A Nuffield Farming Scholarships Trust Report

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Carcass grading and payment systems to improve the eating quality of UK meat

Caroline Mitchell

July 2019

NUFFIELD UK

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A Nuffield (UK) Farming Scholarships Trust Report

"Leading positive change in agriculture.
Inspiring passion and potential in people."

Date of report: July 2019

Title	Carcass grading and payment systems to improve the eating quality of UK meat
Scholar	Caroline Mitchell
Sponsor	Worshipful Company of Butchers
Objectives of Study Tour	To investigate existing and developing technologies in other parts of the world for carcass grading and payment which could improve UK meat quality through producer/processor incentivisation.
Countries Visited	UK, France, Germany, America, Japan, Australia, Italy, Ireland, Spain

Messages

1. The current system of carcass classification used in Great Britain is completely outdated and is holding back the development of the industry by failing to adequately communicate consumer demand back to the processors and producers.
2. Currently red meat producers are being rewarded for producing large amounts of lean meat which is, as a result of that leanness, often dry and flavourless providing an unsatisfactory eating experience.
3. Because of the current payment systems in place all business drivers are geared towards producing a lot of meat cheaply.
4. The current carcass classification and grading system does not prepare the UK adequately for competition on the global market.
5. Without measuring meat quality, we cannot manage meat quality
6. If aspects of Meat Standards Australia were combined with the USDA system it would result in the most comprehensive and robust system. If it is possible to adopt these in conjunction with making the assessments wholly objective, this is the route we should aim for.

EXECUTIVE SUMMARY

The current payment and assessment systems used by UK processors, EUROP (beef and lamb) and LM% (pork), do not correlate well with meat quality.

"*The current system of carcass classification used in Great Britain is completely outdated and is holding back the development of the industry by failing to adequately communicate consumer demand back to the processors and producers*" (Stimulating the introduction of a new method of pig carcass classification, AHDB Strategy Priority 1.2, Year 1 Report)

Red meat animals are produced for consumption and, whilst per-capita consumption of red meat appears relatively stable, the market share of red meat is declining when compared to that of chicken, fish and convenience foods. This suggests that the consumer is not receiving a product with meat quality that meets their expectations: therefore, red meat has room for growth in per-capita consumption by taking some of the market share away from poultry, fish and convenience foods.

It is important that protein farmers focus on the *consumer* as the customer, not the processor and/or retailer. Without consumer demand the need to produce red meat is reduced and carcass value decreases, making the industry unstable. Countries such as Japan, Korea, Australia and the USA already have grading and payment mechanisms that reward the producer for eating quality. If the UK doesn't start focussing on the consumer acceptance of its red meat, then the demand for UK-produced red meat in the home and global markets will decline in favour of better eating quality (and often cheaper) meat produced abroad.

For industry growth we need to produce red meat that satisfies the expectations of the global consumer to further develop international export of fresh meat, as well as maintain and grow home market share.

Some non-UK pork and beef supply chains have payment and grading systems that assess the potential meat quality of a carcass and reward the producer in correlation to the predicted meat quality. It is posited that the UK red meat industry can improve meat quality, increase consumer acceptability and increase market share by utilising existing technologies and knowledge. By rewarding for premium meat quality, the producer is incentivised to implement improvements for meat quality within their production system. By streaming product within the processing facility based on the predicted meat quality, it's possible to manage quality and consistency; thereby consumer expectations are maintained. This should lead to an increase in red meat consumption and improve consumer satisfaction.

During the Nuffield Farming Scholarship study tour a careful study was made of the UK, France, Germany, America, Japan, Australia, Italy, Ireland and Spain, investigating the mechanisms in place to measure meat quality. The main recommendations are:

- Meat Standards Australia is the "gold standard" we should be working towards to enable the UK to compete on the global market and this system should be developed in the UK for pork, beef and lamb;
- The gmSCAN system should be trialled in the UK;
- The compatibility of robotic cutters with each classification and grading system should be considered.

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A UK Nuffield Farming Scholarship consists of:

(1) A briefing in London.

(2) Joining the week-long Contemporary Scholars' Conference attended by all new Nuffield Farming Scholars worldwide, location varying each year.

(3) A personal study tour of approximately 8 weeks looking in detail at the Scholar's chosen topic.

(4) A Global Focus Tour (optional) where a group of 10 Scholars from a mix of the countries where the scheme operates travel together for 7 weeks acquiring a global perspective of agriculture.

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The Nuffield Farming Scholarships scheme originated in the UK in 1947 but has since expanded to operate in Australia, New Zealand, Canada, Zimbabwe, France, Ireland, and The Netherlands. Brazil, Chile, South Africa and the USA are in the initial stages of joining the organisation.

DISCLAIMER

The opinions expressed in this report are my own and not necessarily those of the Nuffield Farming Scholarships Trust, or of my sponsor, The Worshipful Company of Butchers, or of any other sponsoring body.

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1. Personal introduction

Growing up on a beef, dairy and arable farm in West Yorkshire, I was always aware of the agricultural industry. However, it wasn't until I had an Applied Biology honours degree from the University of Nottingham under my belt and no idea what I wanted to do with it, that I started looking at agriculture more closely.

Figure 1: The author, Caroline Mitchell

In May 2006 I started working for JSR Genetics Ltd. What started off as two weeks work experience to develop my CV, soon ended up being a full-time job. After a year with the company writing the Standard Operating Procedures for AI studs and setting up the external auditing programme with SAI Global and AHDB, JSR approached me with a proposal to study an MSc in Meat Science and Technology part-time at Bristol University, sponsored by AHDB (BPEX at the time). Such an opportunity didn't take that much thinking about. Whilst studying for the MSc I was working in the JSR Research and Genetics Department doing two terms of maternity cover for one of the geneticists and putting things in place to start the JSR Food Quality Centre.

In 2011 I established the JSR Food Quality Centre and, as part of my role at JSR, I led a team that consulted industry, both in the UK and internationally, on production of all meat products, specialising in consumer acceptance and supply chain optimisation of pork. The UK client portfolio includes, but is not limited to: JS Sainsbury's; Woodhead Bros; Morrisons; and Cranswick Country Foods. I was appointed a Director of JSR in 2014, heading up the Meat Science Department. Whilst with JSR I served two terms of office with the National Pig Association: Allied Industry Group.

I have been the UK representative for the International Congress of Meat Science and Technology since 2010. I sit on the AHDB Pork Steering group for carcass classification and the management group for the EU COST action CA15215, and am a member of the EU PiG Thematic Group – Meat Quality.

After 13 years with JSR, in July 2019, I became an independent consultant and set up my own business: Food Quality Management Global Limited, trading as FQM Global. My aims are still very much the same: working with producers, processors and retailers, both at home and abroad, focussing on optimising supply chains for meat quality and consumer acceptance.

With the UK market share held by red meat declining, my unique position is aimed at reversing the downward trend in fresh meat sales and maintaining a sustainable industry.

2. My study background

Nearly all my working life has been spent specialising in meat science, particularly looking at simply maintaining market share let alone increasing it. I have become increasingly frustrated by the blind belief, which a lot of producers exhibit, that "British is best". I am extremely proud of the UK agricultural industry and I am a huge advocate of supporting the home industry; however, as a consumer, I have been unfortunate enough to eat some pretty horrendous British meat.

If I, as an educated consumer knowing what to look for on the shelf and how to prepare it at home, can buy meat and still have a bad eating experience, it made me realise that many people will have had an even far worse experience than I.

From work that I carried out at the JSR Food Quality Centre it became apparent that, often, premium products are giving a less favourable eating experience than standard products (see Appendix 1), which to me was very worrying. A consumer, having spent their hard-earnt money on a premium product, and then having had a bad eating experience, will not downgrade to a standard product. They will switch products entirely and the supply chain will then have lost the repeat purchase.

We also know that UK-produced meat is often more expensive than imported meat. This is due to a multitude of factors but these include the higher cost of production seen in the UK as well as the strong GBP£ making it cost effective to import meat from countries with a weaker currency.

With the advent of Brexit and the UK's trading platform in the global market changing, UK-produced red meat will be in direct competition with meat from countries which place a value on meat quality and reward producers for quality indicators i.e. colour, marbling, fat iodine score; thereby producing meat of consistently good eating quality. In addition, some of these countries will be producing meat more cheaply than we can in the UK.

Having thought about this subject for many years I determined that, for red meat to regain some of the market share held by chicken and fish, and compete globally, meat quality needs to be at the forefront of producer and processor business objectives. I believe that a new classification, grading and payment system would achieve this, as long as it included producer rewards for eating quality, and not just for yield of saleable meat.

Two previous Nuffield Farming Scholars have already looked at alternative classification grading systems for beef and lamb. 2006 Nuffield Farming Scholar John Yeomans looked at "Developments in Carcass Classification of Beef and Lamb", while 2013 Nuffield Farming Scholar Keith Williams investigated "Red meat carcass payment: are there better systems than the EUROP grid?" Each Scholar's paper gives a comprehensive overview of beef grading systems adopted globally, which I did not want to repeat. As a result, throughout my studies, I bore the following question in mind:

Question: "Why do farmers produce meat animals?"
Answer: "For the consumer to eat"

3. My study tour: where I went and why I chose these countries

When putting together my Nuffield Farming study plan, I spent a lot of time researching which contacts had already been visited by previous Nuffield Farming Scholars and what had already been written about. I also looked at what technologies have been developed since previous Scholars' studies. Because I am approaching my study from the angle of wishing to improve meat quality and not only grading consistency and accuracy, I determined that some technologies featuring in the earlier studies would need to be visited again. I chose to visit the following countries:

England	**AHDB** to establish what is in the pipeline, what has been tried before and what their long-term goals are. **Harper Adams** staff members to discuss where meat quality sits in the curriculum and where the barriers are in changing the mindset of students and farmers. **SRUC** to see their mobile CT equipment, the CIEL equipment and mobile taste panel lab.
France	To see the **CSB-systems Image-maker** in situ, discuss how a region-wide change in grading scheme was rolled out by **Uniporc Ouest,** and see the criteria France put on meat quality.
Germany	To see the **Frontmatec AutoFOM III™** running on a high throughput slaughter line and to discuss the product with an independent abattoir and the manufacturers
America	A grading system is already in place for cattle which incorporates eating quality. There are plants running the **e+v VBG 2000 Beef cam**, and **BioTronics BioQScanner** for pigs. **World Meat Congress** and **World Pork Expo** were running. The US have a very strong meat science research community and I wanted to discuss certain areas of research in more depth.
Japan	Japan have a globally established brand in the form of **Kobe beef** and **Wagyu.** Many countries have tried to emulate the Wagyu supply chain, a beef production system that prioritises marbling and organoleptic traits of animals. Japan has **Kurobuta** pork supply chains which are also focused on meat quality.
Australia	To attend the **International Congress of Meat Science and Technology**. Australia has the **Meat Standards Australia** classification system which gives an organoleptic quality score for meat. It was important to see this and the **DEXA** systems adopted in some sheep plants.
Italy	To attend **Terra Madre**, a food festival. Global food producers attend to showcase traditional, niche, unique food products. Milan also has the **first digital supermarket** which predicts how the consumer will interact with food at point of purchase in the supermarket of the future.
Ireland	**All-Ireland Meat Science Conference** hosted by AFBI (Agri-Food and Biosciences Institute).
Spain	To visit Mafrica abattoir to see the **gmSCAN** system, a newly EU-authorised (in Spain and Poland) carcass classification system, in situ and to meet with the research team who were involved in the authorisation process.

4. Current situation in the UK

"The current system of carcass classification used in Great Britain is completely outdated and is holding back the development of the industry by failing to adequately communicate consumer demand back to the processors and producers"
(AHDB Strategy Priority 1.2, Year 1 report:
Stimulating the introduction of a new method of pig carcass classification)

This is the situation as of 2019:

Within the United Kingdom (UK) the commercial value of a carcass is generally, although not always, evaluated by an MLCSL employee who is independent from the abattoir. The weight, gender and evaluation [mechanical P2 (pigs) or visual EUROP (cattle & sheep)] are used in combination to determine the commercial value of the carcass and the subsequent payment of the producer by the abattoir. Carcasses can be evaluated by assessing both the quality and compositional attributes. However, in the UK the current focus for pork, beef and lamb is the compositional quality based on weight and the absence of fat, at specific points of measurement, (in cattle and sheep this is combined with conformation) thereby predicting saleable meat yield. By only looking at the compositional attributes and ignoring the quality attributes it is thought that this method may be *"providing perverse incentives to produce a product that does not meet the need of consumers for a better eating quality product*" (AHDB Strategy Priority 1.2, Year 1 report: Stimulating the introduction of a new method of pig carcass classification).

Carcass classification and grading have developed to provide a common language between abattoirs and the producer to underpin payment agreements and provide feedback on carcass attributes in relation to value. The common language also facilitates carcass and primal trade for domestic and international markets.

4.1. Classification and grading

Classification describes the method used to determine the carcass attributes (e.g. Optical Grading Probe measures back fat at P2 in pigs). Grading is particular to each plant. The producer is paid based on how the carcass grades, and the processor uses the grade to determine how best the carcass can be utilised. The definitions for "Classification" and "Grading" were outlined by *AHDB Industry Consulting*:

> **Classification –** The ranking of carcasses according to given parameters describing attributes (e.g. lean yield) of the carcass that are useful to those involved in their utilisation (i.e. selection, trade etc).
>
> **Usage:** to establish carcass evaluation systems based on given carcass quality criteria

> **Grading** – The placing of different values (e.g. Indexes) on carcasses for pricing purposes, depending on the market and requirements of traders.
>
> **Usage:** to establish a payment system based on carcass

Grading systems should be differentiated from Classification systems. It is the grading mechanism that places a value on the carcasses in each of the "classes", based on how the carcass can be utilised and how much return it will make. Classification allows carcasses to be traded unseen, based on a universally understood descriptor.

The classification of a carcass should be the same for all abattoirs, i.e. if a single carcass were to be classified by 8 different processors the "Classification" should be the same.

As explained by *Paul Warriss* in his book "*Meat Science*": Classification schemes automatically lead to product uniformity. However, grading schemes may produce uniform top grades but variation in the poorer grades. Poorer grades are poor for different reasons: too fat, not enough conformation; but they are included together.

Ideally a classification system should be absolutely precise, and the classes should precisely relate to the commercial value.

A detailed explanation of carcass classification and grading for beef, lamb and pork in the UK can be found in Appendix 2.

4.2. Advantages and disadvantages of current UK classification and grading systems:

Advantages	Disadvantages
It's what we know – producers understand their targets and impact on profit/loss	It is subjective – whilst grading staff are trained to the highest standards there is always a risk of error and differences between assessors
Doesn't need a vast amount of space	Assessment fields bear no relation to end-product quality, eating, technical etc
Trading agreements (UK and Export) are built around current system	Cost – have to pay MLCSL fees. Whereas an automated machine is a one-off installation cost and then maintenance fees.

4.3. What is "meat quality"

When aiming to improve meat quality it is important to understand the varying facets included in the term "meat quality". Meat quality can be defined in various ways; however, in general there are functional qualities and conformance qualities, and these, in turn, have further quality categories.

Functional Quality – The desirable attributes in a product i.e. tenderness and flavour.

Conformance Quality – Producing a product that meets the consumer's specifications i.e. removing rind and trimming backfat to a specific thickness, providing portion sized beef steak, chicken breasts etc.

Both are important, because consumers want a product that conforms to their requirements, but it also needs to meet their expectations during eating. It is important to realise that different people

and cultures have varying expectations for functional and conformance qualities. There have also been consumer studies which show that the consumer most often likes what they are used to, showing that preferences can be determined by previous experiences and can also be conditioned.

Meat quality attributes were comprehensively described by *Warris (1996*) amongst others and can roughly be categorised as below. It should be noted that some traits can be associated with multiple attributes. i.e. **marbling** affects 4 attributes: compositional, technical, nutritional and organoleptic quality.

Wholesomeness comprises both:

> **Hygiene Quality** – Both chemical and microbial safety: bacterial load, pathogenic, pH value, water activity, reduction potential, nitrate, drug residues.
>
> **Nutritional Quality** – Protein content, caloric value, vitamin content, mineral content, lipid content, saturated fatty acid content, cholesterol content, utilisation, digestibility.

The first and most basic requirement is that meat should be safe to eat. It therefore should be free of zoonotic parasites, microbial pathogens and hazardous chemicals.

Secondly meat should have nutritional qualities that positively contribute to the consumer's diet. Meat is high in protein, contributes essential fatty acids - such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) - as well as vitamins and minerals to the diet:

> **Composition Quality** – saleable meat yield based on proportions of fat (as Subcutaneous, Intramuscular/Marbling and Intermuscular Fat), lean meat and bone, in conjunction with overall shape/musculature of the carcass. These traits directly affect the profitability of a carcass for the abattoir/processor because higher yields mean more product and potentially greater profit.
>
> **Technical Quality** – Chemical composition of lean; water content and water holding capacity; connective tissue content; pH at 45 minutes post-mortem and 24hrs+ post-mortem; salt absorption capacity; unsaturated fatty acids content. These traits all directly affect the ability to further process the meat: for example, curing to make bacon, or air drying for hams. Technical qualities also affect shelf-life and saleable yield.
>
> **Ethical Quality** – Acceptable husbandry of animals: i.e. production system, breed, medication (antibiotic-free). Assurance scheme: Red Tractor, RSPB, Soil Association etc.
>
> For the consumer the ethical equality of a product can usually be determined by easily identifiable logos on packaging at retail (*see figure 2 overleaf*): for example Red Tractor, RSPCA, Leaf or Organic. These logos are used to identify products that have been produced following the specifications of different assurance schemes.

Figure 2: Some of the logos used on UK packaging to identify assurance schemes

There are also products that have EU Protected Food Names. There are three marks used within the EU (*see figure 3 below*) that highlight regional and traditional foods whose authenticity is guaranteed: Protected Designation of Origin; Protected Geographical Indication; and Traditional Speciality Guaranteed.

Figure 3: Logos for PDO, PGI and TSG products.

Protected Designation of Origin (PDO): Products with this mark must be produced, processed and prepared in the geographical area from which they originate. e.g. Yorkshire Forced Rhubarb.

P**rotected Geographical Indication (PGI)**: Products with this mark must be produced or processed or prepared within the geographical area i.e. Melton Mowbray Pork Pie.

Traditional Speciality Guaranteed (TSG): Products are not determined by geography but based on traditional methods or recipe i.e. Traditional Farm Fresh Turkey.

Consumers can and do use the logos on pack to help inform their purchasing decision. None of the logos in Figures 2 and 3 indicate how the product will eat, although some, such as the organic logo, are often incorrectly perceived to indicate a "tastier" product.

Organoleptic Quality – Appearance such as colour and texture of fat and lean; exudation; cooking loss and marbling; as well as other sensory characteristics such as smell, taste, juiciness, tenderness, and texture.

Appearance is important because this is one of the only criteria the consumer can base their purchase on. The palatability (texture, juiciness and flavour/odour) of a product is the criteria that a repeat purchase is based on. During eating, texture is the most important, then juiciness, and flavour/odour are least important. However, if there are high levels of abnormal flavour/odour it doesn't matter how tender and succulent the meat is, the meat will be perceived negatively.

The organoleptic quality of a product is the meat quality attribute most important to the consumer. Even if a product meets all the other attribute requirements expected of the consumer – if the eating experience is poor, they will not buy the product again.

4.4. Is the meat industry giving the consumer what they want?

If the various stages of a supply chain were asked to rank meat quality components (Wholesomeness, Ethical, Organoleptic etc) in order of preference, each stage would produce a different order of ranking. For the farmer and meat wholesaler yield/lean meat percentage are the most important because this directly affects their profit. But the consumer would rank organoleptic quality as the most important because they have paid for a product that they expect to meet their palatability expectations.

Producers are paid based on parameters that strongly correlate to lean meat percentage/yield. However, the only influx of money into a supply chain comes from the consumer, and this income is then transferred down the chain. Therefore, to increase money in a supply chain the consumer preferences should take precedent, thereby increasing demand and sales which in turn will further increase income.

To the consumer the organoleptic quality of meat is the most important, and yet the correlation between yield and organoleptic quality is often a negative one, with increased yield having a negative effect on organoleptic quality.

Because farmers are rewarded for lean meat percentage i.e. quantity not quality, breeding/genetics companies make genetic improvements that optimise profit for the farmer by focusing on key performance indicators (KPIs) such as Daily Live Weight Gain (DLWG), Feed Conversion Ratio (FCR) and Killing Out Percentage (KO%) as well as Lean Meat Percentage (LM%) because it is these values that directly affect the profitability of the animals on farm.

At nucleus breeding level Genetics companies use heritability (h^2) and Estimated Breeding Values (EBVs) of a given trait to drive genetic improvement. Multiple traits are given a percentage input and combined to create a Net Economic Index (NEI) for an animal. The NEI of a nucleus animal indicates

its ranking in comparison to its peers and ancestors, with those animals which have the highest NEI being the ones that will be most profitable for the farmer. As a result, when purchasing genetics, it is these NEIs that a farmer will look at and these figures that are listed in genetic catalogues. See the catalogue listing for a Limousin Bull “Brutus Hashtag” on the Cogent UK website in Figure 4 below:

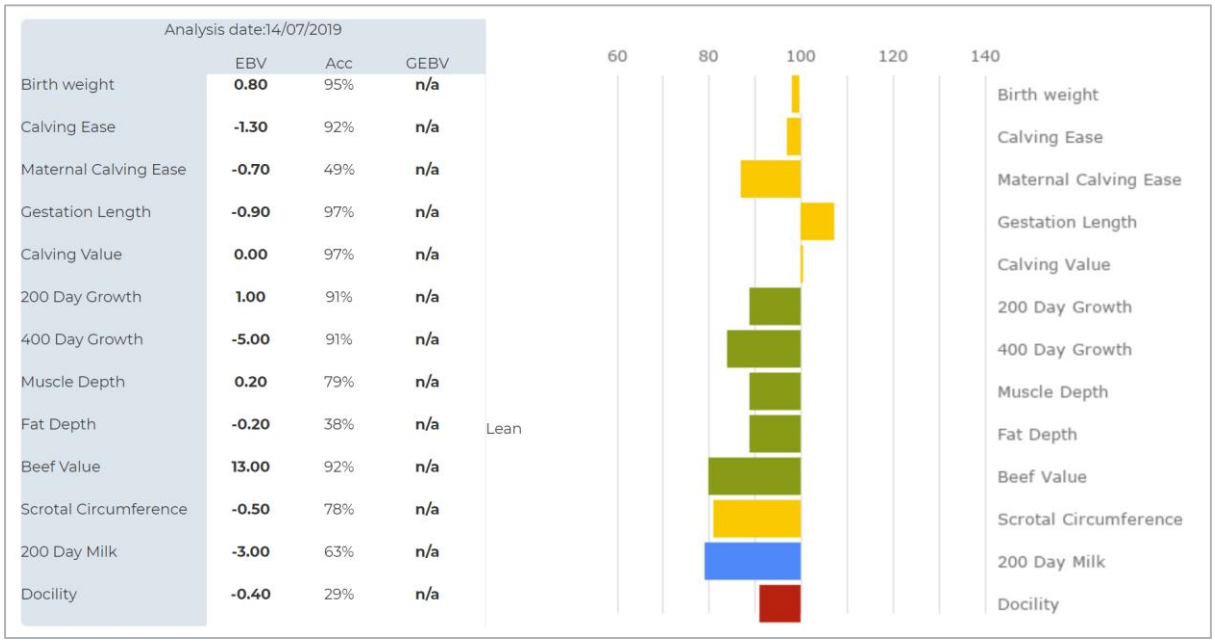

Figure 4: Catalogue listing for Limousin bull on Cogent UK website
Source: https://www.taurusdata.co.uk/beef/animalmanager/animaldetails?id=9393985

The catalogue listing for “Brutus Hashtag” does not contain any EBVs for traits that will directly affect the consumer’s experience: yet without a consumer there is no need to produce beef slaughter animals. If organoleptic traits are not being measured, they aren’t being managed – how does the farmer know if, by selecting this bull as a terminal sire, the consumer will have an improved eating experience?

4.5. Retail trends and consumer acceptance

When viewing the past 20 years (1997 – 2017) of consumer trends for muscle protein consumption (*see figure 5 overleaf*) the trends for pork, beef and poultry appear positive. However, when we look at the longer-term trends from 1974 to 2011 (*figure 6 overleaf*) we can see that overall market share of red meat (pork, beef and lamb) has declined hugely in favour of chicken and convenience foods.

Part of chicken, fish and convenience foods’ increase in market share is due to price/kg, ease of cooking, and health. However, these factors do not wholly account for the decrease in per capita consumption. Global studies tell us that total protein intake increases with income up to approximately 100kg/year/capita. At this point the purchase decision is "upgraded" for either ethical or eating quality reasons: i.e. choosing free-range over standard product. UK red meat, especially pork, is often marketed based on production ethics. However, from eating studies JSR have carried out, we know "standard" pork is often preferred by the consumer to premium pork (*see Appendix 1)* and premium beef is seen to be inconsistent.

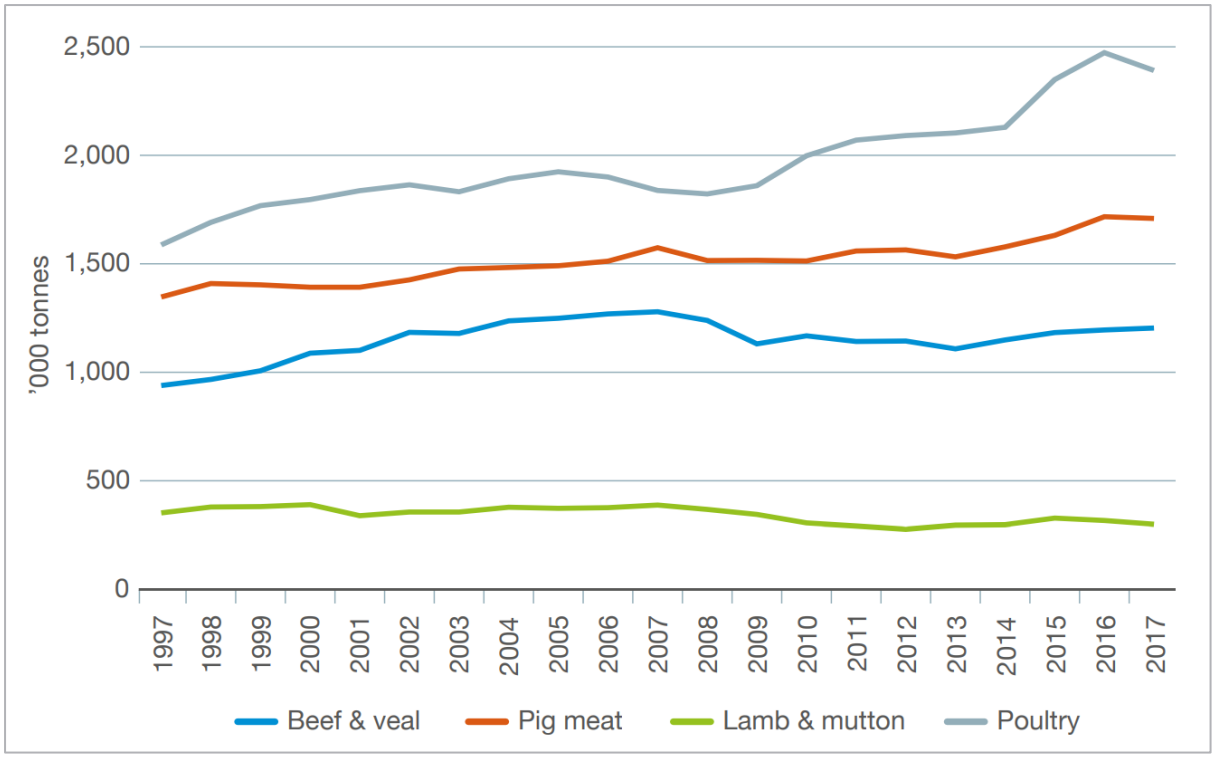

Figure 5: Consumer trends for consumption of Poultry, Beef, Pork and Lamb 1997 – 2017 sourced from AHDB UK Cattle Yearbook 2018

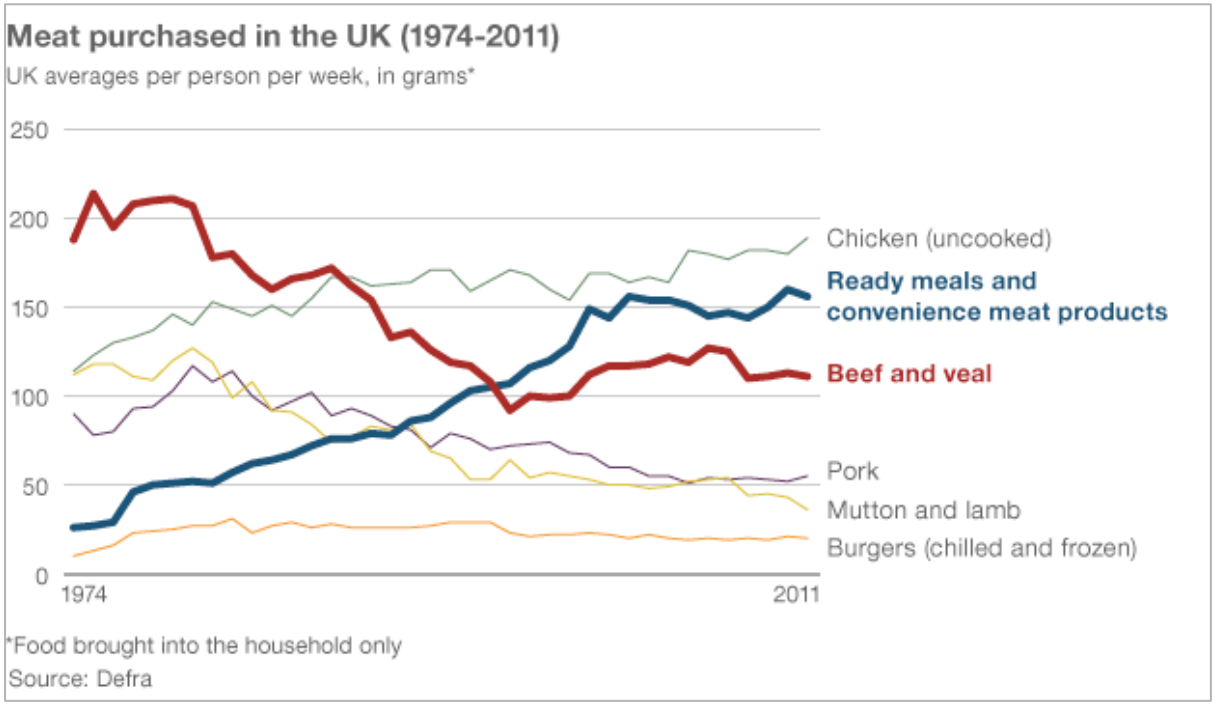

Figure 6: Consumer trends for consumption of Poultry, Beef, Pork and Lamb 1974 – 2011 (AHDB)

Looking at figures provided by AHDB (prices taken for YTD from AHDB-produced figures for period ending 16/6/19) chicken and pork £/kg are fairly comparable at £4.25/kg and £4.65/kg respectively. This would suggest that the increased market share for chicken is not based on retail price. From my own experience conducting trained and consumer taste panels for various retailers the feedback for

pork, beef and lamb always includes a mention that the products are not consistent and that there is too much variability with regards to overall acceptability. Chicken is a very consistent product. If red meat could be as consistent as chicken for meat quality it has a good chance of regaining market share.

It's posited that technologies and systems in use abroad (or currently in development) to assess meat quality on the slaughter line can be applied/modified/adapted for use within the UK. In addition, systems for one meat species could be transferrable to other meat species, thereby allowing the UK to "cherry pick" the best technologies and tailor them to our requirements. The inclusion of meat quality in a grading and payment system would change business drivers on farm, improve consumer acceptance and meat would meet consumer expectations.

4.6. What is on the horizon for the UK?

Phil Hadley, International Market Development Director for AHDB Beef and Lamb, has a longstanding interest in meat science. Within his role as Market Development Director we discussed the perceived image of UK products on the global market and by global consumers. The work that Phil has done with his team in this area has since been published as part of the AHDB Market Intelligence April 2018 Horizon document “International Consumer Buying Behaviour” and the June 2019 Horizon Document “Exploring Asia: Understanding consumer needs”. Both can be found as pdf documents on the AHDB website.

The summary messages from both documents are:

- The UK has great products to export but the consumer needs to have key selling points beyond the country it came from to drive purchase.
- Understanding markets you are supplying is critical; does the product have a gap in the current offering? Where does it fit alongside competitors?
- The UK has a positive reputation for food safety and we can exploit this: especially in China and Japan which rank food safety as a key purchase driver.
- Cuts should be adapted to fit consumer demand for each country and thereby increase demand
- GlobalData (*Figure 7 overleaf)* shows that, valued at US$288.1 billion, Asia-Pacific is the largest market for meat in the world at 30% of the global value. With an expected Compound Annual Growth Rate (CAGR) of 2.2% from 2018-2023 it is an extremely important market both now and for the future.
- Many Asian consumers associate health with reputation of brand, production methods and country of origin.
- The Asian consumer likes an information chain with their purchase and expect QR codes on pack which directs consumer to origin, date and location of slaughter for meat, nutritional information and recipe ideas

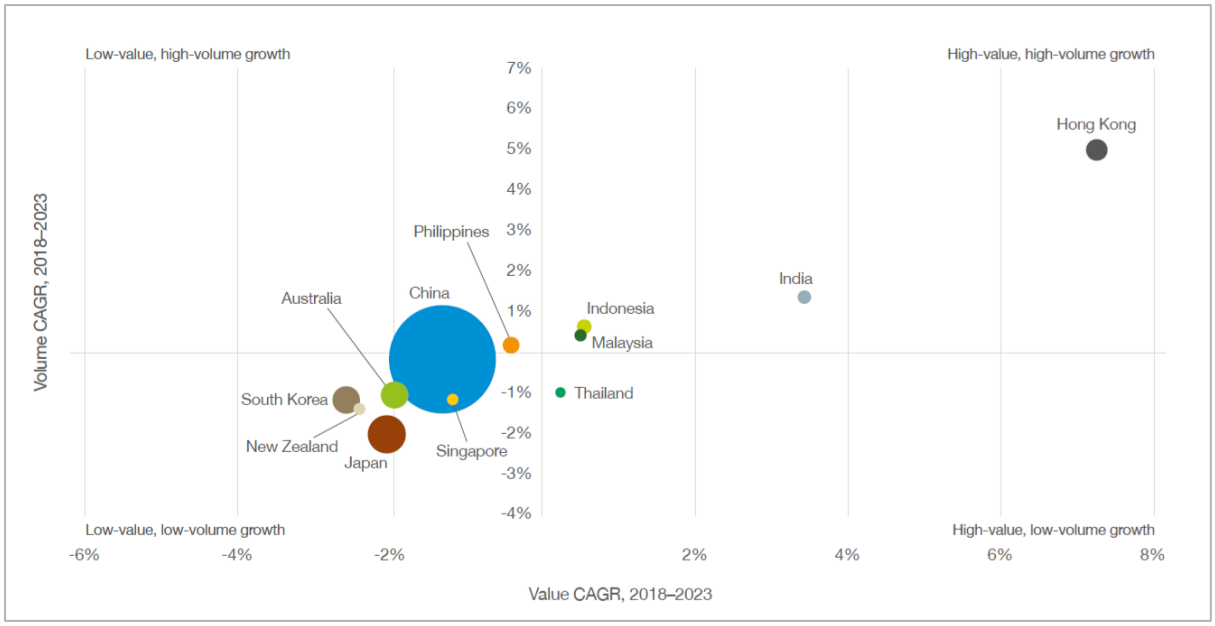

Figure 7: GlobalData Compound Annual Growth Rate (CAGR) Forecast 2018 – 2023; Value and volume growth analysis by country in relative terms. Size of bubble represents market value in US$ 2018

Source: GlobalData Growth Forecast 2018–2023 via AHDB Market Intelligence June 2019

The conversations that I had with Phil about the global market and consumer expectations, in conjunction with my existing knowledge of carcass utilisation imbalance in the UK, led me to conclude that:

4.7. Personal Conclusion re current situation of meat market in UK

> Since the UK cannot compete on cost of production, we need to maintain and expand the reputation we have in Asia for food safety and quality.
>
> But, if we go down the quality route, we need some way to measure and manage quality of meat to ensure the British "brand" is maintained.

5. Observed systems to measure meat quality

During my Nuffield Farming Scholarship study tour I visited the following countries to study systems they had in place to measure meat quality: France, Germany, Italy, Ireland, Spain, America and Japan. My findings are described in the rest of this chapter (5).

5.1. CSB Image-meater:

5.1.i. Summary:

Manufacturer	CSB-System, Geilenkichen, Germany
Methodology	Visual assessment via camera and prediction equations
Species	Pigs
Traits Assessed	Compositional Quality (Primal Yield), Organoleptic Quality (IMF & Colour) in development
Automated?	Yes
Objective/Subjective	Objective
Case Study	Uniporc Ouest & Cooperl Abattoir, Brittany France, November 2017

5.1.ii. Travel Case Study:

Uniporc Ouest is an interprofessional association representing producers, processors and allied industries. There are 36 board members representing those three areas. The aim of the association is to "*guarantee the weighing and grading of pigs and cull animals from the West and North of France*". They operate in 25 abattoirs, using the CSB Image-Meater (manufacturer CSB-System, Geilenkirchen, Germany) in 18 sites, and the Uniporc Ouest's inhouse developed Lean Fat Sensor (LFS) in the remaining 7 sites, with the 18 abattoirs that are using the CSB Image-Meater having the LFS as a backup on the slaughter line. Uniporc Ouest classify the pig carcasses, making them the centre of the transaction between the abattoir and the pig producers. They classify over 20 million pigs a year. The funds for running Uniporc Ouest are raised by taking a tariff from the farmer for each pig that is assessed. As opposed to each processor having their own payment grid, as is most common in the UK, the grid is set by Uniporc Ouest and used across all 25 sites: thereby standardising the "ideal" pig for the *region* - not for each abattoir.

The CSB Image-Meater is an automated visual assessment tool and when the initial trial work was carried out in 2007/2008 a saving of 37 €cents/pig to 29 €cents/pig was seen. The consistency of classification also improved with the manufacturer (CSB-systems) claiming a 0.04% variability to the butchery reference method. The use of the CSB Image-Meater also saw an improvement to their reporting service with producers able to review their classification results 10 minutes after the end of the working day.

The CSB Image-Meater works on a split carcass taking a digitised image of the lumbar and gluteal region (*see Figures 8 and 9*).

Figure 8: The CSB Image-Meater as outlined by Uniporc Ouest. TMP = Total Meat Percentage

Source:https://translate.googleusercontent.com/translate_c?depth=1&hl=en&rurl=translate.google.co.uk&sl=fr&sp=nmt4&tl=en&u=http://www.uniporc-ouest.com/documentation-technique/classement-des-animaux/image-meater.html&xid=25657,15700021,15700186,15700191,15700256,15700259,15700262,15700265&usg=ALkJrhjZ_jX1OlAOgVDpBYoAXcLhbWUKgw

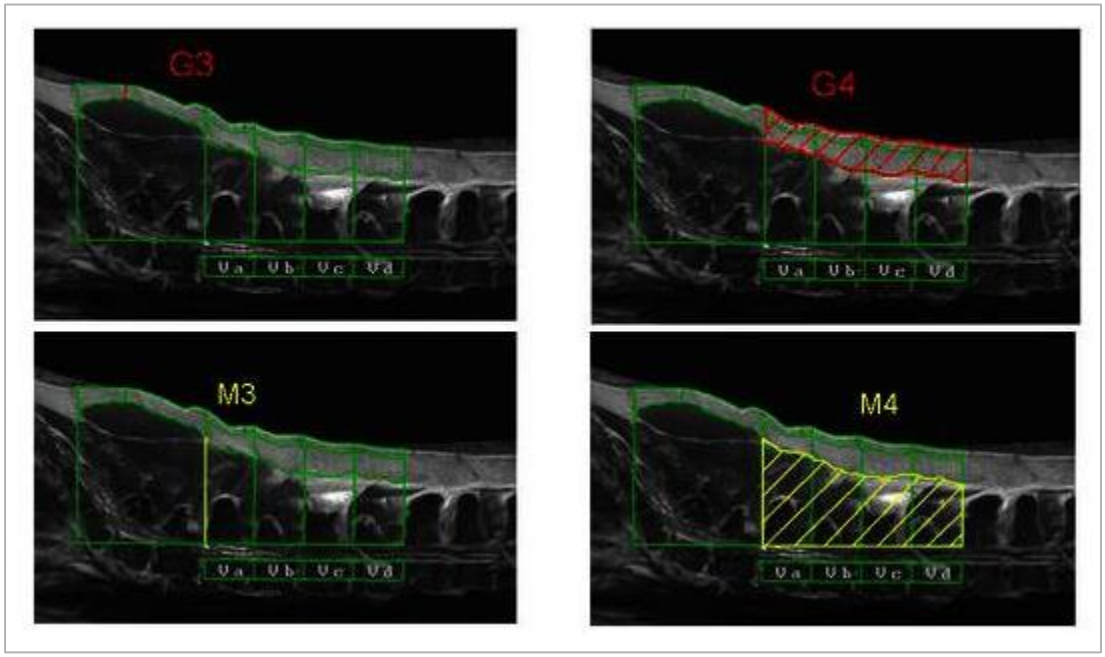

Figure 9: The CSB Image-Meater as outlined by Uniporc Ouest.

Source:https://translate.googleusercontent.com/translate_c?depth=1&hl=en&rurl=translate.google.co.uk&sl=fr&sp=nmt4&tl=en&u=http://www.uniporc-ouest.com/documentation-technique/classement-des-animaux/image-meater.html&xid=25657,15700021,15700186,15700191,15700256,15700259,15700262,15700265&usg=ALkJrhjZ_jX1OlAOgVDpBYoAXcLhbWUKgw

Advantages of the CBS Image-Meater system according to manufacturers are:

- Robust, with a backup camera in each installation
- Completely automated
- Image is recorded and held on a database which the producer has access to
- Small footprint with ability to retrofit into slaughter lines.
- More accurate than competitors (AutoFOM) compared to reference method.
- Developing a high-resolution colour camera that potentially will score IMF and colour of muscle. Thereby allowing some organoleptic measures to be recorded.
- €200K - €270k installation including training

5.1.iii. My conclusions:

The system has good repeatability and consistency. The small footprint and installation fees are also a positive and the electronic ID gambrels (EID) needed for system optimisation are already in place in the main abattoirs. This technology would be suited to the larger UK processors (Cranswick, Karro, Tulip, Woodhead's). Electronic ID gambrels can also be fitted retrospectively for all other abattoirs if needed.

However, the viability of the CSB image-meater system in the UK processing system is questionable. Two of the 4 large UK processors operate a system called "finning" where the loin is cut away from the spinal column prior to splitting to increase loin yields. The detachment of the loin from the spinal column would not allow for an accurate image to be recorded and therefore the calculated results would be inaccurate. A large range of genetics is used in the UK, and multiple production systems cause a considerable amount of carcass conformation variability. There is scepticism that the small image area used to calculate the carcass yield would be robust enough or provide enough information to cope with the variation between animals seen in the UK.

At present the CSB image-meater does not offer any ability to measure meat quality, although they are developing a newer system that will hopefully be able to measure marbling and colour of meat. When this is launched existing systems could be updated. The inability of the system to measure meat quality traits, other than composition quality, means that the system would not at present help in making meat quality a priority within supply chains.

5.2. Human nose scoring (HNS):

Manufacturer	N/A – training of staff required
Methodology	Subcutaneous fat is heated and then "sniffed" by trained operatives
Species	Pigs (although could in theory be used for "bull beef" and "gamey lamb")
Traits Assessed	Organoleptic Quality: Boar taint incidence
Automated?	No
Objective/Subjective	Subjective
Case Study	Cooperl Abattoir, Brittany France, November 2017 Westfleisch Abattoir, Coesfeld Germany, January 2018

5.2.ii. Travel Case Study:

Cooperl and Westfleisch each had operatives, working in pairs in rotation, who were human-nose-scoring carcasses for boar taint. Boar taint is a smell and flavour taint found in fat and lean tissue as a result of an accumulation of Skatole (fat and water soluble, so found in fat and lean tissue) and Androsterone (fat soluble only, not found in lean). Androstenone is a sex pheromone produced in the testicles of the boar (male pig), to stimulate the sow (female) to mate, and concentrated in the salivary glands and fat. It smells of urine/perspiration but not everybody can detect it. Women are more susceptible than men, and people with Asian heritage are also more predisposed to being able to detect it. Skatole is produced by the breakdown of tryptophan in the large intestine by bacteria. When present in meat it has a very unpleasant faecal odour; however, at a very low level it can smell floral and is used in perfumes.

Cooperl and Westfleish each have a licence to export to China and, because boar taint is negatively perceived by consumers, especially of Asian descent, all entire males (non-castrates) are assessed for incidence of boar taint and diverted from certain product routes if positively identified to contain taint.

5.2.iii. My conclusions:

In the UK, castration of boars without pain relief has been prohibited by Red Tractor standards since the early/mid 1990s, meaning that in the UK we only have entire male pigs going to slaughter. From work that I have carried out at JSR Genetics Ltd it is estimated that 12% of UK slaughter progeny have a level of boar taint that would be detectable by a susceptible consumer. However, nobody in the UK currently screens for boar taint.

Studies have shown (*Mather et al, 2012*) that the reproducibility of HNS ranges from 0.19 to 0.32, which reflects the natural variation in the ability of humans to detect different odours. "*The correlations of HNS with androstenone ranged from 0.22 to 0.52, while those with skatole ranged from 0.31 to 0.89, suggesting that skatole is a better predictor of boar taint*." The study concluded that, considering the relationship of HNS with the boar taint compounds, the ability of HNS to capture variation not accounted for by the boar taint compounds, low estimation costs and low time requirements, HNS can be used in large scale evaluations of boar taint.

If existing staff members can be identified as boar taint-sensitive, and trained to detect boar taint on the slaughter line, then Human Nose Scoring is a relatively cheap and easy way to detect tainted animals.

Alternatively, UWE, AHDB and JSR Genetics Ltd have developed a biosensor for the objective detection of boar taint. The system is currently being commercialised and will be available late 2019. If the UK meat producers wish to compete on the global platform, we should at the very least be doing the same as our competitors.

continued overleaf

5.3. AutoFOM III™:

5.3.i. Summary:

Manufacturer	Frontmatec Group, Kolding, Denmark
Methodology	Ultrasound
Species	Pigs
Traits Assessed	Compositional Quality (Primal Yield), Organoleptic Quality (IMF & Colour) in development
Automated?	Yes
Objective/Subjective	Objective
Case Study	Westfleisch Abattoir, Coesfeld Germany, January 2018 Mafrica Abattoir, Sant Joan de Vilatorrad, Spain, June 2019

5.3.ii. Travel Case Study:

Westfleisch abattoir in Coesfeld, Germany, process 8 million pigs a year (1400 pigs/hour) and are running an AutoFOM III™. Mafrica in Spain are also running an AutoFOM III™ and have a line speed of 300 pigs/hour. The manufacturer's claims for AutoFOM II™ can be seen in Appendix 3.

In the UK AutoFOM I™ has previously been used by George Adams, now Tulip Spalding. JSR Genetics Ltd had been involved with a contract at George Adams based on ham yield as calculated by the AutoFOM I™ and, as a result, I had some familiarity with the original system. Since the original model, Frontmatec have further developed the equipment and the AutoFOM III™ captures 256MB of data per animal opposed to the 2MB the Mark I captured. Due to the increased data capture the lean meat percentage prediction error has been halved, suggesting that the AutoFOM Mark I's currently in situ in the UK are now obsolete.

see Figure 10 overleaf

The lean meat percentage, and associated primal yield, generated by the AutoFOM III™, plus carcass hot weight, are used as a factor in Westfleisch's payment grid. The AutoFOM generates a predicted weight for the ham, loin and shoulder based on the ultrasound image generated. The system then uses a regression calculation to predict belly yield. The payment grid has a base price in line with the national quotation, but price paid to the producer is adjusted according to predicted primal yield with each primal having a maximum/minimum weight banding that the producers are rewarded for staying within.

As a result of the paying matrix being implemented the genetics going through the factory are now mainly from a Duroc terminal sire which has improved the consistency of the products. Farmers have also started split-sex-feeding finisher animals, allowing gilts to be killed earlier than boars/castrates, ensuring that they hit the premium on the pay-matrix.

Mafrica also pay farmers based on AutoFOM readings with farmers being rewarded for larger, fatter hams which are used for air-dried ham production.

Figure 10: The AutoFOM III with EID reader in Mafrica Abattoir, Spain. ***Image: author's own***

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5.3.iii. My conclusions:

AutoFOM™ takes up quite a large area physically. As a result, it may not be possible in many of the UK abattoirs for it to be fitted retrospectively.

The ultrasound sensors can be easily damaged and cost €2000 each to replace, making maintenance costs potentially quite expensive.

The AutoFOM does not assess the whole carcass: it takes readings from the back of the pig (ham to shoulder) and then uses regression-derived models, based on the measurement data collected, to predict primal yield. The regression-derived models are developed based on butchery dissection of carcasses to assess primal yields. Accuracy is improving, however, for one of the most important cuts for the export market, the belly predicted yield is still generated by using regression-derived models; the belly region is not itself assessed.

By rewarding farmers for carcasses that are the most profitable for the processor, business decisions have been altered with specific genetics being favoured.

The AutoFOM III™ system does not currently measure any meat-eating quality traits. However, the Frontmatec representative I met with said that AutoFOM IV™ is currently in development and that the system will be updated so that the Analog/Digital converter will be placed in the sensor. It is hoped that the new Mark IV will be able to assess marbling.

5.4. NitFOM™

5.4.i. Summary:

Manufacturer	Frontmatec Group, Kolding, Denmark
Methodology	Ultrasound
Species	Pigs
Traits Assessed	Meat Quality (Iodine value of fat and incidence of individual fatty acids)
Automated?	Yes
Objective/Subjective	Objective
Case Study	Westfleisch Abattoir, Coesfeld Germany, January 2018

5.4.ii. Travel Case Study:

Westfleisch operate a NitFOM™ which, like the AutoFOM, is manufactured by Frontmatec. It is used for the analysis of fat quality traits - such as iodine value and individual fatty acids - directly on the slaughter line. The NitFom™ is the world's first online instrument for grading iodine value and fatty acids in real-time and can provide online data at line speeds up to 1,200 carcasses per hour. It does so with extremely high precision, in real-time, with a prediction error of 1.5 iodine values in hot carcass classification and 2.0 iodine values in cold carcass. Measurement takes 3 seconds per carcass.

5.4.iii. My Conclusions:

Online rapid prediction of fat quality traits (using iodine value or fatty acids as a sorting parameter) allows slaughterhouses to pre-sort carcasses for optimal cutting and provides feedback to the producer on feeding regimes. The NitFom™ can provide data that will have a direct impact on the eating quality of a product.

5.5. gmSCAN:

5.5.i. Summary:

Manufacturer	Denmark gmSteel, Dundalk, Ireland & Lenz Instruments S.L. Engineering, Barcelona, Spain
Methodology	Magnetic induction
Species	Pigs
Traits Assessed	Compositional Quality (Primal Yield), Organoleptic Quality (IMF) in development
Automated?	Yes
Objective/Subjective	Objective
Case Study	Mafrica Abattoir, Sant Joan de Vilatorrad, Spain, June 2019

5.5.ii. Travel Case Study:

Whilst not currently running at this speed, in theory gmSCAN can assess 1000 pigs per hour. It is a robust system with a small footprint (*see Appendix 4*). Because it is no-contact the system is only likely to be damaged by abattoir staff, although the higher risk parts (computer and electronics) are easily replaced if necessary and spares can be kept in stock *(Figures 11 and 12 show a screen readout and the gmSCAN in situ*).

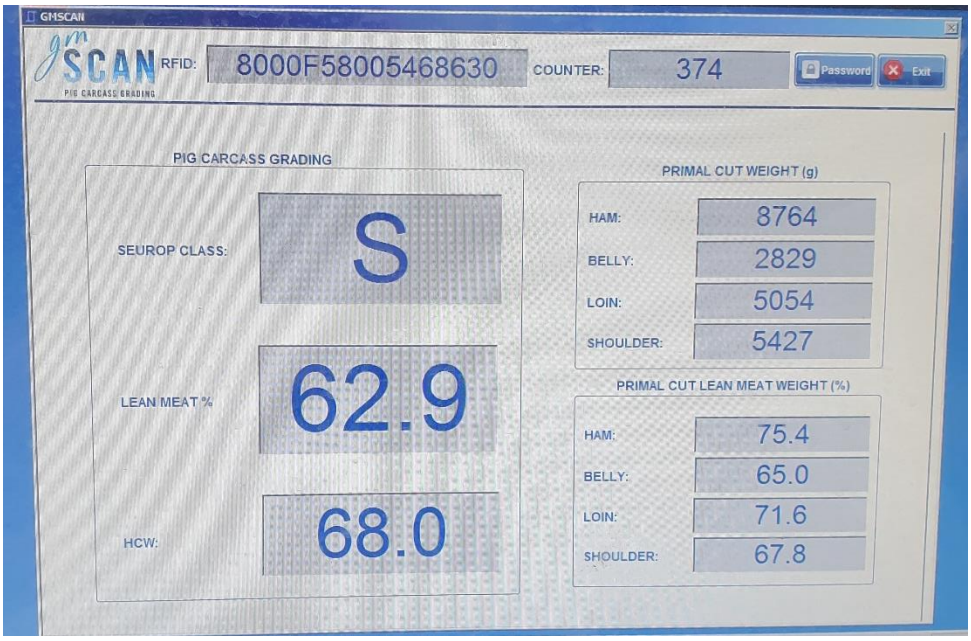

Figure 11: Computer screen readout from gmSCAN. Photo: author's own

Figure 12: gmSCAN in situ at Mafrica, Spain. Photo: author's own

gmSCAN uses magnetic induction to automatically predict total lean meat percentage of the carcass plus the total weight and lean meat percentage of ham, loin, belly and shoulder. The total lean meat percentage is used to classify pigs according to SEUROP. The system is non-contact and takes 700

individual measurements to generate 3 parameters that are combined with hot carcass weight to generate the predicted yields using the following equation:

$$LM\% \text{ of carcass} = A_0 + A_2(Q_1/CW) + A_2(Q_2/CW) + A_3(Q_3/CW) + (A_4 \times CW)$$

Q_1 Magnetic induction response from Ham, Q_2 from middle section,
Q_3 from shoulder area, CW hot carcass weight.

The gmSCAN produces very robust data that is able to cope with a large variation in lean meat percentage (20% LM to >70% LM with an R2 of 0.974)

5.5.iii. My conclusions:

While, like the AutoFOM, the gMSCAN uses regression-derived models to predict carcass yield, the difference is that the gmScan takes measurements from the belly region so the data/measurements and the predicted belly yield are more closely related.

The gmSCAN has a much smaller footprint as well as lower installation and maintenance costs than the AutoFOM™ III. The system also bases its primal yield predictions on more data points than either the AutoFOM or the CSB Meat-imager, resulting in more robust data and a system that can cope with the large variation in carcasses as seen in the UK.

5.6. VBG 2000 Beef cam

5.6.i. Summary:

Manufacturer	e+v Technology GmbH, Germany
Methodology	Visual assessment via camera and regression analysis
Species	Cattle
Traits Assessed	Compositional Quality (Yield Grade), Organoleptic Quality (IMF)
Automated?	No
Objective/Subjective	Objective
Case Study	JBS, Greeley, Colorado, USA, May 2019

5.6.ii. Travel Case Study:

To take the reading, the carcass is split and then cut between the 12th and 13th rib. The rib incision is made there because historically, in the US, where the equipment was observed, this is where the hindquarters were separated from the ribs in US primal wholesale. There is no measurement benefit from using this location. The exposed rib eye surface is given a bloom time of 30minutes prior to being assessed by the USDA and JBS operatives. The camera operative is employed by JBS and the camera determines rib eye area, yield grade and marbling. A USDA operative visually scores the carcass and it is the USDA operative's decision that determines the payment to the producer. However, there is a second JBS operative who reviews the classification given by the USDA staff member and they can contest the classification if they disagree.

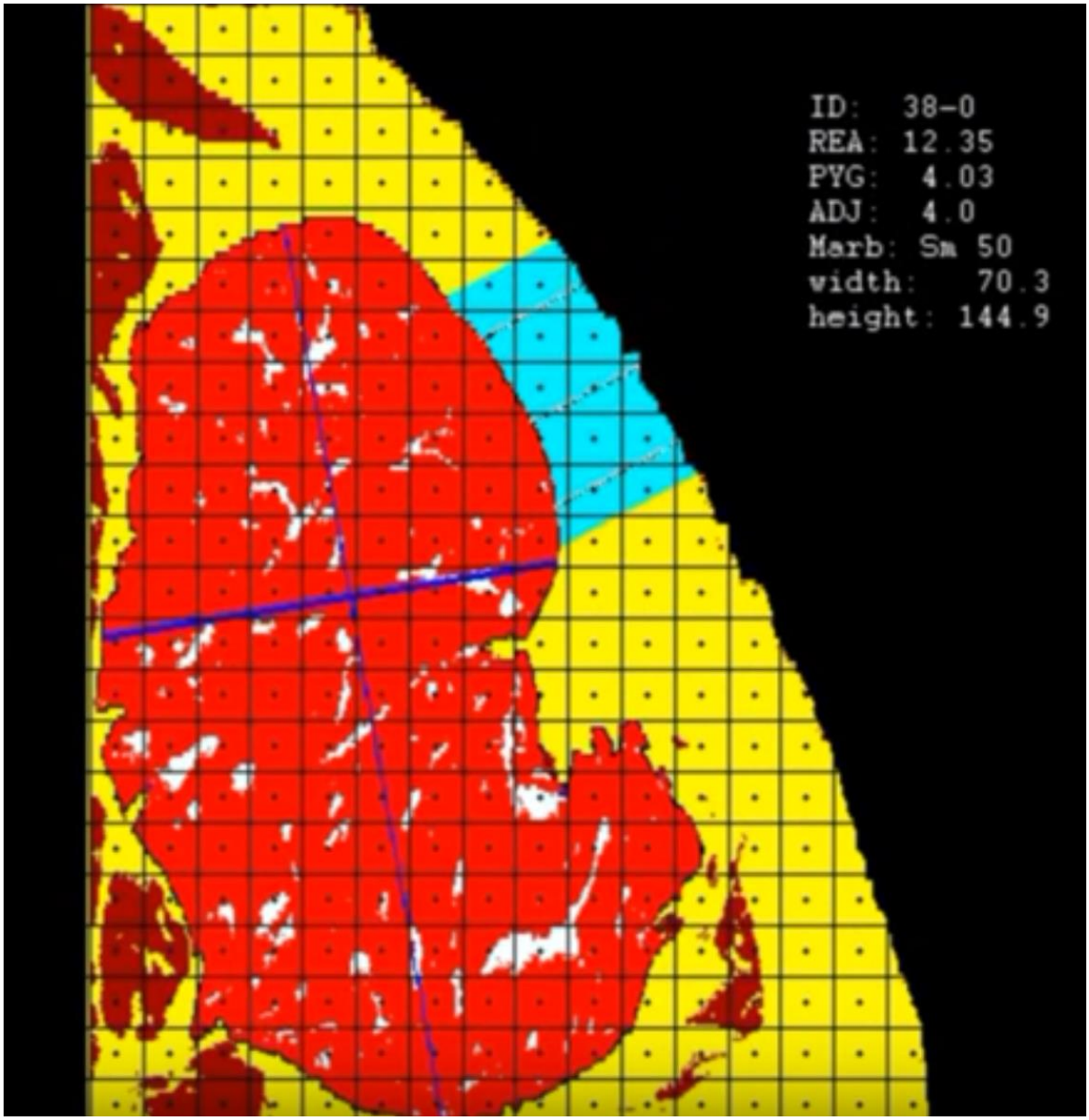

Figure 13: Image generated by VBG 2000 camera provided by e+v.

Using the hot carcass weight as an additional input the VBG 2000 is a hand-operated camera system that determines multiple parameters:

- Yield Grade on a scale of 1 to 5, with Grade 5 being the highest yielding for saleable meat.
- Quality Grade (USDA: Prime, Choice, Select, No Grade) as calculated by the level of marbling in rib eye muscle.
- Rib eye area is calculated from the grid system that is overlaid on the eye muscle in Figure 13 and rib eye height and width
- Hypodermic fat thickness (PYG) is calculated from the area in pale blue in Figure 13
- Total area, Fat:Meat and lean meat percentage are also calculated

5.6.iii. My conclusions:

The VBG 2000 beef cam is hand-operated which means that there is always the possibility for human error. The speed is limited to 450 head/hour due to processing time and human abilities. e+v also manufacture the VBS 2000 which is a visual image assessment (VIA) grading system.

Both the VBS 2000 and the VBG 2000 have their limitations and likelihood of errors. However, if and when used in combination, the data generated is more accurate and robust. The VBG 2000 is a great tool for objectively measuring IMF (IMF being a predictor for organoleptic quality). However, the invasive necessity to split the carcasses between the ribs would require UK abattoirs to alter the way they break down carcasses so that the cut is always in the same place, which at present it is not; it is dictated by what product the butchery line is generating at the time.

5.7. BioQscan®

5.7.i. Summary

Manufacturer	Biotronics Inc, Des Moines, Iowa, USA
Methodology	Ultrasound
Species	Pigs
Traits Assessed	Compositional quality (fat thickness, loin depth and lean meat %), Organoleptic Quality (IMF)
Automated?	No (possibility for further development)
Objective/Subjective	Objective
Case Study	Tyson, Ames, Iowa, USA, May 2018

5.7.ii. Travel Case Study

Biotronics Inc have developed the BioSoft Toolbox II, an ultrasound technology to scan and measure the backfat, loin depth and marbling of live pigs. This technology has been widely adopted by pig genetics companies worldwide. Using the same methodology Biotronics Inc have developed a carcass grading system called BioQscan® which has been adopted by several abattoirs in the US mid-west. Using 3rd generation ultrasound technology the BioQscan® is a non-invasive, fully integrated system that includes ultrasound scanner, computer processing centre and scanning probe and has been proven to work at line speeds of 1,400 carcasses/hour.

See figure 14 overleaf.

The system is housed in a stainless-steel cabinet designed to withstand the challenging environment of a pork abattoir. The system database can be customised to interface with the abattoir carcass sequencing and identification systems. If an abattoir does not already have individual carcass ID system then a sequence number printer can be added. The manufacturer's requirements for installation can be seen in appendix 5.

All classification is carried out by an operative at line speed. There is a guidance bar to ensure the scanner is positioned correctly on the pig and a traffic light system to instantly highlight if there has been a contact error. The system provides instant read out for pork loin Intramuscular fat % (IMF%)

and carcass lean meat % (as seen in Figure 14). The scanner also has a calibration box allowing the abattoir to ensure that the system is accurate at the start of every day, or more frequently if desired.

Some abattoirs use the BioQscan® system to differentiate high quality loins and provide payment premiums to producers who supply animals within the requirements.

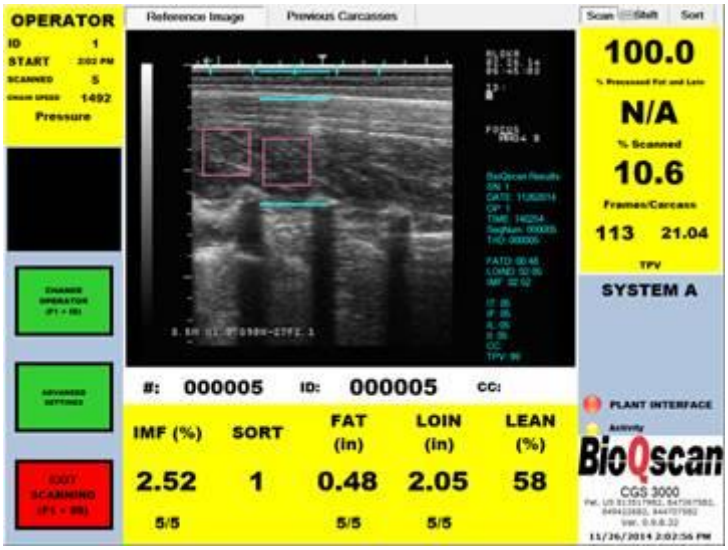

Figure 14: Screen readout generated by BioQScan®
Source*: http://www.biotronics-inc.com/bioqscan.htm*

5.7.iii. My conclusions:

Being both non-invasive and able to measure an organoleptic trait (IMF) is a unique feature when compared to other equipment observed, and whilst not currently automated, the system potentially could be.

The technology could potentially work on cattle and sheep. However, the hide would have to be in situ and de-haired where the probe makes contact which, whilst feasible, would have repercussions for hide value.

See overleaf for 5.8: Japanese grading scheme.

5.8. Japanese grading scheme:

5.8.i. Summary:

Manufacturer	Japan Meat Grading Association (JMGA) and/or Meat Image Japan (MIJ)
Methodology	Observational or MIJ-30 camera
Species	Cattle and Pigs
Traits Assessed	Compositional quality (fat thickness, loin depth and lean meat %), organoleptic quality (marbling amount, firmness and texture of meat, colour and shine of meat, fat colour and shine)
Automated?	No
Objective/Subjective	Subjective (except where MIJ-30 is used)
Case Study	Starzen Meat Processors, Kagashima, Japan, August 2018

5.8.ii. Travel Case Study:

In Japan I was hosted by Piqua Genetics. With them I visited Starzen Meat Processors in Kagashima. I went to a Wagyu beef production unit and Wagyu abattoir. Unfortunately, due to the outbreaks of African Swine Fever in Asia the pig unit and processor I had been scheduled to see suspended all visits.

The Wagyu classification and grading system starts at birth. A history of Wagyu development and the current supply system can be found in Appendix 6.

In 2007 the "Universal Wagyu Mark" was developed (*see Figure 15 below)* as a proof of authenticity and to help protect the Wagyu "brand".

Figure 15: Universal Wagyu Mark for proof of authenticity.

To maintain the high standards expected of Wagyu on the shelf the Japanese Meat Grading Association standards are used, with each carcass being individually assessed after slaughter by an association grader.

Carcasses are given a Meat Quality Grade and a Yield Grade. The meat quality grade is determined by taking measurements on the $6^{th}/7^{th}$ rib cross section, assessing: marbling amount; firmness and texture of meat; colour and shine of meat; and fat colour and shine (see Figure 16 overleaf).

Figure 16: Wagyu Carcasses after grading.
Photo: author's own

The quality grade is on a scale of 1 – 5, with 5 being the best grade. The overall meat quality grade is equal to the lowest grade among the four characteristics. Yield grade judges the final meat yield using the following calculation:

$$\text{Estimated yield for Wagyu} = 67.37 + (0.130 \times \text{thoracic longissimus muscle area cm}^2) + (0.667 \times \text{rib thickness cm}) - 0.025 \times \text{cold split carcass weight kg}) - (0.896 \times \text{subcutaneous fat thickness cm}) + 2.049$$

Using the yield grade, carcasses are put into 1 of 3 categories: A = Estimated yield ≥72%, specification is above average: B = Estimated yield 69 - 72%, specification is average: C= Estimated yield ≤69%, specification is below average. The final carcass grade is a combination of Quality and Yield Grade (*see Figure 17 on next page*). A5 is the best grade and C1 is the worst.

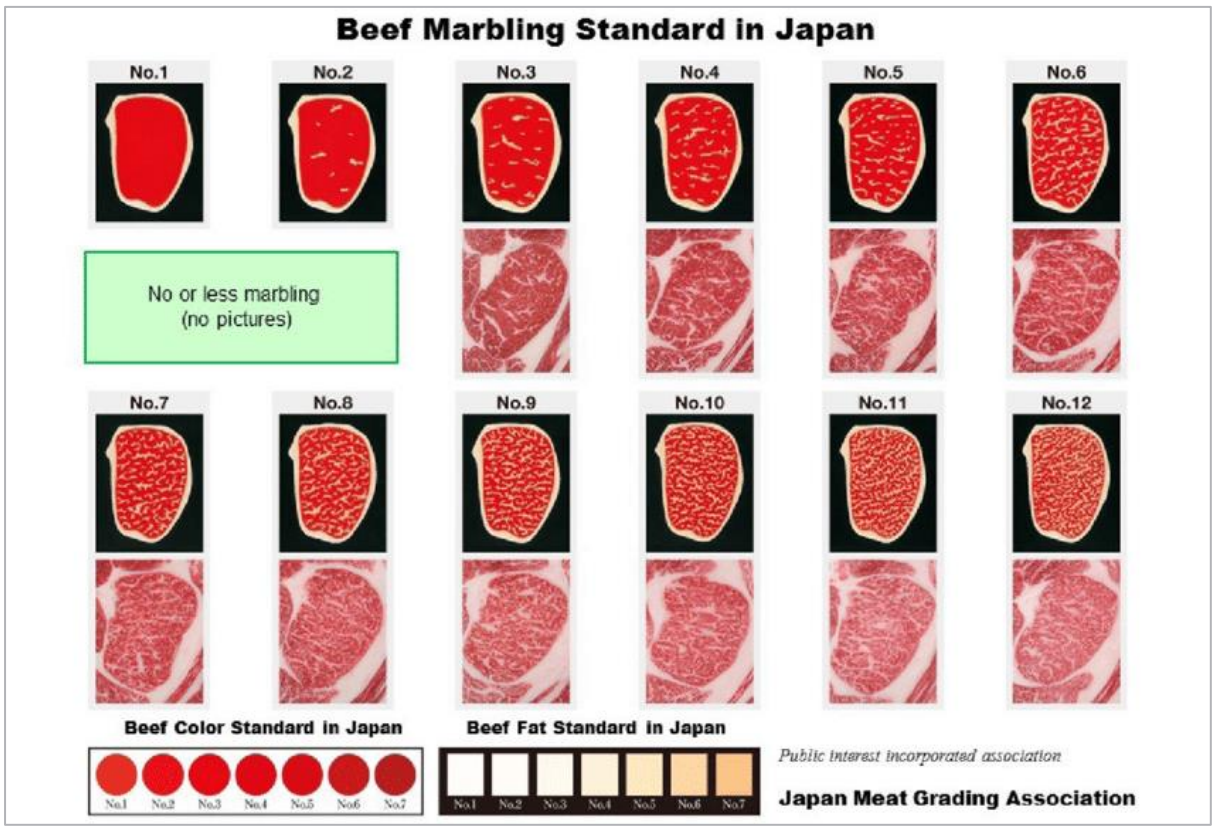

Figure 17: The official Beef Marbling Standard in Japan (*Gotoh et al, 2018*)

Yield Grade		Meat Quality Grade				
		5	4	3	2	1
	A	A 5	A 4	A 3	A 2	A 1
	B	B 5	B 4	B 3	B 2	B 1
	C	C 5	C 4	C 3	C 2	C 1

Figure 18: A Japanese Wagyu grading grid

In 2017, Meat Image Japan launched the MIJ-Camera for taking "Clear and Stable Digital Images for Rib Eye Surface of Beef Carcass". Very similar to the e+v VGB 2000, the MIJ-Camera (*Figure 19 on next page*) is intended for use in factory to make visual assessment semi-automated and objective, opposed to wholly manual and subjective.

The MIJ-30 uses a digital optical system with a resolution of 12Mb. Using individually ID'd carcasses, ID is scanned and then the rib section eye muscle is assessed, with the results being returned within 20 seconds of assessment. When compared to chemical analysis of fat, the MIJ-30 is 90% accurate.

Figure 19: MIJ-30 camera in use. Image sourced:
https://www.farmonline.com.au/story/5668599/digital-imaging-gives-wagyu-a-clear-view-of-premium-market/

Rib-eye area calculations are also highly accurate, as the technology uses automatic edge detection and can compensate for variations in cut angles and carcass rotations.

Every camera has a unique ID. The camera ID is linked to the images taken and therefore each processor has full traceability and owns the images.

5.8.iii. My conclusions:

With farmers being rewarded for producing carcasses with the best organoleptic traits in addition to yield, the main selection criteria when choosing genetics for breeding on farm is marbling. Farmers are looking for terminal sires that have the highest marbling EBVs because it is this, and not carcass yield, that has the greatest impact on their profit margins.

The JMGA system has ensured that the consumer is at the forefront of all business decisions made by both producers and processors.

The MIJ-30 is more accurate than manual subjective scoring system. However, the invasive nature of the assessment would not suit all UK supply chains.

5.9. DEXA (Dual Energy X-Ray Absorptiometry)

5.9.i. Summary:

Manufacturer	Scott Automation, Dunedin, New Zealand
Methodology	Dual Energy X-Ray Absorptiometry
Species	Sheep
Traits Assessed	Compositional quality: lean meat, bone and fat, meat quality (IMF and colour, in development)
Automated?	Yes
Objective/Subjective	Objective
Case Study	JBS, Melbourne, August 2018

5.9.ii. Travel Case Study:

Able to run at over 1000 carcasses per hour (SCOTT claim up to 30 carcasses per minute) the DEXA uses X-ray technology to measure yield of meat, bone and fat in a carcass. The information DEXA provides about each individual carcass then enables the cut specification to be optimised for that carcass. In addition, using the data generated by DEXA enables the boning/butchery schedules to be more precise and pricing mechanisms more reactive.

JBS were using the DEXA in conjunction with robotic cutters which further optimises the carcass yield and, whilst still in development, the robotic cutters had a camera system in place that was assessing marbling and colour of the rib eye section of the carcass. This allowed an additional selection stage to be implemented for back/loin primals, based on their premium potential.

In addition, the ability for DEXA to feedback carcass yield information to producers and genetics companies potentially allows for a more informed breeding programme, permitting progress to be more rapid.

5.9.iii. My conclusions:

The DEXA in conjunction with the robotic cutters allows a higher percentage of high value cuts to be achieved. The use of robots to break down the carcass reduces risk of carcass contamination due to human interaction, and also removes the requirement for skilled labour - something which is becoming harder to source in the UK.

With the potential to also stream for meat quality in the pipeline, the DEXA/Robotic cutter system meets a lot of the supply chain requirements, especially with the feedback on primal yields to both breeding companies and producers. This allows genetic programmes to incorporate EBVs for primal yields into the genetic model if wished, thereby further improving meat quality.

5.10. Meat Standards Australia:

5.10.i. Summary:

Manufacturer	Meat & Livestock Australia
Methodology	Observational (or MIJ-30 camera)
Species	Cattle, sheep (pigs in development)
Traits Assessed	Tropical breed content, hormonal growth promotants, sex, carcass weight, ossification, hanging method, marbling, meat colour, pH, rib fat measurement, fat colour, via auction, cut aging period, cooking method, individual cut.
Automated?	No (possibility for further development)
Objective/Subjective	Subjective and objective combined (MIJ-30 is used in some abattoirs)
Case Study	MLA conference, ICoMST, Melbourne, August 2018

5.10.ii. Travel Case Study:

The MSA classification systems have been well documented by previous Nuffield Farming Scholars. An outline of the MSA classification system can be found in Appendix 7.

During the International Congress of Meat Science and Technology there was a day run by the Meat and Livestock Australia (MLA) discussing how Australia's red meat industry has adopted eating quality science in the form of Meat Standards Australia (MSA), the MSA in the marketplace, and implementation of MSA and its future. What was learnt during these sessions has been included in the Discussion section of this report (*the next chapter, Chapter 6).*

5.10.iii. My conclusions:

The Meat Standards Australia is the most comprehensive classification and grading scheme of any so far observed. Its ability to account for the variation in genetics, production systems, cut and cooking method means it is the most all-encompassing of any classification system.

However, aspects of the system are still very subjective, although trying to be replaced with objective assessment such as through the utilisation of MIJ-30 in Australian Wagyu production. By combining the MSA system with some of the technology outlined previously an extremely robust system could be developed.

6. Discussion of my findings

I would now like to discuss the mass of information that I gathered on my Nuffield Farming study tour.

6.1. Changing the supply chain mindset/changing business drivers

I started my Nuffield Farming Study with the belief, which has since been reiterated by AHDB, that:

> *"The current system of carcass classification used in Great Britain is completely outdated and is holding back the development of the industry by failing to adequately communicate consumer demand back to the processors and producers"*
>
> (AHDB Strategy Priority 1.2, Year 1 report:
> Stimulating the introduction of a new method of pig carcass classification)

Without a consumer, we don't have an industry, so the consumer and their requirements should be at the forefront of every business decision that is made within a meat supply chain. When Meat and Livestock Australia (MLA) were developing their initial Meat Standards Australia (MSA) they ensured that every discussion they had included the "empty chair". This empty chair represents the consumer, the most important person in the discussion, and the least represented.

In order to effectively drive change to see breeding decisions being made for the consumer's benefit we need to change the mindset of those controlling the supply chains i.e. Producer, Processor and Retailer. The best time to change these mindsets is during their education and formative years, although this is a complex issue, hampered by such issues as:

- Inheriting the role of business driver later in life, when motivation is less strong, and priorities are now divided between work and family.
- The old proverb "*those who can do, and those who can't teach"* disparages lecturers' authority and dilutes messages.

Having discussed the education of future farmers in depth with, amongst others, Lynne McIntyre and Simon Marsh at Harper Adams University, I believe that this is an area for further work and research. There is too much reliance on "ask daddy" which, whilst this should not be discouraged as there is a lot to be learnt from the previous generation, it should not be forgotten that the breeds, production systems and markets we are working with are continuously evolving and what was current knowledge 20 years ago is now likely historic.

From MLA's experience in rolling out new classification and grading standards they listed a few key important musts:

- Those liaising with farmers and processors about the changes need to come from the respective industries – not wet-behind-the-ears graduates, failed private businesses or desk jockeys
- Every business decision must have an "empty chair" at the table. The empty chair is the consumer - every decision must have the consumer at its forefront

- The consumer is king. They are the only inlet of money into the supply chain.
- If a business change adds cost to the chain but improves consumer acceptance/repeat purchase, then it should still be done.
- Utilise technology that is available and always scan the horizon for new and emerging technology to assist in improving product quality.
- Utilise technology that is available and always scan the horizon for new and emerging technology to assist in improving product quality.

6.2. Changing the consumer mindset: making meat an occasion not a commodity

At the start of my time in Australia I attended the 64th International Congress of Meat Science and Technology (ICoMST). During the conference Hollis Ashman gave a keynote speech discussing "Analyses of drivers in Australian and Chinese markets for Beef and Pork". Hollis's presentation was of particular interest because it highlighted the difference between Western and Eastern consumer expectations whilst also reiterating that, as the fastest growing population with increased expendable income, business drivers are being determined more and more by the Asian market and less by the home market.

The chunk of meat, which is seasoned (salt and pepper) at the table, served with a carbohydrate and various vegetables or salad and usually accompanied by a sauce (gravy, mustard, mayonnaise, mint sauce etc.) is very much a western culture. The western consumer uses a knife and fork to make the food "bite sized" at the table; the Asian consumer makes all ingredients "bite sized" in the kitchen, as well as seasons and dresses/adds sauce to all ingredients which are then often served in a combined dish e.g. stir-fry with noodles, and eaten with chopsticks, or a curry which is eaten by hand using the carbohydrate as an eating tool.

The discussion of the culture of the western and eastern consumers also highlighted that the western consumer expects a lot of product for their money, as I witnessed in American Walmart's (*see Figure 20 on next page*) where you could buy a gallon of sour cream as a "family pack" – this sour cream was to be used within 3 days of opening which suggests either there is a lot of food waste or sour cream becomes a constituent part of a family meal for several days.

In essence the western consumer views food as a commodity. Hollis stated that for the Asian consumer - and this was particularly noticeable during both my visits to Japan - food is an occasion. In Japan this is demonstrated by the use of food as high-end gifts; tea ceremonies that average 3 hours in length; the understanding shown by the consumer of the importance of marbling; and the pride in "Japanese" products such as Kobe Beef.

In comparison the Western consumer is now often urbanised and disassociated from the food production supply chain. They want their food fast, cheap and in large portions, putting very little of the household income towards food (*see Figure 21, two pages further on*).

However, this does not mean that the Western consumer doesn't have a level of expectation for quality of food. The Western consumer, whilst very much price-led, still expects an enjoyable eating experience that can be repeated consistently.

With the issues of global warming becoming more common in the media, there will continue to be a backlash from activist groups towards the "frivolous" attitude we, the consumer, have towards resources. Some of the backlash is already being seen in the form of campaigns such as "Meat-free Monday" which has a very strong message and, if it were to become a national campaign, would see a further decline in meat sales; meaning that premiumisation may be the only way to maintain cash flow.

To change the mindset of the consumer there is an educational requirement. There are some very beneficial organisations such as FBF (Feeding Britain's Future), which regularly work with schools and educational bodies to make children, teens and young adults more aware of agriculture. However, it is not enough. Agriculture and food security should be part of every child's education.

Figure 20: When food becomes a commodity – a tub of Peanut Butter in Walmart, USA. Photo: author's own

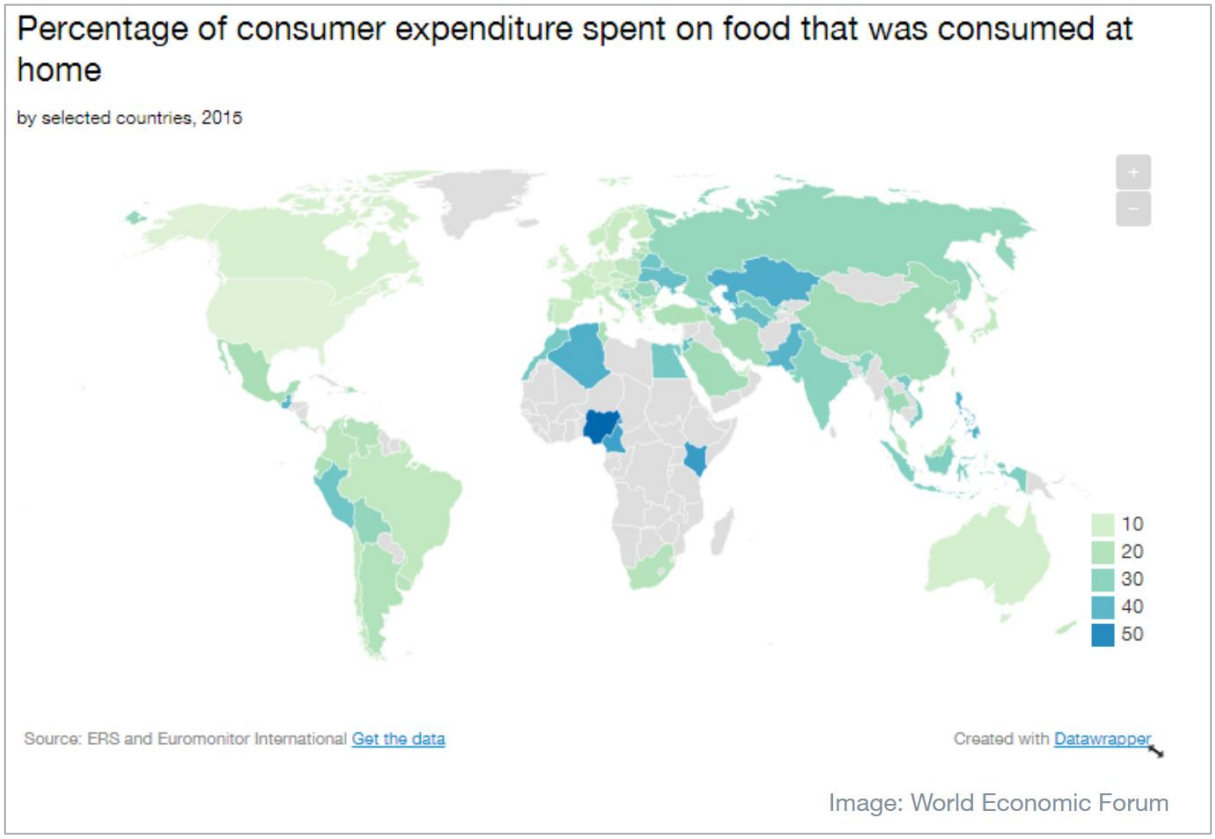

Figure 21: Percentage of family budget that is spent on food.
Source: World Economic Forum. https://www.weforum.org/agenda/2016/12/this-map-shows-how-much-each-country-spends-on-food/

6.3. Global trade, carcass utilisation and brand management:

At the time of writing a BREXIT agreement has still not been reached. However, whatever the outcome is, the UK meat industry will survive because it is part of a global meat market. Within the UK our carcass utilisation is extremely unbalanced across all three red meat species.

	Pigmeat (clean & cull)	Beef & Veal	Lamb
Numbers slaughtered	10,648,000	2,810,000	14,900,000
Tonnes produced	931,000	922,500	299,100
Tonnes exported	278,000	233,498	95,000
Tonnes Imported	1,060,000	639,888	94,200
Tonnes used in the UK	1,713,000	1,204,000	299,900
Figures taken from the AHDB Pork, Beef and Lamb 2018 pocketbook/yearbook respectively			

We know from data generated by AHDB Pork and AHDB Beef and Lamb, that UK production costs for pork, beef and lamb are not only some of the highest within the EU but also some of the highest globally. Although the £GBP has depreciated against the US$ and the Euro over the past 5 years, some

other currencies of major meat exporting countries have depreciated even more: e.g. the Brazilian real and the Argentinian peso. This makes UK exports less competitive against exports from such countries.

To gain and maintain sales of red meat and to maintain a reputation for high quality product we, as a national "red meat industry," need to ensure that UK product is consistent, because if we can't compete on price we need to compete on quality.

As explained by JBS's Mark Inglis, a brand cannot simply be "*a picture on a box*". A brand needs standards and specifications and there needs to be some way of measuring the product to ensure that it sits within the specified bands.

Consistency is key, and downgrading meat that has been produced through a dedicated supply chain may be necessary to ensure brand security. If a premium is being charged, then the product MUST be worth it and a story alone cannot be relied upon for a repeat purchase. It should also be considered that not every product is brand worthy; there will always be a demand for commodity/cheap meat. However, this will not drive the market.

7. Conclusions:

1. The current system of carcass classification used in Great Britain is completely outdated and is holding back the development of the industry by failing to adequately communicate consumer demand back to the processors and producers.
2. Currently, red meat producers are being rewarded for producing large quantities of lean meat which is, as a result of that leanness, often dry and flavourless, providing an unsatisfactory eating experience.
3. Because of the current payment systems in place, all business drivers are geared towards producing a lot of meat cheaply.
4. The current carcass classification and grading system does not prepare the UK adequately for competition in the global market.
5. Without measuring meat quality, we cannot manage meat quality
6. If aspects of Meat Standards Australia (chapter 5.10) were combined with the USDA system it would result in the most comprehensive and robust system. If it is possible to adopt these for pigs as well as sheep and beef, in conjunction with making the assessments wholly objective, this is the route we should aim for.

Footnote to above Conclusion 6: *While the MSA system is extremely comprehensive, it does not assess texture and firmness like the USDA system does. While there is not much evidence to suggest that texture and firmness correlates well with eating quality or consumer acceptability, the Japanese grading system measures this too and, with the Asian market being one of the main ones for growth in the next few years, we should at least have some way of ensuring the product meets their specifications.*

see overleaf for Recommendations

8. Recommendations:

1. The gmSCAN system should be trialled in the UK. Its viability for use on cattle and sheep should also be looked at.
2. The compatibility of robotic cutters with each classification and grading system should be considered since these are a viable solution to the labour issues currently seen in UK meat processors.
3. Boar taint assessment of slaughter pigs should be implemented.
4. The Meat Standards Australia is the "gold standard" we should be working towards to enable the UK to compete on the global market. Even if not all measures are feasible at present, either due to the invasive nature of a lot of the measures, or because the system is still being developed (i.e. pigs), assessments can and should be made.
5. Education of both farmers are consumers is essential. Consumers need to understand the food supply chain better and farmers need to understand consumer demands.
6. This subject, across three meat species, is extremely complex and multifaceted. This report - restricted by a word count - will only ever scratch the surface of this topic and to fully do the subject justice further discussion on consumer trends, global markets and educational needs should be had.

9. After my study tour:

My Nuffield Farming Study Tour coincided with the most turbulent 18 months of my life to date. However, my belief in the necessity to make eating quality a priority within the red meat supply chain has not wavered. I do not see how the UK red meat industry can compete and excel on the global market when our competitors are producing a similar product, more cheaply and more consistently.

I have already been presenting my findings at conferences and discussion groups both at home and abroad, which has led to some very open and interesting discussions. Farmers have a lot of pride in what they do, often rightly so, and many feel that they would benefit from having more information fed back to them with regards to the *quality* of their produce and not just the *quantity* of what they have produced.

Throughout my study tour I have been honoured to sit on the AHDB Pork "Stimulating the introduction of a new method of pig carcass classification" steering group. These meetings have been very insightful and have certainly benefitted my studies. Due to my position on the steering group I am also aware of the next stages that are planned, although unfortunately at the time of writing I am not a liberty to disclose these.

Also, as mentioned in Chapter 1 of this report, in July 2019 I became an independent consultant and set up my own business: Food Quality Management Global Limited, trading as FQM Global. I would hope that in my new role I will be able to discuss the importance of meat quality with more businesses and help them to drive change.

Caroline Mitchell
July 2019

Acknowledgements:

I must start with my family. Without my parents, Hilton and Jane Mitchell, and my brother and his wife, Nicholas and Harriet Mitchell, the past 18 months would not have been possible. They may never understand how much their support helped. Also to my friends who have all been a wonderful support.

To my sponsors the Worshipful Company of Butchers and the Nuffield Farming Scholarships Trust for providing me with such a wonderful opportunity. With particular thanks to Bob Bansback for his constant understanding and insightful guidance, whilst still letting me find my own path.

Rufus Pilgrim for the many cups of tea and long discussions in farm shop cafés.

To JSR Genetics Ltd for allowing me to take the time away from my job to be able to carry out my studies.

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David Evans
David Gerrand
Doyle Wilson
Emma Bleach
Eric England
Erwin Kooke
Frank Dunshea
Geoff Kealey
Henrik Almind
Hideki Yamashita
Katie England
Katsushi Higashi
Kazuharu Arizonzo
Keith Belk
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Lee Leachman
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Lynn McIntyre
Makoto Misaki
Marina Gispert
Mark Haighton
Mark Inglis
Martin Anderson
Mathew Simpson
Mick Sloyan
Mike Coffey
Neil Clelland
Peter Haeberling
Phil Hadley
Phil Woodall
Rembert Pieper
Renee Lysne
Rick Buckle
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Satoshi Ogasawara
Shari Gerrard
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Suzuki Kanako
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Tim Rymer
Tracey Dunshea
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Wakasawa-san
William De Klein
Yoshihiro Yahara

Glossary of Terms:

Composition attributes – saleable meat yield based on proportions of fat (as Subcutaneous, Intra and Intermuscular Fat), lean meat and bone in conjunction with overall shape/musculature of the carcass.

Quality attributes – consists of 5 areas of quality: technical; nutritional; hygienic; ethical and organoleptic (i.e. appearance and eating quality) quality.

Technical Quality – Water Content, Water Holding Capacity, Connective tissue content, pH, salt absorption capacity, unsaturated fatty acids content

Nutritional Quality – Protein content, caloric value, vitamin content, mineral content, lipid content, saturated fatty acid content, cholesterol content, utilisation, digestibility, bioavailability

Hygiene Quality – Bacterial load, pathogenic, pH value, water activity, reduction potential, nitrate, drug residues

Ethical Quality – Husbandry of animals, i.e. Production system, breed, medication (antibiotic free)

Eating quality – Colour, exudation loss, marbling, smell, taste, juiciness, tenderness, texture

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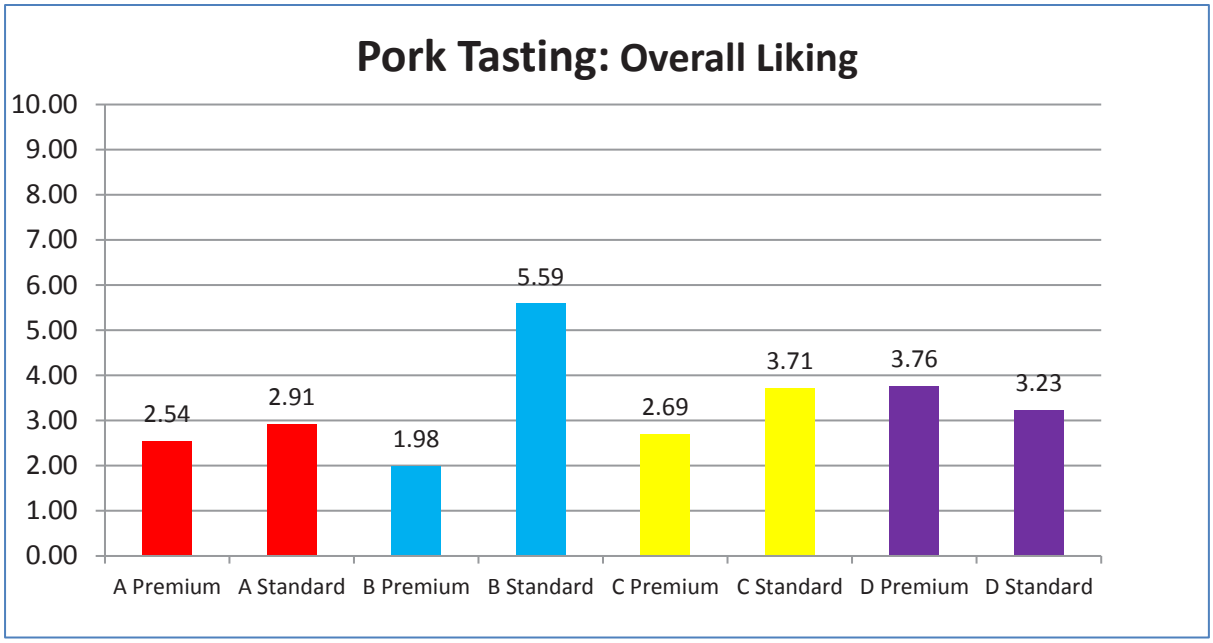
Appendix 1



Anonymised data from internal trained taste panels at JSR Genetics ltd comparing premium pork loin steaks to standard pork loin steaks from the big 4 UK retailers.

Appendix 2

Beef and Sheep Classification

In Great Britain technically trained MLCSL staff have been subjectively classifying beef and sheep carcasses since the 1970s. The classification of beef is a statutory requirement of the "Mandatory EC Beef Carcass Classification Regulations". (Sheep classification is not an EU regulation). The regulations, which have since been amended, came into effect in GB on 1st January 1992. When a cattle or sheep carcass is classified it is described by its conformation and fatness. At present the only mechanical assessment method approved for use in the UK is the VBS 2000 (e+v Technology) machine.

Conformation is a visual assessment of the overall shape of the carcass using the EUROP scale as pictured in Figure 22. As explained in MLCSL literature "*Conformation class E describes carcasses of outstanding shape, particularly of the type produced by double-muscled cattle". Class P describes poorly muscled carcasses of inferior shape, usually produced by cattle of extreme dairy breeds and [cull] cows".*

Of the 5 main conformation classes U, O and P are then sub-divided into upper (+) and lower (-) bands, meaning that there are 8 conformation scale points.

Fatness, as shown in figure 23 is a *"5-class assessment from 1 (very lean) to 5 (very fat, with 4 and 5 being subdivided into leaner (L) and fatter (H) bands"* (https://mlcsl.co.uk/publications/Beef-carcass-classification.pdf).

Figure 22: Cattle conformation classification scale. *Source:* ***MLCSL***

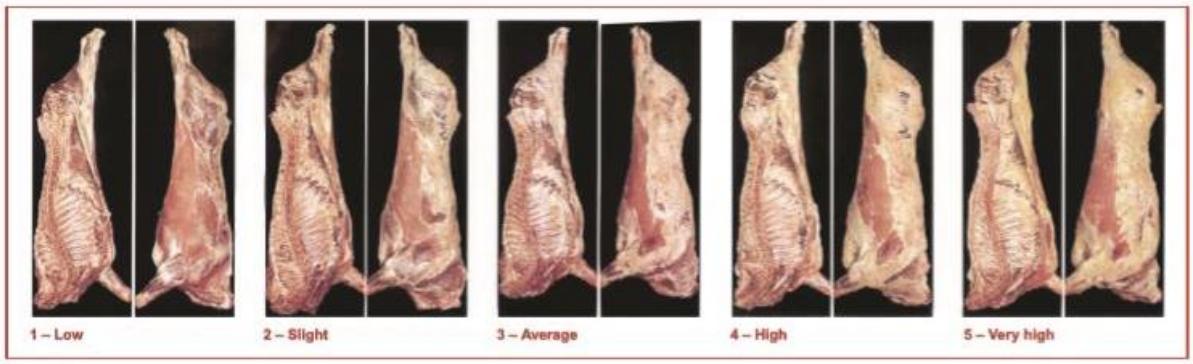


Figure 23: Cattle fatness classification scale. *Source:* ***MLCSL***

The conformation scale and fatness scale are then combined to create a 56-point grid (figure 24). When a carcass is described in classification terms, the conformation class is always given first, the fat class is given second. For example, the most common type of steer beef carcass would have a conformation class of **R** and a fat class of **4L**. This would be recorded as **R4L** and its position is shown in the grid below.

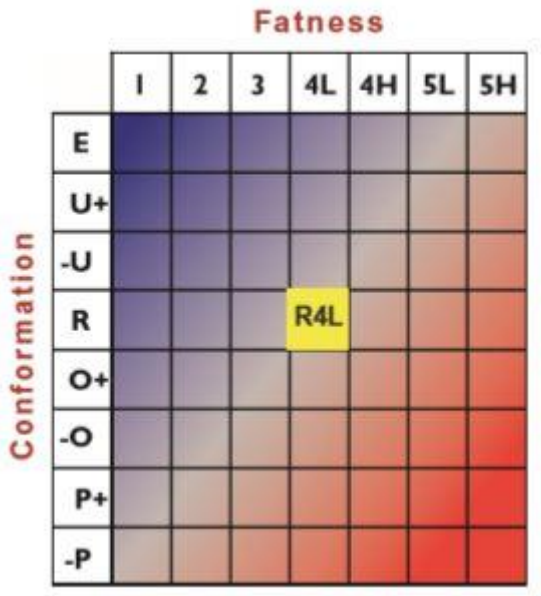


Figure 24: Cattle Classification Grid. *Source:* ***MLCSL***

While there isn't a Mandatory EC Sheep Carcass Classification Regulation, sheep carcasses are still classified within the UK using a conformation/fatness grid similar to that for cattle (*figure 25*), except that only conformation grade P is banded higher or lower (used for cull ewes only) and fat class 3 and 4 are banded higher or low (opposed to 4 and 5 in cattle) as shown in figures 26 and 27.

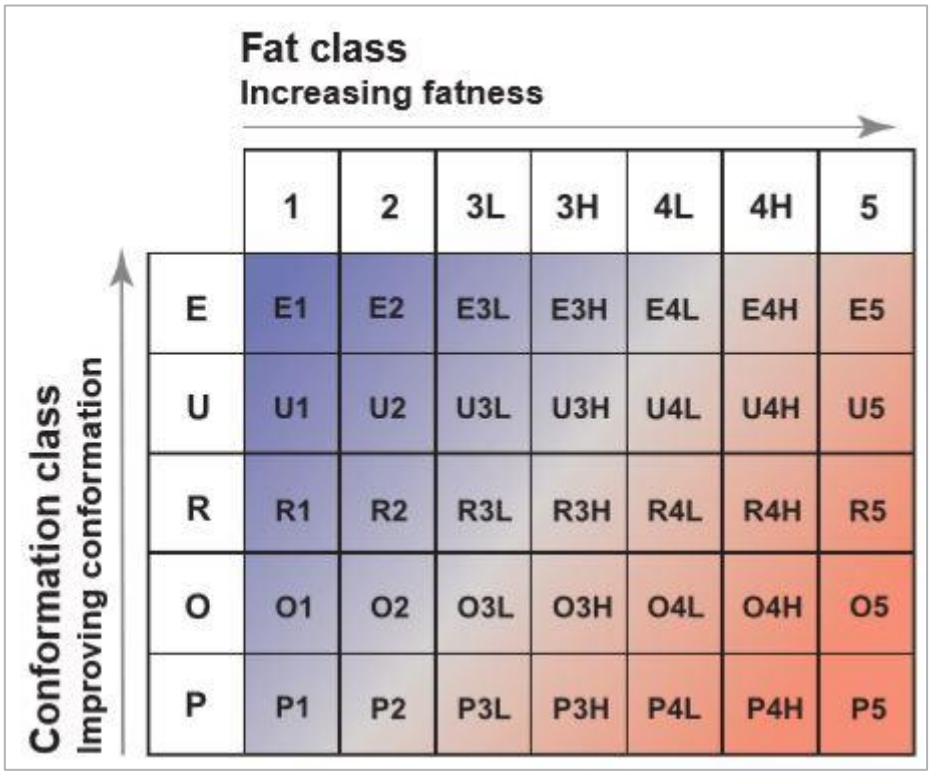


Figure 25: Sheep classification grid. Source: MLCSL

Figure 26: Sheep Carcass Conformation Classification. Source MLCSL

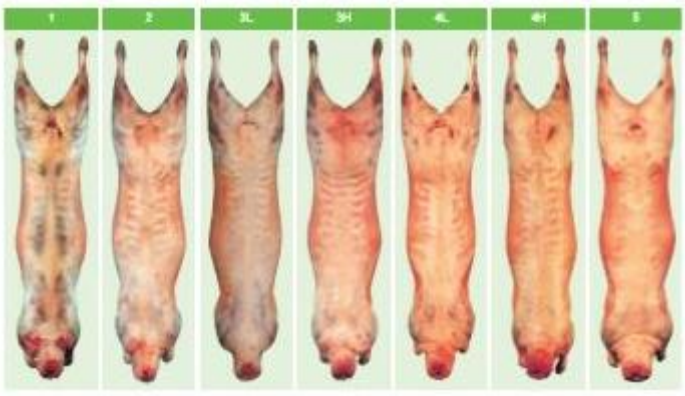


Figure 27: Sheep Carcass Fatness Classification. Source MLCSL

Pig Classification

In Great Britain technically trained MLCSL staff classify pigs as per the mandatory requirements of the "EC Pig Carcass Grading Scheme" which was introduced in 1989. When a pig carcass is classified it is described by its back-fat thickness and a calculated lean meat percentage.

There are five measuring technologies approved for use in the UK: Introscope (Optical Probe), Hennessey Grading Probe (HGP), Fat-O-Meater (FOM), AutoFOM and CSB Ultra-Meater. The HGP, FOM, AutoFOM and CSB Ultra-Meater are all automatic recording probes. Of the five approved methods, only 2 are used in the UK: Introscope and HGP, with Introscope being used in all abattoirs except one. There is one AutoFOM (Mark I) in England. However, this not currently being used to classify pig carcasses as part of the payment mechanism.

The Introscope (*figure 28*) is used to measure the backfat thickness of the pig carcass at the point of P2 (*figure 29*) on the left-hand-side of the carcass. The HGP is used at P2 to measure the rind, backfat and muscle depth; but only Cheales abattoir currently use this system. Both the methods used in the UK to classify pig carcasses are manual and invasive.

Figure 28: MLCSL Introscope. *Source MLCSL*

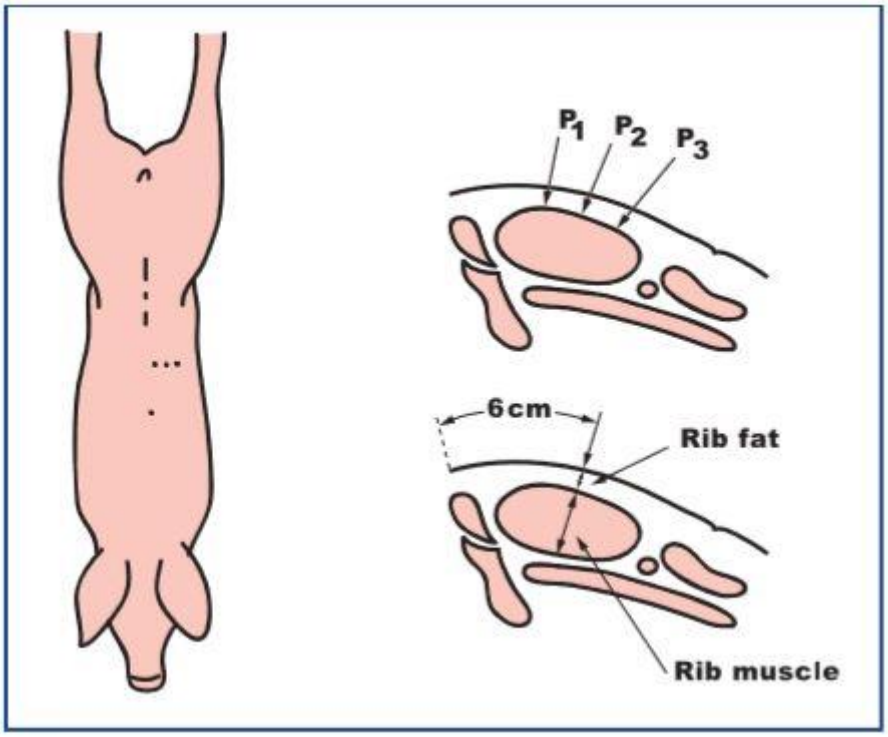


Figure 29: Pig carcass P2 location. *Source MLCSL*

The P2 is used in conjunction with the carcass weight to calculate a lean meat percentage (LM%). In the UK we use the following equation:

Lean Meat % = 65.5 – [1.15 – x P2(mm)] + [0.077 x cold carcass weight (kg)]

Cold carcass weight is calculated from a hot weight, taken up to 45minutes post kill, minus 2% to allow for moisture loss during chilling. Once the LM% has been calculated it is used to allocate an EU Grade or S, E, U, R, O or P as shown in figure 30.

Lean meat EU grade percentage	
60% and above	S
55 – 59%	E
50 – 54%	U
45 – 49%	R
44 – 44%	O
39% or less	P

Figure 30: Percentage of lean meat in pig carcasses and the given EU grades

The producer is then paid for the carcass using a payment grid (*Figure 31 below*) which is based on cold carcass weight and P2. The carcasses that best meet the abattoir's requirements will fetch a

better price. Those that are least favourable will only fetch base price. Therefore, producers aim to produce pigs of a specific weight and P2 so that they target the higher paid fields, since this will directly impact their profit margin. Business drivers are carcass weight and P2, not meat quality.

Boars and Gilts use the same grid
Adjusts are +/- p/kg to the base price

		Deadweight (kg)						
		<50kg	50-60kg	60-80kg	80-95kg	95-100kg	100-105kg	>105kg
P2 Fat Depth	<10mm	-50	-10	+1	+3	+3	-40	Fixed Valuation
	10-12mm	-50	-20	+1	+3	+1	-40	
	13-14mm	-60	-30	-8	+3	0	-40	
	15-16mm	-60	-40	-20	-10	-37.5	-55	
	>16mm	-70	-50	-30	-22.5	-47.5	-65	

Figure 31: An example of a payment grid used in the UK

Appendix 3:

According to the manufacturers (https://www.frontmatec.com/en/other/instruments/carcass-grading-traceability/autofom-iii) AutoFOM III™ is:

- The most accurate instrument in the world for quantifying pig carcass value
- 100% automatic - grades more than 99.8% of all carcasses even at high line speeds
- The only system which provides robust and accurate information about primal value
- Provides exact knowledge on cut-floor performance
- Enables production planning decisions on the basis of verifiable data rather than on assumptions
- Provides valuable feedback for genetic development

AutoFom III™ uses advanced ultrasonic image analysis. The system provides information about classification such as the total lean meat percentage and grading class (SEUROP). AutoFom III™ can also provide the lean meat percentage of the four primal cuts (ham, shoulder, loin and belly) as well as their weight bone-in and bone-out and the weight of lean meat for each cut.

AutoFom III™ can be configured to predict commercial cuts, and also specific fat profiles, such as ham fat thickness, in order to meet your requirements.

The yield information enables optimisation of the sorting of primal cuts and payment to farmers according to the exact market value. This attracts the best pigs in the market and encourages the breeding of pigs with high commercial value.

Appendix 4

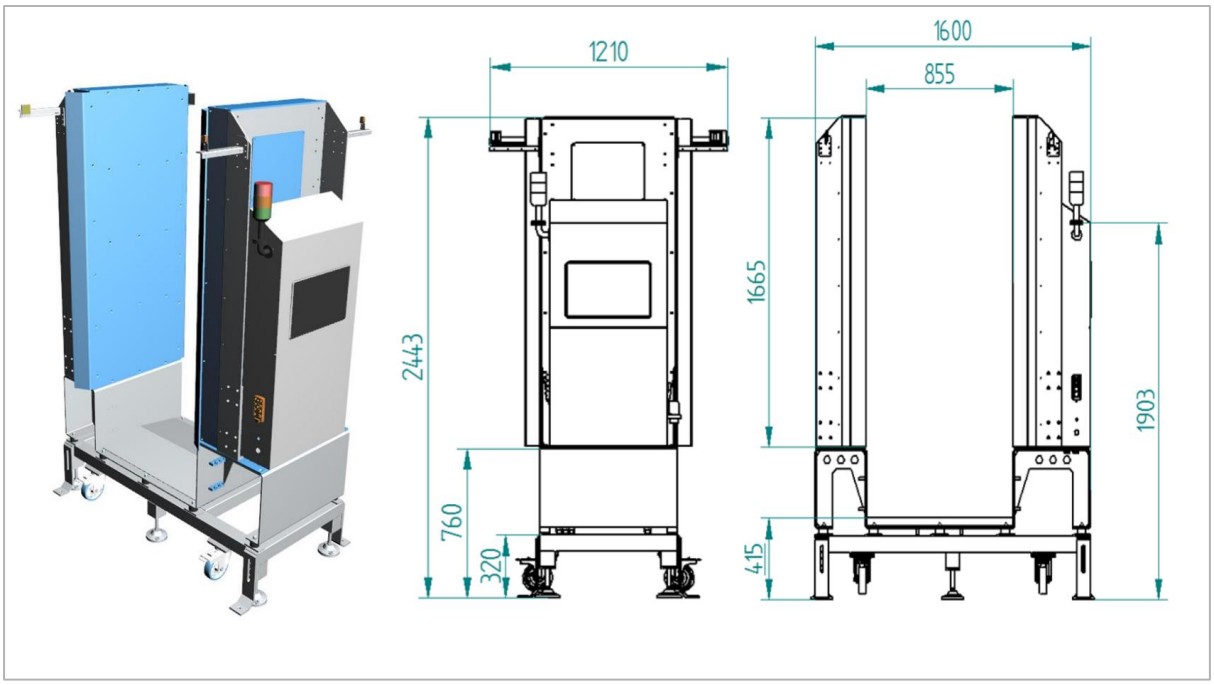


Figure 32: Dimensions of the gmSCAN classification and grading system. (*Source: gmSteel)*

Appendix 5:

BioQScan Manufacturer's requirements to install the equipment:

- Clean 120v power source (USA Installations) & Ethernet.
- Alignment fixture that will turn and maintain carcasses at a correct angle for probe positioning as the carcass moves past the scanning station.
- Over-head counterbalance fixture to assist the probe operator.
- Interface specifications for merging the *BioQscan®* data flow with other in-plant data processing requirements.
- Trolley tracking for carcass identification or alternative numbering system.

Appendix 6:

The initial development of the Wagyu production system in Japan is very closely tied to their history of rice cropping as well as the growth of food culture such as sukiyaki and shabu shabu cooking methods, where the meat is lightly simmered to cook it. Up until 1877 meat consumption was

frequently prohibited in Japan but westernisation changed this to the point that in the 1940s sukiyaki was eaten every Saturday or Sunday in Kyoto.

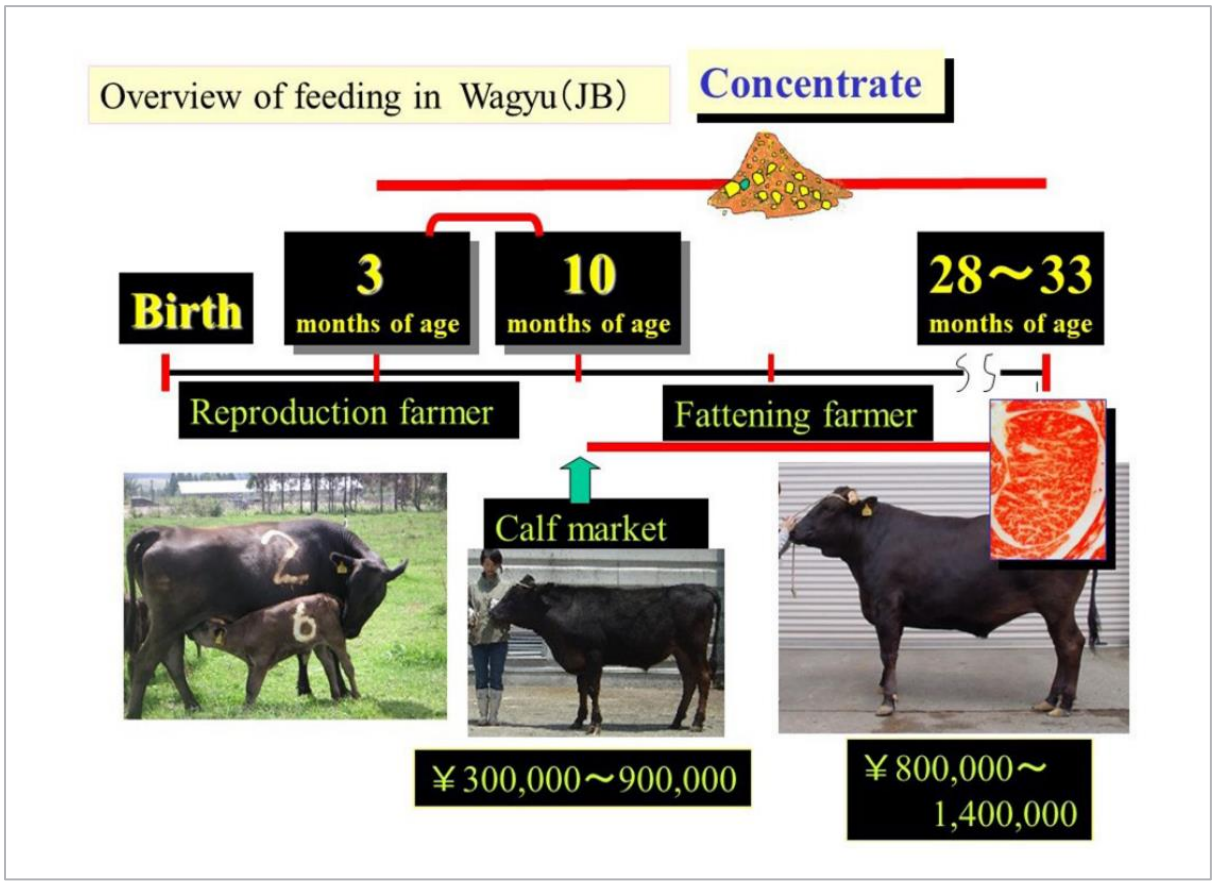


Figure 33: Japanese Black figures (Source Gotoh et al, (2018)

Four, originally region specific, breeds can be used to produce Wagyu: the Japanese Black, Japanese Brown, Japanese Shorthorn and Japanese Polled (a synthetic breed now bred true and certified in 1944 that was founded on Scottish Aberdeen Angus crossed with Japanese black in the 1920s).

The calves are weaned within days of birth, and reared on a milk replacement ration by hand. On the fattening farms the cattle are housed in small groups opposed to large "lots". The dietary rations fed to Wagyu are of great importance. The feed presented is diverse and contains high levels of rice straw and hay, as well having a concentrate and whole crop silage available.

To ensure the authenticity of Wagyu, calves are individually registered at birth and then independently inspected within 4 months, ensuring all documentation is correct and any abnormalities are recorded. If all criteria are met a pedigree certificate is issued within six months of birth.

(Appendix 7 is shown overleaf)

Appendix 7

An overview of Meat Standards Australia grading system in comparison to USDA, EUROP and JMGA, as described by the MLA (https://www.mla.com.au/Marketing-beef-and-lamb/Meat-Standards-Australia/MSA-beef/Grading)

Grading Inputs	**MSA** Meat Standards Austalia	**USDA** United States Department of Agriculture	**EUROP** European Beef Grading System	**JMGA** Japanese Meat Grading Association
Tropical Breed Content	Y			
Hormonal Growth Promotors	Y			
Sex	Y			
Carcass Weight	Y	Y	Y	Y
Carcass conformation		Y	Y	
Ossification (Maturity)	Y	Y		
Meat Texture		Y		Y
Meat Firmness		Y		Y
Milk-fed veal	Y			
Hanging Method	Y			
Marbling	Y	Y		Y
Meat Colour	Y	Y		Y
pH	Y			
Rib fat measurement	Y	Y	Y	Y
Ribeye area		Y		Y
Fat colour	Y			Y
Via auction	Y			
Cut aging	Y			
Cooking method	Y			
Individual cut	Y			

Assuring the eating quality of MSA beef and lamb requires standards to be maintained from paddock to plate.

Cattle that meet the MSA requirements are graded at MSA licensed abattoirs. A National Vendor Declaration (NVD) and an MSA Vendor Declaration, which are checked by the grader and livestock personnel, are sent with the cattle.

Each carcass is graded by an MSA-accredited grader with an eating quality grade assigned for each individual cut.

An MSA Index Value is now generated for every carcass that meets MSA minimum requirements.

Each carcass is identified with a carcass ticket and the following information is recorded in the Data Capture Unit:

- Body number and lot number – cattle from individual vendors will be kept in separate lots
- Carcass weight – important in determining weight for maturity
- Sex – male or female
- Tropical breed content – the hump height is also measured to guarantee the most accurate eating quality grade
- Hanging method – determined as being either Achilles hang or tenderstretch
- Hormonal growth promotants – will affect MSA score obtained for different muscles
- Ossification – measured to determine carcass maturity
- Marbling – using both the MSA and AUS-MEAT measurement systems
- Rib fat – a minimum of 3mm is required, measured at the AUS-MEAT standard site. Overall fat cover is also assessed including any hide puller damage
- pH and temperature – pH is measured using a pH meter and must be below 5.71. The temperature should be below 12˚C, according to AUS-MEAT standards.

Other measurements that do not impact eating quality can be taken at the customer's request, including:

- Eye muscle area (EMA) – measured in square cm using an AUS-MEAT grid
- Fat colour – recorded using AUS-MEAT chips from 0 (white) to 9 (yellow)
- Meat colour – recorded using AUS-MEAT standard meat colour chips.

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