

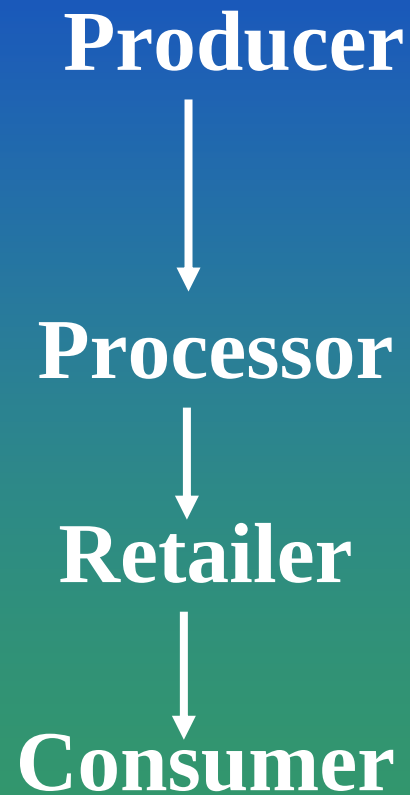
Technologies to determine the quality of meat required by tomorrow's consumers

by Roy Bickerstaffe Lincoln University

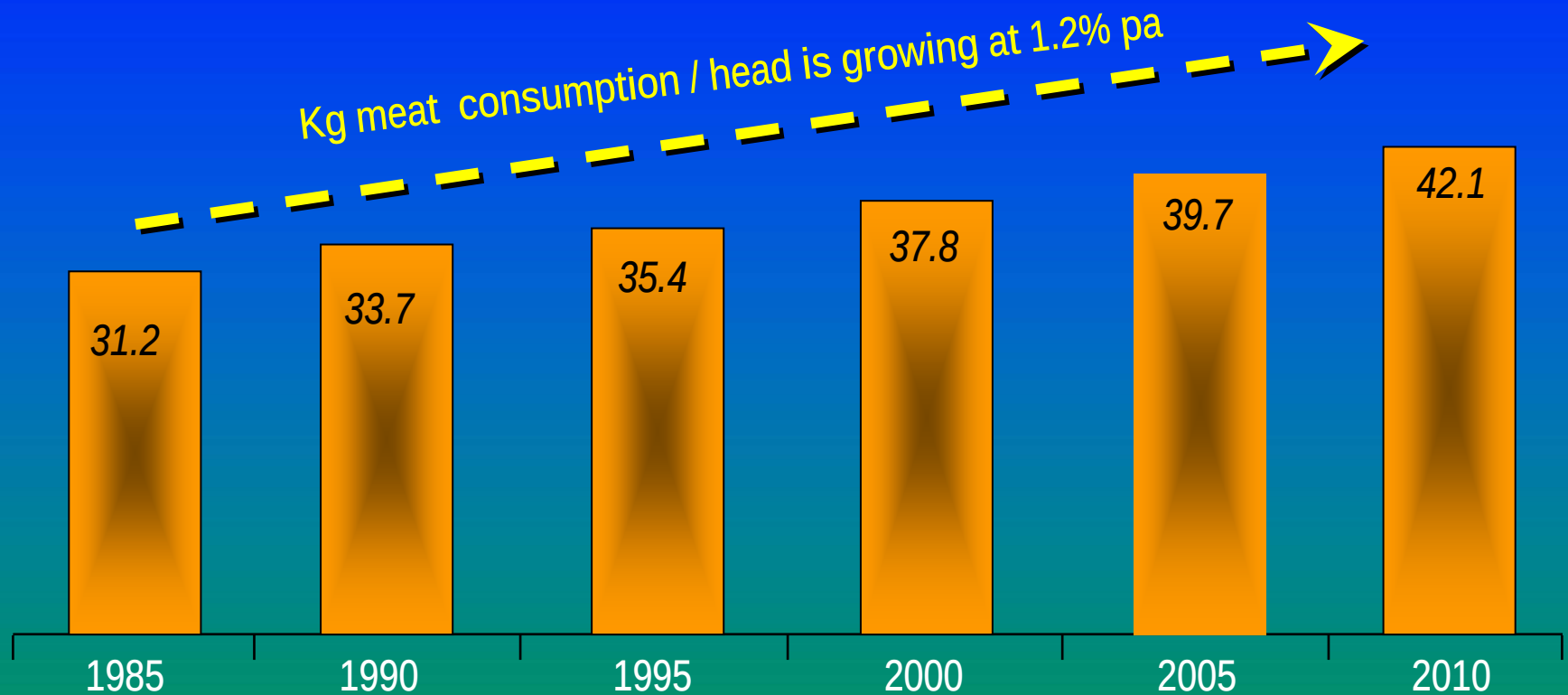


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Future Supply Chain Technologies



Background : an increase in consumer demand for high quality meat,, particularly red meat, occurs as consumer income increases.



Message. *The industry needs to respond by introducing technologies across the supply chain from paddock to plate to improve the yield and quality of meat to meet the expectations of the consumers*

Section 1. Consumers

**Technologies to improve product
quality for consumers**



The specific product characteristics required by affluent consumers is that the meat is

- Safe
- Has consistent High Quality
- Nutritional and healthy
- A natural product

The three major factors influencing meat quality are

- **Tenderness**
- **Taste**
- **Visual Appeal**



Establishing consumer opinions on the tenderness of meat

One - cook the meat



**Two -Ask consumers their opinion
on its tenderness**



**Three: Record the opinion of the consumers
according to the categories listed below**

Very Tender

Tender

Acceptable

Tough

Four : cut the cooked meat into rectangular pieces for tenderness testing



**Five :Determine the tenderness (force ; KgF) to “ bite “
across the fibres using a MIRINZ tenderometer**



Six: Below is the statistical relationship between consumer opinions and machine shear forces.

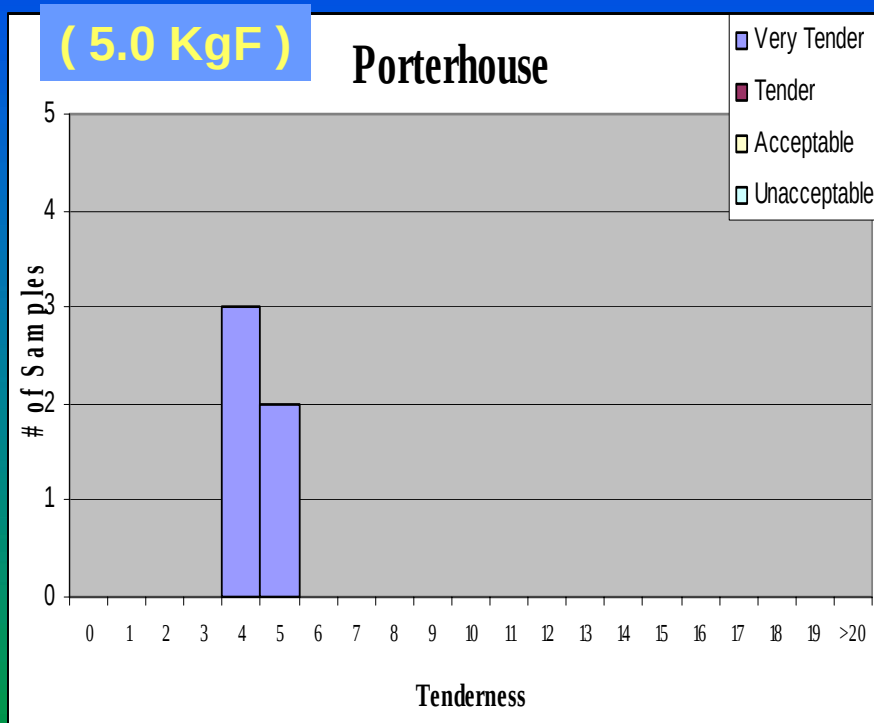
Consumer Expectations	Mean Shear Force (kgF)
Very Tender	4.0
Tender	6.5
Acceptable	9.5
Tough	> 11.0



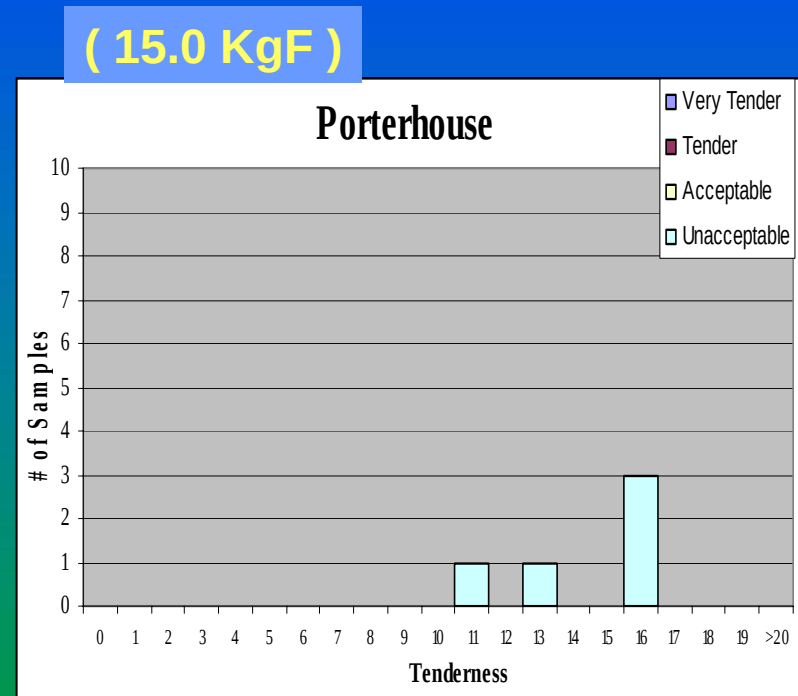
**A snapshot of the tenderness
of meat collected from some
supermarkets.**

Variation in the tenderness of pork sampled from two Supermarkets

Supermarket A



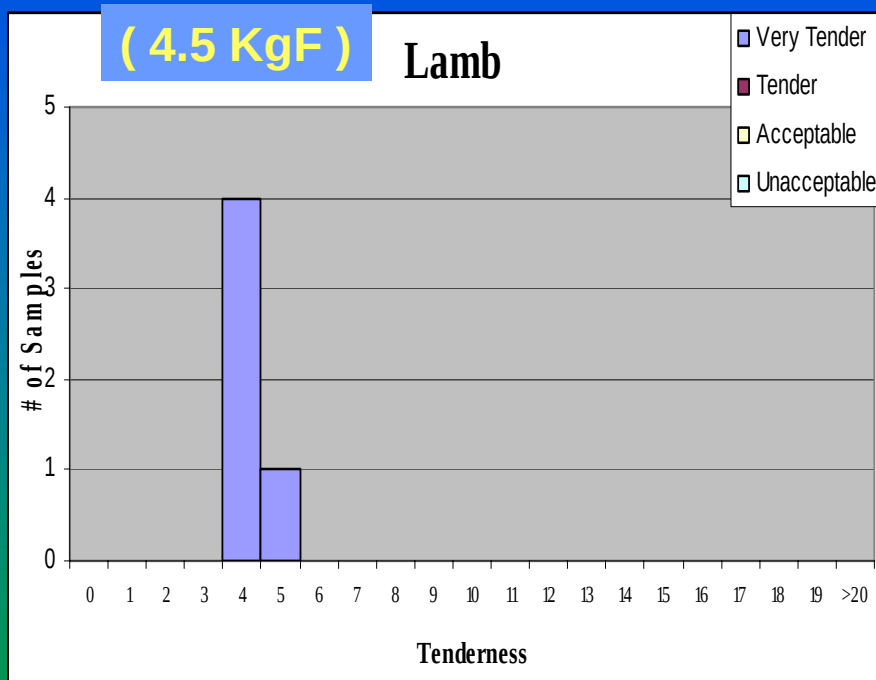
Supermarket b



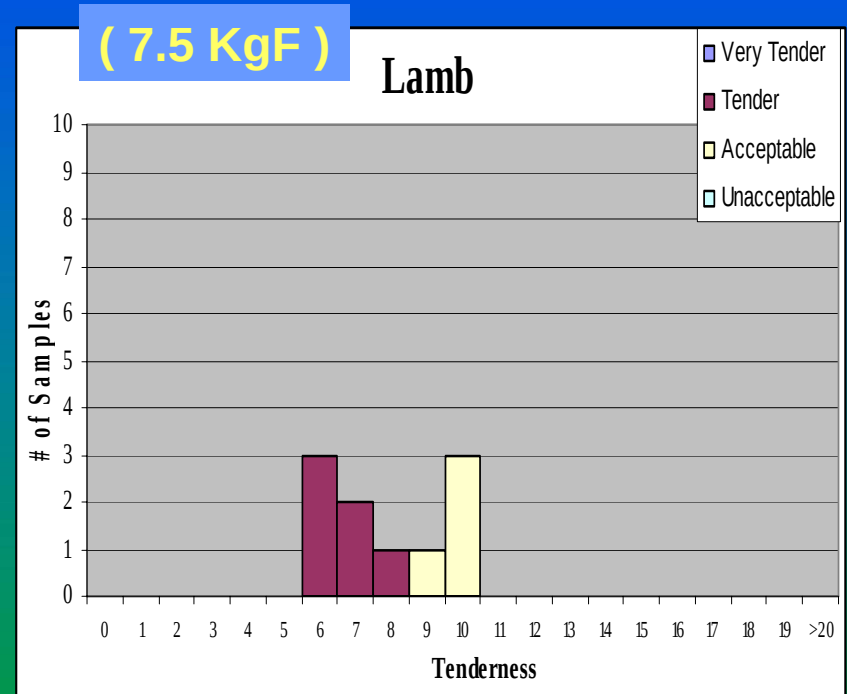
Note Consistent product from Supermarket A and inconsistent product from Supermarket B

Variation in the tenderness of lamb sampled from two Supermarkets

Supermarket A



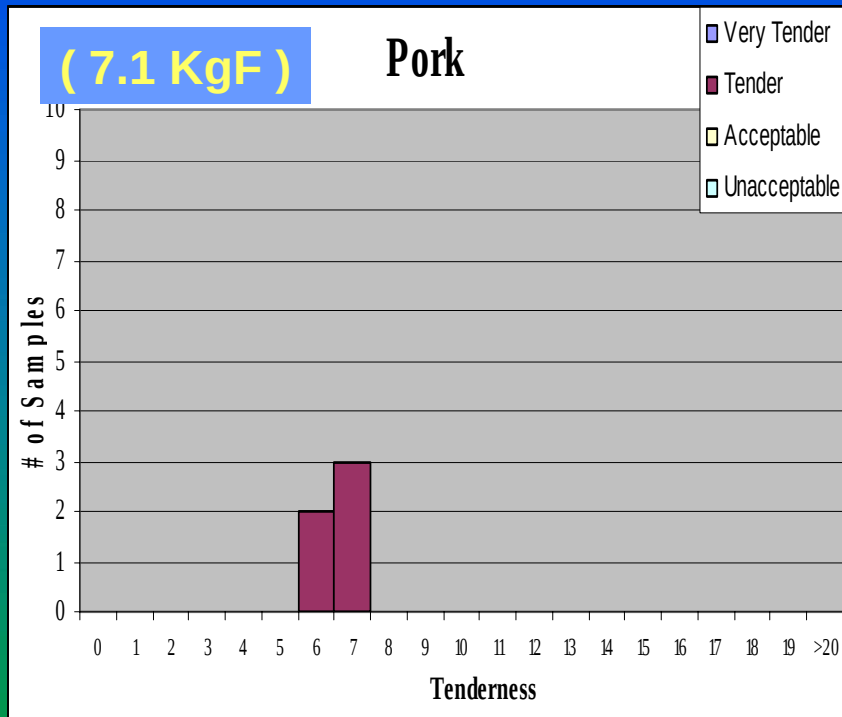
Supermarket B



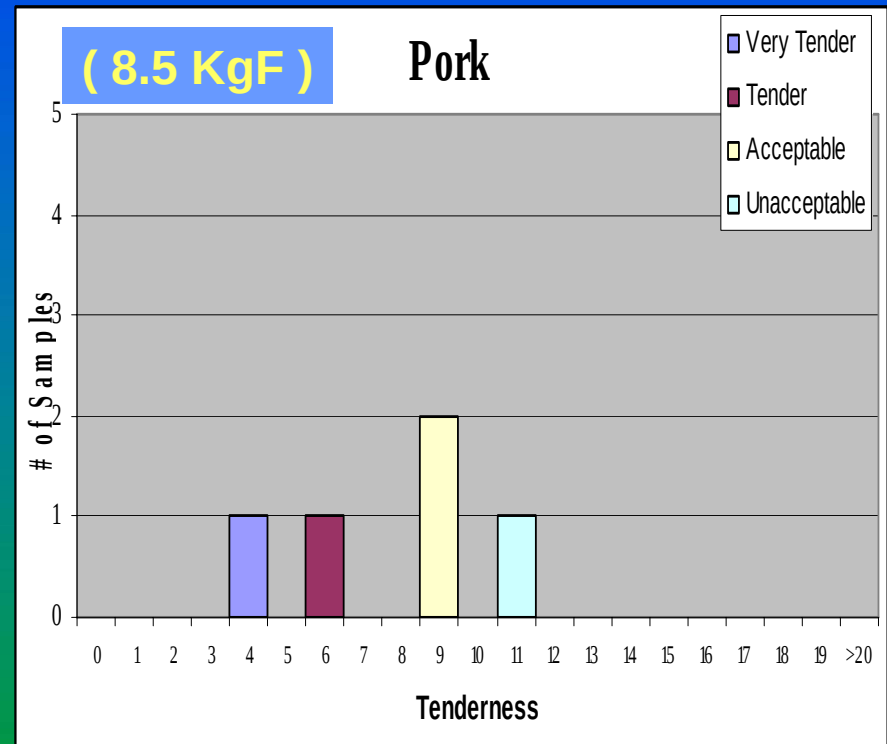
Note Consistent product from Supermarket A and inconsistent product from Supermarket B

Variation in the tenderness of pork sampled from two Supermarkets

Supermarket A



Supermarket B



Note Consistent product from Supermarket A and inconsistent product from Supermarket B

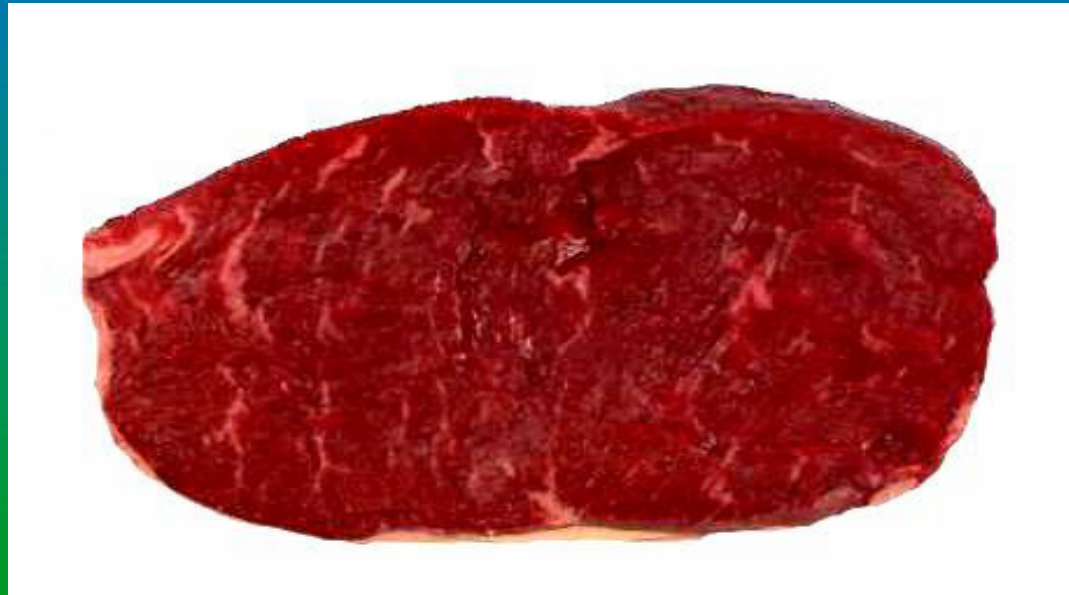


Future Technology

We are designing a hand held tenderometer for rapid and on site market testing of cooked meat.

Questions

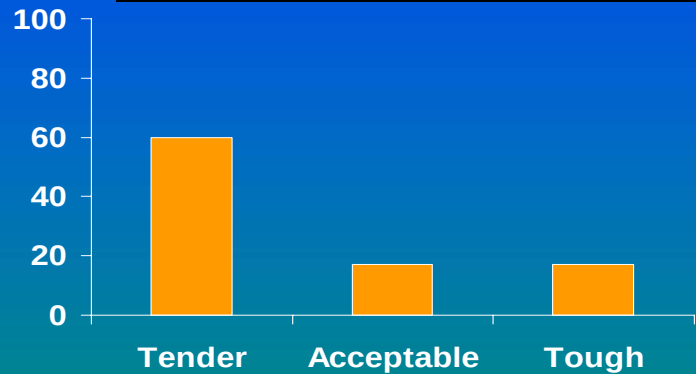
- i) Is tenderness the only factor influencing the consumers perception of the eating quality of meat ?
- ii) Is it possible to have a perfect steak ?



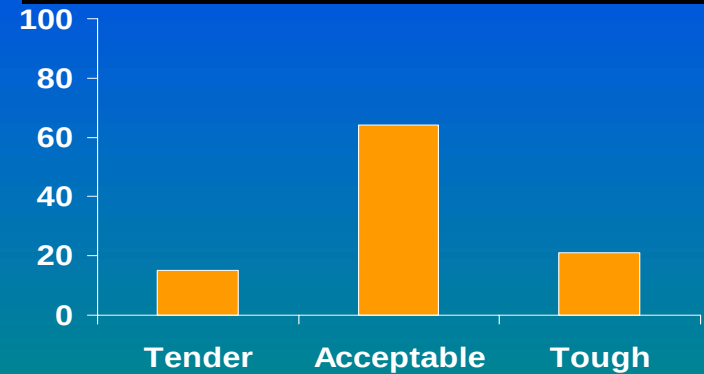
Evaluation of the eating quality of tender steaks (5KgF) by NZ and USA students



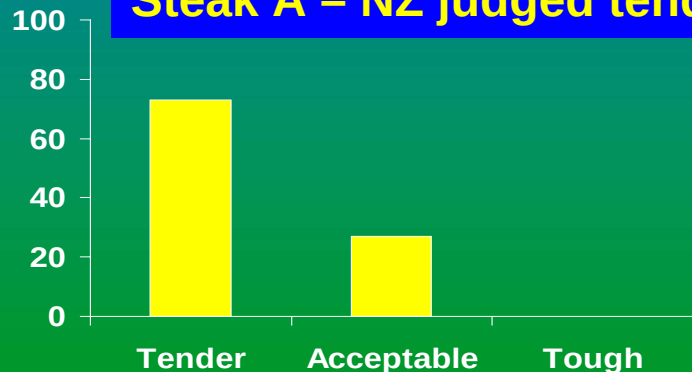
Steak A – USA judged tough



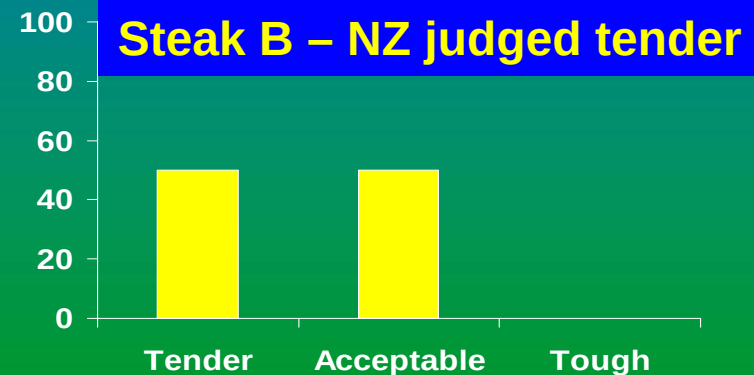
Steak B – USA judged tough



Steak A – NZ judged tender



Steak B – NZ judged tender

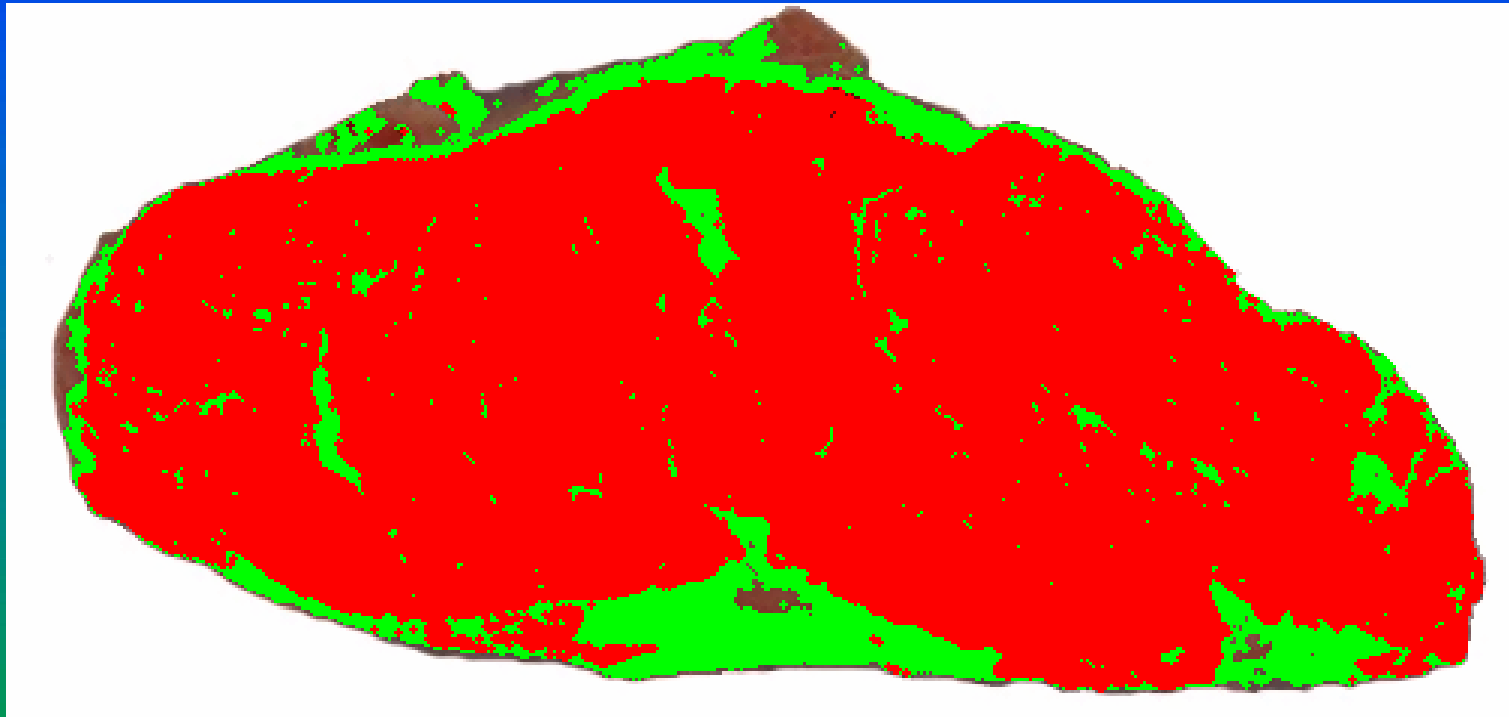


Note :There was a different eating response by the two groups of students

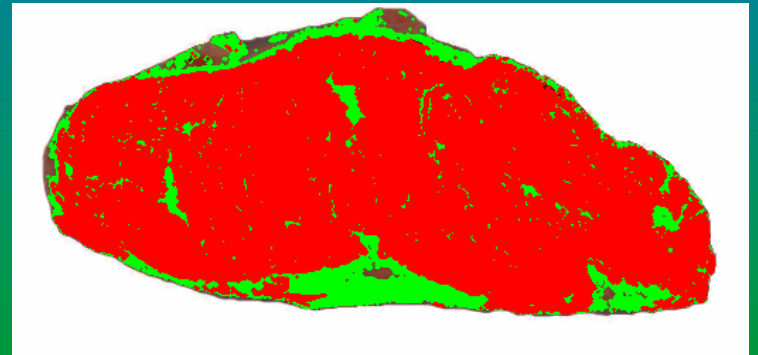
*The steaks were digitised using a potential
new technology to the industry*

Red = Lean meat

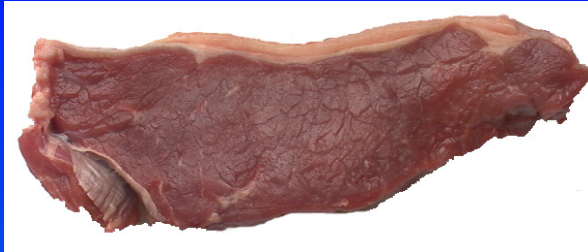
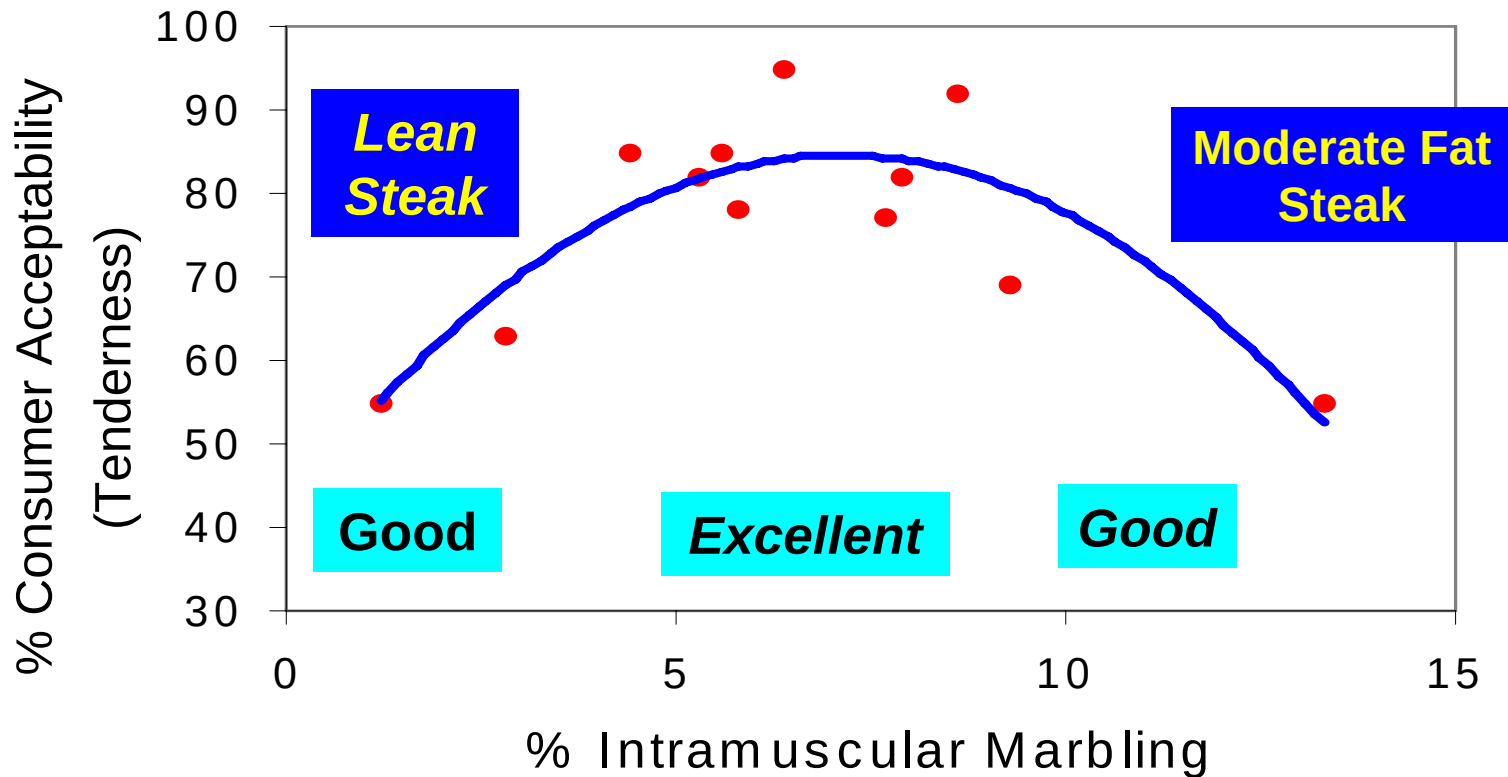
Green = Fat



It appeared that the USA students were more sensitive to the differences in the intra-muscular fat levels in steaks than the NZ students



Evaluating the eating acceptability of tender (5 KgF) steaks with different levels of intramuscular fat by consumers



The message: **Intra-muscular fat influences the juiciness, taste , flavour and perceived tenderness of meat which is detected by consumers**





**Is intramuscular fat an issue
between different Beef breeds ?**

Identifying the best steaks from different Beef breeds in New Zealand by the national “Steak of Origin” competition

- Steaks in the competition are forwarded to Lincoln for analysis
- Steak is allocated into Four Classes
  - a. Best of European
  - b. Best of British
  - c. Best of Crossbreed
  - d. Best of Retail
- Steaks are analysed for pH, tenderness and intra-muscular fat
- The top 4 steaks in each class were taste evaluated by the public and a taste panel



Mean results from the top four steaks from each competition class from three years of the competition

	British	European	Crossbreed	Retail
pH	5.6± 0.9	5.5 ± 0.1	5.6 ± 0.1	5.6 ± 0.1
Tenderness (KgF)	5.1 ± 0.9	5.7 ±1.3	5.2 ± 0.1	5.6 ± 4.9
Intramuscular Fat (%)	3.4 ± 2.1	2.3 ± 1.2	3.0 ± 1.9	4.6 ± 3.0

Message (i) All breeds can produce tender meat

(ii) Breeds vary in their intra-muscular fat levels

Some conclusions for Meat industry

- All Breeds can produce tender steaks if the supply chain is optimized for producing quality meat
- Excellent eating quality steaks require the correct tenderness (5KgF) and marbling (4-6 %) which should be optimized for specific consumers and markets
- Marbling is a more variable parameter across breeds than tenderness but it should be recognized that equally large variations can occur between sires as observed between breeds.

Future Technology. i) A Bio-marker / DNA marker for intra-muscular marbling for stock selection but the markers do need robust market evaluation.

ii) Digital identification of steaks

Our Future Technology Response

To design a portable digital camera device with programmable micro-chips to measure on-line or off-line intra-muscular fat to enable

- Selection of meat with the ideal intra-muscular fat content and
- The calorific value of meat to be determined for future labeling requirements



Section Two

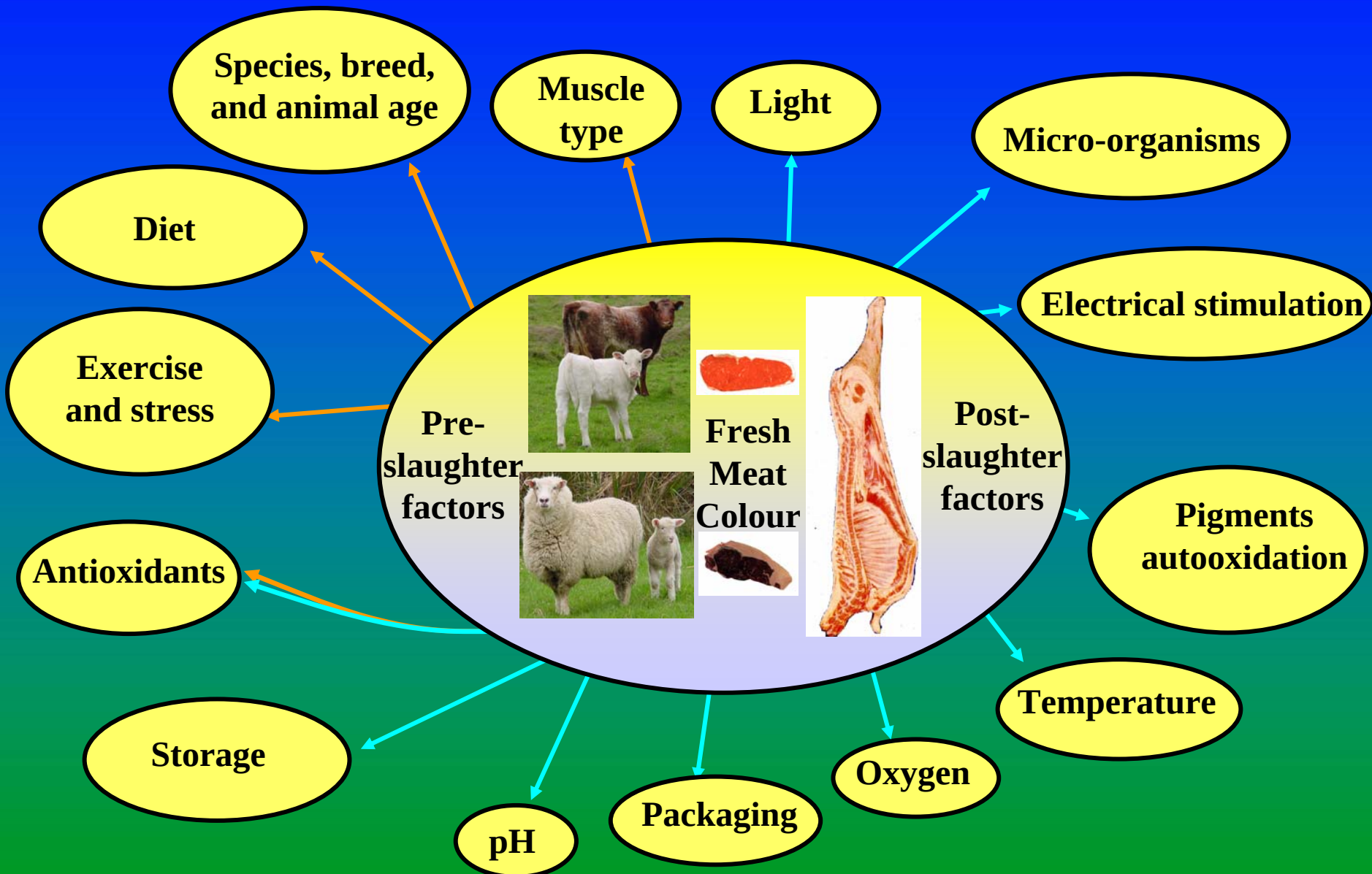
Future Technologies to improve processing

Aspect investigated : colour / colour retention

Colour Changes occur in displayed Retail Meat



Various factors from the farm to retail can contribute to the colour of displayed retail meat: they are



Some examples of the variation in the colour of displayed retail steaks



Below illustrates the changes that occur in the colour of non vacuum packed steaks before and after chilled shelf display for 10 days

Initial Zero time on shelf display



After 10 days shelf display



Note: The good colour retention

Below illustrates the changes in the colour of vacuum packed steaks before and after chilled shelf display for 10 days

Initial Zero time on shelf display

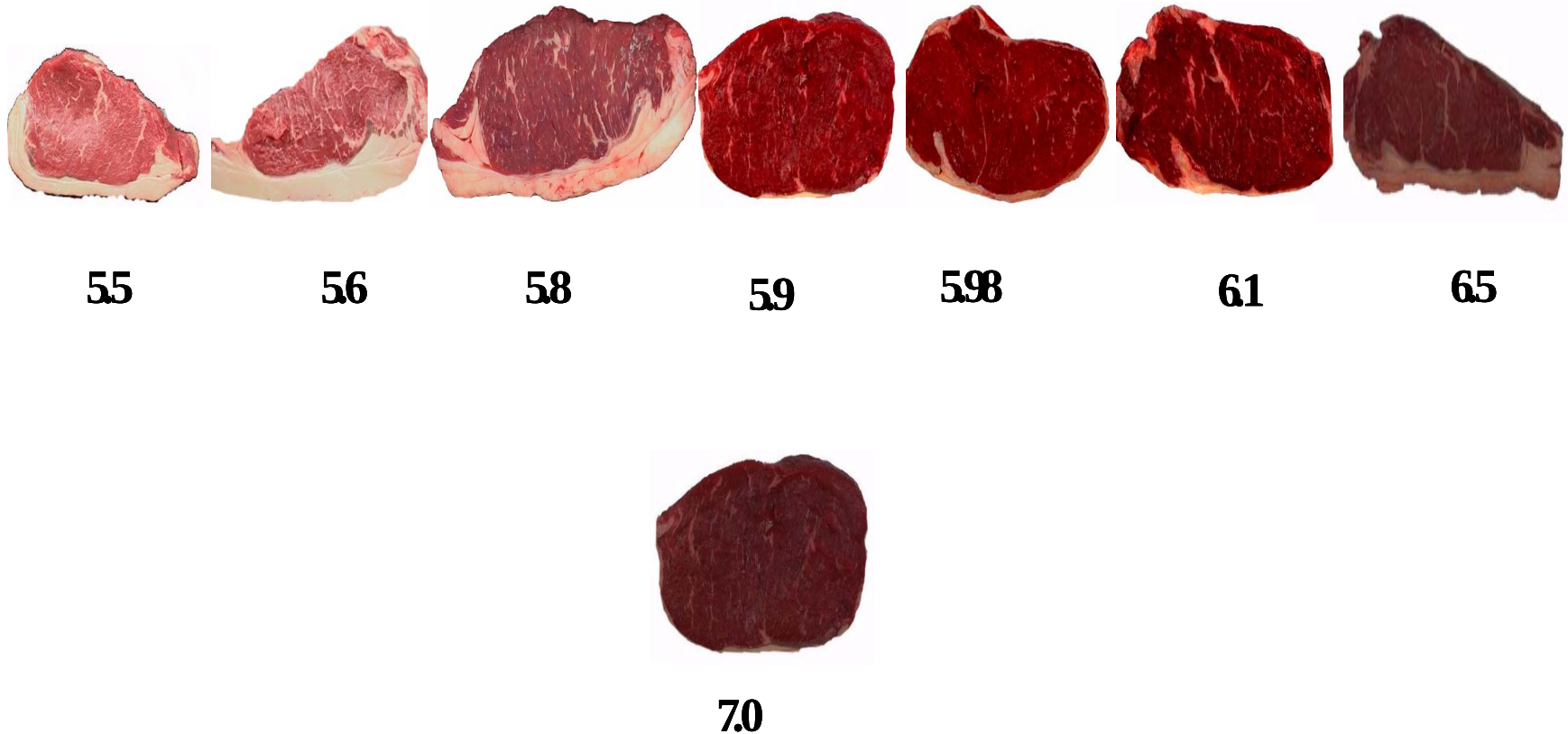


After 10 days shelf display

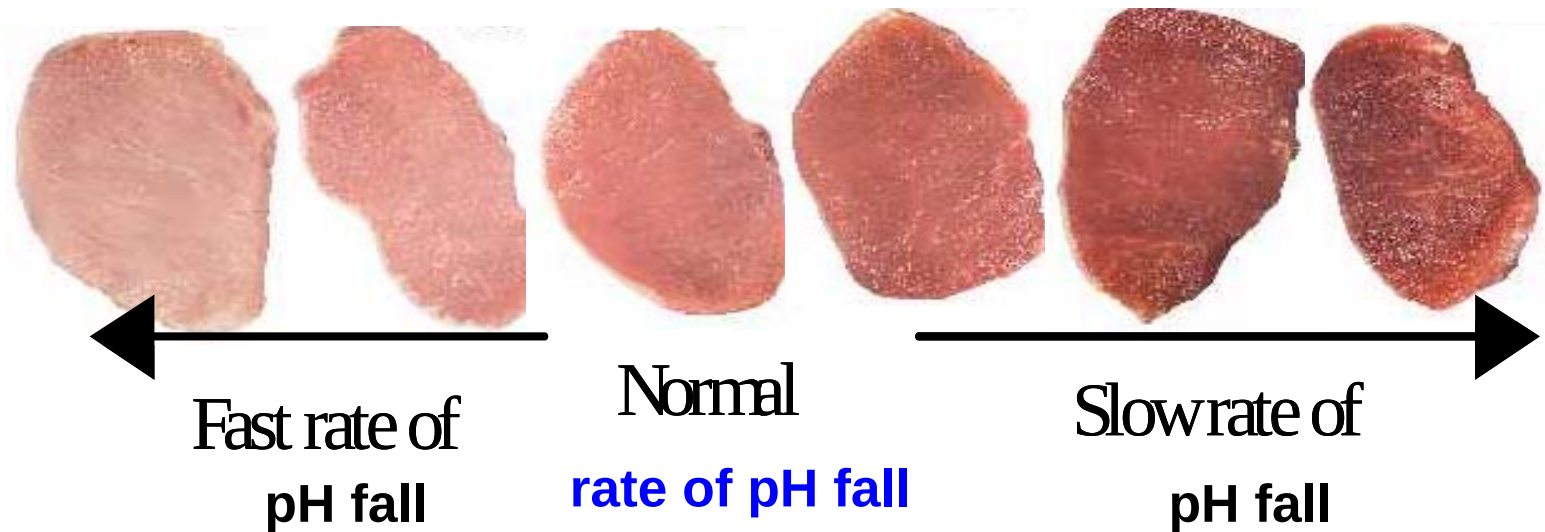


Note : the poor colour retention

Below illustrates of the impact of ultimate pH on meat colour



Below illustrates of the impact of rate of pH fall on meat colour

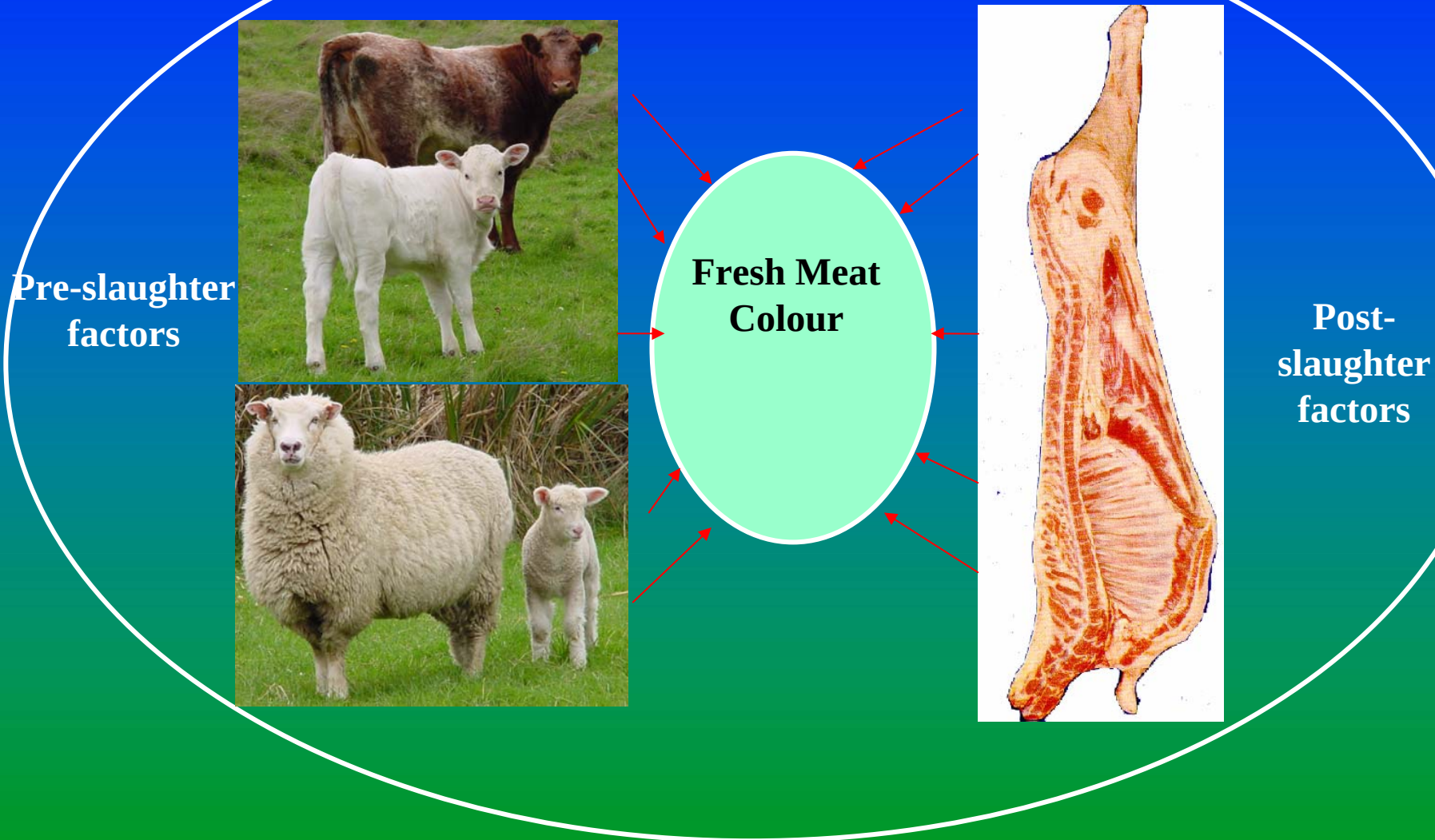




Future Technology Implications –

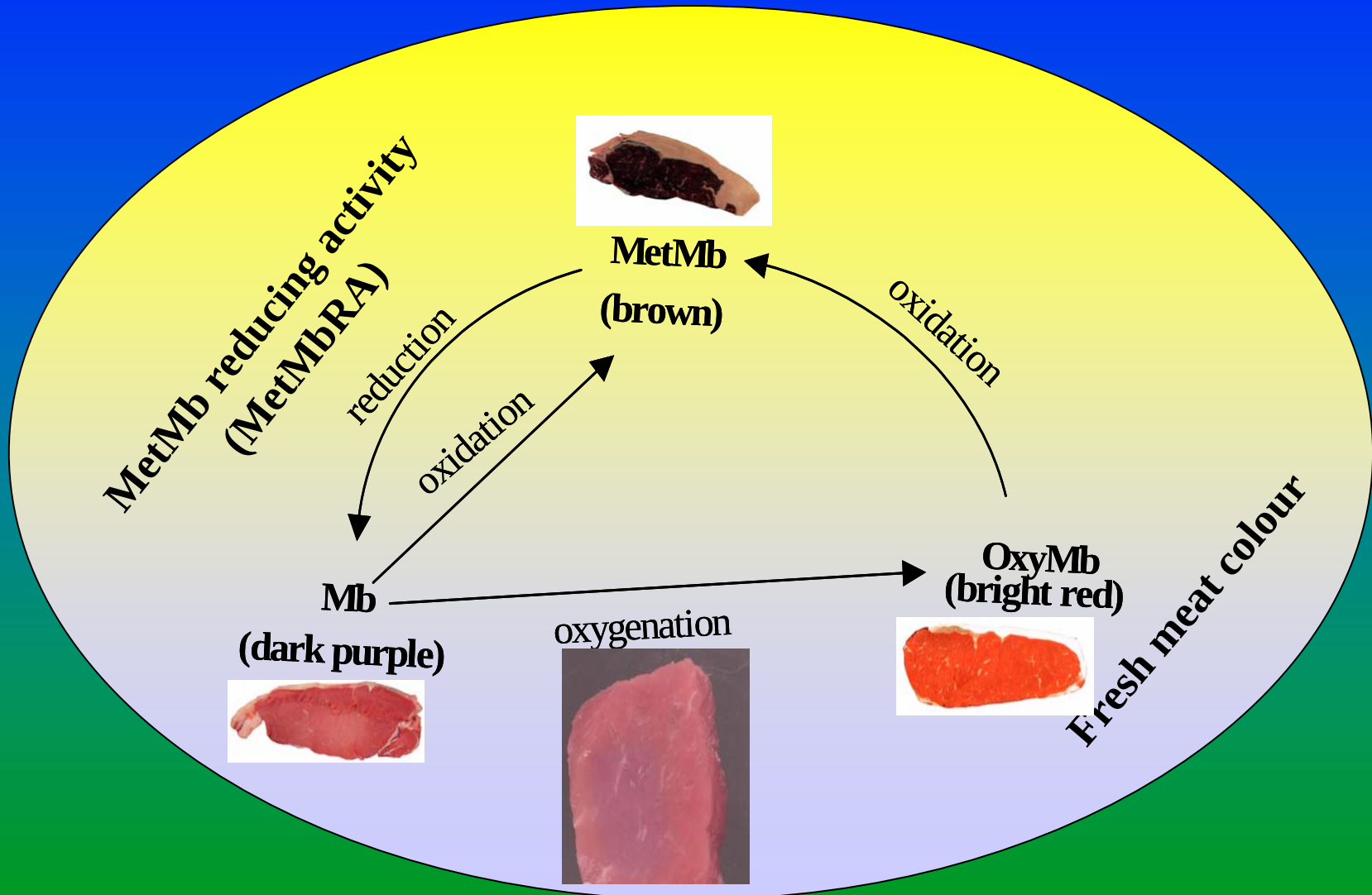
- i) improvements in the reliability of pH probes and their measurement will enable effective on line monitoring**
- ii) Application of knowledge on the factors influencing meat pH will enable systems to be introduced to improve the processing conditions**

There are many factors influencing the colour and colour stability of meat



**Investigating the biochemical
changes responsible for the
colour variation in meat**

We have investigated the biochemical changes that occur in the myoglobin molecule which dictate the colour of the meat and “How fresh / red the meat is ”





Future Technology Implications

The development of enzymatic bioprobes or biosensors to measure

- i) the status of metmyoglobin reductase or
- ii) the reducing or oxidative capacity of tissues



Section Three

**Technologies to improve the
supply of animals**

Approach 1

To use Bio markers (DNA) to select/ identify sheep which are healthy and therefore improved productivity and ability to yield quality meat

Lincoln University has developed commercial gene markers to identify

- i) Sheep without footrot
- ii) Lambs which survive cold stress at birth

Approach Two : To use bio-markers to select animals delivering high yielding quality meat but the science determining muscle breakdown (tenderisation) and synthesis (growth) as outlined below need to be established.

Meat Quality

Muscle protein breakdown



**High
Active
Calpains**

Tender Quality Product



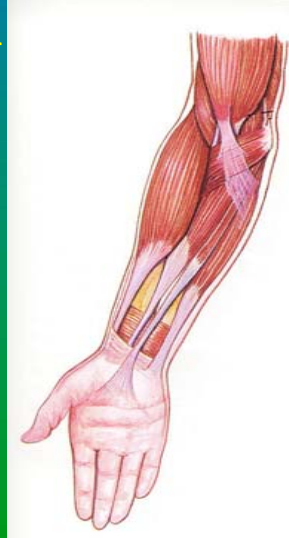
Muscle Yield

Muscle protein synthesis

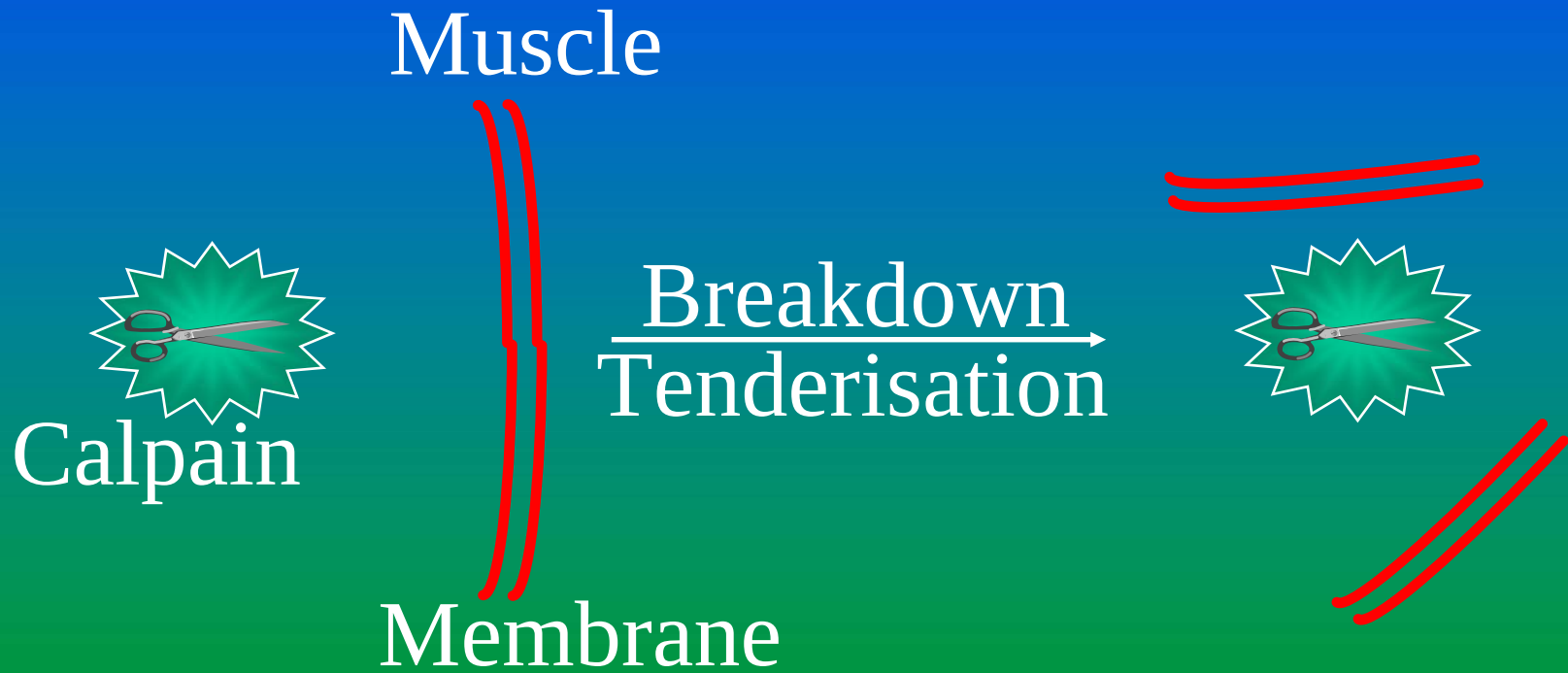


**Low
Active
Calpains**

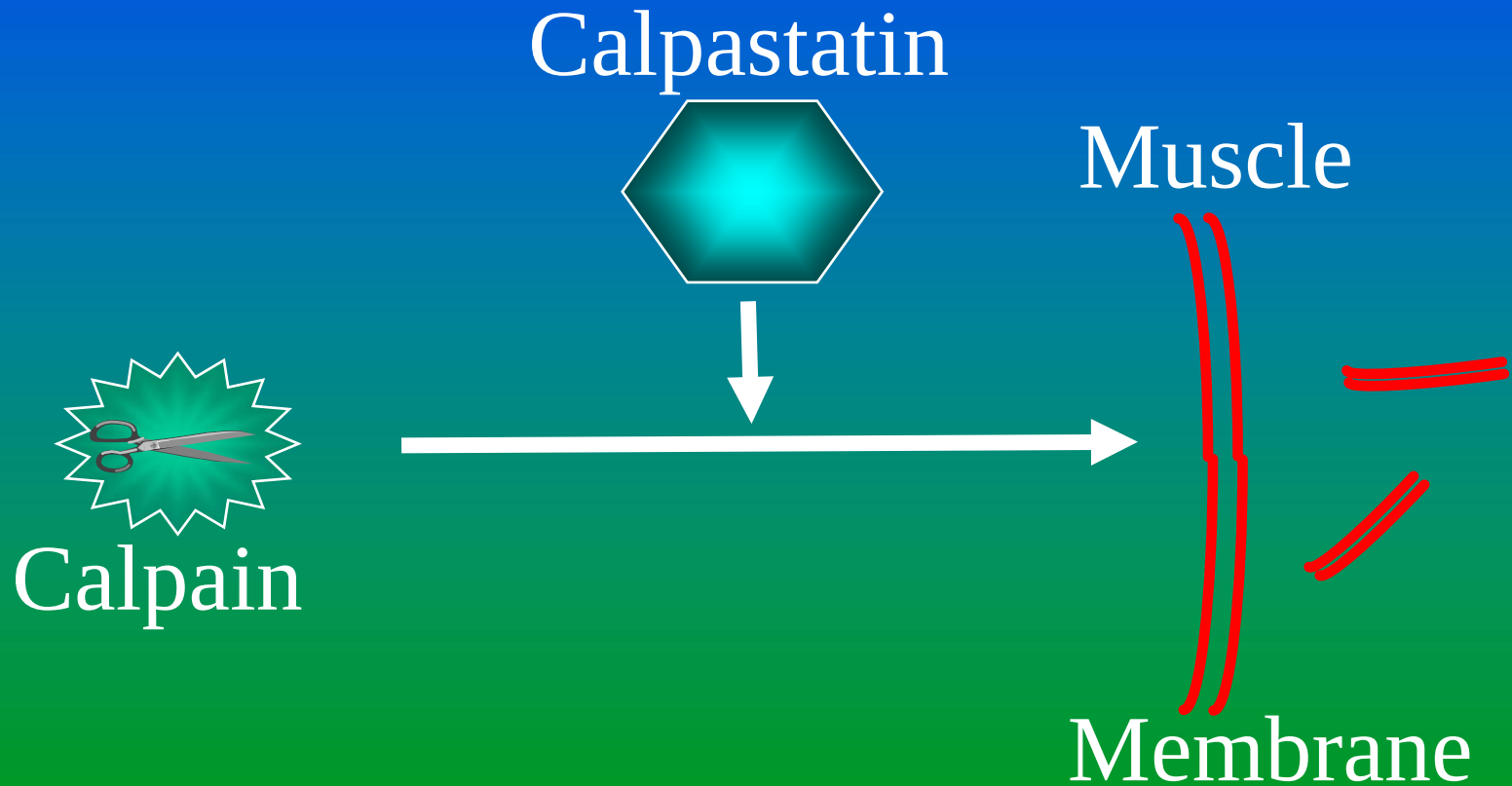
Muscle Growth



The calpain system is involved in muscle breakdown and synthesis



Calpastatin is a natural inhibitor of calpain



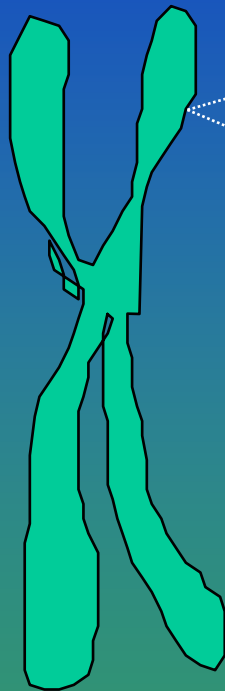
Calpastatin Approach : calpastatin can influence muscle growth and meat quality



On the right are Double Muscle sheep which is due to increased levels of calpastatin in the muscle. The increased muscle growth is accompanied however by tough meat on slaughter

Future Technology – We have investigated the ovine calpastatin gene for inherited SNP's

Sheep chromosome 5



CAST gene
- domain structure



Exons 1A

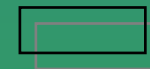
1B

1C

1D

PCR

SSCP analysis



1C/1D amplicon

Below are three allelic variations in the sheep calpastatin gene identified at Lincoln University

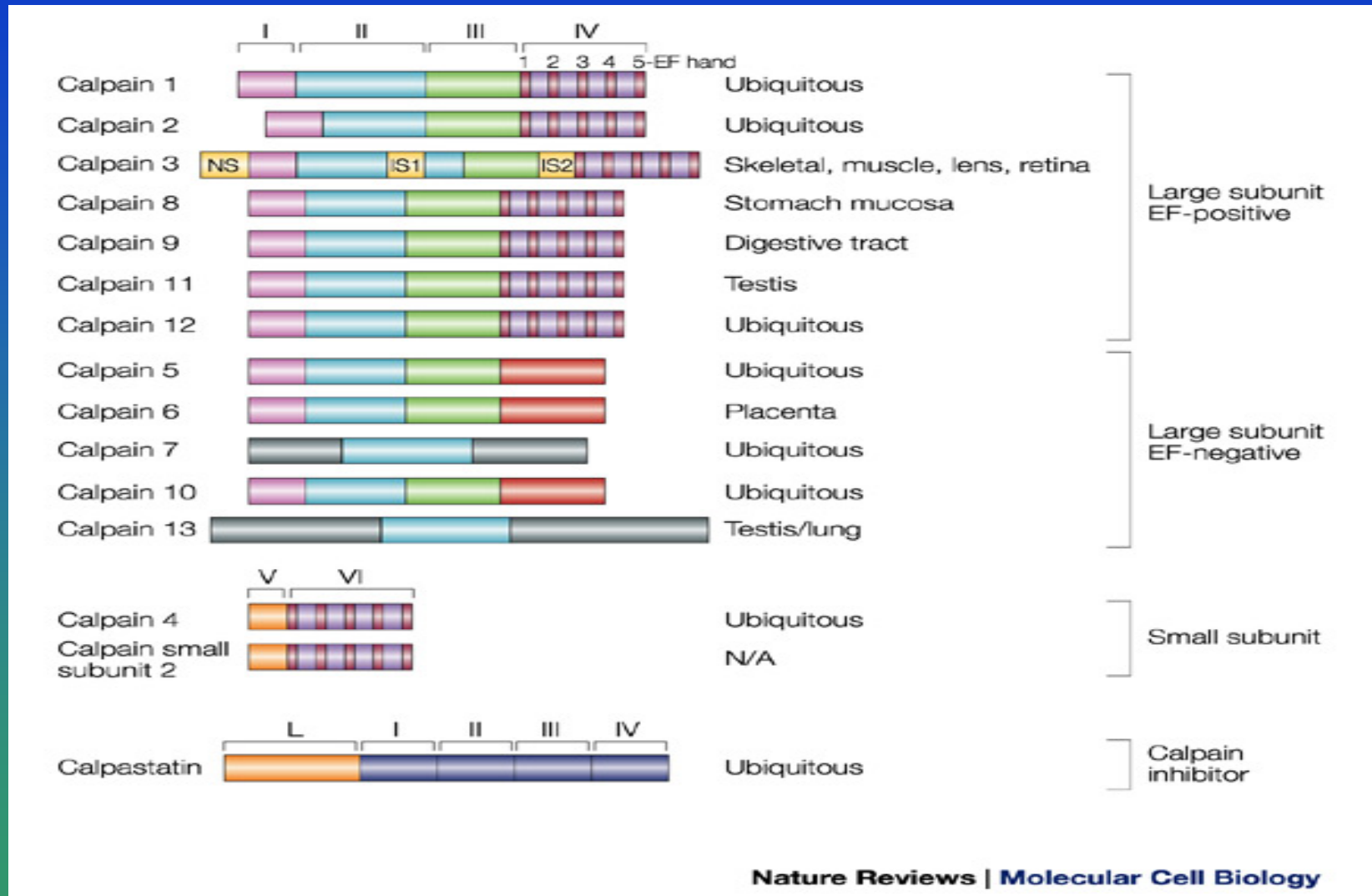


Summary of the calpastatin study

- 3 polymorphic variants of calpastatin Identified
- The variants were designated “alleles” **a, b & c**
- The alleles were inherited through 3 generations

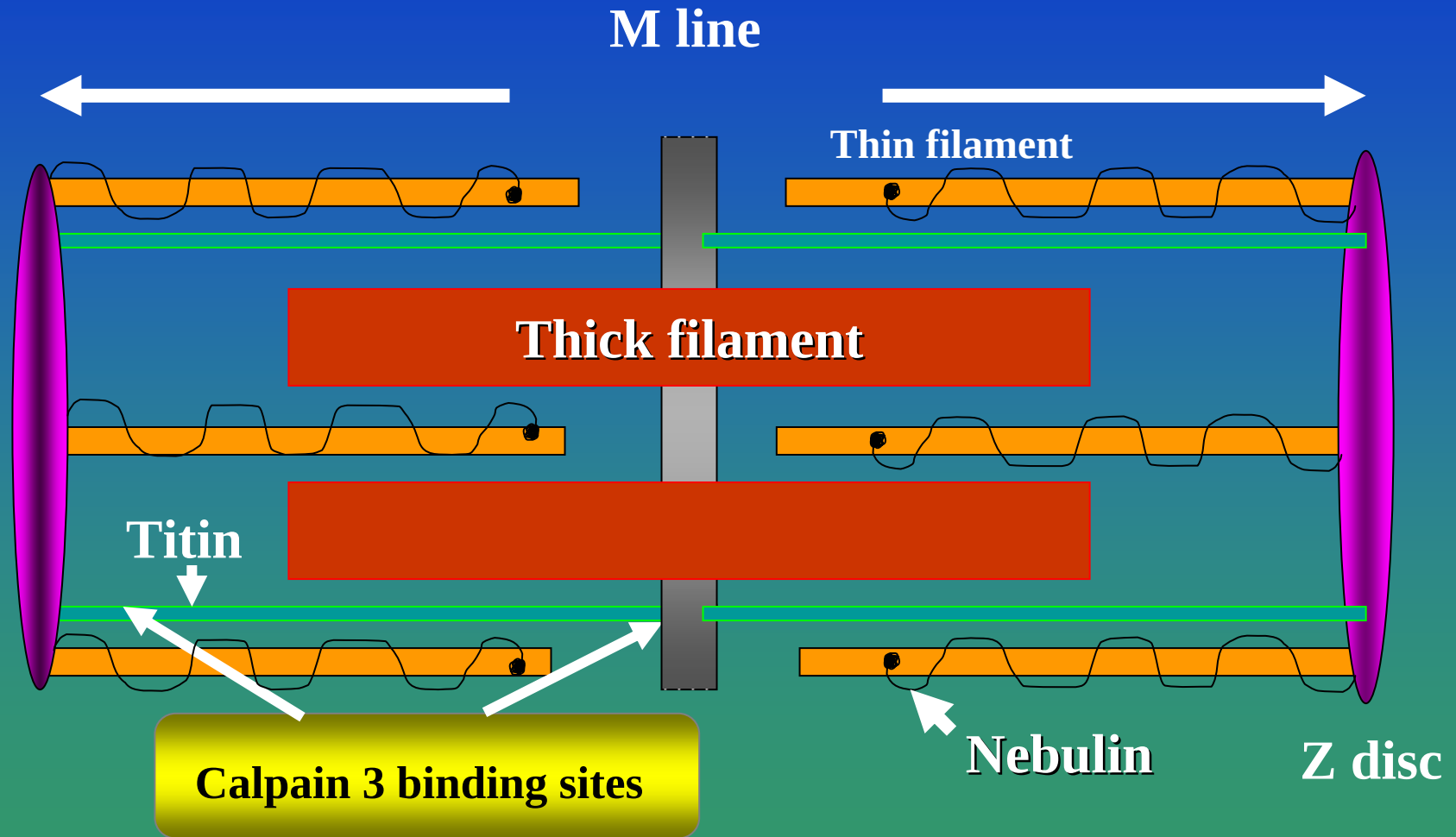
Selecting animals based on the alleles
increased animal growth rates by 5%

Calpain Approach – Which calpain to chase ?

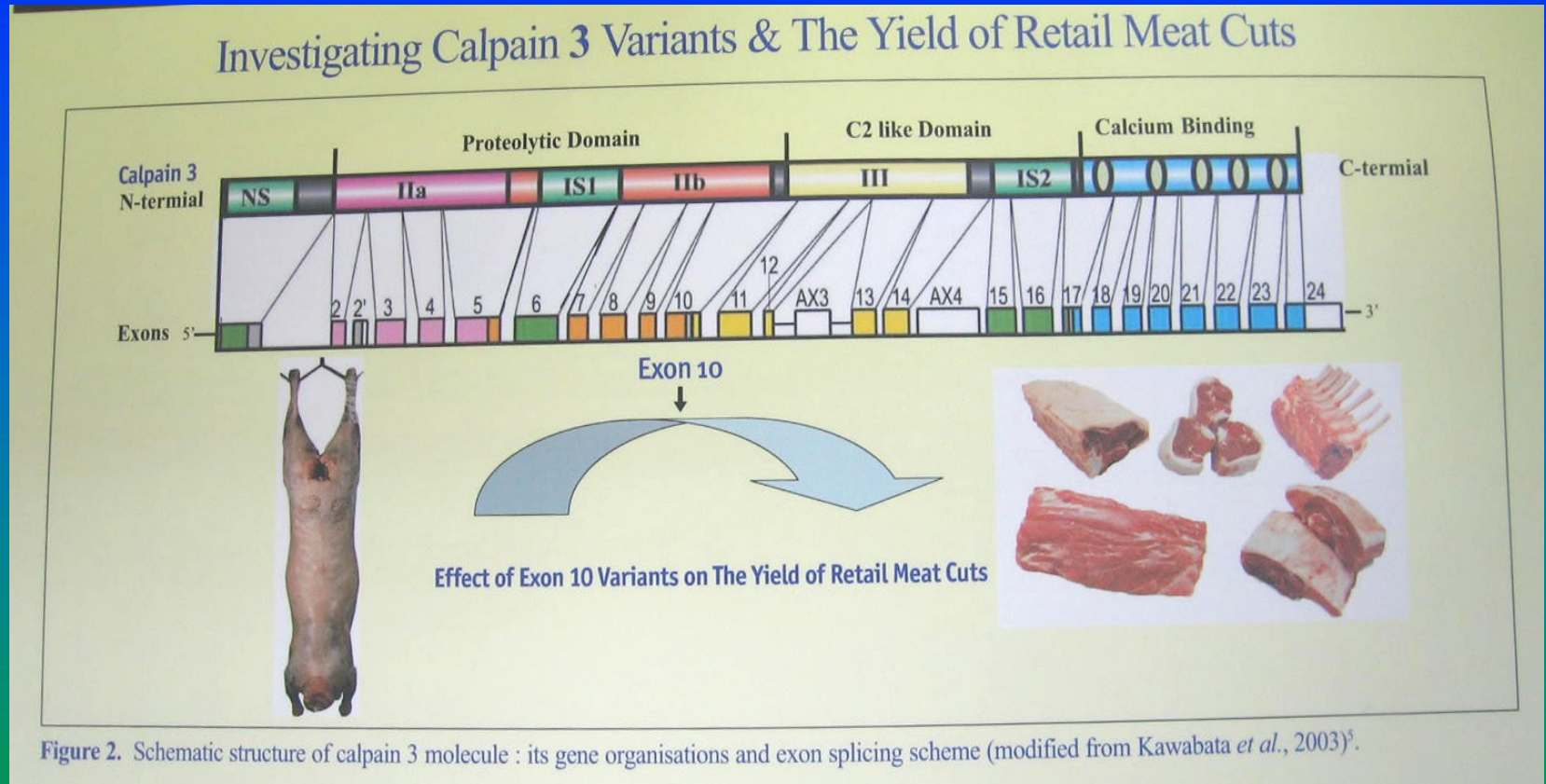


Note There is only one muscle specific calpain (3),the other widely studied calpains (1 & 2) are ubiquitous calpains.

Calpain 3 is muscle specific and membrane bound on titin



Future Technology. To identify if there are gene variations which have associations with differences meat quality and meat yields as outlined below



We have found gene variations in the C2 domain of the calpain 3 gene in sheep

These are three gene variations in calpain 3 as illustrated below

CAPN*03) on exon 10 were identified as illustrated in Figure 1.

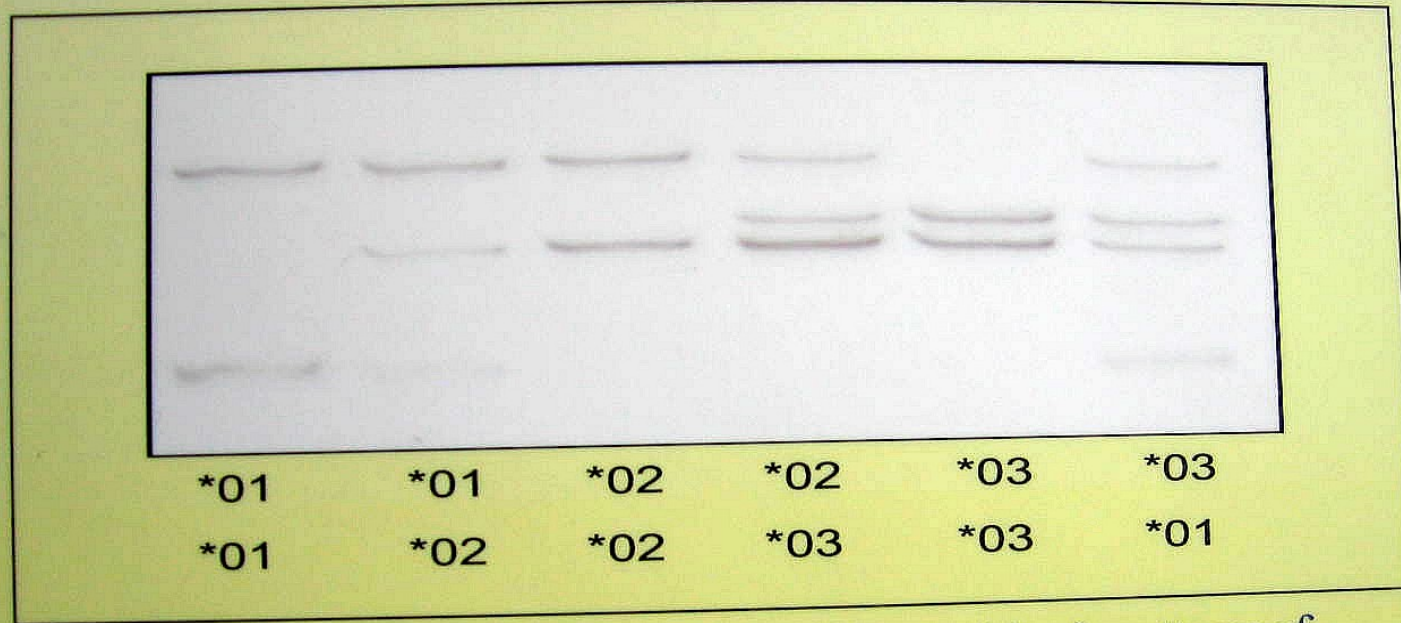


Figure 1. SSCP (single conformational polymorphism) patterns of three calpain 3 variants (*01, *02, *03).

The table below shows that the presence of specific calpain 3 allele variants in lambs significantly increased the weight of some meat cuts

The results show that calpain 3a and calpain 3c produce a consistent effect (Table 2).

Table 2. Impact of the calpain 3 variants on the weight of meat cuts from 17 kg carcasses.

Allelic Variant	Measured Parameter	Weight (kg)		% change in weight
		without allele	with allele	
Calpain 3a	Leg	5.62	5.72	2.45*
Calpain 3b	Leg	5.72	5.72	0.60
Calpain 3c	Leg	5.70	5.80	1.75*
Calpain 3a	Foreshank	0.58	0.60	3.24*
Calpain 3c	French Rack	0.81	0.83	2.50^

Note: *significant and ^tendency to significant.



Future Technology:

i) the calpain 3 gene sequences can be incorporated into bio probes to be used in conjunction with new nanotechnologies to develop new on line technologies to select carcasses for specific markets or

ii) to provide information to producers in partnership arrangements about their stock characteristics or gene information directly to producers to improve their stock characteristics.



Section Four

**Future Technologies to
improve supply chain integrity**

Technology : Improving Food Safety

We have been investigating the influence of specific bacteria that cause the undesirable change in the shelf life of meat as illustrated below



- i. We have identified some specific bacteria involved in reducing shelf life in association with Kulmbach Germany and have DNA taxonomically identified some bacteria involved in shelf life changes
- ii The DNA approach enables quick and fast identification of any undesirable bacterial contamination along the supply chain



Future Technology :

Incorporation of bacterial DNA sequence information into bio-probes and the use of nanotechnologies to use on or off line to rapidly detect unwanted bacteria.



The Meat Team

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Consumers and Calpains

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Equipment Design

Thankyou



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