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REVIEW

Rethinking Meat in Our Diet: The Case Against Its Role in Health

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ABSTRACT

Meat is a rich source of essential nutrients, including high-quality protein, bioavailable iron, zinc, and vitamin B12—nutrients often limited in plant-based diets. However, growing concerns surround the health impacts of meat consumption, particularly industrially processed meats that contain preservatives such as nitrates, nitrites, and high levels of sodium. These compounds have been associated with increased risks of hypertension, colorectal cancer, and other chronic diseases. In contrast, traditional processing methods like fermentation may enhance meat's nutritional value by promoting beneficial microbiota and producing bioactive compounds with potential health benefits. The role of saturated fatty acids (SFAs) in meat remains controversial. While historically linked to cardiovascular disease and type 2 diabetes, recent meta-analyses suggest inconsistent associations, challenging the assumption of a direct causal relationship. These findings point to the importance of considering the broader dietary context, food matrix interactions, and lifestyle factors. This narrative review critically examines current evidence on the health effects of meat consumption, with a focus on saturated fat content, processing techniques, and dietary patterns. Considerable heterogeneity exists across studies, partly due to variations in methodology, population demographics, and confounding variables such as cooking methods and food combinations. The review identifies key research gaps and underscores the need for well-controlled studies that consider these contextual factors. Ultimately, a nuanced understanding of meat's role in human health is essential for developing balanced dietary recommendations. Future research should aim to refine public health guidance by integrating insights from nutritional science, food technology, and epidemiology.

Keywords: Cancer; Cardiovascular Disease; Food Matrix; Human Health; Meat; Nutrients; Recent Meta-Analyses

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1. Introduction

Because it includes all of the required amino acids as well as several minerals and vitamins, meat is an excellent source of protein [1]. More than half of meat's fat is usually saturated fatty acids, and meat contains roughly half of the maximum amount of saturated fatty acids that are advised, while there are minor variations based on the animal's species, nutrition, and age [2,3]. In recent years, the high contribution of saturated fatty acids has drawn several large observational studies have identified favorable links between a high intake of red and processed meat and the risk of cardiovascular disease, cancer, all-cause mortality, and type 2 diabetes [4]. In order to reduce the risk of death and disease, dietary guidelines have advised limiting the consumption of saturated fatty acids to less than 10% of total dietary energy throughout the past 30 years [5,6]. Though they vary in composition with respect to particular saturated fatty acids, saturated fatty acids are present in a wide variety of meals. Additionally, the structure and nutrient content of these foods vary, which results in varying physiological impacts. The various effects of saturated fatty acids from various sources are not taken into consideration by the recent suggestions to reduce saturated fatty acid intake [4].

According to heterogeneity and risk-of-bias analyses, confounders may be the cause of meta-analyses of observational research revealed a relationship between red and processed meat and an increased risk of illness [4]. This highlights the importance of using caution when extending findings from observational research to evaluate the health effects of meat in populations with widely divergent food cultures. The overall makeup of the diet and the matrix from the meals are likely to influence or perhaps create the reported deleterious effects, according to mounting research, rather than the individual nutrients in meat alone having any effect. The caliber of the research and the inclusion of factors related to the various culinary cultures around meat consumption are probably also important. When examining meat and disease, a variety of factors, including cooking techniques, fiber, and calcium, are probably powerful effect modulators. This could also include probiotic metabolites from meat fermentation, which may have unknown physiological and biological consequences.

This study aims to critically evaluate the scientific evidence regarding the health impacts of meat consumption, focusing specifically on meat consumption, saturated fatty acids, processing techniques, and overall dietary context. It also seeks to identify existing research gaps to support the development of more precise and context-sensitive dietary recommendations.

2. Methodology

Relevant peer-reviewed articles were identified through searches in **PubMed**, **Scopus**, **Web of Science**, and **Google Scholar** using keywords such as *Cancer*, *Cardiovascular disease*, *Food matrix*, *Health outcomes*, *Meat consumption*, *Nutrients*, and *Recent meta-analyses*. Studies published between **1998 and 2025** that focused on human subjects, examined the health impacts of meat intake, and addressed dietary context or processing methods were included. Non-peer-reviewed studies, animal studies (except those involving rat models), and irrelevant research were excluded.

3. Food matrix, Meat processing, and Consumption

3.1. Understanding, Challenges, and Research Gaps in Food Matrix

The chemical bonds, to one another make up the food matrix [7]. Rarely are nutrients found in their free state; instead, they are embedded in granules, bigger molecules, or particular compartments. This interaction with other food ingredients influences how nutrients are released from the meal, which in turn impacts how accessible and bioavailable a particular nutrient is [4]. In other words, the food matrix and the interactions between nutrients and host-related variables influence the amount absorbed, not the total amount of a nutrient consumed. The gastrointestinal tract's ability to digest and absorb nutrients is directly impacted by the food matrix.

The most well-known examples of food matrix effects in plant foods are probably the phytate-mineral interactions, where minerals are firmly bound to phytate and only released when the phytate is broken down (by soaking or fermentation), and the carotenoids, which are released from plant cells by chopping or slicing vegetables [8], by being dissolved into lipids in the food matrix, and by a number of other factors [9]. The amount absorbed actually differs across foods.

The absorption of carcinogens, such as dietary mutagens from fried meat, onto chlorophyll is another fascinating example; it has been demonstrated that aflatoxin B1's absorption is powerful enough to lessen DNA damage in humans [4]. The significance of consuming a diversified food matrix that includes fresh greens and meals high in protein is further highlighted by this observation. When it comes to meat, cooking lowers the quantity of peptides, vitamins, and fat while raising the concentration of some minerals, such as zinc and iron (especially in beef), but it has no discernible effect on calcium and magnesium [4].

Consuming more prebiotics enhances the absorption of heme-iron from beef [10], and red meat is a better source of iron because heme-iron is better absorbed than non-heme-iron [11]. This shows that other techniques, like fermenting meat or fortifying it with inulin, might also make iron and perhaps other minerals more accessible. The bio-accessibility of nutrients and non-nutritive compounds may be increased or decreased by food preparation techniques including heating, chopping, or fermentation, depending on the content of the meal.

Although food matrix effects are significant, bio-accessibility and bioavailability are also influenced by meal composition and interactions between foods. One example is the "meat factor," whatever that is [12]. The meat component facilitates the absorption of non-heme iron from the plant products in meals that include both vegetables and meat [13].

3.2. Identifying At-Risk Groups for Low Meat Micronutrient Intake

A number of groups are susceptible to deficiencies in one or more micronutrients: mainly because of age-adapted lifestyles and illnesses, and in elderly people, physiological issues (with the exception of iron and vitamin B12 uptake due to stomach mucosal atrophy) cause less vitamin A, D, E, folate, iron, and calcium absorption.

Due to increased demands, pregnant women are at risk for vitamin D, folic acid, zinc, and iron deficiencies [14], particularly if they forego meat, as is frequently the case. To prevent severe birth abnormalities, supplements are advised, particularly for folic acid. According to Schulz et al. [15], vitamin A insufficiency appears to be a risk factor for women who have twins or give birth frequently.

Vegans run the danger of lacking some micronutrients, such as vitamin B12, riboflavin, and selenium, which are only present in foods produced from animals. In some cases, even taking supplements of these nutrients is insufficient [16].

Micronutrient deficits may clearly be a problem for people on weight loss diets, however the findings of several research provide only shaky scientific support for this. Nonetheless, during the diet, the amounts of important fatty acids, iron, magnesium, zinc, and fat-soluble vitamins should be regulated. According to a recent meta-analysis, diets high in protein and low in carbs but low in fat had a greater effect on weight loss than diets low in fat and protein but high in carbs [17]. The weight reduction was attributed to increased energy expenditure, improved satiety, and a larger decrease of fat cell mass.

Elderly people who are institutionalized or hospitalized are also at danger since the incidence of malnutrition is linked to the degree of illness, functional impairments, and mental health. Numerous micronutrients are affected by this shortage, including selenium, vitamins B1, B6, folate, B12, C, D, and E, as well as important fatty acids [18]. Above important, because thiamine and folate are linked to depression, dementia, and cognitive impairment, they should be within a normal range [19].

Due to decreased appetite, decreased upper gastrointestinal tract motility, poor bioavailability, and metabolic interference, long-term medication use can also result in nutritional deficiencies. This normally only becomes important, though, when vulnerable individuals are given high doses of a particular medicine over an extended period of time.

3.3. Meat as Key Nutrient Source

3.3.1. Fatty Acids

Because red meat's fat comprises about 40% saturated fatty acids, 50% monounsaturated fatty acids, 5% trans fatty acids, and 4% polyunsaturated fatty acids, meat is typically thought of as a primary source of saturated fat [20]. Prior observational research has linked saturated fat to an increased risk of cardiovascular disease and diabetes; however, more recent research suggests that industrial transfats in margarines likely confused this association. Numerous effective methods for modifying the fatty acid composition of beef and pork through deliberate feeding techniques have been developed as a result of attempts to lower saturated fatty acid in meat [21].

In Due to fermentation and biohydrogenation in the rumen, the fatty acid content of ruminant (cattle) flesh reflects the diet composition to a lower extent than that of monogastric animals (pigs, for example). Even though feeding techniques can give beef and pork a more unsaturated fatty acid profile, adding more unsaturated fat frequently degrades the quality of the meat because it is more likely to oxidize and has a less firm structure [21], which leads to meat products that consumers find unacceptable [22].

However, when discussing fat in meat, it is frequently forgotten that meat from ruminants also contains conjugated linoleic acid and special fatty acids derived from the rumen, such as vaccenic, branched-chain, and rumenic acids, which have been linked to a number of beneficial health effects due to their physiological activities [23]. Early research on animals showed positive results. Nevertheless, some Cochrane-based meta-analyses show that ruminant fats had an overall, human intervention trials had a neutral effect on health [4], despite the fact that these ruminant fatty acids are trans-fats that may also have negative consequences.

3.3.2. Amino Acids

With Meat provides us with amino acids, which have an ideal composition for supporting protein synthesis for muscle growth and maintenance, since it is compositionally identical to human skeletal muscle. Skeletal muscle mass must be supported and maintained in order to preserve both metabolic health and physical function. Accordingly, meat is a crucial component of an older person's diet in order to prevent sarcopenia, or age-related deterioration of muscle strength. Therefore, in a cohort of 1822 older people followed for 2–4 years, there was an inverse relationship between the frequency of frailty and the consumption of animal protein [24].

Recent research has shown that consuming animal protein directly improves muscular strength and body composition in younger, physically active people [25]. Although the amount of essential amino acids is frequently used to assess the quality of proteins, the bio-accessibility and bioavailability of amino acids also play a crucial role in determining the nutritional value of proteins. The Digestible Indispensable Amino Acid Score value of 97 is for raw meat, whereas the Digestible Indispensable Amino Acid Score values of 99 and 98 are for boiling and pan-roasted beef, respectively, according to Hodgkinson and colleagues. The Digestible Indispensable Amino Acid Score drops to 80 and 91 in grilled and roasted beef, respectively [26]. Seniors who consume well-cooked meat (cooked at 90°C for 30 minutes) have higher bioavailability of amino acids than those who consume raw meat (cooked at 55°C for 5 minutes), according to a sophisticated isotope-labelling study [27]. This suggests that cooking meat allows for strategic modulation of bioavailability.

Although meat is a major source of necessary amino acids, it also contains peptides with significant bioactive qualities, amino acids, and metabolites generated from amino acids. Therefore, it has been suggested that taurine, creatine, hydroxyproline, carnosine, and anserine—all of which are mostly found in meat—perform significant physiological roles [28]. The microbiota ferments amino acids into compounds that may have both beneficial and detrimental effects on health; this fermentation occurs particularly in the absence of other substrates. Thus, the gut environment is significantly influenced by the makeup of meals and the diet. Diets strong in protein but deficient in dietary fiber, dairy, and other potentially beneficial components may cause a systemic and local pro-inflammatory response, increasing the risk of disease. According to an intervention study that compared Mediterranean diets to traditional diets high in meat and low in dietary fiber, introducing a diverse diet with dietary fiber resulted in a decrease in harmful amino acid metabolites in blood, urine, and stool [29].

3.3.3. Minerals and Vitamins

Meat provides us with minerals and vitamins in addition to proteins. For example, Based on the reference values of various groups, the average daily consumption of 189 g among British adults contributes roughly Zinc, phosphorus, selenium, and Iron account for 52, 38, 28, and 19%, respectively [4]. Diets deficient in animal-based foods make it difficult to receive adequate zinc. While iron can be found in many different meals, its bioavailability is highest when it comes from meat because iron is complexed and found in meat as heme-iron, which has a far higher bioavailability than non-heme-iron. Consequently, since the small intestine absorbs roughly 23% of heme-iron and just 2–8% of non-heme iron [30], red meat remains the best dietary source of iron [11]. Apart from the increased heme-iron availability, meat also contains other, as-yet-undiscovered, substances that increase the absorption of iron from other diets (referred to as the "meat factor") [4]. Meat is a significant source of complex B vitamins, according to vitamin research.

In reality, the only unfermented foods that naturally contain vitamin B12 are meat, fish, and other foods produced from animals (including dairy). Meat and meat products account for about 30% of the total amount of vitamin B12 consumed in the UK [3]. All of this emphasizes the need of considering the significant impact that switching to a vegan diet from a balanced omnivorous diet may have on vitamin and mineral status.

3.4. Processed and Fresh Meat

It is challenging to understand and compare data since the definition of processed meat is variable and differs between countries and studies, even though it is clearly defined in EU law [31]. Meat that has been salted, cured, smoked, or dried is generally accepted to be considered processed meat in cohort studies. However, other studies define red meat as processed meat or certain processed meats, such bacon. This makes it hard to determine whether the observed health consequences are caused by the processing or by meat itself. Industrially produced, cured, and/or smoked meat products are frequently referred to as processed meat. Frying and grilling are common processing methods used in private homes and the catering sector to get the finished, ready-to-eat product. Fried meat can increase the amount of carcinogenic chemicals in meat, despite the fact that it is not equivalent to industrially processed meat.

3.4.1. Industrial Meat Processing

Three basic meat preservation techniques that were discovered in antiquity—drying, curing, and smoking—are the foundation for the industrial manufacture of processed meat products [4]. There is evidence that hanging meat free to allow for ventilation and to remove moisture from the surface reduces water activity, which in turn stops the growth of spoilage bacteria on the meat. Curing meat by rubbing it with salt has been done for over 5000 years. Because the salt contains nitrate, the meat's shelf life was extended by both the salt and the nitrite that was produced when nitrate was reduced.

By decreasing water activity and through nitrite's direct antibacterial action, salt and nitrite permeate the meat's core and increase its shelf life. It may have been found that smoking meat produces a different flavor in addition to a longer shelf life when it is dried over a wooden fire. Smoke has a beneficial effect on shelf life because it contains a variety of substances that stop lipid oxidation and bacterial growth. Together with heat treatment, these three basic preservation techniques—drying, curing, and smoking—have developed throughout time into the various methods currently employed in the meat business to create and improve the durability of a wide range of meat products. Adding antioxidants like ascorbic acid and its salts is a more recent way of meat preservation. However, rather than focusing on a health consequence, the legislation governing this technology is more broadly defined by restricting the water activity [32].

Almost all processed beef products undergo curing, which entails the addition of salt and, typically, nitrite or nitrate. Based on their individual procedures, cured beef products can be broadly classified into two classes [33].

3.4.2. Wet Curing

When wet curing whole items, like cooked bacon and ham or loin, brines including salt, nitrite, ascorbate, and frequently phosphates are injected using a needle. The product is cooked, sometimes smoked, and physically treated (tumbling) to speed up the diffusion of salt. Bacon is an exception; it is smoked, mildly heated, and/or dried for a brief period of time [34]. This also includes so-called enhanced meat, which is sold as "fresh" meat but has additional salt-containing water added; however, the consumer does the cooking. Wet-cured items, such as cooked sausages, are made by combining minced meat with salt and nitrite, adding water, spices, and ascorbate, then filling the casings and cooking (or smoking, if desired). Typical items include frankfurters, mortadella, and wieners.

3.4.3. Dry Curing

Salt is applied to the surface of whole pieces of meat during the dry curing process, usually in conjunction with nitrite and/or nitrate. Before the product is fit for eating, it must go through a drying and ripening period that can last anywhere from a few months to years after the salting procedure. Spanish Iberico and Italian Parma hams are typical items. Minced beef is combined with salt, then allowed to dry and ferment to create fermented sausages. These goods are also smoked, particularly in northern Europe, and spiced and bacterial starter cultures are added to help with the fermentation process. Fermented sausages are typically prepared in the United States and have a restricted drying procedure [34].

3.5. Enhancement of Meat Products

Fortifying processed meat products with substances that may offset or mitigate such detrimental health consequences is one strategy used to counteract possibly deleterious effects linked to eating processed meat. Dietary fiber consumption is linked to positive benefits on gut health, according to a wealth of research. Recent research using a rat model demonstrated that adding inulin to pork sausages had a major impact on the metabolites produced by the gut microbiota in the gastrointestinal tract [35]. Therefore, adding inulin to processed beef increased the production of acetate, propionate, and butyrate—three distinct short-chain fatty acids that have been found to be essential for the positive benefits of eating dietary fiber [4]. Perez-Burillo and associates also demonstrated in a human intervention research that adding dietary fiber to salami, a fermented meat product, increased the production of butyrate when consumed [36]. Additionally, it has been demonstrated that consuming butyrylated starch increases the gut's short-chain fatty acid content and inhibits the production of undesirable O6-methyl-2-deoxyguanosine adducts, a process known as toxic and mutagenic modification, which has been linked to a high consumption of red meat [37]. According to what is now known, short-chain fatty acid-containing substances and fermentable dietary fibers can mitigate the possible negative effects of eating processed meat on the colon. Although little research has been done on fermentable dietary fiber, studies using animal models have shown that it may likewise be very effective in preventing cancer [38].

Interestingly, cohort studies also suggest that colon health benefits from a high calcium diet [4]. Recently, Thøgersen and colleagues examined the impact of supplementing processed beef with either calcium and inulin alone or in combination using a rat model [35]. Remarkably, when compared to consuming unfortified processed meat, the addition of calcium-rich milk minerals dramatically decreased the production of undesirable N-nitroso compounds in the gastrointestinal tract and increased the production of short-chain fatty acids in the colon [35]. Therefore, encouraging findings show that possible negative effects of eating meat can actually be reduced by altering the matrix of meat products, fortifying meat products, or strategically planning meals to include elements like calcium and dietary fiber that counteract any unintended effects of eating meat in the gastrointestinal tract.

4. Fermentation and Maturation

Around the world, a sizable portion of meat is consumed following maturation processes including as dry-aging, dry-fermenting, and dry-curing. Although the original purpose of these procedures was to preserve meat, they are today used to create a wide range of incredibly tasty goods. The ripening process hydrolyzes some ingredients, like proteins and lipids, which leads to the synthesis and release of low molecular weight molecules, both volatile and non-volatile, that give these items their unique and intense flavor [39].

These kinds of meat products vary greatly throughout the world, but they all have some characteristics in common that are noteworthy for their possible health effects: They include: (1) a significant amount of dehydration, which can cause some products to lose up to 50% of their weight; (2) many a significant amount of chemical and biochemical transformation of meat components, including protein and lipid oxidation, protein and lipid hydrolysis, and Maillard type reactions as the most relevant ones; (3) the addition of nitrates and/or nitrites and sodium chloride; and (4) numerous microbial transformations by various mold, bacteria, and yeast species. Proteolysis, lipolysis, nitrosomyoglobin production, acidity, and taste formation are some of the main roles of these bacteria. Although the goal of all these modifications is to create a tasty, shelf-stable product with a specific chewy yet delicate texture, the nutritional and health effects may also be greatly impacted as a result. First of all, dehydration causes a noticeable increase in nutrient density, which means that meat products prepared in this manner include more of the elements that meat is rich in, including iron, zinc, proteins, niacin, pyridoxine, or cobalamin. However, during the ripening process, some substances with health benefits, such as ubiquinone (coenzyme Q10), tend to diminish or even vanish [40].

Second, microbial and endogenous proteases cause considerable proteolysis during maturation, which results in high quantities of free amino acids and peptides with significant molecular weight variations [41]. A higher anabolic potential for foods high in protein has occasionally been associated with this, as it results in faster rates of amino acid uptake during digestion (additional compared to standard cooking) [42]. Furthermore, some of these recently produced peptides exhibit bioactive qualities, primarily antihypertensive and antioxidative effects in rats with hypertension [43]. Longer stomach emptying and greater satiety have also been shown in human investigations [44]. It is commonly recognized that peptides with bioactive qualities are released during the digestion of animal protein. These proteolytic activities occur during the ripening phase of aged meat products, therefore these peptides are already present in the product prior to human digestion. The kind, quantity, and number of bioactive peptides produced in these ripened meat products are significantly influenced by the degree of proteolysis, the kind of enzymes used, and the raw material. Therefore, compared to dry-cured hams cooked for shorter periods of time, 24-month ripened Iberian ham has been demonstrated to have larger amounts of highly active angiotensin-converting enzyme inhibitory activity [45]. The amount, type, and activity of these bioactive peptides in fermented goods have been connected to the type of starter culture [46], and they have also been detected in aged duck, aged beef, and dry-fermented sausages [4]. Research on the impact of antihypertensive peptides on human blood pressure is currently lacking, however it has been hypothesized that their presence could mitigate the effect of their high salt content. Other possible health benefits, including the control of bile acid metabolism and increased satiety, have been associated with the ingestion of hydrolyzed proteins [4]. Indeed, it has been demonstrated that meat hydrolysates enhance the release of cholecystokinin [47], a peptide hormone in the intestines that encourages fullness. Smaller, less frequent meals might follow, which would ultimately lead to a reduction in caloric intake.

Lactic acid bacteria are commonly utilized as starting cultures for fermented meat products because of their distinct biochemical activities, which include lactic acid creation, pH drop, flavor generation, and bio-protective actions [48]. Actually, some commercial starter strains and certain native isolates from dry sausages have shown probiotic qualities. The original process of making dry-fermented items entailed using naturally occurring lactic acid bacteria to ferment additional sugars. Additionally, these products offer the circumstances required for probiotic survival because they are not heat-treated, and it seems that the meat product matrix may help bacteria survive through the gastrointestinal tract [49]. Additionally, a lot of work has gone into selecting and using probiotic bacteria that are appropriate for the difficult conditions of dry-fermented sausages, like high salt, low aw, low pH, low sugar content, nitrites, etc. Most naturally occurring lactic acid bacteria in sausages are highly hydrophobic species, which are typically associated with probiotic potential. Probiotics include, for instance, strains of L. curvatus, Lactobacillus sakei, L. plantarum, L. brevis, L. fermentum, L. lactis, L. pentosus, Pediococcus acidilactici, or P. pentosaceus that have been isolated from commercial fermented sausages from Scandinavia, Greece, Spain, or other countries [50]. The dry sausage environment makes it difficult for other kinds of additional probiotic bacteria to survive.

Negative aspects include the high salt level and nitrites found in these meat products, which have been identified as possible causes of colorectal cancer and hypertension, respectively. The possibility that antihypertensive peptides could reverse their impact on blood pressure in people is still up for debate. Furthermore, during the past few decades, processed meat products in the UK have gradually reduced their salt content [51]. Further progress in this direction seems potentially troublesome because salt alternatives, such as calcium and potassium salts, tend to impart a disagreeable taste, and lower levels may indicate microbiological dangers and textural flaws [51]. In terms of cured products, nitrites have a critical function in stabilizing color, encouraging the development of a distinctive flavor, and regulating microbiological growth, particularly that of Clostridium botulinum [52]. However, their presence in food may cause the production of N-nitrosamines, which are carcinogenic. Although this has been demonstrated experimentally, non-heated goods like dry-cured and dry-fermented sausages have very low or even undetectable quantities of these chemicals. Furthermore, these products' frequent use of high ascorbic acid levels significantly reduces the production of these dangerous substances [51].

5. Meat and Chronic Illness

The majority of research on how eating meat affects health outcomes, such cancer and cardiovascular disease, is observational because of the length of intervention studies required to measure chronic disease endpoints. Because of the large number of research, many organizations have regularly carried out systematic reviews and meta-analyses. Nonetheless, there are differing opinions, making the matter contentious.

5.1. Cardiovascular Disease, Chronic Illness, and Meat

Händel and collaborators have out a thorough review on the associations between processed meat consumption and the morbidity and mortality of chronic illnesses [53]. Because of a high risk of bias and imprecision, the overall certainty in the evidence was very low across all individual outcomes, and the quality of the systematic reviews demonstrating positive associations between processed meat intake and the risk of other cancers and cancer mortality, type 2 diabetes and cardiovascular disease, and cardiovascular disease mortality was moderate. Cohort study results were less likely to indicate a positive relationship than the frequently more biased case-control study results.

Consuming red meat (relative risk 1.14 per 100 g/day; 95% CI: 1.02, 1.28) and processed meat (relative risk 1.12 per 50 g/day; 95% CI: 1.00, 1.26) was positively associated with hypertension, according to Schwingshackl and colleagues' systematic review and linear dose-response meta-analysis of prospective studies [54]. However, the authors come to the conclusion that the meta-evidence for the connection in the included studies was of low quality overall.

In their thorough review of prospective cohort and case-control studies, Lippi and colleagues were unable to identify a substantial association between red meat consumption and ischemic heart disease because of the broad range of criteria used to define red meat and diagnose the condition [55].

According to a recent systematic review and meta-analysis, there is a positive correlation between processed meat intake (relative risk 1.23 per 50 g/day; 95% CI: 1.07–1.41) and heart failure risk, but no correlation between the highest and lowest red meat intake (relative risk 1.04; 95% CI: 0.96–1.12) [56]. Regretfully, there was no grading system for the included studies' quality. Subgroup studies revealed that whereas Americans did not have a significant correlation between processed meat consumption and heart failure, Europeans did (relative risk 1.33 per 50 g/day, 95% CI = 1.15–1.54). In either continent, there was no correlation between red meat consumption and the risk of heart failure [56].

Neuenschwander and associates found in a comprehensive review of prospective cohort studies that the risk of type 2 diabetes was positively correlated with dose-response studies of intake of processed red meat (hazard ratio 1.44; 95% CI: 1.18–1.76), processed meat (hazard ratio 1.37; 95% CI: 1.22–1.54), and bacon (hazard ratio 2.07; 95% CI: 1.40–3.05) [57]. The hazard ratio for unprocessed red meat was 1.11, with a 95% confidence interval of 0.97 to 1.28. The methodological quality of the meta-analyses was generally strong, although the quality of the evidence for processed and unprocessed red meat was intermediate, while the quality of the evidence for bacon and processed meat was high.

5.2. Cancer and Meat

The overall conclusion was rated as sufficient for processed meat and probable for red meat, despite the fact that the continuous update project on the risks of colorectal cancer evaluated the evidence for a link between intake of red and processed meat as strong [58]. The analysis was based on the following criteria: substantial dose-response, no small-study bias, reasonable mechanisms, and overall moderate heterogeneity of the included studies.

This might have been brought on by geographical variations, with notable impacts seen in Europe but not in the Americas or Asia, and published meta-analyses that failed to demonstrate a substantial overall effect. Similar results in a number of recent meta-analyses support these conclusions [4]. Some meta-analyses, however, indicate comparable magnitudes and trends, but they come to the conclusion that the evidence supporting the cancer-causing effect is weak and likely to be influenced by high heterogeneity and confounders [4]. Several factors have been highlighted as potential confounders, including geographic variances, interactions with other dietary factors, and uncertainty around the classification of meat into red and processed meat. There is undoubtedly some scientific disagreement regarding the technical evaluation of the quality of the evidence and the impact of lower intakes on the risk of colorectal cancer, even though official recommendations in the majority of countries support reductions in red and processed meat intake based on the findings of international organizations. Enhanced indicators of red and processed meat consumption and biomarkers associated with their possible mechanisms of action may help rectify some of this by eliminating potential confounding variables [59,60].

5.3. Analysis of Observational Research

The validity of the data in meta-analyses is dependent on the quality of each individual study. The validity and interpretation of the results are significantly impacted by variations in serving sizes between nations as well as variations in the classification of which products belong in the meat and processed meat categories (and which should be excluded) [61]. The features, medical history, and overall nutritional intake of the study participants are equally significant; these factors impact the results but are nearly impossible to completely eliminate despite a number of statistical models.

Although the direction of the effect for colon cancer is very constant, the overall assessment has been reduced due to methodological difficulties and the inadequate observational evidence for the effects of red meat on chronic disease. The most significant consequence of the diverse group of processed meats is colorectal cancer, for which there is moderate-to-strong evidence of negative effects across a number of endpoints. There are disagreements among scientists about how consistent the data is for the majority of endpoints. Some of this dispute is likely to be resolved with improved knowledge and resources, such as biomarkers to allow reliable intake assessments [4,59], differentiation between various processed meat groups, and evaluation of pathways in cancer development. The next part discusses the possible mechanistic and nutritional confounders.

6. Confounders and Co-Factors Are Important

It is crucial to understand which items are substituted for meat in the reduced-meat diet when comparing groups with high and low meat intakes in order to assess relationships between meat intake and disease risk. A diet high in sugar and alcohol and low in fruits, vegetables, whole grains, and dietary fiber does not necessarily result from eating a lot of meat [62]. An analysis of dietary patterns in adult Danes revealed that the 25% of the population with the highest reported meat intake and an unhealthy diet (the highest quartile) consumes approximately 20% more red meat than the 25% of the population with the highest meat content and a healthy diet (144 g/10 MJ versus 121 g/10 MJ) [63].

The disparity is considerably greater for processed meat (32%; 87 g/10 MJ for individuals with a poor diet versus 66 g/10 MJ for those with a healthy diet). An Irish study similarly found that a diet high in processed meat was linked to a diet low in fruit, fish, vegetables, and whole grains, suggesting a less healthful diet [61]. Therefore, if no or insufficient adjustments are done for dietary quality, comparing disease risk in groups with high and low meat intake will unavoidably compare bad and healthy diets. Furthermore, compared to groups that consume large amounts of meat as part of a healthy diet, those that consume large amounts of meat in conjunction with an unhealthy diet were found to consume significantly more foods that may raise the risk of disease, such as fried potatoes, fatty spreads, high-fat gravy, and fast food [63].

Numerous cohort studies offer estimates that incorporate both a basic model that accounts for only basic confounders, such as sex, age, and energy intake, and a more comprehensive model that accounts for additional factors, such as smoking habits, body mass index, social status, and consumption of vegetables, fruits, and whole grains. It can be questioned, nonetheless, if these corrections are adequate to account for all dietary quality variations that come with high and low dietary meat levels. It might also be questioned if adjusting for an excessive number of confounders will affect the outcomes that are actually being studied. It is not uncommon, nevertheless, for the relationships discovered in the simpler model to disappear after considerable confounder corrections [64], suggesting that the estimates are significantly modulated by the corrections.

7. Research Deficits and Suggestions

Table 1 summarizes the issues and recommendations that have been recognized as pertinent to further investigation [65–71]. According to new research, foods should not only be considered as sources of certain nutrients but also as a combination of several nutrients and other elements that influence the final product based on factors including processing, composition, meal composition, and consumer behavior. For instance, butter's saturated fatty acid has a different effect than identical saturated fatty acids found in fermented dairy products [4]. This effect could be partially explained by variations in the amount of calcium found in dairy products or by the way that distinct low density lipoprotein particle sizes are impacted by consumption of saturated fatty acids [72]. An analysis of the total amount of low density lipoprotein particles is a common way to determine the risk of cardiovascular disease. However, small low density lipoprotein particles appear to be strongly associated with cardiovascular disease, while larger low density lipoprotein particles are not.

To distinguish the precise effect, future research should present and analyze the various sizes of low density lipoprotein particles. The pathophysiological effects of salt and other industrial processing additives, in addition to the impact of saturated fatty acid intake, have not yet been determined [73].

Those who consume the most meat also consume fewer fish, vegetables, and whole grains, as can be seen by looking at the baseline characteristics of participants in two large cohorts based on quintiles of total red meat intake [31,74], suggesting that these meat eaters also consume fewer types of dietary fiber. According to other research, those who consume more meat also tend to eat less healthily [74], which may indicate that the lack of dietary fiber or other plant-based components has a greater impact on health metrics than meat consumption alone.

Table 1. Suggestions for Further Study on the Role of Meat in Human Health [65–71].

Area of Study	Focus for Future Research	Recent Reference
Chronic Disease Risk	Clarify causal links between red/processed meat and diseases like cancer, CVD, and T2D.	2023 [65]
Meat Alternatives	Assess nutritional and metabolic effects of plant-based or cultured meat substitutes.	2022 [66]
Nutrient Bioavailability	Study how cooking and processing affect the availability of iron, zinc, B12 in meat.	2021 [67]
Gut Microbiota Interactions	Examine effects of meat-based vs. plant-based diets on gut microbiome composition.	2022 [68]
Processing Methods	Explore how fermentation, curing, or additives modify health outcomes of meat consumption.	2023 [69]
Dietary Patterns vs. Single Foods	Investigate meat's role in the context of overall dietary patterns (e.g., Western vs. Mediterranean).	2023 [70]
Behavioral & Cultural Factors	Study cultural norms, consumer perception, and willingness to reduce meat intake.	2023 [71]

Dietary fiber has a well-established beneficial impact on human health; for instance, switching to a healthier diet has been demonstrated to enhance gut microbiota and functionality without requiring an increase in caloric intake [29]. There aren't enough studies with comparable meat contents, though. A top-notch human intervention study comparing the effects of processed meat with and without the right kinds of dietary fiber in people could clarify the impact on cardiovascular disease risk factors and microbiota and assess whether dietary fiber deficiency has a detrimental impact on metabolic outcomes following processed meat consumption.

Even though there are many observational studies on the relationship between meat consumption and health outcomes, it is challenging to assess the degree to which residual confounders may account for the slight increases in risk linked to consumption of red and processed meat because of confounding variables and various or unclear subgroupings of meat types. Therefore, we support the completion of high-quality randomized controlled trials to evaluate the impact of predetermined meat consumption on pertinent validated biomarkers in both healthy individuals and those at risk for cancer (particularly colorectal cancer), cardiovascular disease, and type 2 diabetes.

8. Conclusions

Meat has long been valued as a rich source of high-quality protein and essential micronutrients. Yet, growing concerns about its potential contribution to chronic diseases—such as cardiovascular disease, type 2 diabetes, and certain cancers—necessitate a more nuanced and evidence-driven evaluation. Current epidemiological findings are often inconsistent, hampered by confounding variables, heterogeneous methodologies, and limited consideration of the food matrix's influence on nutrient bioavailability.

To move the field forward, there is a critical need for high-quality randomized controlled trials that can isolate the specific health effects of red, white, fermented, and processed meats. Future studies must also explore whether thresholds exist where meat consumption transitions from beneficial to harmful, and how dietary components like fiber might modify these effects. Standardized classifications of meat products and advanced biomarkers for intake and physiological response will be pivotal in strengthening causal inferences.

Moreover, research should examine how processing techniques—including fermentation and curing—alter nutritional properties and metabolic responses. The use of refined metabolomic tools and stratified population studies, including individuals at higher metabolic risk, will provide deeper insight into individualized effects.

Beyond the laboratory, these findings hold important implications for public health nutrition, regulatory frameworks, and the food industry. Reformulating meat products, enhancing labeling transparency, and promoting dietary patterns that reflect the complexity of modern eating habits will support more sustainable and health-conscious choices.

In conclusion, rethinking the role of meat in our diet demands a multidisciplinary research agenda—one that integrates nutritional science, metabolism, behavior, and policy—to guide informed, context-sensitive strategies for public and planetary health.

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Conflicts of Interest

The author declares no conflict of interest.

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