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Health Benefits of Edible Mushrooms

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Abstract

Mushrooms are fruiting bodies of macroscopic filamentous saprophytic fungi. Mushrooms are providing valuable biological and economic impact to humankind. They are considered as valued culinary delicacies. Based on their applications, mushrooms can be divided into 3 major categories, they are edible mushrooms, medicinal mushrooms and wild mushrooms. About 12,000 species of mushroom are available around the world. From this approximately 2000 are fit to eat and have medicinal properties. Edible mushrooms have many human health benefits, they are reported with low fat, high protein, high dietary fibre and they are good source of minerals, vitamins and nutraceuticals. Cultivation of mushrooms is mainly done commercially on agricultural wates, thus converting the agricultural wastes into valued human food source and caused a decreased in the environmental pollution. Mushrooms are reported to have antifungal, antiparasitic, antiviral, antibacterial, antiproliferative, antiinflammatory, antioxidant, antitumor, anticoagulant, anti-obesity and antidiabetic properties, etc. Many more progress should be made for mushrooms in the field of food as well as in the areas of medicine and unemployment also.

Key words: Edible mushrooms, delicacy, health benefits, nutritional values, nutraceuticals, medicinal properties.

Introduction

The term, "Mushroom" is generally used for the macrofungi fruit bodies, Ascomycota and Basidiomycota (Das, 2010). They can be appeared either below or above the ground. About 12,000 species of mushroom are available around the world of which approximately 2000 are fit to eat and have applications in medicines and around 35 are commercially cultivated (Beulah et al., 2013). According to their applications, mushrooms can be categorised into 3 main groups, 54 % are edible mushrooms, 38 % are those which have medicinal properties and 8% are available in wild (Royse et al., 2017).

Mushrooms give valuable biological and economic impact to humankind. Since ages, collection and gathering of mushrooms is an additional income generator for the local people. Wild edible mushrooms are consumed by man for nutrition as well as some people used them for medicines also. Mushrooms are reported with great nutritional value, they are found to present with high protein, fiber, vitamins, minerals like selenium, calcium, magnesium, zinc, iron, and sodium, etc, and have very less or no calories and cholesterol (Agahar- Murugkar and Subbulakshmi, 2005; Manzi et al., 1999; Breene, 1990; Sharma and Gautam, 2017; Wani et al., 2010). Mushrooms have been reported to be utilized in traditional medicine. They have high nutritional value and their therapeutic potential are well-established and so they have medicinal utility (Vaz et al., 2011a; Vaz et al., 2011b). Some mushrooms are nutraceuticals while some other mushrooms can give potent nutraceuticals (Elmastas et al., 2007; Ribeiro et al., 2007). Some contain important bioactive compounds and reported to possess high antioxidant potential (Sharma and Gautam, 2017). Mushrooms are reported to be antifungal, antiparasitic, antiviral, antibacterial, antiproliferative, antiinflammatory, antioxidant, anticoagulant, cytotoxic, anticancer, antitumor, antidiabetic and contain compounds like hepatoprotective and hypocholesterolaemia (Wasser and Weis, 1999; Lindequist et al., 2005; Ajith and Janardhanan, 2007). Therefore, it is necessary to find out the nutritional constituents of mushrooms and to check the safety measures of mushrooms consumption by the public (Mattila et al., 2001). The level of mushrooms consumption is increasing because of the nutritional benefits and palatability. More progress can be made for mushrooms in the field of food as well as in the areas of medicine and unemployment also. The present review article mainly focused on nutritional values and medicinal importance of various mushrooms.

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Benefits of Edible Mushroom

Edible mushrooms are the most affordable sources of food, it contains essential amino acids and vitamins which are needed for good health. Production of edible mushroom delivers a promising economic grow up which can give employment to some and also reduce rural poverty. Mushroom can also act as a bio-degrader. It uses agricultural waste such as the material waste from factories, plantation and farm for their growth.

Mushroom as a Delicacy

Mushrooms are fruiting bodies of macroscopic filamentous saprophytic fungi and are known as "vegetable meat". They are considered as valued culinary delicacies. Edible mushrooms have many human health benefits, they are reported with low fat, higher protein and dietary fibre and they are good source of minerals, vitamins and nutraceuticals (Kumar, 2018; Papoutsis et al., 2020). Cultivation of mushrooms is mainly done commercially on agricultural wates, thus converting the agricultural wastes into valued human food source (Zhang & Fadel, 2002) and caused a decreased in the environmental pollution (Das et al., 2021). Some mushrooms are commercially cultivated namely *Lentinula edodes* known as shiitake, *Agaricus bisporus* known as agaric or button, *Pleurotus ostreatus* known as oyster mushroom, *Grifola frondosa* known as hen of the woods mushroom and maitake, *Flammulina velutipes* known as enoki or winter mushroom, *Agrocybe aegerita* known as pioppini, *Pleurotus eryngii* known as king trumpet mushroom, *Hericium erinaceus* known as lion's mane or pom pom mushroom, *Volvariella volvacea* known as paddy straw mushroom, *Boletus edulis* known as porcini, cèpe, or king bolete mushroom and *Calocybe indica* known as milky mushroom (Pandey et al., 2018; El Sohaimy, 2012). Some factors are important for increasing the edible mushroom production, the factors are fresh air, compact material, humidity and temperature.

Food industry is looking forward for the creation of new healthier and more sustainable food products by the reformulation of the already existed products (McClements et al., 2021; Das et al., 2021). The products of meat and fish may be replaced by healthier and more sustainable like mushroom (Das et al., 2021). Mushrooms which are edible are believed to be healthy because they are found to have quality protein, high dietary fibres, phenolic compounds, minerals, and vitamins (Bano et al., 1988; Hernández-Martínez & Navarro-Blasco, 2015; Kurt & Gençcelep, 2018; Lu et al., 2020). Some mushrooms were also being reported to have valuable compounds which have medicinal benefits (Chang, 2009). One of the main advantages of edible mushrooms is that they have umami flavour and fibrous meat like texture, making them good compatibility with meat products (Guinard et al., 2016; Summers et al., 2017; Kumar et al., 2017; He et al., 2020).

Mushroom as a Great Source of Nutrition

In earlier days, mushrooms were mainly consumed for their unique flavors and palatability.
However, now a day various research have been carried out reporting the bio-chemical constituents of mushrooms which help in treating diseases also. Some of the mushrooms which have earlier reported in India were *Hypoxylon vernicosum, Polyporus mylittae, Helvella crispa, A. campestris, Hydnum coralloides* and *M. esculenta* (Rolfe and Rolfe, 1925). Around 100 to 200 gram mushrooms (dry weight) is needed by man of 70 kg for maintaining an optimal balance of nutrition (Lintzel, 1941). The nutritional values have been studied for different mushrooms. Bano (1976) put forward that the food value of mushrooms was lying between vegetables and meat. Edible mushrooms were reported with higher nutrition and they were compared with milk food, egg and meat sources favourably (Gruen and Wong, 1982).

It is known that mushrooms contain good amount of protein content. The amount of protein content in mushrooms is dependent on the substratum composition, pileus size, time of harvesting and the type of mushroom species (Bano and Rajarathnam, 1982). The protein content of the 3 wild edible mushrooms from Manipur were investigated and the protein content of *Macrocybe gigantea*, *Lactifluus leptomerus* and *Ramaria thindii* were obtained to be 37.6, 20.8 and 16.4 %, respectively (Khumlianlal et al., 2022). In *Agaricus bisporus*, protein content was found to be 29.3 percent (Rai and Sohi, 1988). Crude protein in *C. indica, A. bisporus, Volvariella volvacea* and *L. subnudus* was reported to be 14 to 27 percent (Purkayastha and Chandra, 1985). The mycelium of *M. esculenta*, *A. campestris, M. deliciosa* and *A. arvensis* taken in dried forms were found to contain 34.7, 30.16, 29.16 and 28.16 % protein, respectively (Samajipati, 1978). The two edible wild mushrooms namely *Lentinula edodes* and *Schizophyllum commune* of Northeast India were studied and reported with 26 and 16 % protein content and 39% and 34% essential amino acids, respectively (Longvah and Deosthale, 1998). The protein content of seven wild edible mushrooms namely *Russula integra, Clavulina cinerea, Lactarius quieticolor*, *Calvatia gigantea, Ramaria brevispora, C. cibarius,* and *Gomphus floccosus* from the Khasi hills of Meghalaya were found to be ranged from 19.0 to 27.5 % and they were reported to

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contain in an average range between 16.3 (lysine) and 45.8% (methionine) (Agrahar-murugkar and Subbulakshmi, 2005). Crude protein content in the mycelia and the fruiting body of *V. bombycina* were 25.5 and 28.3% (Jagadeesh et al. 2010). Both wild and cultivated type of *Lentinus tuberregium* were taken to study nutrient composition and reported to contain 25% of protein in the cultivated variety and 18.07% in the wild type (Manjunathan and Kaviyarasan, 2011). The amount of crude protein of mushroom just ranks below the animal meat but rank above almost all food which even include milk (Chang, 1980). Generally, mushrooms have more protein than from most of the other vegetables (Bano and Rajarathnam, 1988). Mushrooms contain essential amino acids and therefore, they are good for the vegetarians (Verma et al. 1987). *P. pistillaris* was reported to contain 41.4 % of essential amino acids (Gupta and Sing, 1991). The digestibility of mushrooms is very good as for example *Pleurotus* mushrooms proteins digestibility is like plants (90%) and meat 99% (Bano and Rajarathnam, 1988).

The carbohydrate content of the edible mushrooms is being studied and reported. The energy value, ash, moisture and carbohydrates content of the 3 wild edible mushrooms from Manipur, *Macrocybe gigantea*, *Lactifluus leptomerus* and *Ramaria thindii* were determined and the highest energy value and carbohydrate content were observed in *Ramaria thindii* and moisture percentage of *Macrocybe gigantea*, *Lactifluus leptomerus* and *Ramaria thindii* were found to be 89.44±0.16, 84.79±0.22 and 83.84±0.26, respectively (Khumlianlal et al., 2022). The maximum energy was observed in *Ramaria thindii*, followed by *Lactifluus leptomerus* and *Macrocybe gigantea*. The carbohydrate content on a dry weight basis of *Macrocybe gigantea*, *Lactifluus leptomerus* and *Ramaria thindii* were obtained to be 32 percent, 43 percent and 57.2 percent, respectively (Khumlianlal et al., 2022). *Macrocybe gigantea* obtained the highest ash percent and moisture content. The mycelia and fruit body of *V. bombycine* were reported to contain 34.75 and 38.9% of carbohydrate, respectively (Jagadeesh et al. 2010). The carbohydrate content in *L. decastes, A. bisporus, C. indica, P. florida* and *R. delica were* obtained to be 34.36, 28.38, 49.20, 32.08, 34.88, %, respectively (Pushpa and Purushothama, 2010). Cultivated variety of *L. tuberregium* was found to have 58.05 % carbohydrate and wild variety of *L. tuberregium* have 55.8% (Manjunathan and Kaviyarasan, 2011). The total carbohydrate content in different mushrooms vary from 26 to 82% (Manikandan 2011). *A. auricula* and *L. tuber-regium* reported with the carbohydrates content of 33.23% and 50.2%, respectively (Johnsy et al. 2011). The proximate composition of 4 wild mushrooms were studied and *M. rhodocus* obtained the highest carbohydrate with 48% when compared to the other mushrooms which were undertaken for study (Manjunathan et al. 2011). Total carbohydrate content in the two wild mushrooms was studied and observed that *L. sajor-caju* with 68.24% and 64.95% in *L. torulosus* (Singdevsachan et al. 2013).

The fat content in mushrooms is lesser while comparing with carbohydrates and proteins. The fats and fiber content of *Macrocybe gigantea*, *Lactifluus leptomerus* and *Ramaria thindii* were performed (Khumlianlal et al., 2022). *Lactifluus leptomerus* obtained the highest crude fat and fiber content. The fat content percentage were found to be 5.9%, 3.2% and 2.8% of *Lactifluus leptomerus*, *Macrocybe gigantea* and *Ramaria thindii*, respectively. And the fiber content percentage were observed to be 14.1%, 5.9 % and 6.4% for *Lactifluus leptomerus*, *Macrocybe gigantea* and *Ramaria thindii*, respectively. The fruiting body of the mushrooms contain majorly of unsaturated fatty acids (Thatoi and Singdevsachan, 2014). The fat contents of *A. campestris*, *Suillus granulatus*, and *Suillus luteus* were found to be 2.32%, 2.04% and 3.66% respectively (Singer, 1961). The crude fat contents in *Pleurotus* species were studied and reported to be ranging from 1.08 to 9.4% and with an average of 2.85% (Bano and Rajarathnam, 1982). The fat content of *Pleurotus* species on the fresh weight basis was found to be 0.10 to 0.19% (Rai et al. 1988). *A. bisporus* (Lange) Sing was observed to contain 0.3 g/100g of fat and fresh *P. ostreatus* (Jacq: Fr.) Kumm with 0.4 g/100g (Manzi et al., 2001). The crude fat contents were found to be similar with 2 % in the two wild edible mushrooms from North East India namely *S. commune* and *L. edodes* (Longvah and Deosthale, 1998). Naturally grown and collected mushroom fruiting bodies of 23 mushroom species gathered from different parts of India were taken and studied the total fat and fatty acid contents, the total fat contents were obtained to be 0.6-4.7% and the unsaturated fatty acids were 52-87% which were higher from the saturated fatty acids (Kavishree et al., 2008). The mycelia of *V. bombycina* was reported with 1.15 % of lipid content and fruiting body of *V. bombycina* with 2.72% of lipid content (Jagadeesh et al., 2010). The fat contents of *L. torulosus* and *L. sajor-caju* were studied and reported to be lesser i.e., 1.36 and 2.42 %, respectively (Singdevsachan et al., 2013).

The vitamin content of the 3 wild edible mushrooms from Manipur namely *Macrocybe gigantea*, *Lactifluus leptomerus* and *Ramaria thindii* were analysed and reported (Khumlianlal et al., 2022). They reported niacin, vitamin D, B1, B2, C and folic acid content in the 3 mushrooms and vitamin C was observed to be the most

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abundant which was by followed by niacin, vitamin D and vitamin B2, whereas folic acid and vitamin B1 were observed to be found below the detectable level (Khumlianlal et al., 2022). *Macrocybe gigantea* was found to contain higher niacin (51.5 mg/100 g) (Khumlianlal et al., 2022).

Mineral content has been reported in mushrooms. Wild edible mushrooms were obtained to report with good amount of mineral content than the cultivated ones (Mattilla et al., 2001). *M. esculenta* was reported to contain 0.57 milligram / gram of calcium, 3.31 milligram / gram of phosphorous, 1.21 milligram / gram of iron and 3.83 milligram / gram of potassium (Kaul, 1978). *L. edodes* and *S. commune* of northeast India were obtained to contain good amount of minerals (Longvah and Deosthale, 1998). The cultivated *L. tuberregium* was found to contain 90.8% potassium and for the wild 7.53% (Manjunathan and Kaviyarasan, 2011). *L. torulosus* showed higher iron content of 2.94 mg/kg, 0.85 mg/kg of potassium and 0.24 mg/kg of phosphorus contents while *L. sajor-caju* showed the higher manganese content of 0.12 mg/kg and nickel with 0.05 mg/kg (Singdevsachan et al., 2013). *Macrocybe gigantea* was found to possess the highest concentration of most of the essential minerals like calcium, cupper, potassium, magnesium, sodium, phosphorous and zinc (Khumlianlal et al., 2022). Iron was found to be present in an elevated concentration of 79.741 ppm in *Ramaria thindii*, as compared to *Lactifluus leptomerus* and *Macrocybe gigantea* (Khumlianlal et al., 2022). Their result showed that potassium was the most abundant minerals which were followed by iron, sodium, magnesium, zinc, calcium, cupper and manganese whereas phosphorous was found to be present in very low concentration in the 3 mushrooms (Khumlianlal et al., 2022).

Mushroom as Nutraceuticals

According to Food and Drug Administration, the natural ingredients or compounds which come from natural sources that effect many quality properties of food are generally considered as safe and have great interest because of the safety and healthy attributes (Kumar, 2018; Das et al., 2021). These substances are included in all the stages of downstream processing, during production, during packaging and storage of the food till it gets to the customers. The motive is modifying the taste and texture of the food by improving the nutritional values, safety, freshness, appearance of food products and overall acceptability of the products (Das et al., 2021). The nutraceuticals are being used regularly as dietary supplements, nutraceuticals may be either the whole food or a part of the food or single compound or food extract and they exert medicinal values or health benefits and take an important role in preventing and in treating of several diseases (Das et al., 2021, El Sohaimy, 2012; Reis, et al., 2017). A food item is called as “Functional” when the nutraceuticals are included in the food or food formulation for attaining specific function like the improvement of wellbeing and also the quality of human life, thus by decreasing the danger of disease beyond the food nutritional value (El Sohaimy 2012; Hasler, 2010). Edible mushrooms are known for good nutrition, palatability, less caloric value, great taste and have nutraceutical characters. Because of the unique nutritional and textural natures, mushrooms are being utilized as dietary supplement and regarded as the alternative source of fruits, vegetables, fish, meat, etc (Asgar et al., 2010).

The fortification of food products with good source of protein may be helpful in decreasing the occurrence of protein energy malnutrition (Oyetayo et al., 2007; Das et al., 2021). Mushrooms also contain several secondary metabolites which have medicinal properties and thus, can be utilized in therapeutic purposes (Prasad et al., 2015; Rathore et al., 2017). Mushrooms have umami taste which is a peculiarly pleasant savory taste. Mushrooms are being reported to possess different types of nutraceuticals. The mushrooms fruiting bodies and mushrooms extract contain phenolic acids which are mainly benzoic acid and cinnamic acid derivatives (Das et al., 2021). Many mushroom species are reported to have vanillic, syringic, gallic, p-hydroxybenzoic, caffeic, salicylic, ferulic, protocatechuic, veratric, p-coumaric, cinnamic, and gentisic acids (Nowacka-Jechalke et al., 2018). Different polysaccharides such as mannans, chitin, galactans, xylans and glucan from the mushrooms are being reported to possess potential health benefits (Rathore et al. 2017, Friedman et al., 2016, Ruthes et al., 2015). The nutraceuticals present in mushrooms showed several health benefits and biological activities. The biological activities are antitumor, anticarcinogenic, anti-hypercholesterolemic, anti-obesity, anti-inflammatory, antidiabetic, antiviral, antibacterial, and antimutagenic activities (Reis et al., 2007, Valverde et al., 2015; Borchers et al., 2008, Zhang et al., 2009).

Medicinal Properties of Mushrooms

Many mushrooms are being reported as medicinal mushrooms having anti-inflammatory, antimicrobial, and antioxidant activity, etc (Thatoi & Singdevsachan, 2014). Many researchers have reported that mushrooms have antioxidant activities. The medicinal potential of *Ganoderma lucidum* was reported and it has been reported to

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have high ABTS and DPPH scavenging property (Sheena et al. 2005). The total phenolic and flavanoid content and antioxidant property of 3 wild edible mushrooms from Manipur (*Macrocybe gigantea*, *Lactifluus leptomerus* and *Ramaria thindii*) were performed and the quantification of the organic acids were also performed (Khumlianlal et al., 2022). The total phenolic content of *Ramaria thindii*, *Macrocybe gigantea* and *Lactifluus leptomerus* were 30.99, 29.23 and 26.206 mg Galic acid equivalent per gram and the flavonoid content were 9.187, 6.854 and 6.646 mg quercetin per gram, respectively. The IC50 values of *Ramaria thindii*, *Macrocybe gigantea* and *Lactifluus leptomerus* were 242.0 gram/ milliliter, 550.4 gram/millilitre and 689.0 gram/ milliliter, respectively (Khumlianlal et al., 2022). Tartaric, oxalic, lactic and formic acids were found to be available in the 3 mushrooms and malic and malonic acid were found only in *Macrocybe gigantea* (Khumlianlal et al., 2022). *Termitomyces reticulatus* was also observed to show antioxidant and other phytochemical properties (Loganathan et al., 2010). Antioxidant activity and bioactive compounds like β-carotene, phenol, ascorbic acid and flavonoid of *Cantharellus friessi*, *P. florida*, *Cantharellus cinerius* and *Cantharellus subcibarius* were studied and reported that *C. friessi* was observed show higher phenol content with strong antioxidant activity (Kumari et al., 2011). *A. bisporus*, *Hypsizygus ulmarius* and *C. indica* are commercially grown and they showed antioxidant activity and reported that all three showed moderate to high antioxidant properties (Babu and Rao, 2011).

In vitro antimicrobial activities of aqueous and organic solvent extracts of *A. bisporus* and *P. sajor-caju* were studied and the test organisms were found sensitive to the mushroom extracts (Tambekar et al., 2006). Antimicrobial properties of three *Pleurotus* species have been studied and reported (Loganathan et al., 2008). The antimicrobial activity of ethanol, aqueous, acetone and methanol extracts of *G. lucidum* was examined against *S. aureus*, *P. aeruginosa*, *E. coli*, *S. typhi*, *B. subtilis* and *K. pneumoniae* and observed that the acetone extract showed maximum antibacterial activity and *K. pneumoniae* was observed to be the most susceptive (Quereshi et al., 2010). Aqueous and methanolic extract of *Phellinus* fruit bodies were tested for antibacterial activity against 5 pathogenic bacteria namely *S. typhi*, *E. coli*, *S. aureus*, *Streptococcus mutans* and *P. aeruginosa* and also tested for antifungal activity against 5 fungal strains namely *Mucor indicus*, *Aspergillus niger*, *Aspergillus fumigatous*, *Aspergillus flavus* and *Penicillium* sps. (Balakumar et al., 2011). The aqueous extract was observed to show higher inhibition against *P. aeruginosa* and the methanol extract was obtained to show maximum antifungal activity against *Aspergillus flavus*.

The evaluation of antitumour and anti-inflammatory activities of ethanolic extract of cultured mycelium of morel mushroom, *Morchella esculenta* were performed (Nitha et al., 2006). *Morchella esculenta* ethanolic extract was observed to show significant dose-dependent inhibition of both acute and chronic inflammation in mice model (Nitha et al., 2006). The antitumour activity of *Morchella esculenta* ethanolic extract was estimated and was observed to show significant antitumour activity (Nitha et al., 2006). The chloroform extract of the mushroom, *Ganoderma lucidum* was utilised for the investigation of antioxidant and anti-inflammatory activities and was observed to show remarkable free radical scavenging (Joseph et al., 2009). Antitumor activities of different mushrooms are being studied and reported such as the aqueous extracts of *G. lucidum* (Jones and Janardhanan, 2000), methanol extract of *P. florida* and *P. pulmonarius* fruiting bodies (Jose and Janardhanan, 2000; Jose et al., 2002) and methanol, aqueous and ethyl acetate extract of *P. rimosus* (Ajith and Janardhanan, 2003).

Few reports are available on immunomodulatory properties of mushrooms. From the fruiting bodies of *P. florida,* a water-soluble glucan was characterized and immunomodulatory effects were studied, the glucan showed significant macrophage activity (Rout et al., 2004). Some other mushrooms were also reported for their immunoanhancing activity, *Lentinus squarrosulus* (Bhunia et al., 2010), *Pleurotus ostreatus* (Maity et al., 2011) and *P. florida* (Rout et al., 2005), etc. *Pleurotus florida* showed antioxidant activity, antiinflammatory, and immmunoanhancing activity (Jose and Janardhanan, 2000; Jose et al., 2002; Roy et al., 2009; Dey et al., 2010).

Conclusion

Edible mushrooms have rich nutritional value and have been used in folk medicine also. Edible mushrooms are good source of protein, minerals, fibers, vitamins and nutraceuticals. Edible mushrooms can be used as nutraceuticals as dietary supplements. Edible mushrooms have medicinal and biological activities like antitumor, anticarcinogenic, anti-hypercholesterolemic, anti-obesity, anti-inflammatory, antidiabetic, antiviral, antibacterial, and antimutagenic activities. Edible mushrooms may be included in daily diet. Many more studies on nutraceutical and pharmacological properties of edible mushrooms are to be undertaken to have more

applicability in suitable industries. In addition, commercial cultivation of edible mushrooms is to be encouraged to gain more income.

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