Cancer: Emerging Trends in Nutrition

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Abstract

Cancer is one of the most dreadful diseases worldwide as it is associated with a higher risk of mortality. According to an estimation one in every five is suffering from cancer. Alcohol, toxins, oxidative stress, some viruses, obesity, and a diet high in fats and sugar while low in fiber are strongly correlated with the incidence of abnormal cell growth. These carcinogens modulate cellular proliferation, apoptosis, hormonal, metabolic, and signaling pathways and initiate tumors. Approximately, 30-40% of cancers are preventable and manageable with a healthy natural diet high in phytochemicals. These plants' bioactive components as 6-Shogaol, apigenin, lutein, astaxanthin, allicin, beta-carotene, lycopene, epigallocatechin, curcumin, and sulforaphane, scavenge the harmful agents and protects normal cellular mechanisms. Beyond this protection, nutrition is also used in combination with cancer treatment. The advancement in technology revolutionized the treatment of cancer as genetic profiling and next-generation sequencing lead to early diagnosis and treatment of cancer. Diet in combination with progressive therapies emerging as a new trend to protect and manage cancer

Keywords: Personalized nutrition, Gene profiling, Antioxidants, Tumor

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Introduction

Cancer is a serious health condition that remains a significant cause of mortality globally. Cancer is a severe public health issue that affects both industrialized and developing countries. Globally, an estimated 18.1 million new cancer cases were reported in 2018, with a projected rise to 23.6 million annually by 2030 (Bray et al., 2018). Despite of huge developments taken over the past century in the fight against cancer, it has been a major contributor of health care costs and mortality. According to an estimation, one in every five people are suffering from any sort of cancer, and half of them died from the disease (Ferlay et al., 2021). Modern diagnosis, and treatment tools have transformed cancer treatment, and declined the rising drift of cancer demises over the past century. Although, there remain many malignances with a poor prognosis due to the lack of multiple therapeutic approach. Consequently, novel nutritional therapies and lifestyle modifications are crucial to improve the current situation (Taylor et al., 2022). Moreover, even with a striking progress in general survival, organ impairment from radiation or chemotherapy effects the quality of life for survivors, with remarkable physical indications of pain, fatigue, neuropathy, and cognitive problems. The biological adaptations to dietary bioactive compounds have far and comprehensive impacts that can influence disease progression, differentiation, and development of tumors (Clifton et al., 2021). Approximately, one of third cancers are preventable through proper nutrition. This chapter explores emerging trends in nutrition and their implications for cancer prevention and treatment. So, nutrition has influential role in the inhibition and management of carcinoma by preventing tumorigenesis, deferring tumor growth, and synergizing with a variety of anticancer bioactive compounds (Martínez-Garay & Djouder, 2023).

The Molecular Basis of Nutrition in Cancer

The central objective of cancer research is to figure out the underlying mechanism of cell mutations. The last decade has shown huge developments in our understanding of various types of cancer at their molecular level. This consideration has exposed large numbers of innovative therapies to hinder its development. There are differences in molecules involved in the process of carcinogenesis depending on the type of cell and the pattern of spreading of cells from their local site (Pecorino, 2021). Typically, the cancer develops in adults as the result of multiple carcinogens that causes mutations in genes involved in regulation of cellular growth and altered metabolic changes which causes inflammation and the abnormal growth of cells. The most potent carcinogens include alcohol, smoking, viruses, and toxicants (Pirie et al., 2013). The various carcinogenic agents are shown in figure 1. The toxins in tobacco smoke, alcohol, aflatoxins and hepatitis B virus lead to the generation of liver cell carcinoma (Moorthy et al., 2015).

The multistep model of carcinogenesis revealed that alterations in specific genes such as oncogenes (cancer-driving genes) or tumor suppressor genes (which hinder the abnormal growth of cells) are involved in cancer initiation followed by irregular expansion of cells. This expansion continues until the cell attains the ability to escape growth controls and inhibit the normal mode of programmed cell death (Golemis et al., 2018). However, the initiation and propagation of tumor caused by either intrinsic or extrinsic mechanism. The intrinsic modifications

comprise of errors in DNA replication while extrinsic includes mutagenic carcinogens such as reactive oxygen species produced at damaging rates in response to obesity. These intrinsic or extrinsic sources of mutations causes alterations in biochemistry of cell can speed up the growth of cancer cells by several metabolic changes followed by inflammation (Hanahan & Weinberg, 2011; Senga & Grose, 2021).

Beyond these carcinogens, our diet plays a major role in the development of cancer. The diets with are high in calories especially western diet which contains high amounts of sugars and fats disrupt the normal metabolism and leads towards abnormal cell growth. Several researches revealed that intake of refined sugars, fats and high calorie diet leads towards obesity and certain types of ovarian, endometrial, pancreatic and colorectal cancer (Augustin et al., 2003; Calle et al., 2003; Donaldson, 2004; Higginbotham *et al*., 2004). The intake of refined carbs disrupts the normal cell proliferation signaling pathway of Insulin receptor (IR) and glucagon-like receptor 1(GLP-1). High carbohydrates also causes modulation in genes, gut microbiome and endocrine system which leads towards cancer initiation (Moorthy et al., 2015). The consumption of red meats and diets higher in fats disrupts the normal pathways for the synthesis of leukotrienes and prostaglandins which are risk factor for tumor formation (González-Vallinas et al., 2014). The oxidative stress is also a hallmark of cancer. As over production of free radicals damages the strands of DNA and chromosomal mutations. These reactive species also disturb the normal cell signaling pathways, exaggerate inflammation and generation of tumor. So, foods higher in antioxidants could mitigate cancer (Kamal et al., 2022).

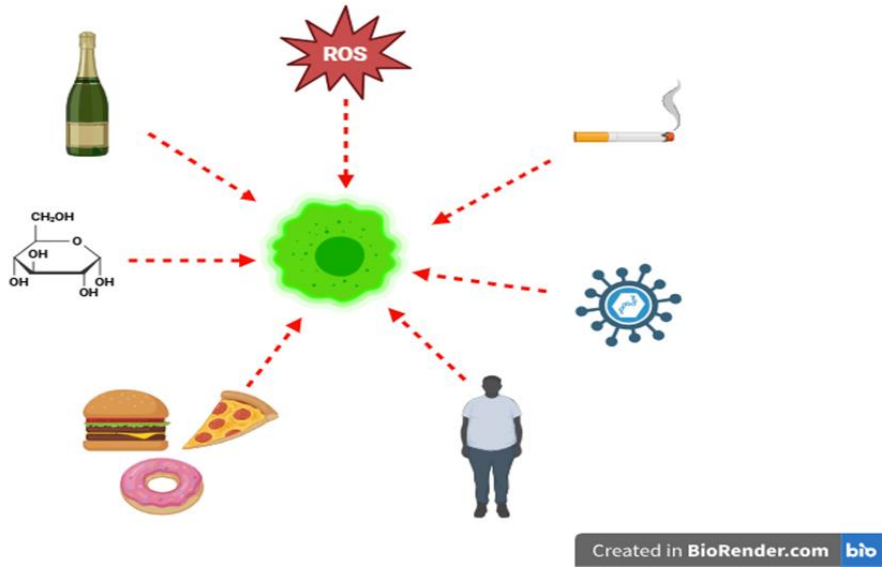

Fig. 1: Carcinogenic agents

Emerging nutritional Trends in Cancer Prevention

Advancements in understanding the cancer's molecular processes have resulted in several anticancer medicines. However, chemically manufactured medications have not greatly increased overall survival rates in recent decades. The new methods and chemoprevention medicines are needed to enhance current cancer therapy and improve efficiency. The phytochemicals, naturally occurring molecules from plants, are valuable resources for developing new medications and cancer therapies (Choudhari et al., 2020).

Table 1: Functional foods in cancer prevention

Functional Food	Sources	Results	Reference
α-Carotene	Yellow and green vegetables	Plasma α-carotene above the lowest quartile was linked to a 40–43% lower risk of invasive breast cancer	(Wang et al., 2015)
β-Carotene	Green leafy vegetables and orange and yellow fruits and vegetables	Participants receiving "factor D" (50 µg selenium, 30 mg vitamin E, 15 mg beta-carotene) had a lower mortality rate (3.84%) than a control group	(Qiao et al., 2019)
Lycopene	Tomatoes, water melon, apricot, and peaches	Dose-response meta-analysis showed that higher lycopene intake (9–21 mg/day) is linked to a lower risk of prostate cancer.	(Chen et al., 2015)
Astaxanthin	Green algae, salmon, trout	Astaxanthin (20.0 µg/ml) reduced cytogenetic effects of gamma irradiation and increased apoptotic cells	(Faraone et al., 2020)
Fiber	Vegetable and cereals	The inverse association was seen only in studies with ≥13 g/day fiber range or ≥25 g/day intake.	(Aune et al., 2012)
Omega-3	Fish or fish oil	EPA 100 µM induces reduced cell viability, increased apoptosis, ROS accumulation	(Fukui et al., 2013)

1. **Functional Foods and Cancer**

The functional foods resemble regular foods that are part of an everyday diet but are recognized for enhancing health beyond their basic nutritional value. In contrast, nutraceuticals are food-derived products available in medicinal formats such as capsules, tablets, powders, and

solutions and have been shown to offer physiological advantages and protect against chronic illnesses (Shahidi, 2009). The process of cancer development is intricate and lengthy, involving a variety of complex factors that progress in stages, ultimately resulting in uncontrolled cancer cell growth throughout the body, known as metastasis (Cencic & Chingwaru, 2010; Kalimuthu & Se-Kwon, 2013). The epidemiological studies have offered convincing evidence that dietary elements can influence carcinogenesis. Further laboratory investigations have shown that several bioactive dietary substances or natural compounds have the potential to prevent cancer (Liu, 2004; Balsano & Alisi, 2009).

During regular metabolism, our bodies generate reactive oxygen species such superoxide, hydrogen peroxide, and hydroxyl radicals. These toxic chemicals damage DNA, proteins, and lipids, causing aging and illnesses such as cancer and atherosclerosis. The antioxidants help prevent this damage by lowering oxidative stress, which has been related to cancer. Consuming antioxidant-rich foods can improve health and lower the risk of degenerative illness (Aghajanpour et al., 2017).

- **Astaxanthin**

It is remarkable in that it both scavenges free radicals and protects against oxidation, limiting their formation. The research suggests that astaxanthin enhances the effectiveness of other antioxidants, including Vitamins E and C. Limited data suggests that astaxanthin can improve the immune system, prevent skin ulcers, lower oxidized LDL cholesterol, and reduce inflammation-induced cardiovascular disorders. Astaxanthin can pass the blood-brain barrier, scavenging free radicals thereby offering neuroprotection (Karppi et al., 2007; Du et al., 2013).

- **Lycopene**

The lycopene is responsible for the rich red color of mature tomato fruits and tomato products. It reduces cholesterol levels by inhibiting cholesterol production, increasing low-density lipoprotein breakdown, and inhibiting the hydroxyl-methylglutaryl coenzyme A which has reducing effects on free radicals. The lycopene also possesses antioxidant properties such as quenching singlet oxygen and scavenging peroxyl radicals, promoting cell-to-cell communication and development (Agarwal & Rao, 2000).

- **Lutein**

The lutein is highly rich in leafy green vegetables, fruits, and colorful vegetables including sweet peppers, corn, peas, and egg yolk which can lower the incidence of breast cancer by 53%. The lutein, along with other antioxidants found in functional foods, can help prevent cancer. the *in-vitro*, lutein inhibits peroxy radicals and has antioxidant properties against oxidative damage (Aghajanpour et al., 2017).

- **Carotenoids**

The primary source of α-carotene are carrots, pumpkins and winter squash. Animal studies have demonstrated that α-carotene is more effective than β-carotene in inhibiting tumorigenesis in various organs, including the skin, lungs, liver, and colorectum. The β-carotene, which is found in green leafy vegetables, orange, and yellow fruits. The carrots and carrot juice are the richest source of α-carotene, with pumpkins and winter squash being the second dense source. The α-carotene has higher activity than β-carotene in inhibiting tumorigenesis in the skin, lungs, liver, and colon (Aghajanpour et al., 2017).

2. **Phytochemicals and Cancer**

The flavonoids are a large family of polyphenolics found in plants, classified into subclasses such as anthocyanidins, flavonols, and isoflavones. The research indicates that the flavonoids may have a positive impact on the prevention and treatment of various cancers, including ovarian, colon, lung, prostate, and breast cancer. The phenolic compounds like green tea polyphenols and epigallocatechin-3-gallate act as anticancer agents by activating transcription systems. Their anticancer effects are linked to mechanisms such as regulating cell cycle progression, inhibiting kinase and protease activities, and preventing the secretion of matrix metalloproteinases (Bosetti et al., 2007).

Table 2: Phytochemicals in cancer prevention

Phytochemicals	Source	Function	Reference
6-Shogaol	ginger	Inhibit the growth of lung cancer cells by decreasing cell proliferation and increasing apoptosis	(Kim et al., 2014)
Allicin	garlic	Allicin suppress the growth of human liver bile duct carcinoma	(Chen et al., 2018)
Curcumin	turmeric	Curcumin has chemopreventive and chemotherapeutic role in different cancer cells	(Wang et al., 2017)
Sulforaphane	broccoli	Inhibit tumor growth by blocking tumor adaptation to hypoxic condition	(Cipolla et al., 2015)
Apigenin	fruits and vegetables	Suppress tumor growth by inducting apoptosis	(Yan et al., 2018)
Epigallocatechin	green tea	Delay the tumor incidence by inducing apoptosis and inhibiting proliferation of human breast cancer	(Thangapazham et al., 2007)
Gingerol	ginger	Inhibited the orthotopic tumor growth as well as metastasis	(Martin et al., 2017)

3. **Probiotic, Prebiotic, and Symbiotic in Cancer Prevention**

The probiotics are living microorganisms that improve the intestinal microflora and contribute to human health. The prebiotics are non-digestible food components that support intestinal flora. Symbiotics combine both prebiotics and probiotics to enhance the beneficial bacterial growth. Studies show that various strains, species, and genera of bacteria can positively impact inflammatory bowel disease, lactose intolerance, hypertension, *H. pylori* growth, and cholesterol levels. The prebiotics may have antimicrobial, anticarcinogenic, hypolipidemic, glucose-modulating, and anti-osteoporotic effects. The symbiotic can also promote beneficial bacterial growth and overall health (Aghajanpour et al., 2017).

Several studies indicate that different strains of bacteria have positive effects on inflammatory bowel disease, lactose intolerance, hypertension, *H. pylori* growth inhibition, and cholesterol reduction. The prebiotics can exhibit antimicrobial, anticarcinogenic, and other beneficial activities, while symbiotic promote healthy bacterial growth. Certain strains, like *L. acidophilus* and *B. longum*, show protective effects against cancer. The probiotics inhibit harmful intestinal bacteria that produce carcinogenic substances. The research suggests that symbiotic can improve the colonic bacterial ecosystem, reduce epithelial exposure to toxins, and enhance mucosal structure, potentially lowering colorectal cancer risk (Rafter et al., 2007).

Nutritional Trends in Cancer Treatment

Cancer treatment has conventionally paid attention to conservative therapies like chemotherapy, radiation, and surgery. However, the role of nutrition in cancer treatment is gaining recognition. In cancer, a patient loses genetic control of the growth and proliferation of cells. Even though it is a genetic disease, still the factors that contribute to the progression of the disease are mainly environmental or lifestyle-based factors. These factors include diet, obesity, excessive body weight, physical activity, alcohol and tobacco consumption, and too much exposure to sun among other factors that have great potential in cancer prevention. A positive behavioral change in diet and lifestyle can have a positive impact on the prevention of cancer. A healthy diet, moderate physical activity, lower body weight, decreased intake of alcohol and smoking, and a positive attitude towards life can significantly reduce cancer burden (Ubago-Guisado et al., 2021).

1. **Nutrition as an Adjunct to Conventional Cancer Treatments**

With a complicated pathophysiology, cancer is one of the main causes of death and morbidity. The chemotherapy, radiation therapy, immunotherapy, and targeted therapy are examples of conventional cancer treatments. However, restrictions like cytotoxicity, lack of specificity, and multi-drug resistance provide a significant obstacle to effective cancer treatment (Gavas et al., 2021).

There is undoubtedly public interest in the role that diet plays in the metabolism of cancer. According to the World Cancer Research Fund and the American Institute for Cancer Research, maintaining a healthy weight, increasing physical activity, and following a balanced diet helps prevent between 30% and 40% of malignancies. Although "prevention" is probably exaggerated, the research does seem to favor risk reduction. Epidemiological studies of breast, prostate, and colon cancer have demonstrated that migration to other nations affects the overall risk of developing these cancers, which has led to theories that dietary changes may change the risk of developing cancer. One proven dietary strategy for avoiding cancer and extending life is calorie restriction. A 15% calorie cut over four years in human trials showed a persistent decrease in hormones and plasma growth factors, which have been linked to an increased risk of cancer **(**Gray et al., 2020).

- **Ketogenic Diet**

The effectiveness of the ketogenic diet in treating epilepsy and its theoretical basis makes it an appealing option. Warburg's finding that cancer cells favor anaerobic glycolysis even when oxygen is present is the basis for the suggested anti-tumor action. Moreover, glycolysis is used by cancer cells to promote fast cell division and metastasis. As a result, ketogenic diets, which are low in carbohydrates and high in fat, aim to limit the body's supply of glucose, which is what cancer cells may use. The precise macronutrient ratio varies throughout the many diet modifications. This diet's most well-known variation is most likely a 4:1 fat-to-carbohydrate and protein ratio. Studies on cells and animals have effectively employed this method. However, conflicting research also revealed that certain cancer cell lines are capable of using fatty acids and ketone bodies (Römer et al., 2021).

- **Mediterranean Diet**

The life expectancy of Mediterranean populations in Europe is high. Their diet is thought to be beneficial to their health in a number of ways. Consuming more vegetables reduced the risk for the majority of epithelial malignancies. Vegetables high in allium had a positive correlation with cancer risk as well. Cancers of the larynx and digestive tract were negatively correlated with fruit consumption. Between 15% and 40% of the population was at risk for digestive tract malignancies due to inadequate consumption of fruits and vegetables. Olive oil and unsaturated fats, which are typical aspects of the Mediterranean diet, were inversely related to the risk of several cancers, particularly of the upper aerodigestive tract. Consuming whole grain foods (and thus fiber) was also linked to a lower risk of developing several types of cancer. Conversely, refined grains were linked to higher risks, as were their glycemic load and index. Numerous food ingredients and micronutrients, such as carotenoids, flavonoids, and folate, have been shown to have inverse relationships with cancer risk; nevertheless, it is still unclear which component or components are primarily responsible for the positive effects of a diet high in fruits and vegetables (Pelucchi et al., 2009).

- **Dietary Antioxidants**

Dietary antioxidants are found in food that ensure the defense of cells, tissues, and DNA against oxidative harm of free radicals. The dietary supplements include macronutrients, minerals, and vitamins. These include tocopherol, carotenoids, ascorbic acids, vitamin D and flavonoids which act as both antioxidants and pro-oxidants. The dietary micronutrients in the form of supplements show significant improvement in the functioning of brain and body metabolism (Akanji et al., 2020).

- **Dietary Supplements**

The dietary supplements contain a wide range of nutrients, including specific phytochemicals, hormones, herbs, macronutrients, vitamins, and minerals that are vital to human health. The patients frequently suffer from nausea, vomiting, diarrhea, and appetite loss after chemotherapy or radiation treatments for cancer. This results in a decreased intake of dietary components and weight loss. Although taking supplements of vital vitamins and minerals might seem like a good idea, it's not always the case. The patients should talk to their doctors before taking any supplements because food interactions with the treatment could impact how well the therapy works. The dietary supplements with

antioxidant qualities are particularly concerning in this context, although supplements without antioxidant qualities may also affect how well cancer treatments work (Mangione et al., 2021).

2. **Personalized Nutrition in Cancer Therapy**

There is no one-size-fits-all approach is the foundation of personalized nutrition. Individual differences in response to nutrition, nutrient status, dietary patterns, eating timing, and environmental exposures are largely due to variations in biochemistry, metabolism, genetics, and microbiota. With an emphasis on the clinical and biological aspects of nutrition practice, personalized nutrition adjusts dietary recommendations to meet particular biological needs based on an individual's health. Customizing dietary advice to each person's genetic profile, cancer type, and treatment plan is known as precision nutrition, or customized nutrition. This method acknowledges that every patient has different nutritional requirements, which may change as their cancer progresses (Bush et al., 2019).

Genetic Profiling

Molecular profiling may also provide clinically useful diagnostic and prognostic data for specific cancers. Given the genomic complexity of cancers, advances in tumor analysis using next-generation sequencing (NGS) and other profiling technologies, the availability of novel therapeutic agents, and an expanding body of knowledge identifying important drivers of oncogenesis have all made precision medicine possible. Precision medicine has already revolutionized cancer treatment: certain treatments can target both common and uncommon cancers to enhance patient outcomes (Malone et al., 2020). Knowing how genetics and nutrition metabolism interact may aid in the development of more individualized and successful dietary interventions. A customized strategy might, for instance, entail altering macronutrient intake in accordance with genetic predispositions to obesity or insulin resistance, both of which are associated with a higher risk of cancer (Pilon et al., 2021).

12.3 Nutritional Support during Cancer Treatment

The reduced skeletal muscle mass is a hallmark of cachexia, a malnutrition linked to long-term conditions like cancer, chronic heart failure, chronic renal failure, and autoimmune illnesses. Patients with advanced cancer may have cancer cachexia. Along with a decrease in skeletal muscle mass, weight loss is another hallmark of cancer cachexia. Since dietary supplementation is insufficient to alleviate cachexia, cytokines and chemicals produced from tumors have gained interest as potential contributing factors. Reduced chemotherapeutic effects, more side effects and treatment interruptions, and even a lower survival rate are all linked to cancer cachexia (Nishikawa et al., 2021).

Managing Cachexia and Malnutrition

A mix of dietary changes, supplements, and prescription drugs can be used to treat cachexia and malnutrition. Certain nutrients, such as branched-chain amino acids and omega-3 fatty acids, have been demonstrated to improve the outcome of cancer patients (De Castro et al., 2022).

Cancer patients may benefit greatly from supplements both during and after therapy. It has been demonstrated that probiotics, vitamin D, and antioxidants strengthen the immune system, lessen adverse effects, and increase the effectiveness of treatment (Akanji et al., 2020).

Conclusion

Cancer is stated as abnormal cell growth and development which often spreads throughout the body and damage multiple organs. Nutrition is a critical constituent in cancer prevention and treatment. The emerging trends highlight the importance of plant's bioactive compounds, specific nutrients, alterations in dietary patterns, personalized nutrition, and genetic profiling in modulation of the risk of cancer and its outcomes. Proper nutrition protects the cellular internal and external environment from the hazards of any carcinogenic agent. It prevents genetic variations and regulate cellular normal growth mechanism. Future research should focus on translating these findings into clinical practice and developing targeted nutritional interventions.

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