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Enhanced Meat Eating Quality from 100% Grass & Forage Systems

Written by:

Jock Gibson NSch

July 2025

A NUFFIELD FARMING SCHOLARSHIPS REPORT

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NUFFIELD Farming Scholarships

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

Date of report: July 2025

Title	Enhanced Meat Eating Quality From 100% Pasture & Forage Fed Systems
Scholar	Jock Gibson
Sponsors	The Royal Highland Agricultural Society of Scotland The Worshipful Company of Butchers
Objectives of Study Tour	• To fully understand the effects of animal diet and nutrition on meat eating quality. • To explore different regimes of 100% grass and forage systems. • To establish key principles in profitable systems delivering good meat eating quality outcomes including nutrient density. • To explore the link between red meat consumption and personal well-being. • To apply those principles to a Scottish/UK based production system. • To establish the key indicators of Meat Eating Quality.
Countries Visited	Brazil, Uruguay, Chile, New Zealand, Australia, Japan, UK, USA, Canada
Messages	• There is room to improve the consistence of 100% grass and forage fed beef. • Providing appropriate nutrition for a continuous growth profile is essential. • Compensatory growth is an economic not a Meat Eating Quality (MEQ) benefit. • Feed and rear for muscle glycogen.

EXECUTIVE SUMMARY

Consumers increasingly choose 100% grass and forage fed (GF100) beef because of perceived benefits of this regime and extrinsic qualities that have a role to play in the perception of the quality of the beef being eaten. However, the intrinsic MEQ traits can be inconsistent and the reality of the eating experience can often not match expectation.

Producing consistently high-quality beef from cattle raised solely on grass and forage presents a significant challenge in the UK. Long, wet winters and short bursts of grass growth limit opportunities for uninterrupted animal development, often leading to periods of nutritional deficit. These gaps compromise key aspects of Meat Eating Quality (MEQ), especially tenderness.

This report explores what drives good MEQ in GF100 systems, drawing on research and visits to nine countries including Uruguay, New Zealand, and the USA. Across these systems, one message was clear: consistency is king. Where beef fails to meet expectations, it's often because cattle have been allowed to stall or regress in growth during periods of nutritional deficit. In contrast, animals with steady, uninterrupted development and appropriate finishing conditions are more likely to produce tender, flavoursome beef.

Key findings include the detrimental effects of compensatory growth, where rapid gain after a nutritional deficit prioritises external fat over intramuscular marbling, degrading eating quality. The UK's seasonal limitations make this a common risk. However, the report also highlights solutions: improved winter management, use of diverse swards, selective breeding for tenderness, and attention to pre-slaughter handling, all of which can improve outcomes without compromising the pasture-only model.

From dry-aged, grass-fed Wagyu in New Zealand to structured eating quality grading in Australia, premium beef is being produced in ways that meet both ethical and sensory expectations that are market driven. Crucially, these systems reward eating quality, not just carcass weight or conformation.

The UK industry, by contrast, lacks such feedback mechanisms. Without incentives or data sharing to promote consistency, we risk undermining consumer trust in GF100 beef, and beef in general. If it is to be marketed as a premium product, it must deliver on the plate.

Grass and forage fed beef has a compelling story, but stories alone won't keep people coming back. For that, we need beef that consistently eats well. This report offers principles and recommendations to help deliver that..

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CHAPTER 1: INTRODUCTION

I am a partner in Edinvale Farms and a Director of Macbeth's Butchers. More importantly though, I am lucky enough to be able to call myself husband to the long suffering Fiona and father to three amazing kids, Aila, Tilly and Rory.

Picture 1: The author Jock Gibson on his farm

I grew up in a first and only generation farming business; I was never intended for farming, nor encouraged to come into the industry and so via an engineering degree and a few years bumming around on yachts, I ended up as a consultant building services engineer. It turned out it wasn't for me and, in 2007, I came back to take on our butchery business, Macbeth's.

Whilst I grew up on a farm, I don't consider myself to be a farmer, nor a butcher for that matter, despite having run the family butchers for 18 years. I do however consider myself to be a producer and consumer of food. I have been lucky that for as long as I can remember I have been participating in the process of taking high quality beef and lamb products from conception to consumption, very much concentrating on the consumption part! As a family, we live to eat rather than eat to live!

In the last 10 years, having taken on our small family farm, that responsibility has become more acute and the line between trying to balance consumer expectations with practical farming has become very fine indeed. As someone who must look the consumer in the eye and reassure them that what we say we do, we do, it has become more important than ever to meet expectations in terms of the eating quality that they will experience.

Undertaking a Nuffield Farming Scholarship has been one of the greatest privileges I have had on many different levels. Not everyone gets that opportunity and so I hope I can share some of that privilege to the benefit of those reading this report.

CHAPTER 2: BACKGROUND TO MY STUDY SUBJECT

Grass fed and finished beef is not the best!

There I have said it, and now that I have washed my mouth out with a wild flower infused tea and self-flagellated with a multi species grass woven whip, I will say it again. Grass fed and finished beef is not the best.

But could it be?

And what do we mean by "the best" anyway?

In the UK, and indeed around the world, we produce beef in many ways to many standards: it could be a 48 month old heifer, a 12 year old cow, a 366 day old bull or an 18 month old stirk. It could be Highland, Aberdeen Angus, Limousin, Belgian Blue or Holstein. It could be grass fed, grain fed, indoor reared, outdoor reared. It could be, and is, anything and everything in between. We have a production system based on inconsistency of production, with the aim of producing a consistent product.

As a producer ourselves, we have pride in our ability to produce great beef which is enjoyed by our customers and for which we have a good reputation. We are also at the sharp end of consumer feedback and what they are looking for when they buy beef, and what they are not! Increasingly they are looking for a product which is produced to a set of high ideals; they are looking for a "pure" product with perceived health and ethical benefits; they are looking for a guilt free eating experience.

As such we have transitioned our farm to one which we only use grass and grass derived feeds such as silage and hay. Whilst this ticks many consumer boxes, I have been uncomfortable with the increased level of inconsistency in the final product we have produced and the negative impact that that has had on our customer satisfaction.

On a broader scale, as more farming businesses go down this route do we, as an industry, risk creating a product that satisfies consumer ideals, right up until they try to eat it and are left dissatisfied? Do we need a product that carries itself, that excites and potentially puts a chef out of a job? Or do all the wider factors that the consumer considers when making a purchase play a greater part than the physical properties of the product itself.

There are arguments that, on the one hand, we are creating meats that are bland and floppy and in need of a sauce to make them a bit more palatable, but on the other hand meats that are tough but flavoursome. Is there a middle ground that also fits consumer ideals and where does the 100% grass and forage fed (GF100) product fit into this?

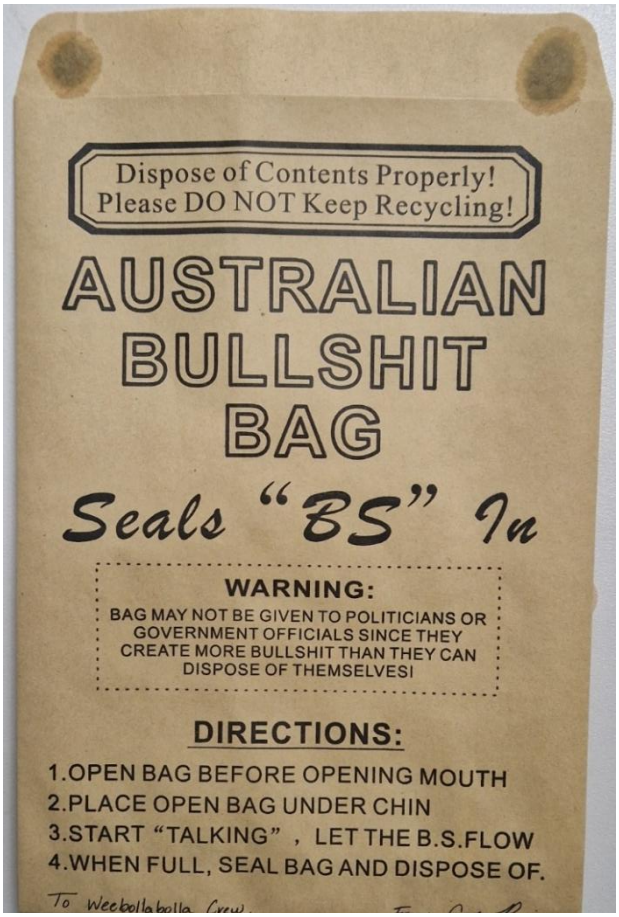
But does how beef eats matter anyway? It has been shown that if a consumer has a bad eating experience with beef, it can be 12 weeks before they come back to eating that product from that category again[1]. Moreover, at the time of writing, the price of beef has hit record levels. Whilst this price increase has not yet filtered down to supermarket shelves, it will eventually have to to some degree, and with an increased price comes increased expectations.

As the UK has left the EU, operating in what was once a relatively protected market from external markets, we are now exposed to free trade agreements with agricultural powerhouses who have broadly equivalent standards, lower cost of production and, in some cases, consistent and predictable Meat Eating Quality outcomes.

The purpose of this study is to understand the critical factors that can make for a product with specific eating quality outcomes, and to understand the principles behind producing meat with good Meat Eating Quality (MEQ) characteristics.

I have tried to write this report in a way which will hopefully encourage me to read it in five years' time when I have forgotten much of what I have learned! I hope that it is readable, accessible and without too much jargon.

There are also times where the language gets emotive. I make no apologies for this. Food, in my opinion, is emotive. Whilst it is of course fuel, it is so much more than that. It makes us feel, stirs memories and, of course, is social.



Picture 2 – I've tried to keep this in my mind whilst preparing this report!

[1] AHDB 2018

CHAPTER 3: MY STUDY TOUR

I was extremely lucky to visit a significant number of farms, processors, butchers and consumers on my travels. There are many other countries that I could have visited, and many that I probably should have visited, but sadly time and budgets both had their limits.

What was quickly apparent is that we do not have the monopoly on producing fantastic beef and lamb in the UK! That said every country was different and as such, so was the product.

There is a brief synopsis of each country visited in Appendix 6.

Uruguay

Alvaro Pereira Gianni Motta	Instituto Nacional de Carnes (INAC)	Meat Promotion Body
Ross Houghton	Estancia Los Principios	Angus Stud
Rafael Leguisamo	Ingleby Farms	Multinational Agri Business. Angus Breeding and Finishing
Alexandro Zimbrano	El Surco	Breeder Finisher. Cattle Trading. Auctioneer

Picture 3 - Possibly the most horrendous picture taken of me! Uruguay is a nation of meat lovers.

Chile

ChileBeef	Feedlot and Beef Retailer & Wholesaler. Export and internal markets
Fundo San Matias	Feedlot
Glynn Byles	Dairy Farm
Andrea Kopfer, Frigosorno	Abattoir and Cutting Plant

Picture 4 - Author and Laura Audry NSch at Frigosorno Plant, Chile.

New Zealand

Lucy & Chris Brandon	Hauturu	Beef & Sheep breeders & finishers
Marc Gascoigne	Gascoigne Farms Ltd	Dairy
Expleo Butchers	Te Awamutu	Retail Butchery
Gerard Hickey	First Light Farms, Hawkes Bay	Grass Fed Wagyu
Clint & Sandra Broad	Keraru	Grass Fed Wagyu
Mark Harris	Beef & Lamb NZ	Development Body
Chris Falconer NSch	Pukerua Farm, Waeranga	Dairy
Cameron Craigie	AgResearch	Research Body, Meat Eating Quality

Tim Burdon	Mt Burke Station	Lumina Lamb
Carlos Bagrey NSch	Royalburn Station	Sheep, Abattoir, Retail,
Nadia Lim		Wholesale, Agritourism
James Brown	Dunedin	Highland Cattle Breeder
Alasdair & Karen McLeod	Ranfurly	Sheep Breeders

Picture 5 - With Chris Brandon. Probably should be talking about grass but likely talking about pig hunting!

Australia

Meat Emporium	Sydney	Meat Retailer
Michael Taylor	Taylor's Run, Uralla	Marino
Richard Daugherty & Sarah Burrows	Balala Station, Balala	Pork & Lamb, Direct Sales
Lachlan Jeffers	Meat Livestock Australia	Eating Quality Grading
Dick Estens	Vitonga Farms, Moree	Citrus Fruit Farm
George Barne	Binneguy Station, Moree	Dryland Cotton
Sandy Munro	Weebollabolla, Moree	Shorthorn Stud
Tamworth Regional Livestock Centre	Tamworth	Auction Mart and Livestock Agent
	Paddock to Plate, Tamworth	Butchers
Brian Penrose,	Penrose Butchers, Tamworth	Butchers
Peter McGilchrist	University New England, Armidale	Prof Meat Science

Caitlin Herbert NSch	Gundamain Pastoral Co, Eugowra	Grain fed beef, prime lambs, merino wool and grain crops
Eugowra Quality Meats	Eugowra	Butchers
Little Big Dairy	Dubbo	Dairy
Stephen & Amity Chase	Waitara Angus, Waitara	Angus Stud
Mark Swift NSch	Parks	Arable
Treen Swift NSch		
Jacob Wolki	Wolki Farms, Albury	Farm & Butchers
Victor Churchill	Sydney	Butchers
Grant Hilliard	Feather & Bone, Sydney	Butchers

Picture 6 - The late Sandy Munro, Weebollabolla Shorthorns. Sandy was an absolute gentleman with a huge generosity of spirit. I was lucky to have met him albeit too briefly.

Japan

Kyota Yoshikawa NSch	Kawaityou-Kawai Kitakatsuragi	Eggs
Shinya Okazaki NSch	YUBOKU, Ehime	Hanaga Beef
Hamburg Labs	Kyoto	Restaurant
Yasu	Matsudo	Vegetables
Tokyo Cowboy	Tokyo	Butchers

Picture 7 - Kobe beef tasting - Evident pride in the product.

USA

	Polyface Farms, Virgina	Beef, Pork, Chicken, Eggs, Direct sales
Keith Wilda	Meatworks, New England	Abattoir
Lucas Young	Valleyside Farm, Woodstock, CT	Beef, Dairy, Direct Retail
Ben Coerper	Wild Harmony Farm, Exeter, RI	Beef, Pork, Direct Sales
Scott Perkins	The Bearded Butchers, Whitefeather Meats, OH	Butchers
Brook Alloway Ben Nowakowski	B&B Farms, Alpena, MI	Beef, Direct Sales
Michelle Sweeten	Sweeten Farms, UP, MI	Beef, Pork
Jon & Tammy Nelson	JNelson Farms, Hope MI	Beef, Direct Sales
Laurie Roedema	Byron Center Meats, Byron Center, MI	Meat wholesaler & retailer
Matt Smith	Louise Earl, Grand Rapids MI	Butchers
Hans Rienche NSch	Blue Diamond Farming Co, IO	Arable
Mercato	Lincoln, Ne	Butchery
Jaclyn Wilson	Wilson Flying Diamond Ranch, NE	Beef Cattle Breeding & Finishing. Direct Retail

Tom German	Thankful Harvest, Holstein	Organic Beef, Direct Sales

Picture 8 - Out bearded at the Bearded Butchers!

Canada

Scott Bradt	Bradt's Butchers, Ontario	Butcher
Josh & Emma Butler	J&E Meats, Ontario	Arable, Beef, Farm, Retail
Aaron Nerbas	Nerbus Bros, Manitoba	Angus Beef, Retail
Clayton Robins NSch	Robins' Family Farm, Manitoba	Beef, Industry Development
Mary-Jane Orr	Manitoba Beef & Forage Initiatives	Industry Development

Picture 9 – Aaron Nerbas, Nerbas Bros. I have never known cold until going to Manitoba.

UK

Andrew Duff	PR Duff, Wishaw	Abattoir, Wholesaler & Retailer
Robert Gilchrist	Aberdeen Angus Society, Perth	Breed Society
Nikki Yoxall	Pasture for Life Association, Howemill, Grampian Graziers	Technical Director. Cattle Breeder, Finisher
Douglas Christie	Durie Farms, Fife	Arable, Beef
Johnny Balfour	PFLA, Balbirnie Farms, Fife	Chair PFLA Beef, Arable
Chris, Denise & Gus Walton	Peelham Farm	Beef, Lamb, Pork, Direct Sales
Michael Shannon	Damn Delicious, Biggar	Beef Finisher, Butcher
Jon McCosh	Kingsbeck Ltd, Biggar	Dairy
Gus & Duncan Nellis	Thistleyhaugh Farm, Northumberland	Beef & Sheep.
Matt Griffin	Niedpath Estate	Beef, Sheep
Giles & Stuart Henry	Oakwood Mill	Beef
Nic & Paul (Reno) Renison	Cannerheugh – Renisons Farm	Beef, Sheep, Layers
Rob Havard	Phepson Angus,	Pedigree Aberdeen Angus

Picture 10 - Doug Christie, Durie Farms. A man most certainly outstanding in his field.

CHAPTER 4: DEFINING MEAT EATING QUALITY

It is impossible to talk about Meat Eating Quality (MEQ) without understanding what factors contribute to MEQ. Traditionally, when talking about MEQ, we have framed it in terms of the intrinsic qualities of the beef we eat.

4.1 Intrinsic Qualities

Flavour

This is the combination of taste and aroma. It can be affected by animal diet, muscle type, ageing process and cooking method.

Tenderness

Tenderness refers to how easy a cut of meat is to chew.

Juiciness

Juiciness points towards the feeling of moisture and succulence when eating a particular cut of meat. It is affected by the level of Intramuscular Fat (IMF) and water-holding capacity. It is considered a key component in delivering flavour.

Overall Palatability

This is a subjective measure of the combination of the above factors.

Nutrient Density

Increasingly we also talk about Nutritional Density and in the future it is likely that this will become more important as we develop a better definition and understanding of what nutritional density is.

4.2 Extrinsic Qualities

As consumers become more sophisticated, there are growing number of extrinsic factors that contribute to MEQ. By their nature they are hard to define and are arguably more about perception of quality rather than a direct influence. They can broadly be centred around:

- Diet (grass v grain)
- Housing indoor or outdoor)
- Hormone use
- Size / weight
- Aging process (this can affect the intrinsic qualities of the beef but it is also used to affect consumer perception of how a cut of meat will eat)
- Age
- Breed
- Fresh / Frozen
- Perceived Welfare
- Wellbeing

Figure 1 - Intrinsic and extrinsic factors affecting Meat Eating Quality.

However there is one factor that trumps all of these:

AVAILABILITY

It is a rare luxury and privilege not afforded to everyone in global society to be able to talk about Meat Eating Quality; for many availability is the key metric by which MEQ is measured. For a significant proportion of global society, red meat is unobtainable due to relative incomes. It therefore seems incongruous in the face of such deprivation in many parts of the world to be talking about something as privileged as MEQ; in the words of my eldest daughter, “it’s a first world problem Dad!”

That said, as beef becomes more expensive and consumer demands are higher, I believe it is still important that the issue of MEQ is explored. UK agriculture exists now in a world facing increased pressure from competing countries and we will be unable to trade purely on country of origin as a value add. As we now compete with other countries that have an eating quality standard, we risk getting left behind.

Furthermore, as organisations look to explore routes to market for specific production methods, e.g. 100% grass fed, there needs to be a level of consistency in the final product across many farms. This is harder to achieve than that required for a single farm selling direct to consumer.

It is also important to note, that the factors that affect MEQ change depending on the market for which the meat is intended. For many, tenderness is the key metric; flavour, particularly when enhanced by dry aging, maybe less desirable. Many markets will consider grain fed as a more premium product to grass fed.

Case Study – Chris Falconer

Chris has had a profound effect on me. I first heard him on the Michael Blanche NSch podcast, The Pasture Pod. I subsequently visited him in NZ. When describing one of our farming practices (which I was probably trying to defend) his retort was,

"Say what you just said but do it in a public place. What would the public say?"

Picture 11 – The author with Chris Falconer (on the right - always!)

Chris was challenging me to get out of my own bubble and think, not just think like a consumer, but a voter; the people who could actively change how farming operates. But he was also challenging producers to advocate for the animals that were under our sphere of responsibility. He asserted that nearly every decision we made was for the benefit of the farmer and rarely for that of the cow. The most significant challenge was the thought that livestock should be put in a "pressure" situation to improve genetics. The question he posed was "who asked the cow" what they thought of that?

We are a nation of animal lovers and yet we sell a product derived from an animal that we treat as a resource and, in this context Chris, posed:

"Where does the balance of power lie between the farmer and the cow?"

There are no easy answers to any of this, and nor should there be. I will however be forever grateful to Chris to form these questions into my everyday farming decision-making process. It helps me to think more in line with a consumer than simply as a farmer, helping me be more responsive to their wants and needs and to challenge our own paradigms as to what is acceptable when raising beef.

4.3 The Importance of chewing

Chewing isn't just a mechanical process of how we eat food; it's also how we release and experience flavour. As we chew:

- Aromatics and volatile compounds are released from the meat and combine with saliva.
- This in turn enhances olfactory perception, which is where most of what we call flavour happens (more than just taste buds).
- The juices mix with saliva, coating the mouth and delivering umami, fat-soluble flavours, and savouriness.
- The texture provides feedback to the brain; we subconsciously associate a slight bite with quality and substance.

While extremely tender meat might feel luxurious, it can also be too soft, lacking resistance, or even bland if you don't chew enough to engage the senses fully.

Tenderness and the Flavour Curve

One can think of the link between tenderness and flavour perception as a curve.

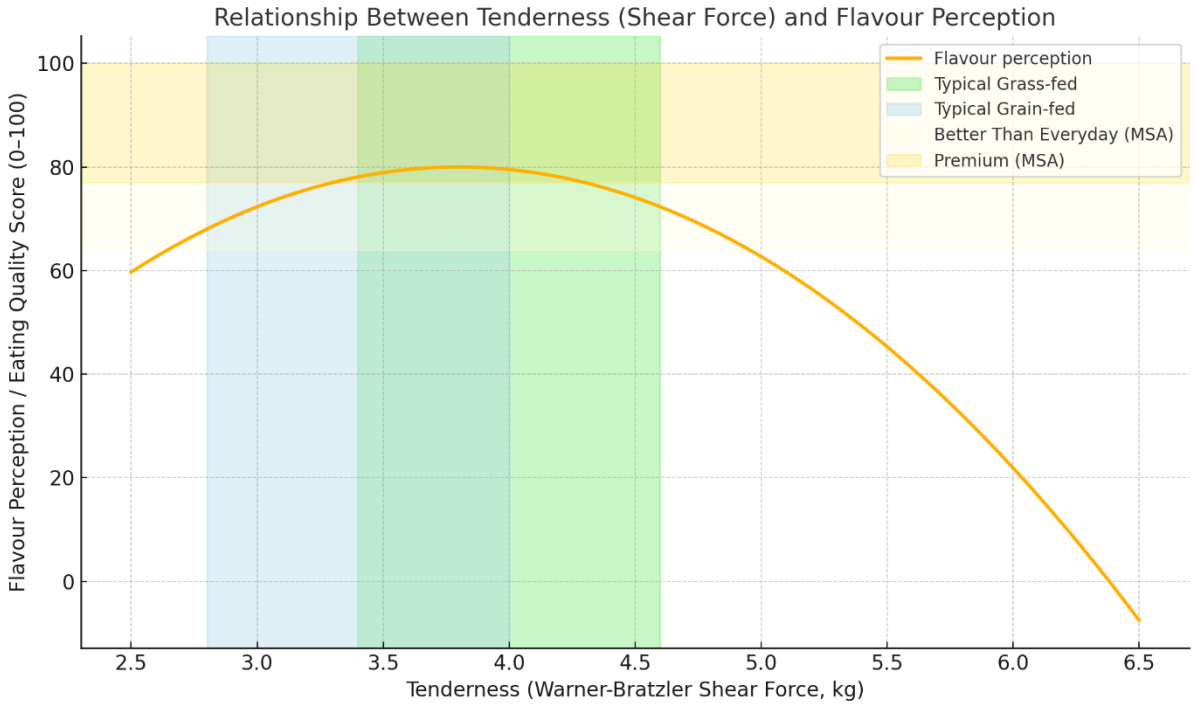


Figure 2 – Relationship between tenderness and flavour perception.[2]

- Too tough: takes too long to chew, gets tiring, might feel like a chore. Flavour eventually develops, but it can be masked by frustration or excessive effort.
- Too tender: virtually melts on contact. While luxurious, it can limit flavour release as chewing is not long enough to fully enjoy.
- Optimum tenderness: has just enough bite to encourage chewing, but it is easy and pleasant to break down. This is where flavour has time to unfold and satisfy.

Chewing also plays an important role in satiety. As we chew, the body starts to release hormones that signal fullness, helping prevent overeating. Meat that requires a bit more chewing tends to be more satisfying, because it contributes to a stronger sense of having eaten a proper meal. In contrast, very tender cuts may offer a luxurious texture but can sometimes feel less filling.

[2] Illustrative graph developed by author based on interpretation of published data including MSA grading thresholds and typical WBSF ranges reported in peer-reviewed studies.

Case Study: Jacob Wolki, Wolki Farms, New South Wales, Australia

Jacob Wolki is an entrepreneur and visionary. Having health issues, he looked at his diet and started to look for meat that was as naturally produced as possible. When he couldn't find it, he started to produce his own.

Selecting breeds suited for the area he farms, he built up an avid following of people looking for highly nutritious meats. Not afraid to break the mould, he markets seemingly inferior products at a premium price. This will include mutton, cull cows, dairy cows and Nguni Steers. The marketing is geared around the extrinsic factors of the product, chiefly how it is produced in a chemical-free, regenerative system with the associated health benefits. Jacob is very much reaching a market where his customers have struggled with health issues and allergies and see conventional beef production as some of the source of this.

When speaking to Jacob, he railed against making claims as to the quality of his product's intrinsic factors, apart from perhaps flavour. To Jacob he is selling a health product.

Picture 12 – The author with Jacob Wolki, Wolki Farms & Butchery

Whilst he now ships his meats throughout Australia, the origin of selling his product is through his innovative self service butchers. All meats are frozen and customers get a code to unlock the door into the butchers, scan product barcodes into an app and then pay electronically before leaving. To get the code though, you must do a farm tour first where you are shown how the meat is produced and the ethos behind it. Whilst this might seem a high barrier to a purchase, it ensure complete buy-in.

Picture 13 - Wolki Self Service Butchery

4.4 Is Fat Flavour?

Fat plays a dual role in meat eating quality; it is both a source and a carrier of flavour.

Intramuscular fat (IMF), otherwise known as marbling are the fine flecks of fat dispersed within muscle fibres. It melts during cooking, releasing a suite of volatile compounds that contribute nutty, buttery, and savoury notes to the meat.

As these fats oxidise during cooking, they generate aldehydes, ketones, and other volatile compounds that define the characteristic aroma and flavour of cooked beef. Fat oxidation is particularly important in delivering the “beefy” notes that consumers associate with high-quality meat.

In addition to producing flavour, fat acts as a flavour vehicle. Many key flavour and aroma compounds are fat-soluble, meaning they are stored and delivered in the fat as it melts. This enhances the eating experience by coating the mouth, improving juiciness, and prolonging flavour release. Fat slows the perception of dryness, smooths mouthfeel, and extends the duration of flavour on the palate, contributing significantly to the succulence and overall satisfaction of the beef.

It is important to distinguish between different types of fat in the carcass. Subcutaneous fat is the external layer found just under the skin. It plays an important protective role during carcass chilling and storage, insulating the muscle and reducing the risk of cold shortening, as well as aiding the ageing process by slowing moisture loss and oxidation. However, most subcutaneous fat

is trimmed before consumption, so it contributes little directly to the flavour of cooked meat. Intramuscular fat, on the other hand, is retained during cooking and is the primary fat type responsible for improving flavour, tenderness, and juiciness. It is this marbling that defines premium eating quality in beef.

4.4.1 Fat and Animal Diet

There are numerous pieces of research to conclude that the composition of fat is significantly influenced by the animal's diet. Cattle finished on grain based diets typically produce softer, more monounsaturated fat with a mild, buttery flavour.

In contrast, cattle raised on forage based systems but particularly grass only diets, tend to deposit firmer fat that is higher in polyunsaturated fatty acids such as Omega 3s and Conjugated Linoleic Acid (CLA). These compounds can lend a more complex, sometimes grassy or gamey flavour profile, depending on the plant species in the diet and the animal's genetics. In general, forage-fed beef tends to have a lower overall fat content but a more distinctive and characterful flavour.

It should be cautioned though, that when we are getting down to distinguishing the flavour of beef depending on what plant species are in the pastures, we are now into the realms of differentiating fine wines! Most of us do not have the skill, experience or desire to do so!

Picture 14 - Winston Churchill Butchers, Sydney. Grass fed and grain fed beef proudly displayed nest to each other.

4.5 Consistency

What came up repeatedly in conversations was the consideration that an eating experience should be consistent. If a consumer goes to a store repeatedly over time, their purchases over that period must have a consistent outcome and it was felt that a lack of consistency was damaging to that market. What was notable is that it was always referred to as an adjective rather than an adverb. It was not that it had to be consistently good, consistently tender, consistently flavoursome; it just had to be consistent.

Picture 15 - Spot the difference! Royalburn Station lambs

The more one delves into it, it is clear how multi-faceted eating quality is, and many of the factors that lead to it are antagonistic to one another. But if we are to try and distil MEQ into a simple definition it would be:

Meat Eating Quality is about how enjoyable something is to eat.

4.6 Grading Systems

In the UK, there is a call for a change in the grading system from what is currently used; the EUROP grid. It should be noted that the EUROP grid is simply a price reporting mechanism based on meat yield and fat cover. It has no quality indicator other than how much revenue is likely to be achieved off a certain carcass.

Many other countries use a marbling-based measure to infer quality on the basis that fat is flavour, succulence and potentially an indicator of tenderness. However, by focussing on one particular outcome, there tends to be a consequence of ignoring other factors.

The most comprehensive eating quality grading system that I saw and from my experience delivered consistently (good) results was the Meat Standards Australia (MSA) system. The MSA system looks at several different factors and, based on extensive consumer testing, has developed an algorithm to predict meat eating quality outcomes including based on cooking style.

There would be many barriers to introducing such a system in the UK and the opportunities for doing so have been explored in the past. It is possible, however, that the UK will soon be the only "premium" producer of beef that does not grade on quality factors.

There is an often cited quote *"what gets measured, gets achieved."* Currently the UK does not seem to have a vision of what it is trying to achieve and therefore how to measure it. If we are to compete on quality with product from other countries, we must be able to measure and reward it. It is also the most obvious route to instil consistency into our production.

Most importantly though, if we are to have "high quality" beef production, we must identify the low quality beef and find alternative markets for it. In short, a failure rate must be established for our quality accreditation schemes.

CHAPTER 5: FACTORS AFFECTING MEAT EATING QUALITY IN 100% GRASS AND FORAGE SYSTEMS

There is no single factor which will guarantee good eating quality, rather it is a mitigation of all aspects that can negatively affect this. There are also factors that should be considered in any system, not just grass systems and these are listed in Appendix 1. In this chapter, I am considering factors that are more critical in a grass-based, outdoor environment.

5.1 Cattle Nutrition

Grass quantity and quality in the UK and specifically Scotland vary significantly throughout the year with extremes of abundance and deficit. Farmers smooth this out by preserving forage or deferring grazing. However any period of feed restriction, whether summer dry or a long winter, under a conventional system usually requires supplementation. This is more difficult in a grass only system and can lead to a nutritional deficit.

Depending on latitude and rainfall, most places in the UK would experience six to seven months of grass growth with a steep growth curve in May which is difficult to manage for quality. The resultant five to six months of winter is in stark contrast to many major beef producing countries where grass growth is more consistent throughout the year, winter is shorter and the period of restriction may be dry summers.

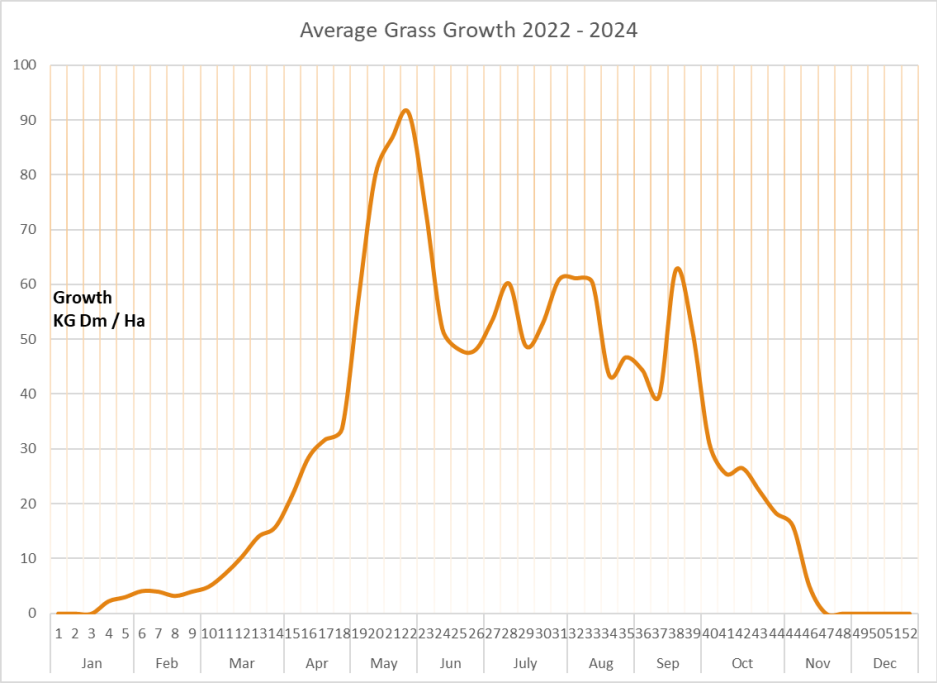


Figure 3 - Grass growth at Edinvale Farm, Dallas, IV36

5.1.1 Ryegrass & Clover Swards

Ryegrass and clover leys are probably the most used grass swards in grass based systems due to their resilience, versatility, ease of management and relatively low cost of establishment, palatability and feed quality. Their impact on growth and finishing varies across the season, driven by the pasture growth stage and sward quality.

Grass Growth Stage Effect on Performance

Early Growth (April - early June)

Swards are in a vegetative, leafy state with very high digestibility and protein levels. This promotes fast lean tissue and skeletal growth but can delay fat deposition due to excess rumen-degradable protein relative to energy.

Reproductive Phase (Mid June - Early July)

Ryegrasses begin to head out, especially if not tightly grazed. Digestibility and energy levels start to decline as fibre and lignin content rise, reducing feed conversion efficiency and slowing fat deposition. Clover may also be shaded out at this point, reducing overall sward quality.

Post-Heading & Summer Regrowth (Mid July - August)

With timely grazing or topping, swards return to a leafy regrowth phase with elevated sugar levels and improved balance of energy and protein. This is the key window for finishing, with ideal conditions for laying down fat.

Autumn Growth (September - October)

If ground conditions remain dry, this period supports a final finishing phase. Regrowth can have high energy and digestibility, especially if clover remains active.

Dormant Phase (November – March)

Typically too cold or wet for meaningful grazing performance. Best reserved for dry cows or light use only.

Grass Growth Stage on Fat Deposition

Fat deposition is driven by energy surplus and occurs once skeletal growth slows. In a forage-only system late July to September offers the best fat cover development, especially following leafy regrowth after heading. Early summer promotes lean gain but may delay finishing if protein overshoots energy.

	DMD (%)	Protein (%)	Effect on Growth	Fat Deposition Suitability	Best For
Early (Vegetative)	75–80	16–25	Very rapid lean growth, especially frame and muscle	Low – too much protein, low energy: cattle stay lean	Autumn born calves, stores, early finishers

Mid (Pre-heading)	70–75	14–20	Balanced muscle + start of fat if genetics allow	Best window for fat deposition — good sugar/protein balance	Finishers in late summer/autumn
Late (Reproductive)	60–70	10–14	Growth slows, more gut fill than LWG	Poor – too fibrous and low energy	Dry cows, maintenance grazing
Autumn Regrowth	72–78	16–22	High LWG possible if ground allows	Good – leafy regrowth has sugars needed for fat finish	Final finishing push (weather permitting)

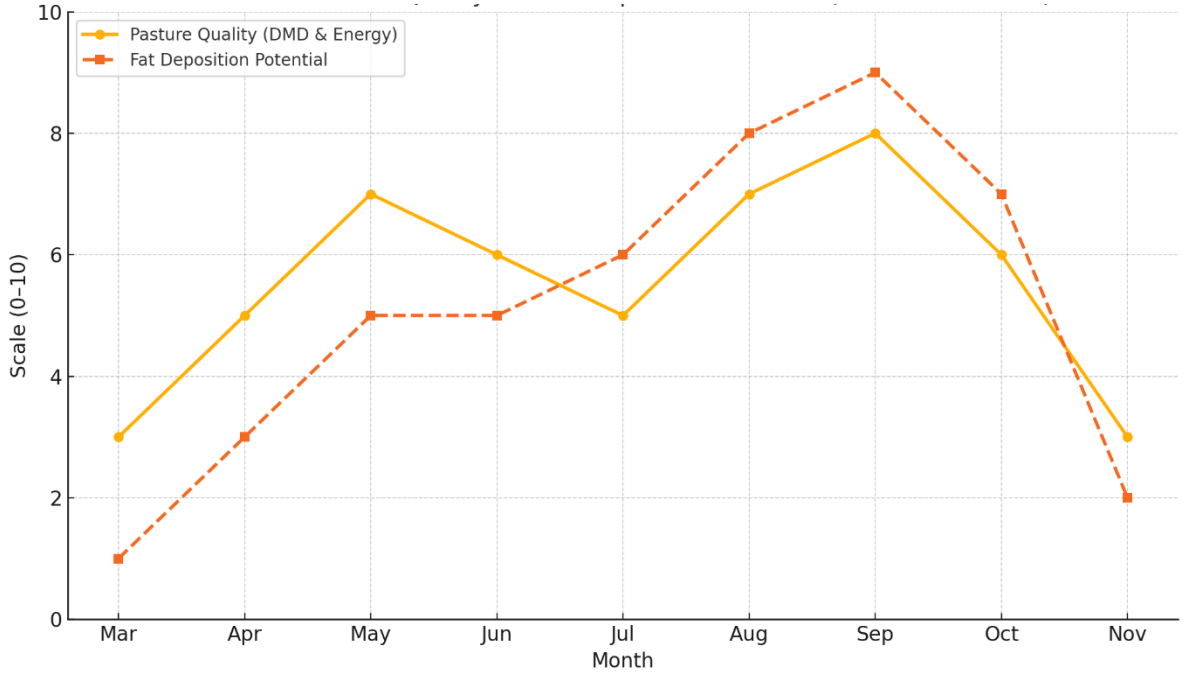


Figure 4 - Indicative Seasonal Pasture Quality & Fat Deposition Potential (North of Scotland)

There is opportunity to use grass growth rates and stages to optimise the finishing of grass fed cattle. However this will introduce a seasonality to the production of beef from this system which may have an impact on customer acceptance, cash flow implications etc. Equally though, it allows for production to be tailored towards the high demand period of Christmas.

5.1.2 Multi Species Swards

A recuring theme in conversations were the benefits of having diverse swards both to benefit the natural health of the animal as well as its nutritional intake. It follows that this diverse nutrition leads to a greater nutritional density in the final product. Diversity in the sward can add resilience in the face of weather events and extend

grazing periods. However, they are all also more difficult to establish and maintain and may reduce some flexibility in managing the sward, needing longer rest periods. Persistence was often cited as an issue but in the short term having a greater variety of plants that you do want often leads to less of the ones that you don't.

Case Study: Lumina Lamb, New Zealand

Tim Burdon, Mt Burke Station, Wanaka

Lumina Lamb is a premium lamb product which has been developed using a breeding and finishing programme designed to achieve high levels of intramuscular fat. Part of the impetus to go down this route was a perceived necessity to move away from commodity lamb production where nearby Australia could out compete New Zealand production on scale and so impact farmgate price.

Picture 16 - Lumina Lamb production - Mt Burke Station

Genetic selection has taken place over 15 years to optimise carcasses for marbling, tenderness and flavour. Lambs are 100% pasture fed and finished on chicory swards or multi herb swards with the aim of boosting IMF and omega 3 fatty acids. There is now a Lumina herb ley! The results show that IMF is typically over 4% (average lamb is 2 – 2.5%) and the product is dry aged for 10 to 14 days.

The product is targeted at high-end restaurants and export markets with an emphasis on its increased health benefits such as higher levels of Omega 3. It also appeals to customers looking for welfare and traceability assurance.

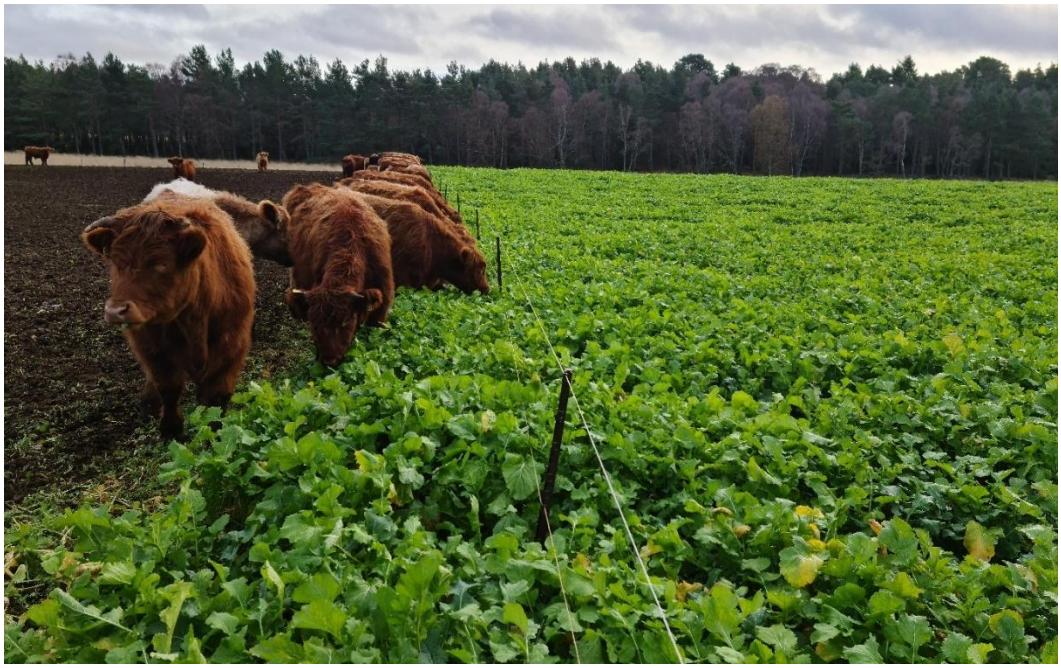
Picture 17 - Much of the productive crop growing is done under pivots

There are now many Lumina Lamb farms, mostly in South Island but some on North Island, fulfilling various parts of the supply chain, whether producing breeding stock or finishing lambs, and there is an integrated supply chain dedicated supplying the food service sector worldwide. This gives producers a premium price and a dedicated market.

Picture 18 - Tim Burdon bemoaning the fact the doctors had grounded him from flying his helicopter. The author is slightly relieved!

5.1.3 Forage Crops

Forage crops are useful in filling a grass supply deficit, and where the establishment fits with a reseeding programme. There are many benefits from utilising forage crops; they are particularly useful for outwintering dry cows. However in the case of growing and finishing stock destined for the food chain, daily growth in wet muddy conditions (even with the mandatory dry run back) is challenging to achieve.



Picture 19 – The author's cattle on a brassica forage crop

5.1.4 Winter Energy Requirement Scenario

Consider a scenario with calves at approximately eight months old in November, overwintered in the north of Scotland, receiving no concentrate supplementation and on deferred grazing and silage made in late June to early July.

Given the prevailing weather conditions (cold, wet, and with limited daylight), animal performance is often constrained by both forage quality and energy expenditure on thermoregulation.

Typical forage quality during this period is modest:

- Deferred grass: ME 8.5–9 MJ/kg DM; CP 8–10%
- Mid-season silage: ME 9.5–10 MJ/kg DM; CP 10–12%

Energy requirements for maintenance in a 250–300 kg calf average 40–45 MJ/day, with growth targets (0.5kg /day) requiring closer to 70 MJ/day and higher protein availability. In practice, winter forage alone rarely meets this threshold, and intake

may be further limited by wet conditions or poor rumen fill characteristics of stemmy grass.

Expected Growth Performance

Under these conditions, calves typically experience:

- Minimal or negative liveweight change over winter
- Estimated average daily gain of −0.1 to +0.2 kg/day, depending on shelter, forage intake, and weather extremes
- Some loss of body condition and frame, especially during prolonged periods of cold stress or snow cover

Physiological Consequences: Connective Tissue and Tenderness

Feed restriction affects not just overall growth, but also the balance between muscle and connective tissue development. During periods of nutritional shortfall:

- Muscle protein synthesis declines, slowing fibre hypertrophy
- Connective tissue turnover decreases, particularly in collagen
- Existing collagen becomes more mature and cross-linked, a key determinant of toughness in cooked meat

This imbalance results in a higher proportion of insoluble connective tissue (gristle) relative to muscle mass, especially in older or slower growing animals. In the absence of rapid refeeding or compensatory growth, this can lead to poorer meat tenderness at slaughter.

5.2 Compensatory Growth

One of the factors that reoccurred during discussions was the requirement for constant growth. Periods of restricted growth through nutritional deficit leads to compromised eating quality.

"Periods of nutritional deficit reduce organ size within animals to conserve energy. When the animal then goes through a period of compensatory growth, much of the weight gain is to the organs as they regain their full capacity. Compensatory growth only happens after nutritional deficit and will always lead to tougher meat."

Gianni Motta – INAC

If an animal goes through a period of nutritional restriction, resulting in static weight, weight loss or stunted growth, it then goes through a period of compensatory growth when nutrition improves. During compensatory growth, the animal goes through a phase of rapid weight gain which priorities subcutaneous fat deposition to restore energy reserves rather than intramuscular fat. IMF tends to require steady and continuous nutrition to develop.

The graph below shows some illustrative growth profiles. The consistent nutrition would be indicative of a supplemented system where energy and protein levels are constantly met.

The scenarios whereby growth is static or negative for a period would be indicative of systems where nutrition does not match the energy and protein requirements of an animal. This is likely to be in situations where energy requirements are much higher, e.g. outwintering, and where the available nutrition is not of a high enough level, e.g. poorer quality silage/hay/deferred grazing.

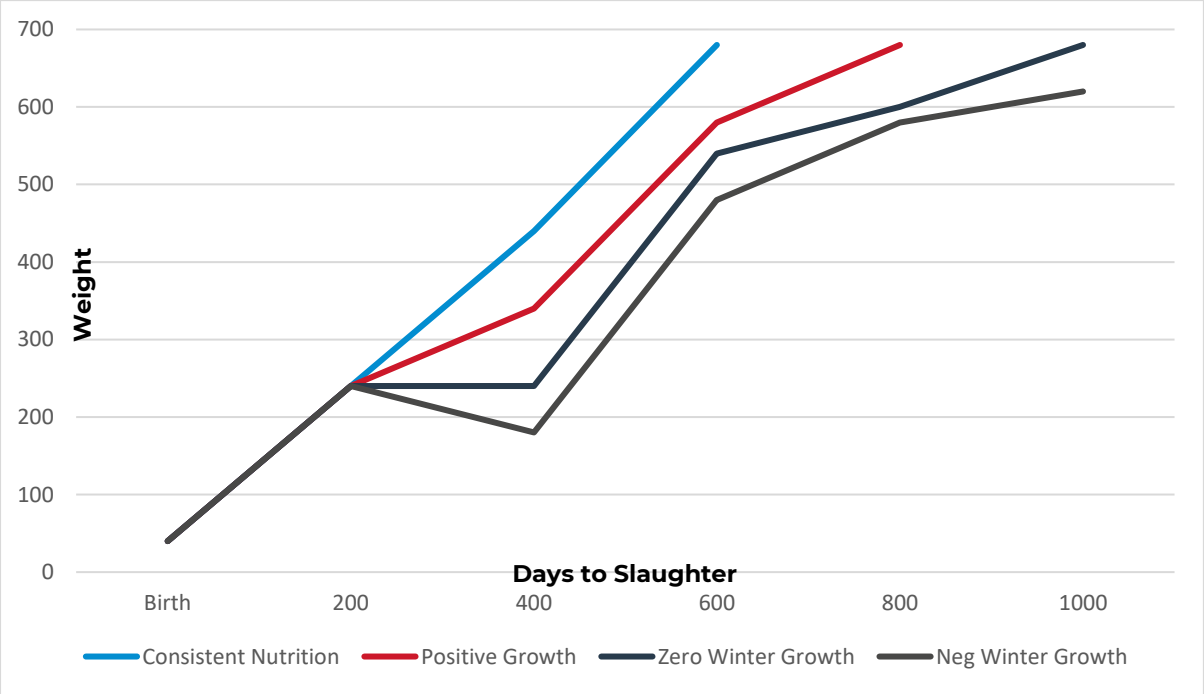


Figure 5 - Growth profile scenarios

Management over the first winter for spring born animals (200 – 400 days) is key to realise the full growth potential of an animal. Compromise during this period increases days to slaughter and may result in lighter finished weights. Growth during this period should target a minimum of 0.5kg / day.

From my own figures, there is a tendency for animals that show a period of static or declining growth in the first winter, to then have subsequent winters of static or declining growth. It is supposed that there is an epigenetic effect of the natural

response to the animal adapting to get through a restricted period as effectively as possible.

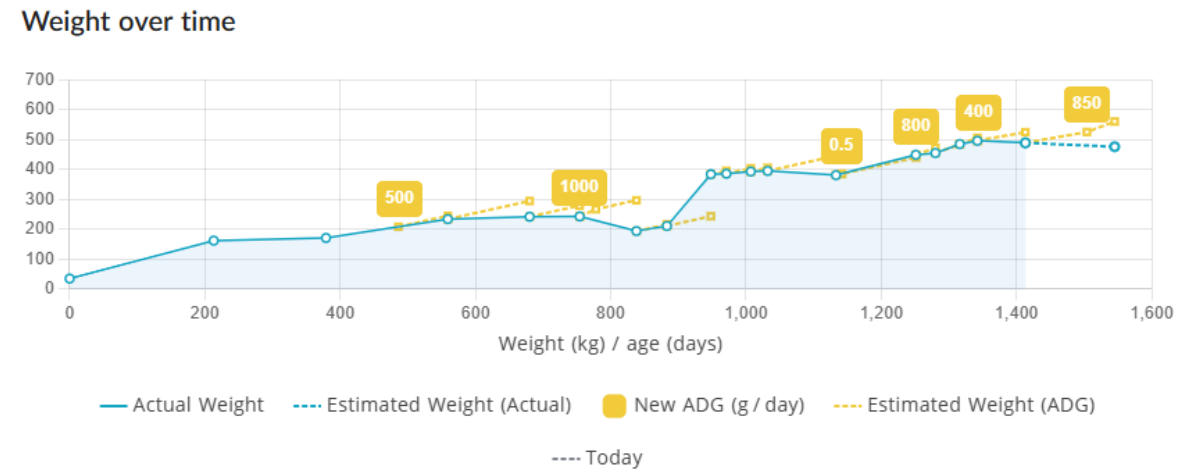


Figure 6 - Example of growth profile from one of the author's own Highland cattle (they are not all like this!)

If high-quality spring grazing is available and calves regain weight rapidly (e.g. >1 kg/day), some of the negative effects of winter restriction may be mitigated. Muscle growth can accelerate, and newer collagen formed during this period tends to be more soluble and less mature, improving tenderness potential. However, unlike muscle and fat, connective tissue does not fully reverse under compensatory conditions. As such, while final eating quality can be improved, the window to optimise tenderness narrows with increasing slaughter age.

There are sectors of the UK industry that actively promote the benefits of compensatory growth; however this is an economic benefit to the farmer and not a benefit to meat eating quality.

5.3 Stress

Stress has a significant impact on the eating quality of beef, particularly through its effects on tenderness, juiciness, and flavour. The influence depends on when and how the stress occurs; whether it's chronic stress over time (e.g. poor nutrition, handling, weather) or acute stress just before slaughter (e.g. transport, mixing groups, rough handling).

Stress depletes muscle glycogen, which is needed post-mortem to produce lactic acid. Without enough lactic acid, the pH of the carcass remains high (>5.8), leading to a condition called DFD (Dark, Firm, Dry) meat. DFD meat retains less water making it dryer, tougher and less juicy. It also has a shorter shelf life and often has a metallic or off flavour.

Stress reduces proteolytic enzyme activity post-mortem, which are responsible for breaking down muscle fibres. This means less tenderisation during ageing, especially if the pH stays high and inhibits these enzymes.

Chronically stressed animals may also develop more connective tissue due to elevated cortisol, further reducing tenderness.

5.3.1 Weather

We think of any weather extreme as stress inducing. In numerous places, however, animals were thriving in -20°C conditions with unrestricted access to forage. Cold is not a significant factor in creating long term stress.

Where there were wet conditions, animals found it harder to thrive. “Mud season” is a difficult period in which to maintain condition in livestock with wet animals requiring more energy for maintenance and wet ground conditions making it less likely that animals would lie down and ruminate.

Picture 20 - Polyface Farms, Virginia, USA

Britain’s biggest asset, rain, is also its biggest liability when it comes to producing beef. We have a climate that allows us to grow a lot of grass with moderate temperatures and a comparatively healthy amount of rain. However, where this goes against us is during the winter period where we get approximately 3/5ths of our annual rainfall, and we do not get the cold and dry conditions experienced in other beef producing countries.

Picture 21 - minus 18°C North Michigan, USA

By and large, our cattle population struggles to maintain or increase condition in such wet conditions. In my travels, but especially in North America, keeping cattle clean and dry was one of the biggest factors in successfully growing livestock, especially in winter.

Picture 22 – minus 37°C Nerbus Bros, Manitoba, Canada

5.3.2 The Glycogen Bucket

The "glycogen bucket" is a metaphor developed through research supported by Meat & Livestock Australia (MLA) to explain the importance of muscle glycogen reserves in animals prior to slaughter. Glycogen is the energy reserve in the muscle

tissue, and its level at the time of slaughter plays a critical role in determining meat quality, particularly pH decline.

In the model:

- The bucket represents the total capacity of the animal to store muscle glycogen.
- Filling the bucket requires good nutrition, low stress, and adequate recovery after handling or transport.
- Leaking or draining the bucket represents the loss of glycogen due to stressors such as handling, mixing, poor weather, transport, or time off feed and water.
- If the bucket is nearly empty at slaughter, there is insufficient glycogen for normal post-mortem lactic acid production, leading to high ultimate pH meat (above 5.8), also known as dark cutting.

The model underscores the cumulative effect of stress across the animal's life, especially in the final 48 hours pre-slaughter. Managing the "bucket" means managing nutrition, minimising stress, and allowing time for animals to refill their glycogen stores before slaughter, through proper rest, lairage conditions, and handling practices.

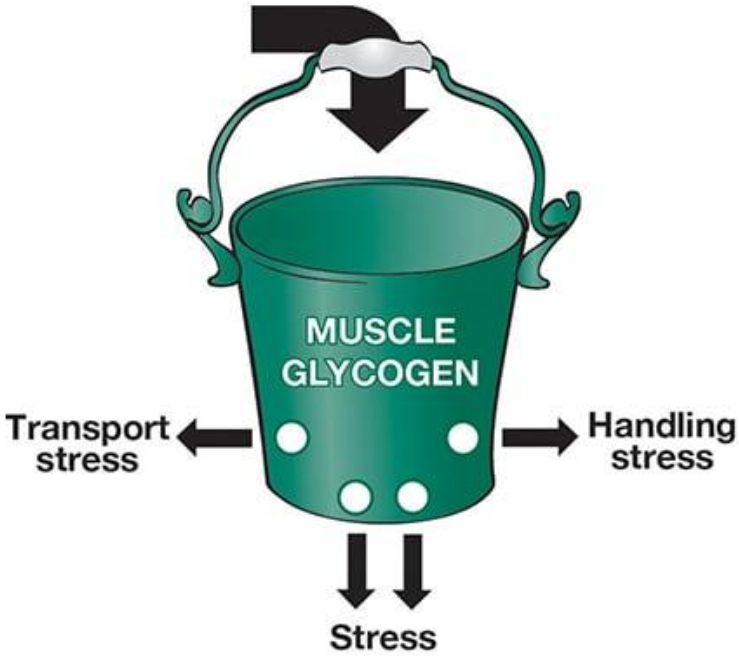


Figure 7 - The Glycogen Bucket. Graphic: MLA

It is often suggested that highly strung animals will adversely affect MEQ. However, thoughts from MLA suggest that meat from those animals generally eats well, but

those animals could have a negative effect on those animals around them. Therefore grouping of animals on the basis of temperament can be important.

5.4 Age / Maturity

Days to slaughter tend to be higher on 100% grass and forage systems and this is potentially the most significant point of balance when trying to achieve good MEQ.

As an animal ages, so the meat tends towards toughness due to greater levels of ossification. Ossification is the process by which soft cartilage turns into hard bone during the growth and development of an animal. It is a measure of physiological maturity and, as ossification increases, tenderness declines.

As age increases, the risk of periods of nutritional deficit or other stresses, such as reproduction, can also adversely affect MEQ outcomes.

However, increased age also leads to a more significant flavour profile (don't knock seven year old Jersey cow beef until you have tried it![3]). This is the clearest attribute where it's seen that flavour and tenderness can be antagonistic.

Picture 23 - Seven Year Old Jersey Beef, Kingsbek Farm.

[3] I was treated to 7 year old Jersey beef at Kingsbeck. The flavour was sensational but might challenge some palettes. There was a compromise on texture with it being a bit more "stringy"

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

1. Each market is individual and will respond with different requirements allowing for targeting of product from different production systems.
2. Static or declining growth will adversely affect MEQ. Minimum growth requirements are 0.5kg / day.
3. Compensatory growth is a sign of inadequate nutrition and can lead to a degradation of MEQ.
4. Keeping young animals clean and dry is essential to ensure daily liveweight gain through the winter.
5. pH measuring 24 hours after slaughter helps determine if meat is likely to Dark, Firm & Dry (DFD).
6. As animals get closer to slaughter, they should be on good nutrition to lift muscle glycogen.
7. Some breeds are likely to have better MEQ outcomes and should be selected in conjunction with suitability for grass and forage systems.
8. Manage for the end result: the way in which finishing stock are managed is likely different to breeding stock.
9. There is value in having diversity of swards.
10. There is a seasonality to grass fed beef due to the seasonality of the diet.
11. What isn't measured can't be consistently achieved. Collection of on farm growth data to evaluate grazing / feeding routines is important.
12. Management of stress prior to slaughter is important. Consideration should be given to moving live cattle from farm straight to slaughter.
13. Meat with poorer MEQ outcomes need to be identified and moved to an appropriate market.
14. **Enhanced Meat Eating Quality needs to be rewarded**

CHAPTER 7: DISCUSSION

There is no doubt about it; this has been a project of privilege. In a world of poor food distribution and accessibility, it seems incongruous to look at something as insignificant as Meat Eating Quality. But is it? As beef comes under more and more pressure to justify its existence, my travels have convinced me of the need for us to ensure that our product is consistently good by every measure.

As an industry we have a tendency to look at other countries and expect us to achieve the same thing here; and whilst I rail against the "that will never work on my farm because..." we do need to fully understand the operating parameters of both our own system and also the system that we are looking at to adopt.

We also must be very careful at drawing out one measure in isolation. In a sense, producing for eating quality is not rocket science, but it is keeping an eye on the detail of many moving parts. Perhaps that is why we don't do it, it's in the too difficult box when the reward for doing so is paltry or non-existent.

Another reason for not acting is the time it takes to affect change. Changing the direction of a breeding programme today might not feed through for 30 months. It might take a further 30 months to undo if one gets it wrong.

One of the challenges that I have had during my studies is access to on farm data. We still tend to judge the merits of animals, and their progress, by eye. It is therefore difficult to properly evaluate outwintering regimes or feeding decisions, for example, to draw specific conclusions. The collection and analysis of on farm data is critical to making informed decisions in any farm business.

Whilst I have travelled to many countries and seen many people, it has offered just a mere snapshot into our global food production system. I have had the luxury of looking specifically at beef eating quality, but it has caused me to question the quality of our food more generally. Food is supposed to nourish and sustain us and yet so often I heard stories as to how it makes people sick.

If we accept that flavour is a proxy for nutrient density, then a lot of our non Ultra Processed Foods are low. In addition to this, our foods seem to be less able to satiate us, leading to larger portion sizes further compounding the issue that our food might not be adding to our overall health.

Underlying all this is that there is a huge proportion of our global society that does not have the luxury of choosing what food they eat; they are solely dictated by the cost of buying the food and then, perhaps, preparing it.

Worryingly though, even the more affluent in society appear to be becoming conditioned to these unhealthy foods. There are many people that would prefer foods that don't challenge unless under controlled situations. Crudely this could be bland and floppy meat that requires a flavour added, tailored to an individual's tastes. What springs to mind here is 40 odd years ago when (certainly in our house) we made the switch from whole milk to semi skimmed. Many people will not make the transition back because of the flavour of the product. Is it any wonder that to boost sales of whole milk at the farm gate, we combine it with syrups and flavours to make it more palatable?

Whether an animal is grass or grain fed is largely immaterial, what is important is the nutrition contained within that animal. We are what the food we eat, eats. If we can produce nutritionally dense grains to supplement a bovine's natural diet, there is the potential there to produce a wonderful piece of beef.

More broadly though, in the UK, we are missing the full range of tools available to us to develop our beef to be more consistently good. We have no mechanism for measuring and thus rewarding MEQ. What isn't measured isn't consistently achieved and therefore there is no focus on improving the quality of what we produce over and above the status quo.

When looking at GF100 beef, there is a lot more aspects to keep in check other than relying on extra nutrition to feed an animal out of the problem. As nutrition can often be sub optimal, other considerations such as environmental conditions, handling, genetics, epigenetics et al play an increasingly important role but with no single aspect key to unlocking excellent MEQ.

Can GF100 beef be the best? If we consider all factors that contribute to MEQ, measure and manage for them, and market appropriately, then yes it certainly can.

CHAPTER 10: ACKNOWLEDGEMENT AND THANKS

My Nuffield journey would not have been possible without the support and encouragement of so many folk to go for it and then to go again when it hasn't worked out. Some standout names, however, include Emily Grant, Robert Gilchrist and John Scott. Their continued interest, engagement and support has been immeasurable.

None of it would have been possible without the generous support of my sponsors, **The Royal Highland Agricultural Society of Scotland (RHASS)** and **The Worshipful Company of Butchers** and indeed special thanks must go to Bob Bansback for his enthusiasm and support during my travels

Thanks go to The Nuffield Farming Scholarships Trust for giving me the opportunity to do this and the wider Nuffield family who have only shown me openness, encouragement and a willingness to see me do well; I hope it has been justified.

It has been an enormous honour to be part of the 2024 Scholarship group. In such a group, my impostor syndrome looms large and it is thanks to the support of the group that I have managed to get as much out of Nuffield as I have.

Picture 24 - 2024 Nuffield Scholars

I have been fortunate to meet so many people from varying walks of life whilst undertaking my travels and studies. I have always been treated with a friendship and openness which has been in stark contrast with how the world feels sometimes! If justice has not been done to this report, it is my failing entirely

despite the patience, wisdom and generosity of the countless people that hosted me and imparted knowledge.

The publication of this report will roughly coincide with the 10-year anniversary of when I became a farmer in less than ideal circumstances and to that end I would also like to acknowledge my wonderful parents. There is not a day goes by where I don't miss them for one reason or another. I would swap everything to have them back, knowing I probably wouldn't have been exposed to many opportunities, including Nuffield, that a career in agriculture has afforded me. I hope that out of a dark place and time, I have bounced forward and in doing so have made them proud.

The "home team" of colleagues have been amazing during my travels, taking on new responsibility and finding new ways of doing things. It has been wonderful to see them grow and flourish and operate two businesses far better than I can! And start a third!

Most of all though, I am hugely indebted to "The Wife and We'ans" for being absolute rocks. It has been awe inspiring to see the enthusiasm that they have shown in my travels and findings but also the way challenges have been faced and dealt with. Nuffield simply would not have been possible without their support and encouragement and I will be forever thankful for it.

Picture 25 - The Clan on the day I left for my travels. Poor Rory thought I was only going for three days. He saw me 10 weeks later!

APPENDIX 1: BROADER MEQ FACTORS

A1.1 Breed

Individual breeds coalesce around a defined set of characteristics such as colour, temperament, appearance, and, to a certain extent, size. In the UK, certain breeds can command a premium price through perceived better eating quality. The prime example of this is the Aberdeen Angus breed which has promoted itself on superior MEQ.

There is the oft quoted saying that "there is a much difference within breed as between breeds themselves!" Whilst this is certainly true, due to the generations of selection around certain traits, there tends to be a genetic standardisation within breeds that lead to certain MEQ outcomes.

The Irish Cattle Breeding Federation (ICBF) has developed a genetic evaluation system to improve Meat Eating Quality in beef cattle, focusing on three key traits; tenderness, juiciness, and flavour. The evaluation uses data from over 5,000 animals, integrating both genomic and phenotypic data to link sires to MEQ outcomes. [4]

Analysis of the data developed in this programme has allowed for a basic ranking of MEQ scoring by breed. The original dataset includes many more breeds, but for this analysis have been filtered out due to low progeny records.

Breed	Average of Juicy	Average of Tender	Average of Flavour	Average of MEQ Total	Sum of Total Progeny Records
Hereford	5.0	4.9	5.0	14.9	1233
Jersey	5.0	4.9	5.0	14.9	149
Aberdeen Angus	5.0	4.5	5.0	14.5	2093
Holstein	5.0	3.0	4.8	12.8	961
Shorthorn	4.5	4.1	3.8	12.4	139
Belgian Blue	4.3	4.4	2.9	11.6	463
Parthenaise	3.9	3.8	3.5	11.2	117
Aubrac	3.6	3.5	3.2	10.3	209
Saler	4.0	1.9	3.4	9.3	197
Charolais	3.8	2.0	2.3	8.0	944
Limousin	2.6	2.4	2.6	7.6	1758
Simmental	1.6	1.0	1.6	4.2	617

Table 1 - Ranking of breed to MEQ outcomes.

[4] https://www.icbf.com/meat-eating-quality/

From the table, one can start to draw conclusions about how breed influences MEQ outcomes with some of the traditional breeds ranking better than some Continental breeds.

Case Study: First Light Farms, New Zealand – Wagyu Beef

First Light Farms in New Zealand produces 100% grass-fed Wagyu beef through a vertically coordinated supply chain focused on eating quality, animal welfare, and regenerative grazing. They use fullblood Wagyu bulls, mainly of Tajima lineage, crossed primarily with Angus or Angus-cross cows to optimise marbling and pasture performance. They also incorporate Kiwi Cross (Friesian/Holstein × Jersey) cows, especially within dairy-based systems, to supply Wagyu-dairy cross calves. These crosses bring fertility, hybrid vigour, and suitability for pasture while offering a cost-effective route into Wagyu production.

All cattle are raised 100% grass fed and the company rewards farmers based on carcase quality, with a strong focus on intramuscular fat.

Picture 26 - First Light Farms Wagyu Striploin. Photo: courtesy of First Light Foods

First Light had a comprehensive stud programme, developing the Wagyu genetics that perform well solely off grass. The use of breeds that naturally have better eating quality characteristics are used to good effect in creating a premium product that is sold worldwide.

Picture 27 - Sandy Broad, a First Light Farm Producer and Gerard Hickey, First Light Foods

A1.2 Genetic

As we can see in A1.1, breeds have a genetic disposition to MEQ outcomes. This has been taken a step further in the US with a collaboration between Callipyge Genetics and Pharo Cattle Company. There is little data available to establish the validity of the programme.

Case Study: Callipyge Genetics and Pharo Cattle Company

Frank Henrix of Callipyge Genetics has utilised a DNA-based tenderness marker. Cattle are scored on a scale from T1 to T10, with T10 indicating exceptional genetic potential for tenderness. While only a small percentage of animals in commercial herds naturally achieve this, the high heritability of the trait means herds can shift dramatically in just two generations through targeted breeding.

The Pharo Cattle Company in the United States has been a leading adopter of Tenet genetics since 2007. Known for its low-input, forage-based systems, Pharo integrates Tenet-certified bulls into its programme to produce cattle that perform well on grass while delivering consistently tender beef.

Kit Pharo's long-standing focus on selecting cattle for low-input, forage-based performance appears to have unintentionally selected for superior meat tenderness at the genetic level. His phenotypic selection policy prioritises traits like fertility, moderate mature size, structural soundness, and the ability to thrive without supplementary feeding. When these sires were later tested using the

Tenet DNA marker for tenderness, over 60% were found to be genetically certified for top-tier tenderness, compared to just 2–5% in the general population. This correlation suggests that selecting for functional and efficient cattle in a grass based system can also lead to improved meat eating quality, even in the absence of initial genetic testing.

A1.2 Double Muscling

Double muscling is typically caused by mutations in the myostatin gene, notably MSTN F94L and MSTN nt821. These mutations supress the usual inhibition of muscle growth which results in a significant increase in muscle mass. Whilst this trait is beneficial for carcass yield, it has mixed implications for eating quality.

Double muscled animals show a shift toward fast-twitch (Type II) fibres, which are associated with glycolytic metabolism, paler meat colour, and lower intramuscular fat. Conversely, animals with more slow-twitch (Type I) oxidative fibres,common in native, grass-fed breeds, tend to produce darker meat with higher flavour intensity and greater fat content.

The increased tenderness often reported in double-muscled animals is due to reduced connective tissue and finer fibre diameter, not necessarily due to higher marbling or succulence. In fact, reduced intramuscular fat and myoglobin levels can result in reduced flavour and juiciness.

	Native Breeds (e.g. Shorthorn, Angus)	**Continental Breeds(e.g. Charolais, Limousin)**	**Double-Muscled Breeds(e.g. Belgian Blue, Piedmontese)**
Muscle Fibre Type	Higher % slow-twitch (Type I)	Balanced, but more fast-twitch (Type II)	Predominantly fast-twitch (Type II)
Myoglobin (Meat Colour)	High (darker meat)	Moderate	Low (paler meat)
Intramuscular Fat (Marbling)	Moderate to high	Moderate to low	Very low
Tenderness	Good, improves with ageing	Variable, ageing-dependent	Naturally high (low connective tissue)
Flavour	Rich, beefy, pasture-influenced	Milder	Mild to bland
Juiciness	Good (higher IMF and WHC)	Variable	Lower (low IMF and water holding capacity)
Post-Mortem Ageing Requirement	2–3 weeks typical	2–4 weeks beneficial	Essential to optimise texture

Cooking Recommendation	Versatile; suited to dry or moist heat	Leaner cuts need care	Moist heat or precise dry cooking preferred
Carcass Yield	Lower conformation but higher fat cover	High conformation	Very high conformation, low fat cover
Suitability for Grass-Fed MEQ	Excellent	Moderate	Limited

Table 2 - Comparative traits of breed types

A1.3 Size

There is the saying that "kilos pay" and we have a system that rewards that. However, as we have larger finished animals, it is harder to cut a standard steak (225g at 25mm to 30mm thick). As the eye muscle area gets larger, so the 225g steak gets thinner. This leads to a product that is harder to cook medium rare and therefore loses succulence as it gets overcooked, or does not realise the potential flavour created by the Maillard reaction.

When looking at worldwide systems, particularly in South America, finished animals were generally much smaller than that produced here, being in the region of 575kg to 675kg.

Picture 28 - Rafael Leguisamo, Ingleby Farms, Uruguay with grass fed and finished stock

A1.4 Lairage Time

There is a link between lairage time and the eating quality of the resulting beef. Optimal lairage, typically between eight and twenty four hours, allows animals to

recover from transport stress, stabilise cortisol levels, and replenish muscle glycogen. This is crucial for a proper post-mortem pH decline.

If lairage is too short (less than six hours), animals may still be highly stressed or exhausted, leading to elevated final muscle pH and a higher risk of DFD meat. On the other hand, excessively long lairage (over 24–48 hours) can result in prolonged fasting and additional social stress from mixing unfamiliar animals, again depleting glycogen stores and compromising meat quality.

Research consistently shows that moderate lairage times, tailored to allow rest without inducing further stress, contribute to more consistent and desirable eating quality outcomes.

A1.5 Other Stresses

Whilst not belittling these other sources of stress, they are well documented and work has been published on how to mitigate them. They are listed here for completeness.

- Transport
- Handling
- Temperament

A1.6 pH

The post-mortem decline in muscle pH plays a pivotal role in determining meat eating quality (MEQ). Immediately after slaughter, muscle pH begins around 7.0 but typically falls to an optimal range of 5.4–5.8 as glycogen is converted to lactic acid. This decline is essential for the development of good MEQ outcomes.

Within the ideal pH range, proteolytic enzymes such as calpains and cathepsins are active, breaking down muscle fibres and improving tenderness. Water-holding capacity is also maintained, helping to preserve succulence, while the meat takes on a bright, attractive colour. These factors combine to enhance consumer appeal and eating satisfaction.

However, if pH remains high (above 6.0), often due to pre-slaughter stress depleting muscle glycogen, the meat can become dark, firm, and dry (DFD). This results in reduced tenderness, muted flavour, and poor shelf life due to increased microbial activity.

Conversely, if the pH drops too quickly while the carcass is still warm, typically to below 5.4, proteins may denature, leading to a pale, soft, exudative (PSE) condition.

APPENDIX 2: FACTORS AFFECTING MEQ NOT RELEVANT TO UK PRODUCTION

There are other factors that a relevant to Meat Eating Quality that are not included in the main body of the report, either because they are not relevant to UK (and by extension European) production, or they are illegal in this country.

Hump Height

Generally an issue with Bos Indicus cattle, greater hump height negatively impacts on meat eating quality

Hormonal Growth Promotants (HGPs)

HGPs are used in many production systems worldwide but have been illegal in Europe since the 80s. They deliver productivity gains in terms of speed of growth but they can lead to an increase in ossification and have other negative effects on MEQ which vary to a greater or lesser degree depending on the muscle.

APPENDIX 3: AGEING

Depending on who one speaks to, ageing is either a dark art consisting of myth and magic designed to entice the customer, or it is a basic requirement of good beef, but you can take it too far! It is absolutely a topic on its own but the author felt it was useful to include an overview of the various processes and their benefits

The Effects of Aging Beef

Aging beef is the controlled process of allowing enzymatic and biochemical activity within muscle tissue to enhance tenderness, flavour, and overall MEQ. It primarily involves proteolysis, which is the breakdown of muscle proteins, by endogenous enzymes such as calpains and cathepsins.

Key Effects:

Tenderness:

Ageing improves tenderness by breaking down structural proteins within the muscle fibres. The key enzymes in this process are μ-calpain and m-calpain which target proteins in the myofibrillar structure, especially around the Z-discs.

Z-discs anchor the actin filaments in the muscle sarcomere and play a critical role in maintaining the muscle's structural integrity. As aging progresses, degradation of proteins like desmin and titin causes the Z-discs to become fragmented or disappear, weakening the muscle structure and making it easier to chew.

This structural breakdown is especially significant in slow-twitch (oxidative) fibres, which contain more Z-disc-associated proteins and are more resistant to initial post-mortem contraction.

Flavour:

Ageing allows flavour compounds to develop through the breakdown of proteins and fats. This generates amino acids, peptides, nucleotides (like IMP), and free fatty acids that contribute to savoury, roasted, nutty, and umami notes, particularly in dry-aged beef.

Juiciness:

This may decline slightly with longer aging, especially dry ageing, due to increased moisture loss. However, improved tenderness can offset a perceived dryness in sensory evaluation.

	Wet Aging	Dry Aging
Process	Vacuum-packed and stored at ~0–2°C	Exposed to air in humidity/temperature-controlled rooms
Duration	7–28 days (commonly)	14–45 days (or longer)
Weight Loss	Minimal	10–20%+ moisture loss
Trim Loss	Minimal (no crust)	High (dry outer layer trimmed)
Cost	Lower – efficient, no special facility	Higher – storage space, time, yield loss
Flavour	Mild, slightly metallic or metallic-bloody	Rich, nutty, roasted, with umami depth
Tenderness	Good improvement	Often excellent due to dehydration enzymatic action
Packaging	Vacuum bag (no oxygen)	Open air (aerobic environment)
Spoilage Risk	Lower – sealed environment	Higher – requires strict hygiene & airflow

Table 3 - Comparison of ageing methods

Optimal Aging Duration

Tenderness Improvements:

- Most tenderness improvement happens within the first 7–14 days post-mortem.
- Muscle structural protein breakdown is largely complete by 21 days in most systems.
- Disruption of the Z-disc region is a key indicator of the proteolytic process and correlates strongly with improved tenderness in aged meat.

Flavour Development:

- Dry-aged beef shows distinctive flavour changes from 21–35 days.
- Wet-aged beef reaches flavour maturity earlier but remains more subtle.

Beef Type	Method	Recommended Duration	Notes
Grass-fed, pasture-only	Wet aging	14–21 days	Avoids over-acidification from vacuum packaging
Grain-fed, marbled	Wet aging	21–28 days	More marbling = better protection against oxidation
Grass-fed premium cuts	Dry aging	28–35 days	For flavour development, if trim loss is acceptable
Wagyu or highly marbled	Dry aging	35–45 days	Can tolerate longer aging due to high fat content

APPENDIX 4: FREEZING

Throughout the countries I visited, there was a much greater adoption of freezing as a way of storing meet and much greater acceptance of buying frozen meat than there would be in the UK. Frozen meat in the UK is largely seen as an inferior product and degrades MEQ. However, it is not as clear as that.

Tenderness

Freezing generally preserves or may even improve tenderness, particularly if the meat has been appropriately aged prior to freezing. The formation of ice crystals during freezing can disrupt muscle fibre structures, resulting in a softer texture. However, this effect is highly dependent on the rate of freezing: rapid freezing produces small ice crystals which minimise structural damage, while slow freezing results in larger crystals that can damage muscle fibres more extensively and potentially lead to a tougher eating experience post-thaw.

Juiciness

One of the most consistent negative effects of freezing is a reduction in juiciness. Moisture loss occurs during thawing as exudate (a mixture of water and soluble proteins) is released. This loss is exacerbated by any damage to the meat's cell structure caused by slow freezing or long-term frozen storage.

Flavour

Flavour is generally well preserved in frozen meat if packaging and storage conditions are well managed. However, oxidation of fats over time, especially in high-fat cuts, can cause rancid or stale flavours. Inadequate packaging may lead to freezer burn, which creates dry, oxidised patches on the meat surface and adversely affects flavour and appearance.

Best Practices for Preserving Eating Quality

To maintain high eating quality in frozen meat, the following practices are recommended:

- Freeze rapidly, ideally using commercial blast freezing, to reduce ice crystal size.
- Vacuum-pack meat to limit oxygen exposure and prevent freezer burn.
- Store at a consistent temperature of -18°C or lower.
- Avoid extended storage periods, especially for meat with higher fat content.
- Thaw slowly in refrigerated conditions, rather than at room temperature, to reduce drip loss and preserve texture.

APPENDIX 5: SYNOPSIS OF COUNTRIES VISITED

Brazil

Brazil opened my eyes to scale. Brazil is one of the biggest global suppliers of beef yet it only exports 20% of its produce with the remaining consumed in country. At one JBS plant visited, they were processing around 2,000 animals per day with capacity for double that. It also hit home as to how aspirational it could be to be able to eat beef and lamb.

Uruguay

With a population of three million (half of which live in the capital Montevideo) the inhabitants are significantly outnumbered by their cattle population of over 14 million. Home of Angus and Hereford cattle, extensive pastoral systems, the most drawn out auctions, and the best traceability and feedback system. There is so much opportunity for farming to be more efficient here but, equally, if there is a country able to compete (and out compete) in a market that favours quality, it would be Uruguay.

Picture 29 - My constant travelling companion - the family's Lucky Pink Unicorn!

Chile

I am grateful to Laura Awdry NSch who organised the visits here. It was the first time that I have seen the entire slaughter process and whilst it cannot be claimed that it was a process where angels sung whilst praise was given to every animal, it was a huge comfort to see the professionalism with which it was done. It was also incredible to see the extent to which every part of the animal was recovered for various markets.

I also got a lot out of seeing a dairy here. There little by way of fancy grass mixes in place but more an established pasture which, over the years, had gained in diversity. As a result, milk quality was of a good quality over straight yield. It also highlighted the different standards of grass management between dairy herds and beef herds.

Chile was also where it challenged my perception that grass fed beef might not be considered a premium product. Here, grain fed was considered superior due to a greater consistency in tenderness and flavour in the finished product.

New Zealand

I really wanted to understand the thinking and principles in New Zealand behind their production. Arguably of all the countries that I visited, it is most like Scotland but without the subsidy safety blanket. I came away impressed at the adaptability of the industry to meet market requirements and develop those markets, making it harder for other countries to compete with them. Primarily an exporting country, there was an enviable laser focus on selling their produce.

Australia

I confess, I was not excited about going to Australia but went under a feeling of duty to look more at the MSA grading system. It was maybe with low expectations but my two weeks in Australia were undoubtedly among the best on my tour. Such is the scale of the country, I didn't get out of New South Wales but I visited everything from feed lots to citrus farms, from regenerative merino wool production to a self-service shop that locks you in if you don't pay!

The take away was what could be achieved with a well functioning grading system; around 190 different brands of beef, using differing production systems but all backed by a MEQ score. It allowed for the right product, with the right story of the right quality to reach the right market at the right price.

Japan

I was flagging when I got to this amazing country and was not ready for the busyness of it. Huge thanks to Kyota Yoshikawa NSch for scooping me up (literally and figuratively) and looking after me.

The market here is very much concerned with the outcome and final experience, and not necessarily how it got there. Whilst production standards were challenging (through our privileged optics), the passion behind what was being produced was certainly not.

USA

The market in the USA rewards tenderness and marbling but not necessarily flavour. Indeed grass fed and well-aged beef is an "acquired taste" rather than something to be sought after. The grass fed producers that I spoke to indicated that grass fed was bought more for perceived health benefits and a concern or even an adverse reaction to conventionally produced beef. For me, the meat (and food in general) was simply a canvas for adding a palette of flavour rather than the flavour being baked into the picture. It was an indication of where we could end up chasing speed, size and efficiency.

Canada

Well it's pretty cold up there! Minus 25°C on a skidoo fairly makes snot freeze rapidly on your face. But the cattle that I saw coped well with cold and dry, however much of the finishing was done under cover with a TMR.

UK

The contrast here with our major competitors is stark. The relatively small size of our holdings compared to the rest of the world makes it more difficult to achieve a consistency of production seen elsewhere. There is also a greater difficulty here of balancing ancillary agricultural activity with (good) food production

However, we have an agriculture sector that celebrates the culture, traditions and diversity of the industry. Whilst we don't have the laser focus of other exporting countries, we have a richness that can't be measured.

Picture 30 – the author will his Highland Cattle

APPENDIX 7: PHOTOS

Food is visual and sensory. It help bring people together and it has been an immense privilege to experience this during my travels.

Picture 31 - Fogo de chao in Brazil

Pictures 32 & 33 - Two amazing folk in Uruguay. Ross Houghton in the left and Alexandro Zimbrano in the right

Picture 34 & 35 - Premium beef option and my next building project. Both in Chile

Picture 10 – In some cases size doesn't matter!

Picture 117 - One of the best days ever with long-time friends, visiting Carlos Bagrie NSch and his wife Nadia Lim

Picture 12 - Fridge in a fridge! Australian Meat Emporium, Sydney

Picture 13 - Generous Hospitality in Moree

Picture 40 & 41 - The Dry Ageing Display - Winston Churchill Butchers, Sydney

Everyone smiles in Japan!

Picture 42 - Shinya Okazaki NSch and Kyota Yoshikawa NSch at YUBOKU

Picture 43 – The Tokyo Cowboy

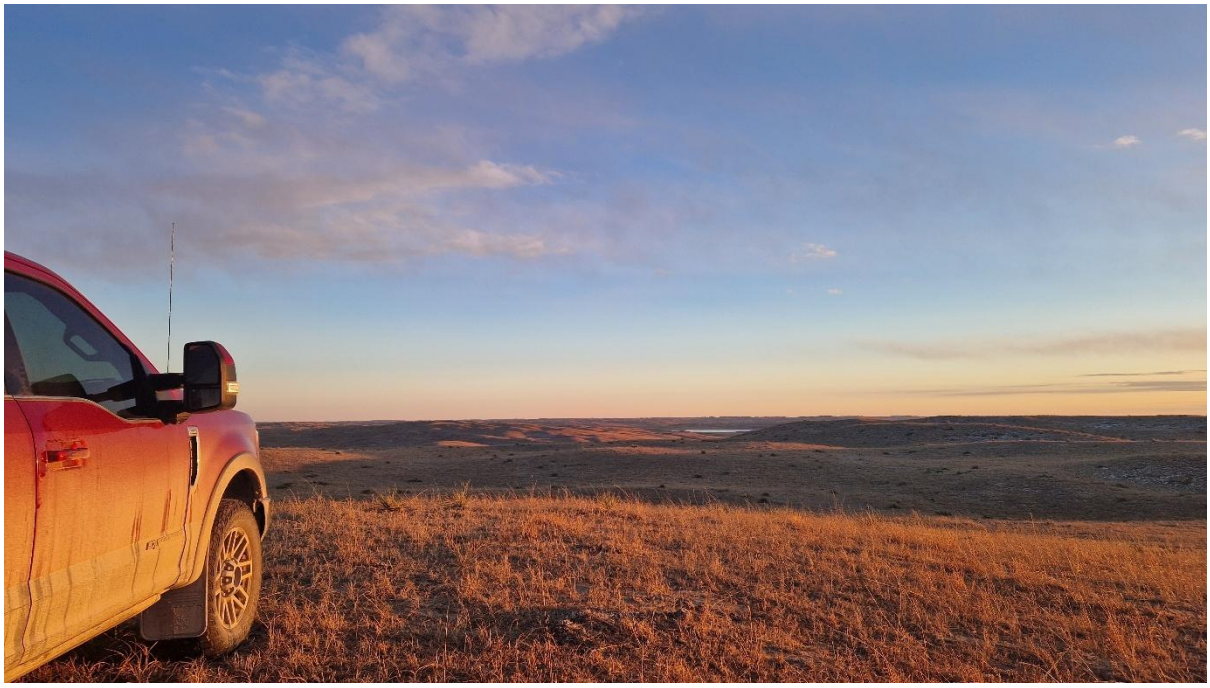
Picture 44 - Yasu

Picture 14 - Blake Vince NSch & Matt McIntosh. Two outstanding Canucks

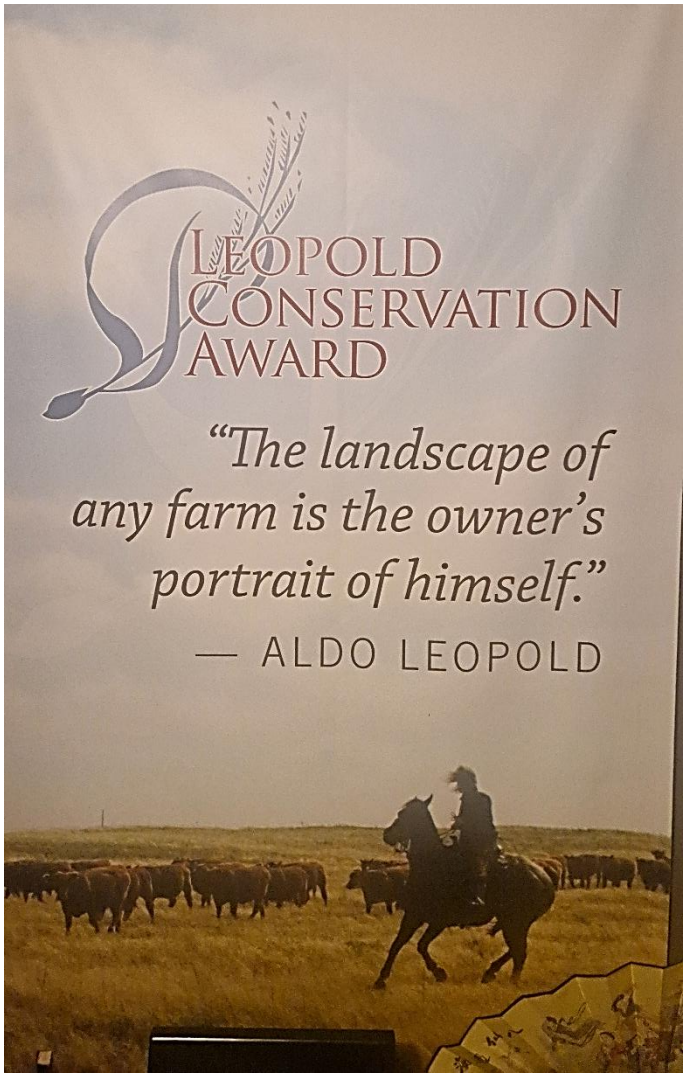
Picture 15 - Emma Butler, J&E Meats, Ontario

Picture 167 - The cold never bothered me anyway! Ben Nowakowski, Alpena, MI

Picture 178 - CSC Roommate Hans Rienche and wife Grace



Picture 18 - Wilson Flying Diamon Ranch



Picture 50 – Seen at Wilson Flying Diamon Ranch – This hit hard!

APPENDIX 8: GLOSSARY & TERMS

The following is a list of terms as used in this report and in their context.

Amino Acids	Small organic molecules that link together in chains to form all the proteins in the body.
Denature	A structural change in proteins when they lose their natural shape due to external stress like heat, acid or pH shifts
DMD	Dry Matter Digestibility.
Exudative	The loss of water from the muscle after slaughter
GF100	100% Grass and Forage Fed
IMF	Intramuscular Fat (marbling)
Maillard Reaction	The chemical reaction between amino acids and reducing sugars that occurs at higher temperatures (above 140°C), i.e. cooking, that gives browned meat its distinctive flavour and aroma. The reaction is what creates the crust on a steak or roast.
Myofibrillar structure	The organised arrangement of contractile proteins inside muscle fibres (muscle cells) that are responsible for muscle contraction and the structural integrity of the meat.
Nucleotides	Small organic molecules that serve as the building blocks of DNA and RNA, but they also play important roles in energy transfer and flavour development in meat.
Olfactory perception	How one senses and interprets smells.
Peptides	Short chains of amino acids linked together by peptide bonds.
Sarcomere	The microscopic structure responsible for muscle contraction and a key component of meat texture and tenderness

Z disks	Structural boundaries within muscle fibres that define the edges of a sarcomere, the basic contractile unit of muscle.

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