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A NARRATIVE REVIEW.

The Rise of Mushroom-Based Nutraceuticals: A Review of Nutritional Potential and Industrial Integration.

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Abstract

Background: mushrooms as a source of bioactive, pharmacologically valuable substances, which puts mushrooms in the range of promising food supplements. Their exclusive makeup, which contains polysaccharides, phenolics, and critical micro nutrients, has attracted the attention of nutrition science and commercial sectors.

Objective: This review attempts to analyze the health benefits, nutritional value, and industrial usability of mushroom-derived nutraceutical substances, as well as the bottlenecks and controversies surrounding their commercialization.

Methods: The literature was scoured to identify the most recent peer-reviewed publications on the topic concerning databases of PubMed, Scopus, and ScienceDirect and timeframes 2010 to 2024. Among search terms, the importance of mushroom nutraceuticals, bioactive compounds, and functional foods, as well as their industrial commercialization, deserves to be mentioned.

Results: Particular species of mushrooms, Ganoderma lucidum, Lentinula edodes, and Cordyceps militaris, reveal antioxidant, anti-inflammatory, immuno-modulatory, and cholesterol-reducing activity. The integration into the nutraceutical market has been increasing at a fast rate, with regulatory gaps, standardization, and scientific validations being significant challenges. In addition, there is the issue of false marketing health-wise, as well as the conflict between usage and abuse in industry.

Conclusion: Nutraceuticals based on mushrooms have a massive potential in terms of both public health and commercial development. Nonetheless, evidence-based regulations and interdisciplinary cooperation are necessary to make sure that products are safe, effective, and developed with responsibility in the growing area.

Keywords: Mushrooms,Nutraceuticals,Bioactive Compounds,Functional Foods,Dietary Supplements,Phytotherapy

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INTRODUCTION

The growing need to consume preventive and health-promoting foods in the world has set nutraceuticals at the forefront of primary care and functional foods **[1]**. Mushrooms are a significant type of nutraceutical; they are enriched with bioactive compounds such as 2-glucans, polysaccharides, phenolics, terpenoids, and essential micronutrients among others**[2,3]**.The compounds show such pharmacological activities as anti-inflammatory,antioxidant,immunomodulatory, cardio protective,andantitumor activity**[4]**.Heretofore, mushrooms have been deployed in traditional medicine systems, such as traditional Chinese medicine (TCM) and Ayurveda. However, now these fungi are being scientifically examined in terms of their use in contemporary functional food and supplement markets**[5]**. Such species as Ganoderma lucidum (Reishi), Lentinula edodes (Shiitake), Grifola frondosa (Maitake), and Cordyceps militaris have been the most explored in this regard**[6]**.As consumer awareness and interest in natural health products have increasingly grown, mushrooms have shown extraordinary commercial success in the global market, especially in nutraceuticals**[7]**. However, they hold great potential, regulatory control, standardization of products, and scientific substantiation of the health claims, but still face difficulties**[8]**.This review critically analyzes the nutritional,value,therapeutic,benefits,and convergence of industrial manufacturing of mushroom-based nutraceuticals, along with areas of developing research and commercial research, as well as ethical issues revolving around the manufacturing of mushroom-based health products

METHODS

This narrative review study was done at the Department of Urology, Institute of Kidney Diseases, Peshawar, between January 2024 and July 2024. A search of the literature was conducted via electronic databases (e.g., PubMed, Scopus, Google Scholar, and ScienceDirect) to find a suitable number of peer-reviewed studies, literature reviews, and clinical reports.The search procedure included the use of the keywords and MeSH terms, including mushroom nutraceuticals, bioactive compounds, functional foods, dietary supplements, and medicinal mushrooms. Effective use of terms was done using the Boolean operators (AND, OR). To guarantee the scope of the latest and most applicable evidence, the search was confined to the English-language articles that were published between **2010 and 2024.**

Inclusion criteria:

1. papers on the gastronomic or curative specifications of edible or medicinal mushrooms
2. The mushroom commercialization or industrial use of nutraceuticals has been studied in
3. The review or clinical trial of mushroom-derived bioactives.

Exclusion Criteria

1. Studies That Are Not Applied In Human Health
2. Non-Peer-Reviewed
3. Low-Quality/Irrelevant.ethodologically Articles.

DISCUSSION

Nutraceuticals based on mushrooms have become widely popular worldwide because they are perceived to hold some therapeutic value, and with consumers of such products demanding more natural health alternatives these days **[9,10].** Asian data (mainly China + Japan) on epidemiological use underline the prevalent application of medicinal mushrooms (Ganoderma lucidum and Lentinula edodes) in traditional medicine systems**[11,12]**. Mushroom nutraceuticals are expected to experience massive growth in the marketplace due to the rise in awareness of their action in immunomodulation, antioxidative-inflammation, and disease protection **[13]**.Bioactive compounds such as β-glucans, ergothioneine, polyphenols, and terpenoids are found in large amounts in edible and medicinal mushrooms and appear to have typical benefits to physiology **[14,15]**. According to comparative studies, some feathery, single-celled Cordyceps militaris species and Grifola frondosa have a high level of antioxidants and immunomodulatory effects **[16]**. Nevertheless, the inconsistency of the bioactive content is common due to the difference in cultivation, extraction, and processing procedures, which creates difficulties in standardization and confirmation of efficacy **[17,18]**.With mushrooms being implemented in the manufacture of functional foods, soft drinks, and dietary supplements, there appears to be continuous innovation in the nutraceutical industry**[19]**. Current developments in fermentation and nanotechnology enhance the availability of the mushroom-derived substances**[20]**. The process of product development using mushrooms is gaining increasing attention among startups and pharmaceutical companies; however, there are regulatory challenges and the need to prove the

effectiveness of these products in clinical conditions**[21]**.There are drawbacks to mushroom nutraceuticals despite their potential. Disseminated product formulation, risk of contamination, and overstated marketing claims are among the worrying issues**[22]**. In addition, the available long-term data regarding safety in human beings is scarce. Non-serious adverse effects associated with allergic responses on treatment,and,drug,interactions,(especially,with,immunosuppressive medicines) should be looked at more closely**[23]**.Research studies ought to concentrate on prospective randomized controlled trials within different populations to enhance their clinical usage since they are exposed to efficacy, dosing, and safety testing**[24]**. A combination of modern scientific knowledge of pharmacology and traditional knowledge, as well as harmonization of the regulations, will also become crucial toward a responsible development of nutraceuticals based on mushrooms.

CONCLUSION

There is an emerging nutraceuticals sector based on mushrooms that is an active area of growth in an overlap between purported traditional medicine and contemporary functional food science. The current review points out the substantial nutritional and therapeutic benefits of different mushroom species, especially Ganoderma lucidum, Lentinula edodes, and Cordyceps militaris, which have potential bioactive compounds with antioxidant, immunomodulatory, and metabolism regulatory properties.Clinically, such nutraceuticals have potential in the treatment of oxidative stress, inflammation, and immune response; aspects that are becoming of concern about prevention therapies. They are confined by a lack of standardized formulations, inconsistent bioavailability, and a general lack of clinical trials to warrant routine clinical use, however.Expanding commercial appeal to mushroom-based products prompts the need for strong regulatory Management and product quality control to maintain the safety of the product and its effectiveness. Moreover, there should be interdisciplinary work among mycologists, pharmacologists, nutritionists, and regulatory bodies to convert the traditional application of mushrooms into evidence-based interventions.Future studies ought to emphasize adequate clinical trials, standardization of doses, longitudinal safety pharmacovigilance, and achievement of validated biomarkers for effectiveness. Closing these disparities will assist in optimizing the therapeutic potential of mushroom nutraceuticals while being ethical and scientifically sound in terms of globally applying the nutraceuticals.

Future Findings

Future research must concentrate on clinical studies of considerable magnitude, pharmacokinetics, and regulatory approval of nutraceuticals derived from mushrooms. It should also emphasize finding standardized biomarkers, optimizing the delivery platforms, and integrating traditional knowledge into modern bioengineering to enhance efficacy, safety, and commercial feasibility.

Summary of Review

This overview discusses the growing use of mushrooms as a source of nutraceuticals by focusing on their bioactive compounds, therapeutic opportunities, and the increase in the use in the industry. Though a few species have been shown to have the capability of antioxidant, anti-inflammatory, and immune boosting activities, there is still a great need to standardize the products, clinically validate and regulate the products. The trend is that scientific rigor is needed in order to explain the health claims related to the consumption of mushroom-based supplements, especially as interest increases on an industrial level. The linkage between the traditional use and contemporary commercialization is needed, and interdisciplinary research and evidence-based regulation are required. Taken as a whole, mushroom nutraceuticals have great potential in the field of human health and prevention, provided they are designed responsibly and proven.

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