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Review Article

Mushrooms from Kinds of Aspects: Spawn, Growing, Nutrients and Biocompounds

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- Health

Abstract

Mushrooms have superior nutritive value and medicinal importance. They are cultivated from spawn in the compost that changes in mixtures of substances. Spawn productions requires in a clean room conditions by using single cell culture and then go on the inoculation to grains and followed packaging in the plants. Cultivation of mushrooms developed by using sorts of Plant and organic materials such as sawdust, wheat straw and gypsum horse manure or chicken manure etc. The compost preparations investigated for using kinds of waste for and evaluated for recycling in the mushroom productions. On the other hand, Mushroom can serve good nutrients such as protein contents, B complex vitamins and nutritive minerals. Mushrooms have been evaluated for their medicinal compounds for chronic diseases, improving health benefits preventing the most common threatened public health diseases. In the review from the spawn introduction, cultivations to nutritive value and medicinal importance of mushrooms were informed by illustrating diagrams and pictures supported by literature data.

ABBREVIATIONS

FS: Federal Standard; ISO: International Standard Organization; ACH: Air-change per hour; FAOSTAT**:** Food and Agriculture Organization; HEPA**:** High-Efficiency Particulate Air; RH: Relative Humidity; ACR: Air-Change Rate; USDA: U.S. Department of Agriculture; GABA: γ -aminobutyric Acid; TCM: Traditional Chinese Medicine; DM: Diabetes Mellitus; WBWDI: World Bank Development Indicators

INTRODUCTION

Mushrooms were old and important topics in food, health, agriculture in the World. They are fungi, we will mention about edible mushroom those are useful items an along the history. Mushrooms have been begun to consume since men discovered them. Mushrooms always have big interest for scientific researches and papers. The main cultivated mushroom species worldwide are *Agaricus bisporus*, *Pleurotus sp* and *Lentinula edodes*, [1] and Turkey has same trends too [2]. Some exotic and medicinal mushroom species: *Agrobye aegrita, Gonederma lucidum, Grifola frondosa, Hericum erinasceus, Pleurotus citrino-pileatus, P. djamor* [3].

It was reported that production of mushrooms in 2005 was (in metric tons) 1,411 in China, 382 in USA, 245 in Netherlands, 139 in France, 138 in Spain, 135 in Poland, 88 in Italy, 80 in Canada, 77 in Ireland, and 74 in the UK. [4]; FAOSTAT 2005; USDA 2005; WBWDI 2007 [5-7].

Mushrooms spawns were produced by using single culture techniques, which are the different samples from usual plant seeds. Production of mushroom spawn is very sensitive and difficult because of clean and hygiene requirements for spawn productions plants.

Growing of mushrooms in the compost or other media and their growing conditions are studied and applied in various techniques.

These preservation techniques of mushrooms are preferred for long shelf life and for the economic aspects. Mushrooms are consumed both fresh and also processed which possess some food treatments like blanching, drying, sterilization, freezing, pickling, modified atmosphere packaging etc, [8,9].

Mushrooms contain essential elements such as nutritive minerals, protein amino acids, vitamins. Mushrooms are medicinal substances or bioactive compounds [10,11]. Mushroom processes are canned, frozen pickled drying, powder, even cosmetics. In the world, mushrooms are nutritive foods and contain functional compounds, such as phenolic bioactive compounds.

MUSHROOM SPAWN AND MUSHROOM CULTIVATION

Mushroom spawn

Mushroom spawn should be obtained in the clean room

conditions such as productions. Spawn production is a single cell culture manufacturing. In the review, spawn productions were explained by pictures from the sources. (Figure 1-5). Clean room provides without creating any contamination. Clean room requires laminar flowing bench and HEPA filters; there are clean room construction designs such as ISO 14644-1 Clean room Standards, Turnkey Clean rooms, and Modular Clean rooms. Class 100, class 1000, class 10k, and class 100k clean rooms. ISO5, ISO6, ISO7 and ISO8 clean room. Hard wall and soft wall Floors, walls, doors, windows, ceilings, structural, temperature and RH control. LEED Clean rooms Soft wall Clean rooms. Medical Device Clean rooms, USP 797 Clean room Compliance, Federal Standard 209E informed by the new ISO 14644-1 international standards. They are still valid applications for clean room constructing. To FS209E are still used; the comparison chart [12], http://www.americancleanrooms.com/ clean room-classifications.

A critical factor in clean room design is controlling air-change per hour (ACH), also known as the air-change rate, or ACR. There is other clean room standards, the U.S. General Service Administration's standards (known as FS209E that FS209E contains six classes, there are some of differences between the ISO clean rooms such as The "cleanest" clean room in FS209E is referred to as Class 1; the "dirtiest" clean room is a class 100,000. https://www.terrauniversal.com/cleanrooms/iso-classification-cleanroom-standards.php [13].

The spawn productions had basic disciplines and studies such as clean room applications, and single cell productions. Spawn production is base of mushroom biology and cultivation [14].

The mushroom spawn production was illustrated as basic and simple pictures as below.

In the figures were given kinds of versions and introductions of spawn and cultivations of mushrooms in different appearances (Figure 1-5).

Mushroom cultivation

An example and common compost type was determined e.g. Mixture of 75% cottonseed hulls, 24% wheat straw and 1% ground limestone. Then it is pasteurized with aerated steam at 65 C for 1 hr by passing the air-steam mixture and filtered air (HEPA filter; 99.9% efficiency) is passed through the substrate for cooling (approximately 1.5 hr.) [18].

The known mushroom growing process was written by the sources [19]. There are main works first one is composting, is made by mixing and wetting the ingredients, gypsum and N source e.g. horse manure, chicken manure, thus fermentation begins after finishing fermentation, Pasteurization applied for killing the organisms which contaminate the compost and second one is composting, spawning, casing, pinning, and cropping.

Mushroom culture comprises kinds of fermentation process for compost and also following several different treatments such as, inoculation, incubation, and production conditions changed according to manufactured species. Mushrooms can degrade several lignocelluloses materials. Cultivation of mushrooms requires some of factors as follows: Key factors to induce fruiting bodies are: changing temperature, high humidity, deficiency of a nutrient, CO_2 concentration in the air, light physical shock. Grain

Figure 1 A simple Mushroom spawn production in pilot scale, http://www.alohaecowas.com/clean-room.html [15], P6.

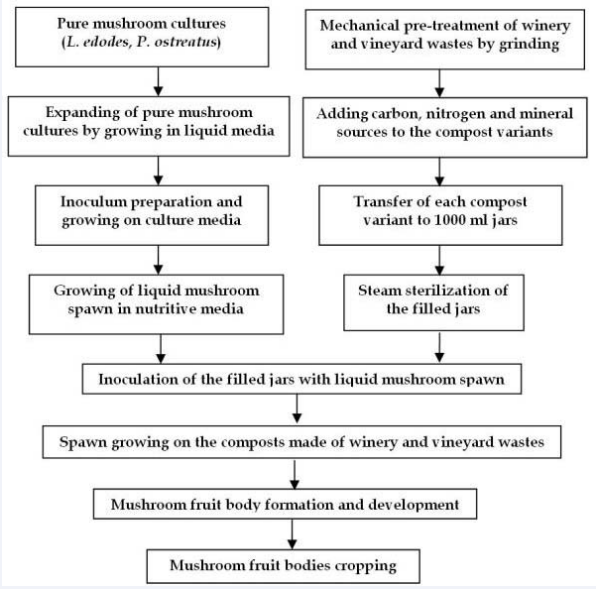

Figure 2 The mushroom growing in winery and vineyard waste http://www.intechopen.com/books/advances-in-applied-biotechnology/biotechnology-of-agricultural-wastes-recycling-through-controlled-cultivation-of-mushrooms [16], P7..

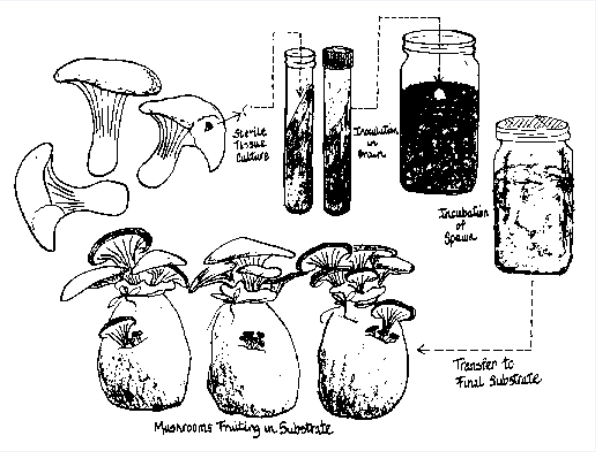

Figure 3 The on ether mushroom growing picture from spawn till fruit forming (Drawings by T. Beauséjour) http://www.mykoweb.com/articles/cultivation.html [17], P8.

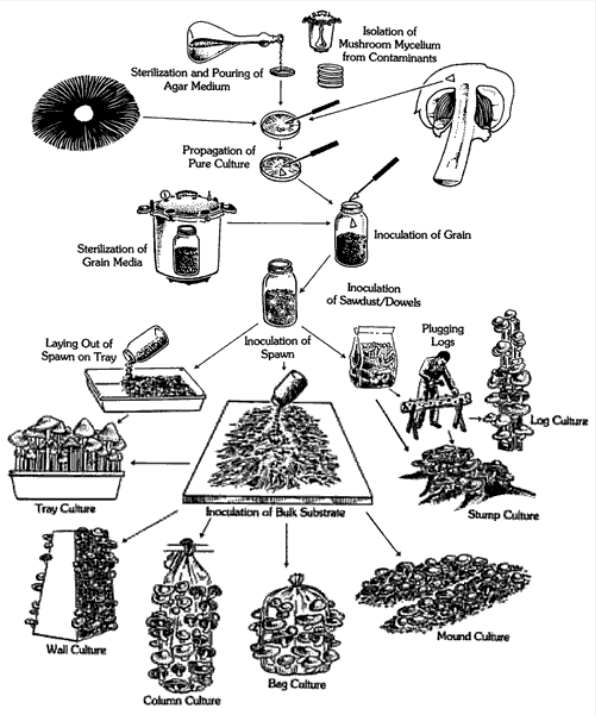

Figure 4 In kinds of culture medium mushroom cultivations https://community.akerkits.com/t/aker-mycelium-cultivation/306 [25], P9.

such as wheat, rye, barley used as substrate because of cost and large surface of them also for their low cost.

Affected factors of mushroom cultivation are temperature, humidity and ventilation. These factors were established for *P. ostreatus* [20]. The appropriate temperature ranges were for spore germination, Mycelia and fruit body (24-28)°C, (20-25)°C, and (10-8)°C respectively those re varied among the different strains. Humidity is also another factor for growing mushroom. Air humidity should be between the 65 and 70 % in range. Fruiting period needs, the suitable air relative humidity can be as high as 85-90%. Ventilation *P. ostreatus* is an aerobic fungus. Its fruit bodies have to get sufficient air.

On the other hand, mushroom growing industry can serve as environment protection media since sorts of wastes can used for compost preparing. Mushroom cultivation can provide sustainable farming with advantages. It uses agricultural waste products e.g. A high production per surface area can be obtained and after picking, the spent substrate is still a good soil condition [21].

The assays of kind usages of compost preparing enhancing yield and evolutions and protecting environment is very common and trendy works worldwide [22-24].

BIOCHEMISTRY OF MUSHROOMS

Nutrients of Mushrooms

Mushroom dietary has both useful and curing effects for human. The edible wild and cultivated mushroom species have very good health effects even can be used in alternative medicine

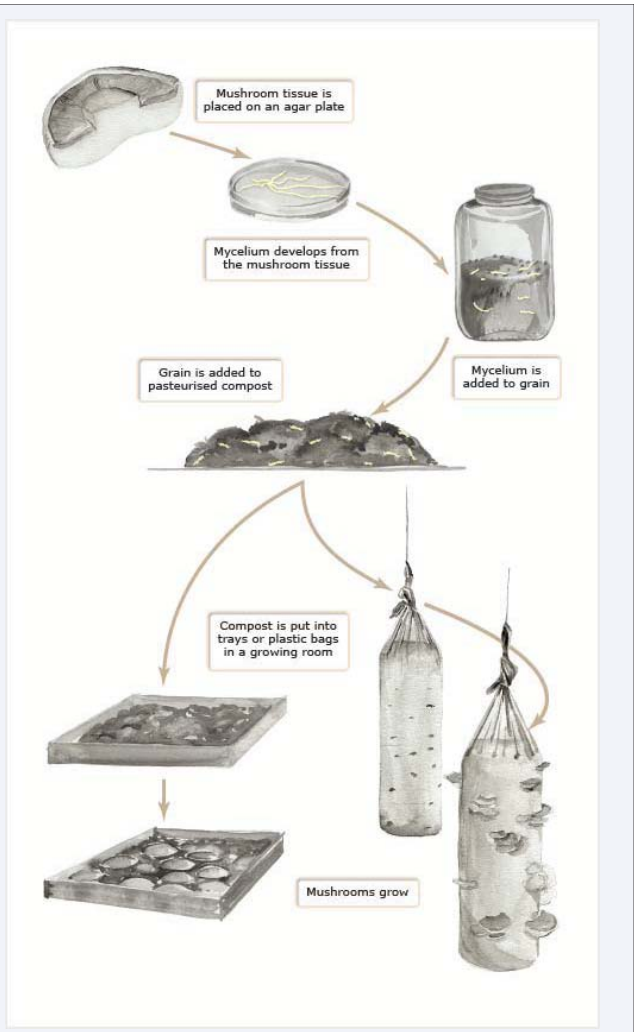

Figure 5 Mushroom growing in tray or plastic bag mediums, P10 http://www.teara.govt.nz/en/diagram/16818/stages-in-commercial-mushroom-production [26].

or probably exact medicine future for preventing effects. In the living conditions due to harmful life conditions such as stress, exhausting and fast life conditions, environment pollution, genetic factors etc can cause to chronic diseases, infections, heart and coroner system diseases, genetic disorders or more and more negative health effects.

Nutrition is one of factors that affecting health as positive or negative. In the literature there are lots of published articles about mushroom composition and medicinal compounds of mushroom species. When examined literature, mushroom species have rich biochemical composition such as high protein level, especially B complex vitamins and vitamin D, and nutritive minerals, good Na and K balance, and very important beta glucans, and other medicinal compounds; phenolic compounds, antioxidant compounds, or elements. Nutrition should be evaluated economic and social levels of countries.

Malnutrition and starvation is the big problem for several countries. On the other hand, chronic diseases are increasing day by day. There can be can met great human migrations, reaching 2.5 or million number persons who need to get well or balanced nutrition. Protein requirement is the indicator for well nutrition. Consuming of edible mushroom species should provide to maintain people both for economical and good health effects. Thus, there were researches about nutritive values of mushrooms. They contain in high ratio quantity and well quality because of amino acid composition and rich in essential and nutritive minerals and B group vitamins [27,28]. These include high protein content, all essential amino acids (thus able to act as a substitute for meat), a chitinous wall that acts as a source of dietary fiber, high vitamin content (B1 , B2 , B12, C, D, and E), micro- and macro elements, carbohydrates, low fat content, and virtually no cholesterol. 2, 4–6 [29]. Mean values of mushrooms were established were as follows (mg/100g); B1, B2, C, folic acid, panthotenic acid, niacin (pp); 0.077, 0.417, 5.06, 0.058, 2.07, 5.32 [30].

Minerals of *A. bisporus* were determined by Matilla et al. (2001) [11], As follows; Ca, K, Mg, P, Na, (g/kg); 0.019, 3.64, 0.10, 0.980, 0.032, Fe, Zn, (mg/kg); 3.7, 5.1 respectively, Çağlarirmak (2007) [10] reported mean protein values of *L. edodes, P. ostreatus* and *P. sajor-caju* were 2.61%, 1.76% and 0.92 % wb. Vitamin C contents of *P. ostreatus* and *P. sajor caju* were 3.38 and 16.01 (mg/100 g wet base). The edible mushroom species *A. bisporus* (white and brown) mushrooms researches about chemical compositions and volatiles flush terms and different harvests time were determined by Çağlarırmak 2008 [2,28], Obtained results indicated that mushrooms were rich in all of the investigated nutrient and superior flavor compounds for consumer acceptance. They have balanced and nutritive components for organism and they can recommended for whole life periods.

The species of following mushrooms; *Rinus comatus, C. militaris, Flammulina velutipes, Ganoderma lucidum, Grifola frondosa, Hericium erinaceus, Lentinus edodes, O. sinensis, Pleurotus ostreatus, Trametes versicolor, and Tremella fuciformis* have been recommended by the United Nations Food and Agriculture Organization as highly nutritious edible mushrooms and as sources of valuable medicinal compounds.

The research gives the results of a proximate analysis (moisture, ash, crude protein, fat, total carbohydrates, and total energy); a bioactive compounds analysis (γ-aminobutyric acid [GABA], ergothioneine, lovastatin, and cordycepin); fatty acid and amino acid analysis; and an analysis of macro and microelement content of fruit bodies and mycelia of 15 higher *Basidiomycetes* medicinal mushroom strains belonging to 12 species [29].

BIOCOMPOUNDS OF MUSHROOMS

Functional properties of mushrooms were investigated in large scale in the world and they are always interesting field for mushroom scientists. In this review, aim of the article can give a summary and some of introductions and reminding from base of mushroom like spawn to harvesting and mushroom biochemistry. Antioxidants and medicinal properties of mushrooms and some of growing conditions and its enzyme activity behaviors were studied and reported in the literatures, [31-34].

Another interesting mushrooms specie were indicated by (Holiday and Cleaver, 2004, Holiday and et al. (2004), Cleavar et al., patent, 2011) [35-37] in some of articles with coworkers. It has medicinal importance too. *Cordyceps sinensis* has been known and used for many centuries in Traditional Chinese Medicine (TCM). In nature, it is found only at high altitudes on the Himalayan Plateau, and is thus difficult to find and harvest. The range of therapeutic uses claimed for *Cordyceps* species is large indeed. In TCM, Cordyceps has been used to treat a wide. Mentioned its medicinal objectives were cleared that including respiration, pulmonary diseases, renal, liver, cardiovascular diseases, hypo sexuality, and hyperlipidemia [35-37].

Kalac (2012) [38], reviewed that mushrooms had D vitamin ergocalsiferol content that is rare found substances in the plants, and brought e new view of antioxidants and phenolic of mushroom species. In the article declared that there exists a consensus that phenolic, particularly phenolic acids are the main mushroom antioxidants. These are two major groups

Hydroxy derivatives of benzoic acid and *trans*-cinnamic acid within the former group,

p-hydroxybenzoic, protocatechuic, gallic, gentisic, vanillic and syringic acids have usually been detected in mushrooms, while *p*-coumaric, caffeic and ferulic acids represent the latter group.

P.ostreatus and *A. bisporus* were the richest in lovastatin [39]. Generally, tree oyster mushrooms were better in antioxidant activity, reducing and scavenging abilities and higher in the content of total phenols. They also reported that shiitake, winter and abalone mushrooms should have the antioxidant properties.

Çağlarırmakc, (2011) [40] reviewed Shiitake mushroom contains lentinan, β-glucan which stimulation of the immune system and can fight the against AIDS and exhibits antitumor activity. Mushrooms have anti carcinogenic effects such as they contain β-glucans, selenium, or ether medicinal compounds.

It was reported detailed functional properties and their biochemistry were explained in the literature. Kinds of 126 medicinal functions were known to be produced by medicinal mushrooms, including antitumor, anti–human immunodeficiency virus, immune modulation, antioxidant,

radical scavenging, cardiovascular, anti hypercholesterolemia, antiviral, antibacterial, antiphrastic, antifungal, detoxification, hepatoprotective, antidiabetic, and many other effects [41,42].

Mushrooms have been applied as medicinal samples or preventing, improving and curing some of chronic diseases such as cancers, cardiovascular diseases, diabetes mellitus (DM) They have bioactive, host defense compounds and antioxidant compounds [10,32,40].

One of the bioactive compounds that was investigated and explained the chemical name, was γ-aminobutyric acid (GABA), and ergothioneine constitute an important source of novel drugs. An important role for GABA in both central and peripheral nervous system control of blood pressure has been established by the scientists.

The other known compound was Lovastatin (mevinolin) is one of the best-known hypocholesterolemic pharmacological agents of natural origin. ergothioneine is only produced by fungi and some prokaryotes. 27,28 Ergothioneine can only be absorbed from the diet and cannot be biosynthesized in humans [39,41,42]. All of compouns were established for improving of human health by using advanced studies in related sciences. Identified substances are known as functional compounds of medicinal and edible mushrooms.

CONCLUSSION

The mushroom production including spawn and growing medium were different from usual plants and have different steps and properties. These properties were given by pictures with by supported literature sources and pictures. On the other hand mushrooms are nutritious samples balanced diet with protein, amino acid, minerals, vitamins and law calorie and also have very important bioactive compounds for health. The biochemistry of edible mushrooms was summarized by following literature.

REFERENCES

1. Rühl, Martin, Christoph Fischer, Ursula Kües. Ligninolytic enzyme activities alternate with mushroom production during industrial cultivation of Pleurotus ostreatus on wheat straw-based substrate. Curr Trends Biotechnol Pharm. 2008; 2: 478-492.
2. Çağlarırmak N. Physical properties, nutrients and estimated volatiles of *Agaricus bisporus* (white) at two harvest. Italian J Food Sci. 2011; 23: 423-431.
3. İlbay ME, Atmaca M. Kültürü yapılan bazı egzotik ve kültür mantarları. VII: Türkiye Yemeklik Mantar Kongresş, Eylül, Korkuteli Antalya. 2004; 22-24.
4. FAOSTAT United Nations. Food and Agriculture Organization. 2005.
5. USDA. Animal and Plant Health Inspection Service, Fresh Fruit and Vegetable Import Manual. 2005.
6. WBWDI World Bank, World Development Indicators (2007). Webb MD, Ewbank G, Perkings J, McCarthy AJ Metabolism. 2001.
7. Sánchez C. Cultivation of *Pleurotus ostreatus* and other edible mushrooms. Appl Microbiol Biotechnol. 2010; 85: 1321-1337.
8. Çağlarırmak N, Ötleş S, Ünal K. Determination of nutritives of canned mushrooms (*A. bisporus*) during storage period. Micologia Aplicada Int. 2001; 3: 97-101.
9. Çağlarırmak N. Chemical Composition and Nutrition Value of Dried Cultivated Culinary-Medicinal Mushrooms from Turkey. Int J Med Mushrooms. 2011; 13: 351-356.
10. Çağlarırmak N. The nutrients of exotic mushrooms (L. *edodes* and *Pleurotus* species) and estimated approach to the volatile compounds. Food Chem. 2007; 105: 1188-1194.
11. Mattila P, Kanko K, Earola M, Pihlava JM, Astola J, Vahterist L, et al. Contents of vitamins, Mineral elements, some phenolic compounds in cultivated mushrooms. J Agric Food Chem. 2001; 49: 2343-2348.
12. Cleanroom Classifications. American Cleanroom Systems.
13. FS209E and ISO Cleanroom Standards. Terra Universal.
14. Spawn Production. Barnard Health Care.
15. Economic potential: diversified agriculture mushroom crop. Diversified Agriculture Program Proposal. ECOWAS.
16. Petre M, Teodorescu A. Biotechnology of Agricultural Wastes Recycling Through Controlled Cultivation of Mushrooms. 2012.
17. Beauséjour TM. Getting Started with Mushroom Cultivation. MykoWeb. 1999.
18. Mushroom Spawn Lab. Penna State College of Agriculture Sciences.
19. Growing Mushrooms. Fresh Mushrooms.
20. Lin Z. Oyster mushroom cultivation. Part II. Oyster Mushrooms. Chapt 5. Substrate GRASS (JUNCAO). JUNCAO (菌草) - Jun(菌) means fungi and Cao(草) means grass in Chinese.
21. Oei P, Nieuwenhuijzen BV. Agrodok 40 Small-scale mushroom cultivation oyster, shiitake and wood ear mushrooms. 2005.
22. Yıldız, R Demir, Bazı Bitkisel Metaryallerin *Pleurotus ostreatus (*Jacq. ex.fr.) Kum.var.*salignus (*Pers.ex.Fr.) Konr.et Maubl.'unGelişmesi ve Ürün Verimi Üzerine Etkileri. Tübitak. 1998; 22: 67-73.
23. E Baysal, Çeşitli Lignoselüloz Esaslı Atıkların (*Pleurotus ostreatus*)'un Verim Özellikleri Üzerine Etkileri. PAU Mühendislik Bilimleri Dergisi. 2000; 271-275.
24. M.Akyüz, S.Kırbağ, Bazı Tarımsal ve Endüstriyel Atıkların *Pleurotus* spp.Üretiminde Kompost Olarak Değerlendirilmesi. Ekoloji. 2009; 27-31.
25. KER Website AKER + Mycelium Cultivation. AKER.
26. Stages in commercial mushroom production. Story: Mushrooms and other cultivated fungi Contents. The Encyclopedia of New Zealand.
27. Maggy Wassilieff. 'Mushrooms and other cultivated fungi - Specialty mushrooms'. Te Ara - the Encyclopedia of New Zealand. (accessed 28 February 2017).
28. Çağlarırmak N. Biochemical compositions of cultivated and edible wild mushrooms and their medical importance. VII. Edible mushroom Congress of Turkey, In conference procceding, Korkueli Antalya. 2004; 107-114.
29. Çağlarırmak N. Determination of Nutrients and volatile constituents of *Agaricus bisporus* (brown) at different stages. J Food Sci Agr. 2008; 89: 634-638.
30. Cohen N, Cohen J, Asatiani MD, Varshney VK, Yu HT, Yang YC, et al. Chemical Composition and Nutritional and Medicinal Value of Fruit Bodies and Submerged Cultured Mycelia of Culinary-Medicinal Higher Basidiomycetes Mushrooms. Int J Med Mushrooms. 2014; 16: 273-291.
31. Ünal MK, Ötleş S, Çağlarırmak N. Chemical Composition and Nutritive Value of Cultivated Mushroom (*Agaricus bisporus*) and Wild Mushrooms Grown in Turkey. Acta Alimentaria. 1996; 3: 257-265.

32. Wasser SP, Weis AL. Medicinal properties of substances occurring in higher Basidiomycetes mushrooms: current perspectives (review). Int J Med Mushr. 1999; 1: 47-50.

33. Wasser SP. Medicinal mushroom science: history, current status, future trends, and unsolved problems. Int J Med Mushrooms. 2010; 12: 1-16.

34. Buswell JA, Cai YJ, Chang ST, Peberdy JF, Fu SY, Yu HS. Lignocellyulolytic enzyme profiles of edible mushroom fungi. World J Microbiol Biotechnol. 1996; 12: 537-542.

35. Jeong S, Jeong Y, Yang B, Islam R, Koyyalamudi S, Panga G, et al. White button mushroom (Agaricus bisporus) lowers blood glucose and cholesterol levels in diabetic and hypercholesterolemic rats. Nutr Res. 2010; 30: 49-56.

36. Holliday J, Cleaver M. On the Trail of The Yak Ancient Cordyceps in the Modern World. 2004.

37. Cleaver PD, Loomis-Powers M, Patel D. Analysis of Quality and Techniques for Hybridization of Medicinal Fungus Cordyceps sinensis (Berk.) Sacc. (Ascomycetes). Int J Med Mushrooms. 2004; 6: 151-164.

38. Cleaver Phillip D, John C. Holliday, Megan Loomis Powers. Method for growing Cordyceps sinensis on a substrate. US Patent No. 8,008,060. 2011.

39. Kalac P. A review of chemical composition and nutritional value of wild-growing and cultivated mushrooms. J Sci Food Agric. 2013; 93: 209-218.

40. Çağlarırmak N. Edible mushroom: as alternative food ıtem, Proceedings of the 7th International Conference on Mushroom Biology and Mushroom Products (ICMBMP7). 2011; 4-7.

41. Chang ST, Wasser SP. The role of culinary-medicinal mushrooms on human welfare with pyramid model for human health. Int J Med Mushrooms. 2012; 14: 95-134.

42. Liu J, Jia L, Kan J, Jin C. *In vitro* and *In vivo* antioxidant activity of ethanolic extract of white button mushroom (*Agaricus bisporus*). Food Chem Toxicol. 2013; 51: 310-316.

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