Automation of Western Rock lobster Processing

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Acknowledgments

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Non-Technical Summary

Automation of processing is widespread in many food production industries. Automation may reduce production costs and improve product consistency. The Western rock lobster industry is heavily reliant on manual handling. This study investigates options for automating processing of frozen rock lobster products. In particular, this study investigated the automation of the following:

- colour grading;
- washing of cooked lobsters; and
- wrapping of tails.

Whilst colour grading was found to be problematic, automated methods of washing of whole cooked and wrapping of tails were found to be applicable in the commercial environment. Basic cost/benefit analyses show that there were potential commercial advantages to automation of washing and tail wrapping under the industry conditions that prevailed when this project was proposed. However, recent changes in the management of the Western Rock lobster industry have resulted in dramatic reductions in the scale of frozen production. As a result, the commercial argument for automation of processing has been weakened greatly.

Background

Currently, labour costs in the Western rock lobster industry are high and availability of labour is extremely poor. This is especially problematic given the processing of Western rock lobsters is a highly manual process. Individual lobsters can be handled up to seven times from the point of receival to the finished product form. Reducing labour by mechanizing process steps may improve process (and product) consistency and (hopefully) profitability and reduce dependence on large numbers of casual untrained itinerant workers required for only short periods at a time. In addition, in recent years there has been an increased reliance on staff who speak only limited English or not at all. Difficulty in communicating makes training difficult and increases the probability for errors in production. Mechanisation also reduces the need for people to perform complex process steps, thereby reducing the potential for non-conformances in processing to occur.

This study focuses on the potential automation of three areas of lobster processing: 1) colour/vision grading, 2) washing the cook residue off boiled lobsters and 3) wrapping of Western Rock lobster tails.

Colour grading

Lobster colour is an important quality parameter for several markets, most notably the Japanese and Taiwanese markets. At present, colour grading is carried out manually, is purely subjective and relies on the grader's experience and perception. A human grader's subjective assessment of colour can change almost daily, depending on the range of colours of lobsters processed on any given day, against which comparative judgments are made. As a result, customers' expectations are sometimes not met, resulting in complaints.

Under GFC's present system, the colour of lobsters must be estimated accurately and identically at two points in the process: firstly, during wrapping and packing in cartons, and secondly during check weighing and labelling of cartons before strapping. Mislabelling or incorrect estimation of colour at the point of labelling provides further opportunity for errors. With the limited availability of experienced processing staff at present, the probability of errors under the current system is increased.

The problems with subjective colour grading are further exacerbated when adherence to a single standard is required across multiple processing sites. These non-conformance issues could be avoided if colour grading was automated and was carried out by objective vision grading systems.

The maximum benefits of mechanisation (specifically of weight grading) can only be achieved if colour grading can be automated. Initial discussions with two manufacturers of vision grading systems suggested it is technically possible, but requires significant validation and testing. Output from colour grading equipment must then be integrated with the decision-making software of a weigh grading system and correct sorting of lobsters demonstrated.

Washing

After cooking, Western Rock lobsters are often covered in a white congealed proteinaceous exudate. Washing this cook residue off boiled lobsters is currently done by hand. This is time-consuming work and uses vast amounts of water. In recent years, GFC has used an estimated 4-6 million litres of water/year. If a satisfactory solution can be found to automate this process, I estimate GFC would save an estimated $230,000 in labour each year and potentially 3-4 million litres of potable water (depending on configuration and potential for water recycling). Given that GFC accounts for approximately 64% of the industry, the total savings across industry are estimated to be $360,000 and 5-6 million litres of water.

GFC has established, from in-house research, that there is significant appendage loss during processing of boiled lobsters. Some of this is associated with poor handling during washing. If, for example, appendage loss during manual washing accounted for 50% of total appendage loss during processing of cooked lobsters and automation of washing could reduce this damage by 50%, it would be worth almost $50,000/annum in extra saleable weight each year plus an additional indeterminate amount for reduced downgrading of boiled lobsters with excessive missing appendages.

Wrapping of Tails

Currently Western Rock lobster tails (mostly destined for the US) are wrapped by hand. This is time consuming and the high turnover of casual, inexperienced workers currently occurring leads to reduced productivity and increased costs. GFC has been investigating options for automatically wrapping lobster products for some time now. One option under investigation is flow wrapping of tails. Small numbers (20-30 pieces) of flow-wrapped tails have been produced in the past, but not under hygienic processing conditions. On that occasion, both pillow packs and heat shrink-wrapped tails were produced. The shrink-wrapped tails were considered superior in appearance after frozen storage. In anticipation of this project, photographs of flow-wrapped tail samples were sent to US tail agents for preliminary feedback. As expected, the comments received back were wide-ranging and raised a number of issues for consideration. For example, the following comments were received: “customers that need to prepare larger volumes for banquets, events, etc., may find it difficult and time consuming to take the shrink wrap off the tail”, “They (the processor) will probably want more money to do this, am I right?” and ”They (the processor) need to be careful that it doesn't look like a customer opened the box and used saran wrap to wrap the tails” were three of the comments received. Issues for investigation include customer perception of packaging/presentation, ease of opening and potential for dehydration during frozen storage, labour savings and a cost/benefit analysis.

The estimated savings from automation of wrapping across industry are estimated to be in the order of $100-150,000/annum.

Cooking/Chilling

Currently, most cooking and chilling of lobsters is done using a batch process. This system allows great flexibility, which is useful given the large daily and weekly fluctuations in production volumes. The alternative to a batch system is continuous cooking and chilling. A continuous system may have advantages, in terms of reduced labour, decreased handling and damage, and improved control and consistency of the process. Some equipment manufacturers also claim improved recoveries with continuous systems. Such benefits have yet to be demonstrated in a large processing facility. In addition the large daily fluctuations in catch patterns mean that any automated cooking/chilling system has to be large enough to cope with the peaks. This applies to virtually all infrastructure in the WRL processing sector, resulting in significant overcapitalization and facilities only partially utilised for much of the season.

Need

There is much information available regarding the benefits of automation in food processing. Much of this information is supplied by equipment manufacturers and is therefore less than objective. In addition many of these claims are not supported scientifically or commercially and most equipment suppliers have had no experience with Western Rock lobster, so claims made based on other products cannot be extrapolated to the processing of Western Rock lobster. This project did investigate options for automation of Western Rock lobster processing from a position of commercial and industry knowledge and scientific expertise to produce definitive cost/benefit assessments. In addition, technical experts associated with the CRC, such as the UniSA and SARDI Research Fellows Muhammad Ashraf and Mohan Raj were written into the project by the CRC to give them additional experience and to provide technical expertise if required. The Fellows travelled to Geraldton several times throughout the project to familiarise themselves with Western Rocklobster processing and assist with the data collection. .

Objectives

1) To develop, trial and evaluate potential options for automation of Western Rock lobster processing

2) To make recommendations regarding future options for automation of Western Rock lobster

Methods

Colour Grading

A Colour Vision Systems Quantum Lite Vision System was integrated with a Linco 8 channel Compact Grader, so that lobsters could be graded by weight and colour (Fig. 1).

Fig. 1) The colour vision unit integrates with the Linco weight grader at Marine Terrace.

Only A and B grade (<571g) whole raw and whole cooked lobsters are separated in red and pink colour grades for sale and typically, the vast majority (<95%) of all frozen whole production is of A and B grade lobsters. The colour of whole cooked lobsters varies in accordance with variations in their shell colour when live/raw. A range of cooked lobster colours is presented in Fig. 2. Not all colours are present in all grades at any one time during the season. For example, during the "Whites" part of the season (typically, November – January), dark red lobsters are present in only very small quantities. In contrast, the very pale lobsters are practically absent during the latter part of the season (March – June).

When lobsters are packed into cartons, they are labelled as either Pink or Red. Red colour grades include colours 1-3 in Fig. 2 and Pink would be colours 4-8. To ensure a uniform appearance upon opening, lobsters of similar colour within the Red and Pink divisions are packed into separate cartons. As a result, there may be 3 "sub-grades" of Pink and 2 or 3 subgrades of Red.

Fig. 2) Variations in the colour of cooked Western Rocklobsters. Lobsters are labelled as either Red or Pink when packed into cartons. The demarcation between Red and Pink lies between colours 3 and 4 in this picture.

Vision Grader Function

At different times during the 2009/2010 season, trials were conducted to test performance of the grader, determine the function of the software, establish colour limits for each grade and examine the correlation of the vision grader output against the human grader decision. During each trial, a sample of whole cooked and washed lobsters was taken from standard production and was graded for colour by eye by an experienced factory grader. Lobsters were tagged, the human colour grade recorded and were then passed through the colour vision grader. The various colour parameters were recorded and correlations with the human colour grade investigated.

Cooked/Raw Correlation

Sample of whole raw Western rock lobsters (both genders, A and B grade, <571g) were taken from standard production and tagged using small numbered plastic tags secured to the lobsters around the body using rubber bands. The lobsters were sorted manually by experienced factory graders into light pink, dark pink, light red and dark red sub-grades. The raw colour grade for each lobster was recorded. The lobsters were then passed through the vision grader and the various colour quality parameters recorded for each lobster.

To establish if the raw colours correlate well with the cooked colours, the lobsters were cooked, chilled and washed according to GFC's Standard Work Instructions for whole cooked lobster before being passed through the vision grader again. The tags were removed each time before passing the lobsters through the grader to avoid any interference from the coloured tags and rubber bands.

Washing

Whole Western Rock lobsters (A and B grade; <571g) were euthanized, sorted, cooked and placed on ice slurry as per GFC's Standard Work Instructions for production of whole cooked lobster. After chilling, samples of lobsters were passed through the wash tunnel.

Throughout the 2009/2010 season a number of trials were conducted in which the function of the wash tunnel was tested. Specifically, the proportion of lobsters requiring reworking after passing through the tunnel was recorded. Specific trials were also conducted to determine the amount of appendage loss to lobsters during mechanical washing. Cooked and cooled lobsters were tagged, and inspected for damage prior to and after passing through the wash tunnel. Lobsters with more than one missing antenna, or more than 2 missing legs on one side of the body were downgraded to local grade with subsequent loss of value.

Wrapping of Tails

In June 2008, thirty 4.54 kg cartons of shrink-wrapped tails (of a range of sizes) were produced at GFC's Sultan Way Factory using an Ilapak Astra PC flow wrapper and inline Cryovac CJ51 heat tunnel. Tails were wrapped with Cryovac 19µm MRX heat shrink film (Fig. 3).

Fig. 3) Heat shrink flow-wrapped lobster tails.

The tails were produced using standard GFC production methods. After wrapping, tails were graded, packed and weighed off into batch weights, before being packed into cartons, which were then lidded, labeled, strapped and frozen to less than -18°C within 14 hours. Cartons of samples were stored at -18°C or lower until required.
In June 2009, cartons of samples were transported by refrigerated sea container to sales agents in the US at -18°C or lower. On arrival, all samples were kept in frozen storage until required.

GFC Research developed a standard questionnaire to present to long-term high volume end users of hand-wrapped Western Rock lobster tails. On behalf of GFC Research, GFC Marketing Executive, Mr Leith Pritchard coordinated customer evaluation of mechanically wrapped tails during his annual visit to the US in October 2009.

The product was presented to ten end users along with samples of standard hand-wrapped *Brolos*™ tails. Eight of the end users surveyed were Head/Executive Chefs, and two were processors. Nine of the ten respondents completed the written questionnaire (appendix 2).

Cooking/Chilling
All lobsters were cooked and chilled using a Standard Work Instruction shown in Appendix 3.

Results/Discussion

Colour Grading

A number of trials were conducted throughout the season. Between trials, gain settings and calibrations were changed on occasion, so that the results of multiple trials are not able to be combined, but rather are presented separately.
Initial trials showed the calibration of the colour vision unit was stable over a 72 hour period during which time the machine was left turned on. Over several 8-10h days of production, the vision unit was observed to correctly classify all lobsters according to the average intensity value assigned to each lobster by the unit. This information was successfully relayed to the Linco weight grader to correctly sort lobsters by the perceived colour and weight.

In February 2010, 134 cooked lobsters were separated into 7 colour groups by eye by two experienced factory staff. These groups were based on the way the staff would pack the lobsters into separate cartons.

When the groups of lobsters were sorted by the colour vision unit, there was significant overlap between colour groups, especially at the darker end of the colour range (Fig. 4).

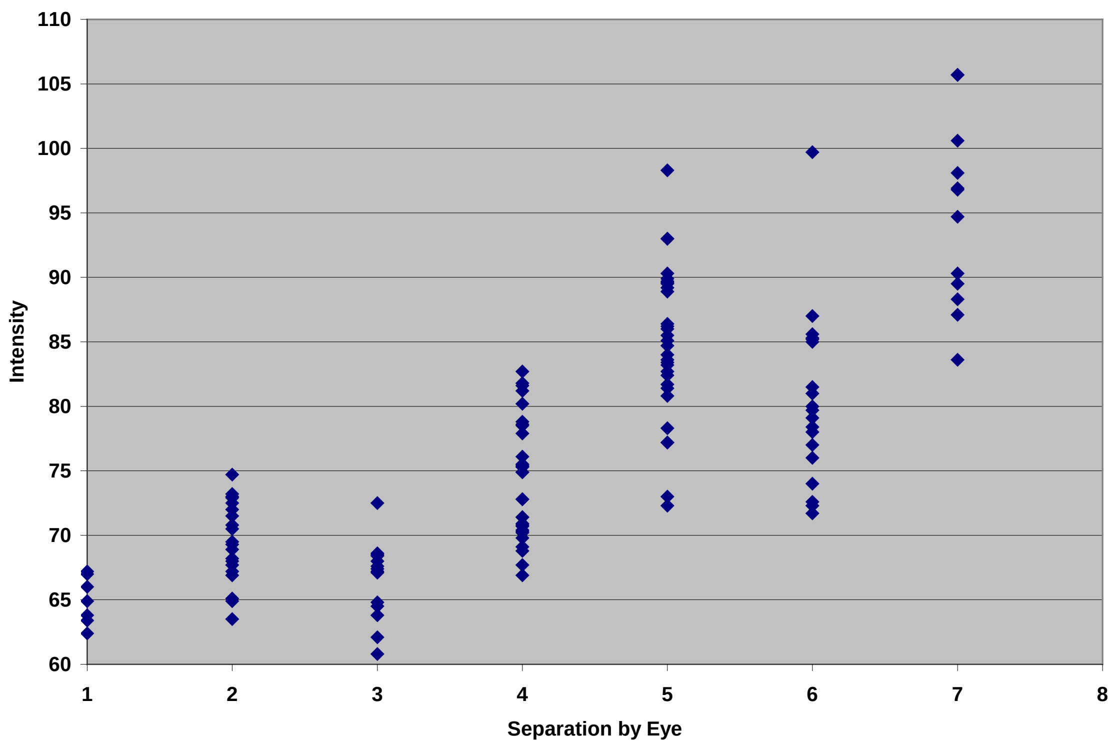

Fig. 4) The intensity average of whole cooked lobsters, as measured by the CVS colour vision grader plotted against colour grades assigned by eye. With the grading by eye, the lobster colour becomes paler as the number increases as shown in Fig. 1. The demarcation between red and pink lobsters was determined to be between grades 3 and 4.

Even though the lobsters were separated into seven groups, GFC only labels cartons of cooked lobsters as either Pink or Red. These are the only two colour categories recognized by customers and about which there is usually a price differential. The subdivisions are made merely to ensure uniformity of appearance within each carton. In this case the distinction between Pink and Red (as determined by the two staff) was between groups 2 and 3. The average intensities of groups 2 and 3 were 69.5 ± 0.7 and 66.5 ± 0.8, respectively. These are not significantly different ($p < 0.05$; Student's t-test, $t = 2.797$). This suggests that even at the coarsest level of colour separation required (i.e. red vs pink), the colour vision unit is not able to distinguish between variations identified by humans, or vice versa, or that perhaps the human grader and colour vision unit are using slightly different qualities to separate lobsters by. In any case, the integrated system was not correctly sorting lobsters by colour. Eventually the vision system was run in the factory to sort into red and pink only. Even at this coarse scale, the grader was not functioning adequately. This was clearly evident in the factory, when wrapping staff would frequently find lobsters in one colour group that were obviously more similar in appearance to those in the other group.

Initially the colour grader was set up to display average intensity only. The above results show that intensity was not useful for accurate colour separation, so CVS was instructed to alter the software so that all available colour parameters were displayed on the monitor. This allowed examination of the correlations between grade by eye and other parameters. At the time, CVS staff indicated they had already examined the other parameters and excluded them because they were of no additional benefit. The additional parameters were hue average, foreground hue and background hue.

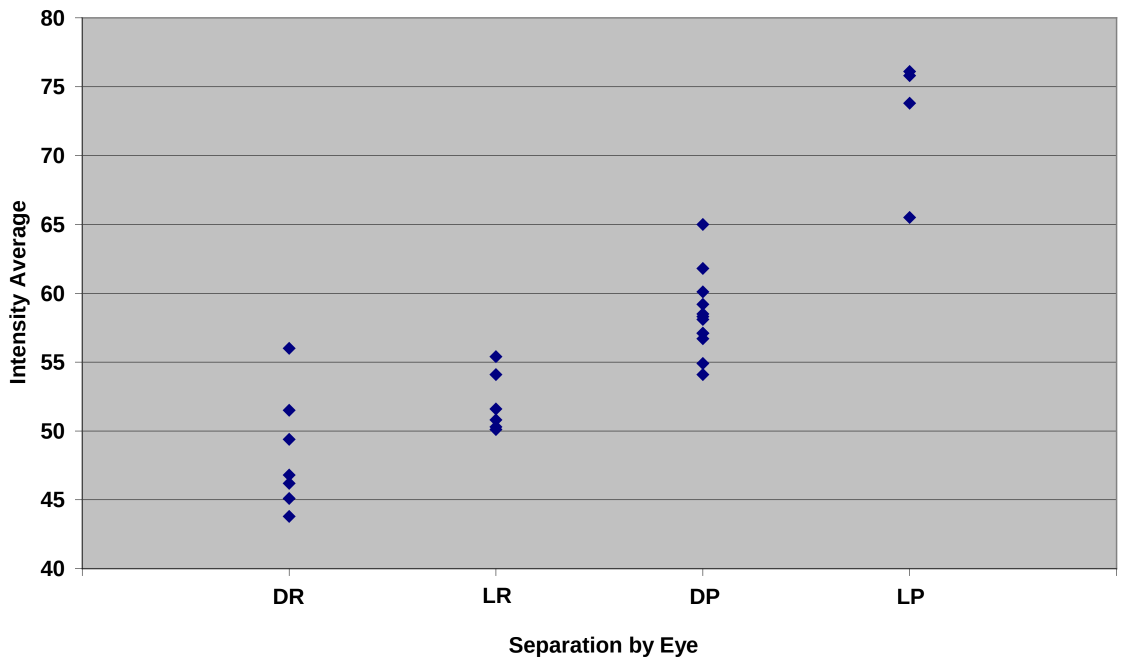

Fig. 5) The intensity average of whole cooked lobsters, as measured by the CVS colour vision grader plotted against colour grades assigned by eye. With the grading by eye, the x-axis labels are as follows: DR = dark red, LR = light red, DP = dark pink and LP = light pink.

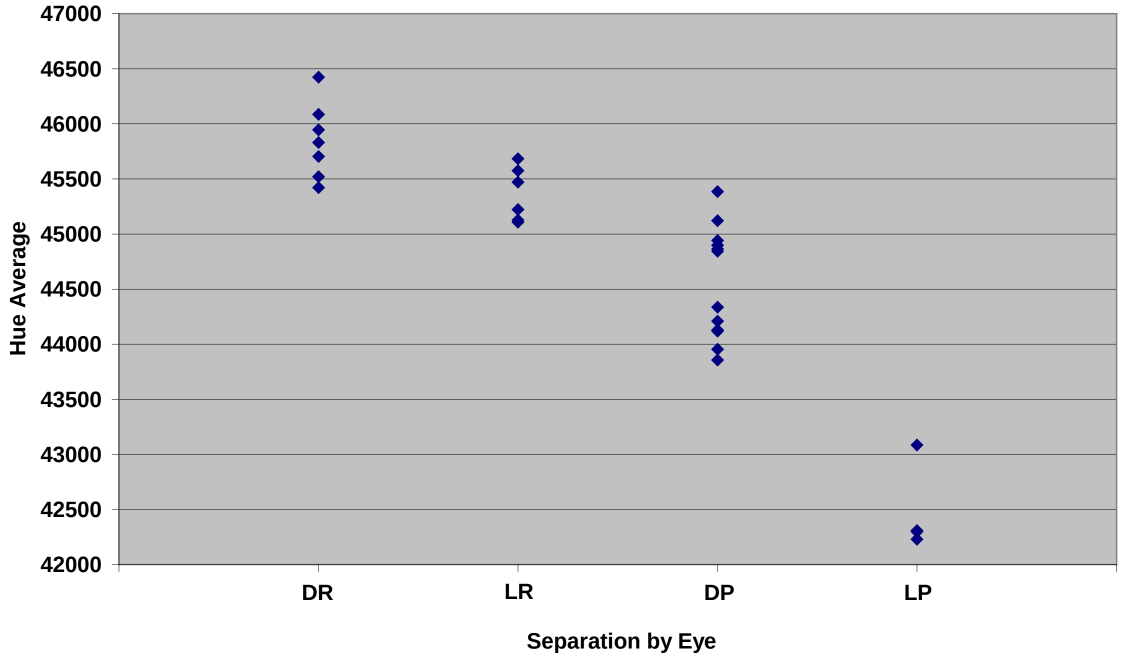

Fig. 6) The hue average of whole cooked lobsters, as measured by the CVS colour vision grader plotted against colour grades assigned by eye. With the grading by eye, the x axis labels are as follows: DR = dark red, LR = light red, DP = dark pink and LP = light pink.

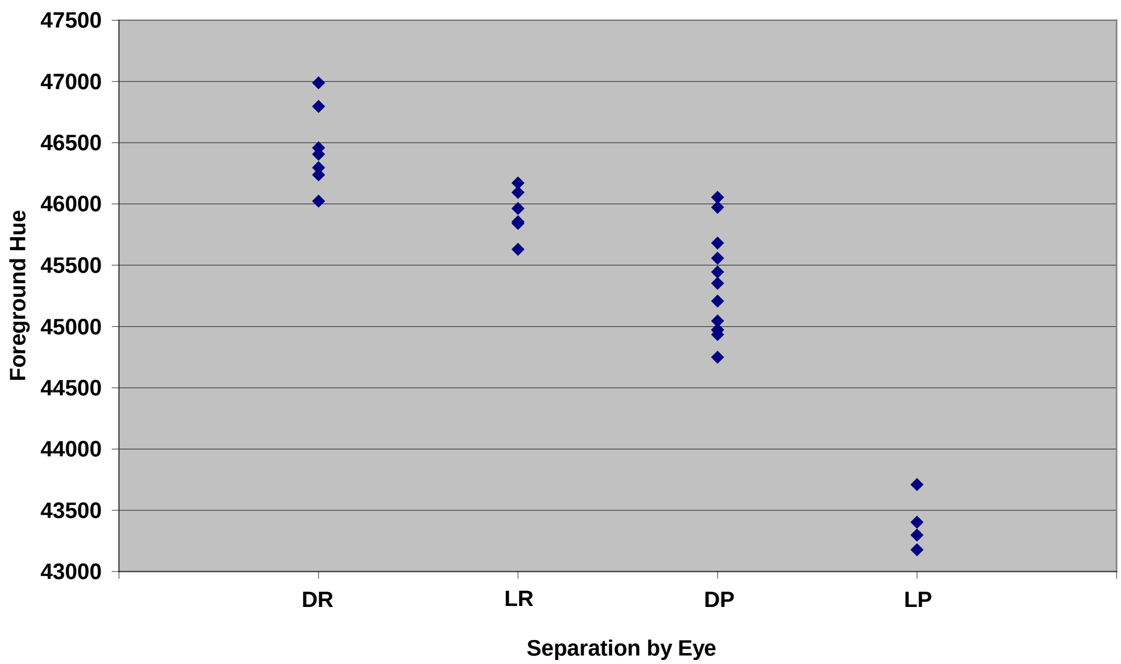

Fig. 7) The foreground hue of whole cooked lobsters, as measured by the CVS colour vision grader plotted against colour grades assigned by eye. With the grading by eye, the x axis labels are as follows: DR = dark red, LR = light red, DP = dark pink and LP = light pink.

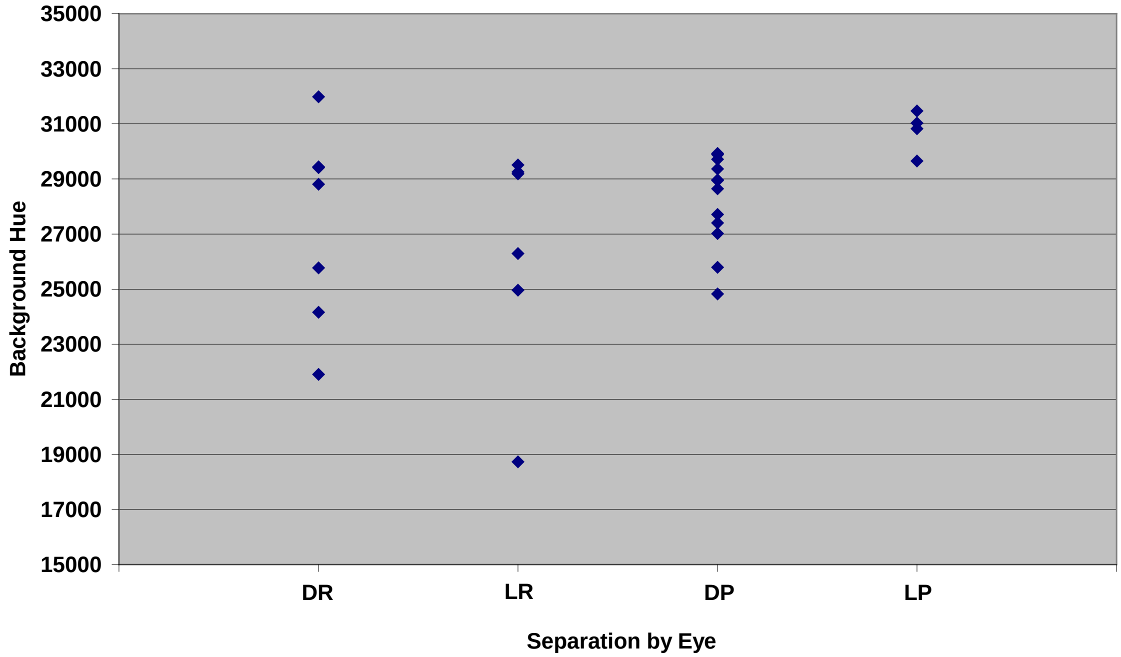

Fig. 8) The background hue of whole cooked lobsters, as measured by the CVS colour vision grader plotted against colour grades assigned by eye. With the grading by eye, the x axis labels are as follows: DR = dark red, LR = light red, DP = dark pink and LP = light pink.

From Figs 5-8, it can be seen that none of the additional parameters gives superior separation of the four colour grades separated by eye. The separation is especially poor, as the lobsters get darker and redder. This confirms the original suggestion by the CVS technicians that average intensity is as effective for colour separation as any of the parameters.

Cooked vs Raw Colour Correlation

As part of the investigation, one objective was to look at the correlation between raw and cooked colours of individual lobsters. If this relationship holds it may be possible to sort lobsters prior to cooking in the knowledge they will end up a certain colour after cooking. For example, a processor might wish to produce pink raw A grade and red cooked A grade. In this case, correct identification of the threshold colour between the two groups would have to be done prior to cooking and assumptions made about how the raw colour would translate to the cooked colour.

Fig. 9 shows the average intensity values of whole raw lobsters of a range of colours plotted against separation into colour grades by eye. As for cooked lobsters, it is clear the vision unit had difficulty separating the different raw colour grades as assigned by eye. In particular for this dataset, there was significant overlap between the Light Red and Dark Pink groups. This is the area of colour sorting, which is of most commercial interest due to the price differential that usually exists between “pink” and “red” lobsters of a given size. However, there may be no net economic impact caused by this overlap as some pink lobsters will be graded as red and some red as pink, i.e there may be no systematic bias to under- or overestimate colour. As previously reported, the data suggest that human graders are using cues other than simply colour intensity to separate lobsters. Trials have not been conducted to present lobsters sorted by the colour vision system to end users to gauge their reaction to the additional apparent variation introduced by automatic colour grading (i.e. is it acceptable or not to the market?). Even though the vision unit does not grade in the same way as a human grader, the final determination of what is acceptable must reside with the end users.

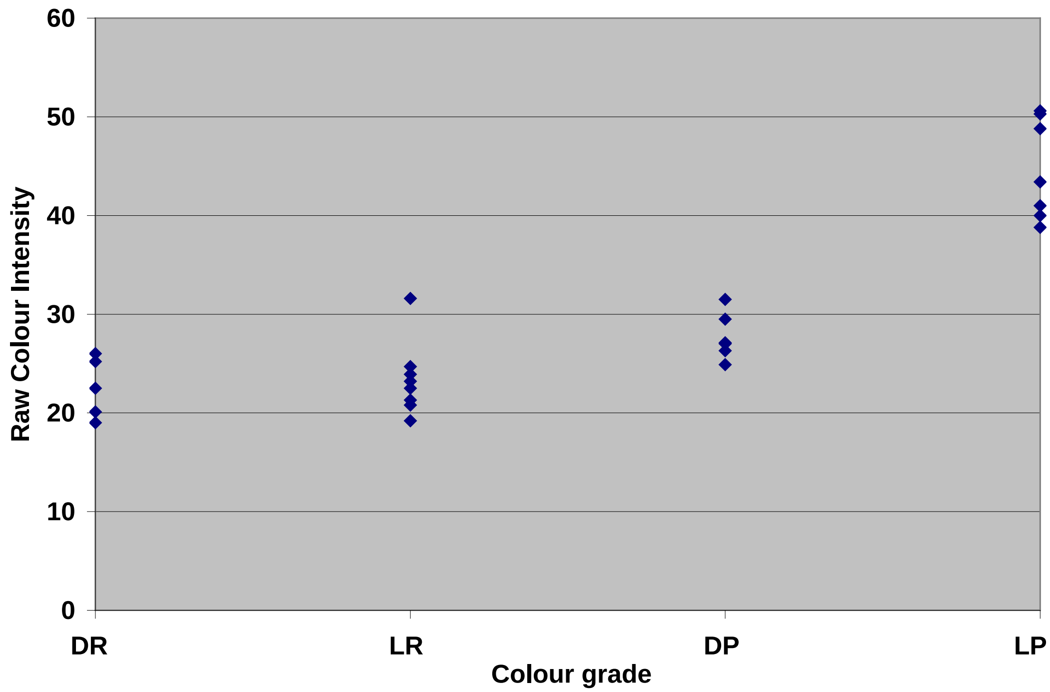

Fig. 9) The average intensity of whole raw lobsters, as measured by the CVS colour vision grader plotted against colour grades assigned by eye. The x axis labels are as follows: DR = dark red, LR = light red, DP = dark pink and LP = light pink.

Cooked average colour intensity could be predicted from raw average colour intensity (Regression, cooked average intensity = 0.9188 raw average intensity + 27.264; $r2 = 0.83$, $p<0.05$). This simply describes statistically what was already known. Raw colour has always been used to estimate the cooked colour of raw lobsters during initial grading of raw lobsters in the factories.

Additional information

The weight grader was extensively tested under commercial conditions, with throughput rates of up to 63 lobsters/minute achieved. This is well matched to the output speed of the wash tunnel ~59 pieces/minute, suggesting the two could be integrated to reduce labour further. The equipment was not fully integrated in the factory and the full benefits of doing so remain to be determined.

Modification of the takeoff chutes would be required to reduce damage to whole cooked lobsters. The gate mechanisms on the Linco grader were found to be too rough to handle whole cooked lobsters without causing significant damage. In trials, 7-10% of lobsters were found to have suffered some form of shell damage during grading (cracking, piercing, etc). This damage was mainly caused by lobsters dropping onto one another out of the gate. With the standard gates and chutes in place, some damage to legs and feelers was also observed, however this was minor. During one set of observations, out of 134 lobsters passed down the grading line, only 4 legs were broken off (0.03 legs/lobster). This rate of appendage loss was not considered excessive, however it is expected this could be reduced further with modification of the chutes.

Washing

The wash tunnel was in constant service for commercial production at GFC's Sultan Way site in the early part of the 2009/2010 season before being relocated to the Marine Terrace site in March 2010. Initial calculations based on the performance of the wash tunnel demonstrated significant savings in labour associated with washing of whole cooked lobsters (Table 1). The throughput rate for each staff member more than doubled.

Table 1. Example of payback calculation on automatic wash tunnel installed at GFC Sultan Way site. Based on an average hourly rate of $24.00

	# Lobsters @ 0.5kg ea.	Staff to wash	Total $/hour	Lobsters/min/staff member	lobsters/h	labour cost/annum
Manual	560,000	12	288	4	2880	$56,000
Automated	560,000	4	96	10	2400	$22,400

Saving/annum	$33,600	
Capital	$100,000	
Payback period	2.98	years

When the tunnel was first installed, rework rates were around 6% (i.e. 6 lobsters in every 100 required rewashing which was mostly done by hand). Improvements were made to the spray manifold and nozzle distribution and this reduced the rework rate to less than 3% (i.e. 3 lobsters in every 100 require some additional washing).

Water use (L/lobster) during washing actually increased by approximately 50% using the automatic wash tunnel (Table 2). Recycling of water was not trialled. The current low cost of scheme water and disposal of wastewater, coupled with the decline in frozen cooked production means there is little commercial incentive to attempt to reduce water consumption.

Table 2. Estimated water use of manual washing of Western Rock lobster compared with automatic washing. Note the total water flow for manual washing assumes the handguns are operating 75% of the time (16 L/min/handgun * 12 staff *0.75 of time operating = 144 L/min)

	l/min from each handgun	No. Staff washing	Total water flow l/min	Total water flow l/h	lobsters washed/h	l of water used/lobster
Manual	16	12	144	8,640	2880	3.0
Automated			180	10,800	2400	4.5

Initially the wash tunnel was set up with a large extraction fan ducted to the hoods covering the wash section of the conveyor. Despite these measures, the wash tunnel produced a large amount of atomization and mist in the factory. This was a concern both from food safety (aerosols) and occupational health and safety (so called “crab asthma”) perspectives. The tunnel was modified to further enclose the wash bay section and this was successful in largely eliminating the misting and removed the need for a large air extraction unit. This was a great advantage when relocating the tunnel.
The wash tunnel was moved to the GFC Marine Terrace site where it was tested for the remainder of the 2009/2010 season. Assessments of its performance showed average throughput speeds of 50-55 lobsters/minute and a rework (rewash) rate of between 1-2%.

Handling of whole lobsters by the automatic wash tunnel was found to be satisfactory. One hundred lobsters were tagged and leg and feeler loss recorded before feeding the tagged lobsters into the wash tunnel. The lobsters were collected after washing and appendage loss reassessed. No legs or feelers were lost during the washing process. However, it is obvious from the accumulated legs and feelers on the floor at the end of the wash tunnel that some damage does occur. The conclusion is that this rate of loss is very low.

Wrapping of Tails

The response to the shrink-wrapped tails was generally positive. Most (nine out of ten) end users thought the shrink-wrapped tails presented better, were better protected whilst wrapped and were at least as easy to unwrap as standard hand-wrapped tails (Table 3). Eight of the ten respondents thought the shrink-wrapped tails were in better condition upon opening.

The single end user who failed to complete the questionnaire was an Executive Chef who, upon first sighting the shrink-wrapped tails stated they would be too difficult to unwrap, before even attempting to do so. When encouraged to unwrap some shrink-wrapped tails, this chef did so quite easily. It was reported that “when pressed, he (the chef) admitted that if he received the shrink-wrapped product he would use it.”

Table 3) Average scores of respondents to questions regarding acceptability of shrink-wrapped and hand-wrapped tails. Respondents were asked to give products a score from 1 (worst) to 5 (best) for each category.

	Hand Wrap	Shrink Wrap	Responses (out of 10)
Wrapped Appearance	2.3	4.8	9*
Ease of Opening	3.0	3.2	9*
Protection of Product	2.3	4.9	9*
Condition after Opening	2.8	4.6	8**

* one respondent failed to complete questionnaire
** one additional respondent was unable to determine condition after opening

In addition, the shrink-wrap film was shown to be durable and maintained the integrity of the product during the 16 month (June 2008 – October 2009) period of frozen storage. There were no signs of freezer burn on any of the product.

Currently in GFC's production, seven staff grade and wrap a total of approximately 50 tails/min. With a flow wrapper in line prior to the tail grader, three staff should be able to manage the same throughput. On a 2800 tonne intake with 10% sent to tails, this reduction in staff equates to a saving of around $9.5K/annum. Quotes for the cost of a flow wrapper + heat shrink tunnel come in at approximately $200K - $220K. Clearly, based on the expected throughput, the payback is not attractive (~21 years). On the positive side, the flow-wrapped tails would be quite distinctive in the marketplace and desirable, but it is difficult to say if this would result in any extra revenue. On a return on investment basis, flow wrapping of lobster tails is uneconomic.

Benefits and adoption

This section needs to be prefaced by a discussion of the current state of the Western Rock lobster industry. When the proposal for this study was first developed, a significant proportion (about 60-70%) of the total industry production of about 11,500 t (6900 – 8050 t) was frozen. In subsequent years, the total catch of lobster has been reduced to 5,500 t as a result of poor larval settlement in the industry. As total annual catches have fallen, there has been a reduced need for frozen production. In the 2010/2011 season a quota system was introduced which eliminated the race to fish and has allowed fishermen greater flexibility to "fish to market". As a result, the percentage total frozen production has dropped dramatically to around 20-30% (1100 – 1650 t). This clearly shows that the need and opportunity for payback has reduced to around 10-15% of its previous scale. This series of events has factored greatly in considering whether it is beneficial to adopt the technologies evaluated in this study.

Colour Grading

Under the present operating conditions, there is no clear return on the inclusion of a $170,000 colour vision unit in the production line. It is not sufficiently accurate to separate lobsters into more than two colours. In addition, there is downstream opportunity for colour separation by staff at the wrapping benches, so there is no labour saving to offset the cost of the unit.

Washing

Automated washing clearly has a payback on the capital investment through increased productivity and reduced labour costs. GFC has implemented automated washing as a direct result of this study and now all whole cooked lobsters are washed mechanically.

Wrapping of Tails

The use of flow-wrapping to automate the wrapping of tails appeared workable. In general the reception of the product in the market was favourable. However, with the great reduction in tail production that has accompanied the reduced total annual catch and the move to quota, the capital expenditure on a flow-wrapper is difficult to justify, even on the scale of GFC's production (currently about 50% of the industry). Thus wrapping remains a manual task.

Further Development

No further development of the concepts tested in this study is planned. Without a significant increase in frozen lobster production, Should frozen tail production increase significantly back to levels similar to those prior to 2008, then automated tail wrapping may become economically viable.
Colour vision grading appears unworkable with the current technology, but may become feasible with further improvements in vision technology. Appreciable work would still have to be done to overcome the damage associated with mechanical handling by automatic weight graders of the types most commonly used.

Planned outcomes

The principal outcome was to demonstrate that automating elements of the processing of Western Rock lobster was financially viable. Viability was only achieved for automated washing of cooked lobsters and automated wrapping of lobster tails under the industry conditions. Recent changes in the management of the Western Rock lobster industry have resulted in dramatic reductions in the scale of frozen production. As a result, the commercial argument for automation of processing has been significantly weakened.

Conclusion

With the recent rapid changes to the Western Rock lobster industry, the incentive to invest in automation of production of frozen products has diminished greatly.
No economic benefit of automated colour grading could be demonstrated and the colour grader was unable to separate colours adequately. There is opportunity to grade manually at wrapping step so no labour saving could arise from insertion of a colour

grader further up the process. Mechanical grading by weight is a separate consideration and does not require a colour vision unit to be effective.

References

No references were used in the preparation of this report.

Appendix 1: Intellectual Property

It has been identified that no new intellectual property was developed from the workshop.

Appendix 2: Questionnaire for tail wrap evaluation

Geraldton Fishermen's Co-operative Ltd

Tail Wrap Evaluation

Company Name: **Date:**

Name of Respondent: **Position:**

1) Please give each of the following a score between 1 and 5 (circle one)

Wrapped Appearance					
Standard *Brolos* Hand Wrap	**1 (best)**	**2**	**3**	**4**	**5 (worst)**
Shrink Wrap	**1 (best)**	**2**	**3**	**4**	**5 (worst)**
Ease of Opening					
Standard *Brolos* Hand Wrap	**1 (best)**	**2**	**3**	**4**	**5 (worst)**
Shrink Wrap	**1 (best)**	**2**	**3**	**4**	**5 (worst)**
Protection of Product					
Standard *Brolos* Hand Wrap	**1 (best)**	**2**	**3**	**4**	**5 (worst)**
Shrink Wrap	**1 (best)**	**2**	**3**	**4**	**5 (worst)**
Condition of Product After Opening					
Standard *Brolos* Hand Wrap	**1 (best)**	**2**	**3**	**4**	**5 (worst)**
Shrink Wrap	**1 (best)**	**2**	**3**	**4**	**5 (worst)**

Which Wrap Do You Prefer? (tick one)

Standard *Brolos* Hand Wrap ☐ **Shrink Wrap** ☐

Please Briefly Explain Why ____________________

2) Would you be willing to receive all future product shrink wrapped? Yes / No (please circle one)

If you answered "No", please give reason(s) ____________________

3) Are there any other comments you would like to add?

Appendix 3: Cooking and Chilling Standard Work Instruction

STANDARD WORK INSTRUCTION FOR PRODUCTION OF WHOLE BOILED FROZEN LOBSTER AT ESTABLISHMENT 832

SWI: 832 WB ver 8

Issued: June 25, 2012

Approved By:

Objective: This work instruction explains the process for production of *Brolos* whole cooked frozen lobsters at Establishment 832.

Tasks:

1. FILL Cookers to designated level with potable tap water. There should be 320 L of water in each cooker. Add fine salt to achieve a final concentration of 25 ppk (i.e. 8 kg/320 L). Start burners.

2. DROWN Live lobsters in potable water at ambient temperature. Leave lobsters in the water at ambient for no more than an hour (if lobsters are to remain in the drown water longer than this, refer to the Work Instruction for icing down for instructions on how to handle the lobsters.

3. GRADE Drowned lobsters out of drowning tubs according to the following criteria:

- **Boiling:**

  - No more than 3 missing legs (can all be on one side) or 1 missing feeler (the base of the feeler, the "horn" must be intact)

  and

  - Membrane between tail and head must be visibly swollen after drowning (Figure 1), unless sodium metabisulphite has been used in drown water. If sodium metabisulphite has been used, the lobsters will not be noticeably swollen. In this case, swelling can be disregarded as a criterion for cooking. The blood inside the swollen membrane should be clear. It may have a grey-blue colour. This is normal. There should be no brown discolouration of the fluid inside. The two bands of muscle visible should be translucent and not milky white.

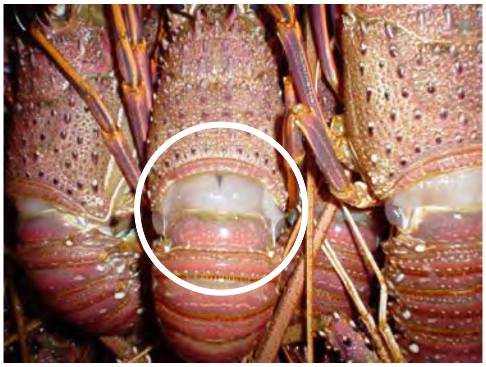

Figure 1. Swollen membrane after drowning

  and

  - No obvious blemishes or cracks on shells

- **Tailing:**
    - More than 3 legs missing and/or more than one missing feeler

    or

    - Membrane between tail and head is not swollen after drowning

    or

    - Blemishes or cracks on the shell.

4. PACK Pack A & B grade lobsters into kibbles together for cooking. If C and D grades are to be cooked they should be packed into separate kibbles. Lobsters must be placed neatly with legs pointing forward and tails curled directly underneath the body (i.e. not twisted to one side; Figure 2). Each kibble should be loaded with 30 kg of lobsters.

Figure 2. Lobsters packed in kibble with tails directly under bodies and legs pointing forwards.

5. COOK Once the water in the cooker is boiling, load the kibbles into the cooker. Turn the timer on immediately. The timer will start straight away. Cooking times are the same for all cookers and are constant for each grade, irrespective of starting product temperature. Cook times are as follows:

- A/B 24 minutes
- C 29 minutes
- D 34 minutes

6. ICE While the lobsters are cooking, add sufficient fine salt to each slurry trough to achieve a final concentration of 10 ppk (i.e. 10 kg/1000L), and fill the troughs with the required amount of potable water. Turn on the aeration. Add sufficient crushed ice to the troughs to bring the temperature of the water to below 4°C. Ensure there is excess crushed ice in the troughs at all times and the aeration is turned on. The slurry temperature should be below 4°C before any lobsters are added. If the temperature increases to greater than 4°C, add more ice.

7. SLURRY When the cook timer alarm sounds, remove the kibble from the cooker immediately. Immediately place the kibbles into the ice slurry. Record the time in on Form 028 Cooking Cooling Record.

8. ICE The slurry temperature should be maintained below 4°C at all times. If the slurry temperature exceeds 4°C, add more crushed ice to bring the temperature down.

9. WASH After a minimum of **40 minutes** in the ice slurry, remove the kibble from the slurry. Record the time out on Form 028 Cooking Cooling Record. Measure the core temperature of 2-3 randomly selected lobsters by inserting a penetration thermometer into the lobster's head via the mouth. Record the temperatures on Form 028 Cooking Cooling Record. Individually wash all lobsters to remove all cooking residue from the shell (Figure 3). Ensure lobsters are washed under the tail. Take care not to damage legs and feelers.