

ORIGINAL ARTICLE

Processed Meat and Cancer Connection: A Bibliometric Analysis of Research Trends and Health Implications

İşlenmiş Et ve Kanser Bağlantısı: Araştırma Eğilimleri ve Sağlık Etkilerinin Bibliyometrik Analizi

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ABSTRACT

Aim: Cancer is a leading cause of mortality worldwide, with dietary factors, particularly processed meat consumption, being associated with an increased cancer risk. This study aimed to systematically analyze the research landscape on processed meat and cancer through a bibliometric approach.

Methods: A bibliometric analysis was conducted using data from the Web of Science Core Collection. The study was conducted in February 2025, and studies and article types in English were included in the research. After restriction from the search, 1536 publications from 1982 to 2025 were included. The keywords "processed meat" OR "cured meat" OR "emulsified meat" AND "cancer" OR "tumor" OR "carcinoma" OR "malignant" OR "malignancy" OR "carcinogenic effect" were used. The analysis encompassed six main categories: basic information, annual scientific production, keyword analysis, trending topics, thematic mapping, and contributions by authors, affiliations, and countries.

Results: A total of 1536 publications published between 1982 and 2025 were analyzed. The annual growth rate was 5.73%, and the average age of documents was 8.97 years. Most of the publications were research articles (73.5%), and the average number of citations per document was 51.32. The most frequently used keywords were "diet," "colorectal cancer," "meat," and "red meat." Frequently studied topics over long periods included "n-nitroso compounds," "case-control studies," and "dietary pattern." Emerging topics in recent years included "Mendelian randomization" and "sustainability." Thematic analysis revealed that "processed meat" and "red meat" were central themes in the field, while "diet quality" and "factor analysis" were identified as emerging or declining topics.

Conclusions: Processed meat consumption is consistently associated with increased cancer risk, emphasizing the importance of holistic dietary patterns. Future research should focus on sustainable meat production, innovative preservation methods, and balanced dietary interventions to promote public health and environmental sustainability.

Keywords: Cancer risk, carcinogenic compounds, colorectal cancer, dietary Factors, Mendelian randomization

ÖZ

Amaç: Kanser, dünya çapında önde gelen bir ölüm nedenidir ve özellikle işlenmiş et tüketimi gibi diyet faktörleri artan kanser riski ile ilişkilendirilmektedir. Bu çalışma, bibliyometrik bir yaklaşım kullanarak işlenmiş et ve kanser üzerine yapılan araştırmaların genel görünümünü sistematik bir şekilde analiz etmeyi, araştırma trendlerini, önemli katkıda bulunanları ve ortaya çıkan temaları değerlendirmeyi amaçlamıştır.

Gereç ve Yöntemler: Bibliyometrik analiz, Web of Science Core Collection veri tabanındaki veriler kullanılarak gerçekleştirilmiştir. Şubat 2025'te yürütülen çalışmaya yalnızca İngilizce dilindeki makaleler ve uygun yayın türleri dahil edilmiştir. Belirlenen kriterler doğrultusunda 1982-2025 yılları arasında yayımlanmış toplam 1536 yayın analize dahil edilmiştir. Aramada "processed meat" OR "cured meat" OR "emulsified meat" AND "cancer" OR "tumor" OR "carcinoma" OR "malignant" OR "malignancy" OR "carcinogenic effect" anahtar kelimeleri kullanılmıştır. Analiz altı ana başlık altında yürütülmüştür: temel bilgiler, yıllık bilimsel üretim, anahtar kelime analizi, trend konular, tematik haritalama ve yazar, kurum ve ülke katkıları.

Bulgular: 1982-2025 yılları arasında yayımlanmış toplam 1536 yayın analiz edilmiştir. Yayınların yıllık artış oranı %5.73 olup, ortalama yayın yaşı 8,97 yıldır. Yayınların çoğunluğunu araştırma makaleleri (%73.5) oluşturmakta ve belge başına ortalama 51,32 atıf alınmaktadır. En sık kullanılan anahtar kelimeler "diet" (diyet), "colorectal cancer" (kolorektal kanser), "meat" (et) ve "red meat" (kırmızı et) olmuştur. Uzun süre çalışılan konular arasında "n-nitroso bileşikler", "olgu-kontrol çalışmaları" ve "diyet kalıpları" yer alırken, son yıllarda öne çıkan konular "Mendel rastgeleleştirme" ve "sürdürülebilirlik" olmuştur. Tematik analizde "işlenmiş et" ve "kırmızı et" merkezi temalar olarak belirlenmiş, "diyet kalitesi" ve "faktör analizi" ise yeni ortaya çıkan veya azalan temalar arasında yer almıştır.

Sonuçlar: İşlenmiş et tüketimi, artan kanser riski ile tutarlı şekilde ilişkilendirilmekte olup, bütüncül diyet kalıplarının önemini vurgulamaktadır. Gelecekteki araştırmaların sürdürülebilir et üretimine, yenilikçi koruma yöntemlerine ve dengeli diyet müdahalelerine odaklanarak halk sağlığı ve çevresel sürdürülebilirliğin teşvik edilmesi gerektiği belirtilmiştir.

Anahtar Kelimeler: Beslenme faktörleri, işlenmiş et, kanser riski, karsinogenik bileşikler, kolorektal kanser, Mendel-yen rastgeleleştirme

INTRODUCTION

Cancer remains one of the leading causes of death worldwide, with numerous factors influencing its development, including genetics, lifestyle, and diet. Among dietary components, meat consumption—particularly processed meats—has been extensively studied for its potential link to cancer risk (1). The International Agency for Research on Cancer, a division of the World Health Organization, has classified processed meats as Group 1 carcinogens based on epidemiological studies associating high consumption with an increased risk of colorectal cancer (2). While this classification has sparked ongoing scientific discussions, research continues to explore the nuances of this relationship, including potential mechanisms, dose-response effects, and individual susceptibility. Studies on processed meat and cancer are among the most widely investigated topics in nutritional science today, reflecting both public health interest and the need for clear dietary guidelines (3). Given the complexity and multidisciplinary nature of research linking processed meat consumption to cancer risk, synthesizing the expanding body of literature has become increasingly challenging. While numerous epidemiological, clinical, and mechanistic studies have been conducted, there remains a need to comprehensively evaluate the evolution of scientific interest, identify research gaps, and monitor shifts in thematic focus over time. In this context, bibliometric analysis offers a valuable method for mapping the intellectual structure of the field, uncovering

collaboration patterns, and highlighting emerging research fronts. A bibliometric approach is particularly appropriate in this area, where the volume of publications is large and heterogeneous, making traditional literature reviews insufficient. Therefore, this study aims to provide a systematic and data-driven overview of research trends on processed meat and cancer by applying bibliometric methods to publications indexed in the Web of Science (WoS)-Core Collection. This analysis is intended to support researchers, policymakers, and public health professionals by clarifying the knowledge structure and future directions in this critical domain. (4). This study aims to analyze scientific publications on meat consumption and cancer using data from the WoS-Core Collection, mapping the evolution of research, citation patterns, and collaborative networks. By providing a comprehensive overview of the field, this analysis seeks to inform future research directions and contribute to a more balanced understanding of the role of meat in cancer risk.

MATERIALS and METHODS

Research Design

This bibliometric analysis used the guide created by Donthu et al. (4). The analysis was conducted by the four suggested phases.

Step 1: Defining the objectives and constraints of the bibliometric study.

Step 2: Selecting the best bibliometric

analysis.

Step 3: Compiling data for bibliometric analysis.

Step 4: Bibliometric analysis is carried out, and the findings are recorded.

Universe of Research

This bibliometric analysis investigates the scientific literature examining the association between meat consumption and cancer. The WoS-Core Collection, a widely recognized and high-impact scholarly database, was used to ensure comprehensive coverage. The search was performed in February 2025 without time restrictions and included all scientific categories. The study focused on peer-reviewed journal articles, reviews, and conference proceedings exploring the link between meat consumption—especially processed forms—and cancer risk. Studies unrelated to human health, such as those involving veterinary contexts or those not peer-reviewed, were excluded from the scope of analysis.

Data Collection

The data collection process was conducted using the WoS-Core Collection. The Boolean search strategy was as follows: (“processed meat” OR “cured meat” OR “emulsified meat”) AND (“cancer” OR “tumor” OR “carcinoma” OR “malignant” OR “malignancy” OR “carcinogenic effect”). The search, conducted on February 11, 2025, yielded 1536 eligible studies. Inclusion criteria required publications to be in English and categorized as journal articles or

research papers. Non-English studies (e.g., German, French, Spanish, etc.), correction publications (n=2), and a retracted paper (n=1) were excluded. Duplicate terms such as “dietary pattern(s)” and “nitrite(s)” were merged to avoid redundancy. No keywords were removed.

Data Analysis

The bibliometric analysis was performed using the R programming language, specifically the Bibliometrix-Biblioshiny package. Author keywords were the primary data source for trend and thematic mapping. Basic metrics—such as publication counts, growth rates, citation averages, and authorship patterns—were calculated. A word cloud and treemap were generated to visualize the top 25 keywords. To examine research evolution, a trend topic analysis was conducted with a five-year window. Additionally, 250 keywords were processed using the walktrap algorithm to create a thematic map and identify core, emerging, niche, and declining themes. All results were presented quantitatively using counts, percentages, and proportions to ensure clarity and reproducibility. The data were analyzed using the Biblioshiny interface of the Bibliometrix package within the R software environment (version 4.2.2) (4,5).

RESULTS

Basic details regarding the included papers are provided in Table 1.

Table 1. Fundamental publishing data

Description	Results
General Information	
Timespan	1982:2025
Sources (Journals, Books, etc.)	472
Documents	1536
Annual Growth Rate (%)	5.73%
Document Average Age	8.97
Average Citations per Doc	51.32
References	52155
Author's Keywords (DE)	2629
Authors	6938
Authors of Single-authored Docs	61
International Co-Authorship	32.68%
Co-Authors per Doc	7.18
Types of Documents	n (%)
Article	1128 (73.5)
Review	305 (19.8)
Proceedings Papers	57 (3.7)
Book Chapters	21 (1.3)
Editorial Materials	11 (0.8)
Letters	11 (0.8)
News Items	3 (0.1)
Most Relevant Sources	n (%)
Nutrients	70 (4.5)
International Journal of Cancer	59 (3.8)
Nutrition and Cancer–An International Journal	46 (2.9)
American Journal of Clinical Nutrition	44 (2.8)
Cancer Causes & Control	44 (2.8)
Countries of Corresponding Authors	n (%)
USA	355 (23.1)
China	149 (9.7)
The United Kingdom	98 (6.3)
Italy	85 (5.5)
France	81 (5.2)

The publications on the subject cover the years between 1982 and 2025, and the

average age is 8.97 years. The annual increase rate of these publications was calculated as 5.73%. Each of these works published by 6938 different authors received an average of 51.32 citations. When the countries of the responsible authors of the publications are examined, the country with the most publications is the USA with 23.1%.

Table 1 indicates the leading journals publishing research at the intersection of nutrition and cancer. “Nutrients” stands out with 70 publications, accounting for 4.5% of the literature, which positions it as the most prominent source in this field. It is followed by the “International Journal of Cancer” with 59 publications (3.8%), highlighting its significant role in cancer research. “Nutrition and Cancer–An International Journal” contributes 46 publications (2.9%), emphasizing its specialized focus on the diet-cancer nexus. In both the “American Journal of Clinical Nutrition” and “Cancer Causes & Control”, 44 articles have been published (2.8% each), underlining their importance in disseminating research bridging clinical nutrition and cancer epidemiology. Overall, these data suggest a robust and diverse publication landscape where both nutrition-centric and cancer-specific journals are integral to advancing our understanding of the interplay between nutrients and cancer. The publications reached their highest level in 2022, and the distribution of publications is displayed by year in Figure 1.

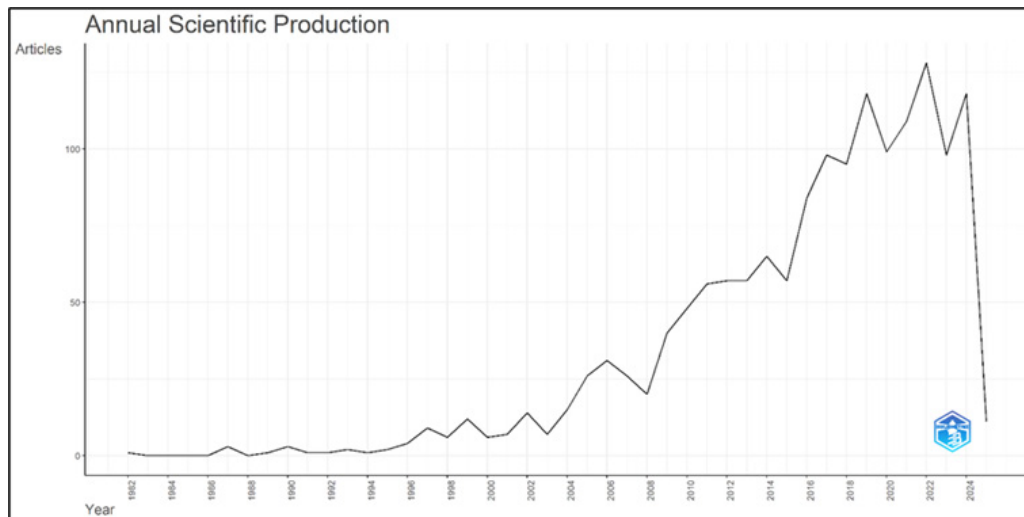


Figure 1: Publications distributed by year

Table 2. Local Impacts by Authors

ElementS	h_Index	g_Index	m_Index	Total Citation	Number of Publications	Publication Year Initial
SINHA R	30	40	1.25	4050	40	2002
BOEING H	26	37	0,743	3575	37	1991
RIBOLI E	25	35	1	3487	35	2001
CROSS AJ	24	35	1.143	3043	35	2005
OVERVAD K	23	32	0.958	2829	32	2002
TJONNELAND A	23	37	0,958	2563	37	2002
WILLETT WC	23	31	0.885	4474	31	2000
WOLK A	23	26	1	2298	26	2003
NORAT T	22	22	0.88	4090	22	2001
TUMINO R	21	31	1	2082	31	2005

Among the researchers in Table 2, Sinha R has the highest h-index (30) and the highest total number of citations (4050). He is the researcher with the highest production, with 40 publications, and his m-index (1.25) is also quite high, indicating that he has demonstrated a stable and effective publication performance since the beginning of his academic career. Considering his publication career starting in 2002, it can be said that Sinha's scientific impact is both continuous and strong.

Table 3. Most Relevant Affiliations

Affiliations	Articles
HARVARD UNIVERSITY	158
HARVARD THE CHAN SCHOOL OF PUBLIC HEALTH	138
GERMAN CANCER RESEARCH CENTER	128
BRIGHAM AND WOMEN'S HOSPITAL	96
MAASTRICHT UNIVERSITY	89
KAROLINSKA INSTITUTE	86
UNIVERSITY OF CAMBRIDGE	83
UNIVERSITY OF TEHRAN MEDICAL SCIENCE	82
INTERNATIONAL AGENCY FOR RESEARCH ON CANCER	78
OXFORD UNIVERSITY	78

According to the institutional distribution in Table 3, the institution with the most publications is Harvard University (158 articles), followed by the Harvard T. H. Chan School of Public Health (138 articles) and the German Cancer Research Center (128 articles). These findings show that institutions, in particular, based in the USA and Europe, play a decisive role in research production in this field.

Table 4. Scientific Production and Citations of Countries

Region	Frequency	Total Citations	Average Citations in Articles
USA	2232	28261	79.60
SPAIN	855	3446	55.60
CHINA	753	4318	29.00
ITALY	734	3185	37.50
UK	580	5663	57.80
GERMANY	488	3759	58.70
FRANCE	479	6448	79.60
DENMARK	336	1517	37.90
NETHERLANDS	329	2210	53.90
IRAN	328	991	19.10

According to Table 4, the USA is the leader in terms of scientific production and impact, having both the highest number of publications (2232) and the average number of citations (79.60). Although France has the same average number of citations, the number of publications and total citations is much lower (479 publications, 6448 citations). The USA has the highest values for both the number of publications and the average citations. This shows that the USA is a leader in both scientific production and the impact of this production on the field. This is probably due to research funding, academic infrastructure, international collaborations, and journal representation.

Table 5. Local Impacts from Sources

Sources	Articles	h_Index	g_Index	m_Index	Total citation
NUTRIENTS	70	23	43	2.091	1948
INTERNATIONAL JOURNAL OF CANCER	59	37	59	1.000	4708
NUTRITION AND CANCER-AN INTERNATIONAL JOURNAL	46	20	38	0.714	1529
AMERICAN JOURNAL OF CLINICAL NUTRITION	44	26	44	1	3157
CANCER CAUSES \& CONTROL	44	24	40	0.828	1665
BRITISH JOURNAL OF NUTRITION	40	22	40	0.88	1782
CANCER EPIDEMIOLOGY BIOMARKERS \& PREVENTION	39	24	39	0.706	2375
PUBLIC HEALTH NUTRITION	28	19	28	0.704	1807
EUROPEAN JOURNAL OF NUTRITION	27	11	21	0.524	451
JOURNAL OF NUTRITION	26	18	26	0.75	1071

According to Table 5, the International Journal of Cancer stands out as the most influential journal in the field, having the highest h-index (37) and total number of citations (4708). Although the Nutrients journal has the most publications (70 articles), it falls behind in terms of h-index (23) and total number of citations (1948). On the other hand, the American Journal of Clinical Nutrition is a strong publication source in terms of both quality and quantity, with its high h-index (26) and total number of citations (3157). These findings suggest that even some journals with a small number of publications may have high citation and impact levels.



Figure 2. Word Cloud

When the word cloud (Figure 2) is examined, the key topics standing out are “diet” (n=255, 13%) and “colorectal cancer” (n=177, 9%). These topics are followed by “meat” (n=167, 9%), “red meat” (n=159, 8%), and “cancer” (n=128, 7%). Again, “dietary pattern” (n=81, 4%), “epidemiology” and “meta-analysis” (n=80, 4%) are among the other topics studied.

When the trend topics of the study (Figure 3) are examined, the most frequently studied topics other than the keywords of the study are “diet, meat, processed meat, colorectal cancer”, while “case-control studies, cured meat, n-nitroso compounds, stomach cancer, lung cancer, nutrition, dietary pattern” are among the topics studied for the longest time (between 10 years and 13 years). Topics such as “processed meat products” (from 2021), “sustainability” (from 2022), and “Mendelian randomization” (from 2023) have received increasing attention in recent years. This indicates that researchers are turning to more specific products (processed meat products), sustainability, and genetically based analysis methods.

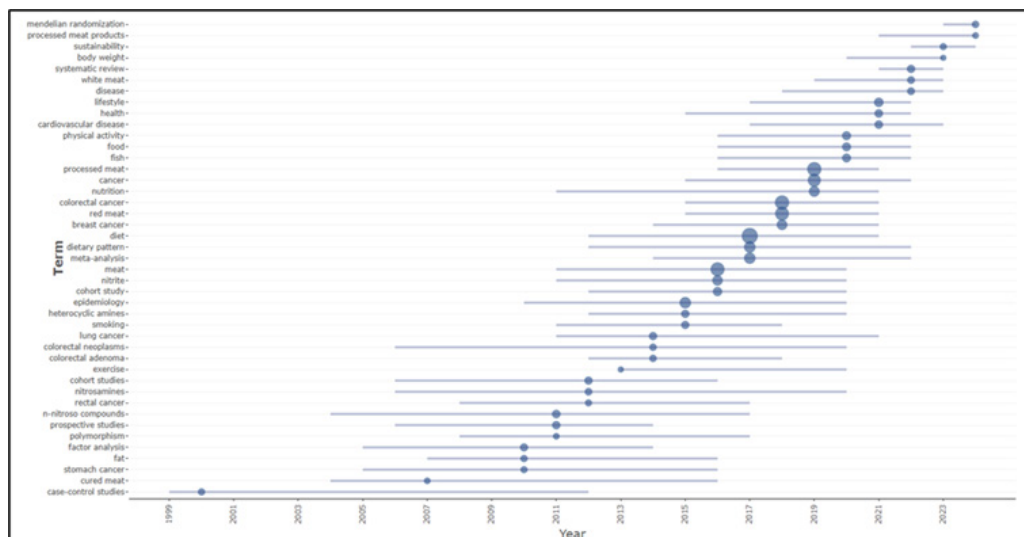


Figure 3. Trending topics

Topics such as “N-nitroso compounds” (from 2004), “nitrosamines” (from 2006), and “colorectal neoplasms” (from 2006) are areas that have been investigated for many years and are still relevant. This shows that the effect of these chemical compounds on cancer risk is still an important area of research. Topics such as “Mendelian randomization” (from 2023) and “sustainability” (from 2022) are new trends emerging in the last few years. Mendelian randomization stands out as a method for examining causal relationships using genetic variation. Sustainability offers a new perspective for examining the relationship between the environmental effects of meat consumption and cancer risk.

Keywords such as “epidemiology” (80 times), “case-control studies” (9 times), “prospective studies” (19 times), and “cohort studies” (17 times) indicate that epidemiological methods are widely used in this field. Cohort studies and prospective studies are especially preferred to examine long-term effects. Keywords such as “meta-analysis” (80 times) and “systematic review” (18 times) indicate that such studies have been increasingly used in recent years. This indicates that researchers are turning to synthesizing existing literature to produce stronger evidence. Keywords such as “diet” (255 times), “dietary pattern” (81 times), and “nutrition” (65 times) indicate that the effect of dietary habits on cancer risk has been widely investigated. Figure 3 shows that topics such as “white meat” (13 times) and “fish” (27 times) were studied less frequently.

Thematic map: This analysis sheds light on the intellectual and conceptual structure of the field. Each node on the map represents a network cluster, and the node names

reflect words belonging to the cluster and having a higher formation network. Node sizes depend on the number of postings containing the keyword and the node’s position, which is established by cluster centrality and density (4). Keywords and a fast greedy algorithm were used to do thematic analysis. The minimal cluster frequency was determined to be five, and each cluster had a single level. Understanding the following concepts is necessary to interpret the analysis.

Centrality: The more important something is to the topic of study, the stronger it is.

Intensity: The stronger the subject, the more integrated and unified it is.

Motor themes are thought to be complex and crucial topics for the field of study.

Basic issues: They draw attention to topics that are still developing in the field of study.

Niche topics: They show that the research field has unique yet well-developed themes.

Themes that are emerging or fading: These are considered to be emerging or fading themes in the field of study.

According to the thematic map (Figure 4), a significant portion of the nodes are among the basic themes representing the topics that continue to develop. Accordingly, the topics of “meat products, nitrite, nitrate, prevention, obesity, lifestyle” are among the basic themes. Again, the topics of “vegetables, stomach neoplasms” are also basic themes. The topics of “processed meat, red meat, mortality” are among the themes guiding the field (motor themes). In addition, the topics of “diet, colorectal cancer” are on the centrality line. The topics of “salt, food safety, vegetarian, antioxidants, lipid preoxidation” are niche themes

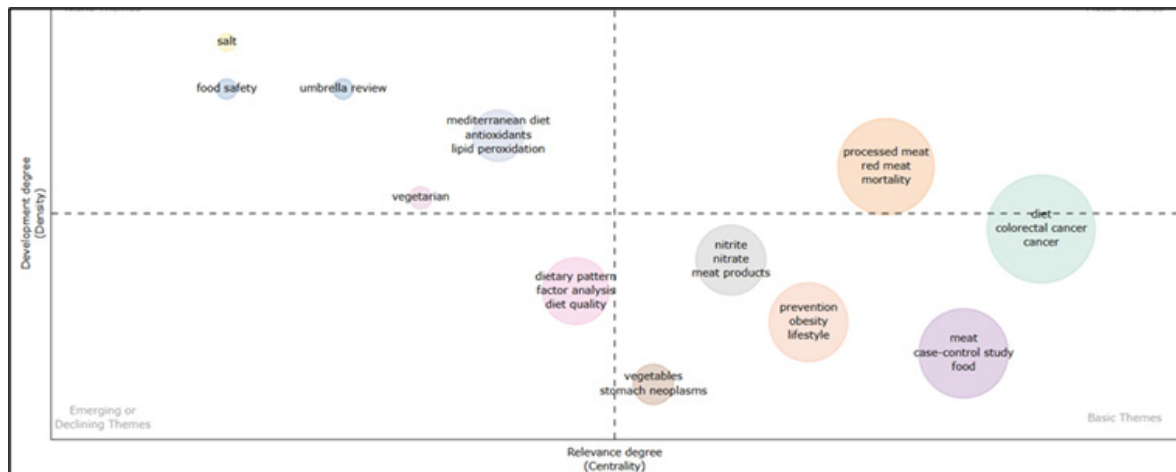


Figure 4. Thematic Map

indicating a developed but isolated field of study. However, the topic of “dietary pattern, diet quality, factor analysis” is among the newly emerging or disappearing themes of the field.

DISCUSSION

The bibliometric analysis of research trends in meat, processed meat, and cancer highlights a sustained and growing focus on understanding the intricate relationship between dietary habits and cancer risk. Beyond primary keywords like “diet,” “meat,” “processed meat,” and “colorectal cancer,” research has delved deeply into subjects such as “case-control studies,” “cured meat,” “N-nitroso compounds,” “stomach cancer,” “lung cancer,” “nutrition,” and “dietary patterns.” These topics have remained focal points for an extended period, ranging from 10 to 13 years, underscoring the scientific community’s recognition of the long-term importance of these factors. The prominence of “case-control studies” signifies the methodological rigor applied to establish associations between processed meat consumption and cancer risk, while the repeated emphasis on

“N-nitroso compounds” reflects concerns about specific carcinogens formed during meat processing. Publications on this subject span over four decades, from 1982 to 2025, with an average publication age of 8.97 years, reflecting a blend of foundational and recent studies that have shaped the field. The steady annual increase in publications (5.73%) signifies a sustained research interest in nutrition, public health, and food science. The high average citation rate of 51.32 per publication indicates that this body of work is highly influential, frequently referenced, and continues to contribute significantly to the broader scientific discourse on diet, meat consumption, and health outcomes. Furthermore, the majority of the research in this area comprises original studies (73.4%), emphasizing empirical evidence over theoretical discourse.

Author impact is another critical component, and Table 3 identifies Sinha R as the most influential contributor in the field, with the highest h-index, most citations, and the highest number of publications since beginning their publication career in 2002. This is followed by other leading scholars such as Boeing H, whose sustained

contributions have shaped the research landscape (6,7). Institutional affiliations further confirm this dominance, with Harvard University leading with 158 articles, followed by the Harvard T.H. Chan School of Public Health (138) and the German Cancer Research Center (128), highlighting the centrality of U.S. and European institutions in this research ecosystem.

From a global perspective, the United States leads in research output (23.1%), highlighting its central role in advancing knowledge and innovation in this domain. The interdisciplinary nature of this research is evident in the involvement of 6,938 different authors, comprising experts from nutrition, epidemiology, food science, and public health. Among the most frequently studied topics, colorectal cancer (9%) stands out as a leading research area, followed closely by "meat" (9%), "red meat" (8%), and "cancer" (7%). Scientific investigations have consistently shown that processed and red meats contribute to colorectal cancer through the formation of harmful compounds such as N-nitroso compounds (NOCs), heterocyclic amines (HCAs), and lipid peroxidation byproducts, all of which have carcinogenic potential (8).

To address these risks, research has focused on innovative strategies to improve meat products and reduce harmful compound formation (8,9). For instance, studies have demonstrated that natural alternatives to synthetic nitrites, such as celery powder and beetroot extract, effectively lower NOC formation in processed meats (10,11,12,13). Additionally, marinating meat with green tea extract before cooking can reduce HCA formation by up to 70%, while natural antioxidants like rosemary extract help curb lipid peroxidation and oxidative damage

(14). Further efforts include reducing sodium content in processed meats and integrating plant-based ingredients (e.g., mushrooms) to enhance both nutritional value and food safety (7). These advancements align with public health goals, aiming to mitigate the health risks associated with processed meat consumption while maintaining consumer preferences and industry viability. A recurring theme in this research is the distinction between meat itself and the methods used to process and cook it. The primary cancer risks stem from smoking, curing, salting, and high-temperature cooking methods, which generate carcinogenic compounds like NOCs, HCAs, and polycyclic aromatic hydrocarbons (PAHs) (15–18). Thus, rather than the inherent properties of meat, it is processing and cooking techniques that elevate cancer risks. This evolving perspective is further reinforced by a thematic map analysis of bibliometric data, which classifies research priorities into basic, motor, central, niche, and emerging themes.

The findings indicate that while "meat products, nitrite, nitrate, prevention, obesity, and lifestyle" continue to be fundamental themes, "processed meat, red meat, and mortality" have emerged as field-leading topics (motor themes). Processed meat consumption, in particular, has been associated with increased mortality and increased risk of chronic diseases, including cardiovascular disease (CVD), cancer, and type 2 diabetes (19). These risks are primarily attributed to the high levels of saturated fats, sodium, nitrites, and harmful compounds such as NOCs, HCAs, and advanced glycation end products (AGEs) found in these products (20). However, the field of food science has made significant

strides in developing strategies to mitigate these harms, offering promising solutions to reduce the health risks associated with meat consumption while maintaining its nutritional and sensory qualities. Another promising area of research focuses on the use of natural antioxidants to inhibit the formation of harmful compounds during meat processing and cooking (6).

Furthermore, “diet and colorectal cancer” occupy a central position in the research network, while “salt, food safety, vegetarianism, antioxidants, and lipid peroxidation” remain niche themes, indicating well-developed but relatively isolated areas of study. Notably, emerging or possibly declining themes include “dietary pattern, diet quality, and factor analysis,” highlighting shifts in research focus. The improvement of red meat’s safety, nutritional quality, and sustainability has become a critical focus in food science, particularly as concerns about its health risks—such as links to cardiovascular disease, cancer, and oxidative stress—continue to grow (21). Niche research areas, including salt reduction, food safety, vegetarian diets, antioxidants, and lipid peroxidation, offer valuable insights and innovative strategies to address these challenges. By leveraging these insights, researchers and the food industry are developing solutions that not only mitigate the harms associated with red meat but also enhance its nutritional value and align with consumer demands for healthier and more sustainable food options (22). One of the most pressing concerns in processed red meat products is their high sodium content, which is linked to hypertension and cardiovascular diseases. Studies have explored the use of salt substitutes, such as potassium chloride

and seaweed extracts, to reduce sodium levels without compromising flavor or safety. For example, a 2024 study demonstrated that reformulated beef sausages with 30% reduced sodium content, using potassium chloride, were well-accepted by consumers while significantly lowering health risks (23). This approach highlights the potential for reducing sodium in red meat products without sacrificing sensory quality. Food safety is another critical area of research, particularly in preventing microbial contamination during red meat processing (24). Natural antimicrobials, such as plant extracts (e.g., oregano, thyme) and essential oils, have shown promise in inhibiting pathogens like *E. coli* and *Salmonella* (25).

The evolving landscape of nutrition research is marked by a clear shift from studying isolated food items to examining broader dietary patterns and diet quality (26). This transition reflects a growing recognition that the interplay of various foods and nutrients within a diet—rather than individual components—holds the key to understanding health outcomes. Emerging themes such as dietary patterns, diet quality, and factor analysis are gaining prominence, suggesting that these areas are likely to become central to future research. At the same time, some older themes may fade into obscurity or become niche areas as the focus shifts toward a more holistic perspective on diet and health. The findings highlight the importance of examining holistic dietary patterns rather than focusing on a single food, and may explain why this theme has gained traction as a major area of research (27). This holistic approach to diet quality is likely to become a main theme as researchers

continue to explore its benefits. The shift toward studying dietary patterns also aligns with the growing interest in personalized nutrition, which considers individual genetic, metabolic, and lifestyle factors when making dietary recommendations. A 2023 study, for instance, used machine learning to examine nutritional trends and forecast how each person would react to various diets (28). The study found that personalized dietary recommendations based on whole dietary patterns were more effective in improving health outcomes than generic advice focused on single nutrients or foods. This emerging focus on personalization is likely to drive further research into dietary patterns and diet quality, solidifying their status as main themes.

Interestingly, research publications peaked in 2022, raising the question of what factors contributed to this surge. Several explanations can be considered, including heightened consumer awareness of dietary health risks, the increased emphasis on food safety following the COVID-19 pandemic, and advancements in meat processing technologies aimed at mitigating health concerns (29). The growing market for clean-label products, plant-based alternatives, and functional foods may have also driven a surge in scientific exploration, as industries and researchers work to align with public demand for safer and healthier meat products.

In light of these findings, the future of processed meat research will likely focus on synergistic antioxidant blends, personalized nutrition approaches, sustainable livestock practices, and advanced food preservation technologies. Innovations such as high-pressure processing (HPP) and vacuum packaging offer promising alternatives to

traditional meat preservation, extending shelf life while reducing reliance on synthetic preservatives (30–33). The potential for plant-based antioxidants (e.g., rosemary extract, green tea polyphenols) to replace chemical preservatives without compromising meat safety is also gaining significant attention. Additionally, dietary interventions such as fiber-rich diets, Mediterranean-style eating patterns, and increased vegetable intake have been shown to counteract the carcinogenic effects of processed meats, further emphasizing the role of diet in mitigating health risks (34,35).

While topics such as processed meat, red meat, and colorectal cancer have dominated the research landscape for decades, newer areas like Mendelian randomization and sustainability are gaining traction as promising avenues for future investigation (36). One of the most notable emerging trends is the use of Mendelian randomization (MR) to explore causal relationships between dietary factors and cancer risk. MR, which uses genetic variants as instrumental variables to minimize confounding, has become a powerful tool in nutritional epidemiology. For instance, MR was employed in a study to show a strong causal relationship between the risk of colon cancer and the diet of red and processed meat (28). This study reinforces the role of these dietary factors in cancer development while showcasing the potential of MR to provide stronger evidence in nutrition research. Future studies could extend this approach to investigate the effects of white meat, fish, and plant-based proteins, addressing current gaps in the literature.

Despite the extensive research on red and

processed meats, the effects of white meat and fish consumption on cancer risk remain underexplored. A study found no significant association between poultry consumption and colorectal cancer risk, suggesting that white meat may be a safer alternative to red and processed meats (37). Similarly, in a report, it was stated that higher fish intake was associated with a reduced risk of several cancers, including colorectal and liver cancers, likely due to the anti-inflammatory and antioxidant properties of omega-3 fatty acids (38).

The strength of this study lies in its comprehensive bibliometric approach, which provides a broad and structured overview of the scientific landscape linking processed meat and cancer. By analyzing a large dataset spanning several decades, the study effectively identifies historical trends, key contributors, and emerging research themes. The use of multiple analytical dimensions, such as keyword co-occurrence and thematic mapping, adds depth to the findings. However, there are several limitations to this study. (i) Data source limitation: Only the Web of Science database was used, potentially omitting relevant studies indexed in other academic databases such as Scopus or PubMed. (ii) Language limitation: The analysis was restricted to English-language publications, excluding potentially valuable research published in other languages. (iii) Lack of content analysis: While the bibliometric approach highlights publication trends and metrics, it does not assess the methodological rigor or quality of the study content. These limitations should be considered when interpreting the results and generalizing the findings.

CONCLUSION

Research on processed meat and cancer underscores the critical role of processing and cooking methods in elevating cancer risk, rather than meat itself. This shift from studying individual food components to examining holistic dietary patterns reflects a growing recognition that overall diet quality plays a more significant role in health outcomes. While topics such as processed meat, red meat, and colorectal cancer have dominated the research landscape for decades, newer areas like Mendelian randomization and sustainability are gaining traction as promising avenues for future investigation. Mendelian randomization offers a robust method for establishing causal relationships, while sustainability highlights the dual benefits of reducing cancer risk and environmental impact through dietary changes.

Future efforts should focus on advancing personalized nutrition, promoting sustainable meat production, developing innovative food preservation techniques, and implementing public health interventions to minimize risks while meeting consumer demands. By integrating these strategies, researchers and policymakers can contribute to safer dietary practices, improved public health outcomes, and more sustainable food systems. This comprehensive approach will not only address the immediate health risks associated with processed meats but also pave the way for a healthier and more environmentally conscious global food landscape.

- Research consistently links processed meat consumption to an increased risk of cancer, especially colorectal cancer. The

presence of carcinogenic compounds like nitrosamines and N-nitroso compounds contributes to this risk.

- The study analyzed 1536 publications from 1982 to 2025, retrieved from the Web of Science Core Collection, focusing on processed meat, cancer, and related dietary factors.
- Research methodologies include case-control studies, cohort studies, meta-analyses, and Mendelian randomization studies. These approaches reinforce the association between processed meat consumption and cancer risk.

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