final report

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Time Domain reflectometry equipment for measurment of lean meat content

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TABLE OF CONTENTS

AMT
AUSTRALIAN MEAT TECHNOLOGY

EXECUTIVE SUMMARY

The aim of this stage of the project is to evaluate the market potential for the use of time domain reflectometry (TDR) technology as a method of measuring chemical lean.

A survey was conducted by Jodie Brown of Mt. Lawley W.A. of a cross-section of abattoir and independent boning rooms. The survey results clearly demonstrate a strong industry interest in obtaining a cheaper method of measuring chemical lean. The cost benefits of the TDR system over the current microwave/coring method of determining chemical lean were found to be substantial; cost savings in labour alone allowing for a payback of equipment costs within 12 months for small to medium sized operators.

Based on the estimated selling price, an initial market adoption rate of 70% of export boning rooms for the TDR system was established. This equates to approximately 60 plants. There is also a large secondary market of domestic boning rooms and meat processors, but the adoption rate in these markets is expected to be much lower and slower.

On the basis of the TDR research and market survey results, it is recommended that the project proceed to the development of a commercial prototype.

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PROJECT OBJECTIVES

The overall objective of the project is to develop a commercially viable method of measuring the chemical lean in cartoned manufacturing meat using time domain reflectometry (TDR) technology.

The specific objective of stage one is to conduct a detailed analysis of the market potential of TDR for chemical lean analysis.

BACKGROUND

Measurement of Chemical Lean

The chemical lean of cartoned manufacturing meat is currently determined in most small and medium sized plants by drilling 10 cores from a random selection of cartons produced, pooling cores from groups of 5 to 10 cartons, mincing them and drying samples in a microwave oven. Coring and analysis is both labour intensive and time consuming, leading plants to restrict sampling to the minimum required. There is a mandatory requirement in export plants to sample at least 5% of cartons of each type or grade of manufacturing meat produced. However adherence to this minimum requirement does not provide a statistically acceptable level of confidence that the product will meet the chemical lean specifications. This leads to the "giving away" of lean meat and to claims from customers for incorrect labelling, costing the industry millions of dollars.

Other technologies are available, but are rarely used as they still require the carton sampling step and are more expensive than the microwave drying technique. In some larger plants, every carton is measured on-line using the EMSCAN MQ27 which at over $150,000 is restricted to only those larger operators. There is a real need for a cheap (around $20,000) but accurate technique for the non-destructive on-line assessment of chemical lean in cartoned meat. Such equipment would be well suited to the small to medium-sized boning rooms.

Time Domain Reflectometry

Time domain reflectometry (TDR) is a widely used method of measuring moisture in soil and has been applied to the measurement of moisture in grains, dried fruits and other porous materials. A strong linear relationship has been established between the TDR measurements and the lean content of minced meat. A single probe unit has been developed and optimised for use in meat. This has been used to evaluate the TDR technique for its suitability for estimating lean content in cartoned manufacturing meat.

The TDR system which has been developed can determine the average chemical lean for a carton in around 1 minute, based on 10 determinations. The time could be further reduced if a multi-probe head was used. The TDR technique is equivalent in accuracy to the coring and microwave drying method for determination of lean content of cartoned manufacturing meat. It is therefore applicable for use in a similar manner to the present coring technique.

Alternatively the TDR system would allow the testing of a far greater percentage of cartons increasing the accuracy of chemical lean testing and thereby reducing the amount of lean meat "give away" and incorrect fat claims.

Target Market

From the points above, it is anticipated that TDR will be used to test a proportion of cartons, the speed of operation making it possible to test a larger number of cartons than is currently possible with the microwave/coring technique. It is also anticipated that the cost of testing would be reduced considerably due to the reduced time and labour input required. It is anticipated that up to 300 cartons per day of manufacturing meat could be measured using a hand held probe.

Based on these assumptions the potential users of this equipment fall into three categories - independent boning rooms, boning rooms attached to abattoirs and meat processors. There are both domestic and export licensed plants in each of these categories. The estimated total numbers of plants in each category are listed below.

Table 1: Potential purchasers of the TDR technology

Plant type	*Export*	*Domestic*
Independent boning room	32	>30
Boning room attached to abattoir	51	22
Meat Processors	59	>100

All plants currently using the microwave/coring technique will be potential purchases. Currently only about 15 large plants use the automatic noninvasive equipment such as the EMSCAN MQ 27.

Some meat processors currently check chemical lean of incoming product as part of their quality control procedures. However as a large proportion of their product is received in frozen form, unsuitable for testing with the TDR system, processors are not considered a major potential market at this stage. The main target market initially will be the export independent and abattoir boning rooms where there is a mandatory testing requirement, followed by the larger domestic independent and abattoir boning rooms.

RESEARCH METHODOLOGY

Industry Survey

A survey questionnaire was produced, see Appendix 1, and circulated to 32 meatworks and boning rooms representing a cross-section of the Australian establishments and including those in the top 25 plants. The questionnaires were numbered to allow for telephone follow up by Jodie Brown of Mt. Lawley, WA to ensure a minimum response rate of 50% and to check for nonresponse bias. The questionnaires were personally addressed to the Plant or Quality Assurance Manager at each plant as these are the people responsible for chemical lean testing and therefore have the main influence in any purchasing decisions relating to chemical lean testing.

The aim of the questionnaire was to ascertain the cost to the plant of the present coring and microwave drying technique and the attitude of the plant to the TDR technique. The cost of the existing chemical lean testing included the direct sampling costs together with an estimate of the cost of fat claims and the incidence of packing "over-lean" to avoid claims.

Estimates of the likely selling price were included and based on this information plants were asked their likelihood of purchasing a TDR system.

Equipment and Sampling Costs

The Tektronix TDR units used in the initial research cost around $12,000. The likely selling price of the TDR system has been based on the cost of the recently developed Campbell Scientific units anticipated to be about $6,000.

A hand-held probe is estimated to cost $800, with a multi-probe head to cost in the region of $4,000. A Pentium-based notebook computer would cost in the region of $3,000. The total cost to assemble a single probe system would be $9,800 and a multi-probe system $13,000.

Based on these costs, a final price for the complete systems was estimated to be $18,000 - $22,000 for the single probe and $25,000 to $30,000 for the multi-probe systems.

In terms of sampling costs, the only cost once the equipment has been purchased is labour. Sampling costs were therefore calculated from the sampling times achieved during the research. The time to sample one carton using a single probe would be 1 to 1.5 minutes. Allowing for some additional time to key in data 50 cartons could be tested in 90 minutes. Therefore in a 7.5 hour day up to 300 cartons could be tested by one person.

Based on an employment cost of $35,000 per annum the cost of chemical lean testing using the TDR equipment would be $27.00 per 50 cartons. This estimate is possibly on the high side as the job could be performed by a junior at $18,000 p.a. plus on costs.

RESULTS

Eighteen completed surveys were returned, giving a 56% response rate. Telephone contact was made with the plants which had not responded to ensure that their reaction to the new technology was in line with that of the respondents.

Current Situation

Production levels of the plants surveyed ranged from 0 to 1,000 cartons to over 6,000, with the majority (72%) processing less than 2,000 cartons of manufacturing meat per day. Two plants had MQ27 systems for measuring chemical lean and one was currently installing a MQ27 system. The remaining 83% of plants used the microwave/coring technique. Only 20% of plants tested more than 5% of their daily production levels.

Product Need

All except one respondent said they would measure more cartons if a cheaper method of chemical lean measurement was available. The one respondent who gave a negative response to this question was already measuring 90% of production with the MQ27 system.

77% of respondents occasionally or more often supplied higher chemical lean to avoid excessive fat claims. The majority of plants received 1 to 10 claims a year for incorrect % fat.

Excessive fat claims are currently estimated to cost plants between $1,000 and $35,000 per year. For plants producing less than 2,000 cartons of manufacturing meat per day, the average cost of excessive fat claims is $6,700 per year. As production increases, the cost of excessive fat claims also increases. Where a larger percentage of throughput is tested, as in plants using MQ27 systems the cost of excessive fat claims is reduced.

These results support the original concept that there is a need for a cheaper, rapid method of estimating chemical lean.

Cost Effectiveness

In terms of cost of testing for chemical lean the figures quoted in the survey ranged from $25,000 to $1.5 million. For plants producing less than 2,000 cartons per day the average cost of measuring chemical lean was $54,000 per year. On average these plants test less than 7% of production. By comparison for a plant with a throughput of 1,000 cartons a day to test 7% of production with the single TDR probe system would cost less than $10,000 per annum.

For $35,000 per year, a plant processing 1,000 cartons per day could measure 30% of its production with the single TDR probe system. This would significantly reduce the likelihood of incorrect fat claims and the need to supply 'over-lean' cartons, leading to considerable cost savings.

Table 2 gives a comparison of the estimated cost of measuring 5% of production using the microwave/coring method and the TDR method. These figures are based on the results of the survey and the labour cost estimates for a single probe TDR system as previously outlined. The table clearly demonstrates the cost advantages of the TDR system over the microwave/coring method. Based on these results the purchase cost of a TDR system would be recouped within 9 months for plants producing 1,000 cartons per day and within 5 months for plants producing 2,000 cartons per day on labour savings alone.

Table 2: Comparison of annual costs of measuring chemical lean

Production	Cost of Measuring 5% of Production	
	Micro/Coring	TDR System
1,000 cartons/day	$39,000	$6,750
2,000 cartons/day	$77,500	$13,500

Market Acceptance and Adoption Rate

Finding an alternative method of measuring chemical lean was considered very important by 76% of respondents, while 94% were very interested in receiving more information on the TDR probe. These figures reaffirm the importance of finding a cheaper method of chemical lean testing.

In terms of adoption rate Table 3 gives a summary of the results of the survey.

Table 3: Propensity to purchase a TDR probe.

Current method of CL measurement	Definitely would purchase	Probably would purchase	Undecided	Probably would not purchase	Definitely would not purchase
Micro/Coring	4	6	3	1	1
MQ27	2	1			

The two boning rooms who gave a negative response both produced less than 1,000 cartons per day and the cost of the TDR system was cited as the reason by one respondent.

It is interesting to note that all the respondents with MQ27 systems were potential purchasers of TDR systems.

Based on these results a conservative estimate of the adoption rate for export boning rooms would be 70%. There are approximately 85 export accredited boning rooms in Australia, giving an initial potential market of 60 plants. Some of the larger throughput plants may require more than one TDR probe.

The adoption rate for domestic boning rooms is expected to be lower due to the fact that there is not a mandatory requirement for testing and the small size of many of these plants. There is estimated to be about 40 domestic boning rooms with a significant throughput that would be potential customers for the TDR technology.

In terms of probe type, there was greatest interest in the multi-probe system with over 50% of respondents indicating that this would be the probe they would be most interested in purchasing, compared with only 11% indicating interest in the single probe.

PEOPLE ISSUES

Industrial relations

It is envisaged that the TDR system will be used to increase the percentage of product tested, producing savings by decreasing incorrect % fat claims, reducing the need for supplying 'over-lean' cartons and removing product losses from testing. However it is possible that some plants will use the system to reduce labour inputs and this could result in individual site IR issues.

Occupational Health and Safety

There are a number of OH&S concerns associated with the microwave/coring method for testing chemical lean, most associated with strain injuries during sampling and the possibility of injury from the coring drill. The TDR system will have the same OH&S problems with sampling as the microwave/coring. However the survey also found a number of operators had OH&S problems in the laboratory, such as burns, cuts from beakers etc and these would be eliminated with the TDR system.

CONCLUSIONS

The TDR system appears to fit a strong market need for a cheaper rapid method of determining chemical lean in manufacturing meat. The cost benefits of the TDR system over the current microwave/coring method suggest that the system will be extremely beneficial to the industry, in particular export boning rooms. Industry adoption, among export boning rooms, is expected to be rapid once a commercial prototype is developed.

RECOMMENDATIONS

Progress to Stage 2 of the initial proposal, construction and evaluation of pre-commercial models.

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Appendix 1

Survey Form

Company Code No.

APPLICATION OF TIME DOMAIN REFLECTOMETRY TO THE MEASUREMENT OF CHEMICAL LEAN IN CARTONED MANUFACTURING MEAT

1. What is your average daily plant production of cartoned manufacturing meat?

   - 0 to 1,000 cartons ☐
   - 1,001 to 2,000 cartons ☐
   - 2,001 to 4,000 cartons ☐
   - 4,001 to 6,000 cartons ☐
   - Over 6,000 cartons ☐

2. How is chemical lean currently measured in your plant?

   _____

3. What percentage of the cartons of manufacturing meat do you currently sample for chemical lean testing?

   _____

4. If a cheaper more efficient method of chemical lean measurement was available would you measure more cartons?

   - Yes ☐
   - No ☐
   - Don't Know ☐

5. Do you ever supply higher chemical lean than required to avoid claims for excessive fat?

   - Never ☐
   - Occasionally ☐
   - Sometimes ☐
   - Often ☐
   - Regularly ☐

6. On average how many claims for incorrect % fat would you receive per year?

Less than 1 ☐

1 to 10 ☐

11 to 20 ☐

More than 20 ☐

7. What is your estimate of the cost, in terms of direct cost and staff time of these claims?

_____

8. What, if any, occupational health and safety problems do you have with your current chemical lean testing method?

In Sampling? _____

_____

In the Laboratory? _____

_____

9. What would you estimate to be the cost of determining chemical lean in your plant, on a yearly basis, including capital and maintenance costs, direct labour costs, giveaway costs, and material costs?

_____

10. How important to your plant is finding an alternative method for determining chemical lean ? (Tick your response)

Very Important *Very unimportant*

☐ ☐ ☐ ☐ ☐

1 2 3 4 5

11. How interested are you in receiving more information on the development of the TDR probe. (Tick your response)

Very Interested *Very uninterested*

☐ ☐ ☐ ☐ ☐

1 2 3 4 5

12. It is estimated that the selling price of the TDR system, including probe, computer and TDR generator for measuring carton chemical lean using a single probe will be $18,000 to $22,000. A multi-probe head system will be $25,000 to $30,000.

At this price what would you estimate to be your company's likelihood of purchasing a probe. (Tick the most appropriate response)

- Definately would purchase ☐
- Probably would purchase ☐
- Undecided ☐
- Probably would not purchase ☐
- Defintely would not purchase ☐

14. Which system do you think your company would be most interested in purchasing? (Tick one)

- Single Probe System ☐
- Multi-Probe System ☐
- Dont't know ☐
- None ☐

Do you have any comments you would like to add?

_____

_____

Thank you for your participation.