

Revolutionary Approaches in Food Science, Technology and Processing

Edited by

Dr. Manisha Maity



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Dr. Manisha Maity

A Review on Edible Oil Sources, Health Impacts, and Current Techniques of Oil Adulteration Detection

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Abstract

Edible oils are an essential part of daily nutrition and contribute to modern societies' culinary, health, and economic aspects. With diverse sources, including plants, seeds, and animal products, edible oils are rich in essential fatty acids, vitamins, and antioxidants. However, concerns regarding adulteration, which involves the addition of inferior substances to oils to increase profit margins, have prompted the development of various detection techniques. Adulteration poses significant health risks, including the intake of harmful compounds, which can lead to chronic diseases such as cardiovascular diseases, obesity, and diabetes. This review explores the major sources of edible oils, their health impacts, and the current methods employed to detect adulteration. Through the synthesis of recent studies and technological advancements, we aim to provide a comprehensive overview of edible oil sources, their benefits and risks, and the effectiveness of adulteration detection methods, with a focus on improving food safety and public health.

1. Introduction

Edible oils are vital in human diets, providing a source of energy, essential fatty acids, and fat-soluble vitamins that are integral to maintaining health (Calugar et al.,2024). They are derived from various sources such as plants, seeds, fruits, and animals. However, due to their widespread consumption and high economic value, edible oils are often subjected

to adulteration. Oil adulteration refers to the practice of adding cheaper or lower-quality substances to high-quality oils, often for economic gain. This practice can compromise the nutritional integrity and safety of oils, with potentially severe health implications for consumers (Shifat & M.M.U, 2023). The detection of adulterated oils has become an area of significant interest for food safety authorities and researchers, resulting in the development of several advanced techniques for identifying oil adulteration.

This review provides an in-depth analysis of the different edible oil sources, their health impacts, and the latest methods used for detecting adulteration. We aim to highlight the importance of addressing oil adulteration for both consumer safety and public health.

2. Sources of Edible Oils

Edible oils are derived from a variety of sources, each contributing different nutrient profiles, including fatty acid composition, vitamins, and antioxidants. The most common sources of edible oils are:

2.1 Plant-Based Oils

Plant-based oils are the most widely used edible oils globally. They are primarily composed of unsaturated fatty acids, which are considered healthier compared to saturated fats. Some common plant-based oils include:

- **Olive Oil:** Extracted from the fruit of the olive tree, olive oil is rich in monounsaturated fatty acids (MUFA), particularly oleic acid. It is also high in antioxidants, such as polyphenols and vitamin E, which contribute to its anti-inflammatory properties. Olive oil is widely associated with the Mediterranean diet and has been linked to cardiovascular health benefits, including the reduction of blood pressure and cholesterol levels (Santa-Maria et al., 2023).
- **Canola Oil:** Derived from the seeds of the canola plant, this oil is rich in both monounsaturated and polyunsaturated fats, including omega-3 fatty acids. It is considered heart-healthy and is commonly used for frying,

baking, and sautéing. Canola oil has a favorable balance of omega-6 to omega-3 fatty acids, making it beneficial for maintaining heart health (MacIntosh et al.,2021).

- **Sunflower Oil:** Obtained from sunflower seeds, sunflower oil is high in vitamin E and linoleic acid, a polyunsaturated omega-6 fatty acid. While it offers health benefits, excessive consumption of omega-6 fatty acids, relative to omega-3, has been linked to increased inflammation and the risk of chronic diseases (Alagawany et al.,2019).
- **Coconut Oil:** Extracted from the meat of coconuts, coconut oil contains a high proportion of saturated fatty acids, particularly medium-chain triglycerides (MCTs), which are metabolized differently from long-chain fatty acids (Silalahi , 2020). Though controversial due to its high saturated fat content, coconut oil has been promoted for its potential antimicrobial properties and metabolic benefits.
- **Palm Oil:** Palm oil, derived from the fruit of the oil palm tree, is one of the most commonly used oils worldwide. It is rich in saturated fats and vitamin E, though its health effects have been debated due to its higher content of saturated fatty acids. Palm oil is also a highly efficient crop in terms of yield per hectare, making it a major commodity for food production (Mahlia et al., 2019).

2.2 Animal-Based Oils

Animal-based oils are typically more saturated than plant-based oils and may contain additional compounds such as cholesterol. Some common animal-based oils include:

- **Butter:** Derived from cream, butter is rich in saturated fats and cholesterol. While it provides essential vitamins such as vitamin A and D, excessive consumption of butter has been linked to an increased risk of cardiovascular disease due to its saturated fat and cholesterol content (Paszczyk ,2022).
- **Lard:** Lard is fat derived from pigs and is commonly used in cooking, especially in baking and frying. Lard

contains a high proportion of monounsaturated fats, but its high saturated fat content has led to concerns about its impact on heart health.

- **Fish Oil:** Rich in omega-3 fatty acids, fish oil is obtained from fatty fish such as salmon, mackerel, and sardines. Omega-3s are essential for cardiovascular health, brain function, and reducing inflammation. Fish oil is often used as a supplement or incorporated into cooking oils.

3. Health Impacts of Edible Oils

The health impact of edible oils is influenced by their fatty acid composition, as well as the presence of bioactive compounds such as antioxidants and vitamins. Below, we explore the general health impacts of different types of edible oils.

3.1 Cardiovascular Health

The consumption of oils high in monounsaturated fats (e.g., olive oil and canola oil) and polyunsaturated fats (e.g., sunflower oil and fish oil) has been associated with improved cardiovascular health by reducing cholesterol levels, lowering blood pressure, and decreasing inflammation (Yahay et al., 2021). In contrast, oils high in saturated fats (e.g., coconut oil, butter, and palm oil) can raise LDL cholesterol levels and increase the risk of heart disease when consumed in excess.

3.2 Weight Management

Oils rich in medium-chain triglycerides (MCTs), such as coconut oil, have been linked to potential benefits for weight management, as MCTs are metabolized quickly and may promote fat oxidation. On the other hand, oils high in omega-6 fatty acids, such as sunflower and soybean oil, when consumed in excessive amounts, may contribute to obesity and related metabolic disorders by promoting inflammation and insulin resistance (Nimbkar et al., 2022).

3.3 Anti-Inflammatory and Antioxidant Effects

Many plant-based oils, such as olive oil, are rich in antioxidants and polyphenols that can reduce oxidative stress and inflammation in the body. These properties may help protect against chronic conditions like arthritis, type 2 diabetes, and

cancer. Oils like fish oil, which are high in omega-3 fatty acids, are also known to possess anti-inflammatory properties that benefit joint health and reduce the risk of cardiovascular diseases (Duranova et al., 2024).

4. Oil Adulteration and Detection Techniques

Adulteration of edible oils is a widespread issue that compromises the quality and safety of oils. The practice involves mixing pure oils with cheaper, lower-quality oils or other substances to increase volume and profits. Adulteration is particularly common in low-cost oils such as palm, sunflower, and olive oils. Common adulterants include cheaper oils like soy oil, cottonseed oil, and palm stearin.

4.1 Health Risks of Oil Adulteration

Adulterated oils can pose various health risks to consumers, including:

- **Toxicity:** Some adulterants, especially industrial oils, contain harmful compounds that can be toxic to the liver and kidneys.
- **Nutritional Deficiencies:** Adulteration can reduce the nutritional quality of oils, depriving consumers of essential fatty acids, vitamins, and antioxidants.
- **Chronic Diseases:** Long-term consumption of adulterated oils may contribute to obesity, metabolic syndrome, cardiovascular diseases, and even cancer.

4.2 Detection Methods for Oil Adulteration

Given the potential health risks of adulterated oils, accurate and reliable detection methods are essential. Several techniques are currently used to detect adulteration in edible oils, including:

- **Physical and Chemical Methods:** These involve the analysis of physical properties such as viscosity, refractive index, and melting point, as well as chemical composition, including fatty acid profile and saponification value. Gas chromatography (GC) and high-performance liquid chromatography (HPLC) are commonly used to detect

specific adulterants (Banti, 2020).

- **Spectroscopic Methods:** Techniques like Fourier Transform Infrared (FTIR) spectroscopy, ultraviolet-visible (UV-Vis) spectroscopy, and nuclear magnetic resonance (NMR) spectroscopy can identify the chemical fingerprint of oils and detect adulteration by comparing the spectral data with reference oils (Sudhakar et al., 2023).
- **Sensor-Based Methods:** Emerging technologies such as electronic noses and electronic tongues, which use arrays of sensors to detect specific volatile compounds or taste attributes, are gaining popularity for the rapid detection of adulterated oils (Mahanti et al., 2024).
- **DNA-Based Methods:** Genetic markers and polymerase chain reaction (PCR) techniques are being explored for detecting adulteration in oils derived from plant or animal sources. These methods offer a high level of specificity for identifying adulterants like animal fats in plant-based oils (Kotasanopoulos et al., 2021).

5. Conclusion

Edible oils are an essential component of a healthy diet, providing a variety of nutrients and health benefits. However, the risk of adulteration in the edible oil market poses significant threats to consumer health and safety. Adulterated oils can lead to the consumption of harmful substances and nutritional deficiencies, increasing the risk of chronic diseases.

The review of edible oil sources and their health impacts underscores the importance of selecting high-quality oils to maintain optimal health. Moreover, advanced detection techniques play a vital role in ensuring food safety and preventing fraudulent practices in the oil industry. Continued research and development of reliable and cost-effective adulteration detection methods will help safeguard consumers from health risks associated with oil adulteration, ensuring that edible oils meet the nutritional standards expected.

References

Alagawany, M., Elnesr, S. S., Farag, M. R., Abd El-Hack, M. E., Khafaga, A. F., Taha, A. E., ... & Dhama, K. (2019). Omega-3 and omega-6 fatty acids in poultry nutrition: effect on production performance and health. *Animals*, 9(8), 573.

Banti, M. (2020). Food adulteration and some methods of detection, review. *International Journal of Nutrition and Food Sciences*, 9(3), 86-94.

Calugar, L., Grozea, I., & Butnariu, M. (2024). Vegetable Oils in Maintaining Health. *Journal Med Clin Nurs Stud*, 2(2), 1-7.

Kotsanopoulos, K. V., Exadactylos, A., Gkafas, G. A., Martsikalis, P. V., Parlapani, F. F., Boziaris, I. S., & Arvanitoyannis, I. S. (2021). The use of molecular markers in the verification of fish and seafood authenticity and the detection of adulteration. *Comprehensive Reviews in Food Science and Food Safety*, 20(2), 1584-1654.

MacIntosh, S. C., Shaw, M., Connelly, M., & Yao, Z. J. (2021). Food and feed safety of NS-B5ØØ27-4 omega-3 Canola (*Brassica napus*): A new source of long-chain omega-3 fatty acids. *Frontiers in nutrition*, 8, 716659.

Mahanti, N. K., Shivashankar, S., Chhetri, K. B., Kumar, A., Rao, B. B., Aravind, J., & Swami, D. V. (2024). Enhancing food authentication through E-nose and E-tongue technologies: Current trends and future directions. *Trends in Food Science & Technology*, 104574.

Mahlia, T. M. I., Ismail, N., Hossain, N., Silitonga, A. S., & Shamsuddin, A. H. (2019). Palm oil and its wastes as bioenergy sources: a comprehensive review. *Environmental Science and Pollution Research*, 26, 14849-14866.

Paszczyk, B. (2022). Cheese and butter as a source of health-promoting fatty acids in the human diet. *Animals*, 12(23), 3424.

Shifat, M. M. U. (2023). Food Adulteration and Consumer Challenges in Bangladesh.

Silalahi, J. (2020). Nutritional values and health protective properties of coconut oil. *Indonesian Journal of Pharmaceutical and Clinical Research*, 3(2), 1-12.

Santa-María, C., López-Enríquez, S., Montserrat-de la Paz, S., Geniz, I., Reyes-Quiroz, M. E., Moreno, M., ... & Alba, G.

(2023). Update on anti-inflammatory molecular mechanisms induced by oleic acid. *Nutrients*, 15(1), 224.

Sudhakar, A., Chakraborty, S. K., Mahanti, N. K., & Varghese, C. (2023). Advanced techniques in edible oil authentication: A systematic review and critical analysis. *Critical reviews in food science and nutrition*, 63(7), 873-901.

Yahay, M., Heidari, Z., Allameh, Z., & Amani, R. (2021). The effects of canola and olive oils consumption compared to sunflower oil, on lipid profile and hepatic steatosis in women with polycystic ovarian syndrome: a randomized controlled trial. *Lipids in Health and Disease*, 20, 1-12.

Nimbkar, S., Leena, M. M., Moses, J. A., & Anandharamakrishnan, C. (2022). Medium chain triglycerides (MCT): State-of-the-art on chemistry, synthesis, health benefits and applications in food industry. *Comprehensive reviews in food science and food safety*, 21(2), 843-867.

Duranova, H., Kuzelova, L., Fialkova, V., Simora, V., Kovacikova, E., Joanidis, P., ... & Gabriny, L. (2024). Coconut-sourced MCT oil: Its potential health benefits beyond traditional coconut oil. *Phytochemistry Reviews*, 1-42.

A Review on Nutrition for Mental Health (Nutritional Psychiatry)

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Abstract:

Nutritional psychiatry is an emerging field that explores the intricate relationship between nutrition and mental health, emphasizing the impact of dietary choices on psychological well-being. Research indicates that various nutrients, including omega-3 fatty acids, B vitamins, antioxidants, and amino acids, play crucial roles in brain function and mental health. For instance, omega-3 fatty acids, found in fish and flaxseeds, are associated with reduced symptoms of depression and anxiety due to their anti-inflammatory properties and ability to support neurotransmitter function. Similarly, deficiencies in B vitamins, particularly B12 and folate, have been linked to mood disorders, highlighting the importance of maintaining adequate levels through diet or supplementation. Antioxidants and polyphenols, present in fruits, vegetables, and whole grains, are recognized for their potential to combat oxidative stress and inflammation, both of which are implicated in mental health conditions. By fostering a balanced and nutrient-dense diet, nutritional psychiatry aims to provide holistic approaches to the prevention and treatment of mental health disorders, encouraging a paradigm shift towards integrating dietary interventions into standard psychiatric care.

Keywords: *mental health, nutrition, omega 3 fatty acids, vitamins B complex, gut health*

1. Introduction

Mental health disorders, including depression, anxiety, and cognitive decline, are significant contributors to the global burden of disease. While the causes of these conditions are multifactorial, including genetic, environmental, and psychological factors, recent evidence highlights the role of diet and nutrition as critical contributors to mental health (O'Neil et al., 2014). Nutritional psychiatry, the study of how diet impacts mental health, has emerged as a field of interest in both research and clinical practice. This review aims to provide an overview of key nutrients and dietary patterns that influence mental health, highlighting their mechanisms and therapeutic potential.

1.1. Nutrition and Mental Health

Nutritional factors are essential for the synthesis and regulation of neurotransmitters, neurogenesis, and brain function (Sarris et al., 2015). Dietary patterns, such as the Mediterranean diet, have been associated with a lower risk of depression and cognitive decline, while nutrient deficiencies have been linked to mental health disorders (Jacka et al., 2017). Understanding the relationship between specific nutrients and mental health is crucial in developing dietary interventions to support mental well-being.

2. Key Nutrients in Mental Health

2.1. Omega-3 Fatty Acids

Omega-3 fatty acids, particularly eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), are essential for brain function and have been widely studied for their role in mental health. These fatty acids influence neuronal structure and function, including neurotransmission and anti-inflammatory pathways (Grosso et al., 2014). Low levels of omega-3s have been associated with an increased risk of depression, and supplementation has shown promising results in reducing depressive symptoms, especially in conjunction with antidepressants (Liao et al., 2019).

Table: 1 *Summary of Studies on Omega-3 Fatty Acids for Mental Health*

Participants	Intervention	Outcome	Reference
Meta-analysis of clinical trials	Omega-3 supplementation (EPA & DHA)	Reduced symptoms of depression	Grosso et al. (2014)
Patients with major depressive disorder	Omega-3 supplementation (EPA > DHA)	Significant improvement in depressive symptoms	Liao et al. (2019)
Adolescents at high risk of psychosis	Omega-3 fatty acids (1.2g daily for 12 weeks)	Reduced transition to psychosis, improved mental health	Amminger et al. (2010)
Patients with major depressive disorder	Omega-3 (EPA/DHA) supplementation	Higher EPA ratio linked with lower depression risk	Sublette et al. (2011)
Adults with depression	EPA-rich omega-3 (2g/day) vs. placebo	Significant decrease in depressive symptoms	Su et al. (2018)

2.2. B Vitamins

B vitamins, particularly B6, B9 (folate), and B12, are involved in the production of neurotransmitters such as serotonin, dopamine, and gamma-aminobutyric acid (GABA), which regulate mood and cognition (Kennedy, 2016). Deficiencies in these vitamins have been linked to mood disorders, including depression. Folate and B12 deficiencies, for example, are common in patients with depression and are thought to contribute to its pathogenesis by impairing the synthesis of monoamine neurotransmitters (Coppen & Bolander-Gouaille, 2005).

Table: 2 *Summary of Studies on Vitamin B for Mental Health*

Participants	Intervention	Outcome	Reference
Patients with depression	Folate and vitamin B12 supplementation	Improved response to antidepressant treatment	Coppen & Bolander-Gouaille (2005)
General population	B vitamins (B6, B9, B12)	Enhanced cognitive function, reduced depression symptoms	Kennedy (2016)
Elderly individuals	Vitamin B12 supplementation	Reduced cognitive decline and depressive symptoms	Young (2013)
General population	B vitamin-rich diet (folate and B12)	Lower risk of depression	Sánchez-Villegas et al. (2009)
Elderly men	B12 and folate supplementation	No significant effect on depressive symptoms	Almeida et al. (2015)

2.3. Amino Acids and Protein

Amino acids, the building blocks of proteins, are critical for the production of neurotransmitters that influence mood and cognitive function. Tryptophan, an essential amino acid, is a precursor to serotonin, a neurotransmitter implicated in the regulation of mood, anxiety, and sleep (Silber & Schmitt, 2010). A diet low in tryptophan can reduce serotonin production, potentially leading to mood disorders. Similarly, tyrosine is a precursor to dopamine, which plays a role in motivation and reward pathways (Jenkins et al., 2016).

Table: 3 *Summary of Studies on Amino Acids and Protein for Mental Health*

Participants	Intervention	Outcome	Reference
Healthy individuals	Tryptophan supplementation	Improved mood and cognition; potential role in the gut-brain axis	Strasser et al. (2016)
General population	Dietary intake of tryptophan	Tryptophan metabolism linked to serotonin production, influencing mood	Fernstrom (2013)
Patients with major depression	S-adenosylmethionine (SAME) supplementation	Significant antidepressant effect	Mischoulon & Fava (2002)
Patients with depression	Creatine supplementation	Enhanced effectiveness of antidepressant treatment	Lakhan & Vieira (2008)
Individuals with depression	Branched-chain amino acids (BCAAs)	Alteration of neurotransmitter synthesis; improvement in mental fatigue	Rao et al. (2008)

2.4. Antioxidants and Polyphenols

Oxidative stress and inflammation are increasingly recognized as underlying factors in many mental health disorders, including depression and anxiety. Antioxidants, such as vitamins C and E, and polyphenols found in fruits, vegetables, and teas, play a role in reducing oxidative stress and inflammation in the brain (Lopresti et al., 2013). Diets rich in antioxidants have been associated with better mental health outcomes, as they help protect neurons from damage.

Table: 4 *Summary of Studies on Antioxidants and Polyphenols for Mental Health*

Participants	Intervention	Outcome	Reference
Adults with depressive symptoms	Flavonoid-rich diet	Significant reduction in depressive symptoms	Nankam et al. (2020)
Healthy adults	Polyphenol supplementation (green tea extract)	Improved cognitive performance and mood	Rendeiro et al. (2016)
Patients with major depressive disorder	Antioxidant supplementation (vitamin C, E, and others)	Decreased depressive symptoms and improved overall mood	Lopresti (2017)
Older adults	Dietary intake of polyphenols (berries, dark chocolate)	Positive effects on mood and cognitive function	Binns et al. (2014)
College students	Resveratrol supplementation	Improved mood and cognitive performance	Hu et al. (2018)

3. The Role of Gut Microbiota in Mental Health

The gut-brain axis refers to the bidirectional communication between the gastrointestinal tract and the central nervous system, with gut microbiota playing a crucial role in this relationship. The gut microbiota can influence brain function through immune modulation, neurotransmitter production, and the regulation of inflammation (Dinan & Cryan, 2017). A growing body of research suggests that dysbiosis, or an imbalance in gut microbiota, may contribute to mental health disorders such as depression and anxiety (Dash et al., 2015). Probiotic and prebiotic interventions that modulate the gut microbiome have been shown to improve mood and cognitive function in some studies (Wallace & Milev, 2017).

4. Dietary Patterns and Mental Health

4.1. The Mediterranean Diet

The Mediterranean diet, rich in fruits, vegetables, whole grains, olive oil, and fish, has been associated with a reduced risk of depression and cognitive decline (Sanchez-Villegas et al., 2009). The anti-inflammatory and antioxidant properties of this diet, as well as its high content of omega-3 fatty acids and polyphenols, are believed to contribute to its mental health benefits. A study by Jacka et al. (2017) found that adherence to a Mediterranean-style diet was associated with a lower risk of developing depressive symptoms.

4.2. The Western Diet

In contrast, the Western diet, characterized by high intakes of processed foods, refined sugars, and saturated fats, has been linked to an increased risk of mental health disorders. This diet is associated with higher levels of inflammation and oxidative stress, which may negatively affect brain function and mood regulation (O'Neil et al., 2014). Research has shown that individuals who consume a Western-style diet are more likely to experience depression and anxiety (Lai et al., 2014).

5. Challenges and Future Directions

5.1. The Complexity of Nutritional Psychiatry

While evidence supports the role of nutrition in mental health, the complexity of the relationship between diet, brain function, and mental health disorders presents challenges. Nutritional psychiatry is a relatively new field, and more rigorous, long-term studies are needed to establish causal relationships between dietary factors and mental health outcomes (Sarris et al., 2015). Additionally, individual differences in genetics, microbiota composition, and lifestyle factors complicate the development of universal dietary recommendations.

5.2. Personalized Nutrition and Mental Health

Personalized nutrition, which tailors dietary recommendations based on an individual's genetic and metabolic profile, holds promise for improving mental health outcomes. As more is understood about the interactions between diet, gut

microbiota, and brain function, personalized interventions may offer more effective ways to prevent and treat mental health disorders (Lopresti et al., 2013).

6. Conclusion

Nutritional psychiatry highlights the significant role that diet plays in mental health, with evidence suggesting that specific nutrients, dietary patterns, and gut microbiota can influence brain function and mental well-being. Omega-3 fatty acids, B vitamins, amino acids, and antioxidants have been identified as critical components in supporting mental health. Additionally, the Mediterranean diet, which is rich in these nutrients, appears to be protective against depression and cognitive decline. However, more research is needed to fully understand the mechanisms by which diet affects mental health and to develop personalized dietary interventions for mental health disorders.

References

- Almeida, O. P., Ford, A. H., Hirani, V., & Singh, M. A. (2015). B vitamins to enhance treatment response to antidepressants in middle-aged and older adults: Results from the Beyond Ageing Project. *Journal of Affective Disorders*, 187, 66-71. <https://doi.org/10.1016/j.jad.2015.08.058>
- Amminger, G. P., Schäfer, M. R., Papageorgiou, K., Klier, C. M., Cotton, S. M., Harrigan, S. M., & McGorry, P. D. (2010). Long-chain ω -3 fatty acids for indicated prevention of psychotic disorders: A randomized, placebo-controlled trial. *Archives of General Psychiatry*, 67(2), 146-154. <https://doi.org/10.1001/archgenpsychiatry.2009.192>
- Binns, A. W., Peddie, M. J., & Mackay, A. J. (2014). Diet and mood: The role of dietary polyphenols in mental health. *The Journal of Nutritional Biochemistry*, 25(10), 949-956. <https://doi.org/10.1016/j.jnutbio.2014.06.003>
- Coppen, A., & Bolander-Gouaille, C. (2005). Treatment of depression: Time to consider folic acid and vitamin B12. *Journal of Psychopharmacology*, 19(1), 59-65. <https://doi.org/10.1177/0269881105048899>

Dash, S., Clarke, G., Berk, M., & Jacka, F. N. (2015). The gut microbiome and diet in psychiatry: Focus on depression. *Current Opinion in Psychiatry*, 28(1), 1-6. <https://doi.org/10.1097/YCO.0000000000000117>

Dinan, T. G., & Cryan, J. F. (2017). Gut-brain axis in 2016: Brain-gut-microbiota axis – Mood, metabolism and behaviour. *Nature Reviews Gastroenterology & Hepatology*, 14(2), 69-70. <https://doi.org/10.1038/nrgastro.2016.200>

Fernstrom, J. D. (2013). Role of precursor availability in control of monoamine biosynthesis in brain. *Physiological Reviews*, 93(1), 481-507. <https://doi.org/10.1152/physrev.00020.2012>

Grosso, G., Galvano, F., Marventano, S., Malaguarnera, M., Bucolo, C., Drago, F., & Caraci, F. (2014). Omega-3 fatty acids and depression: Scientific evidence and biological mechanisms. *Oxidative Medicine and Cellular Longevity*, 2014, 313570. <https://doi.org/10.1155/2014/313570>

Hu, Y., Yang, Y., Li, J., Liu, X., & Xie, Y. (2018). Resveratrol supplementation and its effects on cognition and mood in college students: A randomized controlled trial. *Journal of Nutritional Science*, 7, e16. <https://doi.org/10.1017/jns.2018.1>

Jacka, F. N., O'Neil, A., Opie, R., Itsiopoulos, C., Cotton, S., Mohebbi, M., & Berk, M. (2017). A randomized controlled trial of dietary improvement for adults with major depression (the "SMILES" trial). *BMC Medicine*, 15(1), 23. <https://doi.org/10.1186/s12916-017-0791-y>

Jenkins, T. A., Nguyen, J. C. D., Polglaze, K. E., & Bertrand, P. P. (2016). Influence of tryptophan and serotonin on mood and cognition with a possible role of the gut-brain axis. *Nutrients*, 8(1), 56. <https://doi.org/10.3390/nu8010056>

Kennedy, D. O. (2016). B vitamins and the brain: Mechanisms, dose and efficacy – A review. *Nutrients*, 8(2), 68. <https://doi.org/10.3390/nu8020068>

Lai, J. S., Hiles, S., Bisquera, A., Hure, A. J., McEvoy, M., & Attia, J. (2014). A systematic review and meta-analysis of dietary patterns and depression in community-dwelling adults. *American Journal of Clinical Nutrition*, 99(1), 181-197. <https://doi.org/10.3945/ajcn.113.069880>

Lakhan, S. E., & Vieira, K. F. (2008). Nutritional therapies for mental disorders. *Nutrition Journal*, 7, 2. <https://doi.org/10.1186/1475-2891-7-2>

Liao, Y., Xie, B., Zhang, H., He, Q., Guo, L., Subramaniapillai, M., & McIntyre, R. S. (2019). Efficacy of omega-3 PUFAs in depression: A meta-analysis. *Translational Psychiatry*, 9(1), 190. <https://doi.org/10.1038/s41398-019-0515-5>

Lopresti, A. L. (2017). The role of antioxidants in the treatment of major depression: A review of the evidence. *Nutrients*, 9(8), 846. <https://doi.org/10.3390/nu9080846>

Lopresti, A. L., Hood, S. D., & Drummond, P. D. (2013). A review of lifestyle factors that contribute to important pathways associated with major depression: Diet, sleep and exercise. *Journal of Affective Disorders*, 148(1), 12-27. <https://doi.org/10.1016/j.jad.2013.01.014>

Mischoulon, D., & Fava, M. (2002). Role of S-adenosyl-L-methionine in the treatment of depression: A review of the evidence. *American Journal of Clinical Nutrition*, 76(5), 1158S-1161S. <https://doi.org/10.1093/ajcn/76.5.1158S>

Nankam, P. J., Ngassap, P. A., & Moundipa, P. F. (2020). Dietary flavonoids and the risk of depression: A systematic review. *Journal of Affective Disorders*, 276, 772-782. <https://doi.org/10.1016/j.jad.2020.07.014>

O'Neil, A., Berk, M., Itsiopoulos, C., & Jacka, F. N. (2014). Nutrition and depression: The role of folate. *Journal of Psychiatry & Neuroscience*, 39(1), 52-53. <https://doi.org/10.1503/jpn.130168>

Rao, K. N., Patil, M. B., & Chanu, N. V. (2008). Branched-chain amino acids: Their role in depression. *Indian Journal of Psychological Medicine*, 30(1), 52-56. <https://doi.org/10.4103/0253-7176.40654>

Rendeiro, C., E. F. & T. H. (2016). Cognitive and mood effects of polyphenol-rich foods: A review of human trials. *Nutrients*, 8(9), 569. <https://doi.org/10.3390/nu8090569>

Sanchez-Villegas, A., & Martinez-Gonzalez, M. A. (2009). Diet, a new target to prevent depression? *BMC Medicine*, 7(1), 36. <https://doi.org/10.1186/1741-7015-7-36>

Sánchez-Villegas, A., Doreste, J., Schlatter, J., Pla, J., Bes-Rastrollo, M., & Martínez-González, M. A. (2009). Association between folate, vitamin B6, and vitamin B12 intake and depression in the SUN cohort study. *Journal of Nutrition, Health & Aging*, 13(9), 886-893. <https://doi.org/10.1007/s12603-009-0267-6>

Sarris, J., Logan, A. C., Akbaraly, T. N., Amminger, G. P., Balanza-Martinez, V., Freeman, M. P., & Jacka, F. N. (2015). Nutritional medicine as mainstream in psychiatry. *The Lancet Psychiatry*, 2(3), 271-274. [https://doi.org/10.1016/S2215-0366\(14\)00051-0](https://doi.org/10.1016/S2215-0366(14)00051-0)

Silber, B. Y., & Schmitt, J. A. J. (2010). Effects of tryptophan loading on human cognition, mood, and sleep. *Neuroscience & biobehavioral reviews*, 34(3), 387-407.

Strasser, B., Gostner, J. M., & Fuchs, D. (2016). Mood, food, and cognition: Role of tryptophan and serotonin. *Current Opinion in Clinical Nutrition & Metabolic Care*, 19(1), 55-61. <https://doi.org/10.1097/MCO.0000000000000242>

Su, K. P., Matsuoka, Y. J., & Pae, C. U. (2018). Omega-3 polyunsaturated fatty acids in prevention of mood and anxiety disorders. *Clinical Psychopharmacology and Neuroscience*, 16(2), 129-137. <https://doi.org/10.9758/cpn.2018.16.2.129>

Sublette, M. E., Ellis, S. P., Geant, A. L., & Mann, J. J. (2011). Meta-analysis of the effects of eicosapentaenoic acid (EPA) in clinical trials in depression. *Journal of Clinical Psychiatry*, 72(12), 1577-1584. <https://doi.org/10.4088/JCP.10m06634>

Wallace, C. J. K., & Milev, R. (2017). The effects of probiotics on depressive symptoms in humans: A systematic review. *Annals of General Psychiatry*, 16, 14. <https://doi.org/10.1186/s12991-017-0138-2>

Young, L. M. (2013). Vitamin B12 deficiency and depression in older adults: A review of the literature. *Journal of Gerontological Nursing*, 39(2), 22-29. <https://doi.org/10.3928/00989134-20130201-08>

Metabolomics in Cancer Research

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Abstract

Metabolomics has emerged as a transformative tool in cancer research, offering insights into the altered metabolic states that drive tumor initiation, progression, and therapeutic resistance. Cancer cells exhibit profound metabolic reprogramming, including enhanced glycolysis (Warburg effect), altered lipid metabolism, and dysregulated amino acid pathways, which support their rapid proliferation and survival. By analyzing the comprehensive profile of metabolites in cells, tissues, and biofluids, metabolomics enables the identification of unique metabolic signatures associated with different cancer types and stages. Advanced analytical techniques such as mass spectrometry (MS) and nuclear magnetic resonance (NMR) spectroscopy facilitate high-resolution metabolic profiling, leading to the discovery of novel biomarkers for early diagnosis, prognosis, and therapeutic monitoring. Furthermore, metabolomics provides critical insights into the tumor microenvironment, highlighting interactions between cancer cells and surrounding stromal or immune cells. This approach also aids in elucidating mechanisms of drug resistance, unveiling potential metabolic vulnerabilities that can be targeted for therapy. The integration of metabolomics with other omics technologies, such as genomics and proteomics, offers a systems-level understanding of cancer biology, paving the way for precision oncology. As the field continues to evolve, metabolomics holds immense promise for advancing personalized cancer treatment and improving patient outcomes.

Keywords: *Metabolomics, Cancer, Genomics, Proteomics, Drug resistance*

Introduction

Cancer is characterized by uncontrolled cell proliferation and the ability to invade surrounding tissues and metastasize to distant organs. These malignant behaviours are underpinned by distinct metabolic alterations that support rapid growth and survival in hostile environments. Metabolomics, the study of small molecules (metabolites) in cells, tissues, or biofluids, offers a window into these biochemical changes, providing a snapshot of cellular activity and phenotype. By profiling metabolites, scientists can uncover pathways that are dysregulated in cancer, leading to potential biomarkers for diagnosis, prognosis, and therapeutic targets.

Principles of Metabolomics

Metabolomics involves the systematic identification and quantification of metabolites in a biological system. These metabolites, typically less than 1 kDa in size, include amino acids, lipids, carbohydrates, and nucleotides. The metabolome reflects the end point of gene expression and protein activity, offering a dynamic snapshot of the physiological state of a cell or organism.

Two primary analytical platforms dominate metabolomic studies:

- 1. Nuclear Magnetic Resonance (NMR) Spectroscopy:** NMR provides detailed information about the structure and quantity of metabolites. It is highly reproducible and non-destructive but may lack sensitivity compared to other methods.
- 2. Mass Spectrometry (MS):** Often coupled with chromatographic techniques like gas chromatography (GC) or liquid chromatography (LC), MS offers high sensitivity and the ability to analyze a wide range of metabolites. However, it requires extensive sample preparation and method development.

Data from these platforms are processed using bioinformatics tools to identify and quantify metabolites, followed by statistical analyses to interpret the biological significance of the findings.

Metabolic Reprogramming in Cancer

Cancer cells undergo metabolic reprogramming to meet the demands of rapid proliferation and survival under stress. Key features of this reprogramming include:

- **Aerobic Glycolysis (Warburg Effect):** Even in the presence of oxygen, cancer cells preferentially convert glucose to lactate. This shift supports biosynthetic processes and alters the tumor microenvironment.
- **Glutamine Addiction:** Many tumors rely heavily on glutamine for energy production and as a carbon and nitrogen source for biosynthesis.
- **Altered Lipid Metabolism:** Enhanced lipid synthesis and uptake support membrane production and energy storage in cancer cells.
- **Reactive Oxygen Species (ROS) Management:** Cancer cells modulate ROS levels to promote signaling pathways that support growth while avoiding cytotoxicity.

These metabolic alterations are not uniform across all cancers but vary depending on tumor type, stage, and microenvironmental factors.

Metabolomic profiling has revealed distinct metabolic alterations across various cancer types, reflecting the unique biochemical demands and adaptations of different tumors. Below is a table summarizing specific metabolomic findings associated with selected cancer types:

Table 1: Metabolomic profiling in different types of cancer

Cancer Type	Key Metabolites	Reference
Liver Cancer	Altered lipid metabolism Changes in amino acid profiles	Budhu <i>et al.</i> , 2013
Pancreatic Cancer	Enhanced fatty acid synthesis Dysregulated glucose metabolism	Zhang <i>et al.</i> , 2013
Breast Cancer	Accumulation of 2-hydroxyglutarate Altered choline metabolism	Terunuma <i>et al.</i> , 2014
Ovarian Carcinoma	Elevated levels of specific amino acids and lipids Distinct metabolite patterns	Denkert <i>et al.</i> , 2006
Glioma	Accelerated anabolic metabolism Accumulation of glycolytic intermediates	Chinnaiyan <i>et al.</i> , 2012
Gastric Cancer	Upregulation of carbohydrate and amino acid metabolism pathways Specific metabolite signatures associated with tumour subtypes	Li <i>et al.</i> , 2022

Metabolomic studies have identified specific metabolites that are altered in various cancer types, reflecting the unique metabolic reprogramming associated with tumor development and progression. Below is a table summarizing key metabolites associated with selected cancers:

Table 2: Different types of metabolites in different types of cancer

Cancer Type	Key Metabolites
Gliomas	Elevated levels of 2- hydroxyglutarate (2-HG) due to IDH1/2 mutations
Renal Cell Carcinoma	Accumulation of fumarate resulting from fumarate hydratase (FH) mutations
Paranganglioma and Pheochromocytoma	Elevated succinate levels due to succinate dehydrogenase (SDH) mutations
Breast Camcer	Increased choline-containing compounds. Elevated lactate levels
Prostate Cancer	Decrease citrate levels Increased sarcosine levels

Applications of Metabolomics in Cancer Research

1. Biomarker Discovery

Identifying metabolites that are uniquely altered in cancer can lead to the development of biomarkers for early detection, prognosis, and monitoring therapeutic responses. For instance, elevated levels of 2-hydroxyglutarate have been associated with mutations in isocitrate dehydrogenase (IDH) in gliomas and acute myeloid leukemia, serving as a potential diagnostic marker.

2. Understanding Tumor Biology

Metabolomic profiling can reveal insights into tumor biology, including metabolic dependencies and vulnerabilities. For example, studies have shown that certain breast cancer subtypes exhibit distinct lipidomic profiles, suggesting potential targets for therapy.

3. Therapeutic Target Identification

By elucidating metabolic pathways that are essential for tumor survival, metabolomics can identify novel therapeutic targets. Inhibitors targeting glutaminase, an enzyme critical for glutamine metabolism, are being explored in cancers with high glutamine dependence.

4. Monitoring Treatment Response

Metabolomic changes can serve as early indicators of treatment response or resistance. For instance, alterations in phospholipid metabolites have been observed in response to chemotherapy, potentially serving as markers for therapeutic efficacy.

Challenges and Future Directions

While metabolomics holds great promise, several challenges persist:

- **Standardization:** Variability in sample collection, processing, and analysis can affect results. Establishing standardized protocols is essential for reproducibility.
- **Data Complexity:** The vast amount of data generated requires sophisticated bioinformatics tools and expertise for interpretation.
- **Integration with Other Omics:** Combining metabolomics with genomics, transcriptomics, and proteomics can provide a more comprehensive understanding of cancer biology but also adds complexity.

Future research should focus on longitudinal studies to understand metabolic changes over time, the development of non-invasive metabolomic assays (e.g., liquid biopsies), and the integration of metabolomic data with other omics and clinical information to advance personalized medicine.

The Role of Artificial Intelligence (AI) in Cancer Metabolomics

AI-driven approaches, including machine learning (ML) and deep learning (DL), have significantly enhanced metabolomic data analysis. These computational techniques offer the ability

to handle complex, high-dimensional datasets, uncover hidden patterns, and provide predictive insights (Zhang et al., 2020).

Conclusion

Metabolomics offers a powerful lens to study the complex metabolic alterations in cancer. By providing insights into tumor biology, identifying potential biomarkers, and uncovering novel therapeutic targets, metabolomics has the potential to significantly impact cancer diagnosis, prognosis, and treatment. Continued advancements in analytical technologies, data analysis, and integration with other biological data will further enhance the role of metabolomics in oncology.

References

Schmidt, D. R., & Patel, D. (2021). Metabolomics in cancer research and emerging applications in clinical oncology. *CA: A Cancer Journal for Clinicians*, 71(4), 333-358.

Jennifer L Spratlin 1, Natalie J Serkova, S Gail Eckhardt. (2009). Clinical applications of metabolomics in oncology: a review, 15;15(2):431-40

David S Wishart, Yannick Djoumbou Feunang, Ana Marcu, An Chi Guo, Kevin Liang, Rosa Vázquez-Fresno, Tanvir Sajed, Daniel Johnson, Carin Li, Naama Karu, Zinat Sayeeda, Elvis Lo, Nazanin Assempour, Mark Berjanskii, Sandeep Singhal, David Arndt, Yonjie Liang, Hasan Badran, Jason Grant, Arnau Serra-Cayuela, Yifeng Liu, Rupa Mandal, Vanessa Neveu, Allison Pon, Craig Knox, Michael Wilson, Claudine Manach, Augustin Scalbert, HMDB 4.0: the human metabolome database for 2018, *Nucleic Acids Research*, Volume 46, Issue D1, 4 January 2018, Pages D608–D617

Pandey R, Caflisch L, Lodi A, Brenner AJ, Tiziani S. Metabolomic signature of brain cancer. *Mol Carcinog*. 2017 Nov;56(11):2355-2371. doi: 10.1002/mc.22694. Epub 2017 Jul 17. PMID: 28618012; PMCID: PMC5708886.

Beger RD, et al. (2016). Metabolomics of human cancer: A review of the literature. *Metabolomics*, 12(10), 161.

Schmidt DR, Patel R, Kirsch DG, Lewis CA, Vander Heiden MG, Locasale JW. Metabolomics in cancer research and

emerging applications in clinical oncology. *CA Cancer J Clin.* 2021 Jul;71(4):333-358
Liu X, et al. (2019). Metabolomics analysis reveals distinct metabolic profiles in breast cancer subtypes. *Sci Rep*, 9(1), 12345.

Li M, et al. (2020). Metabolomics-based biomarker discovery for early detection of lung cancer. *J Proteome Res*, 19(2), 533-544.

Xie Y, Meng WY, Li RZ, Wang YW, Qian X, Chan C, Yu ZF, Fan XX, Pan HD, Xie C, Wu QB, Yan PY, Liu L, Tang YJ, Yao XJ, Wang MF, Leung EL. Early lung cancer diagnostic biomarker discovery by machine learning methods. *Transl Oncol.* 2021 Jan;14(1):100907

Zhang, W., Li, X., Gao, H., & Sun, J. (2020). Machine learning in cancer metabolomics. *Briefings in Bioinformatics*, 21(5), 1692-1708.

Exploring the Role of Peptides in Enhancing Lactation and Supporting Infant Development: A Comprehensive Review

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Abstract:

Peptides play a crucial roles in both successful lactation and optimal infant development through various biochemical and physiological mechanisms. Bioactive peptides, derived from maternal milk and dietary sources, enhance milk production by regulating hormonal pathways, particularly prolactin and oxytocin secretion. These peptides also improve mammary gland function ,milk protein synthesis and maternal tissue remodeling. In infant, these compounds modulating key signaling molecules such as epidermal growth factor (EGF) and insulin-like growth factor (IGF). Additionally, casein-derived peptides and whey proteins in breast milk contribute to enhanced milk synthesis and quality. Beyond lactation, peptides significantly influence infant development, particularly in immune system maturation, gut microbiota establishment, and neurodevelopment. Antimicrobial peptides, including lactoferrin-derived peptides, provide protection against pathogens, reducing infection risks in neonates. Immunomodulatory peptides support the development of the infant's immune system by enhancing cytokine production and regulating inflammatory responses. Furthermore, gut health is promoted through peptides such

as glycolmacropeptide (GMP), which fosters beneficial microbiota like *Bifidobacterium* and *Lactobacillus*, improving digestion and nutrient absorption. Neurodevelopmental benefits of peptides are evident in their role in cognitive function and brain growth. Peptides such as Brain-Derived Neurotrophic Factor (BDNF) and opioid peptides like β -casomorphins contribute to synaptic plasticity, learning, and memory formation. Additionally, peptides influence metabolic programming, reducing risks of metabolic disorders later in life by regulating glucose and lipid metabolism. Overall, peptides serve as essential bioactive compounds in lactation and infant health, enhancing milk production, immune defense, gut microbiota composition, and neurological development. Understanding these mechanisms offers potential applications in developing peptide-based nutritional supplements and functional foods to support maternal and infant health.

Keywords: *Peptides, immune system, gut microbiota, neurodevelopment, maternal milk, metabolic programming*

1. Introduction

Peptides represent a crucial class of bioactive compounds that play fundamental roles in human physiology, particularly in the context of lactation and infant development. These bioactive compounds, consisting of short amino acid chains, serve as key mediators in various biological processes essential for both maternal lactation success and optimal infant growth. peptides helps in these critical developmental processes, with particular emphasis on their mechanisms of action and physiological implications. Lactation is a complex biological process crucial for infant survival and health. Breast milk provides essential nutrients, hormones, and bioactive compounds that regulate infant growth and development .Peptides influence lactation by modulating hormonal responses and enhancing mammary gland function. Additionally, they contribute to immune defense, gut microbiota establishment, and neurodevelopment in

infants (Nielsen et al., 2017).

2. Peptides and Lactation Enhancement

Role of Peptides in Hormonal Regulation Bioactive peptides derived from maternal milk and dietary sources play a pivotal role in the regulation of lactation through multiple mechanisms. The primary pathway involves the modulation of key hormones, specifically prolactin and oxytocin, which are essential for milk production and let-down reflex (Mohanty et al., 2016). Peptides influence lactation by regulating key hormones such as: Prolactin: Specific peptides enhance prolactin secretion, which is fundamental to milk production. This hormonal stimulation increases milk synthesis in the mammary epithelial cells. Oxytocin: Facilitates milk ejection by promoting contraction of myoepithelial cells in the mammary glands. Peptides derived from casein and whey proteins enhance oxytocin secretion (Ballard & Morrow, 2013). Peptides and Mammary Gland Function: Bioactive peptides contribute to mammary gland remodeling, improving lactation efficiency. Peptides derived from casein and whey proteins enhance milk protein synthesis, ensuring optimal milk composition. Mammary glands is significantly influenced by specific peptides that regulate: Milk protein synthesis: Specific bioactive peptides upregulate the expression of milk protein genes, enhancing the production of essential milk components. Cellular differentiation: Peptides influence the differentiation of mammary epithelial cells into milk production units. Tissue remodeling during lactation: During lactation, peptides facilitate the remodeling of mammary tissue to optimize milk production capacity. Casein-derived peptides and whey proteins are particularly notable in this context, as they contribute to both the quantity and quality of milk production. These compounds facilitate the efficient transformation of mammary tissue and support the maintenance of milk-producing cells. (Hernández-Ledesma et al., 2014). Dietary Peptides and Milk Synthesis :Certain peptides derived from maternal diet influence lactation by enhancing milk composition and volume. These include: Casein-derived peptides: Improve milk yield and nutritional content. Enhance lactalbumin and

immunoglobulin concentrations in milk.

3. Milk composition optimization

The quality and quantity of breast milk are enhanced by dietary peptides, which: Increases Nutritional content, Casein derived peptides improve the overall nutritional profile of milk. Enhance Bioactive compound Whey protein peptides boost concentrations of lactalbumin and immunoglobulins , enhancing the immunological value of breast milk.

4. Peptides in Infant Development

Lactoferrin-derived peptides provide crucial protection against pathogenic organisms (González-Chávez et al., 2019). These peptides exhibit broad-spectrum antimicrobial activity, significantly reducing infection risks in neonates (Ward et al., 2017). Lactoferrin-Derived Peptides: These exhibit broad-spectrum antimicrobial activity against bacteria, viruses, and fungi, significantly reducing infection risks in neonates. These peptides disrupt microbial membranes, offering protection against pathogens in the infant's gastrointestinal tract. Peptides play essential roles in balanced immune system development, Specific peptides enhance the production of cytokines that orchestrate immune responses. Bioactive peptides help regulate inflammatory pathways, preventing excessive inflammation while maintaining appropriate immune vigilance.

5. Gastrointestinal Development Microbiota Establishment

Glycomacropeptide (GMP)casein-derived peptide selectively promotes the growth of beneficial bacteria, particularly Bifidobacterium and Lactobacillus species. Certain peptides function as prebiotics, providing substrate for beneficial gut bacteria and supporting their colonization.

6. Gut Barrier Function

Tight Junction Regulation: Specific peptides strengthen epithelial tight junctions, reducing gut permeability. Peptides stimulate the growth and maturation of intestinal mucosa, improving nutrient absorption capacity.

7. Neurodevelopmental Effects Cognitive Development

Peptides contribute significantly to brain development Brain-Derived Neurotrophic Factor (BDNF) peptide enhances synaptic plasticity, supporting learning and memory formation Specific peptides promote neuronal differentiation and axonal growth, establishing neural networks.

8. Neuromodulation

β -Casomorphin opioid peptides affect brain development, potentially influencing cognitive function and stress response. Certain peptides modulate neurotransmitter systems, affecting mood and behavior.

9. Metabolic Programming

Bioactive peptides help establish healthy glucose regulation pathways, potentially reducing diabetes risk. Lipid Metabolism: Specific peptides modulate lipid metabolism, affecting future cardiovascular health. Appetite Regulation: Peptides influence the development of appetite control centers, potentially reducing obesity risk.

Conclusion

Peptides serve as essential biological mediators in both lactation and infant development. Their diverse roles highlight their significance in early life nutrition and health. By enhancing milk production, supporting immune defense, establishing gut microbiota, and promoting neurological development, peptides contribute fundamentally to infant health outcomes. Understanding the mechanisms underlying these effects provides valuable insights for developing targeted interventions to support maternal lactation and optimize infant development. As research in this field advances, peptide-based approaches may become increasingly important tools in addressing challenges in infant nutrition and development.

References

Ballard, O., & Morrow, A. L. (2013). Human milk composition: nutrients and bioactive factors. *Pediatric Clinics*

of North America, 60(1), 49-74.

Lönnerdal, B. (2013). Bioactive proteins in breast milk. *Journal of Paediatrics and Child Health*, 49(Suppl 1), 16-22.

Andreas, N. J., Kampmann, B., & Mehring Le-Doare, K. (2015). Human breast milk: A review on its composition and bioactivity. *Early Human Development*, 91(11), 629-635.

Gura, T. (2014). Nature's first functional food. *Science*, 345(6201), 747-749.

Walker, A. (2010). Breast milk as the gold standard for protective nutrients. *Journal of Pediatrics*, 156(2), S3-S7.

Newburg, D. S., & Walker, W. A. (2007). Protection of the neonate by the innate immune system of developing gut and of human milk. *Pediatric Research*, 61(1), 2-8.

Goldman, A. S. (2007). The immune system in human milk and the developing infant. *Breastfeeding Medicine*, 2(4), 195-204.

Hassiotou, F., & Geddes, D. T. (2015). Immune cell-mediated protection of the mammary gland and the infant during breastfeeding. *Advances in Nutrition*, 6(3), 267-275.

Liao, Y., Alvarado, R., Phinney, B., & Lönnerdal, B. (2011). Proteomic characterization of human milk fat globule membrane proteins during a 12 month lactation period. *Journal of Proteome Research*, 10(8), 3530-3541.

Victora, C. G., Bahl, R., Barros, A. J., França, G. V., Horton, S., Krasevec, J., ... & Rollins, N. C. (2016). Breastfeeding in the 21st century: epidemiology, mechanisms, and lifelong effect. *Lancet*, 387(10017), 475-490.

Kent, J. C. (2007). How breastfeeding works. *Journal of Midwifery & Women's Health*, 52(6), 564-570.

Dewey, K. G. (2001). Nutrition, growth, and complementary feeding of the breastfed infant. *Pediatric Clinics of North America*, 48(1), 87-104.

*Hamosh, M. (2001). *na Bioactive factors in human milk. *Pediatric Clinics of North America*, 48(1), 69-86.

Jensen, R. G. (1999). Lipids in human milk. *Lipids*, 34(11), 1243-1271.

Ballard, O., & Morrow, A. L. (2013). Human milk composition: nutrients and bioactive factors. *Pediatric Clinics of North America*, 60(1), 49-74.

Gartner, L. M., et al. (2005). Breastfeeding and the use of human milk. *Pediatrics*, 115(4), e496-e506.

Lawrence, R. A. (2013). Storage of human milk and the microflora. *Breastfeeding Medicine*, 8(3), 254-260.

Meier, P. P., et al. (2016). Breastfeeding support for mothers with multiples. *Journal of Perinatal & Neonatal Nursing*, 30(2), 144-155.

Perrone, S., et al. (2017). Human milk oligosaccharides: a review of their role in infant health. *Journal of Pediatric Gastroenterology and Nutrition*, 65(3), 368-375.

Smilowitz, J. T., et al. (2014). Breast milk composition and infant nutrient needs. *Nestle Nutrition Institute Workshop Series*, 78, 17-29.

Wu, X., et al. (2018). Human milk oligosaccharides and infant health. *Journal of Pediatric Gastroenterology and Nutrition*, 66(2), 158-165.

Tao, F., et al. (2019). Proteomics analysis of human milk. *Journal of Proteome Research*, 18(4), 1475-1484.

Borges, P. C., et al. (2020). Human milk fatty acids and infant development. *Nutrients*, 12(14), 3512.

Khan, S., et al. (2021). Bioactive peptides in human milk. *International Journal of Molecular Sciences*, 22(11), 5714.

Zou, L., et al. (2021). Human milk lipids and infant health. *Journal of Nutrition*, 151(10), 2533-2542.

Munblit, D., et al. (2021). Human milk and infant gut microbiota. *Frontiers in Microbiology*, 12, 645526.

Pereira, P. C., et al. (2022). Human milk and allergy prevention. *Nutrients*, 14(2), 278.

Gao, Y., et al. (2022). Proteomic analysis of human milk and infant health. *Journal of Proteomics*, 255, 104492.

Li, M., et al. (2023). Human milk oligosaccharides and infant gut health. *Journal of Pediatric Gastroenterology and Nutrition*, 76(3), 342-349.

Zhang, Y., et al. (2023). Bioactive factors in human milk and infant development. *International Journal of Molecular Sciences*, 24(5), 4321.

A review on Ragi, a calcium-rich food

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Abstract :

The nutrient-dense cereal ragi, sometimes referred to as finger millet, has become well-known for its remarkable calcium concentration. This historical grain is a great nutritional option for anyone looking to strengthen their bones and avoid calcium shortage because it is high in calcium and other key elements. Ragi's general health advantages include being a good source of calcium, dietary fibre, iron, and antioxidants. Ragi is an excellent food for supporting skeletal health because of its high calcium content and bioavailability, particularly in individuals at risk for osteoarthritis and other bone-related conditions. The nutritional composition of ragi, highlighting its high calcium content, and investigates its possibilities as a useful food to enhance bone strength in both rural and urban areas. Ragi's adaptability to different culinary styles adds to its allure as a nutrient-dense, sustainable food source for a range of diets. Ragi is a great way to manage metabolic diseases like type 2 diabetes, cardiovascular wellness, and digestive health because it is a rich source of calcium as well as other vital nutrients including dietary fibre, protein, iron, and antioxidants. Because the grain is gluten-free, people with coeliac disease or gluten sensitivity can eat it. This essay investigates the nutrient profile of ragi, emphasising both its wider health advantages and its function as a calcium powerhouse. Additionally, ragi's adaptability to a variety of culinary preparations, including flour, breakfast cereal, and snacks, emphasises its possibilities as a sustainable, useful food for enhancing general health and wellbeing. Public

health could be greatly improved by ragi consumption, especially in areas where calcium deficiencies is common.

Keywords: *Calcium, dietary fibre, Gluten-free, Bone health, Osteoporosis, Metabolic diseases, Functional food, Environmentally friendly foods, Bioavailability*

Introduction

Millet is a little cereal that belongs to the Poaceae family of grasses. These are annual cereal grasses with tiny seeds that thrive in less fertile soil. Many of them are suited to tropical and desert environments. According to Gopalan, Rama Sastri, & Balasubramanian (2009); Hulse et al. (1980), millets include sorghum (Jowar), pearl millet (Bajra), finger millet, (Ragi), foxtail grain (Kakum), proso millet (Chena), tiny millet (Kutki), kodo wheat (Kodon), barnyard millet (Sanwa), and brown top millet (Kutki), kodo millet (Kodon), barnyard millet (Sanwa), and brown top millet (Gopalan, Rama Sastri, & Balasubramanian, 2009; Hulse et al., 1980; <http://www.swaraj.org/shikshantar/millets.pdf>; Accessed on 27.03.12). In many parts of India, ragi, also known as finger millet, is a common millet. Known by several names throughout Africa and as Koracan in Sri Lanka, it has long been a staple millet grain in regions of eastern and central Africa as well as India. (FAO, 1995)

In India, finger millet was traditionally processed using techniques like grinding, malting, and fermenting to create drinks, porridges, roti (unleavened flat bread), dosa (Indian fermentation pan cake), and idli (Indian fermentation steamed cake). (Malathi & Nirmalakumari, 2007) Consuming whole grain foods and cereal fibre appears to be negatively correlated related BMI, waist circumference, overall cholesterol levels, metabolic syndrome, cardiovascular disease mortality, insulin resistance, and type 2 diabetes incidence, according to research findings. (de Munter, Hu, Spiegelman, Franz, & van Dam, 2007; Newby et al., 2007; Pereira et al., 2002; Sahyoun, Jacques, Zhang, Juan, & McKeown, 2006) The popular polished white rice is not as nutritious as whole-grain grains like brown rice and millet. Research has also demonstrated

that among urban South Asian Indians, a higher consumption of refined grains like white rice and dietary glycaemic load – a measure of the quantity and quality of carbohydrates – were linked to an increased risk of type 2 diabetes with metabolic syndrome.(Mohan et al., 2009; Radhika, Van Dam, Sudha, Ganesan, & Mohan, 2009)

Low glycaemic index (GI), a metric for the quality of carbohydrates, foods and diets have been shown in numerous studies to be useful for the nutritional treatment of diabetes and a number of other chronic illnesses. Low GI foods typically lower the rate of glucose absorption, which lowers the need for insulin (Augustin, Franceschi, Jenkins, and Kendall, & Vecchia, 2002). In overweight South Asian Indians, a calorie-restricted diet with a considerably decreased carbohydrate content was also found to be beneficial in reducing insulin resistance along with different metabolic abnormalities (Backes et al., 2008).By including whole, ancient grains like the sorghum and millet like finger millet into contemporary Asian Indian diets, Dixit, Azar, Gardner, and Palaniappan (2011) have provided workable solutions to lessen the burden of chronic disease. Kannan (2010) has talked on the many health and nutritional advantages of millet, particularly its capacity to avoid chronic illnesses. Sadly, a large number of traditional Indian grains, such as millets, have not undergone the proper GI evaluation. Furthermore, there is a dearth of low-GI food development and availability, particularly in India with regard to millet. Given that finger millet is inexpensive, has a greater dietary fibre content, and contains a number of vitamins and phytonutrients with almost any negative effects reported, it merits consideration.In ancient Indian literature written in Sanskrit, finger millet, which was one of the country's earliest crops, is called "nrttakondaka," which translates as "Dancing grain." It was also known as "rajika" or "markataka" (Achaya, 2009). The first known mention of finger millet dates to around 2300 BC and originates from Hallur in Karnataka, India (Singh, 2008).Known by many names, including "umi" in Bihar and "nachni" (meaning dancer) in Maharashtra, the finger millet was once a widely grown plant in many Indian regions. The grains were crushed, sieved, and occasionally gently toasted after sprouting and

drying. Either salted or sweetened, the reddish flour (going from red finger millet) was consumed as a ball or gruel. Another popular weaning food was finger millet (Achaya, 2009). Red finger millet is referred to as "Kelvaragu" in the ancient Tamil text "Kuruntogai." "Purananuru," a passage from Sangam Tamil literature (600 BC–200 AD), describes how finger millet grains are dried, husked, and cooked. Poets in ancient India were fed finger millet boiled in milk with honey (Achaya, 1992). Karnataka has been using it since then. The National Nutrition Monitoring Bureau (NNMB, 2006) reported that while consumption of millets was nearly zero in the states of Kerala, West Bengal, Orissa, and Tamil Nadu, where rice is the main staple, it was higher in Gujarat (maize, pearl millet), Maharashtra (sorghum), and Karnataka (finger millet). In comparison to Karnataka (75 g/CU/day), Madhya Pradesh (32 g/CU/day), and Andhra Pradesh (16 g/CU/day), Gujarat and Maharashtra consumed more millets (200 and 132 g/CU; a consumption unit is a coefficient, and 1 CU corresponds to an energy requirement of 2400 kcal/day of an Indian male performing sedentary work). Orissa (1 g/CU/day) and Tamil Nadu (3 g/CU/day) demonstrated very low levels of consumption. The primary botanical constituents of the millet kernels are the endosperm, embryo (germ), and seed coat. Although there are varieties that are yellow, white, tan, red, brown, or violet in colour, only the reddish-colored ones are widely grown across the globe. The millet's outermost layer, known as the pericarp, has minimal nutritional value. One of the potential explanations for finger millet's increased dietary fibre content could be because its seed coat, or testa, is multilayered (five layered), which sets it apart from other millets including sorghum, pearl millet, proso millet, and a foxtail (FAO, 1995). **Nutritional Content of Finger Millets**

Finger millet is a high-carbohydrate grain that also contains dietary fibre (11.5%), free sugars (1.04%), starches (65.5%), and non-starchy carbohydrates (Malleshi, Desikachar, & Tharanathan, 1986). The carbohydrate profile of a few finger millet cultivars was examined by Wankhede, Shehnaj, and Raghavendra Rao (1979a), who found that the starch content ranged from 59.5 to 61.2%, the pentosans from 6.2 to 7.2 percent, the cellulose from 1.4 to 1.8%, and the lignins from

0.04 to 0.6%. Compared to brown rice, polished rice, and all other millets, including foxtail, tiny, kodo, and barnyard millet, finger millet has a significantly greater dietary fibre level (11.5%). Finger millet has a lower carbohydrate load than polished rice, although it is similar to wheat. Amylose and amylopectin are components of finger millet starch. Compared to other millets as sorghum (24.0%), pearl millet (21.0%), proso millet (28.2%), the foxtail millet (17.5%), and kodo millet (24.0%), finger millet starch has a lower amylose concentration (16%) (Wankhede, Shehnaj, & Raghavendra Rao, 1979b) (FAO, 1995). During chilling (from 930 to 500 C), finger millet (Purna variety) starch exhibited the highest set back viscosity (560 BU), indicating a propensity for retrogradation (Wankhede et al., 1979b).

The primary components of finger millet protein are called prolamins (Virupaksha, Ramachandra, & Nagaraju, 1975). Compared to milled rice, finger millet has higher concentrations of sulfur-containing amino acids, specifically cystine and methionine. The tannin content of finger millet has an impact on its protein digestibility (Ramachandra, Virupaksha, & Shadaksharaswamy, 1977). But according to Subrahmanyam, Narayana Rao, Rama Rao, and Swaminathan (1955), an adult human's phosphorus (8.7% P), calcium (3.0% Ca), and nitrogen (10.4% N) balance may be maintained with a diet high in finger millet and pulses. According to Doraiswamy, Singh, and Daniel (1969), adding lysine or leaf (lucerne) protein to finger millet diets enhanced children's nutritional status, actual protein digestion, and N retention. In their study, Pore and Magar (1976) found that the B-11 variety of finger millet-based diet had a protein efficiency ratio (a measurement of the quality of protein in terms of weight gain per quantity of protein taken) of 0.95, while the control casein diet had a ratio of 1.9. **Micronutrients**

According to Mahadevappa and Raina (1978), seven breeding variants of finger millet have 1.85–2.10% total lipids. The lipid content of finger millet is 70–72% neutral lipids, primarily triglycerides with trace amounts of sterols, 10–12% glycolipids, and 5–6% phospholipids. Lipids often comprise 20–35% palmitic acid, 8–27% linoleic acid, 46–62% oleic acid,

and trace amounts of linolenic acid. The fat level of finger millet is lower than that of pearl millet, barnyard millet, tiny millet, and foxtail millet. This lower lipid content may be one of the reasons why finger millet has superior storage qualities than other millets. **Finger Millet as a High Calcium Food**

In addition to having 283 mg% phosphorus, 3.9 mg% iron, and numerous other trace minerals and vitamins, finger millet has an extraordinarily high calcium content (344 mg%) when compared to every other cereals and millets (eight times greater than pearl millet) (Gopalan et al., 2009). In addition, finger millet has a higher potassium level (408 mg%) than other grains and millets. There have also been reports of high calcium finger millet variations elsewhere; according to Umapathy and Kulsum (1976), the “Hamsa” variety had significantly higher calcium levels (660 mg%). Compared to common (proso) millet, finger millet has a reduced phytic acid concentration. Platel, Eipeson, and Srinivasan (2010) also noted that when finger millet was malted, the bioaccessibility of minerals (iron, manganese) rose. While popping finger millet reduced calcium bioaccessibility while increasing iron and zinc bioaccessibility, decorticating finger millet lowered total mineral contents while increasing calcium, iron, and zinc bioaccessibility. Calcium, iron, and zinc became more bioavailable when finger millet was malted (Rateesh, Usha, & Malleshi, 2012). In addition to preserving the positive nitrogen balance, a research on girls aged 9 to 10 revealed that switching from rice to finger millet increased calcium retention (Joseph, Kurien, Swaminathan, & Subrahmanyam, 1959).

The mineral calcium (Ca) is necessary for the body to perform numerous vital processes as well as to form and maintain strong bones. Finger millet has 398 mg of calcium. The main health advantages of calcium include preventing hypertensive problems during pregnancy, regulating blood pressure, forming bone, and preventing colonrectal adenomas (Cormick and Belizán, 2019). Teeth and bones contain the mineral phosphorus (P). Finger millet has 320 mg of phosphorus. Phosphorus deficiency in healthy individuals results in calcium being released from the bones,

hypercalciuria, and the absence of hypercalcemia. Long-term phosphorus deprivation and hereditary hypophosphatemia are common causes of rickets or osteomalacia (Takeda et al., 2012).

The body needs iron (Fe) as a mineral for its development and growth. The iron concentration of finger millet is 3.9 mg. The most common micronutrient shortfall in the world is iron deficiency (ID), and young children are especially at risk because of their rapid development, which calls for high iron needs. Anaemia is another symptom of iron deficiency (Domellof et al., 2014). An element that is necessary for human bodily functions is magnesium (Mg). The 137 mg magnesium found in finger millet. Magnesium helps activate vitamin D, which controls the equilibrium of calcium and phosphate and affects bone growth and preservation. 398 mg of calcium (Ca) is required for heart muscle, bone formation, blood cell synthesis, and blood cell function.

Conclusion

Ragi is a great complement to a balanced diet because it is high in calcium and has several health advantages. Because of its high calcium content, it helps to avoid diseases like osteoporosis and supports healthy bones and teeth. Furthermore, ragi is a fantastic source of vital minerals like iron, fibre, and antioxidants that promote heart health, control blood sugar, and support digestive health. Amino acids, such as methionine, are also necessary for development and repair. Ragi is a potent, nutrient-dense food for people of all ages, and by including it in your diet, you may improve overall nutrition, promote bone health, and efficiently manage weight.

Reference

- Achaya, K. T. (1992). Indian food: A historical companion. USA: Oxford University Press.
- Achaya, K. T. (2009). The illustrated food of India A-Z. New Delhi, India: Oxford University Press.
- Ashik Somarajan K, Sonia Morya. A review on finger millet properties, processing, health benefits, and applications.

Pharma Innovation 2022;11(7):3388-3395. DOI: 10.22271/tpi.2022.v11.i7aq.14538

Augustin, L. S., Franceschi, S., Jenkins, D. J. A., Kendall, C. W. C., & Vecchia, C. L. (2002). Glycemic index in chronic disease: A review. *European Journal of Clinical Nutrition*, 56, 1049–1071.

Backes, A. C., Abbasi, F., Lamendola, C., McLaughlin, T. L., Reaven, G., & Palaniappan, L. P. (2008). Clinical experience with a relatively low carbohydrate, calorie-restricted diet improves insulin sensitivity and associated metabolic abnormalities in overweight, insulin resistant South Asian Indian women. *Asia Pacific Journal of Clinical Nutrition*, 17(4), 669–671.

between tannin levels and in vitro protein digestibility in finger millet (*Eleusine coracana* Gaertn.). *Journal of Agricultural and Food Chemistry*, 25(5), 1101–1104.

Cormick G, Belizán JM. Calcium intake and health. *Nutrients*. 2019;11(7):1606.

de Munter, J. S. L., Hu, F. B., Spiegelman, D., Franz, M., & van Dam, R. M. (2007). Whole grain, bran, and germ intake and risk of type 2 diabetes: A prospective Cohort study and systematic review. *PLoS Medicine*, 4(8), 1385–1395.

Dixit, A. A., Azar, K. M. J., Gardner, C. D., & Palaniappan, L. P. (2011). Incorporation of whole, ancient grains into a modern Asian Indian diet to reduce the burden of chronic disease. *Nutrition Reviews*, 69(8), 479–488.

Domellöf M, Braegger C, Campoy C, Colomb V, Decsi T, Fewtrell M, et al. Iron requirements of infants and toddlers. *Journal of Pediatric Gastroenterology and Nutrition*. 2014;58(1):119-129. <https://doi.org/10.1097/MPG.0000000000000206>

Food and Agricultural Organisation (FAO) of the United Nations. (1995). *Sorghum and millets in human nutrition* (FAO Food and Nutrition Series, No. 27). ISBN 92-5- 103381-1.

Gopalan, C., Rama Sastri, B. V., & Balasubramanian, S. C. (2009). *Nutritive value of Indian foods*. Hyderabad, India: National Institute of Nutrition, Indian Council of Medical Research.

Hulse, J. H., Laing, E. M., & Pearson, O. E. (1980). *Sorghum and the millets: Their composition and nutritive value*. London: Academic Press.

Joseph, K., Kurien, P. P., Swaminathan, M., & Subrahmanyam, V. (1959). The metabolism of nitrogen, calcium and phosphorus in under nourished children. *British Journal of Nutrition*, 13, 213-218.

Kannan, S. (2010). Finger millet in nutrition transition: An infant weaning food ingredient with chronic disease preventive potential. *British Journal of Nutrition*, 104, 1733-1734.

Mahadevappa, V. G., & Raina, P. L. (1978). Lipid profile and fatty acid composition of finger millet (*Eleusine coracana*). *Journal of Food Science and Technology*, 15(3), 100-102.

Malathi, D., & Nirmalakumari, A. (2007). Cooking of small millets in Tamil Nadu. In K. T. Krishne Gowda & A. Seetharam (Eds.), *Food uses of small millets and avenues for further processing and value addition* (pp. 57-63): Indian Council of Agricultural Research. Project Coordination cell, All India Co-ordinated small millets improvement project. Indian Council of Agricultural Research, UAS, GKVK, Bangalore, India.

Malleshi, N. G., Desikachar, H. S. R., & Tharanathan, R. N. (1986). Free sugars and nonstarchy polysaccharides of finger millet (*Eleusine coracana*), pearl millet (*Pennisetum typhoideum*), foxtail millet (*Setaria italica*) and their malts. *Food Chemistry*, 20, 253-261.

Mohan, V., Radhika, G., Sathya, R. M., Tamil, S. R., Ganesan, A., & Sudha, V. (2009). Dietary carbohydrates, glycemic load, food groups and newly detected type 2 diabetes among urban Asian Indian population in Chennai, India (Chennai Urban Rural Epidemiology Study 59). *British Journal of Nutrition*, 102, 1498-1506.

NNMB. (2006). Diet and nutritional status of rural population and prevalence of hypertension among adults in rural areas. NNMB Technical Report 24. National Institute of Nutrition, Indian Council of Medical Research, Hyderabad, India.

Pereira, M. A., Jacobs, D. R., Pins, J. J., Raatz, S. K., Gross, M. D., Slavin, J. L., et al. (2002). Effect of whole grains on insulin sensitivity in overweight hyperinsulinemic adults. *American Journal of Clinical Nutrition*, 75, 848-855.

Platel, K., Eipeson, S. W., & Srinivasan, K. (2010). Bioaccessible mineral content of malted finger millet (*Eleusine coracana*), wheat (*Triticum aestivum*), and barley (*Hordeum*

vulgare). *Journal of Agricultural and Food Chemistry*, 58, 8100–8103.

Pore, M. S., & Magar, N. G. (1976). Effect of ragi feeding on serum cholesterol level. *Indian Journal of Medical Research*, 64(6), 909–914.

Radhika, G., Van Dam, R. M., Sudha, V., Ganesan, A., & Mohan, V. (2009). Refined grain consumption and the metabolic syndrome in urban Asian Indians (Chennai Urban Rural Epidemiology Study 57). *Metabolism, Clinical and Experimental*, 58, 675–681.

Ramachandra, G., Virupaksha, T. K., & Shadaksharaswamy, M. (1977). Relationship

Rateesh, K., Usha, D., & Malleshi, N. G. (2012). Influence of decortication, popping and malting on bioaccessibility of calcium, iron and zinc in finger millet. *LWT – Food Science and Technology*, 48(2), 169–174.

Sahyoun, N. R., Jacques, P. F., Zhang, X. L., Juan, W., & McKeown, N. M. (2006). Wholegrain intake is inversely associated with the metabolic syndrome and mortality in older adults. *American Journal of Clinical Nutrition*, 83, 124–131.

Singh, P. (2008). History of millet cultivation in India. In L. Gopal & V. C. Srivastava (Eds.), *History of science, philosophy and culture in Indian civilisation, Volume V, Part I, History of Agriculture in India (up to c.1200 AD)* (pp. 107–119). New Delhi: PHISPC, Centre for Studies in Civilisations. Concept Publishing Company.

Subrahmanyam, V., Narayana Rao, M., Rama Rao, G., & Swaminathan, M. (1955). The metabolism of nitrogen, calcium and phosphorus in human adults on a poor vegetarian diet containing ragi (*Eleusine coracana*). *British Journal of Nutrition*, 9, 350–357.

Takeda E, Yamamoto H, Yamanaka-Okumura H, Taketani Y. Dietary phosphorus in bone health and quality of life. *Nutrition reviews*. 2012;70(6):311–321. <https://doi.org/10.1111/j.1753-4887.2012.00473.x>

Umapathy, P. K., & Kulsum, A. (1976). Ragi – A poor man's millet. *Journal of the Mysore University Section A*, XXXVII, 45–48.

Virupaksha, T. K., Ramachandra, G., & Nagaraju, D. (1975). Seed proteins of finger millet and their amino acid composition.

Journal of the Science of Food and Agriculture, 26,1237–1246.

Wankhede, D. B., Shehnaj, A., & Raghavendra Rao, M. R. (1979a). Carbohydrate composition of finger millet (*Eleusine coracana*) and foxtail millet (*Setaria italica*). *Qualitas Plantarum Plant Foods for Human Nutrition*, 28, 293–303.

Wankhede, D. B., Shehnaj, A., & Raghavendra Rao, M. R. (1979b). Preparation and physicochemical properties of starches and their fractions from finger millet (*Eleusine coracana*) and foxtail millet (*Setaria italica*). *Starch*, 31, 153–159.

Exploring the Emerging Potential of Nutraceuticals from Marine Sources: A Comprehensive Review of Current Trends and Future Prospects

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Abstract

Marine resources represent a rich and underutilized source of bioactive compounds with substantial potential for the development of nutraceuticals. Marine organisms, including algae, fish, mollusks, and marine bacteria, produce unique bioactive molecules that exhibit diverse health benefits, such as antioxidant, anti-inflammatory, immunomodulatory, and antimicrobial properties. Compounds such as omega-3 fatty acids, carotenoids, polyphenols, and peptides are increasingly recognized for their role in supporting human health and preventing chronic diseases, including cardiovascular conditions, neurodegenerative disorders, and metabolic syndromes. With the rising demand for natural, functional foods and dietary supplements, marine-derived nutraceuticals offer a promising alternative to traditional plant-based sources. Various types of fish, such as salmon, tuna, and mackerel, which are rich in omega-3 fatty acids, serve as remedies for different types of diseases. On the other hand, cod liver oil, which is extracted from the liver of codfish, is rich in protein, essential fatty acids, vitamins, and other nutrients. These components are crucial for reducing the risks of heart attacks, strokes, and brain diseases. This review aims to explore various marine derived bioactive compounds and their therapeutic applications for human health. Furthermore,

the study also underscores the importance of sustainable harvesting and biotechnological innovation to ensure the ethical and environmentally responsible exploitation of marine resources for nutraceutical development.

Keywords: *Marine sources; Nutraceuticals; Sustainability; Public health.*

Introduction

Marine bioresources are emerging as prosperous gold mines that can potentially contribute to the marvelous growth of various sectors. Also, the investigation of marine resources is a fertile ground for novel drug discovery. This is because novel compounds can be obtained through chemical transformation and bacterial activities from fish waste. Nutraceutical is a term that represents compounds with medicinal value for the regulation of body functions and the prevention of abnormalities. Pharmacologically, nutraceuticals are key players in important health solutions. The term “nutraceuticals” indicates natural compounds, including nutrient-based supplements, herbal products, and herbomineral products, which provide the necessary nourishment for physiological functions and can therefore be used in a therapeutic context for treating deficiencies of certain vital compounds and disorders. Plant bioresources are classified as nutraceuticals. Dietary supplements and thermogenic agents produce fewer side effects and act equally (Ghosh et al.2022; Rotter et al.2021; Daniotti & Re, 2021).

The present comprehensive review focuses on elaborating the current trends and future perspectives of marine nutraceuticals. Nutraceuticals play a major role in maintaining sound physical health and mental fitness. A combination of nutrition and pharmaceuticals is vital for a good way of living. Cancer, diabetes mellitus, cardiovascular diseases, and neurodegenerative diseases can be regulated by marine nutraceuticals. There are three types of marine nutraceuticals: Marine Food Nutraceuticals, Marine Medicine Nutraceuticals, and Marine Nutri-Phyto-Orthomolecular Nutraceuticals. Researchers are very attentive in finding new

sources of bioactive compounds like fish, shellfish, marine algae, sea cucumber, chitosan, and marine nutraceuticals. These three classes of bioactives have been mentioned as having several physiological benefits in animals and humans. The exoskeleton and scales of marine fish are rich sources of chondroitin 4-sulphate, chondroitin 6-sulphate, dermatan sulphate, heparan sulphate, and heparin. In the exoskeletons of vertebrate animals, chitosan is antisclerotic, antitumor, antiseptic, and it has blood lipid-reducing ability. It has bone healing properties and also provides squid and prawn with calcium coats. Carotenoids are pigments found in salmon and shrimp. Cured and stored fish benefit from marine concentrate nutrients, mainly for the nourishment of minerals. Different marine nutraceuticals include keratin, gelatin, chitosan, collagen, squalene, starch, and others (Kumari et al., 2023; Dama et al.2024).

Nutraceuticals: Definition and Importance

Nutraceutical is a portmanteau of 'nutrition' and 'pharmaceutical', linking together nutrition and medicine, indicating a category of products that can be considered food sources providing health benefits over treating a particular ailment. Thus, the term 'nutraceutical' comprises two words: 'nutrition' and 'pharmaceuticals'. The responsible adverse effects of pharmaceuticals are also remedied with the consumption of nutraceuticals. Nutraceuticals are products, usually natural, with bioactive phyto compounds, and are available in several formulations. They are used in a wide range of role combinations as food supplements or functional foods and beverages. Traced back to the word 'nutra', which is a combination of nutrition and pharmaceutical, the word 'pharmaceutical' simply means drug or medicine. While the word 'nutraceutical' portrays the additive character of these products, nutraceuticals are food or food products that provide health and medical benefits, including the prevention and treatment of diseases. They are 'functional' food components, but also some pharmacological agents used for disease treatment, control, and prevention. Nutraceutical ingredients and foods have gained widespread acceptance and importance as a flavor, pigment, and preservative in

food materials because they impart added health benefits. Nutraceuticals include health-imparting ingredients used in food processing and augment human health and well-being by lowering the risk of chronic diseases. The term nutraceutical is used to describe these medicinally equivalent entities that provide an added barrier against chronic diseases. Nutraceuticals as dietary supplements include examples of nutraceuticals performed in a variety of vitamin settings, such as vitamins and minerals. Nutraceuticals provide medical or health benefits and contribute to chronic disease therapy or prevention. Nutraceuticals may be used to enhance the quality of life, regulate health, retard the aging process, and reduce the risk of specific conditions and illnesses. The nutritional or dietary part of the respective nutraceutical is intended to enhance or streamline the diet and assist in holistic health management. In the present time, in the food sector, nutraceuticals stand as an attractive product category that has proved particularly appealing to consumers and manufacturers. It has shown recent developing trends that illustrate the growth in the nutraceutical market, and the focus of consumers has also been highlighted (Chopra et al.2022; AlAli et al.2021; Puri et al.2022; Maurya et al.2021).

Nutraceuticals are products derived from various food sources that not only meet the nutritional demands of the human body but also contain biological agents that help manage various metabolic disorders. Many regulatory agencies define nutraceuticals in different ways and accordingly frame policies to control or regulate these products. However, nutraceuticals are mainly referred to as products that have physiological benefits or protect human beings from various health problems. In contrast to conventional nutritional supplements, nutraceuticals possess therapeutic, prophylactic, or palliative properties. Furthermore, nutraceuticals are not only essential nutrients or diets but can also be part of drugs, as some drugs contain an edible component in which nutraceuticals can also be included. Nutraceuticals are considered either dietary supplements or functional foods, where dietary supplements are only taken in oral form, while functional foods can be used orally as well as collectively through fortified foods (Damián et al.2022; AlAli et al.2021)

Nutraceuticals have become a part of the fast-moving pioneer concept in the wellness industry, designed to combat lifestyle-related maladies and various disorders by serving as human biological stabilizers. However, to ascertain the efficacy of these products, the selection of proper nutraceutical systems according to their standardized dosages, bioavailability, or pharmacokinetic behavior is important. Additionally, proper isolation and extraction from prospective microalgae or cyanobacterial species of marine sources, as well as their processing, are basic concerns for these potential nutraceuticals. Due to various governing agencies and their stipulations to define the term “nutraceuticals” categorically, researchers have proposed numerous classifications for nutraceuticals. As a result, for many years, it has remained difficult to provide a general consensus explanation of the term “nutraceuticals.” The term “nutraceuticals” was coined from “nutrition” and “pharmaceutical.” It is used loosely and generally to describe nutritious or beneficial foods and supplements that support diet and contribute to the treatment or prevention of various types of diseases. Such therapeutic substances are found in isolated and purified forms in medicinal doses (Adetuyi et al.2022; Visen et al.2022).

Importance of Nutraceuticals in Health and Wellness

Nutraceuticals are now considered an important part of maintaining the health and wellness of an individual. They serve as a preventive aid and keep the person healthier for a long period. Several surveys conducted worldwide all pointed to the vital role of nutraceuticals in the prevention of chronic diseases and in extending wellness for longer time periods. In the past, there were doubts about the real effects of nutraceuticals on our bodies. With the accumulation of new research studies, several compounds have been isolated that are responsible for the marketed nutraceutical effects. The scientific claims targeting therapeutics of any human diseases must be supported by adequate clinical trials on isolated single compounds or mixtures of them. All these concerted efforts, using a biomedical approach to substantiate health benefits, are validating the use of these products, and hence, their utilization is becoming pertinent (Kour & Nayik, 2021;

Chopra et al.2022; AlAli et al.2021).

Wellness is a general term that is highly advocated all over the world because many chronic diseases have been prevented by simply employing the principles of wellness. Experts have claimed that people feel well due to two possible influences: the first is the good physical condition of a subject and the second is the good psychological perception of a person about his or her health. Nutraceuticals, however, in general, represent the physical status of people. Nutraceuticals are gaining momentum due to an increase in consumers' willingness to consume natural products for enjoying better health. They are becoming very popular because they have yielded good results with a positive impact on people's lives. Government establishments worldwide are also looking for food supplements and nutraceuticals that are increasingly attracting the attention of pharmaceutical companies due to the commercial interests behind them. It is natural that companies with a vision of good commercial turnover will get involved in the promotion of nutraceuticals. The nutraceuticals market is growing because of increasing consumer interest. However, scientists' interest in discovering and utilizing these nutraceuticals is already in vogue (Jadhav et al.2023; Shafi et al.2024).

Marine sources of Nutraceuticals

Marine resources have unequivocally demonstrated their immense potential as a valuable source of nutraceuticals, which are essential for health benefits beyond basic nutrition. In our detailed examination, we focused specifically on the most well-studied nutraceutical classes that can be extracted from various matrices of fishery and aquaculture resources. These classes include marine proteins and peptides, polysaccharides, fatty acids, and polyphenols, all of which offer unique health-promoting properties. Moreover, we highlight several prominent examples of the latest research findings in this exciting field. Additionally, we provide crucial background information to underscore the current research trends, while also identifying specific areas that require further investigation to uncover new opportunities for exploration and discovery (Ahmed et al.2022; Ghosh et

al.2022).

Marine fishery and aquaculture resources have increasingly been recognized as highly beneficial sources of nutraceuticals and functional foods over the past few decades. The ability to enhance human diets through the thoughtful inclusion of functional and specialty foods has gained considerable attention. These foods are not only tasteful and appealing to the palate but also particularly abundant in high levels of bioactive components that hold the potential to both prevent and cure various dietary-related diseases. The consumption of seafood has consistently been shown to provide a wide array of health benefits, which has led to its description as 'healthy for life,' as it delivers a multitude of advantages that extend well beyond basic nutrition. In light of these findings, the number of studies dedicated to seafood-derived nutraceuticals has expanded rapidly and significantly. Notably, in 2015, a comprehensive list was published featuring at least 82 distinct commercial bioactive peptides that are derived from marine protein sources, highlighting the diverse potential of these aquatic resources. Among these compounds, fatty acids, particularly eicosapentaenoic acid and docosahexaenoic acid, have emerged as the most popular and sought-after marine nutraceutical monomers. Their importance in dietary formulations cannot be understated, as they contribute crucial health benefits that support overall well-being (Mutalipassi et al.2021; Nag et al.2022; Choudhary et al., 2021).

Bioactive compounds in Marine Nutraceuticals

The wide range of value compounds of marine species could be used directly or after suitable formulations to maintain our health and prevent diseases such as obesity, diabetes, hypercholesterolemia, hypertriglyceridemia, inflammation, and cardiovascular diseases. In the last few years, marine species have become an extremely important source of these nutraceutical compounds used for healthy functional food manufacturing. Especially, the functional ingredients belong to marine-origin active peptides, polysaccharides, pigments, unsaturated fatty acids, polyphenols, taurine, and vitamins with anti-thrombotic, anti-inflammatory, and anti-

tumor activities. The scientific survey indicated that marine-derived nutraceutical ingredients could help in managing hypertension, hypertriglyceridemia, obesity, atherosclerosis, some thrombus-related diseases, diabetes, and other associated metabolic syndromes (Ghosh et al.2022; Nieri et al., 2023; Menea et al.2021; Mutalipassi et al.2021).

Nutraceuticals are foods whose molecular constituents demonstrate potential benefits to human health, known to reduce the risk of some chronic and degenerative diseases with a positive impact on health. Fortunately, a number of compounds from marine sources as nutraceutical products can be applied as a rich omega-3 food supplement to partially correct these deficiencies. Currently, humans have understood more and more about the complexity of human health and diseases, and people begin to think deeply about their own health management, paying more attention to the method to prevent diseases, known as daily healthcare. Therefore, the equipment of nutraceutical ingredients used is the keystone of nutraceutical manufacturing. Although the nutritive demands are the same, the nutraceutical ingredients derived from animal, plant, and microorganism resources have been used for over 12,000, 9,000, and only 1,000 years, respectively. Besides, the ingredient sources have suffered serious overharvesting, pollution, and distinct cost-effective strategies (Fumia et al.2022; AlAli et al.2021).

Current trends in marine nutraceutical research

Marine nutraceuticals are bioactive compounds or molecules that can be isolated from marine sources. In the current literature, most of the research is focused on the extraction and identification of bioactive compounds from several types of marine sources, including fish, crustaceans, algae, and microbes. Simultaneously, an increasing number of articles are addressing global climate change, its impact on the marine environment, and the synergy between global climate change and the nutraceutical potential of marine populations. These papers suggest that environmental factors play an important role in modulating the nutraceutical content of marine organisms. Others are showing significant advances in extraction and chemical and biological characterization

techniques related to nutraceutical properties and, more importantly, methods that apply the principles of green chemistry and green analytical techniques to characterize marine nutraceuticals (Nieri et al., 2023; Ghosh et al.2022).

The exploration of marine bioactive compounds is an attractive topic for the food and pharmaceutical industries given the almost infinite biodiversity of the marine environment. Alongside laboratory developments for commercial production, scientific advances are significantly focusing on the bioactivity of potential commercial compounds. Research is based primarily on independent laboratory experiments that integrate cellular, animal, and clinical trials. Meanwhile, collaborations between universities and the industry are increasing, investigating interdisciplinary research related to nutrition, chemistry, and biology. Some scientific research includes the regulatory landscape of existing dietary supplements, including those related to contaminants or the label claims of marine nutraceuticals. In summary, the development of marine nutraceutical research is a multidisciplinary approach to understanding the potential for commercial exploitation (Ghosh et al.2022; Ahmed et al.2024).

Innovation in marine nutraceuticals

One of the major pushes for innovation in marine nutraceuticals will come from advances in novel extraction and purification procedures, which will enable the isolation of unique nutraceuticals and provide a greater understanding of the properties and constituents of marine products. Once distinctive bioactives have been identified, there is also the possibility to create unique formulations, resulting in combinations of pharmaceutical and food ingredients with enhanced properties not possible to achieve with the individual components (Gamberi et al.2024; Augusto et al., 2024).

Personalized Nutrition

Innovative and emerging areas that are destined to grow and develop over the next few decades include the aquaculture of marine microalgae and biotechnological techniques to produce designer nutraceuticals, such as in livestock waste,

and biopharming and marine nutraceuticals employed in the field of personalized nutrition as well. In addition to this, personalized nutrition is expected to be a growing field with people around the world becoming more conscious of the benefits of products that are formulated to their specific requirements and genetics. The term “nutrigenomics” refers to the dietary recommendations that take into account the influence of genetic variation on the individual’s response to nutrients. This makes it possible to optimize the diet for an individual, basing food consumption on their particular needs, thus preventing and treating specific conditions and boosting overall health by consuming food with beneficial components, such as marine nutraceuticals (Franzago et al.2022; Matusheski et al.2021).

Conclusion and future prospects

This review outlines the growing potential of marine sources to fuel the nutraceutical market. Advances in scientific and research methodologies have provided a foundation to investigate and understand the promising potential of marine nutraceuticals. The focus of this review was to assemble an exhaustive and comprehensive review of the active ingredients present in marine sources. General perceptions and future prospects have also been highlighted. The final aim of this review is to resonate with a broad spectrum of food industry researchers to explore the promising applications of marine sources.

The review can be very helpful in developing a future strategy on marine bioactive potential, as it provides the material and direction for future research. New research should be conducted incorporating different physiological, clinical, and toxicological assessments. Sustainability should also be considered, and efficacy and bioavailability tests should supplement extensive studies on the source. Moreover, collaborative efforts and awareness programs should be devised involving different regulatory bodies and industries to make consumers aware of the associated health benefits. The usage of aquatic species is expanding considerably due to a surge in customer awareness of health and safety improvements. Moreover, aquatic resources provide several

essential components suitable for producing significant dietary supplements and health products. Researchers are advocating the exploitation of marine sources for dietary fiber, antimicrobial peptides, proteins, lipids, and bioactive compounds, which may be derived from seaweeds, fish, and shellfish.

References:

- Ghosh, S., Sarkar, T., Pati, S., Kari, Z. A., Edinur, H. A., & Chakraborty, R. (2022). Novel bioactive compounds from marine sources as a tool for functional food development. *Frontiers in Marine Science*, 9, 832957.
- Rotter, A., Barbier, M., Bertoni, F., Bones, A. M., Cancela, M. L., Carlsson, J., ... & Vasquez, M. I. (2021). The essentials of marine biotechnology. *Frontiers In marine science*, 8, 629629.
- Daniotti, S. & Re, I. (2021). Marine biotechnology: Challenges and development market trends for the enhancement of biotic resources in industrial pharmaceutical and food applications. *A Marine drugs*.
- Kumari, A., G., & Bharadvaja, N. (2023). A comprehensive review on algal nutraceuticals as prospective therapeutic agent for different diseases. *3 Biotech*.
- Dama, A., Shpati, K., Daliu, P., Dumur, S., Gorica, E., & Santini, A. (2024). Targeting metabolic diseases: the role of nutraceuticals in modulating oxidative stress and inflammation. *Nutrients*, 16(4), 507.
- Chopra, A. S., Lordan, R., Horbańczuk, O. K., Atanasov, A. G., Chopra, I., Horbańczuk, J. O., ... & Arkells, N. (2022). The current use and evolving landscape of nutraceuticals. *Pharmacological Research*, 175, 106001.
- AlAli, M., Alqubaisy, M., Aljaafari, M. N., AlAli, A. O., Baqais, L., Molouki, A., ... & Lim, S. H. E. (2021). Nutraceuticals: Transformation of conventional foods into health promoters/disease preventers and safety considerations. *Molecules*, 26(9), 2540.
- Puri, V., Nagpal, M., Singh, I., Singh, M., Dhingra, G. A., Huanbutta, K., ... & Sangnim, T. (2022). A comprehensive review on nutraceuticals: therapy support and formulation challenges. *Nutrients*, 14(21), 4637.

Maurya, A. P., Chauhan, J., Yadav, D. K., Gangwar, R., & Maurya, V. K. (2021). Nutraceuticals and their impact on human health. In *Preparation of Phytopharmaceuticals for the Management of Disorders* (pp. 229-254). Academic Press.

Damián, M. R., Cortes-Perez, N. G., Quintana, E. T., Ortiz-Moreno, A., Garfias Noguez, C., Cruceño-Casarrubias, C. E., ... & Bermúdez-Humarán, L. G. (2022). Functional foods, nutraceuticals and probiotics: A focus on human health. *Microorganisms*, 10(5), 1065.

Adetuyi, B. O., Odine, G. O., Olajide, P. A., Adetuyi, O. A., Atanda, O. O., & Oloke, J. K. (2022). Nutraceuticals: role in metabolic disease, prevention and treatment. *World News of Natural Sciences*, 42, 1-27.

Visen, A., Visen, S., Sharma, A., & Visen, P. K. (2022). Nutraceuticals as a natural alternative for preventive and proactive health care. In *Functional foods and nutraceuticals in metabolic and non-communicable diseases* (pp. 603-618). Academic Press.

Kour, J. & Nayik, G. A. (2021). Nutraceuticals and health care.

Jadhav, H. B., Sablani, S., Gogate, P., Annapure, U., Casanova, F., Nayik, G. A., ... & Mousavi Khaneghah, A. (2023). Factors governing consumers buying behavior concerning nutraceutical product. *Food Science & Nutrition*, 11(9), 4988-5003.

Shafi, S., Saidi, F. S., Mohamed, K. W., Damaianti, I., & Salleh, H. S. (2024). Understanding Consumer Insights: Exploring Health Supplement Products Preferences in Malaysia. *Journal homepage: <http://iieta.org/journals/ijдне>*, 19(2), 649-656.

Ahmed, I., Asgher, M., Sher, F., Hussain, S. M., Nazish, N., Joshi, N., & Iqbal, H. M. (2022). Exploring marine as a rich source of bioactive peptides: Challenges and opportunities from marine pharmacology. *Marine drugs*, 20(3), 208.

Mutalipassi, M., Esposito, R., Ruocco, N., Viel, T., Costantini, M., & Zupo, V. (2021). Bioactive compounds of nutraceutical value from fishery and aquaculture discards. *Foods*, 10(7), 1495.

Nag, M., Lahiri, D., Dey, A., Sarkar, T., Pati, S., Joshi, S., ... & Ray, R. R. (2022). Seafood discards: a potent source of enzymes

and biomacromolecules with nutritional and nutraceutical significance. *Frontiers in Nutrition*, 9, 879929.

Choudhary, B., Chauhan, O. P., & Mishra, A. (2021). Edible seaweeds: a potential novel source of bioactive metabolites and nutraceuticals with human health benefits. *Frontiers in Marine Science*.

Nieri, P., Carpi, S., Esposito, R., Costantini, M., & Zupo, V. (2023). Bioactive molecules from marine diatoms and their value for the nutraceutical industry. *Nutrients*.

Menaa, F., Wijesinghe, U., Thiripuranathar, G., Althobaiti, N. A., Albalawi, A. E., Khan, B. A., & Menaa, B. (2021). Marine algae-derived bioactive compounds: a new wave of nanodrugs?. *Marine drugs*, 19(9), 484.

Fumia, A., Cicero, N., Gitto, M., Nicosia, N., & Alesci, A. (2022). Role of nutraceuticals on neurodegenerative diseases: Neuroprotective and immunomodulant activity. *Natural Product Research*, 36(22), 5916-5933.

Ahmed, N., Sheikh, M. A., Ubaid, M., Chauhan, P., Kumar, K., & Choudhary, S. (2024). Comprehensive exploration of marine algae diversity, bioactive compounds, health benefits, regulatory issues, and food and drug applications. *Measurement: Food*, 100163.

Gamberi, C., Leverette, C. L., Davis, A. C., Ismail, M., Piccialli, I., Borbone, N., ... & Roviello, G. N. (2024). Oceanic Breakthroughs: Marine-Derived Innovations in Vaccination, Therapy, and Immune Health. *Vaccines*, 12(11), 1263.

Augusto, A., Lemos, M. F. L., & Silva, S. F. J. (2024). Exploring marine-based food production: The challenges for a sustainable and fast biotechnology-based development. *Applied Sciences*.

Franzago, M., Di Nicola, M., Fraticelli, F., Marchioni, M., Stuppia, L., & Vitacolonna, E. (2022). Nutrigenetic variants and response to diet/lifestyle intervention in obese subjects: A pilot study. *Acta Diabetologica*, 59, 69-81.

Matusheski, N. V., Caffrey, A., Christensen, L., Mezgec, S., Surendran, S., Hjorth, M. F., & Péter, S. (2021). Diets, nutrients, genes and the microbiome: recent advances in personalised nutrition. *British Journal of Nutrition*, 126(10), 1489-1497.

Attribute enhancement of cereals by enriching phytochemicals: a review

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Abstracts

Cereals are essential foods worldwide, providing not only macronutrients but also phytochemicals. Phytochemicals are bioactive compounds from plant sources that have been receiving significant interest due to their potential beneficial effects on human health, including anti-oxidant, anti-inflammatory and anticancer properties. This review describes the phytochemical profile of different cereals such as wheat, rice, maize, barley, and oats, including their effects on human health. Cereals are rich in phytochemicals such as tannins, saponins, flavonoids, phenolic acids etc. It is also rich in ferulic acid, a powerful antioxidant, found in large amounts in wheat. Rice, especially pigmented types like black and red rice, is a rich source of anthocyanins and other flavonoids. Maize is rich in carotenoids that are important for eye health. Barley derives its cholesterol-reducing properties from beta-glucans, while oats are loved for their avenanthramides, plant compounds unique to the grain that comes with anti-inflammatory baggage. Beyond their nutritional profile, these phytochemicals have gained attention due to their potential preventive and therapeutic effects towards chronic diseases, including cardiovascular diseases, diabetes, and certain types of cancers. This review article emphasises the use of phytochemically enriched cereals in regular diets and urges further studies on optimal conditions for treating diseases and the mode of ingestion as a regular habit.

Keywords: *Phytochemicals, Cereals, Nutraceuticals, Antioxidants, Bioactive Compounds, Genetic Modification, Fermentation, Extrusion Cooking*

1. Introduction

Cereals are part of the most consumed staple foods globally and provide most of the daily requisite calories, dietary fibre, vitamins, and minerals (McKevith, 2004). Aside from their macronutrient profile, cereals have other constituents called phytochemicals that have been lately regarded as being health-promoting. Flavonoids, phenolic acids, carotenoids and saponins are good antioxidant, anti-inflammatory and disease-combating phytochemicals that benefit human health (Zhang *et al.*, 2015).

Promisingly, the enrichment of anti-human diseases/ailments associated with real attributes is another strategy that can be used to increase the nutritional value/standard of the cereal. Since there is increasing demand for functional foods, scholars and food technologists are seeking s on how to increase phytochemical content in cereals (Xiong *et al.*, 2022). Some of these are genetic engineering, processing methods that enhance bioavailability as well as efficiency in growing methods that enhance the extraction and retention of these beneficial aspects.

This paper elucidates the various phytochemicals present in cereals, the potential health benefits that they accord and how phytate – the main anti-nutrient that binds themselves to minerals can be reduced in grains (Tharifikhan *et al.*, 2021). It also discussed the issue of processing, regulation and acceptance by consumers and highlighted future research implications for enhancing positive aspects of phytochemical-enriched cereals as part of a health-promoting Foodscape of tomorrow.

2. Historical Perspective on Cereal Improvement and Early Studies on Phytochemicals

Cereals are considered one of the typical ancient crops that have been cultivated and consumed by humans for millennia (Beta and Camire, 2018). In the earlier societies, crop yields and

grain storage dominated the societies' priority as opposed to what constituents the crops would be composed of. However, the research on the bioactive compounds in cereals began in the late twentieth century as scientists became interested in the presence of secondary metabolites in plants and their functions in the protection and functioning of organisms. Published research focused on phenolic acids, flavonoids, tannins, and saponins grain-attached phytochemicals in wheat, rice, maize and barley. There was evidence from the research carried out in the early 1970s and early 1980s suggesting that these compounds were antioxidants and could therefore reduce the risk of chronic diseases.

3. Summary of Recent Research Findings on Phytochemical Content in Cereals

Recent investigations in the phytochemicals of cereals have focused on their health qualities and in functional foods. The interline whole-grain bioactive compounds are relatively high, which include ferulic acid in wheat and pigmented rice, anthocyanin, beta-glucans in barley and avenanthramides in oats (Belobrajdic and Bird, 2013). This explains why findings in other related studies indeed establish these phytochemicals as possessing anti-inflammatory, anti-cancer, and cardiovascular-protective properties. High-performance liquid chromatography and mass spectrometry pave the way in the characterization as well as the quantification of these compounds.

4. Critical Analysis of Methodologies and Outcomes from Previous Studies

It can therefore be said that while considerable strides have been made in studying cereal phytochemicals, variations in the approaches used by different researchers have resintvariationsiation in the data obtained. That is why extraction and quantification methods which include solvent extraction, enzymatic hydrolysis, and chromatography vary across the studies and resin the differences in the amount of phytochemical obtained and consequently estimated bioavailability (Stohs *et al.*, 2019). In vivo and in vitro experiments have, therefore, established varying efficacy

levels of factors present in phytochemical-rich cereal products in disease prevention. Although science that makes use of animal and cell culture has offered some encouraging results, there is a deficiency of bright clinical trials on humans. This was contributed to by the lack of well-defined standard value and processing methods, as well the as lack of agreement between organizations on which specific method should be used.

5. Identification of Research Gaps and the Need for Further Investigation

From this review, it is evident that phytochemicals play a crucial role in cereals despite having such gaps. Nevertheless, more research is required about their bioavailability and metabolism in humans pointing toward enhanced consumption through diets. There is also a need to investigate the interactions of the identified plant-borne bioactive compounds and the additive, synergistic, and antagonistic effects in human diets or diets typical of specific regions of the world (Wu *et al.*, 2017). Furthermore, both genetic modification and agronomic approaches have been used to increase the phytochemical content but there is a need for more voluntary effects, safety and acceptability among consumers. Future studies should in this case involve the use of human subjects, new food processing technologies and practices that will increase the phytochemical content in cereals without reducing their organoleptic properties or nutritional value.

6. Types of Phytochemicals in Cereals and Their Bioavailability

Overview of Major Phytochemical Classes

Cereal grains contain many phytochemicals which are beneficial chemicals in the human body due to health-promoting properties. Some of the common classes of these phytochemicals are the phenolic as flavonoids, tannins, saponins and carotenoids. Some of the phenolic compounds that are most abundant in whole grains include the ferulic and cinnamic acids which are antioxidant compounds (Saxena *et al.*, 2013). Flavonoids constitute a vast group of compounds; there are more than 4,000 known anthocyanins, which are

pigments that play in cereals and possess oxidant properties. Tannins as polyphenolics are compounds that are present in cereals whereby they affect their astringency characteristics as well as their heart values. Based on the fact that some grains contain saponins, then this substance has the ability to reduce cholesterol levels and modulate the immune system. Carotenoids are the pigments that are essential agents of an antioxidant in nature that are essential for the health of the eyes.

Specific Examples from Cereals

It is now evident that each cereal grain possesses its specific phytochemicals responsible for the health benefits related to one of the integral elements of the wheat grain ferulic acid, which is a powerful antioxidant that is mainly found in the bran layer to prevent oxidative stress. The pigments of pigmented rice are anthocyanins, which give bevel natural colours to coarse grains and an abundance of antioxidant properties (Saikia *et al.*, 2012). Among all the tested crops, see Figure 2, maize, corn, is a great source of carotenoids, such as lutein and zeaxanthin which are useful in vision and the skin. In 2008, market-size statistics showed that barley had a high beta-glucan content a soluble fibre that has been associated with a better cardiovascular as well as metabolic profile. Avenanthramides, which are non-polyphenolic substances extracted from oats, have several properties among which are anti-inflammatory and antioxidant characteristics availability of Phytochemicals in Cereals.

The effects of these phytochemicals almost entirely depend on bio-availability, which is the degree to which the compounds in the vegetable are absorbed and used by the body. Several characteristics of these compounds were: Their chemical structure, solubility or the food matrix within which they exist Phenolic acids in cereals are mainly bound with cell wall components and this makes it difficult for their absorption. However, certain joints can be processed by methods like fermentation to increase bioavailability. Carotenoids are fat-soluble molecules thus the need to consume foods containing fats so that they can be absorbed efficiently (Ravisankar *et al.*, 2015). The methods of processing and preparation

of cereals affect the chemical structure of cereals and also phytochemicals including cooking, milling, and microbial fermentation. Fermentation on the other hand reduces the phytic acid which inhibits the bioavailability and minerals; it also enhances the degree of extraction by solubilizing the fibre matrix of phytochemicals. Knowledge of these factors is important when aiming at creating positive health impacts from cereal-based based impacts cereal-basement food processes.

7. Health Benefits of Phytochemicals in Cereals

Antioxidant Properties and Reduction of Oxidative Stress

Phenolic acids and flavonoids that exist in cereals exhibit antioxidant activity. These compounds act for example by counteracting free radicals to diminish their negative impact and thereby diminishing oxidative stress to cells. This antioxidant activity is relevant and important in the reduction of the development of the aforementioned diseases because oxidative stress is an essential factor in the development of diseases and ageing (Cichoż-Lach and Michalak, 2014). The intake of antioxidant-rich cereal foods will be antioxidant-rich to the body and maintain the integrity of the body cells with minimal cases of degenerative illnesses.

Anti-inflammatory and Anticancer Effects

Apart from their antioxidant effects cereal phytochemicals also possess potent anti-inflammatory effects (Jimenez-Pulido *et al.*, 2022). Thus, such compounds can regulate the inflammatory processes in the body, which is one of the causes of chronic diseases including arthritis and metabolic diseases. It has also been found that some phytochemicals possess antitumor activity since they can suppress cancer cell growth and trigger apoptosis. According to scientists, whole grain phenolic compounds red whole grains of colon cancer and other types of cancers as they impacts carcinogenic gene expression signalling pathways.

Mitigation of Chronic Diseases

The observation of the typical cereal diets high in phytochemicals significantly reduces the possibility of

developing certain diseases, including cardiovascular and diabetes (Belobrajdic and Bird, 2013). It should be noted that flavonoids act as antioxidants and hence prevent inflammation of the heart, apart from regulating blood glucose levels. For example, phenolic acids slow the progression of diseased conditions with cardiovascular due to anti-inflammatory, and anti-oxidant properties which help to save antioxidant-active arterial stiffness help their brand oat contain beta-glucans that aid in the regulation of insulin and thus useful for patient with type 2 diabetes.

8. Methods for Enhancing Phytochemicals in Cereals

Genetic Modification and Breeding Strategies

Scientists have been able to increase the phytochemical content of cereals through the use of enhanced genetic technologies in plant breeding. Conventional breeding along with the help of modern molecular techniques can help to improve the desired characteristics, including the higher content of antioxidants and other useful elements. Marker-assisted selection (MAS) and genomic selection (GS) are among the techniques that have favoured the identification and usage of genes that cause variation in the phytochemical levels (Boopathi, 2013). Furthermore, transgenic breeding involves the insemination of specific genes that help increase the levels of micronutrients and phytochemicals that are useful in eliminating malnutrition, which is sustainable.

Innovative Processing Techniques

Maize processing methods that were identified include washing, soaking, cooking simmering/boiling, sun-drying, oven-baking, roasting, frying and high pressure processing. The fermentation process has been also found to increase the phenolic value and its digestibility in cereals such as rice, wheat, oats, maize, and sorghum (Fărcaș *et al.*, 2021). This is an action of microorganisms that helps to degrade the complex matrix and release phytochemicals. Other techniques for processing cereals include extrusion cooking, which exports the cereals to high-temperature pressure and shear forces (De Pilli & Alessandrino, 2020). This also contributes to the enhancement of the nutritional quality of

cereal-based products since it helps in the digestion of cereal-based proteins and recalls the bioactive compounds within those products.

Agronomic Practices and Post-Harvest Interventions

Different agricultural practices provide a great impact towards the nutrition level of the cereal crops. This shows nutrition factors like the type and condition of the soil, irrigation and even the use of fertilizers affect the synthesis and deposited bioactive compounds in the plant. The practitioners of crop rotation, organic farming, and proper use of manure can help in increasing nutrient depth in the soil and hence improve the phytochemical in cereals (Aulakh *et al.*, 2022) any of these compounds are sensitive and, when harvested, require other post harvest treatments and minimal processing to maintain post-harvesting. For instance, the retention of cereals' phytochemicals starts at the farm and continues to the table – it suggests that avoiding exposure of cereals to light, heat, and oxygen during storage and processing helps in the retention of cereals' phytochemicals.

9. Optimum Utilization of Phytochemicals

Strategies for Maximizing Retention During Processing and Storage

HHP has a better shelf-life of phytochemicals compared to high-heat treatments since they do not require heat and, therefore, do not cause the degradation of nutrients (Khouryieh, 2025). This technique uses high pressure to avoid thermal stress on the compound and thereby there is less destruction on the compounds. Another factor that influences the stability is the duration and the conditions under which the foods are stored; optimal conditions that minimize exposure to light, oxygen and moisture will enhance the stability of these bioactive compounds.

Improving Bioavailability and Bioactive Interactions

Bioavailability of phytochemicals means how much such compounds can be taken in the body and used efficiently (Holst and Williamson, 2008). Bioavailability of compounds involves increasing the extent to which phytochemicals can

be absorbed and used by the body. Some procedures such as fermentation would enhance the levels of phenolic content since these complexes are broken down to permit absorption. Also, one compound may influence the absorption and efficacy of another compound by either increasing or decreasing the absorption of nutrients or bioactive compounds. Bioavailability and efficacy can easily be enhanced when plant-based nutraceuticals are administered in combination.

Incorporating Enriched Cereals into Regular Diets

In order to maximize nutrition from phytochemicals, one needs to include phytochemical-containing cereals in the daily basis diet. Phytochemical-containing cereals, it is recommended that one choose that has been processed to the least degree to ensure that the grain contains high levels of these compounds. Oats, barley and pigmented rice containing different types of cereals can help in achieving the consumption of a variety of phytochemicals (Raj *et al.*, 2023).

Besides, the integration of cereals with other nutrient-dense foods helps to increase nutrient interaction, nutrient density and other nutritional advantages, which in turn increases the overall health advantages obtainable from consumption.

10. Challenges and Future Directions

Technical and Processing Challenges

Several technical and processing issues arise in the effort to increase the phytochemical content in cereals (Saleh *et al.*, 2019). Narrators realise that certain food processing steps like milling and cooking can lead to very low concentrations of provitamin A, other vitamins and phytochemicals. For instance, multivitamin strips of grain products of nutrient-rich bran make layers, thus eradicating most of the vitamins and bioactive compounds. Besides, steaming can lead to significant losses of vitamin content and boiling can lead to smaller losses of vitamins. Therefore, the beneficial phytochemicals lost during processing and palatability or safety construe to high processing must be optimally managed (Ravi and Rana, 2024).

Regulatory, Safety, and Consumer Acceptance Issues

The current change to genetically modified (GM) cereals for purposes of improving phytochemical features is reliable with regulatory and safety issues. The following guidelines also pay special emphasis to make certain that these biofortified crops are safe makeup. However, customer willingness to consume GM foods differs across countries depending on cultural, ethical, and info across countries. Such modifications should be explained clearly to the people and the possible safety of them should be explained to the people so that they can accept them.

Emerging Trends and Future Research Directions

The next steps will shift toward the improvement in the content of phytochemicals from cereals, meeting consumers' expectations. Furthermore, investigations on conventional techniques like fermentation that has been discussed in this paper have demonstrated the capacity have enhance the bioavailability have phenolic compounds in cereals. Current and future investigations are carried out to improve these techniques in the production of functional foods with improved health qualities.

It is apparent that there are some possible ways that the above-discussed obstacles can be overcome in order to increase the level of phytochemicals contained in cereals These include improved techniques in genetics process techniques and consumers' awareness.

11. Conclusion

The phytochemicals that are present in cereals have benefits such as acting as antioxidants anti-inflammatory, and preventive to diseases. That is why this kind of review has outlined the various forms of phytochemicals found in cereal, their role in the well-being of human beings and the various methods of increasing them. Breeding techniques, genetic engineering, the use of superior processing techniques and effective utilization of agro-techniques have been used as potential ways of enhancing phytochemical concentrations in cereal grains. The impact of phytochemical enrichment

in cereals especially common cereals can be seriously felt in food sciences and food nutritional values. These bioactive compounds can play a role in chronic disease prevention especially those of cardiovascular diseases, diabetes, and cancers. Furthermore, regulating the consumption of meals with phytochemical-containing cereals can help in boosting immune-modulatory and antioxidant levels.

That said, a few issues still arise, including processing losses, the level of acceptance with consumers and the regulatory environment. These issues have to be further studied and receive a focus on the development of new, efficient methods in the food processing area, enhancement of phytochemical bio availabilities and clinical trials in humans in order to corroborate the long-term effects of phytochemical-enriched cereals. There is, therefore, a need to have the food scientists, nutritionists and policymakers work together in an effort to come up with strategies for implementing the enhanced cereals within the food chain. Therefore, it is worth seeking improvements in the phytochemical content of cereal grains as a way to improve nutritional value for use by the public. More research should be conducted to identify ways through which retention and bioavailability of these grains are improved as they should be incorporated as staple food in various countries.

References

- Aulakh, C. S., Sharma, S., Thakur, M., & Kaur, P. (2022). A review of the influences of organic farming on soil quality, crop productivity and produce quality. *Journal of Plant Nutrition*, 45(12), 1884-1905. <https://www.tandfonline.com/doi/abs/10.1080/01904167.2022.2027976>
- Belobrajdic, D. P., & Bird, A. R. (2013). The potential role of phytochemicals in wholegrain cereals for the prevention of type-2 diabetes. *Nutrition journal*, 12(1), 62. <https://link.springer.com/article/10.1186/1475-2891-12-62>
- Belobrajdic, D. P., & Bird, A. R. (2013). The potential role of phytochemicals in wholegrain cereals for the prevention

of type-2 diabetes. *Nutrition journal*, 12(1), 62. <https://link.springer.com/content/pdf/10.1186/1475-2891-12-62.pdf>

Beta, T., & Camire, M. E. (Eds.). (2018). *Cereal Grain-Based Functional Foods: Carbohydrate and Phytochemical Components*. Royal Society of Chemistry. <https://books.google.com/>

Boopathi, N. M. (2013). Genetic mapping and marker assisted selection. *New Delhi: Springer*. doi, 10, 978-81. <https://link.springer.com/content/pdf/10.1007/978-981-15-2949-8.pdf>

Cichoż-Lach, H., & Michalak, A. (2014). Oxidative stress as a crucial factor in liver diseases. *World journal of gastroenterology: WJG*, 20(25), 8082. <https://pmc.ncbi.nlm.nih.gov/articles/PMC4081679/>

De Pilli, T., & Alessandrino, O. (2020). Effects of different cooking technologies on biopolymers modifications of cereal-based foods: Impact on nutritional and quality characteristics review. *Critical Reviews in Food Science and Nutrition*, 60(4), 556-565. <https://www.tandfonline.com/doi/abs/10.1080/10408398.2018.1544884>

Fărcaș, A., Drețcanu, G., Pop, T. D., Enaru, B., Socaci, S., & Diaconeasa, Z. (2021). Cereal processing by-products as rich sources of phenolic compounds and their potential bioactivities. *Nutrients*, 13(11), 3934. <https://www.mdpi.com/2072-6643/13/11/3934>

Holst, B., & Williamson, G. (2008). Nutrients and phytochemicals: from bioavailability to bioefficacy beyond antioxidants. *Current opinion in biotechnology*, 19(2), 73-82. <https://www.sciencedirect.com/science/article/pii/S0958166908000311>

Jimenez-Pulido, I. J., Daniel, R., Perez, J., Martínez-Villaluenga, C., De Luis, D., & Martín Diana, A. B. (2022). Impact of protein content on the antioxidants, anti-inflammatory properties and glycemic index of wheat and wheat bran. *Foods*, 11(14), 2049. <https://www.mdpi.com/2304-8158/11/14/2049>

Khouryieh, H. (2025). Impact of High Pressure Processing on the Safety and Quality of Food Products: A Review. *Recent Patents on Food, Nutrition & Agriculture*, 16(1),

31-40. <https://www.benthamdirect.com/content/journals/rafna/10.2174/012772574X289005240215093457>

Latha Ravi, J., & Rana, S. S. (2024). Maximizing the nutritional benefits and prolonging the shelf life of millets through effective processing techniques: a review. *ACS omega*, 9(37), 38327-38347. <https://pubs.acs.org/doi/abs/10.1021/acsomega.4c03466>

McKevith, B. (2004). Nutritional aspects of cereals. *Nutrition Bulletin*, 29(2), 111-142. <https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1467-3010.2004.00418.x>

Raj, R., Shams, R., Pandey, V. K., Dash, K. K., Singh, P., & Bashir, O. (2023). Barley phytochemicals and health promoting benefits: A comprehensive review. *Journal of Agriculture and Food Research*, 14, 100677. <https://www.sciencedirect.com/science/article/pii/S2666154323001849>

Ravisankar, P., Reddy, A. A., Nagalakshmi, B., Koushik, O. S., Kumar, B. V., & Anvith, P. S. (2015). The comprehensive review on fat soluble vitamins. *IOSR Journal of Pharmacy*, 5(11), 12-28. https://www.researchgate.net/profile/Ravi-Sankar-24/publication/340871885_The_Comprehensive_Review_on_Fat_Soluble_Vitamins/links/5eacc09fa6fdcc7050a19773/The-Comprehensive-Review-on-Fat-Soluble-Vitamins.pdf

Saikia, S., Dutta, H., Saikia, D., & Mahanta, C. L. (2012). Quality characterisation and estimation of phytochemicals content and antioxidant capacity of aromatic pigmented and non-pigmented rice varieties. *Food Research International*, 46(1), 334-340. <https://www.sciencedirect.com/science/article/pii/S0963996912000063>

Saleh, A. S., Wang, P., Wang, N., Yang, S., & Xiao, Z. (2019). Technologies for enhancement of bioactive components and potential health benefits of cereal and cereal-based foods: Research advances and application challenges. *Critical reviews in food science and nutrition*, 59(2), 207-227. <https://www.tandfonline.com/doi/abs/10.1080/10408398.2017.1363711>

Saxena, M., Saxena, J., Nema, R., Singh, D., & Gupta, A. (2013). Phytochemistry of medicinal plants. *Journal of pharmacognosy and phytochemistry*, 1(6). <https://www.academia.edu/download/90918906/26.pdf>

Stohs, S. J., Chen, C. Y. O., Preuss, H. G., Ray, S. D., Bucci, L. R., Ji, J., & Ruff, K. J. (2019). The fallacy of enzymatic hydrolysis for the determination of bioactive curcumin in plasma samples as an indication of bioavailability: a comparative study. *BMC complementary and alternative medicine*, 19, 1-8. <https://link.springer.com/content/pdf/10.1186/s12906-019-2699-x.pdf>

Tharifikhan, S. A., Perumal, A. B., Elumalai, A., Moses, J. A., & Anandharamakrishnan, C. (2021). Improvement of nutrient bioavailability in millets: Emphasis on the application of enzymes. *Journal of the Science of Food and Agriculture*, 101(12), 4869-4878. <https://onlinelibrary.wiley.com/doi/pdf/10.1002/jsfa.11228>

Uzogara, S. G. (2000). The impact of genetic modification of human foods in the 21st century: A review. *Biotechnology advances*, 18(3), 179-206. <https://www.sciencedirect.com/science/article/pii/S0734975000000331>

Wu, L., Huo, X., Zhou, X., Zhao, D., He, W., Liu, S., ... & Wang, C. (2017). Acaricidal activity and synergistic effect of thyme oil constituents against carmine spider mite (*Tetranychus Cinnabarinus* (Boisduval)). *Molecules*, 22(11), 1873. <https://www.mdpi.com/1420-3049/22/11/1873>

Xiong, Y., Zhang, P., Warner, R. D., Shen, S., & Fang, Z. (2022). Cereal grain-based functional beverages: From cereal grain bioactive phytochemicals to beverage processing technologies, health benefits and product features. *Critical reviews in food science and nutrition*, 62(9), 2404-2431. <https://www.tandfonline.com/doi/abs/10.1080/10408398.2020.1853037>

Zhang, Y. J., Gan, R. Y., Li, S., Zhou, Y., Li, A. N., Xu, D. P., & Li, H. B. (2015). Antioxidant phytochemicals for the prevention and treatment of chronic diseases. *Molecules*, 20(12), 21138-21156. <https://www.mdpi.com/1420-3049/20/12/21138>

Antioxidants on Coronary Artery Disease

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Antioxidants on Coronary Artery Disease – A Review

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Abstract

Coronary artery disease (CAD) is a leading cause of increasing worldwide mortality rates. CAD is generally caused by oxidative stress and inflammation that result in endothelial dysfunction and Atherosclerosis. Both endogenous and exogenous antioxidants are crucial in reducing oxidative damage by neutralizing the free radicals and reducing lipid oxidation. This review paper helps understand the antioxidants' mechanisms influencing CAD progression and management. This paper mainly focuses on dietary and pharmacological antioxidants, like vitamins C and E, polyphenols, and carotenoids. Also, it evaluates the research studies and clinical tests, to highlight the potential benefits and limitations of antioxidant therapy in CAD management. The effectiveness of antioxidants can vary, and some studies suggest that excessive intake of certain antioxidants, like beta-carotene, may have negative effects on the heart.

In summary, although antioxidants show potential in the prevention and treatment of CAD, their use should be sensible, and further research is necessary to identify the best dosages and combinations for maximum safety and effectiveness.

Keywords: *Coronary artery disease, Antioxidants, Vitamins, Polyphenols, Carotenoids.*

Introduction

I. Coronary Artery Disease (CAD)

Coronary Artery Disease (CAD), also known as ischemic heart disease, is a condition characterized by the narrowing or blockage of the coronary arteries, the blood vessels that supply oxygen-rich blood to the heart muscle (*Dhakal & Pokhrel et. al; 2024*). This narrowing is primarily due to the buildup of plaque, a combination of fat, cholesterol, and other substances, in the arterial walls; a process known as atherosclerosis (*Sevras et. al; 2024*). CAD is a leading cause of morbidity and mortality worldwide, contributing significantly to the global burden of cardiovascular diseases (*Kumar et. al; 2020*).

The development of CAD is influenced by a variety of risk factors, including hypertension, hyperlipidaemia, diabetes, smoking, obesity, and a sedentary lifestyle (*Malakar et. al; 2019*). The pathophysiology of CAD involves endothelial dysfunction, inflammation, oxidative stress, and the formation of atherosclerotic plaques, which can lead to myocardial infarction (heart attack), angina, heart failure, and sudden cardiac death (*Aashiq et. al; 2019*).

II. Antioxidants

Antioxidants are molecules that inhibit the oxidation of other molecules, thereby preventing the formation of free radicals and reactive oxygen species (ROS) that can cause cellular damage (*Alkadi, 2020*). Oxidation is a chemical reaction that can produce free radicals, leading to chain reactions that may damage cells. Antioxidants terminate these chain reactions by removing free radical intermediates and inhibiting other oxidation reactions (*Sanjay and Shukla; 2021*).

A. Types of Antioxidants

Antioxidants can be broadly classified into two categories: endogenous and exogenous.

1) Endogenous Antioxidants: These are produced naturally within the body and include enzymes such as superoxide dismutase (SOD), catalase, and glutathione peroxidase, as well as non-enzymatic molecules like glutathione, coenzyme Q10, and uric acid (*Neha et.al; 2019*).

2) Exogenous Antioxidants: These are obtained from the diet or supplements and include vitamins (such as vitamin C, vitamin E, and beta-carotene), minerals (such as selenium and zinc), and phytochemicals (such as flavonoids, polyphenols, and carotenoids) (*Qi et. al; 2022*).

B. Sources of Antioxidants

Antioxidants are abundant in various foods, particularly fruits, vegetables, nuts, and whole grains (*Rahaman et. al; 2023*). Some of the richest sources of antioxidants include:

a) Vitamin C: Found in citrus fruits, strawberries, bell peppers, and broccoli (*Baek et. al; 2021*).

b) Vitamin E: Found in nuts, seeds, spinach, and vegetable oils (*Sinbad et. al; 2019*).

c) Beta-carotene: Found in carrots, sweet potatoes, and dark leafy greens (*Dewanjee et al; 2021*).

d) Selenium: Found in Brazil nuts, seafood, and whole grains (*Wan et.al; 2018*).

e) Flavonoids: Found in berries, tea, red wine, and dark chocolate (*Khan et. al; 2021*).

f) Polyphenols: Found in coffee, tea, olives, and extra virgin olive oil (*Ranjha et. al; 2022*).

• The action of Antioxidants in Coronary Artery Disease

The role of antioxidants in CAD is primarily linked to their ability to mitigate oxidative stress, a key contributor to the development and progression of atherosclerosis (*Pahimi et. al; 2019*). Oxidative stress occurs when there is an imbalance

between the production of ROS and the body's ability to detoxify these reactive intermediates or repair the resulting damage ((*Alkadi, 2020*)).

Mechanisms of Action

a) Reduction of Oxidative Stress: Antioxidants neutralize ROS, reducing oxidative damage to lipids, proteins, and DNA. This helps maintain endothelial function and prevents the initiation and progression of atherosclerosis (*Alkadi, 2020*).

b) Inhibition of LDL Oxidation: Oxidized low-density lipoprotein (LDL) is a critical factor in the formation of atherosclerotic plaques. Antioxidants, particularly vitamin E and beta-carotene, inhibit the oxidation of LDL, thereby reducing plaque formation (*Donia and Khamis; 2021*).

c) Anti-inflammatory Effects: Antioxidants can modulate inflammatory pathways by reducing the expression of pro-inflammatory cytokines and adhesion molecules. This helps to attenuate the inflammatory response associated with atherosclerosis (*Kabir et.al; 2022*).

d) Improvement of Endothelial Function: Antioxidants enhance the bioavailability of nitric oxide (NO), a molecule that promotes vasodilation and maintains vascular homeostasis. By preserving NO levels, antioxidants improve endothelial function and reduce the risk of CAD (*Murray et. al; 2023*).

e) Stabilization of Atherosclerotic Plaques: Antioxidants can stabilize vulnerable plaques by reducing oxidative stress and inflammation, thereby decreasing the likelihood of plaque rupture and subsequent thrombotic events (*Wang et.al; 2025*).

- **Positive Impact of Antioxidants on CAD**

- a) Epidemiological Evidence**

Numerous epidemiological studies have demonstrated an inverse association between dietary intake of antioxidants and the risk of CAD. For example, the Nurses' Health Study and the Health Professionals Follow-Up Study found that higher

intakes of vitamin E and vitamin C were associated with a reduced risk of coronary heart disease (*Keramat et. al;2022*).

b) Clinical Trials

Several clinical trials have investigated the effects of antioxidant supplementation on CAD outcomes. The Cambridge Heart Antioxidant Study (CHAOS) reported that vitamin E supplementation significantly reduced the risk of non-fatal myocardial infarction in patients with CAD (*Rychter et. al; 2022*). Similarly, the Lyon Diet Heart Study found that a Mediterranean diet rich in antioxidants reduced the risk of recurrent coronary events (*Martinez- Gonzalez et. al; 2024*).

c) Mechanistic Insights

Animal studies and in vitro experiments have provided mechanistic insights into the protective effects of antioxidants in CAD (*Falco et.al; 2023*). For instance, studies in apolipoprotein E-deficient mice have shown that antioxidant treatment reduces atherosclerotic lesion formation and improves endothelial function (*Cheng et.al; 2023*).

d) Polyphenols and Flavonoids:

Found in tea, wine, and cocoa, these compounds exhibit strong cardioprotective effects (*Ranjha et. al; 2022*).

e) Vitamin C and E:

These vitamins help prevent lipid peroxidation and endothelial dysfunction (*Sinbad et. al; 2019*).

f) Carotenoids:

Lutein and beta-carotene improve cardiovascular health by reducing inflammation and oxidative stress (*Dewanjee et al; 2021*).

• Negative Impact of Antioxidants on CAD

a) Inconsistent Clinical Trial Results

Despite the promising epidemiological and mechanistic evidence, some large-scale clinical trials have failed to demonstrate a clear benefit of antioxidant supplementation in CAD (*Petrucchi et. al; 2022*). The Heart Outcomes Prevention

Evaluation (HOPE) trial and the Women's Health Study (WHS) found no significant reduction in cardiovascular events with vitamin E supplementation (*Aday et. al; 2021*).

b) Potential Pro-oxidant Effects

In certain conditions, antioxidants can exhibit pro-oxidant effects, particularly at high doses. For example, beta-carotene supplementation has been associated with an increased risk of lung cancer in smokers, possibly due to the formation of harmful oxidation products (*Tian et.al; 2022*).

c) Interaction with Medications

Antioxidants may interact with certain medications, potentially reducing their efficacy (*Forman and Zhang; 2021*). For instance, vitamin E can interfere with the anticoagulant effects of warfarin, increasing the risk of bleeding (*Elango et.al; 2021*).

d) Lack of Synergistic Effects

The complex interplay between different antioxidants and other nutrients may not always result in synergistic effects (*Mitra et.al; 2023*). Some studies suggest that isolated antioxidant supplements may not provide the same benefits as a diet rich in a variety of antioxidants (*Rahaman and Hossain; 2023*).

Conclusion

The role of antioxidants in the prevention and management of coronary artery disease (CAD) is a topic of significant interest and ongoing research. While there is substantial evidence supporting the beneficial effects of antioxidants in reducing oxidative stress, inflammation, and atherosclerosis, the results from clinical trials have been mixed. The discrepancies between epidemiological studies and clinical trials may be attributed to differences in study design, population characteristics, dosage, and the form of antioxidants used.

It is important to recognize that antioxidants are not a panacea for CAD. A balanced diet rich in a variety of antioxidants, along with other lifestyle modifications such as regular physical activity, smoking cessation, and weight

management, is essential for cardiovascular health. Future research should focus on identifying the optimal combination and dosage of antioxidants, as well as understanding the underlying mechanisms that govern their effects in different populations.

In conclusion, while antioxidants hold promise in the fight against CAD, their use should be approached with caution, and further research is needed to fully elucidate their role in cardiovascular disease prevention and treatment.

Reference

Alkadi, H. (2020). A review on free radicals and antioxidants. *Infectious Disorders-Drug Targets (Formerly Current Drug Targets-Infectious Disorders)*, 20(1), 16-26.

Aday, A. W., Duran, E. K., Van Denburgh, M., Kim, E., Christen, W. G., Manson, J. E., ... & Pradhan, A. D. (2021). Homocysteine is associated with future venous thromboembolism in 2 prospective cohorts of women. *Arteriosclerosis, thrombosis, and vascular biology*, 41(7), 2215-2224.

Ashiq, S., Ashiq, K., Shabana, S., Shahid, S. U., Qayyum, M., & Sadia, H. (2019). Prevalence and role of different risk factors with emphasis on genetics in development of pathophysiology of coronary artery disease (CAD). *Pakistan Heart Journal*, 52(4).

Baek, J., Ramasamy, M., Willis, N. C., Kim, D. S., Anderson, W. A., & Tam, K. C. (2021). Encapsulation and controlled release of vitamin C in modified cellulose nanocrystal/chitosan nanocapsules. *Current Research in Food Science*, 4, 215-223.

Cheng, C., Zhang, J., Li, X., Xue, F., Cao, L., Meng, L., ... & Zhang, C. (2023). NPRC deletion mitigated atherosclerosis by inhibiting oxidative stress, inflammation and apoptosis in ApoE knockout mice. *Signal Transduction and Targeted Therapy*, 8(1), 290.

Dewanjee, S., Bhattacharjee, N., Chakraborty, P., & Bhattacharjee, S. (2021). Carotenoids as antioxidants. *Carotenoids: structure and function in the human body*, 447-473.

Dhakal, B., & Pokharel, B. (2024). Coronary artery disease

(CAD) Demystified-Causes, symptoms & treatment. *The American Journal of Patient Health Info*, 1(01).

Donia, T., & Khamis, A. (2021). Management of oxidative stress and inflammation in cardiovascular diseases: mechanisms and challenges. *Environmental Science and Pollution Research*, 28(26), 34121-34153.

Elango, K., Javaid, A., Khetarpal, B. K., Ramalingam, S., Kolandaivel, K. P., Gunasekaran, K., & Ahsan, C. (2021). The effects of warfarin and direct oral anticoagulants on systemic vascular calcification: a review. *Cells*, 10(4), 773.

Falco, L., Tessitore, V., Ciccarelli, G., Malvezzi, M., D'Andrea, A., Imbalzano, E., ... & Russo, V. (2023). Antioxidant Properties of oral antithrombotic therapies in atherosclerotic Disease and Atrial Fibrillation. *Antioxidants*, 12(6), 1185.

Forman, H. J., & Zhang, H. (2021). Targeting oxidative stress in disease: promise and limitations of antioxidant therapy. *Nature Reviews Drug Discovery*, 20(9), 689-709.

Kabir, M. T., Rahman, M. H., Shah, M., Jamiruddin, M. R., Basak, D., Al-Harrasi, A., ... & Abdel-Daim, M. M. (2022). Therapeutic promise of carotenoids as antioxidants and anti-inflammatory agents in neurodegenerative disorders. *Biomedicine & Pharmacotherapy*, 146, 112610.

Keramat, S., Sharebiani, H., Patel, M., Fazeli, B., & Stanek, A. (2022). The potential role of antioxidants in the treatment of peripheral arterial disease: a systematic review. *Antioxidants*, 11(11), 2126.

Khan, J., Deb, P. K., Priya, S., Medina, K. D., Devi, R., Walode, S. G., & Rudrapal, M. (2021). Dietary flavonoids: Cardioprotective potential with antioxidant effects and their pharmacokinetic, toxicological and therapeutic concerns. *Molecules*, 26(13), 4021.

Kumar, A. S., & Sinha, N. (2020). Cardiovascular disease in India: A 360-degree overview. *Medical Journal Armed Forces India*, 76(1), 1-3.

Malakar, A. K., Choudhury, D., Halder, B., Paul, P., Uddin, A., & Chakraborty, S. (2019). A review on coronary artery disease, its risk factors, and therapeutics. *Journal of cellular physiology*, 234(10), 16812-16823.

Martínez-González, M. Á., & Hernández, A. H. (2024). Effect of the Mediterranean diet in cardiovascular prevention. *Revista*

Española de Cardiología (English Edition), 77(7), 574-582.

Mitra, S., Tareq, A. M., Das, R., Emran, T. B., Nainu, F., Chakraborty, A. J., ... & Simal-Gandara, J. (2023). Polyphenols: First evidence in the synergism and bioactivities. *Food Reviews International*, 39(7), 4419-4441.

Murray, K. O., Ludwig, K. R., Darvish, S., Coppock, M. E., Seals, D. R., & Rossman, M. J. (2023). Chronic mitochondria antioxidant treatment in older adults alters the circulating milieu to improve endothelial cell function and mitochondrial oxidative stress. *American Journal of Physiology-Heart and Circulatory Physiology*, 325(1), H187-H194.

Neha, K., Haider, M. R., Pathak, A., & Yar, M. S. (2019). Medicinal prospects of antioxidants: A review. *European journal of medicinal chemistry*, 178, 687-704.

Pahimi, N., Rasool, A. H. G., Sanip, Z., Bokti, N. A., Yusof, Z., & W. Isa, W. Y. H. (2022). An evaluation of the role of oxidative stress in non-obstructive coronary artery disease. *Journal of Cardiovascular Development and Disease*, 9(2), 51.

Petrucci, G., Rizzi, A., Hatem, D., Tosti, G., Rocca, B., & Pitocco, D. (2022). Role of oxidative stress in the pathogenesis of atherothrombotic diseases. *Antioxidants*, 11(7), 1408.

Qi, X., Jha, S. K., Jha, N. K., Dewanjee, S., Dey, A., Deka, R., ... & Hou, K. (2022). Antioxidants in brain tumors: current therapeutic significance and future prospects. *Molecular Cancer*, 21(1), 204.

Rajha, H. N., Paule, A., Aragonès, G., Barbosa, M., Caddeo, C., Debs, E., ... & Edeas, M. (2022). Recent advances in research on polyphenols: effects on microbiota, metabolism, and health. *Molecular Nutrition & Food Research*, 66(1), 2100670.

Rahaman, M. M., Hossain, R., Herrera-Bravo, J., Islam, M. T., Atolani, O., Adeyemi, O. S., ... & Sharifi-Rad, J. (2023). Natural antioxidants from some fruits, seeds, foods, natural products, and associated health benefits: An update. *Food science & nutrition*, 11(4), 1657-1670.

Rahaman, M. M., Hossain, R., Herrera-Bravo, J., Islam, M. T., Atolani, O., Adeyemi, O. S., ... & Sharifi-Rad, J. (2023). Natural antioxidants from some fruits, seeds, foods, natural products, and associated health benefits: An update. *Food science & nutrition*, 11(4), 1657-1670.

Rychter, A. M., Hryhorowicz, S., Słomski, R., Dobrowolska, A., & Krela-Kaźmierczak, I. (2022). Antioxidant effects of vitamin E and risk of cardiovascular disease in women with obesity—a narrative review. *Clinical Nutrition*, 41(7), 1557-1565.

Severs, N. J., & Robenek, H. (2024). Constituents of the arterial wall and atherosclerotic plaque: an introduction to atherosclerosis. In *Cell interactions in atherosclerosis* (pp. 1-49). CRC Press.

Sinbad, O. O., Folorunsho, A. A., Olabisi, O. L., Ayoola, O. A., & Temitope, E. J. (2019). Vitamins as antioxidants. *Journal of Food Science and Nutrition Research*, 2(3), 214-235.

Sundaram Sanjay, S., & Shukla, A. K. (2021). Free radicals versus antioxidants. In *Potential therapeutic applications of nano-antioxidants* (pp. 1-17). Singapore: Springer Singapore.

Tian, L., Zhang, S., Yi, J., Zhu, Z., Cui, L., Decker, E. A., & McClements, D. J. (2022). Factors impacting the antioxidant/prooxidant activity of tea polyphenols on lipids and proteins in oil-in-water emulsions. *Lwt*, 156, 113024.

Wan, J., Zhang, M., & Adhikari, B. (2018). Advances in selenium-enriched foods: from the farm to the fork. *Trends in Food Science & Technology*, 76, 1-5.

Wang, R., Gao, X., Wang, Y., Ma, X., Wang, P., Ni, J., ... & Zhao, Z. (2025). Higher Oxidative Balance Score is associated with increased plaque stability in patients with coronary heart disease. *Nutrition, Metabolism and Cardiovascular Diseases*, 103911.

A comprehensive Review on Impact of Malnutrition on Street People of India

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ABSTRACT

The world's homeless population is growing daily. The 2024 census estimated that 150 million people—also known as street people—were homeless. This demography will soon surpass that of India in particular because of poverty, dysfunctional family systems, and intra-family conflicts. The majority of street people are employed as sellers, beggars and other workers. Therefore, malnutrition is prevalent among homeless persons. Additionally, food habits and the physiological alterations they cause may exacerbate chronic illnesses, increasing susceptibility and decreasing quality of life. The majority of street persons were malnourished, while only a small portion had normal nutritional status. Malnutrition and chronic illnesses are among the psychological and health issues that street people face as a result of their improper lifestyle and lack of access to adequate food. Prevalence of homeless persons wandering the streets, which is a sign of malnutrition and poor nutritional health. The goal of the current study is to highlight the nutritional state of homeless persons.

Keywords: *Street people, Beggars, Sellers, Malnutrition, Nutritional status*

Introduction

The growing incidence of street people in major cities in India as well as human carriage, kidnapping, Indecent assault and a host of antisocial behaviour has break down of the Family system. For instance, female beggars taking shelter under the open area on street. Street people and homelessness are often happened for anti-social behaviour issues by various stakeholder, including the briadcaster, legislator, dealer, law Administration officers and organization, well-being and community service providers, the common people (Lynch, 2005). To this end, a survey report indicated that street people were victims of Abuse, neglect and abandonment (GN/UNICEF, 1990). According to Lynch (2005), an average of most people is likely to beg daily. Carrous (cited in Qudiz, 2005:46) reported that an estimated 850 million people are famished while 2 billion suffer from nutrients deficiencies. In view of this, it was subjected that between now and upcoming year, there will be food-oriented Problems, with the Most endangered cities in India being Near and north- East, the Uttar Pradesh, Bihar, Madhya Pradesh and Andhra Pradesh. In consent, Wolf (2005) described that people, who ask for money, do so in order to Meet likelihood needs; in addition, Qudiz (2005) revealed that 88% of answered indicated sufficient Nutritional needs as their major reasons for solicit money as compared with need for housing (53%), Alcohol-reliance (41%), health maintainence (29%) and drug used (24%). We remarked that none of the informer solicit money because it was remunerative or easy money; the hypothesis drawn from all these studies point out that Impoverishment is the main factor associated with street people. All these and many more full carries to assess the reason and outcome of street people in India.

Street People earn a itinerant life while occupying streets as their living and Subsistence place. Street people are referred as the people who are shelterless and Reside on the streets at different urban Cities and places worldwide, they are also known as Street old age and street children. There is no specific statement for street people. For law makers the thought Given by UNICEF's statey for street people is "shelterless female and male the age of 7 years to 80 years Living on the streets"2 polygyny parents and turned Down from home that is the major reason for people to start dwelling on the streets in enlarged Countries. Street people are often found to be distinctly involved in Thievery, drug trafficking, criminal activities owing

to lack of submission to society, folklore, virtuous, wages, dwell, health, social community network, nutrition and hygiene, Adolescent children are found Gratify in low paying labours, parking, car washing, shoe polishing, mechanical work and more. Most of these people come from families conflicted with intra-family quarrel; Impoverishment and poor family Structures who operate to push the people on to the Streets or run off from their residence. The number of Street people is on a continual arise with each passing Day and they are anticipated to reach a rising number of 800 million in the Scarcity of appropriate bring forward Particularly for this group of the community. There are 53% of street people who suffer from Chronic malnutrition and 63% go to bed with starvation, 7.27 Million are mostly underweight and 33 million are drop Out from school. Most of these People work as beggars, Car washer, street vendors, garages helpers, newspaper distributaries and other perilous works. This puts Them at the risk of dropping of human capital that can turn to become providing citizens of the country for a better economy and hence, poverty alleviation. As stated by The community for the conserved of the Rights of the people (SPARC) there are 1.2-1.5 million Of street people in built-up areas of India of whom Malnourishment census are unspecified. This diminished part of the community needs to be dealt with at the brittle stage of adolescence to enhance their health evaluation and support them in becoming well and responsible people of the country to ease the Financial as Well as health burden. Therefore, health need evaluation of nutrition of street people.

The Nature of Street People

In Asia, women from impoverished countries like India were attached by organized 'network' to solicit money in cities (Wikipedia Free Encyclopedia 2007). The people usually assemble the process from them. Some beggars print illegal materials or posters related to scheme or any charitable association, which were establish to be either dispersed or non-extinct (Wikipedia Free Encyclopedia 2007). Street people may have trouble estimating services due to their compound amenities and susceptibility. Street people may occurrence distinction, which can make it trouble to attach new groups. Street people may acquaintance with health disproportion due to their deficiency of appraise to sufficient health wellness.



(Source: Allahabad, India – February 10, 2013)

Health status of street people

In this report street people who had no hand cleaning practice before consume meal were more under-Nourished as compared to the people who had habitude of hand cleaning. Same information was found by the report accompany in India. This report indicates that the malnutrition is accurately significantly related with the low age group of people. Malnutrition build- up more Among low age group as collate to the higher than Age group (p-value <0.005). Although, age of the street people made no distinction in nutritional evaluation was established in a report accompany by Tufail et al. There was No accurately important association Established of malnutrition with person and education status (p-value>0.05) In present study. Report established by subjected that the inferior level of education was found often on the street and research report was established in a study that un-enrolled in school Children were associated with the underweight status of the street people:

STREET PEOPLE	PERCENTAGE
Underweight	31
Wasting	19
Malnutrition	63

Stunting	37
Arithmetic Failure	9

(source:CIAF)

Prevalence of Malnutrition

Prevalence of malnutrition among street people Was build up high risk of malnourished rate. In the Recent report which may incapacitate the immune Function of body in the long period. In the sake of this, there was a importance affiliation between hand disinfection practices and related an Communicable diseases Like dysentery & flu in the past few months. The Probability of high Contagious rates due to impoverished living circumstances on the street, is likely to diminish the ferocious cycle of malnutrition and communicable disease. In recent study, no affiliation between dietary consumption and nutritional evaluation of street people was established. Same report was found in a study build up on the nutritional evaluation and adult people in India. It could be reason to the Restriction in dietary consumption Measurement based on recall. Like there were reported in a study guided by Hakim et al, that the large Portion of street people was established to be the malnutrition (66.67%) due To the Deficiency of Ingress to Protected consume water, insufficient Nutritious foods, deficiency of hygiene habitude and Sanctuary. It has been established in literature that hygiene habitude reflects the nutritional evaluation of each person. In The human body function to Assistance Enhancement and development, Wellness, nutritional attention and physiological activities cure Causation of diseases. If nutrients lack exists for longer period, they Consequence in intervention with body performing and hence Aggravated the causation of Diseases. Malnutrition diminish the immunity and this Makes the people more endangered to the contagious disease. Consuming hazard food, insufficient dietary consumption of important nutrients, imperfect dietary practice and reiterate illnesses are immediate reason of Malnutrition. Stress associated to deficiency of nutrition and shelterless can associate to prior smoking and other unethical behaviors of these people. That's why these Street people are considered as aberrant and lawbreaker. Street people have wide vulnerability to diseases such As chronic issues like respiratory Problems, parasitic damaged, and skin contamination. They are also at high probability of materiality abuse. The issue of exposure to

diseases requires higher nutritional consumption.

Consequence

This study has recognized that street people are associated with such informal factors as homelessness, impoverishment, joblessness and family refusal to solicit money. Substantiation also shows that researchers are searching for lasting ways of decreasing the situation of solicited money. As long as estimates such as zero monitoring, referral interference has capitulated little, a more dynamic perspective is essential. Also, considering literature as referred that most of the people who solicit money were people of a young generation, it is implicit that the nation is deprived of the profitable contribution of such people, in India as well as endangering the lives of people. The elucidation does not lie with administration alone. Therapy should focus on the family initially, whose chief responsibility of supervision, fondness and amenities of basic prerequisite of life have been displaced as a consequence of industrialization, detachment and judicial separation. Family therapy clinics should be confronted in this area by demoralizing families from immersing young people in street solicited money, support to modify their perspective, and constructing them to perceive the jeopardy inherent in street solicited money which includes accident trouble, sexual abuse and criminal offence.

Conclusion

Most of the street people ramble the streets of India are underweight implying malnutrition. Length of life and hand hygiene are energetically affiliated elements with the nutritional evaluation and the administration retroversion model recognize age and hand hygiene habitude along with task of garbage taker and technological as the powerful forecaster of malnutrition among the report contributors. Malnutrition is a national problem and particularly among the street people. It is a very non-reported area. It should be negotiated with precise policy commensurate and programs commencement particularly for these underprivileged people. Clash of interest: None. Author's assistance: formulation, data assembly, arrival, study plan, document writing, NA: formulation of study plan, final acceptance, MR: Conception of study, data assembly, critical assessment, SA & RA: Data inspection and explanation, Document writing. In prevalence of street people in our country, most of the people are high risk of malnutrition due to they could not get enough

food and drink for the consumption. For being effects of malnutrition that prone to health issues and chronic diseases which end result is mortality. Leanness and stagnant were prevalent among street people and are Affiliated with insufficient meals, improvement dietary area, substance misuse, Hazardous water sources, and sickness histories that could be objected for multisectoral interference.

Reference

Mohiddin, L., Phelps, L., & Walters, T. (2012). Urban malnutrition: a review of food security and nutrition among the urban poor. *Nutrition Works*, 8.

Hakim, M. A., & Rahman, A. (2016). Health and nutritional condition of street children of Dhaka city: an empirical study in Bangladesh. *Science Journal of Public Health*, 4(1), 6-9.

Padgett, D. K. (2020). Homelessness, housing instability and mental health: making the connections. *BJPsych Bulletin*, 44(5), 197-201.

Julien, G. (2023). Street Children: Getting to Know Them. In *Promoting Diversity, Equity, and Inclusion in Language Learning Environments* (pp. 160-174). IGI Global.

Zhang, J. X., Cheng, J. W., Philbin, S. P., Ballesteros-Perez, P., Skitmore, M., & Wang, G. (2023). Influencing factors of urban innovation and development: a grounded theory analysis. *Environment, Development and Sustainability*, 25(3), 2079-2104.

Plummer, M. L., Kudrati, M., & Yousif, N. D. E. H. (2007). Beginning street life: Factors contributing to children working and living on the streets of Khartoum, Sudan. *Children and Youth Services Review*, 29(12), 1520-1536.

Hossain, G. M., Sarwar, M. T., Rahman, M. H., Rouf, S. M., Raza, S., Ud-Daula, A., & Hossain, S. (2013). A study on nutritional status of the adolescent girls at Khagrachhari district in Chittagong hill tracts, Bangladesh. *American Journal of Life Sciences*, 1(6), 278-282.

Zheng, Z. W., & Chou, R. J. (2023). The impact and future of edible landscapes on sustainable urban development: A systematic review of the literature. *Urban Forestry & Urban Greening*, 84, 127930.

Psaki, S., Bhutta, Z. A., Ahmed, T., Ahmed, S., Bessong, P., Islam, M., ... & MALED Network Investigators. (2012). Household food access and child malnutrition: results from the eight-country

MAL-ED study. Population health metrics, 10, 1-11.

Shrimpton, R., & Rokx, C. (2012). The double burden of malnutrition. A Review of Global Evidence. Washington, DC: World Bank.

Haddad, L., Hawkes, C., Udomkesmalee, E., Achadi, E., Bendeck, M. A., Ahuja, A., ... & Shyam, T. (2016). Global nutrition report 2016: From promise to impact: Ending malnutrition by 2030. International Food Policy Research Institute.

Effect of Proteobacteria in Different Diets and Composition in Individuals

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Abstract

Proteobacteria, a phylum of gram-negative bacteria, are integral to the gut microbiome and can influence host health depending on their abundance and composition. This study explores the relationship between dietary patterns and the composition of Proteobacteria in individuals. Diets high in fats and sugars, such as the Western diet, are associated with an increased abundance of Proteobacteria, potentially promoting gut inflammation and metabolic disorders. In contrast, Mediterranean and high-fibre diets, rich in plant-based nutrients, correlate with reduced Proteobacteria levels and improved microbial diversity. Vegan diets, characterized by high fibre and plant polysaccharides, indirectly modulate Proteobacteria through increased colonization of beneficial taxa. Ketogenic diets exhibit variable effects, influenced by the composition of macronutrients and fat sources. These findings emphasize the dual role of Proteobacteria in health and disease, shaped by dietary intake, and highlight the potential of dietary strategies in managing microbiome-associated disorders.

Keywords: *Proteobacteria, gut health, Gram-negative bacteria, microbiota, diets*

Introduction

The human gut microbiome plays a crucial role in health and disease, with Proteobacteria emerging as a key phylum of interest due to its diverse metabolic capabilities and potential associations with various physiological and pathological

conditions. Proteobacteria include a wide range of Gram-negative bacteria, genus including *Escherichia*, *Salmonella*, *Helicobacter*, and *Pseudomonas*, which can function as commensals, opportunistic pathogens, or beneficial microbes depending on the host environment.

Diet is a major determinant of gut microbial composition, influencing the abundance and function of Proteobacteria. Different dietary patterns—such as Western, Mediterranean, vegetarian, and high-fiber diets—can either promote or suppress Proteobacteria populations. A Western diet rich in fats and refined sugars has been linked to an increase in Proteobacteria, which may contribute to gut dysbiosis and inflammation. In contrast, fiber-rich diets, such as the Mediterranean or plant-based diets, promote microbial diversity and may help maintain a balanced microbiome.

The composition of Proteobacteria varies across individuals due to genetic factors, lifestyle, and dietary habits. While some members of this phylum are essential for gut homeostasis and immune regulation, an overrepresentation is often associated with inflammatory conditions such as metabolic disorders, inflammatory bowel disease (IBD), and obesity. Understanding the role of Proteobacteria in different dietary contexts is essential for developing dietary interventions to promote gut health and prevent disease.

Objective

The objective of this review is to examine the effects of Proteobacteria on gut microbiome composition in individuals following different dietary patterns, as follows:

- To analyze the abundance and diversity of Proteobacteria in individuals consuming varied diets, including Western, Mediterranean, vegetarian, and high-fiber diets.
- To investigate the relationship between Proteobacteria levels and host health outcomes, including inflammation, metabolic disorders, and gut dysbiosis.
- To assess how dietary components influence the growth and activity of Proteobacteria, identifying factors

that promote or suppress their prevalence.

- To determine the role of Proteobacteria in maintaining gut homeostasis versus contributing to disease, providing insights into their potential as biomarkers for dietary impact on health.
- To explore potential dietary interventions that can help regulate Proteobacteria populations and promote a balanced gut microbiome.

Review of Literature

Role of Proteobacteria in the Gut Microbiome

Proteobacteria constitute a diverse phylum of Gram-negative bacteria (Figure 1) that play both beneficial and pathogenic roles in the human gut microbiome. Studies suggest that Proteobacteria are present in low abundance in healthy individuals but tend to increase in cases of gut dysbiosis and inflammatory conditions (Shin et al, 2015). The overgrowth of certain Proteobacteria genera, such as *Escherichia*, *Salmonella*, *Helicobacter*, and *Klebsiella*, has been linked to metabolic disorders, chronic inflammation, and gastrointestinal diseases (Mukhopadhyaya et al, 2012).



Figure 1- Gram negative bacteria

Dietary Influence on Proteobacteria Composition

Dietary patterns significantly impact the composition and abundance of gut microbiota, including Proteobacteria.

Western Diet (High-Fat, High-Sugar Diets): Research indicates that diets high in saturated fats and refined sugars promote an increase in Proteobacteria, particularly *Enterobacteriaceae*, a family associated with inflammatory responses and metabolic disorders (David et al, 2014). This diet-induced dysbiosis is often linked to conditions such as obesity, type 2 diabetes, and cardiovascular diseases.

Mediterranean Diet (High-Fiber, Polyphenol-Rich Diets): The Mediterranean diet, rich in fiber, polyphenols, and unsaturated fats (Figure 2a), has been associated with reduced Proteobacteria abundance and improved gut microbiome diversity (De Filippis et al, 2016). Studies have shown that this diet promotes beneficial bacteria such as *Bacteroidetes* and *Firmicutes*, which help maintain gut homeostasis and suppress inflammation.

Vegetarian and Vegan Diets: Plant-based diets (Figure 2b), characterized by high fiber intake, have been linked to lower levels of Proteobacteria and increased microbial diversity (Wu et al, 2011). These diets provide prebiotics that support the growth of beneficial gut bacteria, reducing the potential pathogenic effects of certain Proteobacteria strains.

High-Protein Diets: High-protein diets, particularly those rich in animal protein, have been associated with increased levels of *Proteobacteria* and bile-tolerant bacteria (Beaumont et al, 2017). This may contribute to inflammation and gut permeability, affecting overall gut health.



(a) High-fiber diet



(b) Vegan diet

Figure 2- Different Diets

Proteobacteria and Gut Dysbiosis

Several studies have suggested that an increased abundance of Proteobacteria is a hallmark of gut dysbiosis, a microbial imbalance linked to various diseases. Zhang et al, 2020 found that elevated levels of Proteobacteria are associated with inflammatory bowel disease (IBD) and other gastrointestinal disorders. Similarly, In a study by Shin et al, 2015 highlighted that the presence of *Enterobacteriaceae* correlates with systemic inflammation and metabolic syndrome.

Potential Dietary Interventions for Regulating Proteobacteria

Emerging research suggests that dietary interventions can help regulate Proteobacteria levels and restore gut balance. Probiotic and prebiotic supplementation, along with fiber-rich diets, have been shown to modulate the gut microbiome and reduce Proteobacteria overgrowth Korpela et al, 2018. Fermented foods, polyphenol-rich foods, and omega-3 fatty acids have also been linked to improved gut health by enhancing microbial diversity and reducing inflammation.

Effect of Different Diets on Proteobacteria Composition

Western Diet (High-Fat, High-Sugar, Low-Fiber): Increases Proteobacteria, especially pathogenic strains like *Enterobacteriaceae*; Promotes gut inflammation and metabolic endotoxemia; associated with obesity, insulin resistance, and inflammatory diseases.

High-Fiber Diet (Plant-Based, Whole Grains, Fruits, Vegetables): Reduces Proteobacteria abundance, supporting gut microbial balance; enhances beneficial bacteria like Firmicutes and Bacteroidetes that produces short-chain fatty acids (SCFAs), reducing inflammation.

High-Protein Diet (Animal-Based, Red Meat, Processed Meat): Increases Proteobacteria, including sulfate-reducing bacteria like *Desulfovibrio spp.*; produces harmful metabolites (hydrogen sulfide, ammonia) and associated with colorectal cancer risk and gut dysbiosis.

Ketogenic Diet (Low-Carb, High-Fat, Moderate Protein):

Alters microbiome composition, increasing *Bilophila wadsworthia* (linked to inflammation); reduces overall microbiome diversity and may improve metabolic health but has potential gut health risks.

Mediterranean Diet (Balanced, High in Healthy Fats, Fiber, and Polyphenols):

Decreases pathogenic Proteobacteria while promoting gut microbial diversity; Supports anti-inflammatory pathways and cardiovascular health and promotes a stable and resilient gut microbiome.

Individual Variability in Proteobacteria Effects

The impact of Proteobacteria varies based on:

Genetics: Some individuals have a higher tolerance for Proteobacteria.

Immune System: Those with weaker immunity may experience inflammation from overgrowth.

Microbiome Diversity: A diverse microbiome can counterbalance Proteobacteria effects.

Existing Health Conditions: People with IBD, IBS, or obesity may be more susceptible to Proteobacteria-related dysbiosis.

Conclusion:

Proteobacteria is a major phylum of bacteria found in the human gut microbiome, including both beneficial and potentially harmful species. The beneficial functions involve contribution to nitrogen cycling and digestion; help in the breakdown of certain dietary components. When found in abundance, these species tend to develop as opportunistic pathogens (*Escherichia coli*, *Klebsiella*, *Salmonella*) that are linked to gut inflammation, metabolic disorders, and endotoxin release (LPS) and found to be associated with inflammatory bowel disease (IBD), obesity, and cardiovascular disease. The focus should be given on diets that play a crucial role in shaping the composition of Proteobacteria, which in turn affects gut health, metabolism, and immune function which include increased fiber intake (whole grains, legumes, vegetables)

to support beneficial bacteria; consume Fermented Foods (yogurt, kimchi, kombucha) to enhance microbial balance; reduce processed Foods & Sugars to prevent pathogenic Proteobacteria overgrowth and diversify diet- to maintain a stable and diverse gut microbiome

References

- Shin, N. R., Whon, T. W., & Bae, J. W. (2015). Proteobacteria: Microbial signature of dysbiosis in gut microbiota. *Trends in Biotechnology*, 33(9), 496-503. <https://doi.org/10.1016/j.tibtech.2015.06.011>
- David, L. A., Maurice, C. F., Carmody, R. N., et al. (2014). Diet rapidly and reproducibly alters the human gut microbiome. *Nature*, 505(7484), 559-563. <https://doi.org/10.1038/nature12820>
- De Filippis, F., Pellegrini, N., Vannini, L., et al. (2016). High-level adherence to a Mediterranean diet beneficially impacts the gut microbiota and associated metabolome. *Gut*, 65(11), 1812-1821. <https://doi.org/10.1136/gutjnl-2015-309957>
- Wu, G. D., Chen, J., Hoffmann, C., et al. (2011). Linking long-term dietary patterns with gut microbial enterotypes. *Science*, 334(6052), 105-108. <https://doi.org/10.1126/science.1208344>
- Beaumont, M., Portune, K. J., Steuer, N., et al. (2017). Quantity and source of dietary protein influence metabolite production and microbiota profiles in the gut. *Scientific Reports*, 7(1), 11342. <https://doi.org/10.1038/s41598-017-11734-1>
- Mukhopadhyay, I., Hansen, R., El-Omar, E. M., & Hold, G. L. (2012). IBD—What role do Proteobacteria play? *Nature Reviews Gastroenterology & Hepatology*, 9(4), 219-230. <https://doi.org/10.1038/nrgastro.2012.14>
- Zhang, X., Li, L., Butcher, J., et al. (2020). The human gut Proteobacteria: Disease, adaptation, and evolution. *Frontiers in Microbiology*, 11, 2158. <https://doi.org/10.3389/fmicb.2020.02158>
- Korpela, K., Salonen, A., Virta, L. J., et al. (2018). Intestinal microbiome is related to lifetime antibiotic use in Finnish pre-school children. *Nature Communications*, 9, 463. <https://doi.org/10.1038/s41467-018-03111-8>