

To Build Immune System by Using the Mushroom : A Review

Mr. Bansode Akshay R.^{1*} Mr. Somani Shravan J.^{2*}

Mr. Rode Abhijit R.^{3*} Ms. Dhawade Ankita A.^{4*}

Pratibhatai Pawar College of Pharmacy, Shrirampur.

Abstract: -

This review article examines the potential of mushrooms to enhance the immune system. Mushrooms contain various bioactive compounds such as beta-glucans, polysaccharides, and triterpenoids that have been shown to modulate immune function. The article discusses the mechanisms by which these compounds work to stimulate the immune system, as well as the various types of mushrooms that have been studied for their immune-boosting properties. In addition, the article explores the potential therapeutic applications of mushroom-based immunomodulators, including their use in cancer treatment, infectious disease prevention, and autoimmune disorders. Finally, the article summarizes the current state of research on the topic and provides recommendations for future studies to further investigate the potential of mushrooms as immune system boosters.

The immune system is a complex network of cells, tissues, and organs that protect the body against harmful pathogens and foreign substances. The immune system can be modulated by various natural products, including mushrooms. Mushrooms have been used for centuries in traditional medicine for their health-promoting properties, and recent research has demonstrated their potential as immune system modulators.

Keywords: -

Polysaccharides, immunity, immunomodulators, anti-inflammatory

Introduction: -

Mushrooms have been historically used for medicinal functions in many cultures for centuries, and greater recently, lookup has printed their viability for use in immunology. Mushrooms incorporate a range of bioactive compounds such as polysaccharides, beta-glucans, terpenoids, and lectins that have been proven to modulate the immune system. They can beautify immune features by stimulating the manufacturing of immune cells such as herbal killer cells, macrophages, and lymphocytes, and by using merchandising the secretion of cytokines, which are chemical messengers that modify immune responses.

Mushrooms have additionally been proven to possess anti-inflammatory properties, which can assist to limit the severity of inflammatory prerequisites such as hypersensitive reactions and autoimmune disorders. The use of mushrooms in immunology has proven promise for the prevention and therapy of infectious diseases, cancer, and different immune-related disorders. However, greater lookup is wished to utterly recognize the

mechanisms of motion of these bioactive compounds and to strengthen standardized preparations and dosages for medical use.

Mushrooms have been used for their medicinal homes for centuries, and lookup has proven that they have immune-enhancing and anti-inflammatory effects. Mushrooms are prosperous in bioactive compounds, such as polysaccharides, beta-glucans, terpenoids, and lectins, which have been proven to modulate the immune system. The following is an overview of the use of several sorts of mushrooms in immunology.

Medicinal mushrooms (MMs) are a vital supply of herbal immunomodulators.

Representing a subset of all mushrooms, MMs are largely described as macroscopic fungi that are used in the shape of extracts or entire mushroom powder for human fitness benefits. The fitness advantages may additionally come in the shape of assisting to forestall and/or treat ailments in humans, and to ccreatietary the stability of a healthful diet.

Dating lower back heaps of years, MMs have been traditionally used as natural drugs for human health, such as for the cure of infectious diseases, gastrointestinal is, d asthmatic conditions. The biomass or particular extracts from all developmental degrees of MMs, which include the fruiting body, sclerotium, mycelium, and spores, have been used as fitness meals or dietary supplements]. Some of the extracted vitamins from mushrooms acknowledged as mushroom nutraceuticals have been made into tablets or drugs as dietary supplements. Regular consumption of these nutraceuticals has been related to the enhancement of the human immune response, mainly to extended resistance to infectious illnesses and quicker recuperation from a range of ailments [1]

Anatomy and Life Cycle of Mushroom:-

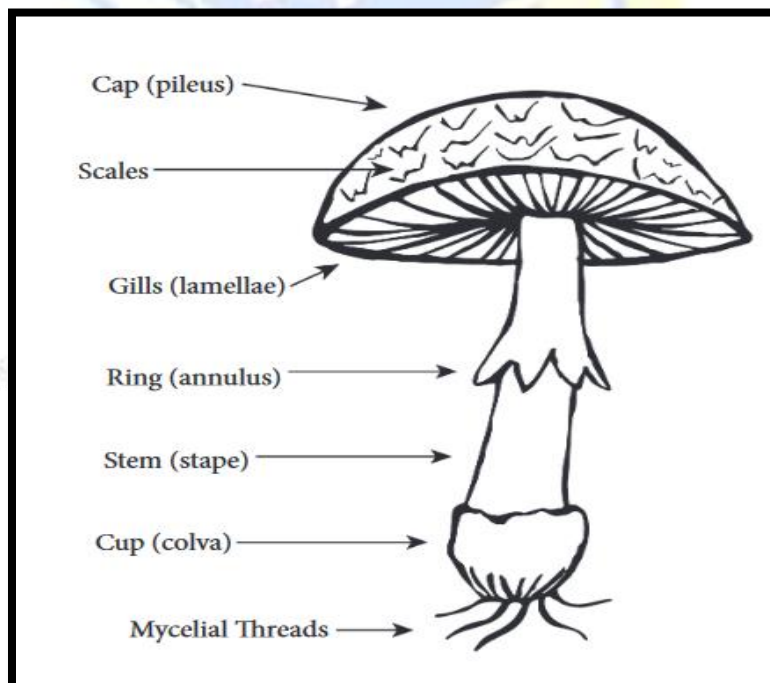


Figure 1. Mushroom Anatomy

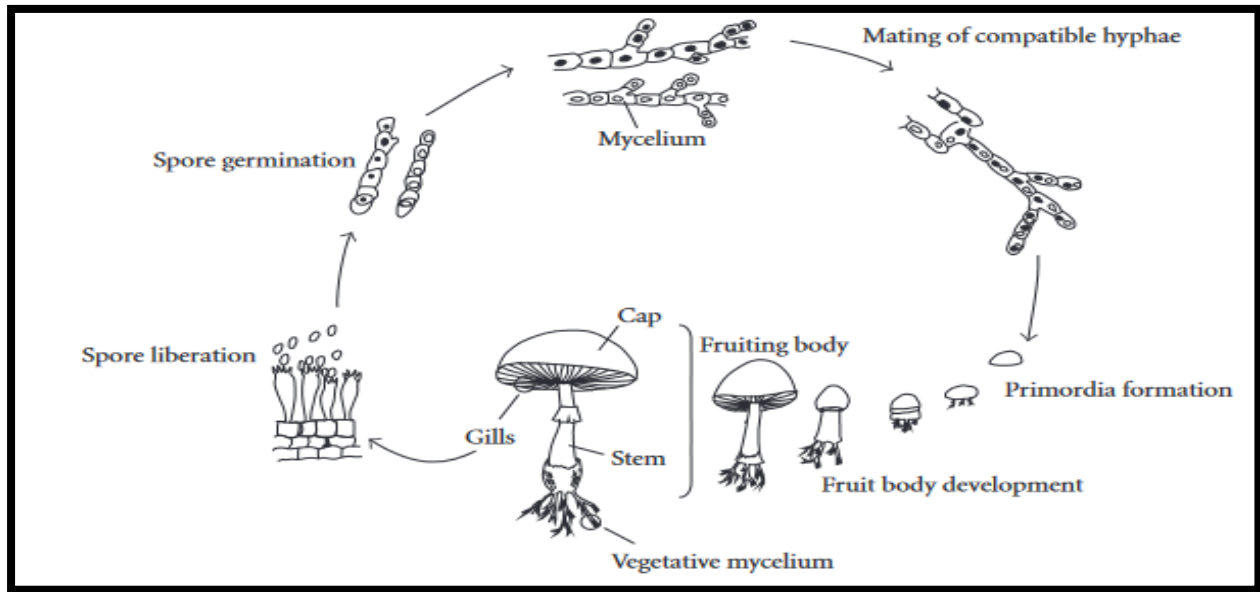


Figure 2. Diagrammatic representation of mushroom life cycle

Some Types of Medicinal Mushrooms: -

As stated above, medicinal mushrooms refer to all macroscopic fungi whose extracts or powder structure from any levels of the mushroom improvement have proven documented really helpful results on the health.

1. Reishi (*Ganoderma lucidum*)

Reishi is a widely widespread mushroom in common Chinese medication and has been used for its immune-enhancing properties. Reishi consists of beta-glucans and polysaccharides, which have been proven to set off immune cells such as macrophages and herbal killer cells. Reishi has been observed to have anti-inflammatory properties, and it might also assist to minimize infection in the body. In addition, reishi has been proven to beautify the endeavor of immune cells in sufferers of cancer, and it may additionally be useful in stopping cancer.



Fig.3 Reishi (*Ganoderma lucidum*)

2. Shiitake (*Lentinula edodes*)

Shiitake is a famous culinary mushroom that has been used for its medicinal properties. Shiitake includes beta-glucans, which have been proven to decorate the immune device by activating immune cells such as macrophages and herbal killer cells. In addition, shiitake has been discovered to have anti-inflammatory houses and can also assist to decrease irritation in the body. Shiitake has additionally been observed to decorate the pastime of immune cells in sufferers with cancer, and it can also be useful in stopping cancer.



Fig.4. Shiitake (*Lentinula edodes*)

3. Maitake (*Grifola frondosa*)

Maitake is every other mushroom that has been used for its immune-enhancing properties. Maitake includes beta-glucans, which have been proven to prompt immune cells such as macrophages and herbal killer cells. Maitake has additionally been determined to decorate the recreation of immune cells in sufferers with cancer, and it can also be beneficial in stopping cancer. In addition, maitake has been located to have anti-inflammatory homes and might also assist to minimize irritation in the body.



Fig.5 Maitake (*Grifola frondosa*)

4. Turkey Tail (*Trametes versicolor*)

Turkey's tail is a mushroom that has been used for its immune-enhancing properties. Turkey tail incorporates polysaccharides, which have been proven to beautify the exercise of immune cells such as macrophages and herbal killer cells. Turkey tail has been observed to decorate the endeavor of immune cells in sufferers with cancer, and it can also be useful in stopping cancer. In addition, turkey tail has been determined to have anti-inflammatory houses and might also assist to minimize irritation in the body.



Fig.6 Turkey Tail (*Trametes versicolor*)

5. Cordyceps (*Cordyceps sinensis*)

Cordyceps is a mushroom that has been used for its immune-enhancing properties. Cordyceps consists of polysaccharides, which have been proven to decorate the endeavor of immune cells such as macrophages and herbal killer cells. Cordyceps has been located to decorate the exercise of immune cells in sufferers with cancer, and it may additionally be useful in stopping cancer. In addition, cordyceps has been determined to have anti-inflammatory houses and may additionally assist to minimize infection in the body.



Fig.7 Cordyceps (*Cordyceps sinensis*)

6. Chaga (Inonotus obliquus)

Chaga is a mushroom that has been used for its immune-enhancing properties. Chaga carries beta-glucans, which have been proven to decorate the exercise of immune cells such as macrophages and herbal killer cells. Chaga has been determined to beautify the pastime of immune cells in sufferers with cancer, and it may additionally be beneficial in stopping cancer. In addition, chaga has been determined to have anti-inflammatory residences and may also assist to minimize infection in the body.



Fig .8 Chaga (Inonotus obliquus)



Figure. 9 A few consultant medicinal mushrooms from the wild

Figure two Shows a few consultant medicinal mushroom species in their herbal habitats. Some medicinal mushrooms are solely determined in the wild, e.g., the ectomycorrhizal mushrooms *Boletus edulis* and *Russula lepida*. However, a giant quantity of medicinal mushrooms is additionally commercially cultivated, such as Shiitake, Ling-zhi, and Lion's Mane.



Figure .10 A few consultants cultivated medicinal mushrooms. [1]

Immunomodulatory Compounds and Commercial Products of Medicinal Mushrooms: -

Mushrooms comprise bioactive polysaccharides and fundamental amino acids, as nicely as minerals, such as calcium, potassium, magnesium, iron, and zinc. A fascinating find out about published that the protein content material in dry mushrooms used to be 228 and 249 g/kg dry depend (DM). Another vital constituent of the mushrooms is carbohydrates, which represent about one-half of mushroom DM. Carbohydrates play a vast position in the medicinal houses of mushrooms via their immune-stimulating β glucans, alongside different polysaccharides [5] The regular content material of ascorbic acid is 150–300 mg/kg DM. B-group diet contents of thiamine (1.7–6.3 mg/kg), riboflavin (2.6–9.0 mg/kg), pyridoxine (1.4–5.6 mg/kg), and niacin (63.8–83.7 mg/kg) had been decided in 4 dried frequent cultivated species. The common ergosterol content material was once 1.98 mg/g, the common diet D2 content material was once 16.88 μ g/g, and diet B2 content material used to be 12.68 μ g/g in 35 exceptional mushrooms. In addition, nutrition D2 content material used to be extended in mushrooms accompanied with the aid of ultraviolet-C (UV-C) radiation [18]

1. Polysaccharides

Among the bioactive compounds derived from mushrooms with immunomodulatory activity, these primarily based on polysaccharides, with or except aspect chain changes (including polysaccharopeptides and polysaccharide proteins) are the most suggested all through the remaining numerous decade [12]

Mushrooms are broadly used for their excessive dietary price as a practical food. Additionally, they have been distinctly favored for their medicinal and therapeutic purposes [16]. Edible mushrooms produce a huge variety of bioactive compounds such as polysaccharides, proteoglycans, terpenoids, phenolic compounds, steroids, and lectins. These compounds have a vast variety of therapeutic consequences and can act as immune-modulatory, anticarcinogenic, antiviral, antioxidant, and anti-inflammatory sellers [14]. The concentration, and efficacy of the bioactive compounds are different and rely on the kind of mushroom, substrate applied, cultivation and fruiting conditions, stage of development, age of the sparkling mushroom, storage conditions, and processing and cooking strategies [13]. Many of the bioactive compounds located in mushrooms showcase vast anti-inflammatory properties. Polysaccharides from eight species exhibited robust antioxidant undertaking in the DPPH radical scavenging assay as nicely as robust inhibitory residences in the proliferation of tumor cells [17]

a. Hybrid mushrooms polysaccharides

Quality characteristics inside the gene pool of any unique suitable for eating mushroom species are limited. The development of new hybrid lines is therefore wished to introduce necessary qualitative and quantitative qualities like excessive bio-efficacy, excessive temperature tolerance, enhanced shelf lifestyles, and shorter cropping intervals inside a gene pool. Production of new hybrid mushroom traces via para-sexual mating is now nicely established.

b. Plant polysaccharides

Now day Plant polysaccharides remoted from one-of-a-kind vegetables and plants have been in the interest of chemists and immunobiologists on account of their due to its range they exhibit antitumor, immunostimulatory, anticomplementary, anti-inflammatory, antioxidant anti-coagulant, and fibrinogenic activities. Now day's plant polysaccharides are a very pleasing supply of additives for the food and drug industries due to the fact of their use in complementary medicine supplement. Plant polysaccharides showed each anti-genotoxic and anti-tumor merchandising activity. A sulfated polysaccharide was once remoted from the inexperienced seaweed *Monostroma angicava* and suggests anticoagulant properties An immunoenhancing polysaccharide remoted from the warm aqueous extract of mature pods (fruits) *Moringa oleifera* (salina) was once located to include solely D-glucose as a monosaccharide unit. A water-soluble polysaccharide was once remoted from the aqueous extract of pods of *Moringa oleifera*. The polysaccharide carries D-galactose, 6-O-Me-D-galactose, D-galacturonic acid, L-arabinose, and L-rhamnose in a molar ratio of 1:1:1:1:1 [12]

2. Proteins

The anti-inflammatory consequences of mushrooms are linked to their amino acid contents (both integral and dispensable), which are known to impact prostaglandin metabolism. The anti-inflammatory properties of *Pleurotus ostreatus* (oyster mushroom) have been partly explained via the presence of amino acids such as leucine, isoleucine, tyrosine, and phenylalanine. Lectins are proteins or glycoproteins successful in selective binding with membrane carbohydrates of specific mobile types, and for this reason, gratifying a necessary position in the legislation of the immune system. Lectins promote the mobile phone adhesion technique and positive lectins have been found to contribute to the activation of lymphocytes, whereas others possess strong anti-proliferative properties. Mushrooms are a huge and yet poorly understood reservoir of lectins with possible medicinal houses [10]

3. Fatty acids

Fatty acids contained in mushrooms are successful in assisting anti-inflammatory methods in people owing to their excessive content material of unsaturated fatty acids). PUFAs are precursors of eicosanoids, which are signaling molecules critical for suitable legislation of mobile techniques in muscles, blood vessels, nerve cells and the immune system. Eicosanoids make sure the stability between inflammatory and anti-inflammatory processes. PUFA encompass n-3, n-6, and n-9 acids. Maintaining suitable ratios of n-3 to n-6 fatty acids in the food plan performs a key position in the prevention of cardiovascular illnesses or cancers. α -Linolenic acid (ALA) is an element fundamental for regular fundamental diet and health and is a precursor of long-chain PUFAs of the n-3 series. Furthermore, it well-known shows robust anti-inflammatory activity. A comparative find out about of the compositions of extra than a dozen species of mushrooms validated that they had been particularly composed of the following fatty acids: linoleic (C18:2 n-6), oleic (C18:1 n-9), and palmitic acids. Cells incubated with EPA, EPA with LPS, DHA, and DHA with LPS had a reduction in cyclooxygenase and FP-receptor expression in contrast to the AA and AA + LPS groups, which demonstrates the anti-inflammatory homes of the EPA and DHA fatty acids. Interestingly, FP-receptor inhibition by using EPA and DHA or their derivatives proves the special position of the FP-receptor as a possible goal for antagonists in illnesses of inflammatory character. Because COX-2 is a key enzyme in the inflammatory response, growing the expression of these proupressingsome compounds may additionally be viewed as a seasoned inflammatory characteristic. In lung epithelial cells, the pro-inflammatory moves of AA had been very mentioned in cells incubated with AA, each with and barring LPS activation. The samples of A549 cells incubated with EPA showed diminished COX-2 activity. [26]

4. Bio elements

Mushrooms showcase excessive potential to assimilate elements from the soil, and as a result, present a treasured supply of these molecules. Zinc, copper, iron, and selenium are among the elements with antioxidant and anti-inflammatory residences amassed with the aid of mushrooms the micronutrient with gia an anti-inflammatory impact located in mushrooms is zinc. Its content material in fruiting our bodies of extraordinary mushroom species takes place in the vary of 150–200 mg/kg d.w. This component can also affect each unique and non-specific immune response of humans. Zinc is a quintessential micronutrient, critical for the everyday functioning of all immune cells, as it influences proliferation, differentiation, and the everyday undertaking of NK cells, neutrophils, macrophages, and T and B lymphocytes. Moreover, it ensures applicable stability between the features of Th 1 and Th two lymphocytes (through the rules of cytokine secretion) which are simple signaling factors in the immune system

5. Terpenoids

Terpenes are the biggest crew of anti-inflammatory compounds in mushrooms and have been removed from a variety of distinct strains. [22] Terpenoids represent a massive team of fungal compounds bearing anti-inflammatory activity. Numerous reviews have been posted on the isolation of new, lively terpene compounds from distinctive species, together with non-edible mushroom species. New terpene compounds have been remoted from 19 examined mushroom species from Japan these are especially acid Ganodermanic and lucidenic, as nicely as gingerols and ganoderiols. The anti-inflammatory impact of triterpene extracts from *G. lucidum* was once additionally decided in LPS-activated macrophages. The extract had a great effect on the limit of COX- two expressions and the inhibition of prostaglandin E2 manufacturing in RAW 264.7 cells. Decreased recreation of iNOS and decreased NO secretion have been observed, alongside with discount in TNF- α and secretion of IL-6. The mechanism of anti-inflammatory motion of the examined extracts was once primarily based on the inhibition of signaling pathways of NF- κ B and AP-1

Scientific Name	Common Name	Specific Constituent	Type of Constituent
<i>Agaricus blazei</i>	Agaricus	B-D-glucan	Polysaccharide
<i>Ganoderma lucidum</i>	Reishi, lingzhi	Ganoderic acid Protein Danoderiol Protein Danderenic acid Protein Lucidenic acid Protein GLPS	Protein Protein Protein Protein Polysaccharide
<i>Cordyceps sinensis</i>	Cordyceps, caterpillar mushroom	Adenosine Cordycepin	Nucleotide Nucleotide
<i>Trametes versicolor</i> (formerly <i>Coriolus versicolor</i>)	Turkey Tail	PSP PSK	Polysaccharide peptide Polysaccharide peptide
<i>Grifolia frondosa</i>	Maitake	Grifolan D-fraction MD-fraction	Polysaccharide Polysaccharide

Abbreviations: GLPS = *Ganoderma lucidum* polysaccharide; PSP = polysaccharide peptide; PSK = polysaccharide K.

Table No.1 Scientific and Common Names of Mushrooms and Their Major Constituents [2]

EFFECTS OF MUSHROOM METABOLITES ON THE ADAPTIVE IMMUNE SYSTEM: -

T lymphocytes

T lymphocytes consist of T-helper (T_H) cells and cytotoxic T (T_C) cells. T_H cells interact with B cells and assist them to divide, differentiate, and make antibodies or engage with mononuclear phagocytes and assist them in damaging intracellular pathogens. T_H cells generate their outcomes by way of releasing soluble cytokines and/or via direct cell-cell interactions. The T_C cells spoil goal host cells that have been contaminated using pathogens. [8]

B cells

Three polysaccharides remoted from *G lucidum*, two heteroglycans (PL-1 and PL-4), and one glucan (PL-3) stronger the proliferation of T and B lymphocytes in vitro to various contents and PL-1 exhibited an immune-stimulating undertaking in mice. PGL, a complicated β -D-glucan, has a sturdy impact on suppressing antibody production[19] PGL, a complicated β -D-glucan, has a robust impact on suppressing the antibody manufacturing GLIS, a proteoglycan remoted from the fruiting physique of *G lucidum*, is a B-cell stimulating factor. This compound inspired B lymphocyte activation, proliferation, differentiation, and manufacturing of immunoglobulins. The activation of B cells via GLIS may additionally be related to the expression of PKC α and PKC γ in B cells. GLIS influenced the proliferation of mouse spleen lymphocytes, ensuing in a threefold to fourfold enlargement in the share of B cells. GLIS additionally activated mouse spleen lymphocytes, and most of the activated cells had been B cells

Mushrooms as an attainable supply of prebiotics:

Recent tendencies in prebiotics have heightened the want to search for any other manageable supply of prebiotics. Mushrooms appear to be an attainable candidate for prebiotics as it includes carbohydrates like chitin, hemicellulose, α -glucans, mannans, xylans, and Galatians (simplified findings on the composition of carbohydrate in mushrooms). Chitin e water-insoluble polysaccharides e accounting for up to 80e90% of dry depend in mushroom phone walls, with the N-containing chitin as one of the skeletal fungal polysaccharides that are accountable for the stress and structure of the wall. Chitin solely affords in some taxonomical teams of Zygo-, Asco-, Basidio- and Deuteromycetes and does no longer current in a different crew like Oomycetes Digestive enzymes secreted by way of the pancreas or brush border of vertebrates, and of mammals in particular, are unable to hydrolyze b-glycosidic bonds. This makes them resistant to acid hydrolysis in the belly and continues to be non-digestible by way of human digestive enzymes [9]

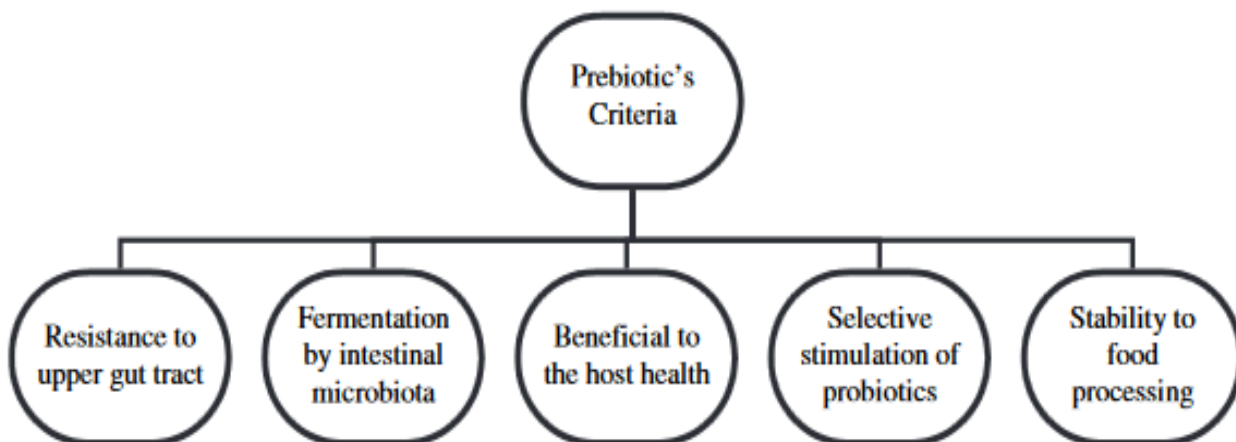


Figure 12. Criteria for classification of a meal's ingredient as prebiotic.

Edible Mushroom's Role in the Prevention of cardiovascular diseases:

In general, mushrooms are pretty excessive in protein, with a vital content material of critical amino acid, but low in fats. Furthermore, these fungi provide a massive quantity of carbohydrates and fiber and nutritionally significant content material of nutritional vitamins (B1, B2, B12, C a, and D) and mineral factors (Ca, K, Mg, Na, P, Cu, Fe, Mn and Se). The safe-to-eat mushrooms comprise an excessive moisture proportion (81.8–94.8%) whose variability in content material relies upon the mushroom specie and different parameters associated with the harvest, growth, culinary, and storage conditions.

Cardiovascular illnesses are among the most frequent motives of demise in the Western world and transition international locations the aetiological threat markers that have been proven to be especially modified by using the weight-reduction plan are associated with lipid and lipoprotein metabolism, hemostatic function, oxidative damage, homocysteine metabolism, and blood strain changes. LDL and HDL cholesterol, triacylglycerol, homocysteine, and blood stress are well-validated and commonly standard biomarkers, being the relaxation of them simply recommended.

However, presently solely LDL and blood strain are viewed as diet-related biomarkers. Traditionally, fit for human consumption mushrooms have been prescribed in Oriental medicinal drugs due to their hypocholesterolemic effects.

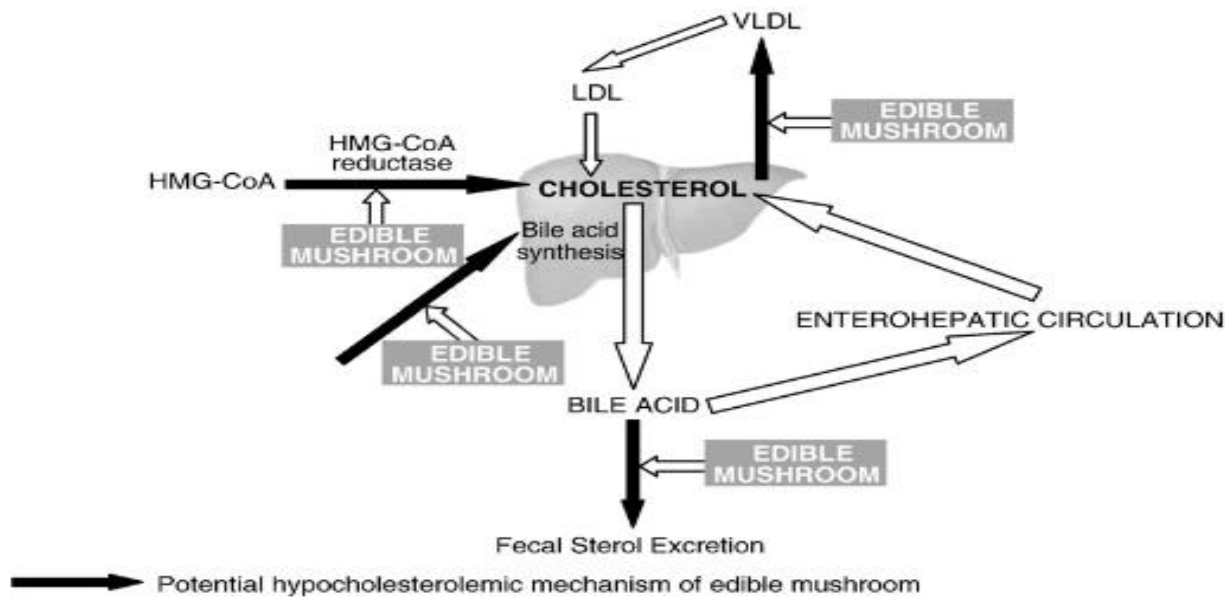


Figure 13. Effect of edible mushrooms on the cholesterol metabolism

Future Perspectives: -

This evaluation has verified the significance of mushrooms as manageable bio factories for the manufacturing of herbal anti-inflammatory metabolites of fantastically assorted chemical structures. The bioactivities of these compounds are exhibited via the down rules of special kinds of inflammatory mediators. In addition to the excessive possible software of anti-inflammatory metabolites from mushrooms in types of unpurified extract and greater pure compounds in clinical applications, they can additionally be used in cosmeceutical merchandise as protected and herbal energetic elements except for undesired facet effects. However, the future clinical utility of anti-inflammatory compounds remoted from mushrooms faces the 5 most important challenges. Firstly, most of the studied mushrooms are no longer cultivable in greenhouses, and for that reason, their availability is seasonal and rather affected with the aid of adjustments in the weather. Secondly, the contents of the bioactive components fluctuate broadly between samples, based on the series time and procedure, the season, and the environment. Thirdly, mushroom cultivation in greenhouses is an open machine and is no longer run by the cutting-edge Good Manufacturing Practice (cGMP) necessities for the manufacturing of bioactive medicinal compounds. Therefore, an extra lookup needs to be finished on the improvement of mushroom cultivation procedures in submerged cultures underneath entirely sterile stipulations to produce bioactive metabolites for pharmaceutical applications. Fourthly, in most of the research performed so far, the anti-inflammatory things to do with mushrooms have been proven the use of crude mushroom extracts or solvent extracts of exceptional metabolites in a combined form. It is necessary, therefore, to isolate and pick out the energetic metabolites for a higher grasp of the anti-inflammatory homes of every precise compound and the viable facet effects, if any. [3]

Conclusion:-

In conclusion, mushrooms contain bioactive compounds such as beta-glucans and triterpenoids that have been shown to modulate immune function. These compounds work by activating immune cells and regulating cytokine production, resulting in enhanced immune responses. Several types of mushrooms have been studied for their immunomodulatory properties, with promising results for their potential use in cancer treatment, infectious disease prevention, and autoimmune disorders. While more research is needed to fully understand the mechanisms of action of mushroom-based immunomodulators and their optimal use in clinical settings, the use of mushrooms as immune system modulators presents a promising avenue for the development of natural, safe, and effective therapies for various diseases.

Reference:-

1. Zhao, S., Gao, Q., Rong, C., Wang, S., Zhao, Z., Liu, Y. and Xu, J., 2020. Immunomodulatory effects of edible and medicinal mushrooms and their bioactive immunoregulatory products. *Journal of Fungi*, 6(4), p.269.
2. Guggenheim, A.G., Wright, K.M. and Zwickey, H.L., 2014. Immune modulation from five major mushrooms: application to integrative oncology. *Integrative Medicine: A Clinician's Journal*, 13(1), p.32.
3. Elsayed, E.A., El Enshasy, H., Wadaan, M.A. and Aziz, R., 2014. Mushrooms: a potential natural source of anti-inflammatory compounds for medical applications. *Mediators of inflammation*, 2014.
4. Friedman, M., 2016. Mushroom polysaccharides: chemistry and antiobesity, antidiabetes, anticancer, and antibiotic properties in cells, rodents, and humans. *Foods*, 5(4), p.80.
5. Jayachandran, M., Xiao, J. and Xu, B., 2017. A critical review on health-promoting benefits of edible mushrooms through gut microbiota. *International journal of molecular sciences*, 18(9), p.1934.
6. Gründemann, C., Garcia-Käufer, M., Sauer, B., Scheer, R., Merdivan, S., Bettin, P., Huber, R. and Lindequist, U., 2015. Comparative chemical and biological investigations of β -glucan-containing products from shiitake mushrooms. *Journal of functional foods*, 18, pp.692-702.
7. Carsten Gründemann , Jakob K. Reinhardt , Ulrike Lindequist , *European Medicinal Mushrooms: Do They Have Potential For Modern Medicine? - An update*, *Phytomedicine* (2019)
8. Lull, C., Wichers, H.J. and Savelkoul, H.F., 2005. Anti-inflammatory and immunomodulating properties of fungal metabolites. *Mediators of inflammation*, 2005(2), pp.63-80.
9. Aida, F.M.N.A., Shuhaimi, M., Yazid, M. and Maaruf, A.G., 2009. Mushroom as a potential source of prebiotics: a review. *Trends in Food Science & Technology*, 20(11-12), pp.567-575.
10. Muszyńska, B., Grzywacz-Kisielewska, A., Kata, K. and Gdula-Argasińska, J., 2018. Anti-inflammatory properties of edible mushrooms: A review. *Food Chemistry*, 243, pp.373-381.
11. Oliveira Lima, C.U.J., de Almeida Cordova, C.O., de Tolêdo Nóbrega, O., Funghetto, S.S. and de Oliveira Karnikowski, M.G., 2011. Does the *Agaricus blazei* Murill mushroom have properties that affect the immune system? An integrative review. *Journal of medicinal food*, 14(1-2), pp.2-8.
12. Chakraborty, I., Sen, I.K., Mondal, S., Rout, D., Bhanja, S.K., Maity, G.N. and Maity, P., 2019. Bioactive polysaccharides from natural sources: a review on the antitumor and immunomodulating activities. *Biocatalysis and Agricultural Biotechnology*, 22, p.101425.
13. Guillamón, E., García-Lafuente, A., Lozano, M., Rostagno, M.A., Villares, A. and Martínez, J.A., 2010. Edible mushrooms: role in the prevention of cardiovascular diseases. *Fitoterapia*, 81(7), pp.715-723.
14. Badalyan, S., 2012. Medicinal aspects of edible ectomycorrhizal mushrooms. *Edible ectomycorrhizal mushrooms: Current knowledge and prospects*, pp.317-334.
15. Mantovani, A., Allavena, P., Sica, A. and Balkwill, F., 2008. Cancer-related inflammation. *nature*, 454(7203), pp.436-444.

16. S. T. Chang and P. G. Miles, *Mushrooms: Cultivation, Nutritional Value, Medicinal Effect, and Environmental Impact*, CRC Press, Boca Raton, Fla, USA, 1st edition, 2004.
17. Chen, P., Yong, Y., Gu, Y., Wang, Z., Zhang, S. and Lu, L., 2015. Comparison of antioxidant and antiproliferation activities of polysaccharides from eight species of medicinal mushrooms. *International Journal of medicinal mushrooms*, 17(3).
18. Huan, G.; Cai, W.; Xu, B. Vitamin D2, ergosterol, and vitamin B2 content in commercially dried mushrooms marketed in China and increased vitamin D2 content following UV-C irradiation. *Int. J. Vitam. Nutr. Res.* 2016, 21, 1–10.
19. Bao XF, Wang XS, Dong Q, Fang JN, Li XY. Structural features of immunologically active polysaccharides from *Ganoderma lucidum*. *Phytochemistry*.2002; 59(2):175–181.
20. Cannon CP. *Clin Cornerstone* 2007;8:11–28.
21. Mensink RP, Aro A, Den Hond E, German JB, Griffin BA, Ten Meer HU, et al. *Eur J Nutr* 2003;42(Suppl 1) 1/6-1/27
22. J. Han, Y. Chen, L. Bao, et al., "Anti-inflammatory and cytotoxic cyathane diterpenoids from the medicinal fungus *Cyathus africanus*," *Fitoterapia*, vol. 84, no. 1, pp. 22–31, 2013.
23. Diniz, R.O., Garla, L.K., Schneedorf, J.M. and Carvalho, J.C.T., 2003. Study of anti-inflammatory activity of Tibetan mushroom, a symbiotic culture of bacteria and fungi encapsulated into a polysaccharide matrix.
24. Akihisa, T., Nakamura, Y., Tagata, M., Tokuda, H., Yasukawa, K., *Pharmacological research*, 47(1), pp.49-52. Uchiyama, E., Suzuki, T. and Kimura, Y., 2007. Anti-inflammatory and anti-tumor-promoting effects of triterpene acids and sterols from the fungus *Ganoderma lucidum*. *Chemistry & biodiversity*, 4(2), pp.224-231.
25. Gdula-Argasińska, J., Czepiel, J., Woźniakiewicz, A., Wojtoń, K., Grzywacz, A., Woźniakiewicz, M., Jurczyszyn, A., Perucki, W. and Librowski, T., 2015. n-3 Fatty acids as resolvents of inflammation in the A549 cells. *Pharmacological Reports*, 67(3), pp.610-615.