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ANTIOXIDANT PROPERTIES AND THEIR DIVERSITY IN MUSHROOM MYCOFLORA

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ABSTRACT:

Mushroom is the well-known and famous Fungal group which has different economic value. It may be edible or inedible, cultivable, or wild, and medicinal or poisonous type. Edible mushroom has specific dietary components which increase the viability of cells by inhibiting free radicles. The process of inhibiting free radicle known Antioxidant properties which is highly determined in mushroom species. The specific antioxidant component of mushroom is phenolic compounds and total antioxidant activity of mushroom reported by the total phenolic content.Which binds with the free radicles and minimize apoptosis, cell death and finally ageing of cells. Antioxidant also reported to as synthetic way but it may have side effects. In natural mean of antioxidant, mushroom is common and known to use with specific test, flavor and aroma. Mushroom may have a lifesaving property as antioxidant property which also increase the durability of life and lifespan of human. The present article exclusively deals with the mushroom species and their antioxidant properties and also their useful roles.

KEYWORDS: *Mushroom, antioxidant, antioxidant activities, antioxidant system, free radicles, reactive oxygen species.*

INTRODUCTION:

Mushroom are distributed world widely and consume as dietary component from ancient time (Singh and Singh, 2022). Mushroom has its own specific test, flavor and aroma with edibility properties (Keles et al., 2011).Mushroom may have edible, medicinal and poisonous type. In the chemical properties of mushroom has 90% water and 10% of their matters. Edible mushroom has attractive nutritional value which can be compared with milk, egg, meat etc. Chemically mushroom contains several types of vitamins and essential amino acids, other than proteins, fats, carotenoids, organic acids etc. Energetic value of mushroom defined between 250 to 350 cal/kg. (Sanchez, 2017).Mushroom is a rich source of phenolic compounds, carotenoids, tocopherol and ascorbic acid. Mushroom has unlimited biological active agents as a source of useful therapeutical and about 700 species of mushrooms reported to have pharmacological activities (Ajith and Janardhanan, 2007).It isaccumulating a variety of compounds including steroids, polyketides, terpenes and phenolic compounds as secondary metabolites. These compounds have antioxidant properties. Among all the antioxidant components, phenolic compounds have large array of biological actions which include free radical scavengingand inhibition of oxidation(Keles et al., 2011; Khatun et al., 2015).

Antioxidant System

It estimated that molecular oxygen evolved about 2.45 billion years ago and introduced as O_2in environment.These O_2systematically evolving from photosynthetic organisms and reactive oxygen species (ROS) in aerobic life on earth. ROS may have two types with different components including indigenous and exogenous(Kosanic et al., 2013; Kump, 2008) (Fig. 1).The O_2 molecules has two free or impaired electrons known free radicle which can damage the cells of all organisms. A free radicle is a chemical compound that contains one or more unpaired electrons in atomic or molecular orbitals (Alliwell, 1994). Free radical is specified as reactive molecules derived from molecular oxygen. In animals specified into human, energy production and immune function performed by the process of oxidation. In normal physiological condition of body, low level of ROS produced by oxidation which maintain normal cell function and antioxidant defense system. Whereas the ROS level exceeds (in high concentration) from normal function, it expresses harmful action by damaging nucleic acids, protein oxidation and peroxidation of lipid (Sanchez, 2017).

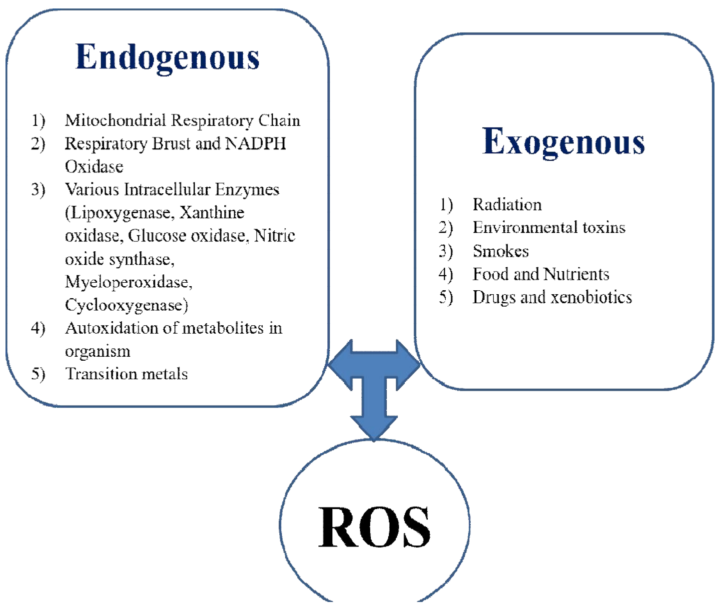

Fig. 1. Endogenous and Exogenous Factors Inducing ROS Generation.

The production of ROS can be reported by different external sources like tobacco, smoke, stress etc. or biproduct of electron transport of mitochondria or by oxidoreductase enzymes and metal catalyzed oxidation (Cederbaum et al., 2009).These reactive chemical compounds (free radicles) are components of cell especially cell wall or nucleic acid (DNA). They involve in important enzyme reaction and changing the chemical composition. By this action, the function of cell may lose or checked and results apoptosis or cellular senescence (Sanchez, 2017; Lakshmi et al., 2004; Cederbaum et al., 2009).So free radicles become a major agent of aging and degenerative diseases like immune system decline, cancer, liver disease, cardiac disease, diabetes, inflammation, kidney failure, stress etc. (Sanchez, 2017; Ma et al., 2018; Lakshmi et al., 2004; Alliwell, 1994)(Fig. 2).

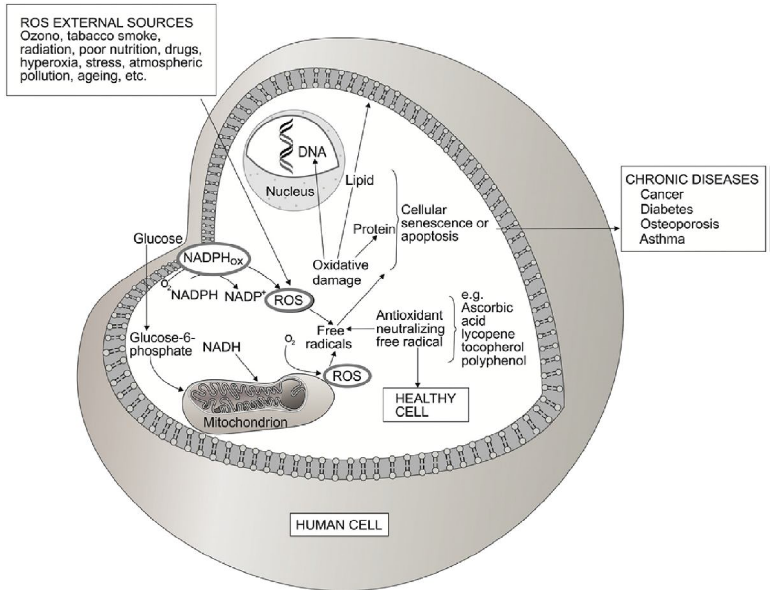

Fig. 2. Representation of human cell, which can be damaged by free radicals generated from internal and external sources. Neutralizing of free radicals by an antioxidant agent.

Neutralizing agents of free radicles are specified as antioxidant agent which play necessary role in cell protection against ROS or Oxidative reaction through the exchange of their own electrons with free radicles. Antioxidant chemical compounds (Vitamin-A/Carotenoids, Vitamin-E/Tocopherol, Vitamin-C/Ascorbic acid, Polyphenol, β-Glaucon, Glutathione etc.) provide most important intra-cellular defense against deleterious effects of ROS (Sanchez, 2017; Khatun et al., 2015).Antioxidant compounds may be two types- Endogenous and Exogenous (**Fig. 3)**. Endogenous antioxidant agents are Proteins and some low molecular weight compounds like Uric acid, Bilirubin, Ubiquinols, Vitamin-C, Glutathione, NADPH, NADH etc. Exogenous antioxidant components are Dietary antioxidant which gain from external nutritional sources (Sanchez, 2017).

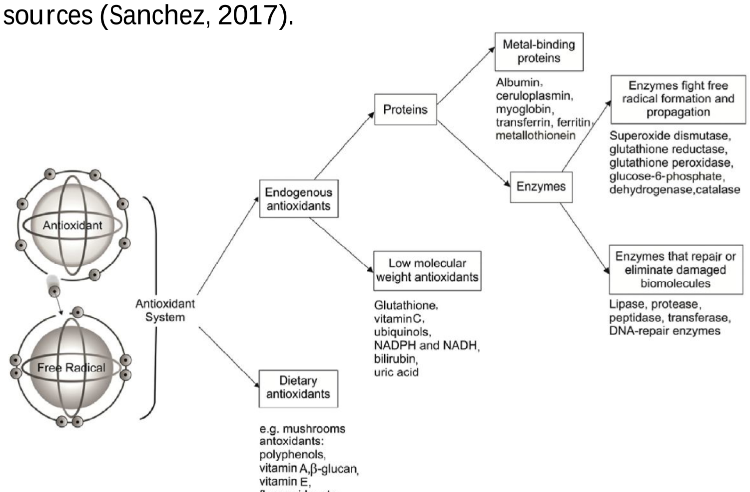

Fig. 3. Representation of antioxidant system.

During 1950s, “Free Radical Theory of Ageing” published by Harman and express the endogenous free oxygen radicals evolved to cause damages of cells. Free radical or reactive species such as ROS (Reactive Oxygen Species), RNS (Reactive Nitrogen Species), RCS (Reactive Carbon Species), RSS

(Reactive Sulfur Species) are influence the cell homeostasis and ageing. In all reactive species, ROS represent the most important and dominating category of living system and more than 90% production reported in eukaryotic cell by mitochondrial ETS (Electron Transport System) (Kozarski et al., 2015).

In mushrooms (Edible & Non edible) species, several bioactive molecules are reported that shows high health promoting properties with different bioactivities like antiviral, antibacterial, antifungal, anticancerous, antiallergic, anti-inflammatory,immunostimulatory, cholesterol lowering, immunosuppressive and especially antioxidant. Antioxidant activities can also say life-saving performance of bioactive molecules. The capacity of antioxidant of mushroom is determined by mainly the amount of phenolic compounds in their extracts (Kosanic et al., 2013; Feleke and Doshi, 2017).In mushroom, main chemical is phenolic compounds like phenolic acid, tannin, lignin, stilbenes, flavonoids, hydroxybenzoic acid, hydroxycinnamic acid and polyphenols which perform a significant antioxidant activity in biological systems by inhibiting free radicles.Number of phenolic compounds in mushroom extracted as 1-6mg phenolics from 1g dried mushroom (Ma et al., 2018).Different type of methods evolved to measure the antioxidant efficiency. The working mechanism of these methods based on antioxidant defense system such as inhibition of free radicals which are able to induce cellular damages (Lakshmi et al., 2004).Two type of antioxidant availability have been seen i.e., synthetic antioxidant and natural antioxidant. Several natural antioxidants have been demonstrated by researchers from different natural products such as cereals, pulses, vegetables, fruits, leaves, roots, and Mushrooms. Natural antioxidant may consume by dietary and medicinal means (Lakshmi et al., 2004).Both type of antioxidant such as natural and synthetic are effective to reducing oxidative damage in human body by ROS. However, some synthetic antioxidants are suspective to have toxic and carcinogenic effects like BHA (Butylated hydroxy anisole), BHT (Butylated hydroxy toluene), TBHQ (Tetra butylhydroquinone)EQ (Ethoxyquin) and PG (Propyl gallate). Therefore,the desired antioxidant is reported to natural antioxidant which has a natural origin. The development and utilization of natural antioxidant are more effective (Kosanic et al., 2012; Kozarski et al., 2015).

Table 1. List of some mushroom species which has antioxidant activities.

S.N.	Mushroom Species	Edibility	References
1	*Agaricus bisporus*	Edible	Ramkumar et al., 2010;Ma et al., 2018; He et al., 2012; Taofiq et al., 2016
2	*Agaricus compestris*	Edible	Akata et al., 2019
3.	*Agrocybeaegrita*	Edible	Mujic et al., 2010
4.	*Agrocybecylindracea*	Edible	Murcia et al., 2002
5.	*Aleurodiscusvitellinus*	Edible	Toledo et al., 2016
6.	*Amanita crocea*	Edible	Alkan et al., 2020
7.	*Amanita porphyria*	Inedible	Reis et al., 2011
8.	*Amanita rubescens*	Edible	Kosanic et al., 2013
9.	*Angelini sps*	Edible	Alkan et al., 2020
10.	*Auricularia auricula*	Edible	He et al., 2012;Hussein et al., 2015;Boonsong et al., 2016;Obodai et al., 2014
11.	*Boletus aestivalis*	Edible	Kosanic et al., 2012
12.	*Boletus edulis*	Edible	Ma et al., 2018; Kosanic et al., 2012;Vamanu and Nita, 2013
13.	*Calocybegambosa*	Edible	Ma et al., 2018; Vishwakarma et al., 2016
14.	*Calocybe indica*	Edible	Ramkumar et al., 2010; Ma et al., 2018; Vishwakarma et al., 2016
15.	*Cantharellus cibarius*	Edible	Kosanic et al., 2013; Ma et al., 2018; Ramesh and Pattar, 2010; Kosanic et al., 2013
16.	*Cantharellus cinerius*	Edible	Kumari et al., 2011
17.	*Cantharellus friessi*	Edible	Kumari et al., 2011

18.	*Cantharellus lutescens*	Edible	Murcia et al., 2002
19.	*Cantharellus subcibarius*	Edible	Kumari et al., 2011
20.	*Clavaria vermicularis*	Edible	Ramesh and Pattar, 2010
21.	*Collybiafusipes*	Inedible	Reis et al., 2011
22.	*Coprinus comatus*	Edible	Akata et al., 2019
23.	*Cortinariusmagellanicus*	Edible	Toledo et al., 2016
24.	*Craterelluscornucopioides*	Edible	Ma et al., 2018
25.	*Cyclocybecylindracea*	Edible	Alkan et al., 2020
26.	*Cyttariahariotii*	Edible	Toledo et al., 2016
27.	*Fistulinaantarcatica*	Edible	Toledo et al., 2016
28.	*Fistulinaendoxantha*	Inedible	Toledo et al., 2016
29.	*Flammulinavelutipes*	Edible	He et al., 2012
30.	*Fomitopsispinicola*	Inedible	Reis et al., 2011
31.	*Ganoderma lucidum*	Edible	Lakshmi et al., 2004; 55
32.	*Grifolafrondosa*	Edible	Yeh et al., 2011
33.	*Grifolagargal*	Edible	Toledo et al., 2016
34.	*Hebelomasinapizans*	Inedible	Reis et al., 2011
35.	*Hemileccinumdipilatum*	Edible	Alkan et al., 2020
36.	*Hericiumerinaceum*	Edible	Mujic et al., 2010
37.	*Hybsizusulmarius*	Edible	Ramkumar et al., 2010
38.	*Hydnum repandum*	Edible	Murcia et al., 2002
39.	*Hydropusdusenii*	Inedible	Toledo et al., 2016
40.	*Hygrocybeacuteconica*	Inedible	Alkan et al., 2020
41.	*Hygrophorusmarzuolus*	Edible	Ma et al., 2018
42.	*Infundibulicybegeotropa*	Edible	Sevindik et al., 2020
43.	*Inocybe splendens*	Inedible	Reis et al., 2011
44.	*Lactariusdeliciosus*	Edible	Ma et al., 2018; Alkan et al., 2020
45.	*Lactarius hepaticus*	Inedible	Reis et al., 2011
46.	*Lactariuspiperatus*	Inedible	Kosanic et al., 2013
47.	*Leccinumcarpini*	Edible	Kosanic et al., 2012
48.	*Lentinus edodes*	Edible	Boonsong et al., 2016; He et al., 2012
49.	*Lentinus sajor caju*	Edible	Hussein et al., 2015
50.	*Lentinus squarrosulus*	Edible	Hussein et al., 2015;Obodai et al., 2014
51.	*Lentinus tigrinus*	Inedible	Reis et al., 2011
52.	*Lepista edodes*	Edible	Murcia et al., 2002
53.	*Lepista nuda*	Edible	Murcia et al., 2002; Toledo et al., 2016
54.	*Letinula edodes*	Edible	Ma et al., 2018; Taofiq et al., 2016; Mujic et al., 2010
55.	*Leucoagaricusleucothites*	Edible	Akata et al., 2019
56.	*Leucopaxillus giganteus*	Edible	Feleke and Doshi, 2017
57.	*Lycoperdonperlatum*	Edible	Ramesh and Pattar, 2010
58.	*Lycoperdonutriforme*	Edible	Akata et al., 2019
59.	*Macrolepiota mastoides*	Edible	Akata et al., 2019
60.	*Macrolepiota procera*	Edible	Hussein et al., 2015; Akata et al., 2019; Vishwakarma et al., 2016
61.	*Marasmiusoreades*	Edible	Ramesh and Pattar, 2010
62.	*Neoboletuserythropus*	Edible	Alkan et al., 2020
63.	*Panaeolusantillarium*	Inedible	Dulay et al., 2015
64.	*Panus conchatus*	Inedible	Hussein et al., 2015
65.	*Phellinus rimosus*	Inedible	Ajith and Janardhanan, 2007

66.	*Piptoporusbetulinis*	Inedible	Reis et al., 2011
67.	*Pleurotus citrinopileatus*	Edible	Khatun et al., 2015
68.	*Pleurotus djamor*	Edible	Ramkumar et al., 2010; Arbayah and Umi Kalsom, 2013
69.	*Pleurotus eryngii*	Edible	Gasecka et al., 2016; Yildirim et al., 2012
70.	*Pleurotus euos*	Edible	Ramkumar et al., 2010; Boonsong et al., 2016
71.	*Pleurotus florida*	Edible	Ramkumar et al., 2010; Lakshmi et al., 2004;Khatun et al., 2015;Ajith and Janardhanan, 2007
72.	*Pleurotus ostreatus*	Medicinal	Taofiq et al., 2016; Obodai et al., 2014; Arbayah and Umi Kalsom, 2013; Ma et al., 2018;Chirinang and Intarapichet, 2009; Gasecka et al., 2016;Iwalokun et al., 2007
73.	*Pleurotus platypus*	Edible	Ramkumar et al., 2010
74.	*Pleurotus pulmonarius*	Edible	Arbayah and Umi Kalsom, 2013; Khatun et al., 2015; Ajith and Janardhanan, 2007; Nguyen et al, 2016;Ramesh and Pattar, 2010
75.	*Pleurotus rimosus*	Inedible	Lakshmi et al., 2004
76.	*Pleurotus sajor caju*	Edible	Boonsong et al., 2016; Ramkumar et al., 2010; Obodai et al., 2014; Lakshmi et al., 2004; Chirinang and Intarapichet, 2009
77.	*Pleurotus tuber regium*	Edible	Obodai et al., 2014
78.	*Pluteus murinus*	Inedible	Reis et al., 2011
79.	*Polyporusdermoporus*	Inedible	Dore et al., 2014
80.	*Polyporustenuiculus*	Inedible	Hussein et al., 2015
81.	*Ramariaformosa*	Edible	Ramesh and Pattar, 2010
82.	*Ramariapatagonica*	Inedible	Toledo et al., 2016
83.	*Ramaria stricta*	Edible	Krupodorova and Sevindik, 2020
84.	*Ramariasubalpina*	Edible	Acharya et al., 2017
85.	*Russulaaurea*	Edible	Alkan et al., 2020
86.	*Russulacyanoxantha*	Edible	Kosanic et al., 2013
87.	*Russuladelica*	Edible	Turkoglu et al., 2017
88.	*Russulaemetica*	Inedible	Reis et al., 2011
89.	*Russulasanguinea*	Edible	Alkan et al., 2020
90.	*Schizophyllum commune*	Edible	Arbayah and Umi Kalsom, 2013
91.	*Suilusgranulatus*	Edible	Mushtaq et al., 2020
92.	*Termitomycesaurantiacus*	Edible	Tibuhwa, 2012
93.	*Termitomycesclypeatus*	Edible	Tibuhwa, 2012
94.	*Termitomycesletestui*	Edible	Tibuhwa, 2012
95.	*Termitomycesmicrocarpus*	Edible	Tibuhwa, 2012
96.	*Termitomyces robustus*	Edible	Obodai et al., 2014
97.	*Termitomyces striatus*	Edible	Tibuhwa, 2012
98.	*Termitomycestitanicus*	Edible	Tibuhwa, 2012
99.	*Tuber aestivum*	Edible	Vishwakarma et al., 2016
100.	*Volvariellavolvacea*	Edible	Ramkumar et al., 2010; Boonsong et al., 2016

CONCLUSION

Antioxidant is the chief and satisfactory component which increase the life of cell and delay the ageing process. Mushroom is the rich natural resource to fulfil the dietary balance of antioxidant. Plant are also rich in antioxidant properties bur mushroom is better, easily available, suitable test with edibility, and economical in subject to human welfare. Phenolic compound is the chief antioxidant factor of mushroom.In subject to knowledge of antioxidant properties of mushroom, much more research is required.

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