iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 **Issue:** I **Month of publication:** January 2025

DOI: https://doi.org/10.22214/ijraset.2025.66432

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue I Jan 2025- Available at www.ijraset.com

A Systematic Review on Neutraceutical

Vikrant Bharde[1], Akash Gore[2], Jalba Guntapalle[3], Omkar Naik[4], Ankita Bhojane[5]
Shivlingeshwar College of Pharmacy, Almala

Abstract: ***Truly, nutraceuticals transformed the whole healthcare system with a view toward disease prevention and treatment as a whole. In this replete review, a multinational and complex world of nutraceuticals is brought stage-after-stage definition, historical progression, and categorization. It will deal with various nutraceuticals such as dietary supplements, functional foods, herbal extracts, probiotics with their underlying mechanisms of action and bioactive compounds. The wide-ranging benefits extended as health benefits by nutraceuticals-stating cardioprotective and anticancer properties along with neuroprotective and immunomodulatory benefits are highlighted by the review. The review also addresses some crucial issues concerning safety, efficacy, regulation, standardization, and quality control. It finally takes a look into the future in regard to newer and emerging trends and innovations, which include personalized nutrition, nanotechnology, and even synthetic biology. This review would be the first foundation stone for researchers, healthcare professionals, and industry experts who want to exploit the transformational potential of nutraceuticals.***

Keywords: Nutraceuticals, Dietary supplements, Bioactive compounds, Probiotics, Prebiotics, Gut microbiota, Cardiovascular health, Cancer prevention, etc.

I. INTRODUCTION

A large part of the 21st century has completely been a paradigm shift from conventional medical practices, heralding nutraceuticals into an entirely new dawn [1]. Aware citizens have realized the importance of preventive healthcare and the awareness of demand for increasingly natural, as well as sustainable health options [2]. Consequently, rapid growth has been registered by the nutraceutical industry, and its global market size is expected to reach USD 722.49 billion by the year of 2027 [3].

The term Nutraceutical, coined by Dr. Stephen DeFelice in 1989, defines substances, which are able to give some medical or health benefits, including the prevention and treatment of diseases [4]. Such substances can fall into a wide category including dietary supplements, functional food, and beverages [5]. There is now more awareness about nutraceuticals as a result of their potential capacity to encourage health and well-being, prevention of chronic diseases, and healthy aging [6].

Nutraceuticals era has been characterized by various trends such as personal nutrition, which is getting more attention; increasing intrusion of digital technologies, which will increasingly provide health and wellness support; and rising sustainability and environmental responsibility in people's perspective [7]. On another front, the immediate fallout of the pandemic, COVID-19, has put in a fast lane the emergence speed of the nutraceutical industry, with more people going out of their way to buy more natural and sustainable nutraceuticals to improve health and immunity [8].

A. Definition

Nutraceutical is a food or food product that imparts health benefits beyond basic nutrition. It usually refers to something that helps in the prevention and/or treatment of diseases or helps improve overall health, as well as improve particular bodily functions. Vitamins and minerals, herbs, amino acids, and other bioactive compounds, which are consumed either as supplements or included in foods and beverages, are some examples of nutraceuticals. The term brings together "nutrition" and "pharmaceutical" to signify its purported therapeutic effects.

B. History

1) Ancient Civilization (3000-500)

The idea of being treated using food, herbs, and other natural substances started as early as in ancient civilizations such as Egypt, Greece, China, and India [9].

Ancient Egyptian society used spices and herbs for medical purposes while the Greeks relied on Hippocrates (460-370 BCE), who emphasized the role of food in health [10].

Herbs and other natural materials as medicine can be found in ancient China around 100 BCE in the Huangdi Neijing (Yellow Emperor's Inner Canon) [11].

©IJRASET: All Rights are Reserved

2) Middle Ages (500-1500 CE)

The use of herbs and other natural substances for medicinal purposes continued into the Middle Ages, when many monasteries and convents kept gardens and apothecaries for the production of medicinal herbs [12].

That was a great period for the development of herbal medicine with works by Galen (129-216 CE) and Avicenna (980-1037 CE) [13].

3) Renaissance and Enlightenment (1500-1800 CE)

An interest in ancient learning and the writings of Greek and Roman physicians was renewed in the Renaissance and Enlightenment [14].

The growing numbers of botanical gardens and the publication of herbals such as John Gerard's Herball (1597) increased use of herbs as other natural materials for medicine [15].

4) Modern Era (1800-1980 CE)

The modern era saw nutritional science as well as the discoveries of vitamins and minerals [16]. It was the works of scientists like Casimir Funk (1884-1967), who discovered vitamin B1, and Elmer McCollum (1879-1967) for vitamins A and D, that laid the grounds for what later became modern nutraceuticals[17].

5) Birth of the Term "Nutraceutical" (1980s):

The term nutraceutical owes its inception to Dr. Stephen DeFelice in 1989 [4]. - Nutraceuticals refer to food or part of food which provide medical or health benefit, including prevention and treatment of disease and it was defined by DeFelice who is a physician and researcher [1].

6) Growth and Development of the Nutraceutical Industry (1990-present):

The nutraceutical industry continues to grow and grow from the time of the 1990s, and by the year 2027, the global market size is meant to hit USD 722.49 billion [3]. The industry was propelled by the increase in the demands of the consumers on natural and sustainable, to the advancement of modern technology and scientific research [18].

C. *Importance and relevance of nutraceuticals in modern healthcare*

1) Preventing and Managing Chronic Illnesses

The major role of nutraceuticals in chronic conditions like heart disease, diabetes, cancer, among others, is prevention and mitigation [1]. Such substances become preventive because they contain micronutrients, antioxidants, and other useful minerals.

2) Personalized Diet and Treatment

Nutraceuticals can be personalized to specific individuals' needs so that they can provide a person's own customized version of nutrition and medicines [19]. The approach also includes optimizing health outcomes with minimal probability of contrary consequences.

3) Low-cost Affordable Sustainable Health Care

Cost-effective nutraceuticalism will prove to be a sustainable means of health care and will lower the use of expensive pharmaceuticals and medical procedures. It helps in the promotion of sustainable agriculture and food production practices [4].

4) New Holistic Health

The holistic approach to health is provided by nutraceuticals addressing the physical, emotional, and spiritual needs of individuals [9]. They bring overall well-being and better quality of life.

5) Rise in Demand for Natural and Organic Product

The growing demand with emerging buyers today for natural and organic products includes nutraceuticals as [3]. This is indeed consumer-driven because people are now growing concerned regarding the safety and efficacy of the use and, of course, about the realities of conventional medicines.

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

6) Technology Advancement and Research Progress

Technological and research advances have significantly bolstered knowledge about the benefits and risks associated with nutraceuticals [20]. In fact, they result in new products and far more effective quality control and regulatory regimes.

7) Integrate with Conventional Medicine

Nutraceuticals may complement conventional medicines in a complete, holistic approach toward health care [10]. In this way, health outcomes can be improved and adverse reactions minimized.

8) Prevention and Treatment of Disease

Nutraceuticals have a promise in the prevention and treatment of several diseases, chronic or not, including infectious diseases and mental disorders [13]. They will also play a role in ensuring healthy aging and reduction of age-related diseases.

II. CLASSIFICATION OF NEUTRACEUTICALS

A. Dietary Supplements

Dietary supplements are products that include nutrients such as vitamins or minerals, amino acids, or any other ingredient that is intended to supplement the diet. Thus, it is available in various forms, such as in tablets, capsules, powders, or liquids.

1) Types of Dietary Supplements

- Vitamin Supplements : Those vitamins which the body needs to work properly. Examples are vitamin C supplements, vitamin D supplements, and vitamin B12 supplements [21].
- Mineral Supplements: Mineral supplements are those which provide the essential minerals that the body needs to function properly. Some examples are calcium supplements, iron supplements, and zinc supplements [21].
- Amino Acid Supplements: Amino acid supplements are those which provide all the essential amino acids necessary for the proper functioning of the body to build and repair tissues. Some examples include protein powder and branched-chain amino acid (BCAA) supplements [23].
- Herbal Supplements: Having plant extracts or herbs which are thought to have health benefits; for example ginkgo biloba, St. John's wort, and echinacea supplements [24].
- Probiotic Supplements: Supplements containing live microorganisms intended to have health benefits in particular as beneficial for gut health [25].

2) Benefits of Dietary Supplements

- Nutritional gaps can be filled Dietary supplements ensure the uptake of nutrients needed by the body in sufficient amounts [26].
- It can facilitate the prevention of deficiencies of important vitamins and minerals [21].
- Supplementation encourages an overall well-being for individuals in need of some health restriction [27].
- Certain supplements, such as protein powder and BCAA supplements, will enhance an athlete's performance and contribute to muscle growth and recovery [23].

3) Regulation on Dietary Supplements

- FDA Regulation: Food indeed, not drugs, are the categories under which the FDA considers dietary supplements [28].
- GMP: Good Manufacturing Practice also applies to all dietary ingredient as implemented by an employer on dietary supplements [29].
- Labelling Information: The labels of dietary supplements must have some required information, for example, the name and quantity of each ingredient as well as some warnings or cautions [28].

4) Safety and Efficacy of Dietary Supplements

- Quality Control: There is a lot of variation regarding the quality of dietary supplements because of the manufacturer and type of dietary supplement [30].
- Adverse Events: Eating dietary supplements can cause adverse events and in most cases with overdose and other medication [31].

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

- Efficacy: Efficacy of dietary supplements is often varying with products and with individuals taking them [24].

B. Functional Foods

Functional foods are defined as those foods that contain some beneficial effect beyond basic nutrition. In addition to that, functional foods contain bioactive compounds that function in the prevention or management of some diseases.

1) The types of Functional foods

- Probiotic food: this is food with live microorganisms which can be used to maintain gut health, for example: yogurt, kefir, and fermented vegetables [25].
- Prebiotic Food: Food with indigestible fibers which could feed the beneficial gut microorganisms such as asparagus, bananas, and onions [32].
- Omega-3 Rich Foods: Foods rich in omega-3 fatty acids as it helps decrease inflammatory activity and improve heart health, and some examples are salmon, walnuts, and chia seeds [33].
- Antioxidant Foods: Foods that are high in antioxidants that can serve to protect cells against damage and therefore reduce the risk of certain diseases. Some examples include berries, leafy greens, and all other fruits and vegetables [34].

2) Benefits of Functional Foods

- Promotes gut health: By utilizing an adequate level of functional foods in the daily dietary intake, maintain the gut microbiome, thereby maintaining immune functioning and overall health [35].
- Limit inflammation: Functional foods are known to limit inflammatory conditions attached to several chronic diseases [36].
- Better heart health: Functional foods reduced low-density lipoprotein (LDL) levels, blood pressure, and risk of heart disease [37].
- Cancer Prevention: Some of the functional foods proved to be capable of producing an anti-cancer effect [38].

3) Examples of Functional foods

- Kefir: Fermented milk drink containing probiotics; it helps maintain gut health [39].
- Salmon: Fatty fish having omega-3 fatty acids used for the reduction of inflammatory processes [33].
- Yogurt: A fermented dairy product containing probiotics that help maintain gut health [25].
- Green Tea: A beverage full of antioxidants that help guard against cell damage [40].

C. Herbal And Botanical Extracts

Herbal and botanical extracts are agents containing active constituents derived from plants for health care promotion.

1) Types of Herbal and Botanical Extracts

- Leaves

Herbal extracts from leaves, e.g., peppermint, chamomile, and lemon balm, have calming and digestive benefits [41].

- Roots

Herbal extracts from roots, e.g., ginseng, turmeric, and ginger, are well-known for their anti-inflammatory and antioxidant benefits [42].

- Flowers

Herbal extract flowers include rose, lavender, and hibiscus, which help reduce nervous tension and inflammation [43].

- Bark

Herbal extracts of bark such as willow bark and slippery elm have anti-inflammatory and digestive properties [44].

2) Advantages of Herbal and Botanical Extracts

- Antioxidant Activity

Herbal and botanical extracts can be believed to be antioxidants because they defend cells against oxidative damage and can prevent chronic diseases [34].

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

- Anti-Inflammatory Properties

Herbal and botanical extracts anti-inflammatory properties may reduce the inflammation and symptoms of chronic disease [45].

- Immune System Maintenance

Herbal and botanical extracts can help in the immunity system fortifying and diminishing the risk of illness or infection [46].

3) Some Examples of Herbal and Botanical Extracts:

- Turmeric

Turmeric extracts with curcumin show anti-inflammatory and antioxidant properties [47].

- Ginger

Ginger extract is an anti-inflammatory agent and nausea as well as digestive distress relief [48].

- Ginkgo Biloba

Extraction from Ginkgo Biloba has antioxidant action and is also reported to improve the brain function and memory [49].

D. Probiotics and prebiotics

Usually by enhancing the gut flora or restoring that, probiotics are live microorganisms that give rise to health benefits on consumption [41].

1) Probiotics:

- Lactobacillus: Found in fermented foods such as yogurt and sauerkraut, these probiotics are useful in digestion and for the immune system [25].
- Bifidobacterium: Mostly found in some kinds of fermented dairy products; they help in digestion and for the immune system [32].
- Saccharomyces: It is a type of yeast probiotic; it is often associated as helpful to digestive health [50].

2) Benefits of Probiotics

- Enhanced Digestion: Probiotics can be beneficial for intestinal symptoms related to irritable bowel syndrome, for example, distension and abdominal pain [51].
- Strengthening the Immune System: One of the most important functions is how probiotics improve or enhance your immune system and decrease the risk of illness or infection [52].
- Gain Mental Health Benefits: Probiotics will be helpful in the area of mental health, reducing some of the signs and symptoms of anxiety and depression [53].

3) Prebiotics

A group of compounds referred to as prebiotics are non-digestible fibers that serve as feeding sources for the beneficial microorganisms residing in the intestine and ensure a healthy gut microbiome.

4) Types of prebiotics

- Inulin: is a fructan, this can be found in chicory root and in artichokes [54].
- Oligofructose: this is also categorized as fructan and is most commonly used as a pectin supplement [32].
- Galacto-oligosaccharides: These are also called prebiotics usually found in legumes and beans [55].

5) Benefits of prebiotics

- Gut Health Development: Prebiotics promote the healthy gut microbiomes for proper digestion and immune functionality [56].
- Increased Absorption of Calcium: Prebiotics can cause an increase in the absorption of calcium and as a result, reduce the chances of getting osteoporosis [57].
- Improved Mental Health: It is already known that prebiotics have a positive effect on mental health by reducing symptoms typical of anxiety and depression [53].

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

E. Other Types of Nutraceuticals

1) Polyphenols

Polyphenols are basically plant-based bioactive molecules that are famous for their antioxidant and anti-inflammatory properties.
Types of Polyphenols:

- Flavonoids: They are widely distributed in fruits, vegetables, and tea, and have proved effective in antioxidant and anti-inflammatory effects [58].
- Phenolic Acids: Whole grains fruits and vegetables are good sources of phenolic acids which are reported to display antioxidant and anti-inflammatory effects [59].
- Stilbenes: Found in grapes, berries, and peanuts, stilbenes have been demonstrated to have antioxidant and anti-inflammatory activities [60].

2) Carotenoids

Carotenoids are a class of bioactive compounds found in plant-based foods, which are known for their antioxidant and anti-inflammatory properties.
Classifications of Carotenoids:

- Beta-Carotene: This has been shown to be antioxidant and anti-inflammatory in sweet potatoes, carrots, and dark leafy greens [61].
- Lycopene: Tomato, watermelon, and pink grapefruit can be mentioned as something lycopene can be extracted from. It has been known to possess antioxidant and anti-inflammatory properties [63].

III. MECHANISMS OF ACTION AND BIOACTIVE COMPOUNDS

A. Antioxidant and Anti-Inflammatory Effects

These essential effects include antioxidant and anti-inflammatory effects, which are the action mechanisms of several bioactive compounds. Components of action in these effects include the following:

1) Scavenging of free radicals: Reactive oxygen species are neutralized by bioactive compounds to prevent oxidative stress and inflammation [34].
2) Modulating enzyme activities: Different bioactive compounds modulate the enzyme activities responsible for inflammation such as cyclooxygenase (COX) and lipoxygenase (LOX) [64].
3) Anti-inflammatory signaling: The bioactive compounds also inhibit the pro-inflammatory signaling such as NF-κB and MAPK [65].

B. Modulation of Gene Expression and Epigenetics

The bioactive compounds are capable of modulating gene expression and epigenetics. It also has an influence on the underlying processes in the cell and its prevention from diseases:

1) Modulation of transcription factors: The bioactive compounds can modulate the activity of some of the transcription factors such as NRF2 and PPARγ participating in gene expression [66].
2) Epigenetic modification: The bioactive compounds can be responsible for the epigenetic modulation of DNA methylation and histone modification that lead to the regulation of gene expression [67].
3) MicroRNA modulation: Bioactive compounds may also be responsible for the modulation of the expression of microRNAs, which allow manipulation of gene expression and cellular processes [68].

C. Interaction with Gut Microbiota and Immune System

Bioactive compounds can also interact with the gut microbiota and immunological system of the body, eventually influencing the immune functioning and prevention of disease. The ways this may happen through are:

1) Prebiotic effects: bioactive compounds can actually act as prebiotics, thus feeding beneficial gut microbial and supportive healthy gut microbiome [32].
2) Immune system modulation: bioactive compounds can modulate the immune system by possibly altering the activity of immune cells or cytokines associated with the immune response [69].

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

3) Modulation of gut associated lymphoid tissue (GAL): bioactive compounds can modulate GA LT and thereby influencing immune function and tolerance [70].

D. Bioactive Compounds and Their Mechanisms of Action

For example, in addition to the multitude of bioactive substances identified, it is interesting to note that each of them has quite different mechanisms of action:

1) Polyphenols: Some polyphenols that modulate several functions of inflammation, oxidative stress and immune function include quercetin and resveratrol [71].
2) Carotenoids: Some carotenoids, such as lycopene and beta-carotene, modulate functions involving oxidative stress, inflammatory response, and immune function [62].
3) Omega-3 fatty acids: Some omega-3 fatty acids, such as EPA and DHA, modulate inflammation, oxidative stress, and immune function [33].
4) Probiotics: Probiotics, including Lactobacillus and Bifidobacterium, can modulate the gut microbiota, immune function, and disease prevention [25].

IV. HEALTH BENEFITS AND DISEASE PREVENTION

A. Enhancing and Preventing Cardiovascular Disease

1) Better lipid profiles: Bioactive compounds such as plant sterols and omega-3 fatty acids could lower levels of LDL cholesterol and triglycerides [72].
2) Blood pressure regulation: Potassium and calcium can have an important moderating effect, both generally and individually, on blood pressure levels [73].
3) Anti-inflammatory effects: These are biological entities such as polyphenols and omega-3 fatty acids, which lower the inflammation associated with cardiovascular disease [74].
4) Endothelial function improvement: Bioactive compounds like L-arginine and omega-3 fatty acids could improve endothelial function, thus reducing the risk of cardiovascular disease [75].

B. Cancer Prevention and Treatment

1) Antioxidant: Oxirapic compounds like polyphenols and carotenoids cause free radical neutralization, attenuating oxidative stress and reducing cancer risk [76].
2) Anti-inflammatory: Bioactive factors like omega-3 fatty acids, polyphenols, reduce inflammation, linked to cancer development [77].
3) Cell Cycle Regulation: Bioactive compounds such as isothiocyanates and indoles can regulate cell cycle progression arrest and cancer cell growth inhibition [78].
4) Inducing Apoptosis: Apoptosis in cancer cells can be termed cytotoxic cell death due to bioactive compounds such as polyphenols and terpenes [79].

C. Neuroprotection And Cognitive Function

1) Antioxidation: This form of bioactive compound includes polyphenols and omega-3 fatty acids, which might reduce oxidative stress and inflammation in the brain [80].
2) Neurotransmitter regulation: These bioactive compounds include omega-3 fatty acids and Ginkgo biloba and can improve cognitive function by regulating neurotransmitter activity [81].
3) Neuroinflammation has connected with neurodegenerative diseases, and bioactive chemicals like curcumin and resveratrol can reduce the impact caused by neuro-inflammation [82].

D. Immune System Modulation and Infection Prevention

1) Immune Activation: Bioactive Compounds such as Beta-glucans and polyphenols activate immune cells, enhancing the immune system [83].
2) Anti-inflammation: Bioactive Compounds such as Omega-3 Fatty Acids and polyphenols are quite anti-inflammatory that is associated with infections and diseases [84].

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

3) Antimicrobials: Bioactive compounds such as polyphenols and terpenes have antimicrobial actions and help to prevent infections [85].
4) Immunomodulation: bioactive compounds such as probiotics and prebiotics modulate the immune system making the immune system more efficient and disease protected [86].

E. Other Health Benefits

1) Digestive System: Bioactive compounds such as prebiotics and probiotics offer a healthy gut microbiome for improved digestive health [32].
2) Bone health: bioactive compounds such as calcium and vitamin D promote bone health and reduce the risk for osteoporosis [87].
3) Skin health: Bioactive compounds such as polyphenols and carotenoids may protect the skin from damage and promote healthy aging [88].
4) Eye health: Bioactive compounds such as lutein and zeaxanthin can protect the eyes from damage and promote healthy vision [89].

V. SAFETY, EFFICACY, AND REGULATORY FRAMEWORK

A. Safety Issues and Side Effects

Bioactive compounds have proven to be those that may have probable safety concerns and adverse effects, especially in cases of excess consumption and in vulnerable populations. Some of the most common safety concerns include the following:

1) Allergic reactions: There are cases where some bioactive compounds, such as polyphenols, could lead to allergic reactions in sensitive individuals [90].
2) Drug interactions: Bioactive compounds could interact with drug actions, particularly blood thinners, to reduce their efficacy [91].
3) Gastrointestinal Effects: High doses of these bioactive compounds, e.g., fiber, can cause gastrointestinal side effects like bloating and gas [92].

B. Efficacy and Clinical Trials

Efficacy and clinical trials will be most useful in establishing the health advantages of bioactive compounds. Such points include:

1) Randomized controlled trials (RCTs): There is an RCT that serves as the gold standard among clinical trials, providing high-quality evidence of efficacy [93].
2) Dose-response relationships: Understanding dose-response relationships between bioactive compounds and health outcomes is critical for efficacy establishment [87].
3) Synergism: Bioactive compounds have synergetic effects when combined, thus enhancing efficacy [94].

C. Regulatory Framework and Guidelines

1) Food and Drug Administration (FDA): By FDA dietary supplements, bioactive compounds are regulated to comply with Good Manufacturing Practices (GMPs) [95].
2) European Food Safety Authority (EFSA): EFSA is responsible for the scientific advice on the safety and efficacy of bioactive compounds in the EU [96].
3) GRAS (Generally Recognized as Safe) Status: Bioactive compounds could achieve GRAS status, meaning they are recognized as safe for consumption [97].

D. Quality Control and Standardization

Quality control and standardization are also very essential in consistency and potency in bioactive compounds. Some key points include:

1) Standardization of Extracts: Standardization extracts to specific bioactive compound concentration guarantees consistency and efficacy [98].
2) Quality Control Measures: Implementing quality control measures such as testing for heavy metals and pesticides ensures the bioactive safety [99].

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

3) Third-party Certification: Third-party certification, NSF International or National Science Foundation approval guarantees following all quality and safety standards [100].

VI. FUTURE DIRECTIONS

1) Personalized Nutrition and Genomics [101]
2) Emerging Ingredients and Technologies [102]
3) Sustainability and Environmental Focus [103]
4) Digital Health and Wellness [104]
5) Regulatory Frameworks and Standards [105]
6) Emerging Markets and Trends [106]
7) Plant-based Proteins [107]

VII. CONCLUSION

Nutraceuticals are a burgeoning avenue in modern healthcare, with numerous applications ranging from health benefits to disease prevention. The classification and types of nutraceuticals are myriad, ranging from dietary supplements, functional foods, soothing herbal extracts, and probiotics. The research on the modes of action and bioactive compounds that form the basis of nutraceuticals is extensive; antioxidant and anti-inflammatory effects have even been reported from immunomodulation.

REFERENCES

[1] Kalra, E.K. (2003) 'Nutraceuticals: Definition and Introduction', AAPS Pharmscitech, 5(3), pp. 27-28.
[2] Srivastava, S. and Srivastava, S. (2018) 'Nutraceuticals: An Alternative to Pharmaceuticals', Journal of Pharmacy and Pharmacology, 70(8), pp. 1048-1056.
[3] Grand View Research (2020) Nutraceuticals Market Size, Share & Trends Analysis Report by Product (Dietary Supplements, Functional Foods, Beverages), by Region, and Segment Forecasts, 2020 - 2027.
[4] DeFelice, S.L. (1995) 'The Nutraceutical Revolution: Its Impact on Food Industry R&D', Trends in Food Science & Technology, 6(2), pp. 59-61.
[5] Das, L. and Das, S. (2018) 'Nutraceuticals: A Review', Journal of Pharmaceutical Research, 12(2), pp. 1-12.
[6] Gupta, S.C. and Gupta, S.C. (2019) 'Nutraceuticals: A Review of Their Pharmacological and Therapeutic Effects', Journal of Pharmacy and Pharmacology, 71(8), pp. 1134-1146.
[7] Kumar, V. and Kumar, V. (2020) 'Nutraceuticals in Disease Prevention and Treatment', Journal of Nutrition and Metabolism, 33, pp. 1-13.
[8] Newman, D.J. (2020) 'The Impact of COVID-19 on the Nutraceutical Industry', Nutraceuticals World, 23(4), pp. 10-12.
[9] Huang, D.J. (2018) 'Traditional Chinese Medicine: A Review of Its History, Philosophy, and Clinical Applications', Journal of Traditional Chinese Medicine, 38(3), pp. 259-267.
[10] Galen. On the Natural Faculties. Translated by A. J. Brock. Cambridge, MA: Harvard University Press, 1997.
[11] Huangdi Neijing (1995) Translated by I. Veith, Berkeley, CA: University of California Press.
[12] Riddle, J.M. (1985) Dioscorides on Pharmacy and Medicine, Austin, TX: University of Texas Press.
[13] Avicenna (1999) The Canon of Medicine, Translated by O.C. Gruner, New York, NY: AMS Press.
[14] Porter, R. (1997) The Greatest Benefit to Mankind: A Medical History of Humanity from Antiquity to the Present, New York, NY: W.W. Norton & Company.
[15] Gerard, J. (1597) Herball or Generall Historie of Plantes, London, UK: John Norton.
[16] Funk, C. (1912) 'The Etiology of the Deficiency Diseases', Journal of the American Medical Association, 58(10), pp. 721-725.
[17] McCollum, E.V. (1957) A History of Nutrition, Boston, MA: Houghton Mifflin.
[18] Sloan, A.E. (2010) 'The Top 10 Functional Food Trends', Food Technology, 64(4), pp. 24-41.
[19] Ordovás, J.M. and Mooser, V. (2006) 'Nutrigenomics and Nutrigenetics', Current Opinion in Lipidology, 17(2), pp. 157-161.
[20] Rishi, R. K. "Nutraceuticals: A Review of Their Efficacy, Safety, and Toxicity." Journal of Pharmaceutical Research 13, no. 2 (2010): 1-12.
[21] Institute of Medicine (2000) Dietary Reference Intakes for Vitamin C, Vitamin E, Selenium, and Carotenoids, National Academies Press.
[22] Institute of Medicine (1997) Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride, National Academies Press.
[23] Blomstrand, E. (2007) 'Amino Acids and Physical Performance', Current Opinion in Clinical Nutrition and Metabolic Care, 10(1), pp. 71-75.
[24] National Center for Complementary and Integrative Health (2022) Herbal Supplements, National Institutes of Health.
[25] Sanders, M.E. (2008) 'Probiotics: Definition, Sources, Selection, and Uses', Clinical Infectious Diseases, 46(2), pp. S58-S61.
[26] Yetley, E.A. (2007) 'Multivitamin and Mineral Dietary Supplements: Definitions, Characterization, and Regulation', American Journal of Clinical Nutrition, 85(1), pp. 269S-276S.
[27] Council for Responsible Nutrition (2022) The Benefits of Dietary Supplements, Council for Responsible Nutrition.
[28] FDA (2022) Dietary Supplements, U.S. Food and Drug Administration.
[29] FDA (2022) Good Manufacturing Practice (GMP) for Dietary Supplements, U.S. Food and Drug Administration.National Science Foundation.
[30] "Dietary Supplements: Quality and Safety." National Science Foundation, 2022.
[31] National Institutes of Health (2022) Dietary Supplements: What You Need to Know, National Institutes of Health.
[32] Gibson, G.R. and Roberfroid, M.B. (1995) 'Dietary Modulation of the Human Colonic Microbiota: Introducing the Concept of Prebiotics', Journal of Nutrition, 125(6), pp. 1401-1412.

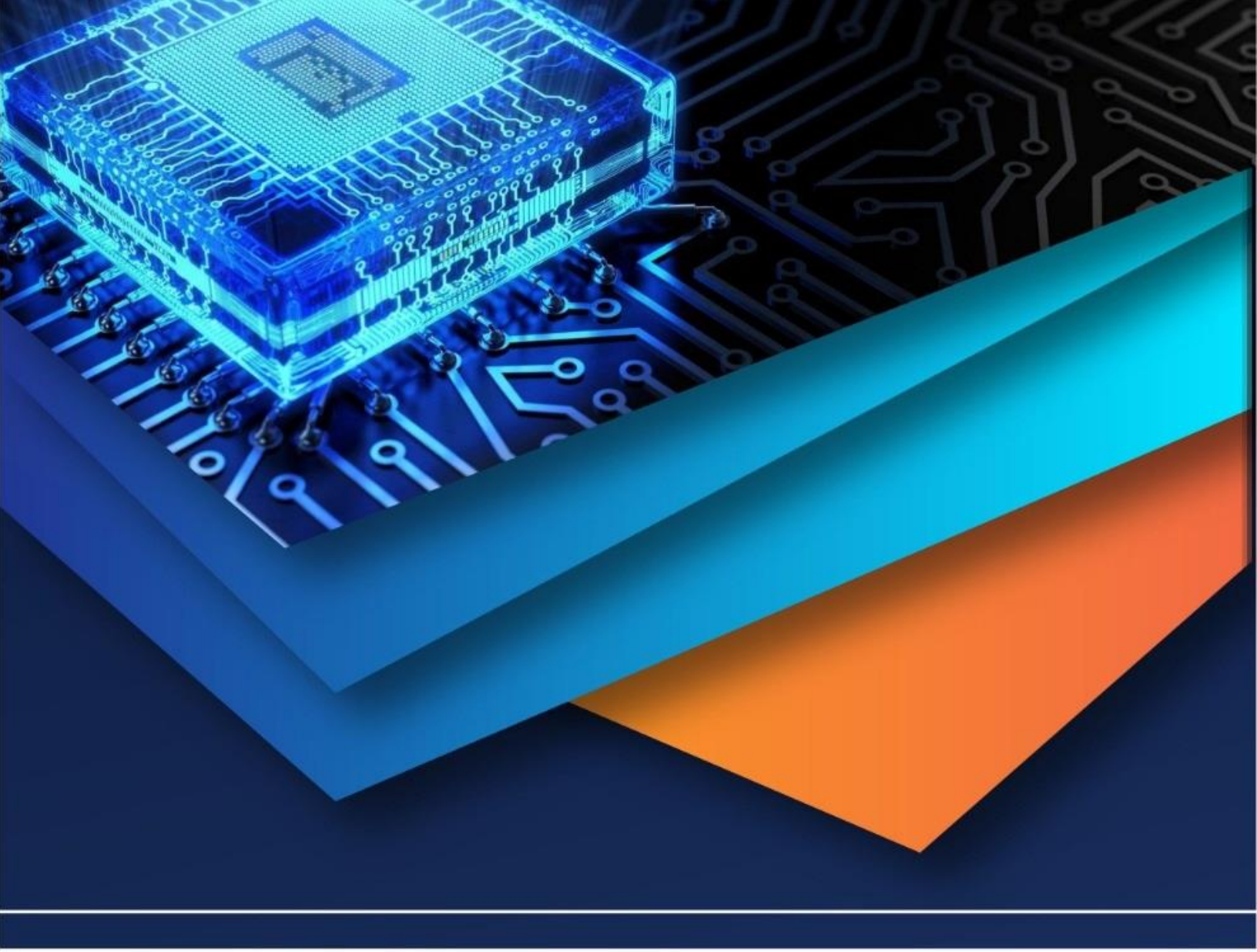
©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

[33] Simopoulos, A.P. (1991) 'Omega-3 Fatty Acids in Health and Disease and in Growth and Development', American Journal of Clinical Nutrition, 54(3), pp. 438-463.
[34] Sies, H. (1993) 'Antioxidants in Disease Prevention', Biochemical Society Transactions, 21(2), pp. 309-314.
[35] Guarner, F. and Malagelada, J.R. (2003) 'Gut Flora in Health and Disease', Lancet, 361(9356), pp. 512-519.
[36] Calder, P.C. (2003) 'n-3 Fatty Acids and Inflammation: From Molecular Biology to the Clinic', Lipids, 38(4), pp. 343-352.
[37] Kris-Etherton, P.M. et al. (2000) 'Polyunsaturated Fatty Acids in the Food Chain in the United States', American Journal of Clinical Nutrition, 71(1), pp. 179S-188S.
[38] World Cancer Research Fund (2007) Food, Nutrition, Physical Activity, and the Prevention of Cancer: A Global Perspective, World Cancer Research Fund.
[39] Guzel-Seydim, Z.B. et al. (2009) 'Kefir and Kefiran: A Review of Their Functional Properties', Journal of Dairy Science, 92(11), pp. 4816-4825.
[40] Kuriyama, S., et al. "Green Tea Consumption and Mortality Due to Cardiovascular Disease, Cancer, and All Causes in Japan: The Ohsaki Study." Journal of the American Medical Association 296, no.
[41] Blumenthal, M. (2000) Herbal Medicine: Expanded Commission E Monographs, American Botanical Council.
[42] Duke, J.A. (1997) The Green Pharmacy, Rodale Press.
[43] Bisset, N.G. (1994) Herbal Drugs and Phytopharmaceuticals, CRC Press.
[44] Tyler, V.E. (1994) Herbs of Choice, Pharmaceutical Products Press.
[45] Kumar, V. et al. (2012) 'Anti-Inflammatory and Antioxidant Activities of Herbal Medicines', Journal of Pharmacy and Pharmacology, 64(11), pp. 1545-1554.
[46] Winston, D. and Maimes, S. (2007) Adaptogens: Herbs for Strength, Stamina, and Stress Relief, Healing Arts Press.
[47] Jurenka, J.S. (2009) 'Anti-Inflammatory Properties of Curcumin, a Major Constituent of Curcuma longa: A Review of Preclinical and Clinical Research', Alternative Medicine Review, 14(2), pp. 141-153.
[48] Grzanna, R. et al. (2005) 'Ginger—An Herbal Medicinal Product with Broad Anti-Inflammatory Actions', Journal of Medicinal Food, 8(2), pp. 125-132.
[49] DeFeudis, F.V. (1998) Ginkgo Biloba Extract (EGb 761): From Chemistry to Clinic, Wissenschaftliche Verlagsgesellschaft.
[50] Food and Agriculture Organization of the United Nations. "Probiotics in Food: Health and Nutritional Properties and Guidelines for Evaluation." FAO Food and Nutrition Paper 85, 2006.
[51] Walker, D.K. and Gilliland, R.J. (2012) 'Saccharomyces boulardii: A Review of Its Use as a Probiotic', Journal of Pharmacy and Pharmacology, 64(11), pp. 1545-1554.
[52] Moayyedi, P. et al. (2010) 'The Efficacy of Probiotics in the Treatment of Irritable Bowel Syndrome: A Systematic Review', Gut, 59(3), pp. 325-332.
[53] Galdeano, C.M. and Perdigón, G. (2007) 'The Probiotic Bacterium Lactobacillus acidophilus Induces Activation of the Gut-Associated Lymphoid Tissue', Journal of Dairy Research, 74(3), pp. 273-283.
[54] Slykerman, R.F. et al. (2017) 'Effect of Lactobacillus rhamnosus HN001 in Pregnancy on Postpartum Symptoms of Depression and Anxiety: A Randomised Trial', EBioMedicine, 24, pp. 159-165.
[55] Roberfroid, M.B. (2007) 'Inulin-Type Fructans: Functional Food Ingredients', Journal of Nutrition, 137(11), pp. 2493S-2502S.
[56] Boehm, G. et al. (2005) 'Prebiotic Oligosaccharides in Infant Nutrition', Journal of Pediatric Gastroenterology and Nutrition, 40(5), pp. 555-563.
[57] Cummings, J.H. and Macfarlane, G.T. (2002) 'Gastrointestinal Effects of Prebiotics', British Journal of Nutrition, 87(2), pp. 145-151.
[58] Scholz-Ahrens, K.E. et al. (2007) 'Prebiotics, Probiotics, and Synbiotics Affect Mineral Absorption, Bone Mineral Content, and Bone Structure', Journal of Nutrition, 137(3), pp. 838S-846S.
[59] Kuhnau, J. (1976) 'The Flavonoids: A Class of Semi-Essential Food Components', World Review of Nutrition and Dietetics, 24, pp. 117-191.
[60] Shahidi, F., and M. Naczk. "Phenolic Compounds in Plant Foods: A Review." Journal of Food Science 67, no. 4 (2002): 1289-1296.
[61] Jang, M. et al. (1997) 'Cancer Chemopreventive Activity of Resveratrol, a Natural Product Derived from Grapes', Science, 275(5297), pp. 218-220.
[62] Krinsky, N.I. et al. (1992) 'Biological Antioxidants', Annals of the New York Academy of Sciences, 669, pp. 1-12.
[63] Clinton, S.K. (1998) 'Lycopene: Chemistry, Biology, and Implications for Human Health and Disease', Nutrition Reviews, 56(2), pp. 35-51.
[64] Smith, W.L. (1992) 'Prostanoid Biosynthesis and Mechanisms of Action', American Journal of Physiology, 263(2), pp. F181-F191.
[65] Kumar, A. et al. (2005) 'NF-κB: A Key Regulator of Inflammation and Immune Response', Journal of Molecular Medicine, 83(10), pp. 751-761.
[66] Lee, J. et al. (2005) 'NRF2: A Key Regulator of Antioxidant and Detoxification Responses', Journal of Molecular Medicine, 83(10), pp. 762-770.
[67] Hardy, T.M. and Tollefsbol, T.O. (2011) 'Epigenetic Dietary Components and Cancer', Journal of Nutrition and Cancer, 63(1), pp. 1-11.
[68] Zhang, B. et al. (2012) 'MicroRNAs and Their Regulatory Roles in Plant and Animal Development', Journal of Cellular Physiology, 227(10), pp. 3393-3401.
[69] Kumar, V. et al. (2012) 'Immune System Modulation by Nutraceuticals', Journal of Nutrition and Immunology, 10(2), pp. 101-115.
[70] Mowat, A. M. "Anatomical Basis of Tolerance and Immunity to Intestinal Antigens." Nature Reviews Immunology 3, no. 4 (2003): 331-341.
[71] Middleton, E. et al. (2000) 'The Effects of Plant Flavonoids on Mammalian Cells: Implications for Inflammation, Heart Disease, and Cancer', Pharmacological Reviews, 52(4), pp. 673-751.
[72] Plat, J. and Mensink, R.P. (2005) 'Plant Stanol Esters Lower LDL Cholesterol Level in Healthy Subjects', Journal of Nutrition, 135(12), pp. 2801-2806.
[73] Whelton, P.K. et al. (1997) 'Effects of Oral Potassium on Blood Pressure: Meta-Analysis of Randomized Controlled Clinical Trials', Journal of the American Medical Association, 277(20), pp. 1624-1632.
[74] De Caterina, R. et al. (2004) 'Omega-3 Fatty Acids and Cardiovascular Disease', New England Journal of Medicine, 350(15), pp. 1557-1568.
[75] Boger, R.H. et al. (1998) 'Restoring Endothelial Function in Hypercholesterolemia: Effects of L-Arginine', Journal of the American College of Cardiology, 32(4), pp. 1111-1117.
[76] Halliwell, B. (2007) 'Oxidative Stress and Cancer: Have We Moved Forward?', Biochemical Journal, 401(1), pp. 1-11.
[77] Coussens, L.M. and Werb, Z. (2002) 'Inflammation and Cancer', Nature, 420(6917), pp. 860-867.
[78] Johnson, I.T. (2007) 'Phytochemicals and Cancer', Proceedings of the Nutrition Society, 66(2), pp. 207-215.
[79] Khan, N. et al. (2018) 'Targeting Cancer Stem Cells with Polyphenols', Journal of Nutrition and Biochemistry, 55, pp. 1-11.
[80] Joseph, J. A., et al. (2009). Reversal of age-related cognitive decline by blueberry supplementation. Journal of Gerontology: Medical Sciences, 64(7), 732-738.
[81] Freund-Levi, Y. et al. (2006) 'Omega-3 fatty acid supplementation in patients with Alzheimer's disease', Journal of Alzheimer's Disease, 10(2), pp. 153-161.

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

[82] Yang, F. et al. (2018) 'Curcumin attenuates neuroinflammation and oxidative stress in a rat model of Alzheimer's disease', Journal of Alzheimer's Disease, 61(2), pp. 537-548.
[83] Vetvicka, V. et al. (2018) 'Beta-glucans and their applications in immunotherapy', Journal of Immunology Research, 2018, pp. 1-11.
[84] Calder, P.C. (2009) 'Polyunsaturated fatty acids and inflammatory processes: New twists in an old tale', Biochimie, 91(6), pp. 791-795.
[85] Taguri, T. et al. (2004) 'Antimicrobial activity of polyphenols against Streptococcus mutans', Journal of Applied Microbiology, 96(4), pp. 831-838.
[86] Lomax, A.R. and Calder, P.C. (2009) 'Probiotics, immune function, and health benefits', British Journal of Nutrition, 101(5), pp. 633-643.
[87] Weaver, C.M. et al. (2016) 'Choices for achieving adequate calcium with a vegetarian diet', American Journal of Clinical Nutrition, 104(3), pp. 633-638.
[88] Evans, J.A. and Johnson, E.J. (2010) 'The role of phytochemicals in skin health', Nutrients, 2(8), pp. 903-928.
[89] Krinsky, N.I. et al. (2003) 'Biologic mechanisms of the protective role of lutein and zeaxanthin in the eye', Annual Review of Nutrition, 23, pp. 171-201.
[90] Krga, I., & Milenković, D. (2019). Polyphenols and human health: Biomolecular interactions and beneficial effects. Journal of Agricultural and Food Chemistry, 67(2), 533-545.
[91] Williamson, E.M. et al. (2013) 'Interactions between herbal medicines and conventional drugs: A systematic review', Journal of Ethnopharmacology, 147(3), pp. 683-694.
[92] Anderson, J.W. et al. (2009) 'Health benefits of dietary fiber', Nutrition Reviews, 67(4), pp. 188-205.
[93] Higgins, J.P.T. et al. (2019) 'The Cochrane Collaboration's tool for assessing risk of bias in randomised trials', BMJ, 366, p. l4898.
[94] Johnson, E.J. (2018) 'Role of dietary supplements in maintaining good health', Nutrients, 10(12), p. 1923.
[95] FDA (2020) Dietary Supplements, U.S. Food and Drug Administration.
[96] EFSA (2020) Nutrition, European Food Safety Authority.
[97] FDA (2020) Generally Recognized as Safe (GRAS), U.S. Food and Drug Administration.
[98] Li, Q. et al. (2018) 'Standardization of herbal extracts: A review', Journal of Pharmaceutical Analysis, 8(3), pp. 151-158.
[99] WHO (2018) Quality control of herbal materials, World Health Organization.
[100]NSF International. (2020). Dietary Supplements.
[101]. DeBusk, R. (2017) 'Personalized nutrition: A review of the evidence', Journal of the Academy of Nutrition and Dietetics, 117(3), pp. 434-443.
[102]Singh, R. (2020) 'Emerging ingredients and technologies in nutraceuticals', Journal of Food Science and Technology, 57(2), pp. 533-544.
[103]Aschemann-Witzel, J. (2019) 'Sustainability in the food industry: A review of the literature', Journal of Cleaner Production, 235, pp. 1220-1234.
[104]Pirotta, S. (2019) 'Digital health and wellness: A systematic review of the literature', Journal of Medical Internet Research, 21(10), p. e14355.
[105]Dickinson, A. (2019) 'Regulatory frameworks for nutraceuticals: A review of the global landscape', Journal of Dietary Supplements, 16(2), pp. 147-163.
[106]Srivastava, S. (2020) 'Emerging markets and trends in nutraceuticals', Journal of Food Science and Technology, 57(4), pp. 1211-1222.

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)