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Review Article

Roughage and concentrate based feeding and their impact on beef quality – A review

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Abstract

The feeding system is a major factor that affects the physicochemical, nutritional, and sensory quality of beef. This review examines the impact of roughage and concentrate-based diets on beef quality, emphasizing nutrient absorption, carcass composition, fatty acid profile, and flavor. Roughage-based systems, which are heavy in fibrous forages, help generate slimmer carcasses and increase good fatty acids like omega-3 and conjugated linoleic acid (CLA). This makes meat healthier and less likely to go bad. Feeding concentrates, on the other hand, speeds up growth, makes the carcass heavier, and adds fat to the muscles, which makes the meat more tender, juicy, and popular with customers. But if you consume too much concentration, it might mess with your metabolism and produce acidosis, so you need to be careful about what you eat. Using both feeding methods along with precision feeding technology can make animals perform better and increase the quality of the meat while keeping the rumen healthy. Consistently high-quality beef production that fulfills both consumer needs and sustainability goals may be achieved by continuing to improve feeding procedures.

Introduction

Beef is an important source of high-quality protein and micronutrients that are necessary for good health. It is a big part of the world's nutrition. It is the third most eaten meat in the world, after poultry and pork, with per capita consumption levels of 6.4 kg, 14.0 kg, and 12.2 kg, respectively (Mwangi et al., 2019; OECD and FAO, 2025). More people and higher household incomes around the world have led to a higher demand for beef. By 2027, consumption is expected to rise by 8% in developed countries and 21% in developing countries compared to 2015–2017 (Mwangi et al., 2019). These trends show that we need to improve feeding systems to make them more efficient and improve the quality of beef. Meat quality is a complex trait that includes sensory traits like tenderness, juiciness, and flavor, as well as visual traits like color and nutritional factors like lipid profile and fatty acid composition (Garmyn, 2020; Kutay et al., 2024; Listrat et al., 2016).

The feeding system is one of the most important things that affects these traits. There are two main types of beef feeding strategies: roughage-based and concentrate-based (Manni et al., 2018). Roughage-based diets, including pasture, hay, and silage, generally yield leaner carcasses with reduced intramuscular fat (IMF) (Zhu et al., 2022). These systems produce beef that is higher in good omega-3 fatty acids, conjugated linoleic acid (CLA), and trans-vaccenic acid, which makes the n-6/n-3 fatty acid ratio healthier (Daley et al., 2010; Nogoy et al., 2022). On the other hand, concentrate-based systems, which include high-energy grains, speed up growth, increase carcass weight, and add marbling, making the meat more tender and juicier (Nguyen et al., 2021). Nonetheless, these regimens may also increase total fat and saturated fat levels, thereby disrupting the nutritional equilibrium (Dos Anjos et al., 2023a).

Research indicates that altering the concentrate to roughage ratio significantly affects IMF accumulation, fatty acid profiles, and sensory attributes (Gou et al., 2025; Lukkananukool et al., 2023; Van Elswyk and McNeill, 2014). Feeding high-forage diets with legumes like alfalfa raises the levels of monounsaturated fatty acids (MUFA), which makes the food taste better and juicier (Gao et al., 2023; Zhu et al., 2022). Higher energy concentrates diets, on the other hand, improve marbling and tenderness by increasing IMF deposition. This review compiles recent evidence regarding the impact of roughage and concentrate-based feeding systems on the meat quality of beef cattle, focusing on nutritional composition, sensory characteristics, and production efficiency. A better understanding of how these things are related will help us come up with feeding practices that are sustainable and meet changing consumer demands for quality and health.

Roughage based and concentrate based feeding systems are two main ways to feed ruminants (De Nascimento et al., 2020). They differ in the type and amount of feed ingredients used. A roughage based diet consists of fibrous plant materials like fresh

forage, hays, silages, and straws (Hasan et al., 2021 and 2022; Jeon et al., 2019; Kobir et al., 2022). These materials provide structural carbohydrates and a high neutral detergent fiber (NDF) fraction, which gives the ration bulk, a chewing stimulus, and physical effectiveness (Ma et al., 2024; Mustafa et al., 2020). People usually talk about and rate roughages in terms of fiber metrics (NDF, ADF, lignin) and particle size/physical effectiveness instead of just energy density (Miah et al., 2024; Moyo et al., 2018). This is because they tend to have less metabolizable energy per kg dry matter (DM) and more chewing/rumination demand (Mazed et al., 2004; Shi et al., 2023). High-fiber roughages help rumen papillae grow, which makes it easier for the body to absorb volatile fatty acids (VFAs) and improves the overall efficiency of digestion (Suárez et al., 2007). On the other hand, concentrate based systems focus on feeds that are low in crude fiber but high in easily fermentable carbohydrates and proteins, such as grains, oilseeds, meals, and many industrial by-products. Concentrates are usually thought of as feeds with low crude fiber (often <18% DM) and high nutrient density (Akhter et al., 2022; Hossain et al., 2022 and 2023; Kidanea et al., 2022). Scientists have discovered the reason why the producers are giving the cattle more concentrate. High concentrate diets have been shown to improve the digestibility of nutrients like dry matter, organic matter, and crude protein, which means that cattle get more nutrients overall (Grant, 2023).

Scientific literature supports the claim that high concentrate diets improve nutrient digestibility, including dry matter, organic matter, and crude protein, which leads to higher overall nutrient intake in cattle (Sarkar et al., 2008; Kawsar et al., 2006; Moniruzzaman et al., 2002). For example, a study by Chen et al. (2021) found that adding more concentrate to the diets of Angus cows made it easier for them to digest nutrients and improved ruminal fermentation parameters (Chen et al., 2021). Research conducted by Norrapoke and Pongjongmit (2025) indicated that a diet consisting of 60% high-quality pellet feed for beef cattle optimized the digestibility of organic matter and neutral detergent fiber, underscoring the influence of concentrate quality on nutrient utilization (Norrapoke and Pongjongmit, 2025). But concentrated feeding isn't all good. To avoid metabolic disorders like acidosis, which can happen when animals switch quickly from a high roughage diet to a high concentrate diet without proper adaptation (Mao and Wang, 2025), concentrate feeding strategies should be carefully managed. The combination of roughage and concentrate is also a good way to feed beef cattle. In Brahman crossbred cattle receiving a basal diet of grass and rice straw, concentrate supplementation (0.6–2.4% BW) markedly enhanced the digestibility of dry matter, organic matter, and crude protein, while diminishing NDF digestibility, thereby illustrating the efficacy of concentrate incorporation in low quality roughage based systems (Quang et al., 2015).

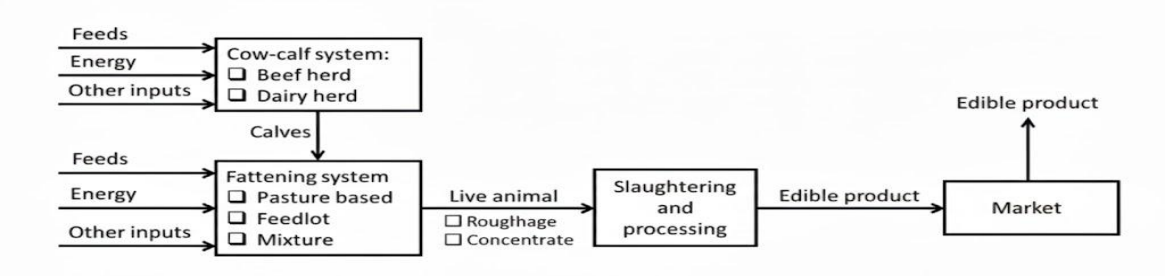

Figure 1: A beef production system based on different feeding approaches (modified from De Vries et al., 2015).

Method of evaluation of meat quality and composition

Most of the time, meat quality is defined as either fresh meat-eating quality, which describes meat for eating fresh, or technological quality, which describes meat for further processing (Azad et al., 2022; Kerry et al., 2002). Water-holding capacity, color, and texture of fat are the most important quality factors for technological quality (Mobin et al., 2022; Akintan et al., 2024; Mia et al., 2023 and 2024, Torun et al., 2023; Tushar et al., 2023). Texture, juiciness, and flavor/odor are the main things that make food good to eat, but for many people, fat content is also important (Jooste, 2000; Kerry et al., 2002). Computer vision and imaging spectroscopy are established technologies capable of providing reliable, rapid, and cost-effective quality evaluations. Reflectance is what computer vision mostly uses to find external quality traits like color, size, shape, and texture (Brosnan and Sun, 2004). There are many ways to measure the composition of meat, but most of them take a lot of time and money. It is possible to use chemical methods to check the quality of fresh meat, but this is not a good idea because it takes too long and costs too much. The level of saturation is the most common way to measure the quality of fat. This can be done by finding the amount of iodine (iodine number) (Jooste, 2000) or by gas chromatographic analysis (which finds the fatty acid composition) (Mitsumoto et al., 1991). Physical parameters such as color and melting point are also commonly measured (Hugo & Roodt, 2007).

Feeding systems are another critical factor influencing meat composition and quality attributes. Feeding roughages tend to produce leaner carcasses with improved oxidative stability and higher proportions of beneficial fatty acids such as omega-3 and conjugated linoleic acid. Conversely, concentrate diets enhance marbling, tenderness, and juiciness through increased intramuscular fat deposition. Understanding these dietary effects is essential when interpreting analytical results from technologies like near-infrared (NIR) spectroscopy, which can predict parameters such as fat content, moisture, and tenderness (Geletu et al., 2021; Hashem et al., 2020, 2021, 2023 and 2024; Mitsumoto et al., 1991). Integrating knowledge of feeding systems with advanced analytical tools provides a more comprehensive and accurate assessment of meat quality in both research and industrial applications.

Impact of feeding on meat quality attributes

Feeding systems that use roughage and concentrate ratios have a direct effect on the physical and chemical properties of meat (Table 1). The ratio of roughage to concentrate in the diet can change the color, marbling, fat composition, and pH of the meat, which are all important quality factors for both consumers and processors (Dos Anjos et al., 2023b). Diets high in roughage often help the body store more beneficial polyunsaturated fatty acids, while diets high in concentrate tend to make the muscles store

fatter and affect the tenderness of the meat. The pH of meat, which is an important sign of quality and shelf life, can also be changed by what we eat.

Recent research offers comprehensive comparisons of these effects across different animal production systems. Meat is mostly water (about 70–75%), with protein (about 20%) and different amounts of fat, ash, and other minor parts. This chemical makeup is what gives meat its quality (Panea & Ripoll, 2018). The water-holding capacity, texture (like firmness or shear force), color (through myoglobin and its redox state), and pH of meat are important physical traits that affect how it looks, how juicy it is, and how well people like it (Lan et al., 2025). The chemical state of muscle, including factors like pH changes from post-mortem glycolysis, fatty acid composition, protein denaturation, and oxidative status, affects WHC, tenderness, flavor precursor availability, and shelf life (Bejaoui et al., 2023; Tushar et al., 2023; Mostafa et al., 2025). The color of meat is mostly determined by the heme-protein myoglobin, which is a chemical property that directly affects how the meat looks (Yu et al., 2017). The interaction between chemical composition (fatty acids, moisture content, muscle proteins) and physical structure (muscle fiber size, connective tissue content, marbling) determines sensory attributes such as juiciness, tenderness, and flavor (Geletu et al., 2021).

Table 1: Comparative effects of roughage- and concentrate-based feeding systems on key meat quality attributes in beef cattle

Attribute	Roughage (forage) diets typical effects	Concentrate (grain) diets- typical effects	Citations
Intramuscular fat (marbling) and total fat	Lower IMF / leaner carcasses; slower fat deposition (less marbling for same finishing time).	Higher IMF and overall carcass fat; faster deposition of adipose and higher backfat and marbling.	(Evans et al., 2024)
Fatty-acid profile (PUFA, MUFA, n-3, CLA, n-6: n-3)	Higher n-3 PUFA and CLA, lower n-6: n-3 ratio; more beneficial omega-3/CLA signature (pasture signature).	Higher MUFA and n-6 PUFA, increased n-6: n-3 ratio (more oleic and n-6 accumulation with grains).	(Ponnampalam et al., 2024)
PUFA (g/100g FA)	5.13 ± 0.62	4.02 ± 0.49	(Terevinto et al., 2023)
SFA *(g/100g FA)*	50.09 ± 2.54	46.64 ± 2.39	(Terevinto et al., 2023)
MUFA *(g/100g FA)*	40.08 ± 2.68b	47.49 ± 2.19a	(Terevinto et al., 2023)
PUFA/SFA	0.10 ± 0.02	0.09 ± 0.02	(Terevinto et al., 2023)
Lipid oxidation and oxidative stability (shelf-life)	Greater oxidative stability is often reported (due to higher antioxidant intake from fresh forage and beneficial FA profile), lower lipid oxidation during storage in many studies.	Higher susceptibility to lipid oxidation (higher total lipid and more n-6 PUFA can increase oxidation) unless antioxidants are supplemented.	(Terevinto et al., 2023)
pH	5.63	5.65	(Peripolli et al., 2025)
WHC (%)	25.49	27.21	(Alqaisi et al., 2021a)
pH and water-holding capacity (WHC)	Mixed results - pasture beef is often leaner and firmer; pH differences minimal when animals handled similarly; WHC depends more on pre-slaughter stress and aging than solely diet.	Concentrate finishing (with higher IMF) frequently gives greater juiciness on cooking and can improve perceived tenderness/juiciness partly via higher fat content; WHC effects variable.	(Peripolli et al., 2025)
Tenderness and juiciness (sensory)	Can be less tender and less juicy if IMF is low and finishing is short; but long-term forage finishing with proper finishing duration can produce acceptable tenderness.	Generally, more tender and juicier (higher IMF improves tenderness, juiciness and palatability) in many comparisons.	(Lukkananukool et al., 2023)
Connective tissue / collagen (shear force)	May show higher connective tissue contribution to toughness when IMF is low; collagen solubility depends on age and finishing length.	Lower relative connective-tissue toughness because IMF cushions and reduces shear force; concentrate finishing often lowers WBSF (Warner–Bratzler shear force).	(Lukkananukool et al., 2023)

A recent study (Alqaisi et al., 2021) found that Holstein steers fed high-concentrate (HC) diets exhibited superior carcass traits compared to those on low-concentrate (LC) diets. The HC group showed higher dressing percentage and hot carcass weight, suggesting improved muscle deposition and growth efficiency. Although pH values were slightly lower in the HC group, indicating a potentially more favorable postmortem muscle acidification, cooking loss was marginally greater, which may reflect increased tenderness. Color parameters revealed that HC-fed steers produced meat with greater redness and yellowness, implying enhanced visual appeal associated with higher energy intake. However, proximate composition, including moisture, crude protein, fat, and ash contents, remained comparable between treatments, suggesting minimal influence of concentrate level on the muscle's basic chemical makeup.

Table 2: Effect of feeding diets with high and low concentrate contents on carcass characteristics and on the pH value, cooking loss, and the chemical composition of the longissimus dorsi muscle of Holstein steers (Alqaisi et al., 2021)

Item	HC	LC
Dressing percentage (%)	53	48
Hot carcass weight (kg)	206	155
pH	5.45	5.71
Cooking loss (%)	22.99	19.98
Color ^{L}	39.91	41.46
Color ^{a}	23.84	19.03
Color ^{b}	6.85	5.03
WHC (%)	27.21	25.49
Moisture (%)	74.12	74.61
Crude protein (%)	21.33	21.34
Crude fat (%)	3.10	2.63
Crude ash (%)	0.95	1.20

Note: Figures presented in least square means (LSM); SE, standard error of the mean; HC, high concentrate diet; LC, low concentrate diet. Color intensity (L, brightness; a_, redness and b_, yellowness); WHC, Water holding capacity; SE, standard error of the mean.

Carcass traits and composition

The proportion of roughage and concentrate in beef cattle diets markedly influences carcass yield and composition. Concentrate-rich feeding enhances growth rate, slaughter weight, and dressing percentage compared with forage-only systems, reflecting greater nutrient availability and efficiency (Mwangi et al., 2022; Doyle et al., 2023). High-concentrate finishing also increases subcutaneous and intramuscular fat deposition, which contributes to improved tenderness, juiciness, and flavor, whereas forage-finished carcasses are generally leaner and darker, with lower intramuscular fat (Oh et al., 2024). However, forage-based systems typically yield meat with a more favorable fatty-acid profile higher in PUFA and n-3 fatty acids offering nutritional benefits despite reduced carcass fatness (Doyle et al., 2023).

Duckett et al. (2013) found that concentrate-fed (CON) steers and forage-fed (FOR) steers performed very differently. Concentrate finishing significantly improved average daily gain (ADG) during both the initial and overall finishing phases (1.67 vs. 0.91 kg/d and 1.56 vs. 0.99 kg/d; $P < 0.01$) (Table 3). Because of this, the steers that ate concentrate had higher harvest weights (587 kg vs. 484 kg) and hot carcass weights (352 kg vs. 252 kg; $P < 0.001$). Furthermore, feedlot-finished cattle demonstrated enhanced fat deposition and marbling, as indicated by increased fat thickness (1.37 cm compared to 0.56 cm) and marbling scores (657 compared to 409; $P < 0.001$). On the other hand, forage-fed steers had a slightly higher boneless, closely trimmed retail cut yield (BCTRC) (51.6% vs. 49.6%; $P = 0.013$), which means their carcasses were leaner and had less fat under the skin. Additional compositional analysis of the rib section confirmed these performance disparities. Carcasses finished in feedlots had 9–11th rib sections that were much heavier (5.27 vs. 3.25 kg; $P < 0.001$) and had more total fat (34.2 vs. 18.3%; $P = 0.028$). Forage-finished steers, on the other hand, had a higher percentage of fat-free lean (52.6% vs. 41.0%) and bone (29.1% vs. 24.8%; $P = 0.032$) and a lower overall carcass fat content ($P = 0.028$).

In general, the findings indicate that concentrate-based diets accelerate growth and fat deposition, resulting in improved carcass marbling and higher dressing percentages. Conversely, forage-based diets produce leaner carcasses with greater retail cut yields, reflecting a clear trade-off between rapid growth and the efficient production of lean meat. Moreover, these compositional patterns suggest that feedlot diets promote greater fat accumulation, whereas pasture-based diets favor muscle and bone development. Consequently, forage-fed carcasses are typically leaner, characterized by higher nutrient density and lower energy content.

Table 3. Least squares mean for finishing treatment of carcass measures 9th to 11th rib section weight and carcass composition (Duckett et al., 2013)

Variable	CON	FOR	SED[1]	*P*-value
***ADG*, Early finishing, kg/d**	1.67^{a}	0.91^{b}	0.10	0.001
Late finishing, kg/d	1.17	1.26	0.14	0.534
Overall finishing, kg/d	1.56^{a}	0.99^{b}	0.10	0.004
Harvest wt[2], kg	587^{a}	484^{b}	7	< 0.001
HCW, kg	352^{a}	252^{b}	6	< 0.001
Dressing[2], %	62.3^{a}	54.3^{b}	0.6	< 0.001
KPH, %	2.22^{a}	1.56^{b}	0.16	0.021
Fat thickness[3], cm	1.371^{a}	0.557^{b}	0.092	0.002
Rib-eye area[3], cm2	83.3^{a}	64.9^{b}	2.5	0.004
Marbling score[4]	657^{a}	409^{b}	13	< 0.001
BCTRC[5], %	49.6^{a}	51.6^{b}	0.4	0.013
–10–11th Rib section wt, kg	5.27^{a}	3.25^{b}	0.13	< 0.001
9–10–11th Rib section composition				
Fat-free lean, %	41.0	52.6	4.8	0.085
Fat-free LM, %	20.5	26.2	2.1	0.068
Fat-free other lean, %	20.5	26.3	2.3	0.087
Total fat, %	34.2^{a}	18.3^{b}	4.3	0.028
Subcutaneous fat, %	13.5^{a}	8.6^{b}	0.3	< 0.001
Intermuscular and intramuscular fat, %	20.7	9.8	4.1	0.062
Total bone, %	24.8^{b}	29.1^{a}	1.2	0.032

[1]SED between concentrate and forage finishing treatment means. [2]Adjusted to 4% shrink in harvest weight. [3]At the 12th rib. [4]Marbling score: numerical score with 100-point subunits where Abundant90 valued 1090 and Practically Devoid00 valued 200. [5]BCTRC = boneless, closely trimmed retail cuts. [a,b] For concentrate vs. forage finishing, means in the same row with uncommon superscripts differ ($P < 0.05$).

Key determinants of eating quality

The roughage-to-concentrate ratio in finishing diets is a key management tool for improving beef eating quality because it changes how much energy and nutrients the animal gets (Rodrigues et al., 2024). Cows fed on grass produce lean, healthy meat, while those fed on concentrate produce tender, flavorful, and more expensive marbled meat (Figure 2). Increasing dietary concentrate raises energy density, which usually leads to the deposition of intramuscular fat (marbling), which makes the meat seem more tender and juicier (Abebe et al., 2024).

Recent reviews indicate that higher concentrate (grain) finishing typically enhances overall carcass fatness and intramuscular lipid content in comparison to high-roughage systems (Dos Anjos et al., 2023b). Diets high in concentrates change rumen fermentation to make more propionate, which is a glucogenic VFA pathway that provides substrates for new fat cell growth in muscle (Acciaro et al., 2025). In contrast, diets high in roughage promote the production of acetate and communities that break down fiber, which are linked to leaner carcasses and different patterns of fat deposition (Nogoy et al., 2022).

The fatty-acid profile of beef is significantly influenced by its diet; grain-finished beef generally contains higher levels of total fat and specific saturated and monounsaturated fatty acids (Nogoy et al., 2022). Finishing on pasture or with a lot of roughage changes the intramuscular fat to have more polyunsaturated and long-chain omega-3 fatty acids, which can give the meat a unique, sometimes milder, flavor (Davis et al., 2022). The changes in fatty acids affect both the nutritional value and the way people taste beef, with omega-3s and CLA often being used as signs of pasture-influenced taste (Nogoy et al., 2022). Consumer studies and beef quality reviews consistently rank flavor as the attribute with the largest influence on overall eating satisfaction, followed by tenderness and juiciness (Liu et al., 2022). Intramuscular fat enhances juiciness by incorporating meltable lipids and altering water retention and mouthfeel (Rodrigues et al., 2024). The composition of the diet also impacts post-mortem muscle biochemistry: nutrient availability and muscle energy status affect the activity of proteolytic enzymes that regulate tenderization (Abebe et al., 2024). Many studies have found that diets that help people have more energy and more muscle lipid content are linked to faster or greater post-mortem proteolysis (Abebe et al., 2024). But giving cattle a lot of concentrate can make them more likely to get subacute and acute ruminal acidosis (SARA), which is bad for their health and performance (Ogata et al., 2019).

Rumen pH instability due to sudden increases in concentrate disrupts fiber-digesting populations and may diminish feed efficiency, immune function, and carcass quality (Ogata et al., 2019) . Moderate concentrate inclusion often around 60-70% on a dry-matter basis in intensive finishing systems has been reported as a practical compromise between growth, marbling, and rumen health in recent trials (Gou et al., 2025). Feeding systems that mix early high nutrition or strategic concentrate finishing with later pasture exposure can make marbling better while keeping the good fatty acids from the pasture (Nishino et al., 2025). The color and firmness of meat can also change depending on what the animal eats.

For example, a diet high in roughage can make some muscles' oxidative metabolism work harder, which can make the meat a little darker and firmer (Sakowski et al., 2022). On the other hand, finishing with concentrate tends to boost glycolytic muscle traits, which can affect the final pH drop and tenderness (Rodrigues et al., 2024). Recent predictive models seek to estimate intramuscular fatty-acid composition based on dietary composition and plasma markers, enhancing the capacity to customize finishing rations for specific sensory outcomes (Acciaro et al., 2025). To get the best tenderness, juiciness, and flavor, practical feeding strategies combine moderate concentrate inclusion, high-quality roughage, controlled adaptation, and monitoring of rumen health (Dey et al., 2025).

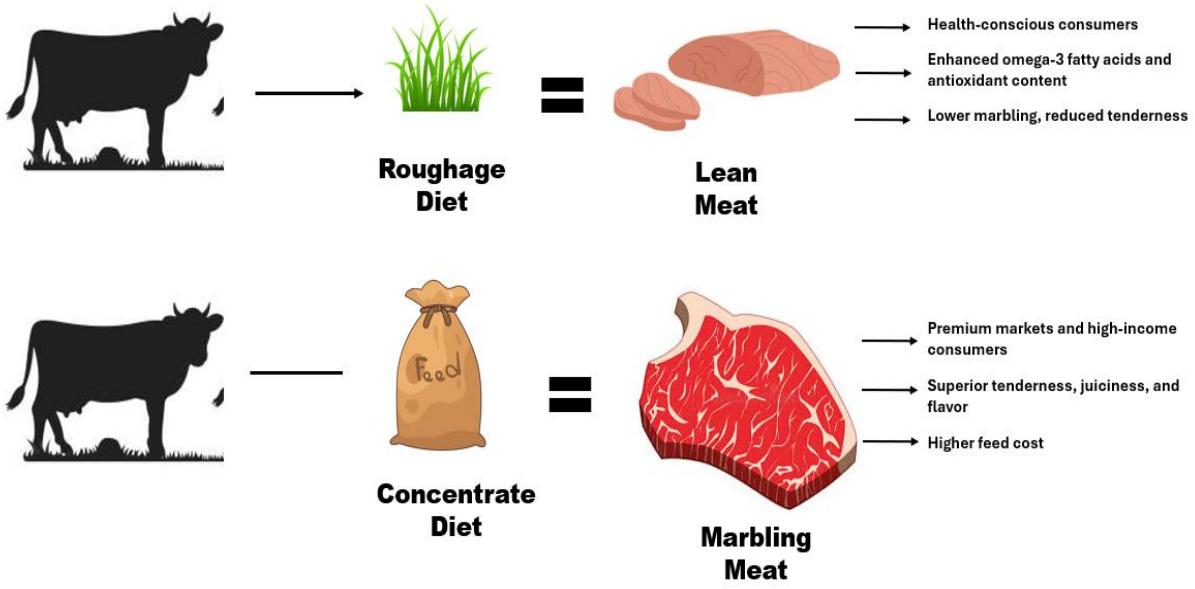

Figure 2. Dietary Influence on Lean and Marbled Beef Production.

New nutritional technologies like precision feeding, additives, and ration formulation tools are being used to get the most marbling while lowering the risk of acidosis and keeping the good fatty acids (Abebe et al., 2024). The current evidence indicates that adjusting the roughage-to-concentrate ratio is a primary, manageable factor for customizing beef tenderness, juiciness, and flavor to meet specific market and consumer demands (Rodrigues et al., 2024).

Future perspectives

Future perspectives on roughage and concentrate based feeding and their impact on beef quality stress the need for precision feeding technologies that can change the roughage to concentrate ratio in real time based on rumen fermentation metrics and animal performance indicators. Researchers will focus on sustainability by finding ways to lower methane emissions and environmental footprints while keeping or improving the tenderness, juiciness, and flavor of meat. Improvements in rumen microbiome analysis are likely to help us understand how changes in diet affect microbial communities and how these changes affect lipid metabolism and muscle proteolysis. For example, a recent study found that the rumen microbial community structure differed significantly between diets and was associated with feed-efficiency phenotypes, highlighting diet-microbiome interactions as a key driver of nutrient utilization (Ortiz-Chura et al., 2025). New metabolomic and lipidomic tools will help us figure out how the composition of feed affects intramuscular fat deposition and sensory traits.

New types of feed, such as probiotics, rumen buffers, and targeted lipid supplements, may make it possible to feed animals high-energy diets without harming their rumen health. Genetic and breed specific research will facilitate personalized feeding regimens that enhance food quality across various production systems. Adaptive feeding systems will be in line with market segmentation, giving both premium marbled and grass-fed niche beef unique flavor and nutritional profiles. In the end, future beef production will use the roughage to concentrate ratio as a changing, data driven parameter that works with precision monitoring, genetic potential, and quality prediction models to make beef that is always high quality and meets the needs of a wide range of customers (Michelena et al., 2025).

Conclusions

It is very important to find a balance between roughage and concentrate-based feeding methods in order to figure out the nutritional content, taste, and overall value of beef. In the past, people have looked at beef production in two ways: either via roughage to keep the nutrients intact or through concentrates to improve market performance. However, new data shows that this division is not helpful; for development to be sustained, both approaches need to be combined. This paradigm is being changed by a number of developments that are coming together. The growing demand for pasture-raised and grass-fed beef has made roughage-based systems more accepted outside of specialist markets. This has led to economic incentives to make the most of forage consumption instead of just maximizing concentrate use.

At the same time, environmental demands, especially the need to cut down on greenhouse gases and make sure that feed resources last, have made people more interested in how environmentally friendly feeding practices are. Improvements in feed analysis, metabolomic profiling, and rumen microbiome characterization now enable farmers to make data-driven decisions that were previously impossible. Modern cattle production should not see roughage and concentrate systems as two different ways of doing things. Instead, they should be combined into one nutritional framework. Managing forage quality, adding concentrates, and tailoring responses to each animal may all improve the quality of the meat and the value of the carcass.

In the future, precision feeding technology, microbiome research, and metabolomic profiling will make it possible to create diets that keep the rumen healthy, have less of an effect on the environment, and make sure that meat quality stays the same. By using adaptive, data-driven feeding models, producers can make sure that the market works well with nutritional and environmental sustainability, which will change the future of beef production.

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