,000	Prime movers, transport
Fuel, oils & consumables		$20,000	Includes PPE, OH&S issues
Travel for crew		$10,000	Changing crews- different areas
Annual maintenance		$60,000	Conservative estimate – may double
Annualised capital cost (depreciation @ 10%)		$269,000	
Total	**$110,850**	**$419,000**	
Assumed Rate of kernel produced (tonnes)	*362.5*	*7,250*	*Based on 72.5 kernel tonne/day X 5 days, 20 weeks/year.*
Cost/ kernel tonne	$305.79	$57.79	
Total cost of kernel cutting, chilling & delivery	**$363.59**		
NB: No raw material cost included			

Discussion:

The initial capital outlay required to build a replica of the Razorback system, including improvements and additions as deemed relevant to our Australian standards and operating expectations, was evaluated to be in the order $2.69 million.
By normal factory standards, this figure is high, relevant to the capability and expected output of the line. This is primarily due to the need to build the equipment into a single functional line, but with the capability to be a mobile, modular system.
Of the $2.69million, in excess of $1 million of cost can be directly attributed to the requirement for mobility, so that the system could be moved to different geographic corn growing areas to take advantage of the available season spread.

The direct cost of producing cut and chilled corn kernels for subsequent freezing at the factory, is estimated at $305/tonne. It is difficult to put a precise figure on the cost of transporting chilled kernel to the factory. The best estimate is that the transport cost of cut, chilled kernels will be, at best, around 65% (on a kernel weight basis) of the cost associated with using the normal system of transporting whole cob to the plant for subsequent cutting. This assumption has been factored into the above costs.

The indirect costs developed in this model are estimated around $58 /tonne, based on a usage of 20 weeks each year, producing 7, 250 tonnes kernel annually. This number has a limited validity, as it is too hard, in this paper, to accurately present a valid comparison with the indirect costs associated with static factory production systems, as each factory will have its own unique operating environment and fixed cost structure.

Subsequently, the most valid use of this cost analysis, in the first instance, is in comparing the Direct operating costs of this system with those known at the factory.
Because disclosure of specific cost structures within the Simplot factory would contravene internal Simplot policies relating to confidentiality and Intellectual Property, these comparisons will only be made in a general sense for the purpose of this report.

Suffice to say, the direct cost as calculated in this analysis, i.e. $305/kernel tonne, is many fold the actual cost of cutting kernel at the Bathurst factory.
One of the potential benefits of this system was considered to be the opportunity to spread the load of inventory across the year by harvesting corn over a wider time-frame using available geographic spread.
The current cost of carrying frozen inventory to service customer requirements across the year is estimated to be around $250/tonne. The best this proposed system could provide would be to halve the average inventory load, saving a potential $125/ tonne.
Even when this benefit is written back against the cost of producing corn kernel, under this method the cutting cost is still several-fold (>2X) more expensive than that currently being incurred.

There are also other costs which have not been taken into account. These include the cost of bin usage (hire & un/loading in field and factory) as well as the potential for additional energy cost which may be necessary in raising the temperature of delivered chilled corn to the required blanching temperature, prior to freezing at the factory.

The conclusion is therefore that cost of kernel produced under this system will result in being more expensive, by a quantum in the order 2-3 times that currently being incurred.

Recommendation:

The expected benefits of the work were identified in the Project outline as follows:

The ultimate key outcome is the retention of the Australian sweet corn industry, through streamlined factory operations and improved production efficiency allowing an internationally competitive cost manufacturing base. This will be via:

- *Reduced raw material costs;*
- *Reduced capital costs;*
- *Less waste material;*
- *Lower freight costs; and*
- *Improved environmental management.*

When evaluated against the above criteria, it is clear that the Project failed to identify a potential opportunity to reduce the cost of corn kernel production using this system of in-field kernel cutting. In addition, there are still many unresolved issues which would need to be addressed, such as the maintenance of the desired organoleptic qualities of the cut corn during transport and handling as well as the effectiveness of controlling all of the potential food safety/ hygiene-related issues.

Subsequently, and as required by the expectations of the project outcomes, it is recommended that the Project VG06082 does not proceed to the second stage to involve more detailed analysis.