final report

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Business development & facilitated adoption of NIR measurement of key eating quality traits

Phases 2 & 3

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Abstract

NIR is one of several spectroscopic tools for determining chemical and physical properties of food and food products covering an electromagnetic spectrum from 780nm-2500nm. NIR has been shown to measure fat, moisture and protein content of meat. NIR allows a non-destructive multiconstituent chemical analysis in just a few seconds. The NIR technology provides many of the key attributes needed for rapid process control being; intrinsically safe, rugged and easy to integrate into a system.

Park et al. (1998)[1] amongst others have identified near-infrared reflectance as a method for predicting beef tenderness. The release of a commercial application for beef tenderness testing, QualitySpec, was announced in 2007[2]. The US company, Analytical Spectral Devices, Inc (ASD) is the manufacturer of this instrument that claims to allow the processor a real-time, non-invasive, indicator of the tenderness of the meat. However, there are limitations in the accuracy and predictability of the US technology given that it is incompatible with Australian processing and grading systems. In particular, this measurement predicts objective tenderness at 14 days post-mortem for one Bos Taurus cut only.

The cattle in Australia are Bos Indicus thus the algorithm developed by ASD is not applicable in Australia. Research on the application of Near Infrared (NIR) Spectroscopy, jointly funded by MLA and MWNZ, has produced results which indicate that there is significant potential to use this technique as a high quality on-line measurement technology. It is particularly useful in assisting the determination of eating quality attributes including tenderness, juiciness and other quality traits that consumers relate to either a good or bad meat eating experience.
The overall aim of the projects to date has been to develop an on-line commercial method on at least one measurement site to accurately and reproducibly measure specified quality and/or eating quality traits on beef carcasses or meat portions using commercially available VISNIR technology. Research jointly funded by MLA & AgResearch into measurement of beef eating quality traits using Near Infrared Spectroscopy (NIR) was completed in September 2009 (phase 1). A summary of the results and insights to date, revealed at an NIR technical review meeting in July 2009 is presented below:

NIR capability	Process		Measurement	Stage of development (R^2)*	Market Ready
	Slaughter (hot carcase)	*Chiller (cold carcase)*			
Meat colour	✓		PREDICT	TBD	
Marbling	✓		PREDICT	TBD	
Ossification	✓		DIRECT	TBD	
pH_u	✓		PREDICT	67%	
pH decline	✓		PREDICT	TBD	
Meat colour (MSA)		✓	DIRECT	69%*	
Meat colour (Hlab L)		✓	PREDICT at 14days	71% L**	
Marbling		✓	DIRECT	81%	
Ossification		✓	DIRECT	92%	
pH_u		✓	DIRECT	86%	
Purge		✓	PREDICT at 14days	31%	

Hot grading → Marbling, Ossification
Filter dark cutters → pH_u
Objective grading → Meat colour (Hlab L), Marbling, Ossification, pH_u, Purge

A target R2 of 90+% and/or the measurement accuracy of the NIR method is equal to or better than that of the conventional method
***Combination of labour, cost reductions, carcase yield and/or quality/value increase*

[1] *Park et al. (1998), "Near-Infrared reflectance analysis for predicting beef longissimus tenderness", J.Anim. Sci. v76, p2115-2120*
[2] Food Australia March, 2007, page 78

The NIR results for colour compared well against the MSA standard:

Performance of the NIR (ASD) unit according to MSA colour standard for graders[3]

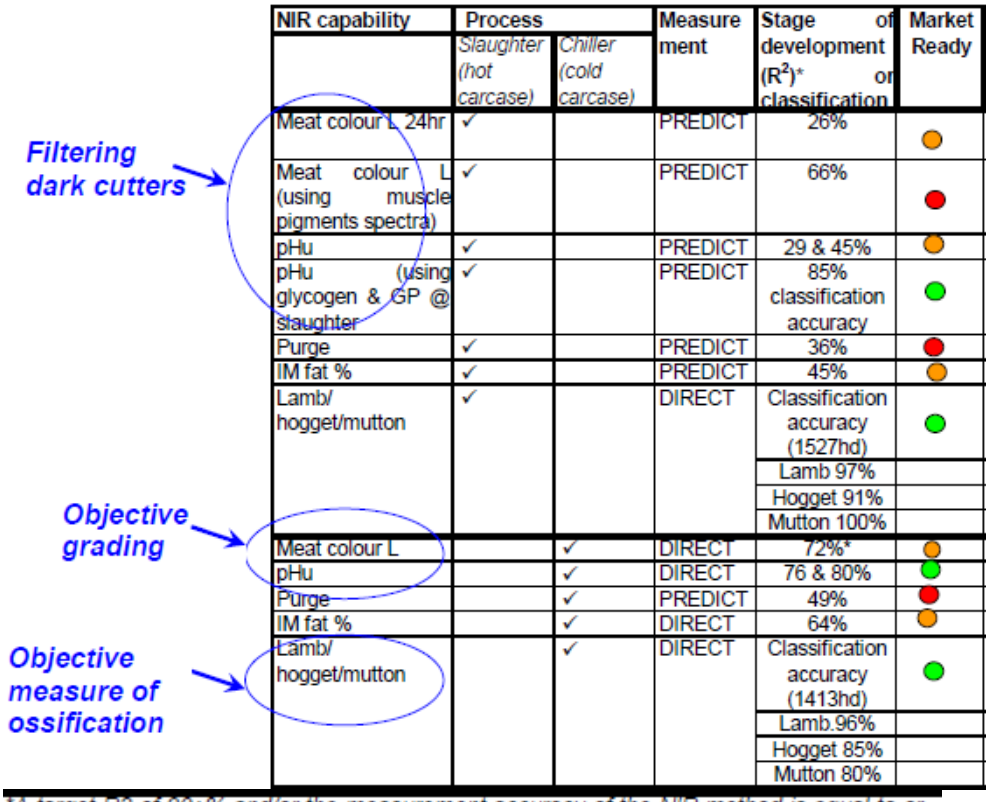
Parameter	MSA standard	ASD instrument results
Score > +- 1	10%	16%
Score > +- 3	0%	0%

The NIR results for marbling didn't compare as well against the MSA standard:

Performance of the NIR (ASD) unit according to MSA marbling standard for graders

Parameter	MSA standard	ASD instrument results
Within 50 points	70%	63%
> 110 points	0%	10%

Meat attributes of sheep were measured by Stuart Baud of DPI, showing encouraging (trial ready) results on ossification and pH.



NIR capability	Process: Slaughter (hot carcase)	Process: Chiller (cold carcase)	Measurement	Stage of development (R^2)* or classification	Market Ready
Meat colour L 24hr	✓		PREDICT	26%	
Meat colour L (using muscle pigments spectra)	✓		PREDICT	66%	
pHu	✓		PREDICT	29 & 45%	
pHu (using glycogen & GP @ slaughter	✓		PREDICT	85% classification accuracy	
Purge	✓		PREDICT	36%	
IM fat %	✓		PREDICT	45%	
Lamb/ hogget/mutton	✓		DIRECT	Classification accuracy (1527hd)	
				Lamb 97%	
				Hogget 91%	
				Mutton 100%	
Meat colour L		✓	DIRECT	72%*	
pHu		✓	DIRECT	76 & 80%	
Purge		✓	PREDICT	49%	
IM fat %		✓	DIRECT	64%	
Lamb/ hogget/mutton		✓	DIRECT	Classification accuracy (1413hd)	
				Lamb.96%	
				Hogget 85%	
				Mutton 80%	

*A target R2 of 90+% and/or the measurement accuracy of the NIR method is equal to or better than that of the conventional method
**Combination of labour, cost reductions, carcase yield and/or quality/value increase

Plant management indicated their interest in using NIR technology if it could improve MSA grading consistency with particular reference to the four subjectively assessed meat quality traits namely marbling, ossification, meat & fat colour listed in order of importance. Most expressed concern that the current subjective assessment system contributed to too much variation between graders and subsequent cost inefficiencies associated with mis-grading of carcasses.

[3] *Project P.PSH.0315, Feasibility of Measuring MSA Grading Parameters using NIR, G.Geesink et al.*

The one lamb processor interviewed considered NIR technology potentially provided a valuable tool to protect the integrity of the lamb brand which he considered under threat because of perceived deficiencies in the current lamb branding regulatory system.

All meat companies nominated regulatory approval of NIR technology and its nominated applications by all relevant regulatory authorities namely Aus-Meat, MSA & AQIS as mandatory before they would consider investment and implementation of NIR technology

1 The Project

Key project activities completed during the period January to June 2010.

Total time input 4.5 days.

- Submitted processor consultation feedback report to MLA on the potential adoption of VISNIR technology to measure meat quality traits. Identification of VISNIR commercial applications with 2 early adopter processors. All processors interviewed stated that their potential interest in adopting VISNIR technology was conditional on the measurement technology being endorsed by Aus-Meat.
- Liaison with Aus-Meat & MSA to define mandatory instrument accuracy standards for the nominated VISNIR spectrophotometer when used to measure meat colour, marble score, pH and ossification in beef carcasses. Drafted and submitted a briefing document on VISNIR technology for circulation to members of the Aus-Meat Standards committee.
- Drafted preliminary experimental protocols and budget estimates for the proposed VISNIR instrument validation study to achieve Aus-Meat standards committee endorsement.
- Ongoing liaison with NZAgResearch re the design and performance specifications for a VISNIR spectrophotometer customised for Australian meat processing plants. NZAgResearch and MLA are currently negotiating a draft agreement with ASD for the manufacture of a customised spectrophotometer and associated technical and calibration upgrade support. ASD manufactured and supplied the QSBT instrument used in the initial R&D phase.

2 Key issues

- Developing an experimental protocol to gain Aus-Meat regulatory approval for a customised VISNIR spectrometer is proving more difficult than expected. Some of the reasons for this include a lack of clarity from Aus-Meat on what the minimum instrument accuracy standards will be other than an instrument must exceed the current accuracy standards being achieved by manual grading, greater clarity what Aus-Meat regards as an acceptable sample size, a need for more formal commitment from MSA for the project and uncertainty on who will fund such a validation study.
- ASD have indicated they have withdrawn any further R&D support for the QSBT spectrophotometer. This instrument was custom built for use in USA beef processing plants specifically for measuring shear force but has not been commercially successful. Both MLA and NZAgResearch used the QSBT spectrophotometer in their R&D phase to develop calibration models for pH, meat colour and marbling with reasonable success. Its large probe size made it unsuitable to measure ossification. ASD now propose we should change to their LabSpec Pro instrument which shares the same spectrophotometer as the QSBT instrument but has a different and much smaller probe head. The suggestion appears reasonable except that verification will be required that scan data collected with the QSBT instrument may still be able to included in future data calibration sets collected with the Lab Spec Pro instrument. Changing to another manufacturer's instrument that

uses different optics would almost certainly rule this option out. Also the Lab Spec Pro already has a successful track record in the meat industry. It is the instrument used by Vic DPI to develop successful truth in labelling calibrations to distinguish lamb from hogget from mutton on hot and cold carcasses. It was also the instrument used to develop successful calibrations for measuring beef ossification on cold carcasses. However the "off the shelf" Lab Spec pro instruments are not suitable for day to day operation in a meat processing plant. They need to be industrialised. This should not be too difficult a task for ASD given their previous experience in developing the QSBT instrument. Another "more futuristic" alternative to consider is to investigate the potential for a direct light VISNIR instrument. Such instruments are mounted in a fixed position and take scans as the target object moves past the instrument. They remove the need for an operator and do not need to make contact with the object being measured. Both are key positive attributes from a meat processors perspective. However whether the quality of the spectral data collected from direct light instruments allows reliable calibrations is unknown

3 Recommended Actions

1. Resolution and agreement between MLA, MSA and Aus-Meat on the need, design, instrument accuracy targets and funding required to validate the ability of VISNIR technology to accurately measure the nominated MSA meat quality traits.
2. Resolution and agreement between MLA, NZAgResearch and ASD on the specifications, initial purchase cost, and ongoing operational and calibration upgrade support costs for a customised VISNIR spectophotometer to measure nominated MSA meat quality traits.
3. The successful resolution of action items 1 and 2 above are essential before the 2 processors identified as "early adopters" of VISNIR technology are prepared to undertake an MDC project with MLA.