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Review

Mushrooms for integrated and diversified nutrition

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Mushrooms were considered as "Objects of mystery" by the primitive man, and were realized as food much before civilization. Mushrooms have been variously used in different cultures from being priced as "Food of Gods" in the Roman culture to tools of psychological sedation for the Mexican warriors. Most of the edible mushrooms are saprophytic growing on decomposed organic plant matter. Mushrooms play varied and important roles in human nutrition and health. They are unique nutrition dense vegetables with quality high protein, very low fat, zero cholesterol, low carbohydrates, low glycemic index, high fiber, good cardiac friendly sodium to potassium ratio and some unique bioactive compounds like ergothioneine and polysaccharides. These unique nutritive properties of mushrooms make them a recommended food for diabetics, body weight management, hypertension and cardiac well-being. The concept of selenium rich mushrooms for slowing down the progress of AIDS has been gaining importance in the recent years. Apart from being a healthy vegetable, the unique lignocellulosic waste-based production system of mushrooms makes them the most eco-friendly zero waste green technology with immense environmental benefits (Gupta *et al*., 2004, Jain *et al*., 2014 and & Pandey *et al.,* 2014). Despite many environmental and nutritional benefits; mushrooms yet have not become a part of daily nutrition in the Indian diet and the per capita consumption still remains very low at 70 grams per annum. There is a need to educate and enhance the awareness among the people about the nutritional and health potential of mushrooms. There is also the need to draw the attention towards integrating mushroom technology in successful agro-residue management programs, livelihood programs, national nutrition programs and women empowerment and rural development schemes which ultimately culminate in providing better daily nutrition.

Mushrooms as part of nutrition sensitive agriculture

Nutrition sensitive Agriculture is a strategy which aims to ensure the sustained production of diverse, nutritious, culturally suitable, safe and affordable food for daily diet. This approach requires action at every stage of the food chain from farm to fork. This approach can result in improving the health through availability of nutritious, safe and diverse food, income generation to enhance accessibility to health services and input efficient technologies (www.fao.org). Among the many principles that are applied in nutrition sensitive agriculture, facilitation for diversified food production, production of nutrient-dense crops, reduction of seasonality, creation of employment and women empowerment are the aspects where mushrooms can play a very important role and bridge the gap in a modest way.

Mushroom for nutrition & health

The food we eat is vital to our health and well-being. Nutritionists and doctors are becoming increasingly aware of the links between diet and major health problems, such as heart disease, obesity, tooth decay *etc*. Diet is recognized as an important contributory factor for well-being. Following a healthy, varied diet in order to reduce the risk of such problems does not just mean ensuring adequate intake of protein or vitamins and minerals but it is a1so important to strike the right balance. The best and most sustainable way to strike this balance is through increasing the diversity of our food plates. One way to enhance this food plate diversity is to include various types of mushrooms in the daily diet.

Nutrition through mushrooms

Protein

Protein is an essential element of nutrition required for efficient physiological functions, vital performance of hormones and enzyme action of the human body. Mushrooms are one of several vegan-friendly sources

Table 1. General nutrition facts of most common mushrooms (Serving size 100 g fresh)

	Button mushroom	Oyster mushroom	Shiitake mushroom
Calories	22, calories from fat 3	33, calories from fat 3	34, calories from fat 4
Total carbohydrate	3 g (1% daily value)	6 g (2% daily value)	7 g (2% daily value)
Sugars	2 g	1 g	2 g
Proteins	3 g	3 g	2 g
Total fat Saturated fat Trans fat	0 g (1% daily value) 0 g 0 g	0 g (1% daily value) 0 g 0 g	0 g (1% daily value) 0 g 0 g
Cholesterol	0 mg	0 mg	0 mg
Dietary fiber	1g (4% daily value)	2 g (9% daily value)	2 g (10% daily value)
Sodium	5 mg (0% daily value)	18 mg (1% daily value)	9 mg (0.5%daily value)
Iron	3%of daily value	7%of daily value	2%of daily value
Vitamin A	0%	1%	~
Vitamin D*	325% of DV	651 % of DV	490 % of DV

*(in 84g of 1 pulse UVB exposed mushrooms; Percent Daily Values are based on a 2000 calorie diet). **Source:** USDA SR23 2010 Nutritional Data and Kalaras, 2012

of protein and contain 2-4% protein on fresh weight basis and 10 - 40% on dry weight basis. It is remarkable that 100 g of dry mushrooms can cover 29.41% to 66.00% of the Recommended Dietary Allowance (RDA) of protein for men and from 35.80% to 80.35% for women. The amino acid profile of common mushroom protein suggests that Protein Digestibility Corrected Amino Acid Score (PDCAAS) is approximately 0.66 which is equivalent to legumes and has a digestibility of 70%. The highest score is 1, which applies to animal protein sources. Wheat has a PDCAAS of 0.44 and those of vegetables at 0.73 (WHO, 2007). Mushrooms are a better source of protein compared to common fruits and vegetables with the exception of some green leafy vegetables like fenugreek or drumstick leaves and cauliflower (Fig1). A combination of these vegetables with mushrooms can become a better source of protein for vegetarians vis-à-vis either of these alone. Legumes (dals) are the main source for protein for the predominantly vegetarian population. Some amount of protein is also obtained through cereals and dry fruits. The daily value (DV%) of proteins obtained from 100 g dry mushrooms is higher as compared to commonly consumed cereals and equivalent or higher than pulses but lower to meat (Fig 2).

Protein quality - Amino Acids

Approximately 25-35% of the total amino acids in mushrooms occur as free amino acids, the remainder being combined in the protein. The composition of the growth substrate may also have a significant effect on the amino acid composition of mushroom without changing the apparent crude protein. The data generated at ICAR-IIHR shows that mushrooms contain all the 20 amino acids including the 9 essential amino acids. Mushrooms contain all essential amino acids in higher quantity as compared to most of the common cereals, legumes & nuts. They are especially rich source of isoleucine, phenylalanine, tryptophan and Lysine which are the limiting amino acids in most of the legumes and cereals. Mushrooms are a better source of isoleucine, methionine, phenylalanine and tryptophan as compared to fruits and vegetables. They are a very good source of branched chain amino acids leucine, isoleucine and valine which are important to build muscle, decrease muscle fatigue and alleviate muscle soreness. The high isoleucine content in mushrooms is perhaps associated with its immune enhancing properties by inducing the expression of host defense peptides (i.e., β-defensins) that can regulate host innate and adaptive immunity (Fig 3a & 3b).

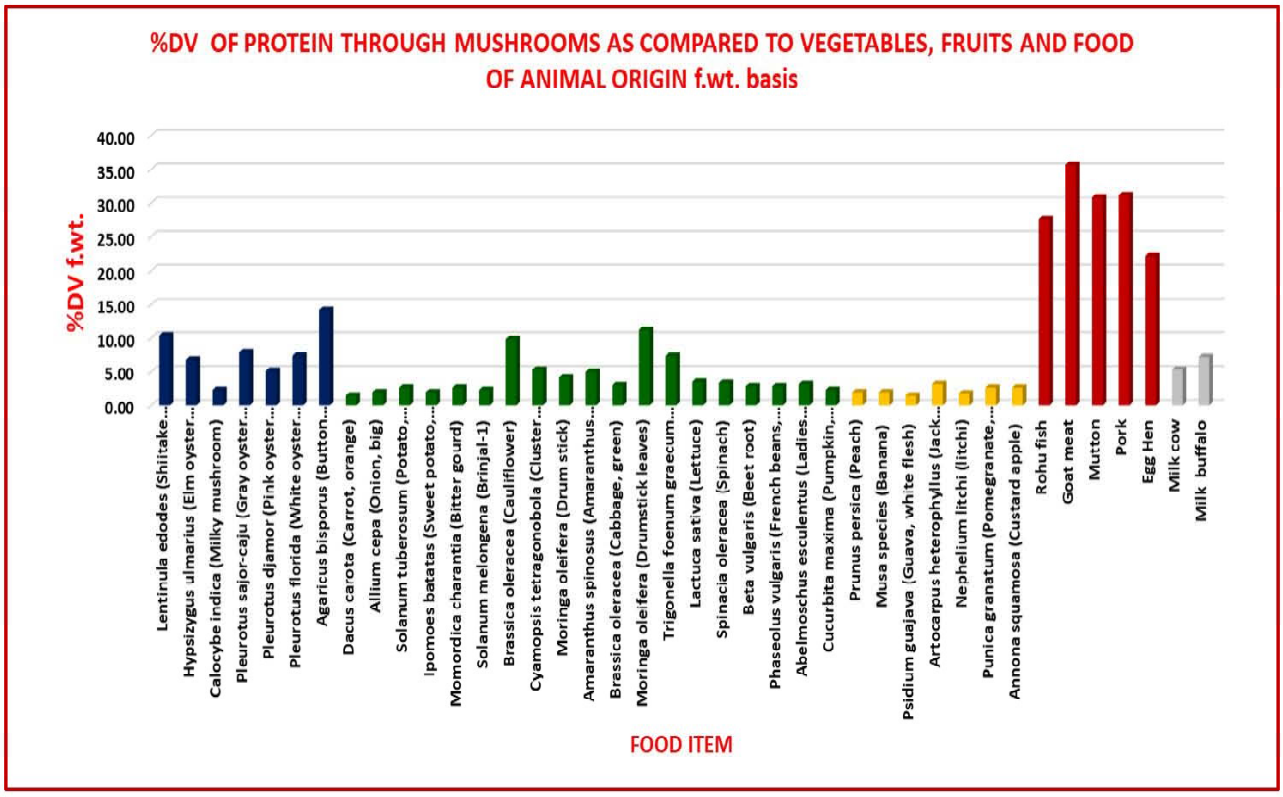
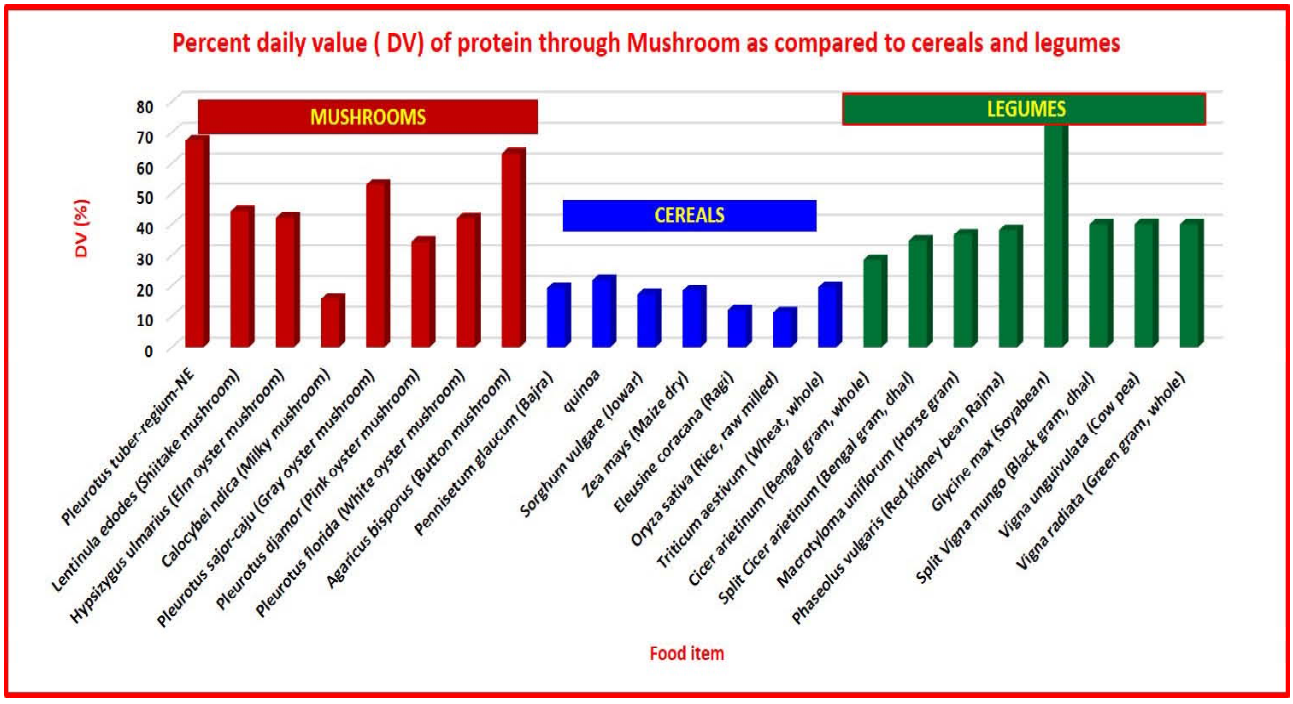


Fig 1. Comparison of daily value contribution of protein through mushroom and commonly consumed vegetables, fruits, meat and milk (Pandey et al., 2020; Longyah et al. 2017)



DV% calculated as per RDA requirement of Indians -ICMR report, 2010

Fig 2. Comparison of daily value contribution of protein through mushroom and commonly consumed cereals & legumes (Pandey et al., 2020; Longyah et al. 2017)

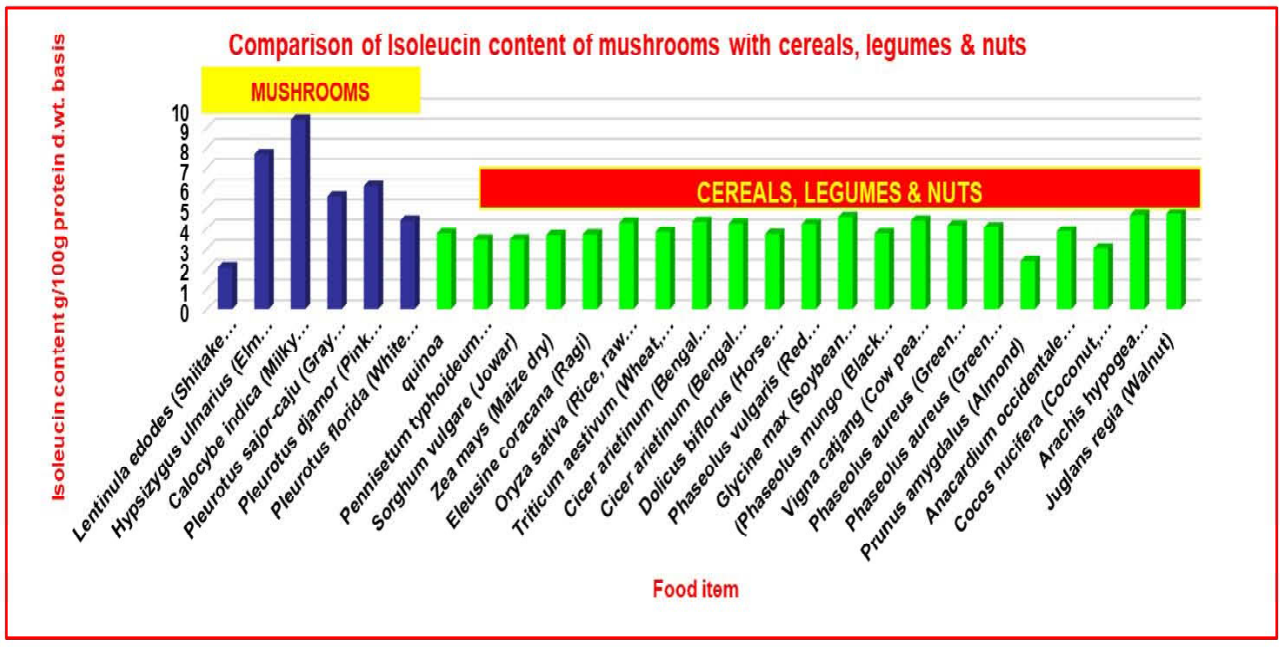


Fig 3a. Comparison of isoleucine of mushroom and commonly consumed cereals & legumes (Pandey et al., 2020; Longyah et al. 2017)

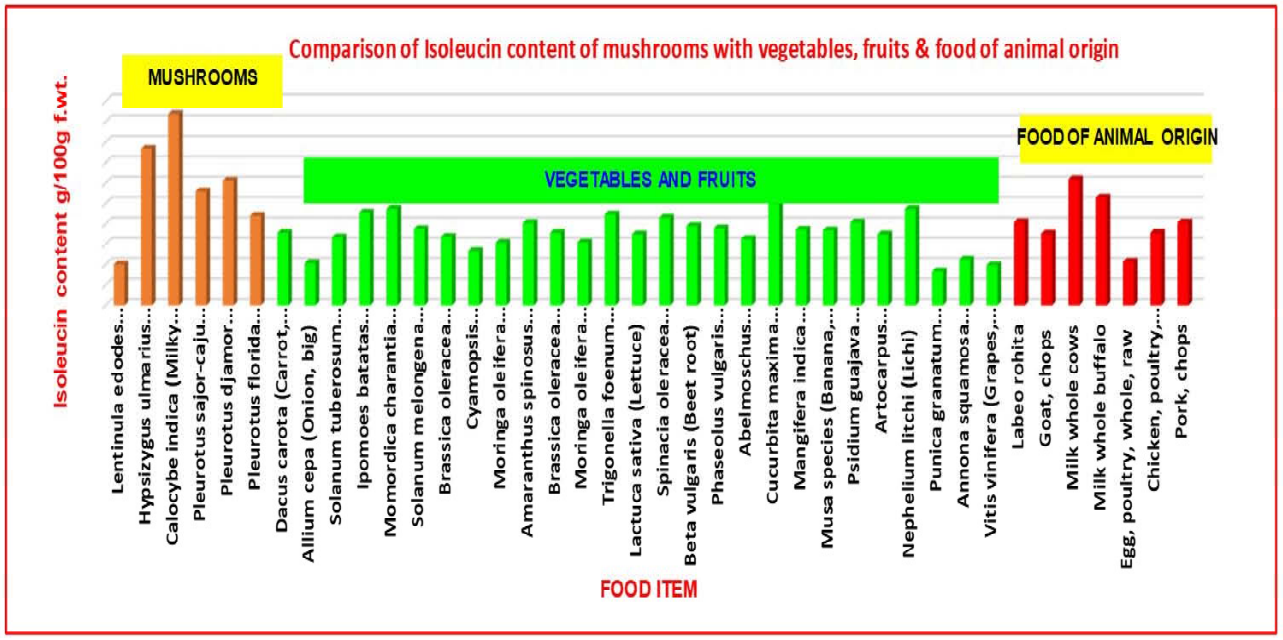


Fig 3b. Comparison of isoleucine of mushroom and commonly consumed vegetables, fruits and food of animal origin (Pandey et al., 2020; Longyah et al. 2017)

Although mushrooms are lower to meat in protein content but are devoid of many harmful ingredients like high saturated fatty acids, sodium and cholesterol found in meat. It has also been shown clinically that the consumption of same quantity of mushroom protein versus meat protein led to higher satiety factor and the feeling of fullness leading to curbing of hunger and prospective consumption (Julie *et al.,* 2017).

Carbohydrate, fat & fiber

Mushrooms are low calorie foods due to lower amount of carbohydrate, very low sugar (no glucose), high

fiber. The carbohydrate quality of mushrooms is better due to the presence of complex carbohydrates like β 1-6 glucans with high immune boosting properties. Mushrooms are low fat foods. Although mushrooms are not a choice source of lipids, they contain essential fatty acids such as linoleic, oleic, and linolenic acids. Therefore, compared to other vegetarian and animal origin food; mushrooms have the advantage of possessing high levels of polyunsaturated fatty acids (PUFA). Dietary fiber (DF) means carbohydrate polymers with ten or more monomeric units, which are not hydrolyzed by the endogenous enzymes in humans. Mushrooms as source of DF have been underutilized as compared to other conventional sources of DF such as cereals, fruits, legumes and vegetables. In general edible mushrooms are rich in DFs with diverse beneficial health effects. Mushroom cell walls contain a mixture of fibrillar and matrix components which include chitin (a straight-chain (1'!4)-β-linked polymer of N-acetyl-glucosamine) and the polysaccharides such as (1'!3)-β-d-glucans and mannans, respectively. These mushroom cell wall components are non-digestible carbohydrates (NDCs) that are resistant to human enzymes and can be considered as source of DF as well as prebiotic medium for good gut health. Fiber content of mushrooms is lower as compared to vegetables and fruits. Foods of animal origin lack fiber totally. Hence a blend of mushrooms with meat is a very healthy and nutritious way of reducing meat intake. Mushrooms are low energy foods as compared to fresh vegetables, fruits and very low as compared to food of animal origin due to their very low carbohydrate and fat content. Hence mushrooms are recommended diets for type II diabetes and for weight reduction. Mushrooms have very low carbohydrate, fat, fiber and energy as compared to commonly consumed grains, legumes and dry fruits (Fig 4a, 4b, 4c, 4d, 4e, 4f, 4g & 4h).

Glycemic index and glycemic load of mushrooms

Mushrooms are a low Glycemic index (GI) and low Glycemic load (GL) food, meaning that they do not spike blood sugar level. Although mushrooms are technically fungi, they are considered white vegetables - like onions and garlic - with a low GI of 10–15 and a GL of less than 1 per cup (70 grams), indicating that they do not spike the blood sugar levels.

Vitamins and antioxidants

Mushrooms appear to be good sources of several vitamins. Vitamin A (retinol) activity is relatively common although several mushrooms have detectable amounts of provitamin A measured as mg carotene equivalent. Similarly, although vitamin D activity is rare in mushroom but mushrooms contain the sterol called ergosterol, which is converted to vitamin D under ultraviolet radiation rendering mushrooms as the only vegetarian source of vitamin D. Mushrooms are a very good source of the water-soluble B vitamins. Mushrooms are a very good source of B vitamins such as B_1, B_2, B_3, B_6, and B_{12} which is higher as compared to plants. It is assumed that 100 g of mushrooms can satisfy 2–9, 10–34, 7–12, and 1–8% of the daily demand for vitamins B_1, B_2, B_3, and B_6, respectively. Fresh mushrooms are characterized by a higher content of B vitamins than those subjected to drying. The ability of mushrooms to convert ergosterol in vitamin D2 (ergocalciferol) under ultraviolet-B light (UVB) with a wavelength of 280-315nm exposure is of immense importance. Vitamin D2 is a strong antioxidant which prevents the peroxidation of lipids. The ability of mushrooms to convert ergosterol to vitamin D2 under UVB has become a specialized skill to produce Vitamin D rich mushrooms which is being used as supplement to mitigate Vitamin D deficiency. Among the cultivated mushrooms the highest conversion to vitamin D2 happens in oyster mushrooms in which mere 10 minutes exposure leads to the formation of 3µg/g of vitamin D2. Consumption of merely 30-50g of UVB exposed fresh elm oyster mushroom can fulfill 100% daily requirement (15-20 µg) of vitamin D in human beings.

Ergothioneine- the unique mushroom antioxidant

Ergothioneine is a unique sulfur containing antioxidant specific to mushrooms. It is a biogenic key organic cation transporting substrate, a new type 1 (OCTN1). It is a strong hydroxyl radical (˙OH) scavenger and inhibitor of ˙OH generation through hydrogen peroxide, which has been catalyzed through iron and copper ions. It can protect against the damage due to oxidative stress and reduce reactive oxygen substances' side effects. Ergothioneine protects the water-soluble proteins from oxidative damage. Mushrooms are very rich source of this antioxidant which is not found in plants or other food sources (Fig 5).

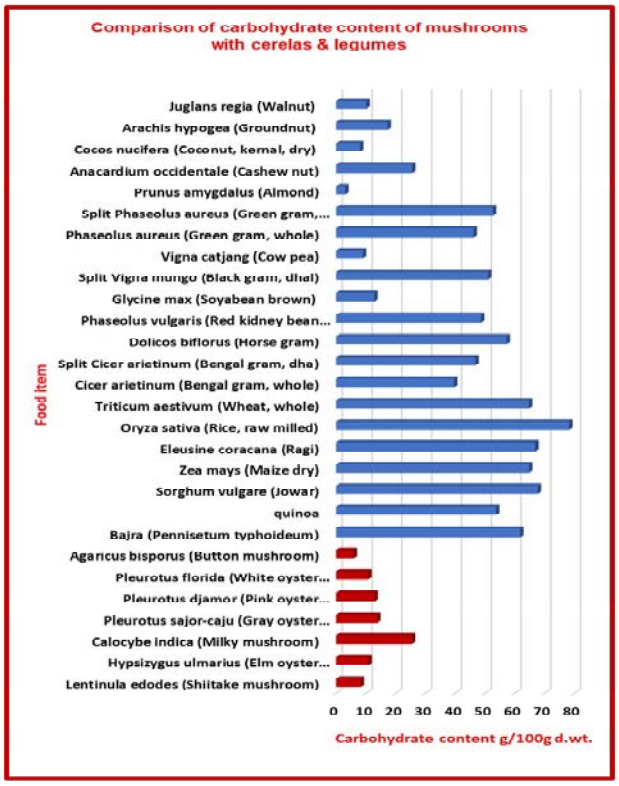


Fig 4a. Comparison of carbohydrate of mushrooms, cereals, legumes and nuts on dry weight basis

Fig 4b. Comparison of fat content of mushrooms, cereals, legumes and nuts on dry weight basis

Fig 4c. Comparison of fibre content of mushrooms, cereals, legumes, nuts and food of animal origin on dry weight basis

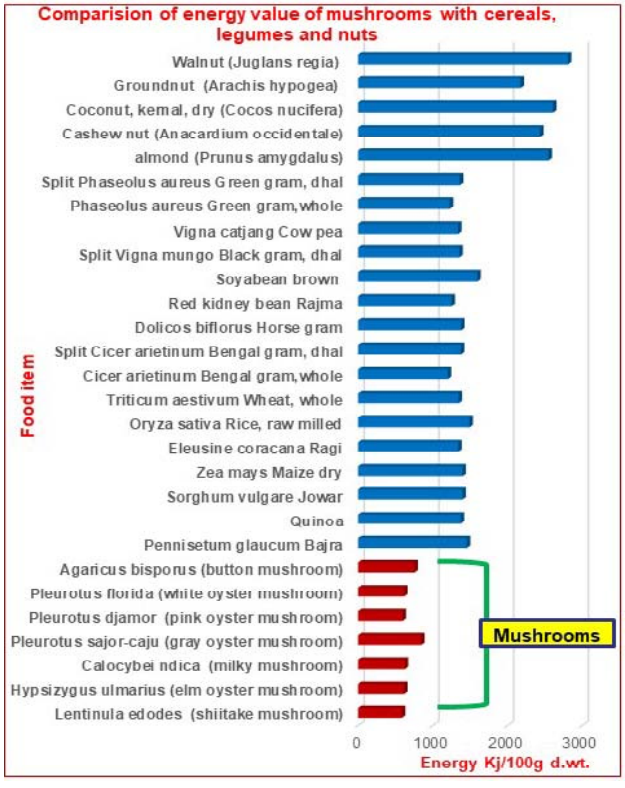


Fig 4d. Comparison of energy value of mushrooms, cereals, legumes and nuts on dry weight basis

Fig 4e. Comparison of carbohydrate of mushrooms, vegetables, fruits and food of animal origin on fresh weight basis (Pandey et al., 2020; Longyah et al. 2017)

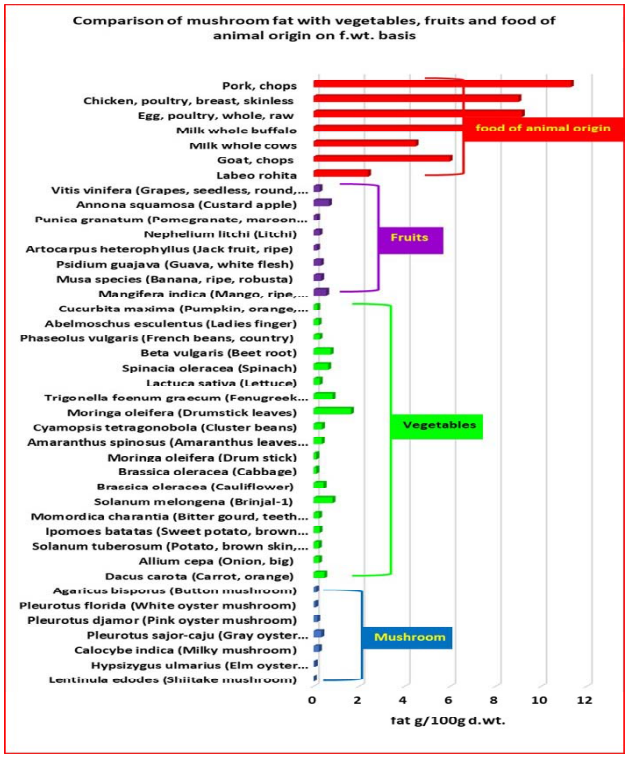


Fig 4f. Comparison of fat content of mushrooms, vegetables, fruits and food of animal origin on fresh weight basis (Pandey et al., 2020; Longyah et al. 2017)

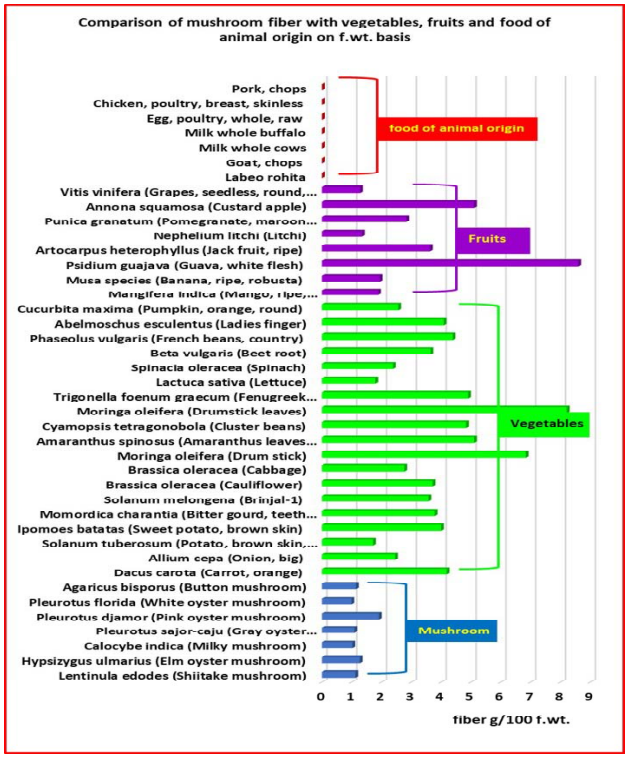


Fig 4g. Comparison of fibre content of mushrooms, vegetables, fruits and food of animal origin on fresh weight basis (Pandey et al., 2020; Longyah et al. 2017)

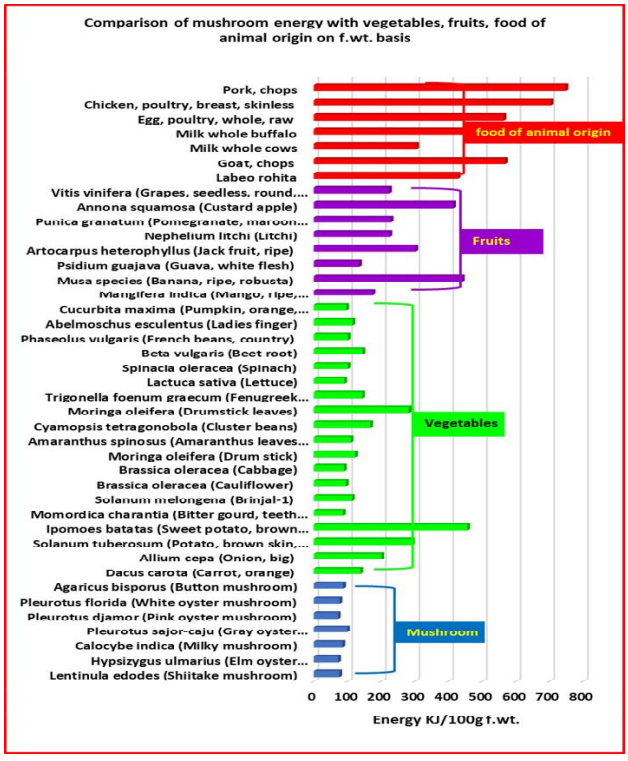


Fig 4h. Comparison of energy of mushrooms, vegetables, fruits and food of animal origin on fresh weight basis (Pandey et al., 2020; Longyah et al. 2017)

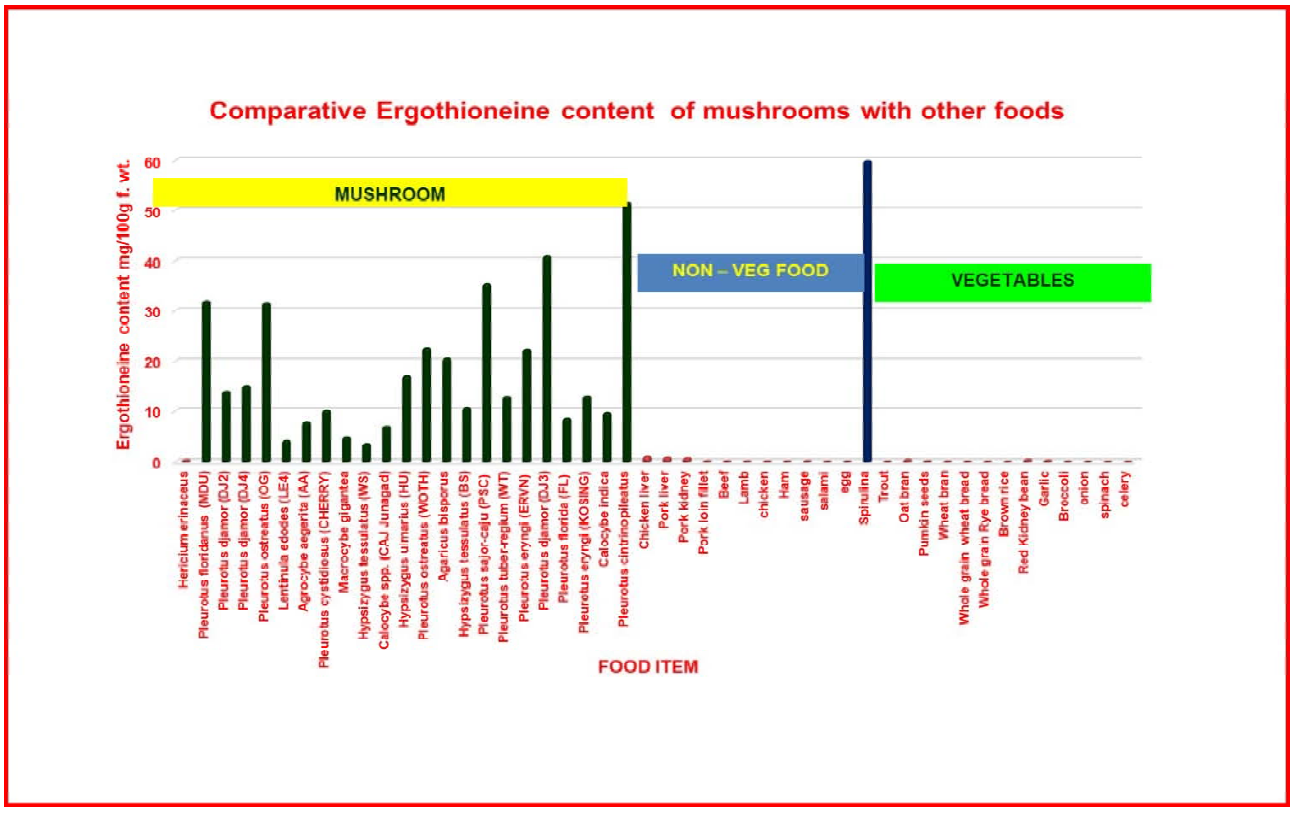


Fig 5. Comparison of ergothioneine content of mushrooms and other foods (Pandey et al., 2020; Longyah et al. 2017

Minerals in Mushrooms

Many minerals are required for better health and these are called essential minerals. Essential minerals are classified into major minerals (macronutrients) and trace minerals (microminerals or micronutrients). These two groups of minerals are equally important, but trace minerals are needed in smaller amounts than macro minerals (https://www.uofmhealth.org/health-library/ta3912). A balanced diet usually provides all of the essential minerals. The phosphorus, sodium, potassium, calcium, iron, zinc, copper and Selenium content of mushrooms is higher as compared to most of the common cereals and nuts. The phosphorus, copper, zinc and selenium content are higher as compared to most of the common vegetables and fruits. Mushrooms are good source of calcium as compared to non-leafy vegetables, fruits and common animal products. They are also a good source of iron with high iron bioavailability of 17% as compared to plant sources. Mushrooms are very low in sodium content. Shiitake, elm oyster and button mushrooms can significantly contribute towards fulfilling the daily requirements of minerals like calcium, phosphorus, potassium, iron, copper, zinc and selenium (Table 2). Further the bioavailability of various micronutrients is higher in mushrooms due to absence of anti-nutrient substances like phytates found abundantly in plant sources.

Sodium/potassium ratio important for health

Sodium is often blamed for boosting blood pressure while potassium is praised for keeping it in check. These two minerals work in tandem throughout the body. The ratio of sodium to potassium in the diet may be more important than the amount of either one alone. Our Palaeolithic hunter-gatherer ancestors consumed about 11,000 milligrams (mg) of potassium a day from fruits, vegetables, leaves, flowers, roots, and other plant sources, and well under 700 mg of sodium. That's a sodium-to-potassium ratio of 1 to 16. Today, we get more sodium (3,400 mg) than potassium (2,500 mg), for a ratio of 1.36 to 1. The higher the sodium-potassium ratio, the greater the chances of cardiovascular disease (Yang *et al.*, 2011). Mushrooms have a lower sodium to potassium ratio as compared to commonly consumed foods thereby important for cardiac well-being.

Table 2. Per cent daily value (DV %) of minerals obtained through consumption of 100 g fresh mushrooms

Mushroom variety	P	Na	K	Ca	Mg	Fe	Mn	Cu	Zn	S
Lentinula edodes (Shiitake mushroom)	33.14	3.15	21.29	25.08	5.42	4.36	21.05	15.55	10.34	14.3
Hypsizygus ulmarius (Elm oyster mushroom)	21.89	1.59	16.5	13.91	4.2	9.07	8.85	13.11	6.24	21.22
Calocybe indica (Milky mushroom)	10.72	2.81	15.34	17.4	2.59	8.16	2.95	25.77	3.66	5.14
Pleurotus sajor-caju (Grey oyster mushroom)	19.68	2.02	9.67	8.64	4.78	9.43	22.8	7.55	14.31	19.64
Pleurotus djamor (Pink oyster mushroom)	18	2.02	12.3	5.04	4.78	5.88	20.1	12.66	9	11.64
Pleurotus florida (White oyster mushroom)	26.32	2.02	13.47	11.2	8.12	12.32	20.45	9.85	18.5	13.87
Agaricus bisporus (Button mushroom)	41.76	5.46	39.15	10.08	7.1	7.32	11	53.99	14	199.57

Foot Note : DV% calculated as per RDA requirement of Indians (ICMR report, 2010)

Mushroom blends for synergistic nutrition

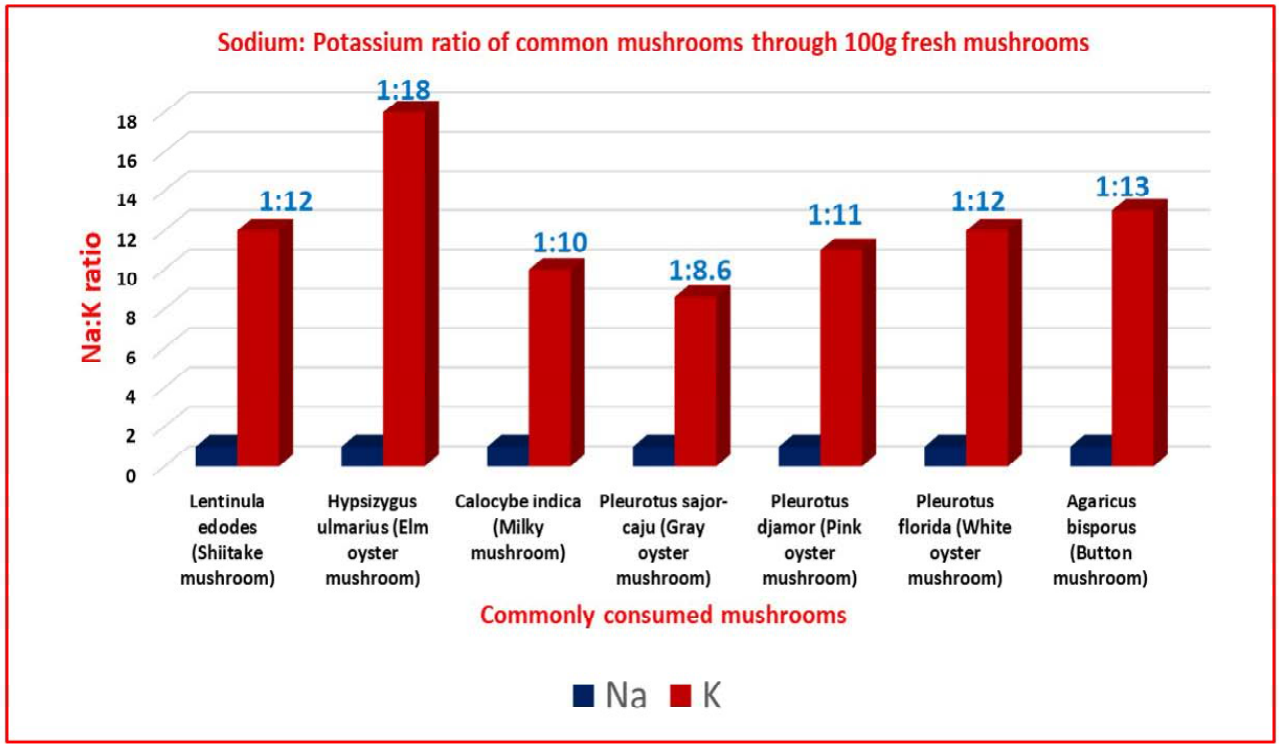
Mushrooms with unique nutrition, light aroma and neutral pH are highly amenable as blended foods with both vegetarian and non-vegetarian ingredients.

Mushrooms for vitamin nutrition

Vitamin B complex is a group of eight essential nutrients that play roles in many organs and bodily systems. Although they can work together in the body, they also carry out their own unique functions. Vitamins of B complex are water soluble vitamins. Mushrooms are an excellent source of vitamin B complex. Mushrooms however lack vitamin C and A. Hence soup blends containing mushrooms with carrots, broccoli, cauliflower and spinach can be an excellent source for vitamin A, B & C nutrition. Vitamin D also called as sunshine vitamin is a very essential vitamin associated with bone health and calcium metabolism in the human body. Mushrooms are not only an excellent source but also the only vegetarian source for vitamin D. Mushrooms can be exposed to sunlight or UV light to enhance their vitamin D content. Vitamin D is a fat-soluble vitamin. Hence its bioavailability to the body can be increased many folds by consuming sun or UV exposed mushrooms sautéed in ghee or butter.

Mushrooms - The perfect blend with non-vegetarian food to reduce carbon foot print

Livestock agriculture is a major cause of concern for climate change and rapid environmental degradation due to the production of very potent greenhouse gas methane. Globally, 14.5 percent of



Note: As per ICMR (2010), a healthy sodium to potassium ratio in the food should be 1:1.8

Fig 6. Sodium potassium ratio of commonly consumed mushrooms

all human-related greenhouse gas emissions is through livestock sector alone. It is not just the methane from cows or manure that contributes to animal agriculture's carbon footprint, it is the fossil fuels required to ship, process, package, and refrigerate the meat as well. A UN released advice states that "governments should eliminate meat industry subsidies and tax meat production" in order to reduce the global rise in consumption and the environmental damage that goes with it (riseofthevegan.com, Aug 14, 2016, accessed on 15-09-2021). In Europe, the Italian mayor expressed her wish to turn Turin into the first vegan city, encouraging the residents to stop consuming meat and turn to vegetarian and vegan diets. She stated '*The promotion of vegan (milk/egg-free) and vegetarian (meat-free) diets is a fundamental act in safeguarding our environment, the health of our citizens and the welfare of our animals.*' The German Govt. banned meat and meat related products in all its Govt. function since 2017 to set an example and its serious commitment in the fight against the "effects of the consumption of meat" and betterment of environment. (https:// www.riseofthevegan.com accessed on 15-02-2020). Burgers are possibly the most ubiquitous meal globally. It is also the most resource-intensive meal due to presence of beef filling. A simple modification of the same diet blended with mushrooms will not only lead to a healthy diet but also save the environment and its resources and lead towards a more sustainable method of nutrition. USA alone consumes 14 billion burgers annually using 71% of all beef consumption. McDonalds alone purchases 1 billion pounds of beef per year. The production of this huge amount of beef leads to production of 3.64Mt of greenhouse gasses per annum. A small modification in the burger recipe by replacing 30% of beef with mushrooms can lead to a healthier and tastier product which will reduce greenhouse gas emission, water consumption and land requirement by 29% (Reynolds, 2018). Meat consumption can be amicably reduced without losing flavor, texture or taste. Blend of mushrooms with meat not only enhances taste and nutrition but also helps in reduction of saturated fat, sodium and calorie intake and adds additional nutrients like B vitamins, vitamin D, antioxidants and potassium. This mushroom meat blend is gaining lot of importance among dieticians, professional chefs and home cooking (http://www.blenditarian.com).

Table 3. Per cent bioavailable iron from iron fortified oyster mushroom

Age / Sex requirement	*Bioavailable iron requirement (mg/day)	Percent of bioavailable iron available from 10 g Fe fortified Elm oyster mushroom powder (%)
12-16 years, girls	2.02	36
12-16 years, Boys	1.82	40
Adult males		
Pregnant women	1.14	64
Lactating women	1.31	56
Menstruating women	2.38	30
Postmenopausal women	0.96	76

As per Nazanin *et al.* (2014).

Value addition of mushrooms

Iron fortified mushrooms

Iron is one of the most important trace elements required for human health. India is very high on iron malnutrition. Both the quantity and bioavailability of iron from a food source is important towards mitigation of iron malnutrition and mushrooms score very high on both the aspects. Perhaps that is the reason that oyster mushrooms have been given the sobriquet of 'Blood builder' by the Chinese. Due to their highly porous texture, mushrooms are highly amenable for osmo- fortification techniques thereby enhancing targeted nutrition component. ICAR-IIHR is the first institution in the country to have successfully employed this technique and standardize the technology for the production of iron fortification in oyster mushrooms (Patent pending). The Iron enriched mushroom developed at ICAR-IIHR contains 33.8 mg of iron per 100 g dried iron enriched mushroom powder. Thus, consumption of merely 10 g iron enriched mushroom can give 16.09% DV for iron requirement of an adult women and 19.88% DV for adult men. Studies have also been conducted on the bioavailability of iron in animal model system and recipe has been developed for the delivery system for mass nutrition programs so that it can help in mitigating iron malnutrition.

Bioavailability of iron from iron fortified mushroom

One of the major reasons for iron deficiency is low bioavailability of iron especially from vegetarian foods of plant origin. It is reported that the non-heme iron from plant sources has a bioavailability of 5-8%. Hence bioavailability studies were conducted at ICAR-IIHR in collaboration with ICAR-NIANP in animal model to study the bioavailability of iron from iron fortified mushrooms. The study showed the bioavailability of iron from normal non-fortified mushroom was 17.7% as compared to the bioavailability of 21.68% from iron fortified mushroom. Considering the above bioavailability data and iron content of iron fortified mushroom; it can be inferred that consumption of 10 g of iron fortified mushroom powder gives 0.73 mg of bioavailable iron (Nazanin *et al*., 2014). Table 13b shows the percent daily value requirement of bioavailable iron available form iron enriched mushroom.

Delivery system for mass nutrition

Any iron fortification method is incomplete until a proper delivery system is also standardized so that the benefit of the innovation can reach the target population. This innovation of the process of production of iron fortified mushroom was taken to a logical and meaningful conclusion through the standardization of recipe for Arka mushroom fortified rasam powder which is available as licensed technology from ICAR-IIHR. This technology relates to the usage of dry oyster mushroom powder for the production of rasam powder. The same recipe can be used for the delivery of iron by substituting normal mushroom powder with iron fortified oyster mushroom powder.

Enhancing mushroom accessibility through technology and policy interventions

Mushrooms are indoor crops and require semi-permanent to permanent structures depending on the mushroom variety chosen and the local ambient climate of a place. Space and cost of mushroom growing structures are one of the constraints in rural

Fig 7. Arka mushroom rasam powder

and urban areas which makes the accessibility of fresh mushrooms difficult. ICAR-IIHR has developed models and technology which can address these issues.

Mushrooms for terrace / backyard - The Ready to Fruit (RTF) concept:

Although mushrooms are excellent nutrition source for vegetarians and a very delicious way to reduce the intake of non-vegetarian food; yet have not become a part of daily Indian diet. Mushrooms often have been projected as food for God and for the Elite. They have been sold at prices beyond the buying capacity of an average Indian. ICAR- IIHR has been consistently working towards making mushrooms as a part of daily Indian diet of every home so that mushrooms in their own humble way may contribute towards country's nutritional security and mitigation of malnutrition. The 'Ready to Fruit' (RTF) Bag technology was developed to bring mushrooms to rural homes in the villages where there is space, skill and resource constraints. Women were provided with pre-seeded and fully-grown RTF bags to grow mushrooms at home. Each one kg bag could yield 250-300g and if bag opening is done in a planned and staggered way; this technology can make available mushrooms on a daily basis. The RTF bags have not only become popular in resource crunched rural households but also in the urban homes with space constraints.

Mushrooms for Poshan Vatikas

Ministry of Women and Child Development is promoting establishment of "Poshan Vatikas" across the country. The ministry plans to set up Poshan Vatikas across all anganwadi canters with the aim to provide a fresh supply of fruits, vegetables and even medicinal plants, especially in aspirational districts. There is need to ADD MUSHROOMS to these Vatikas to bring about a healthy and diversified nutrition integration. The RTF technology developed by ICAR-IIHR very well fits into these Vatikas where mushrooms can be harvested on daily basis. ICAR-IIHR has also developed suitable low-cost outdoor structures which can be easily installed outdoors in small spaces.

Mushroom technology in MANREGA

Mushroom growing is labor intensive and for a country like India where unemployment is rampant, mushroom growing can create jobs both in semi-urban and rural areas (Martinez-carrera, D. *et al*., 1998). Some technologies can utilize family labor, thus providing employment to all members of the family. The labor of out of school youths and women can be effectively utilized. Mushroom growing can be taken up by exclusive women groups too as the activities are mostly indoors **(**Pandey and Veena, 2003). Mushroom cultivation can be integrated in many of the rural upliftment policies of the Government of India. Like Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGA), Mid-day meals and Aanganwadi. The unemployed rural youth, landless and women groups can be engaged in a centralized mushroom growing farm at Panchayat levels. Fresh mushrooms can be sold both in rural and through linkages in the urban areas. Excess production can be easily sundried to make it enriched with vitamin D and the dried mushroom can be powdered and stored for long periods. Such powders can be utilized to produce mushroom value-added products like Arka Mushroom rasam powder, Arka mushroom chutney powders, Mushroom millet biscuits, Mushroom based health drinks etc. which can open novel avenues for rural agro-premiership especially among women. Mushrooms can be integrated in Mid-day meal schemes of rural schools. This integration will have twofold benefit. Firstly, providing nutritious vegetable to the rural poor and secondly creating employment for many who will take up the responsibility of making the mushrooms available in the villages. The agro residues produced at the village level can be utilized by women to grow mushrooms. As spin off, women and unemployed rural youth get employment, better nutrition for the village school and entrepreneurship through mushroom value-added products. The spent mushroom substrate after harvest can be composted to make quality enriched organic manure for the field in the village.

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