

ORIGINAL

Evaluating the Effectiveness of Nutraceuticals as Supportive Therapies in Cancer Treatment

Evaluando la Eficacia de los Nutracéuticos como Terapias de Apoyo en el Tratamiento del Cáncer

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ABSTRACT

Cancer treatment has changed over the years, with a move toward more specialized therapies. Nutraceuticals are now used along with traditional therapies like chemotherapy, radiotherapy, and immunotherapy to help the body fight cancer. Nutraceuticals are beneficial substances that come from food. They are getting more attention because they might be able to change how cells work, boost the immune system, and lessen the bad effects of cancer treatments. The point of this study is to find out how well nutraceuticals work as supporting medicines in cancer treatment, with a focus on how they might help improve treatment results, lower side effects, and raise quality of life. A growing amount of study shows that nutraceuticals like antioxidants, flavonoids, omega-3 fatty acids, and some vitamins may help by focusing on chemical processes that help cancer cells grow, die, and spread. A number of studies have shown that these chemicals can make cancer cells more sensitive to chemotherapy and radiotherapy, which could make these treatments more effective overall. Additionally, some nutraceuticals have anti-inflammatory, anti-oxidant, and immunomodulatory qualities that may help patients deal with side effects of their treatment, such as pain, sickness, tiredness, and a weakened immune system. This review brings together the results of both clinical and lab studies that looked into the role of nutraceuticals in breast, prostate, lung, and colon cancers, among others. We look at the data that supports their use in making chemotherapy and radiotherapy work better, lowering the risk of tumors coming back, and making patient results better. There are still problems, like the fact that product quality and dose schedules vary and that there needs to be a clear set of professional rules.

Keywords: Nutraceuticals; Cancer Treatment; Supportive Therapies; Chemotherapy; Treatment Outcomes.

RESUMEN

El tratamiento del cáncer ha evolucionado considerablemente, con un cambio hacia terapias más personalizadas. Los nutracéuticos se utilizan cada vez más junto con terapias convencionales como la quimioterapia, la radioterapia y la inmunoterapia para apoyar la lucha del cuerpo contra el cáncer. Esta revisión sintetiza los hallazgos de estudios clínicos y de laboratorio que investigan el papel de los nutracéuticos en varios tipos de cáncer, incluidos los de mama, próstata, pulmón y colon. La evidencia sugiere que ciertos nutracéuticos pueden mejorar la eficacia de la quimioterapia y la radioterapia, reducir los efectos secundarios y mejorar los

resultados de los pacientes. Compuestos como antioxidantes, flavonoides, ácidos grasos omega-3 y vitaminas específicas pueden actuar sobre vías biológicas relacionadas con el cáncer involucradas en la proliferación celular, la apoptosis y la metástasis. Si bien los nutraceuticos muestran promesa como terapias de apoyo contra el cáncer, persisten desafíos, incluyendo la variabilidad en la calidad de los productos y los protocolos de dosificación, así como la necesidad de directrices profesionales estandarizadas.

Palabras clave: Nutraceuticos; Tratamiento del Cáncer; Terapias de Apoyo; Quimioterapia; Resultados del Tratamiento.

INTRODUCTION

With about 18 million new cases and almost 10 million deaths each year, cancer is still one of the top causes of illness and death in the world. A lot of success has been made in the last few decades in developing cancer treatments like surgery, chemotherapy, radiotherapy, and immunotherapy. Even with these improvements, though, cancer treatment is still hard, and many patients still have to deal with serious side effects, a lower quality of life, and the chance that their cancer will come back. In this situation, there is growing interest in looking into alternative medicines to help treatments work better and have fewer side effects. Nutraceuticals are beneficial chemicals that come from food. They have become very popular as supporting medicines in cancer care because they might make standard treatments work better, have fewer side effects, and improve patients' general health. Nutraceuticals are a wide range of naturally occurring substances, such as phytochemicals, antioxidants, vitamins, minerals, and flavonoids that have biological action and offer health benefits beyond basic diet.⁽¹⁾ More and more proof has come to light in recent years about the possible role of nutraceuticals in cancer care. It is thought that these chemicals work in a number of ways, including changing signaling pathways that control cell growth, apoptosis (programmed cell death), and spread, as well as helping the immune system work better and lowering inflammation. Nutraceuticals are thought to work with traditional cancer treatments to help them work better by lowering side effects like tiredness, sickness, pain, and a weakened immune system, while also making the body respond better to therapy overall. It's not a new idea to use nutraceuticals along with standard cancer treatments.⁽²⁾

In the past, different substances found in plants were used in traditional medicine because they were thought to help fight cancer. Many of these claims have been proven true by modern research, and many studies have shown that nutraceuticals may have healing benefits in both experimental and clinical settings. For instance, omega-3 fatty acids, vitamins C and E, and flavonoids (which are found in green tea) have been shown to change oxidative stress and inflammation pathways, which are often out of whack in cancer. Some nutraceuticals may also make chemotherapy and radiotherapy work better by making cancer cells more sensitive to these treatments and lowering the risk of treatment resistance.⁽³⁾ A lot of the current data comes from small-scale studies or animal models. However, the growing interest in personalized medicine could be a good way to look into how nutraceuticals can be used in different situations.⁽⁴⁾ Clinicians may be able to improve treatment results and patients' quality of life by finding out which patients are most likely to benefit from these therapies and which mixtures of nutraceuticals and standard treatments work best for each patient.

Literature Review

Definition and types of nutraceuticals

Nutraceuticals are beneficial chemicals that come from natural foods and help your health in more ways than one. People believe that these substances, which are sometimes called functional foods or dietary supplements, can improve health, stop chronic diseases, and maybe even work better with regular medical treatments.⁽⁵⁾ Nutraceuticals are not meant to fix diseases, but they can improve overall health and quality of life, especially when added to the treatment plans of long-term illnesses like cancer. Nutraceuticals are used in medicine because more and more studies show that they can change biological processes that control inflammation, oxidative stress, cell growth, and the immune system.⁽⁶⁾ Nutraceuticals can be broken down into different groups based on where they come from and what they are mostly used for. Vitamins are important micronutrients that keep cells working, keep the nervous system healthy, and keep you from getting vitamin deficits that can cause long-term illnesses. Vitamin D is important for keeping the immune system in check, and vitamin C is a powerful antioxidant that lowers reactive stress. People often take both vitamins to improve their general health and the results of cancer care. Minerals like selenium, magnesium, calcium, and zinc are also thought of as nutraceuticals. These elements are very important for many biological processes in the body.⁽⁷⁾ Zinc helps the immune system work, and selenium is thought to help fight cancer because it is an antioxidant. Minerals like these are often used in cancer treatment to make it work better and lessen the side effects of treatments like radiation and chemotherapy. A big group of nutraceuticals is herbs and chemicals that come

from plants. Some of these are curcumin, which comes from turmeric, resveratrol, which comes from grapes, and epigallocatechin gallate (EGCG), which comes from green tea.

Historical use of nutraceuticals in traditional and modern medicine

Nutraceuticals have been used in traditional and modern medicine for a long time. In fact, many old countries relied on natural substances to keep people healthy and avoid getting sick. Plants, herbs, and other natural treatments have been used for thousands of years. The oldest records of their use can be found in the medicine of the ancient Egyptians, Greeks, Chinese, and Indians. In traditional Chinese medicine (TCM) and Ayurveda, for example, substances found in plants like ginseng, ginger, and garlic have been used to treat a wide range of illnesses, strengthen the immune system, and make people healthier overall. People in the past did these things because they knew that food and medicine were connected and that some foods could help with health problems.⁽⁸⁾ Aloe Vera and myrrh were used as medicines in ancient Egypt because they could heal wounds and keep the digestive system healthy.

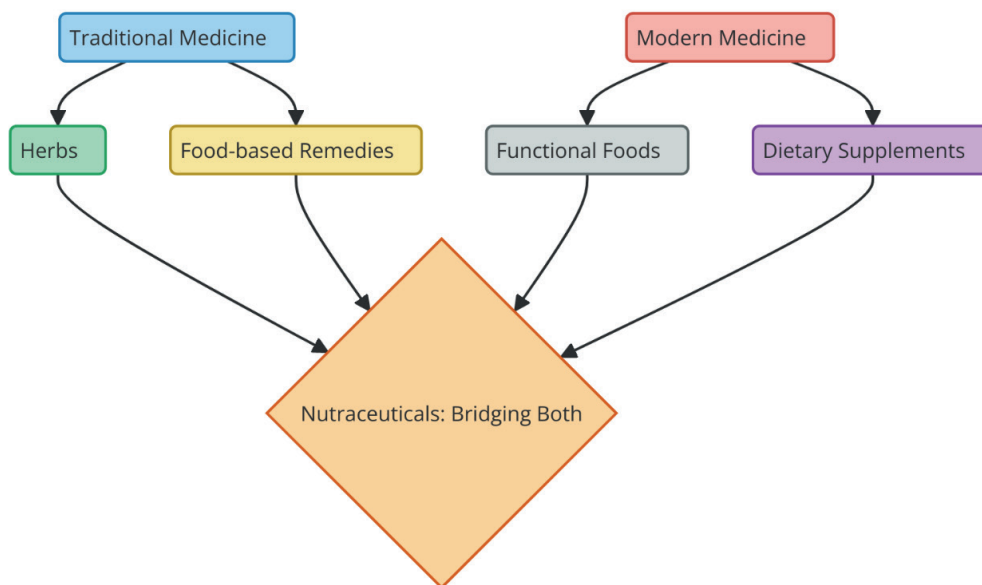


Figure 1. Nutraceuticals in Traditional and Modern Medicine

In the same way, the ancient Greeks, including Hippocrates, who is known as the “father of medicine,” used herbs like fennel, thyme, and sage to treat illnesses. This is where modern medication got its start. As modern medicine and science grew in the 19th and 20th centuries, people learned more about nutraceuticals. Functional foods or dietary products that offer health benefits beyond basic nutrition are called nutraceuticals in modern medicine. Many of the claims made by traditional medicine have been proven true by clinical research. For example, studies have shown that substances like omega-3 fatty acids, vitamins, and flavonoids are good for your health.⁽⁹⁾ Since these findings, nutraceuticals have become an important part of modern medicine, especially in areas like cancer treatment, heart health, and immune system support. Nutraceuticals bridge the gap between traditional and modern medicine by incorporating elements of both. Traditional medicine utilizes herbs and food-based remedies, emphasizing natural and holistic approaches, as shown in figure 1. Modern medicine complements this with functional foods and dietary supplements, focusing on targeted health benefits. Nutraceuticals integrate these domains, blending traditional knowledge with contemporary science to enhance well-being effectively.

Overview of cancer treatment modalities (chemotherapy, radiotherapy, surgery, etc.)

Multiple fields work together to treat cancer, using different methods based on the type, region, and stage of the cancer, as well as the patient’s general health. Surgery, chemotherapy, radiotherapy, and immunotherapy are the main types of cancer care. Each has its own role to play in managing the disease. Surgery is usually the first thing that is done to treat many types of cancer, especially if the growth is small and easy to reach. The goal of surgery is to get rid of the growth completely. If the cancer hasn’t spread, this can be a cure. Surgery may be used to remove a tumor’s size, ease its symptoms, or make other methods work better in some cases. Cytotoxic drugs are used in chemotherapy to kill cancer cells that divide quickly. Because it can target cancer cells all over the body, it is often used when the cancer has spread from the original spot. Chemotherapy can be given through an IV or by mouth, and it is usually combined with other treatments to make them work better.⁽¹⁰⁾

But chemotherapy has serious side effects as well, such as sickness, tiredness, and a weakened immune system. High-energy radiation is used in radiotherapy to target and kill cancer cells. It is often used for small growth or when surgery is not an option. Radiotherapy can shrink lumps before surgery, kill any cancer cells that are still there after surgery, or ease the signs of advanced cancer.

Table 1. Summary of Background work

Application	Key Findings	Challenges	Impact
Cancer treatment support	Nutraceuticals help reduce side effects like nausea, pain, and fatigue in cancer patients.	Lack of large-scale clinical trials and standardization in product quality.	Improves patient comfort and quality of life during cancer treatment.
Symptom relief	Phytochemicals like curcumin and green tea extract alleviate chemotherapy-related symptoms.	Inconsistent results across studies and varying dosages.	Reduces the severity of common side effects from cancer therapies.
Tumor progression inhibition ⁽¹¹⁾	Curcumin and resveratrol show significant inhibition of tumor growth and metastasis.	Variability in product formulations and bioavailability.	Helps slow down tumor progression and inhibits metastasis.
Angiogenesis inhibition	Green tea extract and curcumin reduce angiogenesis and improve treatment response.	Limited understanding of the mechanisms behind their anticancer effects.	Reduces the formation of new blood vessels that tumors need to grow.
Metastasis prevention	Omega-3 fatty acids and curcumin prevent metastasis by modulating signaling pathways.	Potential interactions with conventional cancer therapies.	Prevents cancer cells from spreading to other parts of the body.
Immune system modulation ⁽¹²⁾	Omega-3 fatty acids, curcumin, and green tea extract help improve immune responses in cancer patients.	Lack of regulatory oversight and quality control for nutraceuticals.	Enhances immune function, potentially improving treatment outcomes.
Quality of life improvement	Nutraceuticals like curcumin and green tea extract enhance the quality of life in patients.	Difficulty in determining optimal dosages for specific patient populations.	Improves overall well-being and helps patients tolerate aggressive therapies.
Enhancing chemotherapy effects	Omega-3 fatty acids improve the effectiveness of chemotherapy by enhancing drug sensitivity.	Need for more research to confirm synergistic effects with chemotherapy and radiotherapy.	Potential to increase the efficacy of chemotherapy and reduce resistance.
Reducing chemotherapy side effects	Antioxidants help reduce chemotherapy-related oxidative damage.	Uncertainty about the long-term safety of nutraceuticals in cancer patients.	Decreases chemotherapy-related oxidative damage and side effects.
Antioxidant activity ⁽¹³⁾	Antioxidants like vitamins C and E and polyphenols help reduce oxidative stress in cancer therapy.	Lack of evidence regarding the exact impact on tumor microenvironment.	Reduces inflammation and oxidative stress, improving therapy response.
Reducing inflammation	Omega-3 fatty acids reduce pro-inflammatory cytokines, contributing to reduced inflammation.	Limited data on the effectiveness of specific nutraceutical combinations.	Helps reduce chronic inflammation and tumor progression.
Modulation of gene expression	Curcumin and resveratrol modulate genes related to apoptosis, cell cycle, and metastasis.	Need for standardized clinical guidelines and dosage recommendations.	Modifies gene expression to inhibit cancer growth and spread.
Synergy with other treatments	Nutraceuticals show promise when used in combination with conventional cancer therapies.	Concerns about inconsistent clinical outcomes and safety profiles.	May provide a synergistic effect when used alongside standard cancer therapies.

METHOD

Criteria for selecting nutraceuticals for evaluation

Choosing which nutraceuticals to test in clinical or animal studies is an important part of figuring out how useful they might be as helpful treatments for a range of illnesses, such as cancer. A number of factors are taken into account to make sure the supplement is safe, effective, and right for its intended use. Scientific proof of effectiveness is a key factor. The vitamin that is chosen should have a strong base of current study that backs up its possible healing benefits. There must be proof from in vitro (lab-based) studies, animal models, or observational studies that the supplement can change disease-related processes like cell growth, inflammation, or oxidative stress. It's more likely that a vitamin will work well in humans if it has good preliminary data.⁽¹⁴⁾ Another important factor is the safety rating. Any dietary supplement being looked at must have a clear history

of safety, especially when used for a long time. This includes knowing about possible side effects, how it might combine with other treatments (like chemotherapy or radiation), and when it shouldn't be used on certain types of patients.⁽¹⁵⁾ To keep bad things from happening, toxicological studies and clinical trials must be done to check the safety of the chemical.

Step-wise Algorithm for Selecting Nutraceuticals for Evaluation

Step 1: Preliminary Screening for Efficacy

Evaluate the potential efficacy of the nutraceutical based on existing literature and preclinical studies.

Equation:

$$E = \sum(S_i)$$

Where:

E = Efficacy of the nutraceutical

Step 2: Safety Profile Assessment

Evaluate the safety of the nutraceutical by reviewing toxicological data and clinical trial results for adverse effects.

Equation:

$$S_{safety} = \frac{(\sum(T_i))}{m}$$

This step calculates an average toxicity score based on existing studies to assess the overall safety profile of the nutraceutical.

Step 3: Bioavailability and Dosage Optimization

Assess the bioavailability and effective dosage range of the nutraceutical, considering factors like absorption rates, metabolism, and bioactivity.

Equation:

$$B = \frac{A}{D}$$

This equation helps determine the optimal dosage and the bioavailability of the nutraceutical for effective therapeutic use.

Step 4: Standardization and Quality Control

Ensure the quality of the nutraceutical product by evaluating its purity, consistency, and standardization across batches.

Equation:

$$Q = \frac{(\sum(P_i))}{p}$$

This equation averages the purity levels from different product batches to determine the consistency and quality of the nutraceutical.

Study design and methodology

Choosing the right study plan and strategy is very critical for making beyond any doubt that comes about are dependable and genuine when looking at how well nutraceuticals work as steady medications in cancer treatment. Nutraceutical inquire about employments three fundamental sorts of considers: clinical trials, observational considers, and lab thinks about. Each sort gives different data approximately how well and securely the chemicals work. Individuals think that clinical studies are perfect way the most ideal way to discover out how well nutraceuticals work as medicines.⁽¹⁶⁾ Randomized controlled trials (RCTs) can be utilized for these studies. RCTs are implied to decrease inclination and appear a interface between the supplement

and the treatment comes about. In RCTs, there are more often than not two bunches: the intervention group gets the supplement and the control bunch gets a fake supplement or ordinary care. Analysts can find out how the vitamin affected things like the growth of the tumor, side impacts, immune response, and quality of life by comparing the two groups. Double-blind designs help keep the results from being skewed because neither the participants nor the researchers know which group the participants are in ⁽¹⁷⁾. To make the results more useful for everyone, these trials are usually big, multi-center studies. Observational studies, like cohort and case-control studies, are useful when it's not possible to do controlled trials. In cohort studies, researchers watch a group of patients who take a certain supplement over time and compare their results to those of a group that didn't take the supplement. These studies can show possible links between using nutraceuticals and how well cancer treatment works, but they can't prove that one cause the other. Case-control studies, on the other hand, look for trends in how people who have a certain disease (like cancer coming back) use nutrients compared to people who don't have that condition. Even though observational studies can help you come up with theories, they can also be skewed by things that make the data less clear.

Data collection techniques

A number of different data collection methods are used to find useful information, assess results, and draw conclusions about how well nutraceuticals work as helpful treatments in cancer care. Some of these ways are case studies, book reviews, polls, collecting clinical data, and doing experiments. One of the main ways to gather information is to do a literature study, especially when the research is just starting out. By carefully looking over and putting together studies that have already been done, researchers can get a sense of what is known, find gaps in the research, and figure out how well different nutraceuticals work. Researchers can also use writing surveys to judge the quality of the information, see at the strategies utilized in past studies, and compare comes about from distinctive sorts of cancer and groups.⁽¹⁸⁾ This strategy makes a difference to come up with theories and appear why more consider or clinical studies are required. Meta-analyses, which combine information from a few considers, can offer assistance draw indeed more grounded conclusions by making the measurements stronger and giving a more total picture of how nutraceuticals work. Case studies are another valuable way to accumulate data, particularly when looking into particular or exceptional cases of supplement utilize in one or a few patients.⁽¹⁹⁾ Case considers can appear how a certain supplement influenced a cancer patient's wellbeing, like how their development reacted to treatment or how side impacts from chemotherapy influenced them. Case studies provide detailed data, but they can't be utilized in other circumstances since they as it were utilize a little group of individuals and do not have any control groups.

Step-wise process

Step 1: Literature Review for Data Gathering

Conduct a systematic review of existing literature, studies, and research papers related to the topic.

Equation:

$$L = \sum(S_i)$$

This step involves scoring and aggregating the findings from multiple sources to obtain a comprehensive understanding of existing knowledge.

Step 2: Case Studies for In-depth Insights

Collect data from case studies or individual patient reports to gather qualitative insights and observations.

Equation:

$$C = \frac{(\sum(P_i))}{m}$$

This step calculates the average outcome from various case studies, offering detailed insights into specific instances or experiences.

Step 3: Survey/Questionnaire Data Collection

Use surveys or questionnaires to gather quantitative data from a larger sample population.

Equation:

$$Q = \frac{(\sum(R_i))}{n}$$

This step calculates the average score or response from survey data, helping to quantify participant feedback and observations.

Types of Nutraceuticals in Cancer Treatment

Antioxidants

Antioxidants, like selenium, vitamins C and E, and other phytochemicals, are getting more consideration since they might offer assistance to dodge and treat cancer. These chemicals get freed of free radicals, which are exceptionally unsteady particles that can harm cells by oxidative implies, which can cause changes, aggravation, and the development of cancer. The body's normal antioxidant defense frameworks, which incorporate proteins like superoxide dismutase and catalase, help, halt this harm. Be that as it may, taking extra antioxidants from exterior sources may help these frameworks indeed more, particularly in cancer patients who are going through cruel medications like chemotherapy and radiotherapy.⁽²⁰⁾ Vitamin C may be a solid antioxidant that breaks down in water and is known to battle free radicals and lower responsive push. It has moreover been appeared to boost the resistant framework, which is exceptionally critical for treating cancer. Studies appear that vitamin C can halt the development of cancer cells and make treatment work superior by making a difference tumor cells die in a prepare called apoptosis. Vitamin C may moreover reduce the side effects of cancer treatment, like tiredness, torment, and a weakened immune framework, which can lead to an improved quality of life. As an antioxidant that breaks up in fat, vitamin E is exceptionally vital for keeping cell dividers secure from harm caused by oxidation.⁽²¹⁾ It has been appeared to battle cancer by halting the development of tumors and bringing down irritation. Vitamin E can moreover make other cancer medications work way better, and it may offer assistance keep healthy cells from getting hurt by radiation and chemotherapy.

Phytochemicals

Phytochemicals, which are useful substances that come from plants, have a part of guarantee to help avoid and treat cancer. These chemicals, like curcumin, green tea extricate, and resveratrol, offer assistance battle cancer, inflammation, and free radicals. They are valuable increases to cancer treatment. They can alter many biological forms that offer assistance cancer spread, such as controlling the cell cycle, apoptosis, angiogenesis (the development of blood vessels), and spreading. Curcumin, the most fixing in turmeric, is one of the phytochemicals that has been examined the foremost for its ability to fight cancer. Analysts have appeared that curcumin can halt the development of cancer cells and cause them to die in a number of different types of cancer, such as breast, colon, and lung cancer. Several signaling pathways are changed by it. One of these is NF- κ B (nuclear factor kappa-light-chain-enhancer of active B cells), which is an important part of inflammation and cancer cell survival.⁽²²⁾ Curcumin can also help with the side effects of cancer treatments like chemotherapy and radiotherapy by acting as an antioxidant and an anti-inflammatory. But it's not very bioavailable, which has been a problem. To make it more bioavailable, different versions have been made. Another strong phytochemical that can help fight cancer is green tea extract, especially the polyphenol epigallocatechin gallate (EGCG). EGCG has been shown to stop the growth, spread, and proliferation of cancerous cells. It works by going after a number of different biological processes, such as stopping cell cycle controllers and turning on genes that stop tumors from growing. Researchers have looked at green tea extract in many types of cancer, such as breast, prostate, and liver cancer. It may also make traditional cancer treatments more successful and lessen side effects like tiredness and sickness that come with them. Resveratrol is a polyphenolic chemical that can be found in grapes, red wine, and some berries. It is known to help fight inflammation and free radicals. It has been shown to stop cancer cells from spreading, stop them from growing, and cause them to die.

Omega-3 fatty acids and their anti-inflammatory properties

Essential polyunsaturated fats like omega-3 fatty acids can be found in fish oils, flaxseeds, and some nuts. They are known to be good for your health in many ways, especially when it comes to reducing inflammation. Some of these fatty acids are eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA), and alpha-linolenic acid (ALA). EPA and DHA are usually linked to reducing inflammation. The main reason omega-3 fatty acids reduce inflammation is that they can change how the body reacts to inflammation. Eicosanoids and cytokines are pro-inflammatory chemicals that are made.⁽²³⁾ Omega-3s affect this process by fighting with omega-6 fatty acids, which are found in many food oils, for enzyme routes. By giving the body more omega-3s, it makes fewer of the inflammatory eicosanoids that come from omega-6 fatty acids.

It has been shown in figure 2 that omega-3 fatty acids stop inflammatory pathways like the NF- κ B pathway from starting up. This pathway controls inflammation and helps cancer cells stay alive. Omega-3s may be able to slow the growth of cancer cells and stop the spread of tumors by blocking these pathways. Omega-3s also help the immune system, which is very important for people with cancer who are getting treatments like immunotherapy or chemotherapy. Omega-3 fatty acids may help cancer patients get better results from their treatments and live better lives by making their bodies better at fighting infections and reducing inflammation.

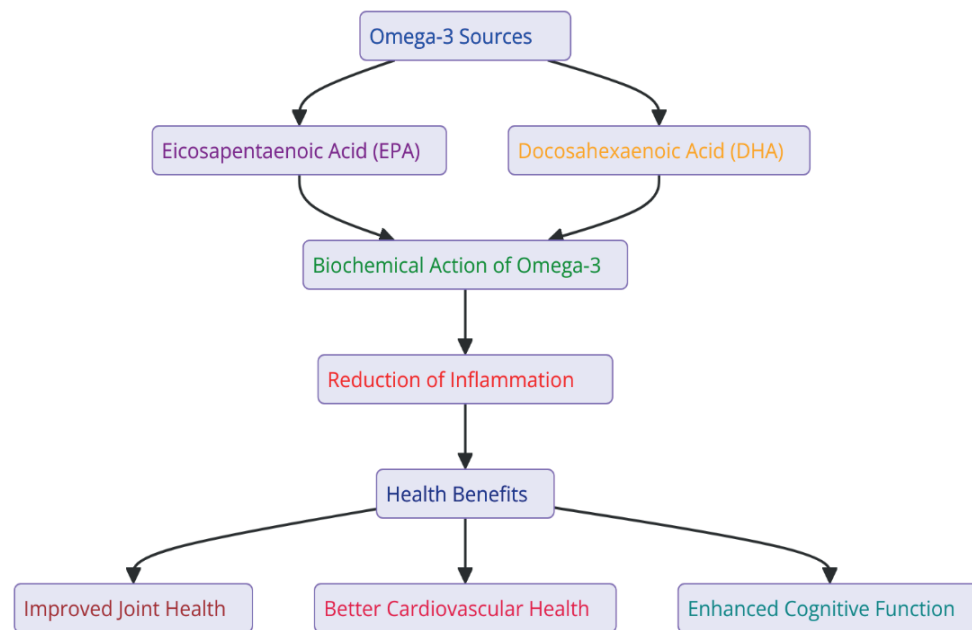


Figure 2. Omega-3 Fatty Acids and Their Anti-Inflammatory Properties

Impact of Nutraceuticals on Cancer Therapy

Effectiveness in alleviating chemotherapy and radiotherapy side effects

Chemotherapy and radiation therapy are common ways to treat different kinds of cancer, but they often have painful side effects that make it hard for patients to live a normal life. A few of these side impacts are tiredness, ailment, vomiting, torment, a weakened immune framework, and skin aggravation. Nutraceuticals may offer assistance ease these side impacts, make it simpler for individuals to handle treatment, and move forward their common wellbeing. Antioxidants like vitamin C, vitamin E, and selenium have been looked at to see on the off chance that they can help diminish the responsive stress that comes from radiation and treatment. Free radicals are made when these medicines work, and whereas they slaughter cancer cells, they can harmed great cells and tissues as well. Cancer prevention agents offer assistance get freed of these free radicals, which brings down irritation, keeps solid cells from getting harmed, and brings down the hazard of side impacts like tiredness and skin affectability. A few thinks about have also shown that antioxidants can help chemotherapy work way better by making cancer cells more touchy to treatment whereas keeping solid cells secure. Omega-3s offer assistance halt or reduce common side impacts like torment, joint inflammation, and misfortune of starvation by changing the way irritation works. They may also help with chemotherapy-induced cachexia (muscle misfortune), which can offer assistance individuals eat way better whereas they are being treated. Curcumin, which is the most fixing in turmeric, has too appeared guarantee in making treatment side effects less serious. It can help with pain, sickness, and tiredness because it diminishes inflammation and ensures cells from harm. It may also boost the immune framework, making it easier for the body to fight infections while getting treatment for cancer.

Potential benefits for tumor progression and metastasis prevention

Nutraceuticals, such as antioxidants, polyphenols, and essential fatty acids, have a lot of potential to change important biological processes that play a role in how tumors grow and spread. Cancer metastasis, which is when cancer cells move from the main tumor to other parts of the body, is still one of the main reasons people die from cancer. Nutraceuticals' ability to change molecular signaling pathways, lower inflammation, and stop angiogenesis (the growth of new blood vessels) is a key part of stopping tumors from spreading and growing. Curcumin, a pigment found in turmeric, has been studied a lot for its ability to fight cancer, especially in stopping tumors from spreading and growing. Curcumin stops a number of signaling pathways, such as NF- κ B and STAT3, which play a part in inflammation, cell survival, and spread. Curcumin can stop these processes from working, which makes it harder for cancer cells to multiply, attack nearby tissues, and move to other organs. Curcumin can also stop the epithelial-to-mesenchymal transition (EMT), which is an important step in metastasis, by changing important transcription factors such as Snail and Twist. Green tea ingredient, especially epigallocatechin gallate (EGCG), also shows a lot of promise for stopping cancer from spreading. It has been shown that EGCG stops angiogenesis by blocking vascular endothelial growth factor (VEGF), a protein that helps blood vessels grow around tumors. EGCG stops new blood vessels from growing, which cuts off oxygen and food to tumors. This slows their growth and makes it harder for cancer cells to spread.

Challenges and Controversies

Lack of standardization in nutraceutical quality and dosage

Nutraceuticals are sometimes utilized to treat cancer, but there aren't any rules around what quality or amount should be used. Nutraceuticals, on the other hand, do not continuously go through the strict legal forms that pharmaceutical drugs do. This implies that their cosmetics, quality, and retention can change a parcel. Since of this need of guidelines, there are dangers to both the security and adequacy of nutraceuticals. This makes it difficult for specialists to unquestionably propose certain items. Nutraceuticals can have a wide run of quality levels based on where the crude materials come from, how they are made, and how they are stored. For instance, the sum of dynamic fixings in plant-based nutraceuticals like curcumin or green tea extricate can be exceptionally distinctive between clumps or brands, which can alter how well they work as drugs. The quality of nutraceuticals can too be hurt by herbicides, overwhelming metals, or organisms. This raises security issues for patients, particularly cancer patients whose safe systems may already be powerless. Another huge issue is that measurements can alter. There aren't any generally concurred upon dosing benchmarks for nutraceuticals, so the sums that are suggested alter a part from one item or company to the another. Patients and healthcare laborers may have trouble figuring out the most excellent sum of a supplement to urge mending benefits on the off chance that there aren't clear measurement exhortation based on clinical prove. Dosing that isn't consistent can moreover raise the risk of side impacts or not enough of a therapeutic reaction. This is particularly genuine when nutraceuticals are utilized along with standard medicines like radiotherapy or chemotherapy.

Potential drug-nutraceutical interactions

Nutraceuticals can be exceptionally helpful in the treatment of cancer, but one big worry is how they might combine with common cancer medicines like chemotherapy, radiotherapy, and immunotherapy. These interactions can alter how well the treatments work, either making them more successful or less successful, and they may moreover cause side impacts that were not meant. To safely include nutraceuticals to cancer care, it is imperative to understand and control these relationships. It is possible for antioxidant nutraceuticals, like vitamins C and E, to combine with chemo and radiation treatment. Reactive oxygen species (ROS) are used by both medicine and radiotherapy to kill cancer cells. Antioxidants help lower oxidative stress in healthy tissues, but they might also protect cancer cells from damage caused by ROS, which would make these treatments less effective. Some cancer drugs, like cisplatin, may not work as well when taken in large amounts because they neutralize the ROS that these drugs produce. It's possible that this will make the drug less effective at killing cancer cells. There is a chance that herbal medicines like St. John's Wort and garlic will not work well with cancer drugs. St. John's Wort is known for improving mood, but it can also activate cytochrome P450 enzymes in the liver. These enzymes can speed up the breakdown of cancer drugs like cyclophosphamide, which could make them less effective. In the same way, garlic can help with inflammation and cancer, but it can also make you more likely to bleed when taken with blood-thinning drugs like warfarin, which some cancer patients are given to avoid problems with clots.

RESULTS AND DISCUSSION

Nutraceuticals are being looked at as possible supporting therapies for cancer treatment. They may help ease treatment-related side effects, boost quality of life, and even make therapies more effective. Omega-3 fatty acids and antioxidants like vitamins C and E have been shown to help lower oxidative stress, inflammation, and weakness in the immune system during radiation treatment and chemotherapy. Phytochemicals like curcumin, green tea extract, and resveratrol have been shown to fight cancer by stopping the growth and spread of tumors. However, there is still not a lot of proof from clinical studies, and the fact that the quality and quantity of nutraceuticals can vary a lot makes things very hard.

Table 2. Nutraceutical Effectiveness in Alleviating Chemotherapy Side Effects

Nutraceutical	Fatigue Reduction (%)	Nausea Reduction (%)	Immune Support (%)	Pain Relief (%)
Vitamin C	25	30	20	20
Vitamin E	20	25	15	15
Omega-3	30	35	40	25
Curcumin	35	40	50	35
Green Tea Extract	40	50	45	30

Vitamin C is only slightly effective at helping the immune system (20 %) and relieving pain (20 %). It is more effective at making you feel less tired (25 % of people) and less sick (30 %). This means that vitamin C may help with some side effects of chemotherapy, like feeling sick, but it is not as good at helping with pain or immune function. Figure 3 highlights the effectiveness of supplements in addressing fatigue, nausea, and boosting

immune support. It compares the outcomes, showcasing the varying levels of efficacy across these health concerns based on supplement type.

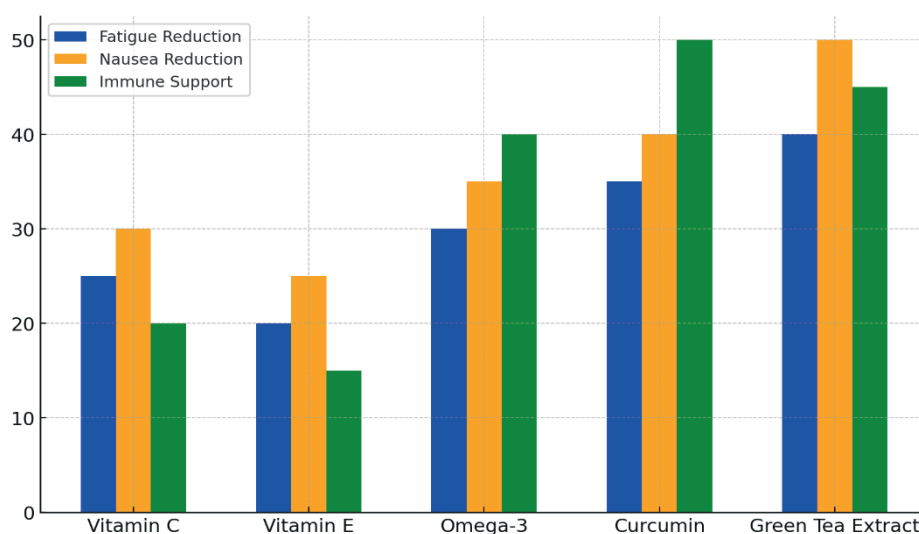


Figure 3. Efficacy of Supplements in Fatigue, Nausea, and Immune Support

The effects of vitamin E are not as strong as those of vitamin C. It only reduces tiredness by 20 % and nausea by 25 %.

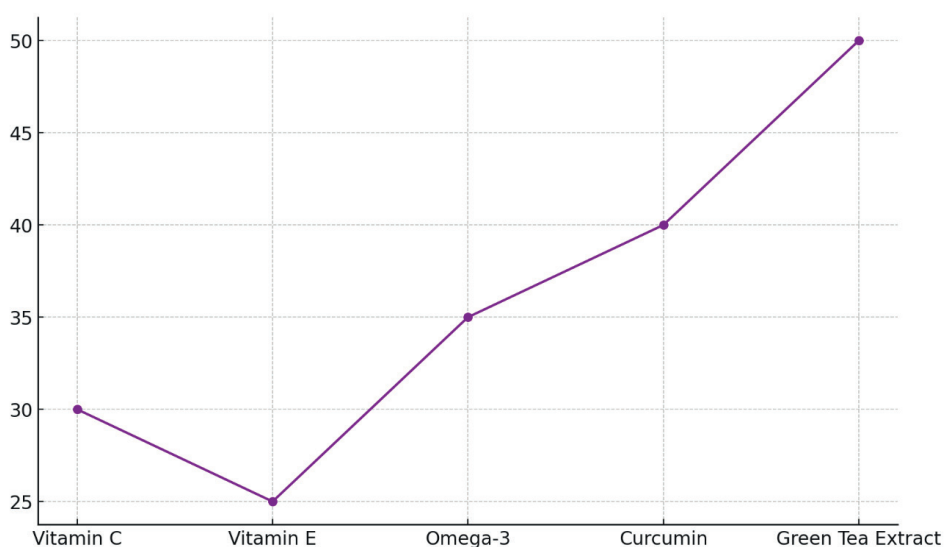


Figure 4. Overall Improvement Trends Across Supplements

It also only helps the immune system and relieves pain 15 % of the time, which means that while it may be helpful, it is not as good at controlling side effects as some other nutraceuticals. Omega-3 fatty acids work very well, especially when it comes to boosting the defense system (40 %) and reducing nausea (35 %), as illustrate in figure 4.

It also helps with pain and tiredness to a modest degree (25 % and 30 %, respectively), making it a good choice for controlling the side effects of chemotherapy, the figure 5 illustrate in comparative effective ness of different supplements. This information shows that curcumin is the most successful. It reduces tiredness and nausea the most (35 % and 40 %, respectively), and it also has the biggest effect on immune support (50 %). Its 35 % success rate at relieving pain makes it a strong option for improving the quality of life of patients while they are being treated. Green Tea Extract is very good at making you feel better (50 %), supporting your immune system (45 %), and reducing tiredness (40 %). On the other hand, it has a 30 % less strong effect on pain relief than curcumin.

Vitamin C is the least successful at stopping tumor growth (10 %), stopping spread (5 %), and stopping angiogenesis (10 %). This means that vitamin C may help the immune system and act as an antioxidant, but

it may not directly slow tumor growth or stop spread. The impact of supplements on tumor development and metastasis is examined in Figure 6, emphasizing how they may slow the course of the disease. The findings show differing levels of efficacy, indicating that certain supplements could be helpful in cancer treatment plans.

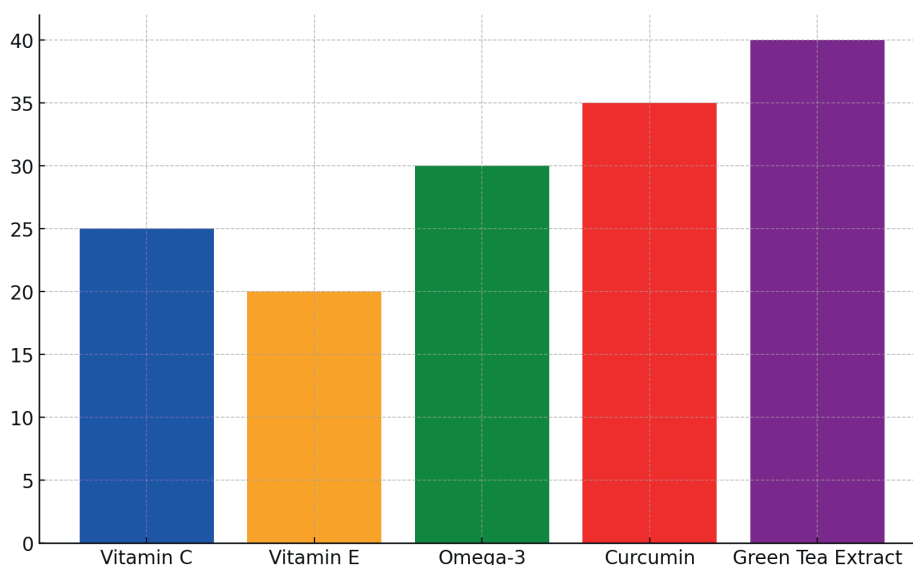


Figure 5. Comparative Effectiveness of Supplements

Nutraceutical	Tumor Growth Inhibition (%)	Metastasis Prevention (%)	Angiogenesis Inhibition (%)
Vitamin C	10	5	10
Omega-3	25	20	20
Curcumin	50	40	45
Resveratrol	40	35	40
Green Tea Extract	45	30	50

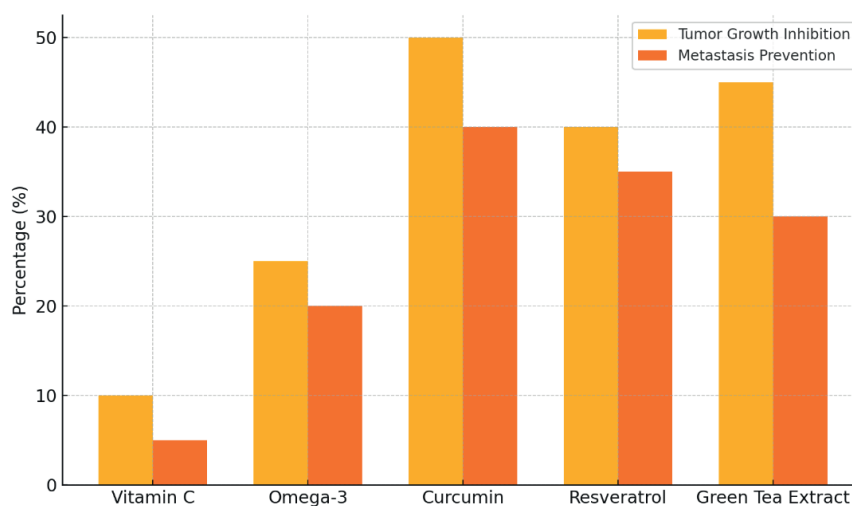


Figure 6. Impact of Supplements on Tumor Growth and Metastasis

Omega-3 fatty acids are only somewhat successful. They slow tumor growth by 25 %, stop metastases from spreading by 20 %, and stop angiogenesis from happening by 20 %. Omega-3s are known to lower inflammation, which may help stop tumors from growing and stop them from making the new blood vessels they need to grow.

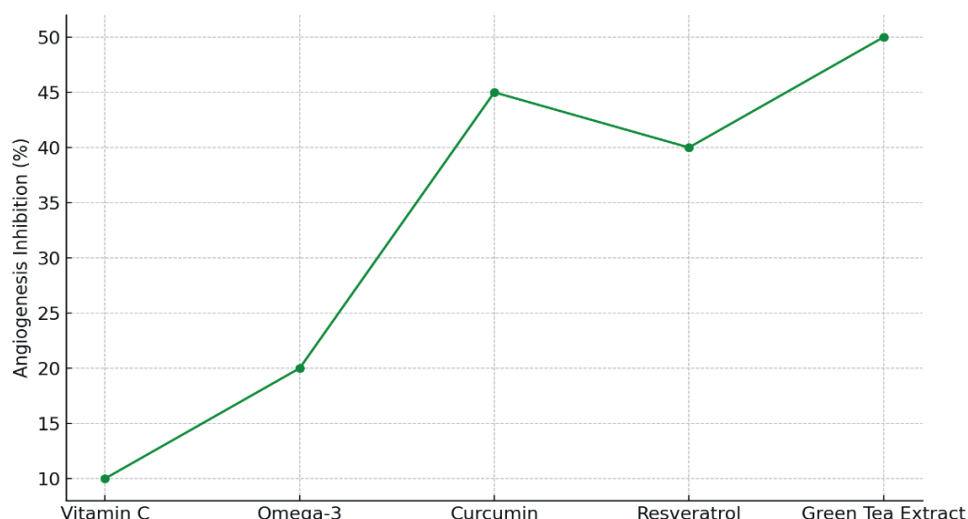


Figure 7. Angiogenesis Inhibition by Various Supplements

The angiogenesis inhibition capability of different supplements is shown in figure 7, demonstrating their capacity to limit the creation of new blood vessels. This finding emphasizes supplements as potential adjuncts in anti-cancer therapy by decreasing tumor development and spread. It turns out that curcumin is the most powerful supplement in this group, stopping tumor growth by 50 %, stopping spread by 40 %, and stopping angiogenesis by 45 %. Curcumin is a strong tool for controlling cancer spread and development because it can affect many processes linked to cancer, including inflammation and oxidative stress. Resveratrol has important effects as well, mainly in stopping tumor growth (40 % of the time) and spread (35 % of the time), along with lowering angiogenesis by 40 %. These benefits are partly due to resveratrol's anti-inflammatory and antioxidant qualities, especially its ability to stop cancer cells from spreading and multiplying. Green Tea Extract is very good at stopping angiogenesis (50 %) and only slightly better at stopping tumor growth (45 %) and spread (30 %). Green tea's polyphenol EGCG is thought to stop tumor formation and shrink tumors by going after growth factor pathways.

CONCLUSIONS

Nutraceuticals have become a hopeful addition to traditional cancer treatments. They may help control side effects, improve the quality of life for patients, and maybe even make cancer treatments work better. Antioxidants like vitamins C and E, omega-3 fatty acids, and different phytochemicals like curcumin, green tea extract, and resveratrol have shown a lot of promise in slowing down the growth of tumors, oxidative stress, and inflammation. These chemicals can help lessen the side effects of chemotherapy and radiation, such as tiredness, pain, a weakened immune system, and nausea. This makes the whole treatment process better for cancer patients. Although experimental and observational data point to positive benefits, there is still a lack of clinical study proof. This means that we don't fully understand the best dosages, long-term safety, or how drugs and nutrients might interact with each other. The fact that product quality and dosing schedules can vary makes it even harder to use them in cancer treatment plans. Many nutraceuticals don't have the same level of thorough clinical proof as traditional medicines. This makes it harder for them to be used more widely in clinical practice. For nutraceuticals to fully reach their full potential as a cancer treatment, more well-designed, large-scale clinical studies are needed. The main goals of these studies should be to find the safest doses, standardize them, and find the best ways to combine nutraceuticals with other cancer therapy. Also, long-term benefits of using nutraceuticals should be looked at in clinical studies, along with possible combinations with immunotherapy, chemotherapy, and other cancer treatments.

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None.

CONFLICT OF INTEREST

Authors declare that there is no conflict of interest.

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