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The Nutritional Profile Of Beef And Its Implications For Dietary Health

Abdullah Omar A Alshuqair , Yasser Ali A Almotawa , Muqbil Hamoud Muqbil Alotaibi , Thamer Sulaiman Alghofaili , Khaleel Abdulrahman Abdullah Alshamasi , Abdullah Ali Almohanna , Mohammad Salem Almaqattar , Asem Abdulaziz A Alasem , Hana Ali Hamedi Alenzi, Khalid Mahdi Bin Mohammed Refaei , Meshari Suliman Hamad, Almihbash , Wafaa Abdelsayed Abdullah Bamasoud , Bandar Saleh Ammash Almutairi , Maram Ibrahim Alnutayfi , Ahmed Hamad Tumahyi, Yahya Abdullah Tumayhi

Abstract:

Beef, a widely consumed red meat, is a significant source of essential nutrients in the human diet. This review examines the nutritional composition of beef and its potential role in promoting overall health when consumed as part of a balanced dietary regimen. The analysis considers the macronutrient profile, including protein, fat, and micronutrient content, such as iron, zinc, and vitamins. The review also explores the potential health benefits and risks associated with beef consumption, addressing factors like saturated fat, cholesterol, and the growing body of evidence regarding the relationship between red meat intake and chronic disease risk. Strategies for incorporating beef into a healthy, sustainable diet are discussed, with a focus on portion control, cooking methods, and the inclusion of lean cuts. This comprehensive assessment aims to provide a nuanced understanding of the nutritional value and dietary implications of beef, guiding health professionals and consumers in making informed choices regarding the role of red meat in a balanced, health-promoting diet.

Keywords: *Beef, red meat, nutrition, macronutrients, micronutrients, chronic disease, dietary recommendations.*

1. Introduction

Protein has nutritional, functional, and biological characteristics and is crucial for maintaining human health. An comprehensive evaluation of the quality of dietary protein encompasses the analysis of amino acid content, digestibility, rate of protein digestion, and the potential for the production of physiologically active peptides, also known as bioactive peptides (5). Animal protein, when consumed, supplies the human body with all 9 necessary amino acids. Red meat is notably a rich source of heme iron, which has more bioavailability than nonheme iron found in plants. It also contains many vitamins, including B vitamins, and minerals like copper, manganese, zinc, and iron.

Furthermore, recent studies indicate that the type of protein consumed in the diet (animal-based versus plant-based) and the nutrients it contains can have varying effects on the gut microbiota. The gut microbiota is known to play a crucial role in connecting food and the host's body, and it can either promote or protect against chronic and metabolic diseases such as cancer and cardiovascular disease. The human digestive system has a vast population of 10 trillion microorganisms, including bacteria, viruses, fungus, and protozoa.

Among them, the composition of bacteria in the intestines, referred to as the "gut microbiota," is particularly important due to its involvement in human diseases (14, 15). Microbiota differentiation, which refers to specific alterations in some bacteria or groups of microbes, disrupts gut homeostasis. Gut dysbiosis is defined by detrimental disturbances in the microbial composition (16), leading to heightened systemic inflammation due to the release of inflammatory chemicals from the gut, such as bacterial LPSs. Inflammation also exacerbates the likelihood of developing metabolic and chronic disorders, including obesity, diabetes, and cancer (14, 17).

The human digestive system has five primary bacterial phyla, namely Firmicutes, Bacteroidetes, Actinobacteria, Proteobacteria, and Verrucomicrobia. The bulk of bacteria, around 65% of the total, is composed of Firmicutes (Gram-positive) and Bacteroidetes (Gram-negative) (18). The composition of resident bacteria in the human gut differs across people due to several variables, such as the method of birth, gender, age, health condition, body weight, dietary habits, level of physical activity, and medical background, especially the use of antibiotics (19). Dietary modifications have a swift and significant impact on the composition of microorganisms in the colon, suggesting that nutrition has a greater effect on the microbiota than the genetic makeup of the host (20, 21). Multiple published research have specifically examined the microbiota's reaction to dietary carbohydrates, since these bacteria play a key role in breaking down starches that cannot be digested. In addition, human research have also examined how the microbiota responds to the amount and type of dietary fat consumed (24, 25). However, there is little knowledge on the microbiota's reaction to and breakdown of protein.

2. The relationship between protein and the microbiota

The colonic bacteria possess significant proteolytic capacity. The metabolic activity of the gut microbial population is potentially more effective than the enzymatic control of the host in the small intestine (26, 27). Within the gastrointestinal system, proteins undergo hydrolysis by peptidases, resulting in the formation of polypeptides. These polypeptides are then broken down further into sequences of amino acids, including tripeptides, dipeptides, and individual amino acids. Bacterial proteases have the ability to produce small peptides and individual amino acids that can undergo fermentation to generate short-chain fatty acids (SCFAs) such as acetate, propionate, and n-butyrate.

Additionally, they can also produce derivatives of branched-chain amino acids and branched-chain fatty acids, including isobutyrate, isovalerate, and 2-methylbutyrate (28, 29). The amino acids Arginine, Aspartic acid, Glycine, Phenylalanine, Proline, Serine, Threonine, and Tryptophan are more susceptible to bacterial digestion rather than digestion by the host organism (30). While the process of digesting and absorbing dietary protein is very effective in healthy individuals, around 10% of it ends up in the large intestine and may be used for bacterial fermentation (31, 32). The microbiology approaches that relied on early human fecal culture found Bacteroides and Propionibacterium as the two most prevalent genera with proteolytic properties (28). Additional significant genera that have been suggested include Bifidobacterium, Clostridium, and Streptococcus (28, 33).

Several variables may impact the ratio of dietary protein that reaches and undergoes digestion by bacteria in the large intestine. Nevertheless, protein bioavailability may be modified by protein alterations during cooking and interactions with other dietary components (34). Moreover, microbial enzymes use distinct cleavage sites compared to digestive enzymes, resulting in the production of dissimilar peptides with varying biological activity (35).

Recent investigations suggest that bacteria in the human digestive system may play a role in the creation of harmful substances from proteins. For example, microbial metabolism may convert l-carnitine into trimethylamine (36, 37). Consequently, the relationship between the microorganisms in the colon and the protein in our food has generated considerable attention due to its potential effects on human health. This is because the composition of the microorganisms is influenced by our diet, and the enzymes produced by these microorganisms affect the generation of bioactive chemicals derived from protein.

3. Protein obtained from beef in one's diet

Protein-derived bioactive compounds are typically small peptides with a molecular weight of less than 5 kDa. These peptides are either produced during the breakdown of proteins or are specific sequences of amino acids within the protein itself. When isolated, these compounds have a positive impact on bodily functions and may have potential health benefits beyond their nutritional value. Bioactive peptides may be created by three distinct methods: The breakdown of food occurs via three main processes: 1) digestion facilitated by digestive enzymes, 2) digestion facilitated by microbial enzymes, and 3) food processing or ripening facilitated by purified or microbial enzymes (38, 39).

Both the location of digestion and the enzyme responsible for it lead to the formation of different peptides, which in turn affects their bioactivity (35). The generation of peptides and the constraints and possibilities associated with these processes have been thoroughly examined (40). While the protein requirements are well established, with the recommended daily allowance (RDA) for protein being 0.8 grams per kilogram of body weight per day, and an intake of up to 2.5 grams per kilogram of body weight per day being considered acceptable, there are no official guidelines for protein-derived bioactive compounds. Additionally, there is limited information available regarding the specific requirements and health benefits associated with these compounds.

Peptides generated from proteins possess several bioactive characteristics such as antihypertensive, mineral-binding, antibacterial, immunomodulating, cell-modulating, anticarcinogenic, anti-inflammatory, and cholesterol-lowering effects (40, 42, 43). The significance of biologically active peptides derived from various dietary protein sources, such as milk, fish, seaweed, and soybeans, in promoting human health has been extensively researched. However, the impact of bioactive molecules found in protein-rich diets, especially beef, on human health is not as well understood (44).

The bioactive peptides and amino acids derived from muscle meat include anserine (β-Ala-1-methyl-His), carnosine (β-Ala-His), l-carnitine (β-hydroxy-γ-trimethylaminobutyric acid), glutathione (γ-Glu-Cys-Gly), and taurine (46,47). The primary dipeptides found in mammalian skeletal muscle are carnosine (β-Ala-His) and anserine (β-Ala-1-methyl-His), both of which include histidine (48). There is a scarcity of research on the presence of amino acids and peptides in beef, and the existing ones provide inadequate information and conflicting results. A single research on beef (49) has been conducted to analyze the presence of all amino acids, both proteinogenic and nonproteinogenic, as well as short peptides. The study found that glutamine is the most prevalent amino acid in beef, followed by taurine, alanine, glutamate, and β-alanine (50). After death, proteins undergo breakdown, leading to the formation of pieces called polypeptides. These polypeptides may be broken down even further by peptidyl peptidases and aminopeptidases, resulting in the synthesis of smaller peptides and individual amino acids (51). The levels of these biologically active dipeptides are reduced in cooked beef flesh relative to fresh muscle; yet, cooked beef remains a significant provider of carnosine and anserine (52).

Animal flesh is a comprehensive and balanced source of dietary protein, including all the necessary amino acids. It also provides vital fatty acids, vitamins, and minerals (53). Moreover, animal protein stimulates feelings of fullness and increases the amount of energy used and fat lost in comparison to plant proteins (54). Observational studies have identified red meat intake as a risk factor for cardiovascular disease and other metabolic illnesses, including type 2 diabetes mellitus. However, new research suggests that this association may be limited to the consumption of processed red meat (3). Regardless of the contentious health results, most of the research included in this review focused on the effects of consuming excessive amounts of beef within a diet that is rich in fat or sugar. This particular dietary pattern, commonly referred to as the Western diet or standard American diet, is linked to a higher risk of chronic noncommunicable diseases (55). It is characterized by a significant consumption of refined and processed foods, such as processed meats, added sugars, and fats, while having a low intake of fruits, vegetables, and whole grains. Moreover, a recent clinical study revealed that ultraprocessed foods contribute to weight gain regardless of calorie intake, emphasizing the importance of further examining the link between unprocessed and processed red meat and the risk of chronic diseases (56). This investigation should particularly focus on understanding the role of gut microbiota and related metabolites in mediating the effects of lean beef or beef proteins.

When consumed with a diet that is rich in fat or sugar, beef protein may have negative effects on health, the composition of microbes in the body, and the integrity of the intestinal barrier. This is in contrast to casein or white meat protein. For instance, beef protein can lead to an increase in the abundance of Proteobacteria, which is linked to an imbalance in the microbial ecosystem (dysbiosis). Nevertheless, alterations in the bacterial makeup due to the use of high-fat + beef and high-sucrose + beef diets are similar to those seen in animal studies using Westernized diets. These changes include a rise in Desulfovibrionaceae and a reduction in Lactobacillaceae (57,58). Notably, changes in the abundance of Bacteroidetes, Firmicutes, and Proteobacteria caused by a high-fat diet are not associated to obesity. This suggests that the content of the diet, especially the amount of fat, has a role in the response of the microbial community. In addition, no notable disparities were seen in the serum markers of well-being or microbial composition when different protein sources (beef, casein, soy) were ingested with a low-fat diet (59).

Gram-negative bacteria, such as Bacteroidetes, secrete lipopolysaccharide (LPS), which is an endotoxin. LPS may cause systemic inflammation and metabolic endotoxemia by increasing the production of proinflammatory cytokines if it enters the bloodstream from the colon. Several animal investigations have shown a reduction in the relative abundance of Bacteroidetes when animals were fed a beef diet, as compared to a nonpurified diet (57) or a casein diet (10, 58). Furthermore, the levels of LPS-binding protein, which serves as a marker for disruption to the intestinal barrier, were shown to be the greatest in the casein group compared to the other low-fat groups (60). Thus, it is possible that high-fat diets may have a more significant negative effect on the microbial composition compared to dietary protein sources.

Animal studies have shown that eating beef leads to an increase in the relative abundance of Firmicutes (10, 57, 58), while simultaneously reducing the presence of Bacteroidetes (10, 57). To put it simply, red meat consumption may lead to an increase in the Firmicutes/Bacteroidetes ratio, a factor that is often linked to higher BMI in humans (61). The few human studies we found in our literature search had inconsistent results, with contradicting changes in the relative abundance of Firmicutes being reported (62, 63). Moreover, human subjects that were fed a high-beef diet (380 g/d) showed significant elevations in Bacteroides, which is a species belonging to the Bacteroidetes phylum (64).

The 2015-2020 Dietary Guidelines for Americans suggest consuming 26 ounces per week (737 grams per week), or around 3.71 ounces per day (105 grams per day), of protein sources such as meats, poultry, and eggs. Given that 1 ounce (28.35 grams) of meat contains approximately 7 grams of protein, this means that consuming this food type would provide around 26 grams of protein per day. However, protein requirements can differ depending on individual needs, so it is possible to consume more protein from this food group to meet higher protein recommendations based on body weight, such as 2.5 grams per kilogram per day. The disparity between recommended protein quantities and those employed in human research highlights the need of assessing the influence of protein quality and quantity on the human microbiota, particularly in individuals with high protein consumption, such as athletes (65).

The nutritional, functional, and biological characteristics and digestibility of protein are influenced by food processing, preparation, and storage. Studies conducted on human fecal batch cultures in a laboratory setting demonstrate that both the kind of meat and the way of cooking have an influence on the composition of microorganisms present (66). Furthermore, consuming excessive amounts of beef can lead to negative effects that are specifically linked to cooking at high temperatures. This can cause the formation of polycyclic aromatic hydrocarbons and heterocyclic amines, as well as the production of N-nitroso compounds by microbes or the presence of the nonhuman sialic acid N-glycolylneuraminic acid (68).

Furthermore, the precise processes connecting beef consumption with the onset of chronic noncommunicable illnesses are not well comprehended, although they may be associated with micronutrients such as iron and zinc, which have been shown to affect microbial composition (63). Ultimately, excessive consumption of beef, particularly in the context of a diet that is already heavy in sugar or fat, has detrimental effects on the gut flora.

4. Conclusion

Human studies show that there are only little changes in the composition of gut bacteria when people consume beef for a short period of time (1-4 weeks). Further investigation is required to: 1) clarify the alterations in the microbiota caused by the consumption of beef, both in recommended quantities and excessive amounts as per dietary guidelines, and in conjunction with other nutrients; 2) carry out metabolomics studies related to the microbiome to comprehend the relationship between changes in microbiota and the physiological state of the host; 3) Explore the function of bioactive chemicals obtained from beef in relation to different diets; 4) Assess if other nutrients, including complex carbohydrates, might mitigate some adverse impacts of increasing beef intake within high-fat and/or high-sucrose diets; 5) Determine changes in short-chain fatty acid (SCFA) synthesis associated with beef intake; and 6) devise more efficient and suitable methods to investigate microbial breakdown of dietary protein, including beef.

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