EVALUATION OF NUTRITIONAL QUALITY AND HEALTH BENEFITS OF OYSTER MUSHROOM

JAZIYA.S

Thesis submitted in partial fulfillment of the requirement
for the degree of

Master of Science in Home Science
(Food Science and Nutrition)

Faculty of Agriculture
Kerala Agricultural University, Thrissur

2011

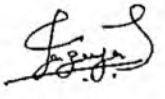
Department of Home Science
COLLEGE OF AGRICULTURE
THIRUVANATHAPURAM -695 522

DECLARATION

I here by declare that this thesis entitled **"Evaluation of nutritional quality and health benefits of oyster mushroom"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title of any other university or society

Vellayani

Date



Jaziya.S
2007 – 16 - 104

CERTIFICATE

Certified that this thesis entitled **"Evaluation of nutritional quality and health benefits of oyster mushroom"** is a record of research work done independently by **Jaziya.S (2007 -16 – 104)** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

Vellayani

Dr. Mary Ukkuru.P
(Chairman, Major Advisor)
Professor and Head

Approved by

Chairperson:

Dr. Mary Ukkuru.P
(Chairman, Major Advisor)
Professor and Head
Department of Home Science
College of Agriculture, Vellayani,
Thiruvananthapuram, 695 522

Members:

Dr. P.V.Nandini
Professor
Department of Home Science if
College of Agriculture, Vellayani,
Thiruvananthapuram, 695 522

5/7/11

Dr. Suharban.M
Professor and Head
Department of Plant pathology
College of Agriculture, Vellayani,
Thiruvananthapuram, 695 522

4/7/11

Dr. Saifudeen.N
Professor and Head
Department Soil science and chemistry and
College of Agriculture, Vellayani,
Thiruvananthapuram, 695 522

External Examiner
Mrs. G. Hemalatha
Associate Professor
Dept. of Wood Science & Technology
Home Science College & Res. Inst.
TNAU, Madurai - 625 104

ACKNOWLEDGEMENT

*I am grateful to" **Almighty god**" who provided me the strength to fulfill the task in a satisfactory manner. I am in doubted for numerous blessings that he showed upon my life.*

*I feel great pleasure and deep sense of gratitude to **Dr. Mary Ukkuru.P** for her valuable and affectionate guidance, constant encouragement and unfailing patience through out the course of this research work and in the preparation of the thesis. This work would not have been possible without her help and support.*

*I extend my sincere gratitude to **Dr. P. V. Nandini** for her valuable suggestions, ever willing help and constant criticism which had been rendered whole heartedly through out my research work.*

*I wish to express my gracious thanks to **Dr. Suharban.M** for her whole hearted co operation and help during the period of investigation.*

*My heartfelt thanks to **Dr. Saifudeen.N** for her keen interest, immense help, constructive suggestions and timely support and co operation rendered throughout the course of this research endeavor.*

*I am obliged to **Mr. C. E. Ajith kumar** programmer, Department of Agriculture Extension for executing the statistical analysis of the data.*

*I also extend my acknowledgement to all **teaching and non teaching staffs** of the Department of Home Science for the help rendered to me during the course of study.*

I sincerely thank the facilities rendered by the Library of College of Agriculture, Vellayani.

From the depth of my heart I thank my friends Naziya, Sheela and ***Manjusha*** *for their indispensable help, love, moral support and constant encouragement.*

My loving thanks to my seniors and my juniors for their loving support and encouragement throughout my research work.

On a personal note I express my love and gratitude from my deep heart to my dearest ***Vappa and Umma.*** *The love, support, patience and constant encouragement given by them was a real source of inspiration with out which I could not complete this research endeavor.*

From the depth of my heart I thank my ***Father in law, Mother in law, Brother in law and my Sisters*** *for their loving support and encouragement throughout my research work.*

I express my heartfelt indebtedness to my husband ***Haris*** *for his loving emotional support and continuous encouragement during my course of research work.*

I thank all those who extended help and support to me during the course of my work.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

P	-	*Pleurotus*
AAS	-	Amino acid score
EAA	-	Essential amino acid
NI	-	Nutritional index
IF	-	Inflammation factor
Fig	-	Figure
G	-	Gram
mg	-	milligram
et al	-	and others
g/100g	-	gram per 100 gram
Kcal/100g	-	kilo calories per 100 gram
min	-	minutes
T	-	Treatments
ppm	-	Parts per million
d/w	-	Driedweight
BMI	-	Body mass index
WHR	-	Waist hip ratio

Introduction

1. INTRODUCTION

Mushrooms are the most visible members of the economically and ecologically important kingdom of fungi. The Pharaohs prized mushrooms as a delicacy and the Greeks believed that mushrooms provide strength for warriors in battle. The Romans regarded mushroom as a gift from God and served them only in festive occasions while the Chinese treasured them as a health food and consume for its medicinal properties (Ranote et al., 2007). There are over 14,000 mushrooms of which only about 3,000 are edible and about 700 exhibit medicinal properties (Omisore, 2010). Mushrooms are gaining popularity all over the world due to its pleasant aroma, taste and fleshy texture (Kamal et al., 2009)

In India commercial cultivation of mushroom is extended to three mushroom namely button mushroom (*Agaricus bisporus*), paddy straw mushroom (*Volvariella volvaceae*) and oyster mushroom (*Pleurotus florida*). Oyster mushroom rank second among the important cultivated mushrooms in the world and constitute about 2.7 per cent of the total production of fresh mushroom (Dabbour and Taruri, 2002). Oyster mushroom is an edible mushroom of the tropic and subtropical region. An attractive feature of this group of mushroom is that they can utilize a large variety of agricultural waste product and transform lignocellulosic biomass to food of high quality, flavor and nutritive value (Narayanaswamy et al., 2009)

Named for their faint resemblance and flavor similarity to oysters, oyster mushrooms are a mainstay in Japanese and Chinese cuisine. They have perhaps the most colour diversity of all of the edible mushroom; white, yellow, pink, grey, brown, and black oyster mushrooms are common and prevalent (Witcomb, 2008). Oyster mushrooms are widely cultivated and consumed in the state of Kerala and is generally called as "Chippikkoon" in Malayalam.

According to Adejumo and Awosanya (2005) mushrooms have been a food supplement in various cultures and they are cultivated and eaten for their edibility and delicacy. The edibility of mushroom may be defined by the criteria that include absence of poisonous effects on humans and desirable taste and aroma (Mattila et al., 2000).

The food value of mushroom is being increasingly realized as they are low in carbohydrate, cholesterol and fat and high in B complex vitamins and minerals (Dunkwal et al., 2006). Medicinal value of mushrooms are known from time immemorial with their ability to lower cholesterol and blood pressure, boost immune system and inhibit tumour growth (Ming et al., 2010). Medicinal mushrooms are as effective part of self care program for chronic recurring infections like cold and flu as well as general weakness and fatigue.

Many varieties of mushrooms are valued greatly as nutritious food, as tonic foods and as important sources of medicinal compounds such as antitumour/ antiviral and other pharmaceutically active compounds. Owing to the delicate flavor and, exotic preferences and awareness about their nutritional and medicinal values mushrooms are assuming increasing popularity and acceptance in the daily diet. Boa (2004) viewed that edible mushrooms are consumed by mankind for their nutritional and for medicinal value as cosmestibles.

According to Witcomb (2008) major medicinal properties attributed to mushrooms include anti cancerous, antibiotic, anti viral activities and lipid lowering effects, hypoglycemic effects and enhanced immunity.

Mushrooms are considered as a probiotic food and fight off illness by maintaining physiological homeostasis and thus increase our body's adaptive abilities and vitality (Oatman, 2000).

The Indian diet which is predominantly vegetarian and cereal based, provide rich calorie but lack good quality protein. It is universally accepted that the protein of mushrooms can effectively supplement the cereals which are deficient in lysine. They also help in digestion and are good for diabetic patients due to no starch and negligible sugars. Mushrooms are thus being recognized now as, deliciously palatable non conventional source of protein which can bridge the protein gap in the Indian diet (Rai et al., 2003).

A systematic approach to explore the health benefits of oyster mushroom in relation with its nutritional quality among human subjects is highly essential in order to promote and popularize the commercial cultivation of oyster mushroom further.

The present investigation is taken up with the objective to assess the nutritional quality of oyster mushrooms and to ascertain the effect of processing on its constituents. The study also envisages to elaborate the health benefits of oyster mushroom through conducting case studies among selected human volunteers.

Review of Literature

2. REVIEW OF LITERATURE

Literature pertaining to the study is reviewed under the following sub titles.

2.1. Production and cultivation of mushrooms

2.2 Nutritional value of mushrooms

2.3. Medicinal value of mushrooms

2.4. Processing and value addition of mushrooms

2.1. PRODUCTION AND CULTIVATION OF MUSHROOMS

Mushrooms are being cultivated in more than 100 countries of the world with and estimated total production of over 12 million tons (Kamal et al., 2009).

Rama and John (2000) reported that importance of mushrooms as health food is well recognized in India and its production is increasing at a faster rate, from 4000 tonnes in 1985-86 to 30,000 tonnes in 1996-97. Major mushroom growing states in India are Punjab, Madhya Pradesh, Maharashtra, Himachal Pradesh, Goa, Tamil Nadu and Kerala (Indian Agriculture, 2003).

The state of Haryana ranks third in producing mushroom which has produced 6164 tonnes of mushrooms during the 2007 and it has set a target of producing 7000 tonnes of mushroom for 2008. (www.freshplaza.com).

Verma (1999) stated that Punjab alone produces 20-25 per cent mushrooms out of the total production in India. India exported 11'797.63 MT of mushrooms valued at rupees 5,105.30 lack in 2003 (Indian agriculture, 2003)

Mushroom production can play an important role in managing farm organic wastes when agricultural and food processing by products are used as growing media for edible fungi (Beetz and Kustudia, 2004). The cultivation of edible mushrooms not only helps in recycling of agro wastes but also filling up the protein gap prevalent among large population of country (Periyassamy and Natarajan, 2002).

Lindequist et al. (2005) reported that more than 2000 species of mushrooms exist in nature, however less than 25 species are widely accepted as food and only a few have attained commercial importance. Though 20 genera of mushrooms are being cultivated throughout the world only three types viz, White button mushroom (*Agaricus bisporus*), Oyster mushroom (*Pleurotus spp*) and Paddy straw mushroom (*Volvariella volvacea*) are grown commercially in India (Rai et al., 2003).

Oyster mushroom rank second among the important cultivated mushrooms in the world and constitute about 2.7 per cent of the total production of fresh mushroom (Dabbour and Taruri, 2002). China the world leader in oyster mushroom production, contribute nearly 85 per cent of the total world production of about a million tones (Flatt, 2010).

Beetz and Kustudia (2004) of the opinion that among the different cultivated mushroom, *Pleurotus* species are the easiest and cheapest to grow. *Pleurotus* mushroom grows over a wide variety of lignocelluloses crop waste, require very little pretreatment, cultivation does not compete with other food crops for land and they grow easily under tropical conditions (Bano et al., 1992). Teweri and Pandey (1991) reported that most part of South India is ideal for cultivation of oyster mushroom. Sohi (1986) reported that Oyster mushrooms are better in consumer aspects than the generally grown button mushroom.

Ranganathan and Somasundaram (1998) stated that mushroom can also be grown under different climatic conditions and on agricultural and industrial wastes. According to Choi (2004) mushrooms can be grown on cotton waste mixed with wheat bran and it also produce higher yield. According to Vyas (1999) mushroom can be cultivated in-doors and does not need large space. Mushroom cultivation apart from being a source of food production can be a means of livelihood and a source of economic empowerment for women in both urban and rural areas and for small farmers ((Narayanaswamy et al., 2009).

2.2.NUTRITIONAL VALUE OF MUSHROOMS

Mushrooms are being recognized as important food item from ancient times and its utilization is being increasing day by day because of their significant role in human health, nutrition and disease (Khan et al., 2008).

Earlier it was believed that mushrooms are devoid of nutrients but now researchers have proved mushrooms as a nutritionally sound food of great value and can be considered as meat for vegetarians (Ranote et al., 2007). Apart from being tasty, edible mushrooms are cheap sources of high quality proteins, vitamins, minerals, fibres, antioxidants and water and several growth promoting substances and also add flavour to the vegetarian diet (Nita, 2009).

Chang (1996) stated that mushrooms are an important food item concerning human health, nutrition and disease prevention and widely used as food and food supplement.

According to Grieger (2010) besides adding a wonderful earthy taste and meaty texture to foods, mushrooms also contain essential nutrients. They contain virtually no fat or cholesterol, low in sodium and a good source of fiber.

Sadler (2003) reported that mushrooms are rich in protein, minerals and vitamins and contain abundance of essential amino acids. Jiskani (2001) and Buigut (2002) reported that mushrooms are considered as source of proteins, vitamins, fats, carbohydrates, amino acids, and minerals.

Many species are high in dietary fibre, protein and vitamins such as thiamine, riboflavin, niacin, biotin, cobalamines and ascorbic acid. Mushrooms are also a source of some minerals, including selenium, potassium and phosphorus (*http*://www.msnb.msn.com).

Deepak et al. (2000) viewed that mushroom contain nutrients viz minerals, fiber, vitamins, essential amino acids and enzymes but low in fat and calories.

White button mushrooms are devoid of mankind for their characteristic aroma, texture and nutritional values (Arumughanadhan et al., 2003). They are a good source of non starchy carbohydrates, proteins, dietary fiber, minerals and vitamins and fat content is quite low (Kumar and Barmanray, 2007). Mushrooms when used as ingredient in diet provide variety in taste taste, texture and nutrients (Kumar and Barmanray, 2007).

Vitamin B3 in oyster mushroom is 5 to 10 times higher as compared to any other vegetables (Dill, 2007). Sivaprakasham (1986) considered the nutritive value of mushrooms as intermediate between vegetables, egg and meat protein. The nutritional profile of mushroom is far better than vegetarian foods. Mushrooms

contain a high proportion of water (Wittingerova, 1991). Investigation by Lintzel (1990) indicated that 100-200gm of mushrooms by dry weight are required to maintain nutritional balance in a normal human being weighing 70 kg.

Chang (1996) and Ereifj and Raddad (2000) observed that mushrooms are valuable health food –low in calories and high in vegetable proteins. The nutritive value of *Pleurotus* species was evaluated by Turner (1993) and the biological efficiency was reported to range from 12.5-72.4 per cent with high protein content.

Fresh mushroom contained moisture 89.75 per cent, protein 3.68 per cent, carbohydrate 4.53 per cent, fat 0.32 per cent, ash 0.78 per cent and crude fiber 0.52 per cent (Kumar and Barmanray, 2007). Sanmee et al. (2003) reported the protein content as 14.0-24.2, carbohydrate 41.6-65.1, 2.7-9.5, fiber 8.3-16.8 per cent in dried mushroom. Kushalappa (2010) reported that an adult meets 7.7 per cent of his protein requirement and 16.6 per cent of iron requirement from mushrooms.

In general 100gm of mushrooms contains 89.9 gm of water, 1-5 gm of carbohydrates, 2-8 gm of proteins, 1-2 gm of fibre, 0.2-1 gm of fat, 5-15 gm of vitamins, 0.5-1 gm of minerals and the caloric value of mushroom is 18-29 kcal/100 gm. (Henze (1991) ; Geetha and Suharban (1997).

Calories

Mushrooms fall between high grade vegetables and low grade meats and provide about 35 calories/100 g (Singh et al., 2001). Adejumo and Awosanya (2005) reported that energy value of mushroom varies according to species to species, which is about equal to that of an apple. Dunkwal and Jood (2009) reported dried oyster mushroom contains 412 kcal/100 gm.

Carbohydrate

The carbohydrate in the mushroom are at a level of 4.5-5 per cent but are in the form of glycogen, chitin and hemicelluloses instead of starch. Starton (1990) found that mushroom has 3.8 per cent complex carbohydrate. While starch was found to be 0.02-0.3 per cent in mushrooms (Shanmugham and Jayarajan, 1990). The carbohydrate constituents of the mushroom species are mainly mannose (36.23 per cent), glucose (34.70 per cent) and xylose (16.83 per cent) (Kim et al., 2009).

Protein

Chandra and Smasher (2002) and Dunkwal et al. (2006) were of the opinion that the proteins of mushroom are of high quality and rich in various essential amino acids. The use of mushroom may contribute significantly in overcoming protein deficiency in the developing countries where good quality proteins from animal source are either unavailable or un acceptable for religious beliefs.

According to Jiskani (2001) the protein value of mushroom is twice as that of asparagus and potatoes, four times as that of tomatoes and carrots and six times as that of oranges.

Ereifj and Raddad (2000) reported that mushrooms are relatively high in digestible protein among vegetable foods. Protein content of mushrooms may vary from 14 per cent to as high as 44 per cent depending on the species of mushroom.

Turner (1993) evaluated Biological efficiency of *Pleurotus species* and reported to range from 12.5-72.4 per cent with high protein. In *Pleurotus sajor caju* crude protein content vary from 18.46-27.78 per cent. (Gupta et al., 2004). *Pleurotus florida* has 3.02 per cent protein content, (Randhawa and Ranote, 2004). According to Kumar and Barmanray (2006), white button mushroom (*Agaricus bisporus*) has 3.68 per cent protein. Oyster mushrooms are rich in protein and the quality of protein is nearly equal to animal derived protein (Natures janitor,2010).

Mushroom protein are comparable to muscle protein in nutritive value. Being a good source of vitamins and proteins it is considered to be a distinct food. The digestibility of proteins in these is 72-83 per cent (Kushalappa,2010).

Mushrooms form an excellent source of high quality proteins comprising most of the essential amino acids in good proportion as well as vitamin and minerals (Richardson, 2000).

The average total free amino acid in edible and medicinal mushrooms are 120.79 and 61.47 mg/100 gm respectively (Kim et al., 2009)

Ogawa (1993) detected amino acids such as cystine 1.74 mg/100 gm fresh weight , histidine 2.25 mg and leucine 5 mg, fifteen bound amino acids cystine, histidine, lysine, aspartic acid, serine, glysine, glutamic acid, alanine, hydroxy praline. methioniine, praline, phenyl alanine, valine, isoleusine and leucine in mushrooms.

Amino acids viz. cystein 1.74 mg/100 gm (fresh weight) histidine (2.25 mg) lysine (4.77 mg) arginine (12.13 mg) metheonine (5.56 mg) phenyl alanine (5.46 mg) and leucine (5 mg) are reported in mushrooms (Ogawa,1993).

Fat

According to Starton (1990) mushrooms have almost no fat. Mushroom is a low fat food containing 1.1-8.3 per cent fat on dry weight basis. Mushrooms contain all the classes of lipids including free fatty acids, glycerides, sterols and phospholipids Kumary and Murthy (2002). It is apparently clear that 72 percent of the total fatty acids in mushrooms are unsaturated. The high unsaturation is attributed to the presence of linoleic acid that, accounts for 76 per cent in *L.edodes*, 70 per cent in *Volvariella volvaceae* and 60 per cent in *A. bisporus.* (Ranote et al., 2007).

Essential fatty acid of n-3 series namely linolenic acid was higher in *pleurotus ostreatus*, which may be considered as health promoting factor in mushrooms (Murakava et al., 2007).

Fibre

Oyster mushroom contains as much fiber as one medium tomato (Natures janitor, 2010). 100 gm dried mushroom contains 26 g of fiber (Shelly et al, 2008). Kelvin (1991) found that crude fibre content was 0.95-1.10 per cent on fresh weight basis. Fibre content in *Pleurotus* species ranged between 0.7 and 1.3 per cent on fresh weight basis. On dry weight basis *Pleurotus species* was reported to contain 7.5-27.6 per cent fibre (Turner, 1993).

Vitamins

Mushrooms are an excellent source of B complex vitamins including riboflavin, niacin, pantothenic acid, thiamine, biotin, folate and vitamin B12 (Park and Ho, 2001; Ranote et al., 2007). According to Goyal (2002) 100 g of mushroom seems to take care of daily requirement of thiamine of an adult where as 25-40 g of mushroom can meet the daily requirement of riboflavin of an adult.

Oyster contains 4.8 mg of thiamine, 4.7 mg of riboflavin and 108.7 mg niacin per 100 g of mushroom (http://www.driedmushroom.US/oyster mushroom) Bano and Rajarathnam (1988) reported that thiamine content was 1.4-2.2 mg , niacin 6.06-7.0 mg, riboflavin 6.7-9.0 mg , pantothenic acid 21.2-33.3 mg and folic acid 1.2-1.4 mg in 100gm of dried mushroom. Niacin which is the most abundant vitamin in mushrooms ranged from 81-135 mg/100 g of dried mushroom (Stroller and Hall, 1988).

Randhawa and Ranote (2004) found that ascorbic acid content of *Plerotus florida* and *Pleurotus sajor caju* was 5.4 and 5.1 per cent respectively of fresh weight basis. Rai and Saxena (1989) stated that vitamin C content in *Pleurotus sajor caju* and *Pleurotus ostreatus* was found to be 4 and 3 mg respectively per 100 g of mushroom on fresh weight.

Oyster mushrooms produce large amount of vitamin D when exposed to uv light (Bowerman and Susan (2008); Koyyala mudi et al. (2009) and Lee et al. 2009). The mushroom is the only vegetarian source of vitamin D in edible form (Nita , 2009).

Qutila et al. (1999) found that ergocalciferol in mushrooms increase serum 25 hydroxyl vitamin D concentrations as effectively as supplements, allowing mushrooms to be recommended as a natural source of vitamin D. Pro vitamin D is present in some edible mushrooms particularly Shiitake and can be converted to vitamin D by ultraviolet rays.

Minerals

Oyster mushrooms contain most of the mineral salts required by the human body (Stephanie, 2002). Mushrooms contain several key minerals including copper, potassium, niacin and folate (Marion, 2006). Oyster mushroom contain most of the mineral salts that are required by the human body. Calcium, phosphorus and iron content in oyster mushrooms is double the amount available in beef, pork and chicken meat.

Like most vegetables, mushrooms are rich in minerals as may be evident from their ash content 8-10 percent in *Agaricus bisporaus,* 5-15 per cent in *Pleurotus spp,*11-15 per cent in *Volvariella volvacea* and 7.0 per cent in *Lentinus edodes.* Most abundant mineral present in mushroom is potassium (45 percent of total ash content), followed by phosphorus, sodium, magnesium and calcium which together constitute about 56-70 percent of total ash content (Chang and Miles, 1989)

The nutritional analysis of the button mushroom has showed that they contain 22 mg of calcium, 80 mg of phosphorus, 5 mg of iron per 100 gm of fresh sample (Kushalappa, 2010). Sarker et al. (2007) reported that 100 gm of fresh oyster mushroom contains calcium as 2400 ppm, zinc 30.92 ppm, iron 118.40 ppm, copper 3.75 per cent, potassium 1.3 per cent, sodium 0.19 per cent, phosphorus 0.97 per cent.

Husseyin et al. (2009) reported that the calcium content of dried mushroom as 0.17-8.80, potassium 12.6-29.1, sodium 0.03-4.85, phosphorus 0.64-4.49, zinc 26.7-185, iron 50.1-842 and copper 9.23-107 mg/100gm.

The mineral content of *Pleurotus* species as reported by Caglarirmak (2007) were (mg/kg wb) calcium 23.66-81.16, sodium 750.77-773.67, potassium 2225.00-2687.00, phosphorus 716.31-998.47, iron 7.94-14.80, zinc 9.31-11.18 mg.

Shelly et al. (2008) reported that the dried mushroom contains 3.90 per cent and 1.94 per cent Na and P respectively and it also contains K 3.70, Ca 23.8, Mg 20.29, Fe 29, Cu 30.10 and Zn 21.31 mg /100 gm.

Among edible mushrooms, *Agaricus bisporus* has the highest sodium content. The magnesium and calcium content ranged from 57.4-106.2 and from 11.8-162.2 mg/100g of dried mushroom and the Na & K content ranged from 23.8-162.8 and from 2132-5809 mg/100g dried mushroom respectively (Losato et al.,1988). Nita (2009) stated that selenium is mainly found in animal proteins so the mushrooms is the best source of selenium for vegetarians. Selenium content ranged from 0.63-16.08 mg/100g died mushroom (Losato et al. 1990).

Edible mushrooms contain higher amount of heavy metals than plants (Demirbas, 2000). Many mushroom species are known to contain heavy metals such as cadmium, lead or mercury. From the point of view of Svoboda et al. (2002) the heavy accumulation of cadmium, lead or mercury in some edible mushrooms is of great concern in human health.

2.3.MEDICINAL VALUE OF MUSHROOMS

Oatman (2000) reported that there may be 20,000 species of mushroom of which 2000 are nutritionally edible and about 300 are known to be medically active..

King (1993) reported that mushrooms are functional food and a source of physiologically beneficial and non toxic medicines. Attempts have been made in many parts of the world to explore the use of mushrooms and their metabolites for the treatment of a variety of human ailments (Losato,1988). According to Halpern et al. (2002) mushrooms have a long history in traditional Chinese medicine as well as traditional Tibetan medicine.

Chang and Miles (1989) and Rai et al. (2003) have reviewed the antibiotic activities and hyperlipidemic effects of mushrooms and found that mushrooms are anti carcinogenic, hypolipidemic, hypo cholesterolemic and anti hypertensive.

Mushrooms are low calorie food with very little fat and are highly suitable for obese persons. The fat content is low but rich in lenoleic acid and deficient in cholesterol, which makes mushroom suitable for heart patients (Rai et al., 2003).

Oyster mushrooms are suitable for people with high blood pressure, obesity and diabetes due to their low sodium/ potassium ratio, starch, fat and calorific value (Flat, 2010).

2.3.1.Hypo cholesterolemic effect of mushrooms

Mori et al. (2008) reported that edible mushrooms depict blood cholesterol reducing properties. Flat (2010) stated that oyster mushrooms are natural sources of statin, a cholesterol lowering drug. Studies have shown that they typically contain 0.4-2.7 per cent statins. Oyster mushrooms found to lower cholesterol (Dill, 2007). According to Luthra et al. (1991) *Agaricus bisporus* has the medicinal value of lowering plasma total lipid, cholesterol and glyceride level. The best known therapeutic agent reccomended for correcting hyper cholesterolemia is levostatin and its analogues.

Fukushima et al. (2000) reported that *Agaricus bisporus* has the ability to lower serum cholesterol, VLDL, HDL and LDL cholesterol concentration. Bhandari et al. (1991) reported that dried *pleurotus florida* incorporated at 5per cent or 10 per cent level in hyper cholesterolemic diet in albino rats resulted in lowering cholesterol and glyceride levels in plasma without effecting on free fatty acid and phospholipids levels and hence considered to be good hypo cholesterolemic agent.

Chihara (1993) recommended mushrooms for people with cholesterol related ailments as it contains anti morigenic and hypo cholesterolemic agents. Grunde and Cimerman (1995) found that recent research has found that the oyster mushroom naturally contains the cholesterol drug lovastatin.

According to Jones (1997) Shiitake and Maitake mushroom lower serum cholesterol levels. Garcha and Khanna (2003) reported that button mushroom and oyster mushroom are known to lower the plasma lipid/cholesterol levels and protect against the development of atherosclerosis, a heart disease. Mori et al. (2008)

pointed out that supplementation of mushroom prevents the development of atherosclerosis.

According to Borchers et al. (2008) the ability of some mushrooms to inhibit tumor growth and to enhance immune system has been a subject of research for approximately 50 years.

2.3.2.Hypoglycemic effect of mushrooms

Rai et al. (2003) reported that mushrooms are considered as "delight of diabetic" since mushrooms are low calorie, high protein food with almost no starch and sugars. According to Wiley (1995) Maitake has also been shown to be beneficial in reducing blood sugar level.

P.ostreatus posses hypoglycemic effects in human subjects (Khatun et al., 2007). Study conducted by Kress (1991) indicated that mushrooms contain more mannitol and hence highly suitable for diabetics.

2.3.3.Hypertensive action of mushrooms

Dill (2007) viewed that due to low sodium concentration enhancing mushroom consumption can be recommended for persons suffering from hypertension. Jones (1997) reported that Shiitake mushroom have the ability to lower blood pressure. According to Tam et al. (1986) an aqueous extract from *Pleurotus sajor caju* has been shown to exhibit hypertensive action .

Due to alkaline ash, high potassium, sodium ratio and high fiber content, mushrooms are suitable for people with hypertension, hyper acidity and constipation (Rai et al., 2003).

2.3.4.Carcinogenic effect of mushrooms

Edible mushrooms have the ability to fight against tumour activity (Nayana et al., 2002). Hetland et al. (2008) reported that the mushrooms may stimulate the immune system and exhibit anti cancer activity.

Hobbs (1997) reported that in Japan, Russia, china and USA several anti tumour agents have been developed from the fruiting body and mycelia of *Lentinus edode*, the antitumour activity of *L.edode* is due to the presence of polysacharides, base proteins, quinoid base and acid proteins in the mushroom and poly acetylene from oyster mushroom.

According to Fullerton et al. (2000) the proteins from *Volvariella volvacea* could inhibit the respiration of tumour cells. Randhava and Ranote (2004) reported that quinoid derivatives from *P.ostreatus* and *A.bisporus* are found to have anti tumour activity. Borchers et al. (1999) reported that the compound in particular (1-3) beta glucans present in whole mushrooms and isolated mushroom exert tumor inhibitory effects.

Coriolus versicolor is a medicinal mushroom widely prescribed for the prophylaxis and treatment of cancer and infection in China (Chu et al., 2002). Mizuno (1991) reported that number of mushrooms serve as sources of anti cancer drugs. Recent research indicates that common white button mushroom exhibit potential to fight cancer (Maier, 2010).

Garcha and Khanna (2003) reported that polyacetylene from oyster mushroom and quininoid from *Agaricus bisporus* are found to have anti tumour activity.

Benfield (1997) reported that Reishi has been called as an immune potentiator and enhance the production of interleukin -1&II. He has also reported that Reshi extracts exerted an inhibitory effect on tumour growth. According to Jones (1997) Maitake *(Grifola frondosa)* helps to stimulate the immune system of cancer patients and possess anti cancer benefits when used consistently as a food or tea.

Nyana et al. (2002) explained the therapeutic use of mushrooms for the prevention and control of cancer and cardiovascular disease. Cohen et al. (2002), Periyassamy and Natarajan (2002) had reported that *Pleurotus pulmonarius* act as an anti tumour agent. Sone (1992) reported that the *Volvariella volvacea* has the anti tumour activity.

Hobbs (1995) reported that the presence of complex polysaccharide in mushroom structure have the unique ability to act as immune modulators and are valued for their potential role in cancer and AIDS treatment .

Zhang et al. (2009) reported that mushroom extracts have been shown to possess anticarcinogenic properties and to stimulate immune response. *Pleurotus ostreatus* suppresses food-borne carcinogen, inflammation-induced colon carcinogenesis and inhibits endotoxemia in mice (Sliva et al., 2009)

Zhang et al. (2009) found that dietary intake of mushrooms decrease breast cancer risk in pre- and postmenopausal Chinese women. Research has also shown

oyster mushroom has anti cancer properties. In vitro research has shown oyster mushrooms can reduce the growth of human breast cancer and colon cancer cells (Jedinak and Sliva, 2008).

In 2009, a phase I/II human trial, conducted by Memorial Sloan- Kettering Cancer Center, showed maitake mushroom could stimulate the immune systems of breast cancer patients (Deng et al., 2009). According to Chinese medicine, mushrooms enhance immunity and convert cancer cells to normal cells because they contain a compound called beta glucan (Konno, 2004)

According to Dikkie (1989) mushrooms are rich in fibre and useful in preventing many non nutritional disorders like constipation, diverticulus and duodenal cancer.

2.3.5.Other medicinal properties of mushrooms

According to Nair (1991) the prominent medicinal ingredient of mushrooms are polysaccharides which are different in their composition, mode of connection, degree of ramification and polymerization that have the effect of strengthening health and immunity. Oyster mushroom stimulate the immune system (Nozaki et al., 2008).

Kodama et al. (2005) recommended consumption of edible mushrooms in the daily diet as it improve health, and modulate immunity. An in vivo experiment showed that mushrooms could stimulate both the innate immune system and adaptive immune system (Kodama et al., 2004).

According to Hobbs (1997) watery extract of whole mushroom is reported to hinder blood coagulation. Jiskani (2001) reported that mushrooms behave as adaptogens performing broad based actions supporting the function of nervous, hormonal and immune systems.

Shuoji et al. (2004) stated that adaptogens boost body's resistance to toxic environmental influences, stress and pathogens like bacteria and viruses and are especially noted for their ability to build endurance and reduce fatigue.

The edible mushroom *P.pulmonarious* has anti oxidant and anti inflammatory effects, (Cohen et al., 2002; Periyassamy and Natarajan, 2002). Jose et al. (2002) reported that methanol extract from *pleurotus pulmonarious* possess significant anti oxidant activity. Total phenols are the major naturally occurring antioxidant components found in methanolic extracts of medicinal mushroom (Mau et al., 2002 and Volentao et al., 2005).

According to Li et al. (2007) *P.cystidiosus* has strong antioxidant activity. Barros (2007) has pointed out that mushrooms have antimicrobial activity due to the presence of phenols and flavanoids.

Antioxidants in mushroom include ergothionine, and exhibit anti biotic, antifungal and antimicrobial properties (Nta, 2009). Rai (1995) found that edible mushrooms show various anti bacterial, anti fungal, anti protozoal and anti viral effects. Garcha and Khanna (2003) reported that polysacharide from Oyster mushroom and quinoid derivatives from Button mushroom have antibacterial and anti protozoal activity.

According to Dharmandra (1996) the compounds like hemicelluloses, polysaccharides, peptides, nucleotides, complex starches and other metabolites found in some of the edible as well as medicinal mushrooms are classified as most defense potentiator (HDP). According to Chilton (1993) both cellular components and secondary metabolites of a large number of mushrooms have been shown to effect the immune system of host and therefore could be used to treat a variety of disease conditions.

Chang (1992) reported that *Agaricus bisporus* was shown to be especially rich in tryptophan which is an anti depressant dietary additive and pain killer. Clinical studies conducted in China during 1990's among 2000 patients with chronic bronchitis, revealed that a tablet form of Reishi syrup shown marked improvement within two weeks among 60 to 90 per cent of the patients (Stanislaus, 1996).

According to Weley (1995) maitake has been shown to be beneficial in obesity and constipation . Hobbs (1995) recommended intake of 3-7 g of maitake per day in tea or in soups and other dishes as a general health supplement.

2.4.PROSESSING AND VALUE ADDITION OF MUSHROOMS.

Mushrooms are gaining immense popularity and the consumers demand for variety has led to the development of readymade or value added processed foods from mushrooms (Kumar and Barmanray, 2007).

Chaliha (2007) pointed out that mushrooms being highly perishable development of appropriate storage and processing technology of great significance in order to extend the marketability and availability of mushrooms.

Harsh and Joshi (2008) reported that value added products from mushrooms offer promising enterprises. Drying, canning and freezing are initially accepted methods of mushroom preservation. (Randhava and Ranote, 2004).

Chandra and Smasher (2002) were of the view that dehydration appears to be a promising and cost effective method of preservation for mushrooms in the Indian condition as dehydrated mushroom are easy to transport as compared to canned, pickled and frozen product. According to Ranote et al. (2007) mushrooms have their potential to replace traditional items like burger, patties, cheese sandwiches, stuffed dosa, biriyani, fritters, omelets and poached eggs and these products are gaining importance day by day.

Edible mushrooms are used extensively in cooking, in many cuisines (notably Korean, European, Chinese and Japanese). Their flavor normally intensifies during cooking and their texture holds up well to usual cooking methods (Craig, 2003).

Mane et al. (2000) reported that dried mushroom powder made either from *Pleurotus spp* , *Agaricus bisporus, Calocybe indica* can be incorporated to various conventional recipes to increase their nutritional quality . Mushroom powder can be incorporated with wheat flour , maize and millet flour to make rotis and bread for daily consumption. Mushroom powder act as a good supplementary food item to cereal and millet preparations .

According to Indian food industry (1998) India engaged in processing and marketing of wet and dry mushrooms and their products has launched mushroom biscuits of different taste and flavour. Randhava and Ranote (2004) reported that fresh button mushroom was preferred over oyster mushroom for the making of mushroom soup powders.

Tyagi and Nath (2005) had developed food products like sev, papad, biscuits, chutney and pickles acceptable to the Indian palate using *Pleurotus* mushrooms. Craig (2003) stated that it is popular to add mushrooms to soups, salads and sandwiches or to use them as an appetizer. This also add an appetizing touch to vegetable based casseroles and stews.

Joshi et al. (1991) reported that mushroom can produce products like chutney, soup etc. He has of the opinion that lactic acid fermentation of mushroom for preservation and preparation of sauce. A highly nutritious, energetic and ready to serve soup can be prepared by binding the mushroom powder with whey (Singh, 1994).

Joshi et al. (1991) prepared sweet chutney from edible mushrooms having a shelf life of over one year with better sensory qualities. Standardized *Pleurotus* mathri is a new value added product, formulated using 10 g *Pleurotus* powder 90 g refined wheat flour (maida), 2.0 g of salt 0.5 g baking powder , 35 ml water and 200 g hydrogenated vegetable oil (Kumar et al., 2006).

Khader and Pandmavathi (1991) reported that mushroom can also be utilized in the preparation of various weaning foods. Sharma et al. (1991) reported that soup powder can be prepared with different mushroom varieties.

Value added products from mushroom is a promising enterprise especially for the unemployed educated woman because it is basically an indoor activity and can be effectively managed by woman. More over mushroom could be popularised both in rural and urban sector (Chaliha, 2007). Value added products will not only

cater to the protein and micronutrient requirement but at the same time will enable the population to live a healthy life

Materials and Methods

3. MATERIALS AND METHODS

The present study entitled "Evaluation of nutritional quality and health benefits of Oyster mushroom" (*Pleurotus florida)* was conducted in a systematic manner and the methodology adopted is discussed under the following headings.

3.1.Selection of mushroom
3.2.Conduct of the study
3.3.Quality evaluation of oyster mushroom
3.4.Prossessing treatments applied to account nutrient loss in oyster mushroom
3.5.Assessment of health benefits of oyster mushroom
3.6.Statistical analysis

3.1.SELECTIION OF MUSHROOM

Most versatile and commercially cultivated oyster mushroom *(Pleurotus florida*) was selected purposively for the study. The study material was collected from the Instructional Farm, College of Agriculture, Vellayani and also from the local mushroom growers in Thiruvananthapuram (Plate 1).

3.2.CONDUCT OF THE STUDY.

The study was carried out in two experiments. Under the first experiment quality evaluation of oyster mushroom and the effect of processing on the nutrient composition and chemical constituents of oyster mushroom was studied. The health benefits of oyster mushroom was investigated in the second experiment through case studies conducted among selected human volunteers.

3.3. QUALITY EVALUATION OF OYSTER MUSHROOM

Chemical and nutritional composition of the oyster mushroom is a major parameter influencing the quality of mushroom. Nayana et al. (2002) reported that oyster mushroom *(Pleurotus florida)* is a delicious edible mushroom with valuable therapeutic values and is considered as a functional food

3.3.1.Assessment of chemical and nutritional composition.

In the present study macro and major micro nutrients present in the fresh and processed oyster mushroom were estimated. Nutrients such as calorie, total carbohydrate, protein, fat, vitamins viz. vitamin C, B complex vitamins viz thiamine, riboflavin and niacin were the estimated nutrients. minerals and trace elements viz. iron, calcium, phosphorus, sodium, potassium, zinc and copper were also ascertained in the mushroom under study. Apart from the above, chemical constituents such as fiber, tannin, poly phenols and moisture were also assessed in the fresh and processed mushroom.

3.3.1.1.Estimation of macro nutrients in oyster mushroom

Oyster mushroom is considered as a rich source of carbohydrate, protein and fat (Jiskani, 2001 and Buigut, 2002). Calorie content of the fresh and processed oyster mushroom was analyzed in the bomb calorimeter while carbohydrate and fat were estimated by the method suggested by Ranganna (2001). Protein was determined by Lowrys method (1951).

Plate- 1 Fresh oyster mushroom (*Pleurotus florida*)

3.3.1.2. Evaluation of mushroom protein

According to Ghosh and Chakravarty (1990) the quality of proteinaceous food depends on its amino acid composition in relation to the protein content and digestibility. Amino acid composition may also serve as a good relative measure to compare mushroom with other food stuffs of established nutritive value. In the present study the quality of protein in mushroom was analyzed in detail by estimating amino acid content of the test protein through HPLC method. Total of 18 amino acids including 8 essential amino acids were determined. Based on the essential amino acid content, amino acid score (AAS), essential amino acid index (EAA index), nutritional index (NI), were also computed.

Essential amino acid index is the ratio of essential amino acids contained in a food to the essential amino acid content in reference protein(Ghosh and Chakravarty,1990). In the present investigation, EAA calculations were done following the method as advanced by Oser (1959). Amino acid score also called chemical score, is considered as second alternative to the animal feeding studies for the determination of nutritional value. It is based on the amount of limiting amino acid present in the test protein in relation to its presence in reference protein. Amino acid score was calculated using the following formula.

$$\text{Amino acid score} = \frac{\text{mg of amino acid/ gm test protein}}{\text{mg of amino acid /gm reference protein}} \times 100$$

In the present investigation the EAA index was computed using the formula given below

$$\text{EAA index} = \frac{\text{Geometric mean of amino acids in the mushroom}}{\text{Geometric mean of amino acids in reference protein.}} \times 100$$

Nutritional index (NI) based on the protein quality was also computed in the present investigation by using the formula presented by Crisan and Sanda (1978).

$$\text{Nutritional index(NI)} = \frac{\text{EAA index x \% protein}}{100}$$

3.3.1.3.Estimation of vitamins in oyster mushroom

Mushrooms are excellent sources of B complex vitamins including thiamine, riboflavin, niacin, pantothenic acid, folate etc with fair source of vitamin C (Ranote et content al., 2007).

In the present experiment, B complex vitamins viz.. thiamine, riboflavin and niacine were estimated by flurimetry. While vitamin C was determined by the method suggested by Ranganna (2001).

Table:1 Methods adopted for the determination of nutrients and other chemical constituents in oyster mushroom

Nutrients/chemical constituents	Methods adopted
Calorie(kcal)	Bomb calorimeter
Total carbohydrate (g)	Ranganna(2001)
Protein(g)	Lowrys method(1951)
Total fat(%)	Ranganna(2001)
VitaminC (mg)	Ranganna(2001)
Thiamine(mg)	Flourimetry method
Riboflavin(mg)	Flourimetry method
Niacin (mg)	Flourimetry method
Total ash(g)	Sadashivam and Manikkam(1992)
Calcium(mg)	Sadashivam and Manikkam(1992)
Phosphorus(mg)	Flame photometric method.
Sodium(mg)	Flame photometric method.
Potassium(mg)	Flame photometric method.
Iron(mg)	AOAC method(1990)
Zinc(mg)	AOAC method(1990)
Copper(mg)	AOAC method(1990)
Moisture (%)	AOAC method(1990)
Fiber(g)	AOAC method(1990)
Tannin(mg)	Sadashivam and Manikkam(1992)
Totalpolyphenols(mg)	Sadashivam and Manikkam(1992

3.3.1.4.Estimation of minerals and trace elements in oyster mushroom

Mushrooms are acclaimed to be top in various minerals viz iron, calcium, phosphorus, sodium, potassium, zinc and copper (Ghosh and Chakravarti, 1990). In the present study, minerals such as phosphorus, sodium, potassium, were determined by flame photometry. Calcium was determined by the method suggested by Sadashivam and Manikkam (1992). Iron, zinc and copper were determined by AOAC method (1990).

3.3.1.5. Estimation of other constituents in oyster mushroom

Moisture content of oyster mushroom was recorded as it is an indicator of freshness of the mushroom. Moisture and fiber content was determined by AOAC method(1990) and other chemical constituents viz tannin and poly phenols were determined by method suggested by Sadashivam and Manikkam (1992).

3.3.2. IF Positives and anti oxidant property of oyster mushroom

IF (Inflammation factor) positives or IF rating provides an estimation of the particular food's effect on inflammation process in the body. IF positives are denoted by the presence of known anti-inflammatory nutrients two including vitamin C, folate, zinc and selenium. Among the anti inflammatory nutrients, vitamin C and zinc was determined in the mushroom under study.

Anti oxidants are substances or nutrients in the foods which can prevent or slow the oxidative damage to our body. When our body cells use oxygen, they

naturally produce free radicals which can cause damage. Anti oxidants act as free radical scavengers and prevent and repair damage done by the free radicals (Tsang, 2005).

There are many chemicals that perform as antioxidants such as vitamin C and vitamin E, beta carotene, selenium and poly phenols. Krumm (2009) pointed out that mushrooms are good source of antioxidants such as vitamin C, vitamin E selenium, ergothionine, and poly phenols.

In the present study tannin and poly phenols present in the oyster mushroom were determined apart from vitamin C.

3.4.PROCESSING TREATMENTS APPLIED TO ACCOUNT NUTRIENT LOSS IN OYSTER MUSHROOM.

Mushrooms are generally cooked within no time. Simple cooking methods viz. boiling, blanching, steaming and drying are followed for cooking mushrooms. In the present study nutritional quality of the mushroom after processing and the nutrient loss were ascertained.

3.4.1.Boiling

Boiling is the simplest method in which foods are cooked in a liquid at boiling point. While adopting boiling method, water soluble vitamins will be partially lost (Dake, 2009). In the present study mushrooms were cut in to small pieces and boiled for 10 minutes and nutrients were estimated in order to account the nutrients loss.

3.4.2.Blanching

Blanching is a simple technique used to keep vegetables crisp and tender (Bertholle et al., 2001). Blanching preserves texture, colour and flavour and is used as a pre treatment for various purposes. In the present study, cleaned mushrooms were cut in to pieces and tied in a muslin cloth, and dipped in boiling water for two minutes.

3.4.3.Steaming

Steaming is the cooking of food by the application of steam (Vallejo, 2003). In this cooking process, the food is put into a steamer, which is a cooking utensil that consists of a vessel with a perforated bottom, placed over a vessel containing water. As the water boils, steam rises and cooks the food in the upper, or perforated vessel. Steaming is preferable to boiling because there is no loss of mineral salts. The flavour retention is also more in steamed foods. In the present experiment, cleaned mushrooms were cut in to pieces and steamed for 5 minutes.

3.4.4.Drying

Sun drying is the traditional method for reducing the moisture content of food by spreading the food in the sun (Flickety, 2011).

In the present study, cleaned mushrooms were cut in to pieces and dried in the open sun spreading over a tray till it is crisp. Care was taken to avoid dust particles to settle over the mushrooms, by covering a thin sheet.

3.5. ASSESSMENT OF HEALTH BENEFITS OF OYSTER MUSHROOM

To assess the health benefits of oyster mushroom, supplementation study was carried out in which dried mushroom supplement was prepared in the laboratory and distributed for consumption to the selected human volunteers with specific disease condition.

3.5.1. Formulation of the mushroom supplement

Oyster mushroom was sun dried, powdered in a grinder and sieved using a fine mesh of about 10x size. No chemicals or preservatives were added to the mushroom powder. Dried mushroom powder was packed in five g sachet for distribution to the respondents selected for the case study (Plate 2) . Bhandari et al. (1991) reported that dried *P.florida* incorporated at 5 per cent or 10 per cent level in hyper cholesterolemic diet in albino rats resulted in lowering the lipids, cholesterol and triglyceride levels in plasma.

3.5.2.Standardization of recipes with mushroom supplement

Various recipes were standardized in the laboratory incorporating mushroom supplement, in order to ensure the prompt inclusion of the supplement in the diet of respondents.

Recipes standardized with mushroom powder were commonly consumed popular breakfast dishes like dosa, idly, chapatti etc (Plate 3). Apart from the above, other dishes like chutney powder, rice, curd, and black tea were also standardized in the laboratory (Plate 4). In all the recipes five g of mushroom powder was incorporated, which neither alter the texture nor the acceptability of the preparation.

Plate- 2 Mushroom supplement

Plate-3

Standardized recipes with mushroom supplement

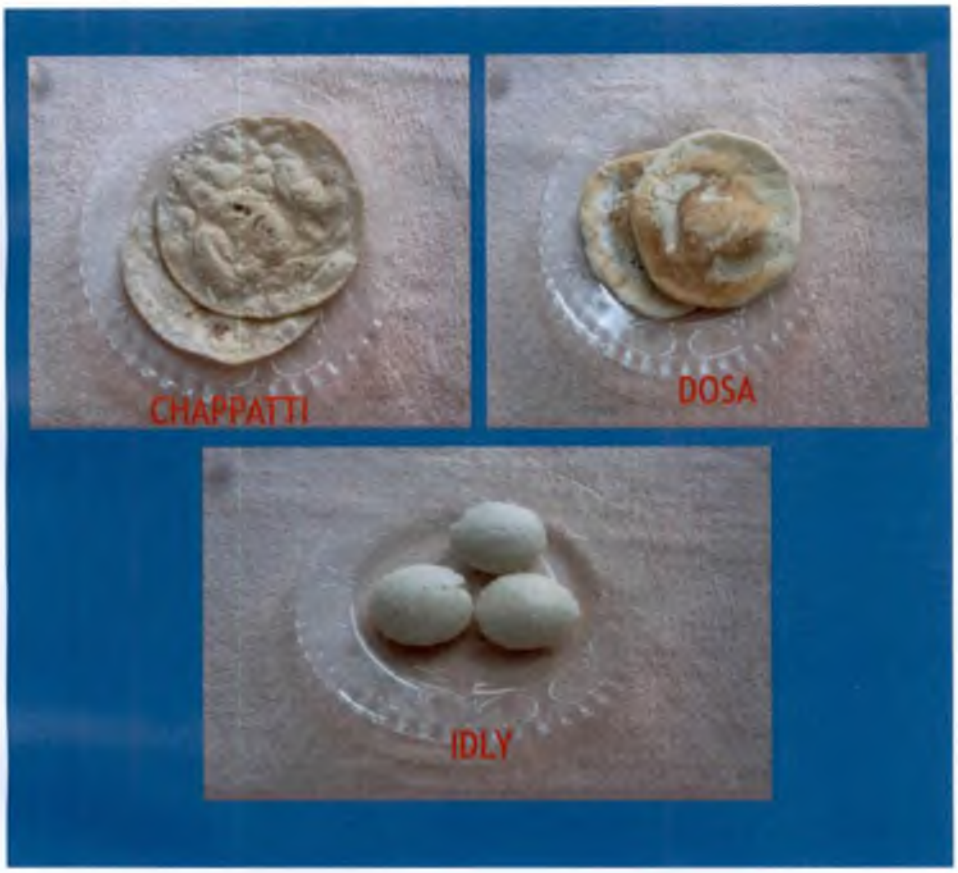


Plate-4
Standardized recipes with mushroom supplement

3.5.3Conduct of case studies.

3.5.3.1.Selection of subjects for the case study

In the present experiment subjects were selected for investigating the effect of mushroom supplement on three disease condition viz. Hyperglycemia, hyperlipidemia, and hypertension. For each disease condition two subjects with similar clinical parameters were selected. Subjects were identified through personal interview based on the following criteria.

i. Willingness to co operate in the study
ii. Age between 40-55
iii. subjects with similar sex for each disease condition
iv. Blood profile of the subjects

Disease condition	Blood profile
Hyper gycemia	Fasting blood sugar 140 mg and above
Hyper lipidemia	200 mg/dl and above
Hyper tension	120/80 mmHg and above

v. Persons who are not under medication for the hyperglycemia, hyperlipidemia and hyper tension.

The investigator screened more than 100 respondents for the initial screening from the faculty members of the college of Agriculture, Vellayani and also outside

Plate -5 Subjects under case study

the campus. A list of hyperglycemic, hyper lipidemic and hypertensive subjects was prepared. From among the above list, person under medication were deleted. Following the criteria suggested for selection of two subjects each for three disease condition were screened. After selection, preliminary information regarding their medical history, socio economic background, dietary and life style pattern were collected through a suitably structured pre tested questionnaire (Appendix 1).

3.5.3.2. Socio economic profile

The socioeconomic profile of the subjects such as socioeconomic level, religion and family background in general has a very distinct part to play in determining attitude and food consumption, health and behavioural pattern of the individual (Arrora, 1991).

The socio economic profile collected from the subjects were family size, type of family, educational status, occupation of family members, total monthly income, income spent on food and health care etc.

Details regarding socioeconomic profile of respondents were collected using a pre tested schedule through personal interview.

3.5.3.3. Medical and health status

Details on the medical history of the subjects, food consumption pattern, use of medicines, other personal habits like alcohol consumption, smoking, chewing pan etc were collected through the interview schedule. Investigation on the blood glucose, lipid profile and blood pressure of the respondents were estimated. Nutritional status of the respondents were estimated through anthropometry.

Anthropometric measurements relevant to the study include height, weight, waist and hip circumference. Measurements were recorded using standard technique as detailed below.

3.5.3.3.1.Measurement of height

The height is a measure of longstanding nutritional status. To determine height, an anthropometric rod was fixed vertically on a smooth wall, perpendicular to the ground taking care to see that the floor area was clean and smooth.

The subjects were asked to remove their slippers and to stand with the centre of the back touching the wall with feet paralleled and heels, buttocks, shoulders and back of head touching the wall. The head was held comfortably erect, the arms hanging closely by the side.

A smooth, thin ruler was held on the top of the head in the centre crushing the hair at angles to the wall and the height read off from the lower edge of the ruler to the nearest 0.5 cm. Each reading was taken twice to ensure the correctness of the measurement.

3.5.3.3.2.Measurement of weight

Weight is the measurement of body mass (Gopalan, 1988). Body weight is the most widely used and simplest reproducible anthropometric measurement for the evaluation of nutritional status of individuals. Weight was measured using a platform balance.

3.5.3.3.3.Waist and hip measurement

According to Lean et al. (1995) waist circumference is used as a measurement that indicates the need for weight measurement. In the present study, the circumference of waist was measured by passing a fiber glass tape around the waist and for hip measurements, the circumference of hip at the maximum point of proleons was measured using fiber glass tape as per the technique suggested by Bray (199I)

3.5.3.3.4.Waist hip ratio

After recording waist and hip measurements of the subject, waist hip ratio of the subjects were calculated by dividing the circumference of hip by waist as suggested by (Chanda et al., 1995)

3.5.3.3.5.Body Mass Index

Body mass index is used as a good indicator of nutritional status. From the recorded height and weight, body mass index was computed. It is expressed as the ratio of weight to height square.(weight(kg)/height(m^2)) (Delpeuch, 1992).

3.5.3.4. Current dietary pattern

According to Swaminathan (1993) through diet surveys, information on nutrient intake level, sources of nutrients, food consumption pattern and preferences of the subjects could be collected. Food habits of the respondents were collected in order to understand whether diet has any influence on their disease condition.

3.5.3.5. Life style pattern

Life style pattern include the personal habits, stress and strain in the daily life, type of food they consume etc. Life style pattern has its own effect on the health of an individual. Personal habits of the subjects such as the consumption of alcohol, smoking etc., were recorded. Data regarding the habit of doing exercise as well as the stress and strain faced by the subject were also recorded.

3.5.4.Diet counseling

'One to one' diet counseling was imparted to the selected six respondents under case study regarding the dietary regime to be followed for the specific disease condition, need for special diet, foods to the restricted for disease condition, importance of mushroom supplement in the diet, how to incorporate the supplement in the diet etc. During the counseling session, incorporation of mushroom supplement in the diet was also demonstrated to the subjects.

3.5.5.Conduct of feeding trial

Mushroom supplement was distributed to the selected subjects for consumption for a period up to three months. Subjects were given five g sachet of mushroom supplement distributed on a weekly basis. Investigator has made good rapport among the respondents and ensured the incorporation of supplement daily in the diet. Investigator also helped to tackle any problem if arised during the course of incorporation of mushroom supplement. Investigator has made interaction with the respondents personally and through phone to know whether the subjects were consuming the supplement regularly. The supplementation study continued for three months.

3.5.6. Assessing the efficacy of the supplement on the medical profile of the selected subjects

Feeding trial over a given period of time is considered as the most reliable method to determine the impact of the food. The feeding experiment was conducted for a period of three months to assess the efficacy of mushroom powder on hyperglycemia, hyperlipidemia and hypertension. Blood profile of the subjects recorded before the introduction of the supplement and after 45^{th} and 90^{th} day of supplementation.

3.6. Statistical analysis

In order to obtain meaningful interpretation, the generated data was subjected to suitable statistical analysis.

Results

4. RESULT

Results of the present study entitled " Evaluation of nutritional quality and health benefits of oyster mushroom" (*Pleurotus florida)* were discussed under the following headings.

4.1. Quality evaluation of oyster mushroom
4.2.Effect of processing on the nutritional value of oyster mushroom
.3.Assessment of health benefits of oyster mushroom

4.1. QUALITY EVALUATION OF OYSTER MUSHROOM

In the present study, quality evaluation of oyster mushroom was ascertained by assessing the chemical and nutritional composition of fresh and processed oyster mushroom.

4.1.1.Assessment of chemical and nutritional composition of fresh oyster mushroom

Nutritional composition and selected chemical constituents present in the fresh oyster mushroom were assessed and results are depicted in table 2.

Table 2. Chemical and nutritional composition of fresh oyster mushroom.

NUTIENTS/100 g	MEAN VALUE
MACRO NUTRIENTS	
Energy (kcal) (d/w)	453
Carbohydrate (g)	4.70
Protein (g)	5.60
Total fat (%)	0.80
VITAMINS	
Vitamin C (mg)	12.4
Thiamine (mg)	5.43
Riboflavin (mg)	8.70
Niacin (mg)	55.9
MINERALS	
Calcium (mg)	12.46
Sodium (mg)	125.0
Potassium (mg)	623.0
Phosphorous (mg)	477.0
Iron (mg)	10.86
Copper (mg)	0.730
Zinc (mg)	1.470
OTHER CONSTITUENTS	
Moisture (%)	90.3
Fiber (g)	3.20
Tannin (mg)	1.40
Polyphenols (mg)	4.30

4.1.1.1.Estimation of macronutrients

Carbohydrate content of fresh oyster mushroom under study was found to be 4.7 g/100 g whereas protein content was recorded as 5.6 g/100 g, which is comparatively higher than those reported in other mushrooms. The fat content of fresh oyster mushroom was found to be negligible and recorded as 0.8 percent.

4.1.1.2.Estimation of Vitamins

Mushrooms are excellent source of B complex vitamins including thiamine, riboflavin, niacin, pantothenic acid, and vitamin C. Vitamin C content of fresh oyster mushroom studied was 12.4 mg/100 g where as thiamine, riboflavin, and niacin content was estimated as 5.43 mg, 8.7 mg, and 55.9 mg respectively per 100 g mushroom.

4.1.1.3.Estimation of minerals and trace elements

Mushrooms are good sources of minerals and it is higher than those present in fruits and vegetables (Cicil, 2000). Phosphorous and potassium are the main minerals found in mushrooms, whereas copper and iron are also present in appreciable amounts (Mayuri, 2009). Other minerals present include sodium, calcium, magnesium, and some of the trace elements.

Calcium content of the oyster mushroom under study was estimated to be 12.46 mg, while phosphorous content was recorded as 477 mg/100 g. Iron content was estimated to be 10.86 mg, whereas sodium and potassium content were 125 mg

and 623 mg respectively. Trace elements estimated were zinc and copper and the values obtained were 1.47 mg and 0.73 mg respectively.

4.1.1.4.Estimation of other nutrients

Other constituents such as moisture, fiber, tannin and polyphenols were estimated in oyster mushroom. Mushrooms are highly perishable commodity, and it contains more than 90 per cent moisture. Moisture content of oyster mushroom under study determined was 90.3 per cent.

Tannin content was found to be 1.4 mg while polyphenols estimated to be 4.3 mcg/100 g. Apart from the above, fiber content of oyster mushroom was found to be 3.2g.

4.1.2. Quality evaluation of mushroom protein

Quality of mushroom protein was reflected through applying the indices such as AAS, EAA Index and NI. In the present investigation 18 amino acids including 8 essential amino acids were estimated and the results are depicted in table 3 compareing with reference protein value.

As indicated in table oyster mushroom contains appreciable amounts of all the essential amino acids. Content of eight essential amino acids viz. isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine were found to be 3.6 g, 5.9 g, 4.9 g, 1.75 g, 10.2 g, 5.2 g, 0.81 g and 3.8 g respectively.

A striking feature is that, the content of essential amino acids viz. leucine, lysine, phenylalanine and threonine were exceptionally higher than that of the reference protein

Table 3. Essential amino acid content of oyster mushroom in comparison with reference protein

Sl:no	Essential amino acids	Amount of essential amino acid content in oyster mushroom(g/100 gm)	Amount of essential amino acids in reference protein egg(g/100 gm)
1	Isoleucine	3.6	4.10
2	Leucine	5.9	5.20
3	Lysine	4.9	4.40
4	Metheonine	1.75	2.10
5	Phenylalanine	10.2	3.60
6	Threonine	5.2	2.50
7	Tryptophan	0.81	0.90
8	Valine	3.8	4.50

Apart from the essential amino acids, other amino acid content determined are given in table 4. Other amino acids present are serine (4.9 g), glutamic acid (17.2 g), proline (3.72 g), glycine (3.6 g), alanine (4.4 g), tyrosine (7.3 g) and histidine (3.2 g). Cystine and arginine were not found in the oyster mushroom studied.

Highest amount of amino acid present in the oyster mushroom was glutamic acid (17.2 g) followed by aspartic acid(10.5 g) and phenylalanine(10.2 g) which is an essential amino acid.

Table 4. Other amino acids present in oyster mushroom

Serial:no	Amino acids	Amount of amino acid content in oyster mushroom(g/100 gm)
1	Aspartic acid	10.5
2	Serine	4.9
3	Glutamic acid	17.2
4	Proline	3.72
5	Glycine	3.6
6	Alanine	4.4
7	Tyrosine	7.3
8	Histidine	3.2

Amino acid composition of oyster mushroom was compared with other two species *P.citrinopleleatus* and *P.sajor caju.* It was noticed that highest value of amino acid in *Pleurotus* species was glutamic acid which was even higher than the other two *Pleurotus* species viz *P.citrinopeleatus* and *P.sajorcaju.*

Table 5. Comparison of amino acid composition of oyster mushroom *P.florida* with *P.citrinopeliatus* and *P. sjaor caju.*

Amino acids	Amount of amino acids g/100 gm		
	P.florida	*P.citrinopeleatus*	*P.sajor caju*
Isoleusine	3.6	1.84	2.04
Leucine	5.9	3.34	3.49
Lysine	4.9	3.19	3.35
Methionine	1.75	1.00	1.19
Phenylalanine	10.2	4.60	3.63
Threonine	5.2	2.8	2.8
Tryptophan	0.81	-	-
Valine	3.8	2.39	2.78
Glutamic acid	17.2	11.13	12.31
Aspartic acid	10.5	4.56	6.17
Serine	4.9	2.6	3.10
Proline	3.72	2.4	2.99
Glycine	3.6	2.75	2.68
Alanine	4.4	3.90	3.66
Cystein	-	6.5	7.1
Tyrosine	7.3	1.78	2.08
Histidine	3.2	1.26	1.20
Arginine	-	3.00	3.03

To understand the protein quality of oyster mushroom amino acid score (AAS) was determined, which is used as a tool to assess protein quality. Based on the essential amino acid content of oyster mushroom, amino acid score(AAS) was computed as per the method suggested by Oser (1959).

Table 6. Comparison of Amino acid score of *P.florida* with *P.citrinopeleatus* and *P.sajor caju.*

Amino acids	Amino acid score		
	P.florida	*P.citrinopeleatus*	*P.sajor caju*
Isoleucine	87.8	54.12	60.0
Leucine	113.46	61.85	64.63
Lysine	111.36	72.50	76.14
Mtheionine	83.33	45.83	52.78
Phenylalanine	283.33	100.0	98.45
Threonine	208.0	98.62	97.24
Tryptophan	90.0	-	-
Valine	84.4	58.29	67.80
Limiting amino acid sequence	**Methionine, valine,isoleucine**	**Methionine, isoleucine,valine**	**Methionie, isoleucine,leucine**

Amino acid score of *P.florida* for each individual amino acid was higher than the other two species. Highest amount of amino acid score of *P.florida* under study was observed for threonine (208.0) and lowest was for methionine (83.33). Next to threonine highest score was observed in leucine (113.46) followed by lysine (111.36), tryptophan (90.0), isoleucine (87.8) and valine (84.4). Amino acid score and sequence of limiting amino acids indicated sulphur containing amino acids in

these mushrooms when whole egg was reference protein. Sequence of limiting amino acids in *P.florida* was methionine, valine and isoleucine.

EAA index of oyster mushroom was computed as mentioned in methodology and found to be 119 while the nutritional index based on the protein quality was determined as 6.42 for the studied oyster mushroom.

4.1.3. Anti inflammatory Factors (IF Positives) and anti oxidant property of oyster mushroom

IF positives present in the oyster mushroom are vitamin C, zinc and selenium. Anti inflammatory nutrients possess anti effects on inflammation process of a food in the body.

The result revealed that the oyster mushroom contain 12.4 mg vitamin C on fresh weight basis. It also contains the anti inflammatory nutrient zinc 1.4 mg on fresh weight basis. IF positive quality of oyster mushroom contribute to its positive impact on health.

Antioxidants prevent the oxidative damage caused to our body to some extent. Antioxidants present in the oyster mushroom other than vitamin C and zinc are polyphenols, tannin and fibre. The poly phenol content of fresh oyster mushroom estimated to be 4.3 mg while tannin and fibre content was found to be 1.4 mg and 3.2 g on fresh weight basis .

4.2. EFFECT OF PROCESSING ON THE NUTRITIONAL VALUE OF OYSTER MUSHROOM

Oyster mushroom was subjected to different processing methods viz, blanching, boiling, steaming, and drying, which are the commonly adopted methods for cooking and processing mushrooms.

4.2.1. Effect of processing on the macro nutrients of oyster mushroom

The oyster mushroom subjected to different processing treatments were assessed with regard to its nutrient content. The result of the changes in macro nutrients with processing are given in table 7.

Data revealed that the calorie content of the oyster mushroom was significantly different when subjected to different processing methods ($F_{3,8} = 442.04$, $P > 0.01$)

Calorie content of the mushrooms treated with different processing methods ranged between 38.9 to 453.0 kcal. It was found that the dried mushrooms depicted highest calorific value with 453.0 Kcal per 100g and was significantly superior to all the other treatments. However, all the other processing treatments T_1 (38.90), T_2 (39.0), T_3 (40.0) were found to be on par with each other though all of them are significantly inferior to T_4. The calorific value was found lowest in T_1 (boiling).

Carbohydrate content of oyster mushroom subjected to different processing methods indicated that the mean values of carbohydrate content of oyster mushroom was significantly different from each other ($F_{4,10}$=4795.213, $P > 0.01$) and the value ranged between 2.0-39.43 g. According to the result, the highest carbohydrate

content was noticed in dried mushroom with a mean value of (39.43 g) and was significantly superior to all the other treatments. A close observation on the various treatments on the carbohydrate content revealed that T_1 (2.0), T_2 (2.46), T_3 (2.86) were on par with each other. The lowest carbohydrate content was observed in T_1 (boiled mushroom) with the value of 2.0 g.

Table 7. Effect of processing on the Macro nutrients of oyster mushroom

Treatment Mean values						
Nutrients	T_1	T_2	T_3	T_4	F value	CD value
Calories(Kcal)	38.90	39.00	40.00	453.0	$F_{3,8}=442.04^{**}$	61.38
Carbohydrate (g)	2.00	2.46	2.86	39.43	$F_{4,10}=4795.213^{**}$	0.2818
Protein (g)	3.00	3.60	3.80	20.43	$F_{4,10}=627.6096^{**}$	0.85
Fat (%)	0.10	0.35	0.65	2.85	$F_{4,10}=12.59^{**}$	1.20

T_1-Boiling, T_2-Blanching, T_3- Steaming, T_4- Drying

** Significant at one percent level, * significant at five per cent level

Percentage loss of carbohydrate was observed to be highest (57.9 per cent)in boiling treatment. The minimum loss was observed in steaming (39.77 per cent) Table (8). Drying enhanced the carbohydrate content of the sample by moisture loss, there by concentrating the carbohydrate content.

Table 8. Percentage loss and gain of nutrients during processing

Nutrients	Boiling	Blanching	Steaming	Drying
Carbohydrate	57.9	48.13	39.77	728.07
Protein	35.07	22.5	17.57	339.07
Fat	80	58.33	13.33	301.67
Vitamin C	73.64	71.5	68.54	65.94
Thiamine	66.24	63.23	54.43	27.83
Riboflavin	68.04	61.54	52.84	18.9
Niacin	62.9	61.37	59.21	9.04
Calcium	66.88	58.55	49.71	64.74
Sodium	41.2	31.56	28.41	331.73
Potassium	28.73	22.69	16	445.23
Phosphorus	26.9	23.74	19.28	76.39
Iron	51.19	41.37	37.38	91.29
Copper	87.31	81.5	76.87	68.56
Zinc	97.88	96.51	96.51	72.36
Moisture	1.52	1.11	1.11	96.13
Fiber	68.73	67.77	53.07	524.77
Tannin	87.98	83.07	75.06	78.9
Polyphenol	24.71	20.11	17.72	138.2

Changes in the protein content of oyster mushroom treated with different processing techniques, revealed that there was significant difference in protein content when applied different processing methods ($F_{4,10}$= 627.6096, P> 0.01). Total protein content of mushroom vary from 3.0-20.43 g. The highest protein content was noticed in T_4 (dried mushroom) with a mean value of (20.43 g) and lowest in T_1 boiled mushroom with a mean value of (3.0 g). A close observation on the various

treatments on the protein content revealed that T_1 (3), T_2 (3.6), T_3 (3.8) were found to be on par with each other.

The data on the loss of protein during processing indicated that the highest loss was observed in boiling (35.07 per cent) followed by blanching (22.5 per cent) and steaming (17.57 per cent) Table (8). Drying enhanced the protein content.

Changes in the fat content of the mushroom treated with different processing technique indicated that fat content fall between 0.10 to 2.85 per cent. When oyster mushroom was processed significant difference was observed in the mean value of fat content ($F_{4,10} = 12.59$, $P > 0.01$).

T_4 (dried) was found to recorded higher fat content (2.85 g) when compared with others, and found to be significantly superior to all the other treatments. Among the four processing treatments, T_1 (boiling) had the lowest value (0.1) of fat, while T_2 and T_3 were 0.35 g and 0.65 g respectively. The loss of fat content was noticed to be highest in boiling method 80 per cent and lowest in steaming 13.33 per cent. As expected drying enhanced the fat value up to 301.67 per cent.

4.2.2.Effect of processing on the vitamin content of oyster mushroom.

Effect of processing methods on the vitamin content of oyster mushroom is depicted in table 9.

As indicated in the table, the mean values of vitamin C content of oyster mushroom treated with different processing technique were found to vary significantly ($F_{4,10} = 1234.49$, $P > 0.01$)and the values ranged between 3.2-20.5. The highest vitamin C content was noticed in T4 (20.5) and lowest in T_1 ((3.2). It was

observed that among four processing treatments, dried mushroom recorded higher vitamin C and that of boiled mushroom showed the lowest. Close observation on the various treatments on the vitamin C content revealed that T_1 (3.2) and T_2 (3.5) were on par while slightly higher value was recorded in T_3 (3.9).

Boiling decreased the vitamin C content of oyster mushroom maximum(73.64 per cent) and the loss was minimum in steaming (68.4 per cent). Drying process enhanced the vitamin C in oyster mushroom as 65.94 per cent.

Table 9. Effect of processing on the vitamin content of oyster mushroom

Treatment mean values						
Nutrients	T_1	T_2	T_3	T_4	F value	CD value
Vitamin C(mg)	3.2	3.5	3.9	20.5	$F_{4,10}=1234.49^{**}$	0.68
Thiamine(mg)	2.53	2.76	3.43	7.53	$F_{4,10}=161.58^{**}$	.525
Riboflavin(mg)	3.33	4.13	5.06	10.73	$F_{4,10}=.7621^{**}$	13.87
Niacin(mg)	22.8	23.73	25.06	61.46	$F_{4,10}=951.44^{**}$	1.36

T_1-Boiling, T_2-Blanching, T_3- Steaming, T_4- Drying

** Significant at one percent level, * significant at five per cent level

Thiamine content of Oyster mushroom subjected to different processing methods varied from 2.53-7.53mg. Significant difference was noted between the treatments ($F4_{,10}$ = 161.58, $P < 0.01$). The highest thiamine content was found in T_4 (7.53) and lowest in T1 (2.53). It was observed that among the four processing treatments, dried mushroom recorded highest thiamine content while boiled

mushroom depicted the lowest thiamine value. Treatments T_1 (2.53), T_2 (2.76) and T_3 (3.43) were on par as far as thiamine content was concerned.

On taking in to account of the percentage loss of thiamin in oyster mushroom under study, highest loss was recorded in boiling (66.24 per cent) and lowest was recorded in steaming (54.43 per cent). Loss of thiamine in boiling and blanching were on par. Drying increases the thiamine content in oyster mushroom by 27.83 per cent .

Changes in the riboflavin content of oyster mushroom subjected to different processing methods were significantly different ($F4, 10 = 762$, $P < 0.01$). Riboflavin content of T_1, T_2, T_3, T_4 were 3.33, 4.13, 5.06 and 10.73 respectively and were on par with each other. The highest riboflavin content after treatment was noticed in T_4 (dried) with mean value of 10.73 and lowest in T_1 (boiled) with a mean of 3.33.

Changes in the niacin content of oyster mushroom subjected to different processing methods indicated that significant difference was noted in the niacin content of oyster mushroom subjected with different processing technique ($F_{4,10} = 1951.44$, $P < 0.01$). The highest niacin content after treatment was noticed in T4 (dried) with mean value of 61.46 and lowest value in T_1 (boiled) with a mean value of 22.8. Niacin content of oyster mushroom after processing treatments showed 22.8, 23.73and 25.6 respectively in T_1, T_2 and T_3.

Maximum loss of niacin during processing was reported in boiling (62.9) followed by blanching (61.37) and steaming (59.21). The percentage loss of niacin in boiling and blanching were on par while niacin was increased up to 9.04 per cent during drying process.

4.2.3.Effect of processing on the mineral content of oyster mushroom.

In the present investigation, the mineral content of oyster mushroom subjected to different processing techniques were also analyzed and results are depicted in table 11.

Table 10. Effect of processing on the mineral content of oyster mushroom

	Treatment mean values					
Nutrients	T_1	T_2	T_3	T_4	F value	CD value
Calcium (mg)	4.18	5.16	6.26	20.53	$F_{4,10}=1313.8^{**}$	0.85
Sodium (mg	61.4	71.46	74.76	450.86	$F_{4,10}=24666.26^{**}$	3.30
Potassium (mg)	444.0	481.6	523.30	3396.66	$F_{4,10}=2018.59^{**}$	109.99
Phosphorous(mg)	348.6	364.0	385.33	842.0	$F_{4,10}=953.77^{**}$	26.24
Iron (mg)	5.30	6.36	6.80	20.76	$F_{4,10}=1030.89^{**}$	0.62
Copper (mg)	0.29	0.43	0.53	2.34	$F_{4,10}=0.247.081^{**}$	0.16
Zinc (mg)	0.11	0.18	1.18	5.34	$F_{4,10}=5079.6^{**}$	9.91

T_1-Boiling, T_2-Blanching, T_3- Steaming, T_4- Drying

** Significant at one percent level, * significant at five per cent level

As indicated in table, the mean value of calcium content of oyster mushroom subjected to different processing method was found to be significantly different from each other ($F_{4,10} = 1313.82$, $P < 0.01$).

The highest calcium content was noticed in T4 with a mean value of 20.53mg. A close observation of the various treatments on the calcium content of

oyster mushroom revealed that T_1 (4.18), T_2 (5.16), T_3 (6.26) were on par. The lowest calcium content was observed in boiled mushrooms.

Highest amount of calcium was lost during boiling (66.88 per cent). Loss of calcium during blanching and steaming were 58.55 per cent and 49.71 per cent respectively, where as 64.74 per cent of calcium increases was increased noted during drying.

Changes in the sodium content of oyster mushroom treated with different processing techniques indicated that the mean value of sodium content of oyster mushroom differ significantly ($F_{4,10}$ = 24666.26, $P < 0.01$). Sodium content was 61.4 mg, 71.46 mg, 74.7 mg and 450.8 mg respectively in T_1, T_2, T_3 andT_4.

The highest sodium content was noticed in T_4 with a mean value of 450.86 mg. It was observed that the dried mushroom was significantly superior to all the other treatments in the sodium content. A close observation on the various treatments on the sodium content revealed that T_2 (71.46), and T_3 (74.76) were found to be on par with each other.

The percentage loss of sodium content was noticed to be highest in boiling method 41.2 per cent and lowest in steaming 28.41 per cent. Drying on the other hand enhanced the sodium content up to 331.73 per cent.

Changes in the potassium content of oyster mushroom treated with different processing technique showed a significant difference between the processing methods ($F_{4,10}$ =2096.59, $P < 0.01$). The highest potassium content was noticed in T_4 with a mean value of 3396.66 and lowest value in boiled mushroom T_1 (444).

On comparing the 4 processing treatments it was observed that potassium content of T_1 (444) and T_2 (481.66) were on par. Whereas mean value of T_3 was 523.33.

Table 8 depicts the potassium loss during processing of mushrooms. It was revealed that highest per cent of potassium was lost during boiling (28.73 per cent) followed by blanching (22.69 per cent). The lowest value was noted in steaming (16 per cent). Boiling blanching and steaming resulted in potassium loss while potassium was enhanced during drying.

Phosphorus content of oyster mushroom treated with different processing technique indicated significant difference between the treatments ($F_{4,10}$ =953.74, $P < 0.01$). Phosphorus content of T_1, T_2, T3, T_4 are 348.66, 364, 385.3 and 842.0 respectively.

The highest phosphorus content after treatment was noticed in T4 (dried) with mean value of 348.66. Phosphorus content in T_1 (348.66), T_2 (364) and T_3 (385.33) were found to be on par.

It was revealed that phosphorus content of oyster mushroom during drying has increased to (76.39 per cent). While highest per cent of loss was found in boiling (26.9 per cent) followed by blanching (23.74 per cent) and steaming (19.28 per cent).

Iron content of oyster mushroom when processed was also found to vary significantly between the treatments ($F_{4,10}$ = 1030.89, $P < 0.01$). The highest iron content was noticed in T4 with a mean value of (20.76). Boiled mushroom depicted the lowest value. A close observation of iron content of various treatments on the

iron content revealed that T_1 (5.3), T_2 (6.36) and T_3 (6.80) were found to be on par with each other.

The highest loss of iron was recorded in boiling (51.19 per cent) and lowest in steaming (37.38 per cent).

The copper content of oyster mushroom treated with different processing methods revealed that the highest value of copper was observed in T_4 (2.34) and lowest in T_1 (0.29). Analysis of the data revealed that significant difference at one per cent level was observed between treatments. ($F_{4,10} = 0.247.081$, $P < 0.01$).

Table 8 showed the significant difference in percentage loss of copper content during processing. The highest percentage of loss of copper was in boiling (87.31 per cent) followed by blanching (81.5 per cent). The lowest per cent of loss was reported in steaming (76.87 per cent). While drying copper content was increased up to (68.56 per cent).

As indicated in the table, the mean value of zinc content of oyster mushroom treated with different processing technique was found to differ significantly ($F_{4,10} = 5079.6$, $P < 0.01$).

On taking into account of the recorded values, highest zinc content was noticed in T4 with a mean value of 5.34. It was observed that the dried mushroom was significantly superior to all the other treatments in the zinc content.

A close observation on the various treatments on the zinc content revealed that T_1 (0.11), T_2 (0.18), T_3 (1.18) were on par with each other. The lowest content of zinc was noticed in T_1 (boiled mushroom).

Percentage loss of zinc observed to be on par with the treatment of boiling, blanching and steaming. The per cent of loss of zinc was highest in boiling 97.88 per cent. Where as the blanching and steaming had same loss of 96.51 per cent. But it was observed that drying increases 72.36 per cent of zinc.

4.2.3.Effect of processing on other chemical constituents in oyster mushroom.

Other chemical constituents such as moisture, fiber, tannins and polyphenol content of oyster mushroom subjected to different processing methods were also analyzed in detail results of which are given in table 11

Table 11. Effect of processing on other chemical constituents in oyster mushroom

Treatment Mean values						
Nutrients	T_1	T_2	T_3	T_4	F value	CD value
Moisture (%)	91.71	90.44	90.35	3.5	$F_{4,10}=1741.92^{**}$	3.62
Fiber (%)	1.0	1.0	1.5	20.13	$F_{4,10}=4490.62^{**}$	0.39
Tannin (mg)	0.16	0.33	0.23	2.46	$F_{4,10}=49.63^{**}$	0.55
Polyphenol(mcg)	3.23	3.43	3.96	10.23	$F_{4,10}=10.23^{**}$	0.30

T_1-Boiling, T_2-Blanching, T_3- Steaming, T_4- Drying

** Significant at one percent level, * significant at five per cent level

Mushrooms are highly perishable commodity, and it contains more than 90 per cent moisture. Moisture content of oyster mushroom under study determined was 90.3 per cent.

As indicated in table 11 moisture content of oyster mushroom subjected to different processing techniques differ significantly from each other. ($F_{4,10}$ = 1741.92, $P < 0.01$).

Moisture content was higher in T_1 (91.71) and was on par with T_2 (90.44) and T_3 (90.35). Drying reduced the moisture content and T_4 depicted the lowest value 3.5. Moisture loss was minimum and almost same in boiling, blanching and steaming while drying reduces the moisture level to the maximum 96.13 per cent.

Changes in the fiber content of oyster mushroom treated with different processing data revealed that the fiber content of oyster mushroom treated with different processing method are significantly differ from each other ($F_{4,10}$ = 4490.62, $P < 0.01$).

On comparing the mean values of fiber content, it was found that the highest fiber content was obtained in T_4 with a mean value of (20.13). A close observation on the various treatments showed that T_1 (1.0), T_2 (1.0), T_3 (1.5) were found to be on par with each other.

The percentage loss of fiber during boiling (68.73 per cent) blanching (67.77 per cent) and steaming (53.07 per cent) were on par.

Changes in the tannin content of Oyster mushroom treated with different processing technique were found to be significantly different. ($F_{4,10}$ = 49.63, $P < 0.01$). On comparing the mean value of tannin content, it was observed that the highest tannin content was obtained in T4 with a mean value of 2.46. Tannin content of oyster mushroom after processing vary between 0.16-2.46. A close observation on the various treatments applied revealed that T_1 (0.16), T_2 (0.33), T_3 (0.23) were found

to be on par with each other. Highest amount of tannin content was lost during boiling (87.98 per cent) while loss in blanching and steaming are 83.07 per cent and 75.06 per cent respectively.

Data on the polyphenol content of oyster mushroom treated with different processing technique also found to vary significantly. ($F_{4,10} = 1387.39$, $P < 0.01$). According to the result, T4 had the highest polyphenol content with a mean value of 10.23 and it was significantly superior to all the other treatments.

On comparing the treatment values, T_1 (3.23), T_2 (3.43), T_3 (3.96) were on par with each other. Boiling treatment showed the lowest poly phenol content when compared with other treatments.

On taking in to account of the per cent loss of polyphenols in oyster mushroom during processing, highest loss was recorded in boiling (24.71 per cent) and the lowest was recorded in steaming (7.72 per cent).

4.3. ASSESSMENT OF HEALTH BENEFITS OF OYSTER MUSHROOM

Attempts have been made in many parts of the world to explore the use of mushrooms and their metabolites for the treatment of a variety of human ailments (Jose et al., 2002)

In the present investigation, health benefits of oyster mushroom was assessed by supplementing oyster mushroom powder to selected subjects with specific disease condition through case studies.

Mushroom supplement was prepared in the laboratory as detailed in the methodology. Supplementation study was carried out by selecting human volunteers with specific disease conditions.

4.3.1. Formulation of the mushroom supplement and Standardization of recipes

Oyster mushroom was sun dried and powdered using a grinder and sieved using a fine mesh of about 10x size. Dried mushroom powder was packed in five g sachet for distribution to the respondents selected for the case studies. No chemicals or preservatives were added to the mushroom powder.

Various recipes were standardized in the laboratory incorporating mushroom supplement, and to suggest different ways to incorporate supplement in the daily diet which will enable the prompt inclusion of the supplement in the diet.

Various recipes were standardized with mushroom supplement in the breakfast dishes such as dosa, idly, chapatti. Other recipes standardized were chutney powder, black tea, rice and curd. Plates (3& 4) depicts the mushroom supplemented preparations.

In all the preparations five g of mushroom powder was incorporated. In the case of dosa and chapatti, incorporation of mushroom powder does not rendered any colour change or off flavour. While as in idly. slight dull colour was imparted. Chutney powder prepared was very much acceptable , since the flavour of mushroom powder blended well with the chutney flavour. Mushroom powder mixed along with the rice gave much acceptance among the subjects, since with other dishes, mushroom supplement yielded good flavour. Similarly mixing the supplement along with curd also gave very encouraging results. Adding supplement to the black tea

was less acceptable. Subjects were asked to incorporate of the powder in whatever way they want.

However all the subjects were of the opinion that, the supplement was easy to incorporate in the diet in different forms, and through different dishes. None of the respondents expressed any difficulty for consumption of the supplement. Incorporation of mushroom supplement does not hinder the acceptability of the dish also.

4.3.2.Results of case study on the hyper glycemic subjects

Two hyperglycemic subjects selected for the case study were subject 45 years (A) and subject 47 years old (B). Both of them were females. One belongs to Hindu community, where as the other respondent was of Muslim. Both of them were from nuclear family and follow small family norm. Respondent A was holding government job while respondent B was a house wife. Both of them were well educated and belonged to middle income family. They had an income ranged between 20,000/-to 30,000/- per month .

Considering the monthly expenditure pattern on food, it was noticed that both of the subjects spend Rs 4000/-to 6000/- per month. They spend Rs 500/-to1000/- per month for meeting health needs.

Dietary pattern of the two subjects indicated that both of them were non – vegetarians and generally follow 3 meals a day and do not follow any special diets for their disease condition.

Frequency of consumption of various food groups in the diet, it was noticed that subject A include cereals, pulses, vegetables, milk and milk products and tea daily; fish and fruits on alternate days and meat products once in a week while the respondent B include cereals, vegetables, fish, milk and milk products daily in the diet, pulses and fruits on alternate days, meat and bakery items once in a week.

The study revealed that both the respondents were of the habit of doing exercise like morning walk regularly for one hour. They were having some stress and strain in their daily life which was either related to health or financial problems.

Health profile of the subject

Table 12. Anthropometric parameters of the two hyperglycemic subjects

Body measurements	Subject A	Subject B
Height	162cm	162cm
Weight	60kg	58kg
Waist circumference	81cm	80cm
Hip circumference	87cm	87cm
BMI	22.90	22.13
Waist hip ratio	0.91	0.91

On assessing the anthropometric measurements of two respondents, which is a direct indicator of health status, it was found that both of the subjects were of the same height. Body weight of subject A and B were found to be 60 kg and 58 kg respectively.

Based on the Broca's index used to assess the ideal weight of the subjects, it was revealed that both of them were not follow ideal body weight.

Srilekshmi (2003) stated that body mass index expressed as the ratio of weight to height in m^2 (wt(kg)/ht(m^2)) which is used as a parameter for detecting chronic energy deficiency, over weight and obesity. Body mass index (BMI) of subjects A and B were found to be 22.90 and 22.13 respectively, which indicate that the two subjects fall under the normal BMI.

Abdominal fat accumulation increases the risk of a number of chronic degenerative diseases. Waist to hip ratio indicates the risk of developing various degenerative disease. The waist hip ratio (waist circumference divided by hip circumference) therefore is a simple method for distinguishing between fatness in the lower trunk(hip and buttocks) and fatness in the upper trunk (waist and abdomen area). A WHR of >1.0 for men and >0.85 for women is an indicator of abdominal obesity. Lower trunk fatness (lower waist to hip ratio) is often referred to as 'gynoid obesity' upper trunk or central fatness (higher waist to hip ratio) is called 'android obesity'.

Waist hip ratio of both the subjects A and B were found to be 0.91 which indicate that both the subjects were at risk and are prone to develop degenerative diseases. Both of them come under the gynoid obesity.

Morbidity pattern of the two subjects revealed that subject A is quite often susceptible to fever and other infections while subject B seemed to be healthy. Both of them are having diabetes for the past 3 years. Biochemical profile of the subjects revealed that subject A was having fasting blood glucose level of 186 mg/dl and subject B having 170 mg/dl and confirms that both are diabetic.

Impact of mushroom supplement on the blood sugar levels

Both the subjects were willingly participated in the mushroom supplementation study and were not taking any oral hypoglycemic agents for controlling the disease. Mushroom supplement was distributed to the subjects for a period of three months. Close observation was made by the investigator and ensured that the subjects were consuming the supplement promptly.

Both the subjects were incorporated the mushroom supplement in the breakfast preparations viz. dosa and idly. They also used to mix the supplement with curd and consumed it along with rice.

The efficacy of the mushroom supplement was assessed by monitoring blood sugar levels at different intervals. The blood sample of both of the subjects were collected and blood profile was analysed, details of which are given in the table 13.

Table 13. Fasting blood sugar level of respondents.

Monitoring intervals	Fasting blood sugar level of subjects	
	Subject A	Subject B
Initial	186mg/dl	170mg/dl
45th day	150mg/dl	140mg/d
90th day	115mg/dl	110mg/dl

The result revealed that initial value obtained for fasting blood glucose of subject A and B were 186 mg/dl and 170 mg/dl respectively. After supplementation of 45 days it was reduced to 150 mg/dl and 140 mg/dl respectively. At the end of 90th day, fasting blood sugar level was again monitored and the values were 115 mg/dl and 110 mg/dl respectively. A steady decline was observed in the two subjects studied with regard to fasting blood sugar level.

4.3.3. Result of case study on the hyper cholesterolemic subjects

Two hyper cholesterolemic subjects selected for the case study were subject (A) 49 years old and subject (B) 50 years old. Both of them were females and belonged to Hindu community. Respondents belonged to nuclear family and follow small family norm. Both of the subjects were graduated house wives and belonged to middle income family. They had an income ranged between 10,000/-to20,000/- per month .

Considering the monthly expenditure pattern on food, it was noticed that both of the subjects spend Rs 4000/-to 6000/- per month. They also spend Rs 500/-to1000/- per month for meeting health needs.

Dietary pattern of the two subjects indicated that both of them were non – vegetarians and generally follow four meals a day pattern. They do not resort to any special diets for reducing the cholesterol level in the blood, and also were not aware about such practices.

Frequency of consumption of various food groups in the diet, it was noticed that subject A include cereals, pulses, vegetables, fish, fruits, milk and milk products, etc. daily, meat twice in a week and bakery items on alternate days. While the

respondent B include cereals, vegetables, fish, milk and milk products daily in the diet, pulses and fruits on alternate days, meat and bakery items twice in a week.

Both the respondents were of the habit of doing exercise like morning walk regularly for one hour. They were doing some other exercise also.

Health profile of the subjects

Health condition of the two selected hypercholesterolemic subjects were ascertained and details were given in table 14.

Table 14. Anthropometric parameters of the two hyper cholesterolemic subjects

Body measurements	Subject A	Subject B
Height	158cm	159cm
Weight	65kg	62kg
Waist circumference	83cm	81cm
Hip circumference	89cm	86cm
BMI	26.04	24.52
Waist hip ratio	0.93	0.94

Subject A recorded body height of 158 cm with body weight of 65 kg while respondent B was having body height of 159 cm with body weight of 62 kg. As per the Broca's index it was revealed that both the subjects were not maintaining ideal body weight.

Body mass index of subjects A and B were found to be 26.04 and 24.52 respectively, indicating that the subject A was over weight while the subject B was under normal BMI.

Waist hip ratio of the subjects was computed as 0.93 and0.94 respectively in subjects A and B. The result indicated that both the subjects were at risk, and depict gynoid obesity.

Morbidity pattern of the two subjects revealed that both the respondents do not fall sick frequently. However both of them are having elevated blood cholesterol level for the past two years and was not taking any medicines for controlling the condition.

Biochemical profile of the subjects revealed that subject A was having fasting blood cholesterol level of 250 mg/dl and subject B having 270 mg/dl

Impact of mushroom supplement on the cholesterol levels

Both the hyper cholesterolemic subjects were not on medication and participated enthusiastically in the feeding experiment. Mushroom supplement was distributed to the subjects for a period of three months. Direct monitoring was done by the investigator.

Both the subjects were incorporated the mushroom supplement mainly in the breakfast dishes and they also used to make chammandi powder with the supplement and consumed it along with some breakfast dishes and rice. Both the subjects did not express any difficulty in the incorporation of supplement in the daily diet.

The impact of the mushroom supplement was assessed by determining the blood cholesterol level periodically. The blood sample of both of the subjects were collected and blood profile was analyzed.

Change in the blood cholesterol level

Table 15. Blood cholesterol level of respondents.

Monitoring intervals	Blood cholesterol level of subjects	
	Subject A	Subject B
Initial	250 mg/dl	270 mg/dl
45th day	230 mg/dl	245 mg/d
90th day	200 mg/dl	215 mg/dl

The result showed that value obtained for fasting blood cholesterol level was 250 mg/dl and 270 mg/dl for subjects A and B respectively, initially while it was decreased to 230 mg/dl and 245 mg/dl after 45 days and 200 mg/dl and 215 mg/dl after 90 days respectively. Result revealed remarkable decline in the cholesterol level of the subjects selected.

4.3.4. Results of case study on the hypertension subjects

Two hypertension subjects selected for the case study were 50 and 51 years old. Both of them were females and one belonged to Hindu community, and the other Christian. Both of them belonged to nuclear family and follow small family norm. Both of the subjects were holding government job and they were graduates. Both of

them belonged to middle income family. They had an income ranged between 20,000/- to 30,000/- per month .

An amount of Rs 4000/- to 6000/- per month was incurred for meeting food expenditure by subject A while an amount of Rs 1000/- to 4000/- per month by subject B. Both of them spend Rs 500/-to 1000/- per month for meeting health needs.

Dietary pattern of the two subjects indicated that both of them were non – vegetarians and generally follow three meals a day pattern. They do not follow any therapeutic diets for controlling hypertension.

Frequency of consumption of various food groups in the diet, it was noticed that subject A include cereals, vegetables, fish, fruits, milk and milk products, etc. daily, pulses and bakery items on alternate days and meat once in a week. While the respondent B include cereals, pulses, vegetables, milk and milk products daily in the diet, fish and fruits on alternate days, meat and bakery items once in a week.

Both the respondents were of the habit of doing exercise like morning walk regularly for one hour. They were having some stress and strain in their daily life which was either related to health or financial problems.

Health profile of the subjects

Health condition of the two selected hypertension subjects were ascertained and details were given in table 16.

On assessing the anthropometric measurements of the two respondents, it was found that subjects A and B were having 160 cm and 159 cm of height respectively.

Body weight of subjects A and B were found to be 65 kg and 66 kg respectively. On the basis of Broca's index both the subjects were above the ideal weight.

Table 16. Anthropometric parameters of the two hypertension subjects

Body measurements	Subject A	Subject B
Height	160cm	159cm
Weight	65kg	66kg
Waist circumference	82cm	83cm
Hip circumference	87cm	89cm
BMI	25.39	26.14
Waist hip ratio	0.94	0.93

Body mass index of subjects A and B were found to be 25.39 and 26.14 respectively, indicating that both of them are over weight.

On assessing waist hip ratio of the two subjects was found to be 0.94 and 0.93 respectively which is above the recommended standards of 0.85 (females) (Jain and Singh, 2003).

Morbidity pattern of the two subjects revealed that both the respondents do not fall sick frequently. However both of the respondents recorded elevated blood pressure for the past 3 years. Both the subjects having blood pressure above the normal values.

Impact of mushroom supplement on the blood pressure levels

Both the subjects were willingly participated in the experimental case study. Both the subjects were not taking any medicine for controlling hypertension.

Both of them were incorporated the mushroom supplement in daily breakfast side dishes and they also used to make chutney powder with the supplement and consumed along with breakfast dishes and rice. Respondents were not reported any difficulty in consuming the mushroom supplement daily.

The impact of the mushroom supplement was monitored by determining the blood pressure at different intervals given in table 17.

Table 17. Blood pressure level of respondents.

Monitoring intervals	Blood pressure level of subjects			
	Subject A		Subject B	
	Systolic,mmHg	Diastolic mmHg	Systolic,mmHg	DiastolicmmHg
Initial	139 mmHg	89 mmHg	140 mmHg	90mmHg
45th day	139 mmHg	89 mmHg	139 mmHg	90 mmHg
90th day	130mmHg	Below 85	Below 125	Below 85

The result showed that initially the value obtained for blood pressure level for subjects A and B found to be 139-89 mmHg for systolic pressure and 140-90 mmHg for diastolic pressure.

After 45 days of supplementation there was not much change in the blood pressure level of the two subjects. When monitored after 90^{th} day there was slight reduction in the blood pressure level of the subjects and was 130-85 and 125-85 respectively in subjects A and B.

DISCUSSION

5. DISCUSSION

The technical advances made during recent decades along with myriad, other implications resulted in edible mushroom cultivation attaining global dimensions. The food value of mushrooms is being increasingly realized as they are in low in carbohydrate and considered as a food source of various nutrients such as protein, vitamins and minerals (Buigut, 2002; and Jiskani, 2001).

Owing to their delicate and pleasing flavour, exotic preferences and awareness about their nutritional and medicinal virtues mushrooms are assuming increasing popularity and acceptance in the daily diet. The result obtained from the present investigation throw light on the above aspects which are discussed below.

5.1.Quality evaluation of oyster mushroom.

Chemical and nutritional composition of the oyster mushroom is a major parameter influencing the quality of mushrooms. According to Chaliha (2007) mushrooms provide valuable nutrients to the diet consumed. The quality of oyster mushroom was assessed in order to understand the amount of nutrients and chemical constituents present in the oyster mushroom and how best it could be utilized for health promotion.

5.1.1. Assessment of chemical and nutritional composition of fresh oyster mushroom

The major nutrients assessed in the present investigation were calories, proteins, fat, vitamins viz. vitamin C, B complex vitamins viz. thiamine, riboflavin

and niacin. Minerals and trace elements such as iron, calcium, sodium, potassium, phosphorus, zinc and copper were also assessed in the oyster mushroom.

5.1.1.1.Estimation of macronutrients

In the present study, the macronutrients present in the oyster mushroom were estimated with regard to the calories, total carbohydrate, protein, and fat. Randhawa and Ranote (2004) pointed out that oyster mushroom (*Pleurotus florida*) is a good source of macronutrients such as carbohydrate, protein, and fat.

The calorie content of oyster mushroom on dry weight basis was 453kcal/100 gm.

Carbohydrate content of fresh Oyster mushroom was 4.7 g/100 g, which was on par with the findings of Kumar and Barmanray (2007) who had reported 4.54 g of carbohydrate in mushroom. However, Starton (1990) found carbohydrate content in the fresh mushroom as 3.8 g/100g. Alam et al. (2008) reported that *P.florida* contains 5.2g of carbohydrate on fresh weight basis. Carbohydrate content of mushroom was found to vary slightly depending on the variety and species. Carbohydrate of *P.species* reported as 5.24 g/100 gm (USDA,2009), while Robinson (2010) reported 9.52 g of carbohydrate in fresh oyster mushroom and is approximately 3 per cent of daily requirement of carbohydrates.

Gupta et al. (2004) stated that protein is one of the most important food factor that determine the adequacy and quality in a diet. Oyster mushroom under study recorded 5.6 g /100 g of protein. The content of protein varied from 7.81-11.63 per cent on fresh weight basis (Sarker et al., 2007). Quality of mushroom protein is excellent and comparable with meat, egg and milk (Aletor, 1995). The proportion of

total protein in most of the edible mushrooms varies from 2.5 to 3.0 g /100 g on fresh weight basis (Rai et al., 2003).

Randhawa and Ranote (2004) reported 3.2 g protein in *Pleurotus florida* while Kumar and Barmanray (2007) found 3.6 per cent of protein in fresh mushroom. Manzi et al. (2001) opined protein content varies between 1.5 to 7.9 g /100 g in fresh mushroom while Flatt(2010) viewed that protein content varies between 1.6-2.5 per cent. Kusalappa (2010) analyzed the protein content of button mushroom and found, it contains 3.85 g of protein on fresh weight. Barros et al. (2007) reported that fresh mushroom *Agaricus arvensis* and *Lentinus deliuosus* contain 2.87-2.96 g of protein. Zaman (2004) recorded 7.85-8.81 per cent protein in oyster mushroom. Hadwan et al. (1997) also reported higher protein values(9.7-15.07 per cent) in oyster mushroom. Alam et al. (2008) reported that fresh mushroom *P.forida, P.ostreatus* and *P.sajor caju* found to have 2.6 g, 3.4 g and 3.2 g of protein respectively.

The fat content of oyster mushroom was recorded as 0.8 per cent. Kumary and Murthy (2002) stated that mushroom contains all the classes of lipids including free fatty acids, glycerides, sterols and phospholipids.

Rai et al (1988) found that fat content of *Pleurotus* species on fresh weight basis vary from 0.10 to 0.19 percent. Kumar and Barmanray (2007) reported that fresh mushroom contains 0.32 per cent of fat. Gupta et al. (2004) noted that fat content of fresh mushroom found to be 1.90 per cent. Ude et al. (2001) pointed that fat content found to be 2.2 per cent in fresh mushroom. Macro nutrient content of oyster mushroom is depicted in Fig(1).

Fig. 1 Macro nutrients present in fresh oyster mushroom

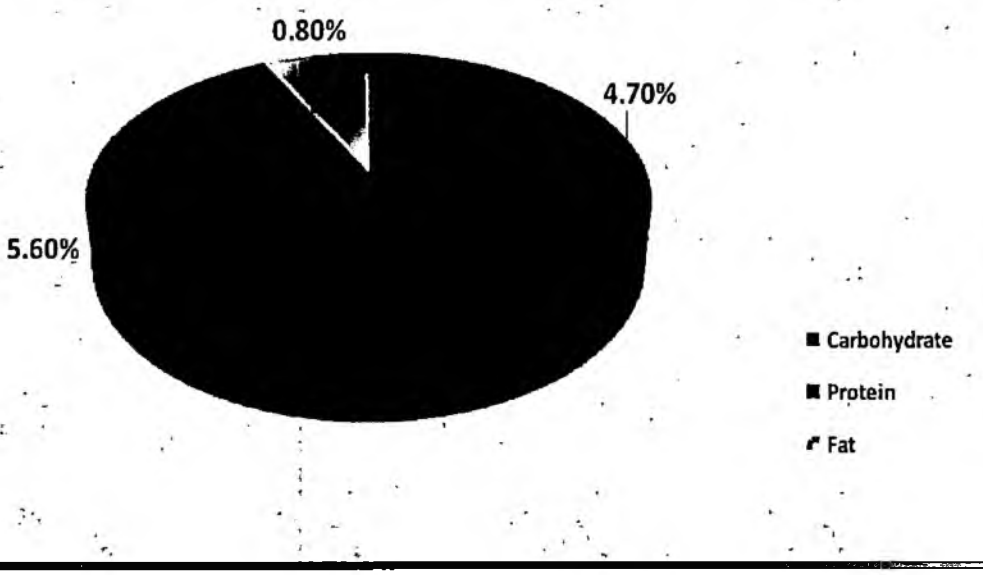
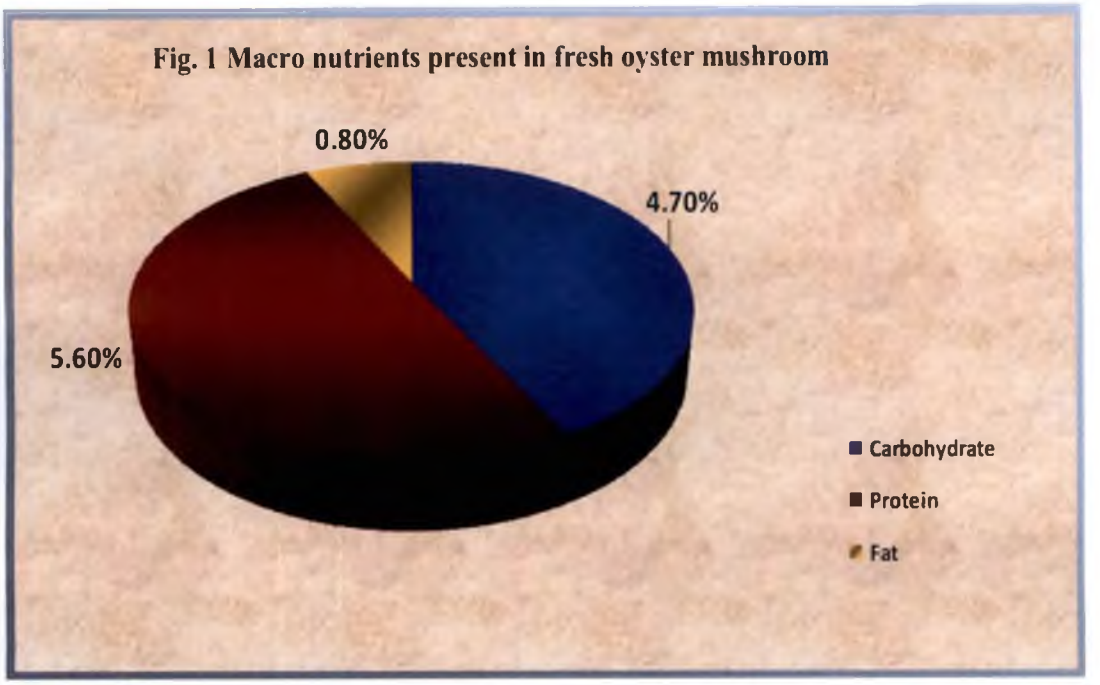


Fig. 1 Macro nutrients present in fresh oyster mushroom



5.1.1.2. Quality evaluation of mushroom protein.

Gopalan et al. (1991) viewed that quality of mushroom protein is superior to the vegetable protein and is as good or just inferior to animal proteins because it contain all the essential amino acids needed for the human health.

In the present investigation, 18 amino acids including 8 essential amino acids were estimated in the oyster mushroom which gave more precise data on the quality of protein.

Eight essential amino acids viz. isoleusin, leusine, lysine, methionine, phenylalanine, threonine, tryptophan and valine in oyster mushroom under study were found to be 3.6 g,5.9 g,4.9g,1.75 g,10.2 g,5.2 g, 0.81 g and 3.8 g respectively.

Among the 18 amino acids present in the oyster mushroom, glutamic acid (17.2) was found to be very high followed by aspartic acid (10.5), phenylalanine(10.2) and tyrosine (7.3). Among the essential amino acids, phenylalanine was exceptionally high when compared to reference protein in the oyster mushroom studied. Similarly leucine, lysine and threonine content were also higher than the reference protein (Fig.2)

Bano and Rajarathnam (1982) reported that *P.florida* contains isoleucine 5.2 g, leusine7.5 g, lysine 9.9 g, methionine 2.8 g, phenylalanine 3.5 g, threonine 6.1 g, tryptophan 0.81 g and valine 6.9 g respectively. Dunkwal and Jood (2009) reported that total lysine content of mushroom ranged between 6.0 to 6.25 g/100g, while methionine content was 1.8 g/100g.

Amino acid content of the *P.florida* when compared to *P.citrinopeleatus* and *P.sajor caju*, it was observed that glutamic acid content was the highest and it was even higher than the other two species.

Data clearly indicated that oyster mushroom is superior to *P.citrinopeleatus* and *P.sajor caju* with respect to amino acid composition and also with essential amino acid content.

Determination of amino acid score (AAS) is another index to evaluate protein quality. Threonine recorded the highest amino acid score (208) followed by leucine(113.46) and lysine and all the three are essential amino acids. Where as in *P.citrinopeleatus*, phenylalanine recorded the highest score (100) followed by threonine (98.62) and lysine (72.5). In *P.sajor caju*, similar pattern was noticed threoninne (97.24) lysine (76.14).

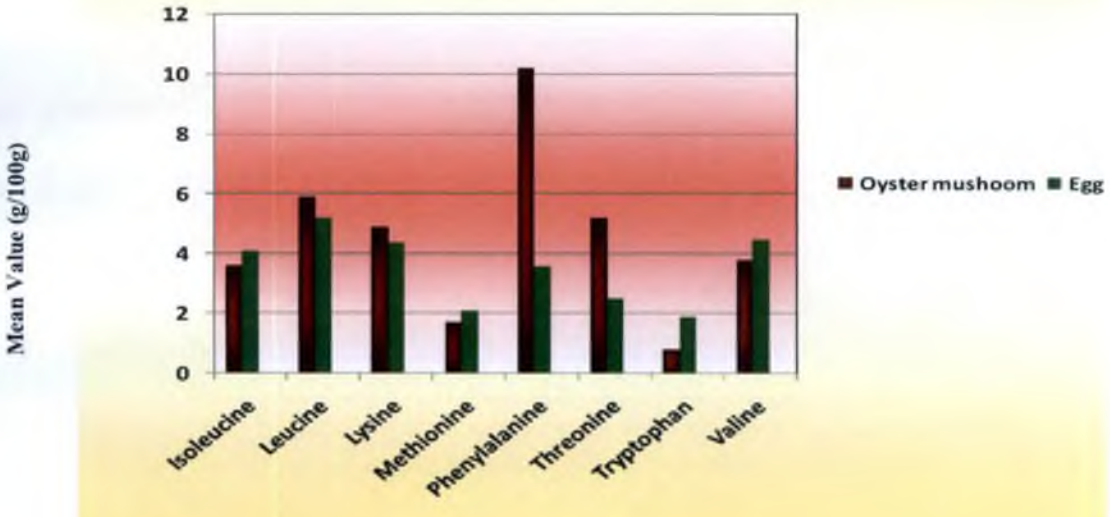
The above data confirmed that AAS was also in favour and better in oyster mushroom, and superior in protein quality when compared to *P.citrinopeleatus* and *P.sajor caju.*

Sequence of limiting amino acids in *P.florida* was methionine, valine and isoleucine. In *P.citrinopeleatus* sequence of limiting amino acid is methionine, isoleucine and valine while in *P. sajor caju* methionine, isoleucine and leucine.

EAA index of oyster mushroom computed was found to be 119 while the nutritional index based on protein quality was determined as 6.42.

Ghosh and Chakrabarty (1990) reported that the EEA index of *Pleurotus sajor caju* as 72.04 and nutritional index as 12.78.

Fig 2: Essential amino acids of oyster mushroom in comparison with refernce protein



5.1.1.3.Estimation of Vitamins

In the present study, the vitamins assessed were vitamin C, thiamine, riboflavin, and niacin. Nita (2009) reported that mushrooms are good sources of vitamis C and B vitamins like riboflavin, thiamine, pantothenic acid, folate etc.

Vitamin C content of oyster mushroom was recorded as 12.4 mg/ 100 g. Bano and Rajarathnam(1988) reported that vitamin C content of oyster mushroom ranged between 11.4 – 47.73 mg/100 g on fresh weight basis.

The thiamine content of oyster mushroom studied was observed to be 5.43 mg /100 g which was much higher than reported by Ranote et al. (2007) in *Pleurotus* species 1.16 to 4.80 mg /100 g.

Riboflavin content of oyster mushroom was recorded as 8.7 mg/100 g. Niacin content of the fresh oyster mushroom observed to be 55.9 mg. Ranote et al. (2007) reported the niacin content of fresh oyster mushroom ranged between 46.0 to 108.7 mg. B complex vitamins present in the oyster mushroom are depicted in Fig (3).

5.1.1.4.Estimation of minerals and trace elements

In the present investigation, the minerals and trace elements present in the oyster mushroom were assessed with regard to the phosphorus, calcium, sodium, potassium, iron, and zinc. The presence of various mineral elements enrich food value of mushrooms. Mineral content of oyster mushroom is depicted in Fig (4).

Calcium content of the oyster mushroom studied was 12.46 mg/100 g. Nutrition data (2007) reported 9.4 mg/100 g of calcium content in fresh mushroom.

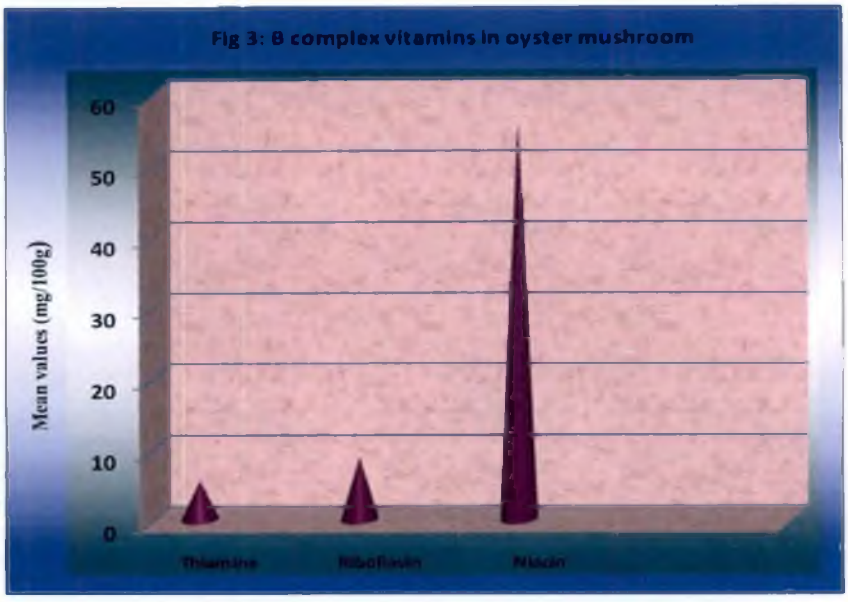


Fig 3: B complex vitamins in oyster mushroom
Mean values (mg/100g)
60
50
40
30
20
10
0
Thiamine
Riboflavin
Niacin

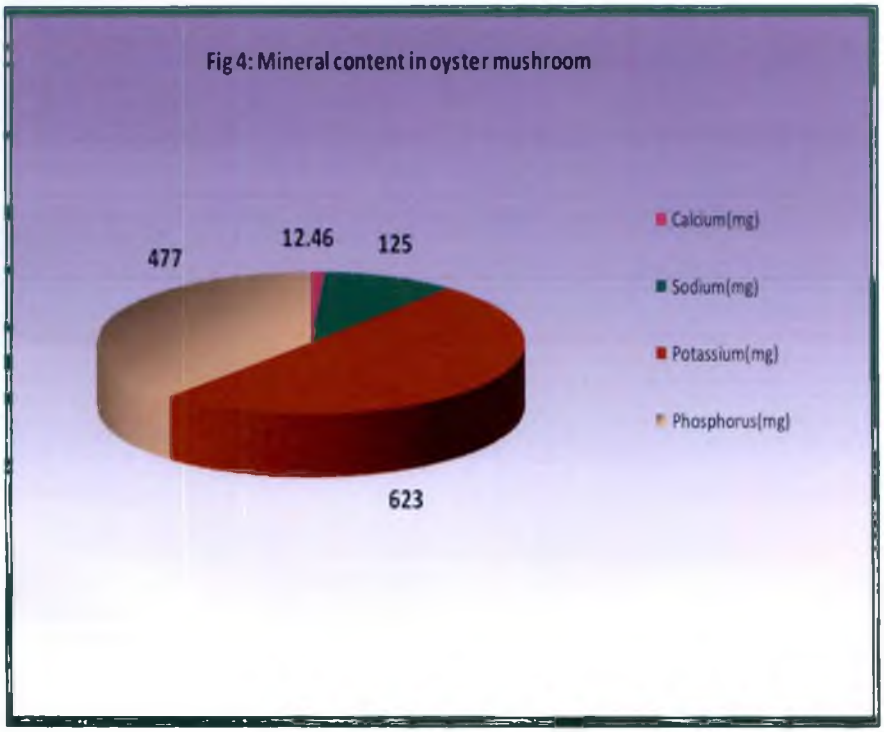


Fig 4: Mineral content in oyster mushroom
12.46
125
477
623
Calcium(mg)
Sodium(mg)
Potassium(mg)
Phosphorus(mg)

According to Anderson and Fellers (1982) reported calcium content of fresh mushroom ranged between 3 to 20 mg/100 g. Kushalappa (2010) reported that calcium content of button mushroom as 22mg/100 g and that of oyster mushroom as 0.1-2.4 mg (Sanmee et al., 2003).

Sodium content of fresh mushroom observed to be 125 mg/100 g as against 61 mg/100 g as reported by Chang and Hayes (1988) in fresh mushroom.

Craig(2003) viewed that mushrooms are excellent source of potassium, a mineral that helps to lower elevated blood pressure and reduces the risk of stroke. Potassium content of oyster mushroom under study was observed to be 623 mg/ 100g which is on par with Robinson (2010) who has reported 622 mg in fresh oyster mushroom. Nutrition data (2007) reported 555 mg of potassium in fresh mushroom. Nita (2009) reported that a medium mushroom has more potassium than a glass of orange juice or a banana. Krumm (2009) reported that fresh mushroom have 300 mg of potassium per cup.

Phosphorus content of oyster mushroom under study was recorded as 477 mg/100 g. Chang and Hayes (1988) found that *Pleurotus* species contains 476 mg of phosphorus on fresh weight basis, which was much higher than reported by Kushalappa (2010). The author had reported 80 mg of potassium in button mushroom.

Iron content of oyster mushroom under study was estimated to be 10.86 mg/100 g. Chang and Hayes (1988) reported that iron content of *Pleurotus* species as 8.5 mg/100 g. Iron content of fresh mushroom observed to be 15.2 mg/100 g (http://www. Driedmushroom.US/ oyster mushroom, 2010)

According to Das (2005) 7.63 mg/ 100g of iron was found in the edible species of mushroom. Nutrition data (2007) reported 2.7 mg/100 g of iron in fresh mushroom. Though iron is low quantity in mushroom but it is present in available form and has been shown to maintain blood hemoglobin level (Rai et al., 2003)

Copper content of oyster mushroom under study was found to be 1.9 mg/100 g. Nutrition data (2007) reported 0.8 mg of copper in edible mushrooms. Where as 0.1 to 1.2 mg of copper was reported by Anderson and Fellors (1982). According to Craig (2003) a single serving of mushroom is said to provide about 20 to 40 percent of the daily needs of copper.

Zinc content of the oyster mushroom in the present study was found to be 1.47 mg/100g. Nutrition data (2007) reported that the mushroom contains 1.4 mg of zinc on fresh weight basis. USDA(2009) reported 0.66 mg/100 g zinc in fresh mushroom.

5.1.1.5.Estimation of other nutrients.

Moisture content of the oyster mushroom studied was determined as 90.3 per cent. High perishability of the mushroom is due to its moisture content and it varies with the species. Adejumo (2005) pointed out that high moisture content promote susceptibility to microbial growth and enzyme activity in mushrooms.

According to Gupta (2004) fresh mushroom have 91.07 per cent of moisture. Ude et al. (2001) reported 88 percent of moisture in fresh mushroom. Manzi et al. (2004) found that moisture content of edible mushrooms on fresh weight basis varies from 67.2 to 91.5 per cent. According to Nutrition data (2007) 90 per cent of moisture is present in edible mushroom on fresh weight basis. Similar value was also

reported by Barros et al. (2007). Gupta et al. (2004) were of the opinion that moisture content of mushroom depend upon the cropping and watering conditions and type of substrate used for cultivation.

Fibre content of fresh oyster mushroom under study was found to be 3.2 g/100 g. The value obtained was almost similar to those reported by Ude et al. (2001). He has reported fibre content as 3.3 g. Nutrition data (2007) reported that fresh mushroom contains 3.4 g of fibre. Alam et al. (2008) reported *Pleurotus florida* contains 3.0 g fiber on fresh weight basis. If While USDA (2009) reported *Pleurotus* species contains 2.0 g of fibre on fresh weight basis.

Randhava and Ranote (2004) reported that *P.florida* contains 1.02 g and *P.sajor caju* 1.08 g fibre on fresh weight basis. *Agaricus bisporus* mushroom contains 0.94 g of fibre (Kumar and Barmanray, 2007). Kelvin (1991) found that the fibre content of mushroom as 0.95-1.10 per cent on fresh weight basis.

Tannin content of oyster mushroom under study was found to be 1.4 mg/100 gm. Randhava and Ranote (2004) reported that *P.florida* and *P.sajor caju* contains 0.02 mg and 0.018 mg tannin respectively which was much lower than the recorded value.

According to Manzi et al. (2001) polyphenol content of fresh oyster mushroom under study was found to be 4.3 mcg/100 gm. Poly phenol content of fresh mushroom was found to be 51.4-403.8 mg.

5.1.2. Anti inflammatory Factors (IF Positives) and Anti oxidant property of oyster mushroom

Inflammation plays an important role in various diseases such as rheumatoid arthritis, atherosclerosis, and asthma. The anti-inflammatory factor is the constituent in the food that produce no inflammation (Jegtvig, 2010). Hyman (2006) reported that most of the fruits and vegetables have anti inflammatory factors (IF positives in mushroom are the anti inflammatory nutrients like vitamin C, folate, zinc and selenium(Nutrition data, 2007).

Oyster mushroom under study was found to contain 12.4 mg of vitamin C on fresh weight basis. It also contains the anti inflammatory nutrient zinc as 1.4 mg on fresh weight basis. The presence of vitamin C and zinc contribute to the positive effect of mushroom on health.

Ajith and Janardhanan (2001) reported anti-inflammatory effect of methanolic extract of mushrooms. Moriarty (2007) viewed that mushrooms are good sources of Vitamin C, B vitamins and minerals including selenium and zinc.

Mattila et al. (2001) reported folate 0.64 mg/100g, zinc 47-92 mg/kg and selenium 3.2 mg/kg mushrooms on dry weight basis.

Antioxidants are compounds in food that help to ward off illness and boost the body's immune system by acting as free radical scavengers, helping to mop up cell damage caused by free radicals. According to Weber and Lamacraft (2009) antioxidants are important in healthy diet and lifestyle. Sourav (2010) stated that antioxidants are naturally occurring chemicals found in foods that work to counter the detrimental effects of oxygen free radical. Whole foods like fruits and vegetables

contain the most antioxidants such as vitamin C, vitamin E, zinc, poly phenols, tannin, fibre etc

The poly phenol content of fresh and dry oyster mushroom under study was recorded as 4.3 and 10.23 mg respectively. While tannin and fibre content found to be 1.4 mg and 3.2 g on fresh weight basis. Guthalu et al. (2006) studied the anti oxidant properties of mushrooms and reported that mushrooms are having high antioxidant property because it contain poly phenols, an antioxidant nutrient. The total poly phenol content in methanolic extract of mushroom ranged between 0.7-11.2 mg/100 g (Guthalu et al., 2006). According to Nicoli et al. (2001) the antioxidant property of phenol containing foods are different depending on the degree of phenol compounds. Mau et al. (2002) also reported the antioxidant properties of mushrooms. Elmastas et al. (2007) found that *Pleurotus ostreatus* act as antioxidant agent.

5.2.Effect of processing on the nutritional value of oyster mushroom

The way the food is cooked is absolutely essential for avoiding nutrient loss. As mushrooms are very precious with abundant nutrients and medicinal values, it is essential to understand the nutrient loss during cooking of mushrooms. Schultz (2010) pointed out that cooking causes the loss of some nutrients in vegetables and fruits.

Khader and Padmavathy (1991) reported that the dried mushroom contains high nutrient content when compared with immature and mature stages because during drying process, the food loses moisture and there is an increase in concentration of nutrients in the remaining mass.

In the present study, changes in the nutrient content of oyster mushroom subjected to different processing treatments were ascertained.

5.2.1. Effect of processing on the Macro nutrients of oyster mushroom

Energy value of the oyster mushroom ranged from 38.9 to 453.0 kcal respectively when treated with different processing methods. It was found that the dried mushroom was significantly superior to all the other treatments. However, the other processing treatments T_1 (38.90), T_2 (39.0), T_3 (40.0) were found to be on a par with each other though all of them are significantly inferior to T_4 (453) Dunkwal and Jood (2009) reported that wheat and brassica grown mushroom contains 412 and 411 kcal/100 g on dry weight basis. Ekanem and Ubengama (2002) reported 412 to 686 kcal/100 g in oyster mushroom on dry weight basis.

The carbohydrate content of oyster mushroom get concentrated after drying and it was found to be reduced when subjected to boiling, blanching and steaming. Comparison of treatment means depicted an increasing trend of carbohydrate on drying. Highest carbohydrate content was noticed in T_4 (39.43) and was significantly superior to all the other treatments in the carbohydrate content. Almost similar results were reported in *P.*florida-40.3, *P.sajor caju* 39.4 and *P.ostreatus* 37.2 g on dry weight basis (Khan et al., 2008). Alam et al. (2008) found the carbohydrate value as 42.83 g in *Pleurotus florida* per 100 gm dry matter.

47.9 g carbohydrate was found in dried oyster mushroom by Watanabee et al (1994) which are slightly higher than the values obtained in the present study. Dunkwal et al. (2009) reported that oyster mushroom grown on wheat and brassica straw reported to have 52.34 and 50.52 per cent of carbohydrate content on dry

weight basis. Almost similar values were also reported by other workers in different mushroom varieties (Goyal, 2002; Ekanem and Ubengama, 2002).

Significant difference was noted in carbohydrate content of oyster mushroom under study in all processing treatments. However drying enhanced the carbohydrate content.

Data regarding processing treatments depicted a gradual reduction in carbohydrate during boiling, blanching and steaming. The carbohydrate value recorded in boiling was 2.0 g, where as in blanching and steaming, the value were 2.46 g and 2.86 g respectively. Highest amount of carbohydrate was lost during boiling when compared with other methods.

On account of percentage loss of carbohydrate, it was noticed that highest loss was recorded in boiling (57.9 per cent) treatment and the lowest in steaming (39.77 per cent).

Lowe (2009) pointed out that the starch from vegetable is insoluble in water. The loss of starch from vegetables occurs when the cell wall is broken by cutting, disintegration of starch during cooking or from abrasion which will occur in violent boiling.

Protein content of oyster mushroom treated with different processing treatment ranged from 3.0-20.43 g. The highest protein content was noticed in T4 with a mean value of 20.43 g.

According to Kuner and Ozdemir (2000) protein content of mushrooms ranged from 19 to 39 g in 100 g dried matter. In the present study protein value was

recorded as 20.43 g/100 g d/w. Almost similar values were reported by Paraskevi et al. (2009) in wild edible mushrooms. Khan et al. (2008) reported 20.6g of protein in *Pleurotus florida* on dry weight basis. Protein content of *P.florida* is relevant to the findings of Shashirekha et al. (2005). Banik and Nandi(2004) also reported similar values in *P.*species.

Protein content of oyster mushroom showed a decreasing trend while processing. The protein content of oyster mushroom after various treatments were T_1 (3.0),T_2 (3.6), T_3 (3.8) and was significantly different from T_4 ($F_{4,10}$=75.6,p>0.01).

The per cent loss of protein was observed to be highest in boiling 35.07 per cent and lowest in steaming 17.57 per cent. Gopalan et al. (2010) stated that some proteins may be lost if vegetables are cooked in water and the cooked water is discarded. Alvi et al. (2003) reported 31 per cent of protein was lost during cooking of colocacia.

Fat content of the oyster mushroom ranged from 0.10-2.85 per cent respectively when treated with different processing methods. It was observed that fat content increased during drying to 2.85 er cent. Khan et al. (2008) reported fat content in different varieties of *P.*species viz *P.florida, P.sajorcaju* and *P.ostreatus* as 3.9, 4.0 and 2.6 per cent respectively. Almost similar values were reported by Alam et al. (2007). According to Ranote et al. (2007) fat content of oyster mushroom on dry weight basis ranged between 1.1-8.3 per cent.

In the present study, T_4(dried) was found to have higher fat content when compared with others. Among the four processing treatments boiling had the lowest fat value(0.1) while blanching and steaming were 0.35 and 0.65 respectively.

On taking in to account of the per cent loss during processing it was observed that highest loss of fat was observed in boiling 80 per cent and lowest in steaming 13.33 per cent.

5.2.2.Effect of processing on the vitamin content of oyster mushroom.

Mushrooms are a good source of vitamin C and B vitamins viz. thiamine, riboflavin, niacin, folate, biotin, pantothenic acid. These vitamins are lost when vegetables are cooked in boiling water.(www.lifeplusvitamin.com.2003). Processing and cooking conditions may cause loss of vitamins. Losses vary widely according to cooking method and type of food.

Vitamins including vitamin C and B complex like thiamine, riboflavin and niacin present in oyster mushroom treated with different processing technique ranged from 3.26-20.6 mg, 2.53-7.53 mg, 3.33-10.73 mg and 22.8-61.46 mg respectively.

In the present study, it was observed that all the vitamins are higher in dried mushroom, vitamin C 20.6 mg, thiamine 7.53, riboflavin 10.73 and niacin 61.46 respectively (Fig.5).

Bano and Rajarathnam (1988) reported the thiamine content as 1.4-2.2 mg, and riboflavin as 6.7-9.0 mg in dried mushroom. Niacin which is most abundant vitamin ranged from 81-135 mg/100 gm of dried mushroom (Stroller and Hall, 1988).

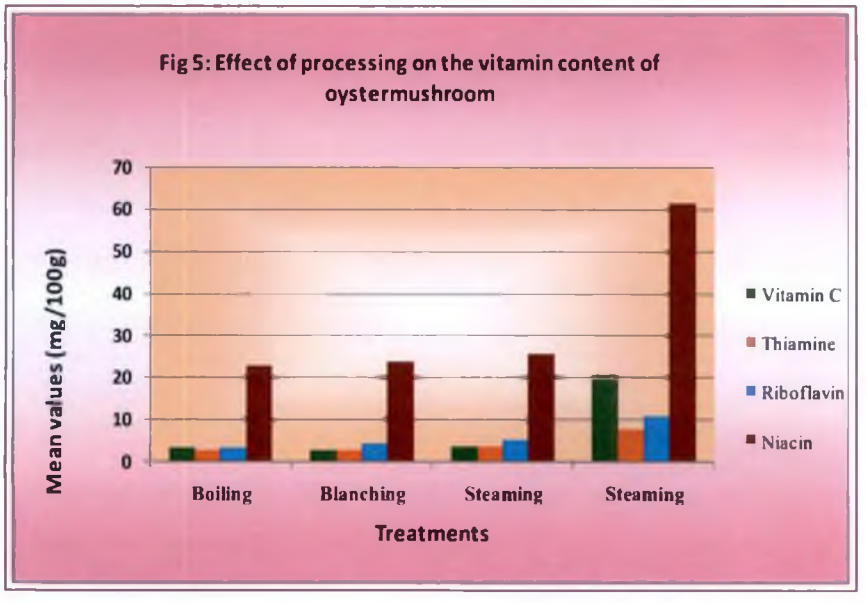


Fig 5: Effect of processing on the vitamin content of oystermushroom
Mean values (mg/100g)
70
60
50
40
30
20
10
0
Boiling
Blanching
Steaming
Steaming
Treatments
Vitamin C
Thiamine
Riboflavin
Niacin

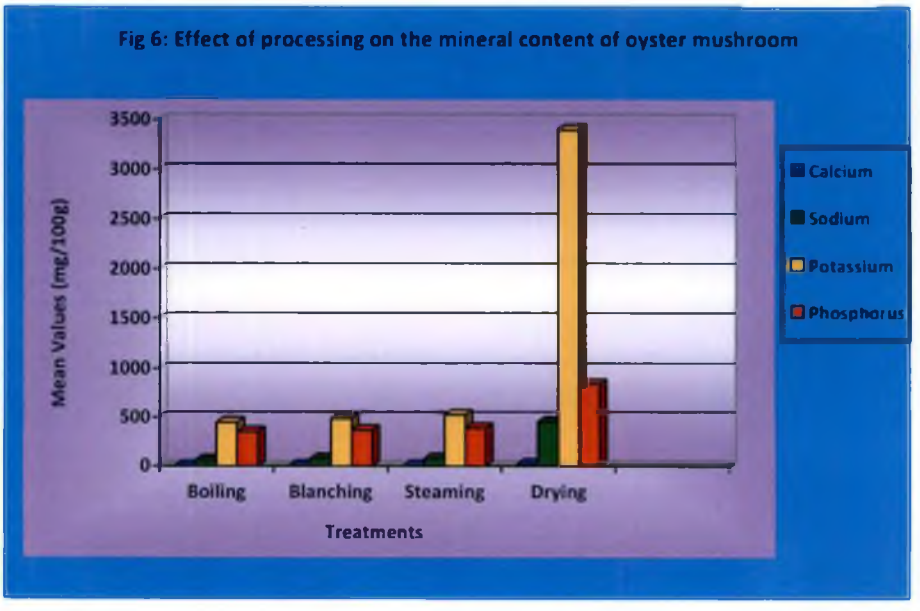


Fig 6: Effect of processing on the mineral content of oyster mushroom
Mean Values (mg/100g)
3500
3000
2500
2000
1500
1000
500
0
Boiling
Blanching
Steaming
Drying
Treatments
Calcium
Sodium
Potassium
Phosphorus

Boiling is the cooking method that cause the greatest loss of nutrients in vegetables (Schultz, if 2010). Many of the water soluble vitamins are transferred in to the water and lost if the vegetables are drained and the water is thrown away.

Blanched mushrooms showed minimum loss of vitamins when compared to boiled oyster mushroom. Blanched mushroom recorded vitamin C content of 12.8 mg, thiamin 2.76 mg, riboflavin 4.13 mg and niacin 23.73 mg respectively.

Blanching even for a short period of time causes the loss of some vitamins (Mushroomapplication.com, 2010). Steaming is generally considered to be the best method to cook vegetables in order to preserve the nutrients. Steaming is a relatively quick method of cooking so the vegetables are only exposed to heat for a short time (Schultz,2010). The nutrient loss was comparatively less in the steamed oyster mushroom compared to boiled and blanched mushroom.

5.2.3.Effect of processing on the mineral content of oyster mushroom.

Changes in the mineral content of oyster mushroom subjected to different processing method was also determined in the study. As the moisture is removed from the mushroom, as in drying the concentration of nutrients is high

Results indicated an increase in calcium content in dried mushroom sample. Calcium content was as high as 20.53 mg in T_4 (dried). The result is supported by Jandaik (1989) who found that the calcium content of mushroom on dry weight basis as 20 mg/100 gm. Calcium content was found to be 33 mg/100 g on d/w (http://www. Driedmushroom.US/ oyster mushroom, 2010).

In a study, Alam et al. (2008) found that the calcium content of dried *P.florida* was found to be 33.7 mg/100 g. Losato (1988) observed calcium content of mushroom ranged between 11.8-162.2mg/100gm on dry weight. The lowest value of calcium content was seen in T_1 (4.18 mg) followed by T_2 (5.16 mg) and T_3(6.26 mg). As indicated in table, the mean value of calcium content of oyster mushroom subjected to different processing method was found to be statistically different from each other ($F_{4, 10}$= 1313.82, P < 0.01).

The per cent loss of calcium during processing was observed to be highest in boiling (66.88 per cent) and lowest in steaming (49.71 per cent).

The principal mineral in foods that may be lost during cooking or processing are the salts of calcium, sodium and potassium. Calcium salts are not so soluble as the other salts found in vegetables (Lowe, 2019). Alvi et al. (2003) reported that appreciable amount of calcium was lost during cooking of tomato, brinjal and bitter gourd.

Sodium content of oyster mushroom treated with different processing treatment indicated that the mean value of sodium content of oyster mushroom differ significantly ($F_{4,10}$=24666.26,p>0.01).

The highest sodium content was noticed in T4 with a mean value of 450.86. It was noticed that the dried mushroom was superior to all the other processing treatments viz. boiling, blanching and steaming and their values determined to be T_1 (61.4), T_2 (71.46), T_3 (74.76) respectively. Losato (1988) opined that the sodium content of mushroom ranged between 23.8-162.8 mg on dry weight basis. Vetter (2002) reported that dried mushroom contains 100-400 ppm of sodium content. Sodium content of dried oyster mushroom found to be 837 mg/100 g (http://www.

Driedmushroom.US/ oyster mushroom, 2010). It was much higher than the values obtained in the present study.

The per cent loss of sodium content was noticed to be highest in boiling method 41.2 per cent and lowest in steaming 28.41 per cent.

Potassium content of the Oyster mushroom treated with different processing method ranged between 444 - 3396.6 mg. The highest value of calcium was recorded by dried oyster mushroom (3396.6 mg). The study revealed that the potassium content was enhanced in drying as the concentration of nutrients is more when moisture is lost. The study conducted by Losato (1988) reported that the potassium content of dried mushroom ranged from 2132 – 5809 mg/100 g. Kamal et al. (2009) found that dried mushroom contain 3636.0 mg/100g of potassium. The value is almost similar to the value obtained in the present study.

Highest percentage loss of potassium was noticed in boiling (28.73 per cent) and lowest in steaming (16 per cent) followed by blanching (22.69 per cent). In support of the above findings Schultz (2010) noticed that 70 per cent of potassium is lost during boiling of vegetables.

Phosphorous content of the oyster mushroom treated with different processing method revealed that highest potassium content was observed in dried oyster mushroom (842.0 mg). The lowest value was noticed in boiling (348.6) followed by blanching (364.0) and steaming (385.3). Phosphorus content of Oyster mushroom treated with different processing technique indicated significant difference between the treatments ($F_{4,10}$ =953.74, $P < 0.01$).

Study conducted by Agarwala and Jandack (1989) found that phosphorous content of *Pleurotus sajor caju* was 760 mg on dry weight basis. Phosphorus content of mushroom on dry weight basis was reported by Kamal et al. (2009) as 1392 mg/100gm.

As expected the highest per cent loss of phosphorous was noted in boiling. While lowest in steaming (19.28 per cent).

Loss of phosphorus was 65 per cent in navy beans while cooking and the loss was 36 per cent in blanched spinach (wh.food.com,2010).

With respect to iron content in processed mushroom dried mushroom depicted highest iron content (20.76). Paraskevi et al. (2009) reported that edible mushroom on dry weight basis contains 7.22 mg of iron .This value was quite low as compared to those recorded in the present investigation.

Alam et al. (2008) studied the iron content of *P.sajor caju* and reported to contain 33.45 mg of iron on dry basis.

Result showed that as with other nutrients, iron loss was also highest in boiling (51.19 per cent) and lowest in steaming (37.38 per cent). Loss of iron content during cooking vegetables was reported to be 51.5 per cent (wh.food.com,2010).

Husseyin et al. (2008) reported 9.23 mg of copper in dried mushroom .In the present study copper content of dried oyster mushroom was found to be 2.34 mg/100g. Highest copper content was noticed in dried sample and lowest value in boiled mushroom. The copper content in *Pleurotus* mushroom was higher as 12.2-21.9 ppm as compared to other mushrooms (Bisaria et al., 1987).

Paraskevi et al. (2009) observed in his study that dried mushroom contains 7.83 – 75.06 mg of copper.

The highest per cent of copper was lost in boiling (87.31 per cent) followed by blanching (81.5 per cent). The lowest per cent of loss was found in steaming (76.87 per cent).

Shchuttz (2010) observed that boiling and draining vegetables results in loss of 45 per cent to 59 per cent of copper during cooking of navy beans (wh.food.com,2010).

Drying of oyster mushroom enhances the zinc content. Maximum zinc content was noticed in T_4 (5.34) mg/100g. Alam et al. (2008) reported that dried *P.florida* contains 16mg of zinc. Observed value was very much lower than the reported values.

Husseyin et al. (2008) observed that zinc content of oyster mushroom ranged from 26.7 – 185 mg on dry weight basis.

Sanmee et al. (2003) reported in his study that the highest amount of zinc was noticed in drying and ranged between 37.8 – 253 mg.

Most of zinc was found to be lost during processing as observed in the present study. The loss was 97.88 per cent in boiling and 96.51 per cent in blanching and steaming.

4.2.3.Effect of processing on other nutritional contents in oyster mushroom.

Moisture content was higher in T_1 (91.71) and was on par with T_2 (90.44) and T_3 (90.35). Drying reduces the moisture content and T_4 depicted the lowest value 3.5.

The method of drying reduces the moisture content to the maximum 96.13 per cent. All the other processing treatments enhances the moisture level. The per cent of moisture gain during boiling were 1.52 per cent, blanching 1.11 per cent and steaming 1.11 per cent respectively.

Fiber content of dried oyster mushroom was as high as mushroom treated with different processing method ranges from 20.1mg/100g.

Alam et al. (2008) reported that fiber content of *P.florida* was found to be 23.29g on dry weight basis. The fiber content of dried mushroom as 11.59 g (Dunkwal and Jood, 2009). Where as Sanmee et al. (2003) reported 8.3 – 16 g of fiber in dried mushroom. Gupta et al (2004) reported the fiber content ranged from 11.72 – 13.23 per cent on dry weight basis.

The per cent loss of fiber during processing was observed to be 68.73 while boiling. Alvi et al. (2003) reported 32 per cent loss of fiber while cooking tomato.

On assessing the changes in the tannin content of oyster mushroom during processing it was observed an increase during in drying and decrease when subjected to different processing methods.

It was noted that 87.98 per cent of tannin was lost during boiling mushroom. Somsub et al. (2008) reported that boiling of vegetables decreases tannin content up to 44.93 per cent.

The dried mushroom had exhibited higher phenol content (10.23mg) when compared with other processed mushrooms. Similar observation was reported by Guthalu et al. (2006) The total poly phenol content in mushroom ranged between 0.7-11.2 mg/100 g. Fistulenia hepatica a wild mushroom showed the highest phenol content (111.72 mg/kg) on dry weight (Vaz,2010).

According to Moss(2004) phenolic antioxidant are much more sensitive and amount of phenol increase or decrease during cooking or processing. The author reported that that 20-30 per cent loss of phenol antioxidant in many vegetables.

5.3. ASSESSMENT OF HEALTH BENEFITS OF OYSTER MUSHROOM

For assessing the health benefits of oyster mushroom two subjects each with human volunteers having diabetes, cholesterol and hypertension were selected for the case study.

Pleurotus species popularly named the oyster mushroom have a positive effect on human nutrition. Besides *Pleurotus* species modulate the immune system it have hypoglycemic activity, lower blood pressure and blood cholesterol. In addition they effectively reduce lipids in general and specifically low density lipoprotein

(LDL) cholesterol (Nina and Ana, 2001).

5.3.1. Formulation of the mushroom supplement and standardization of recipes.

Mushroom supplement was formulated in the laboratory without adding any chemical preservatives. Dried mushroom powder was packed in five g sachet for distribution to the respondents. Five g supplement per day was incorporated in the daily diet of selected subjects. Incorporation of mushroom supplement was accomplished without any difficulty in the subjects. They incorporated the supplement either in the breakfast preparation or along with lunch.

Various breakfast recipes were standardized in the laboratory incorporating mushroom supplement, in order to ensure the prompt inclusion of the supplement by the respondents. Mushroom when used as an ingredient in diet enhance the taste texture and nutrients (Kumar and Barmanray, 2007).

In the case of dosa and chapatti, incorporation of mushroom powder does not rendered any colour change or off flavour. While as in Idly slight cream colour was imparted. Chutney powder prepared was very much acceptable , since the flavour of mushroom powder blended well with the chutney flavour. Mixing mushroom powder along with the rice gave much acceptance among the subjects. Since mixing the supplement with curd and other dishes yielded encouraging result. However adding supplement to the black tea was less acceptable to the subjects.

However all the subjects were of the opinion that, the supplement was easy to incorporate in the diet in different form, and through different dishes. None of the

respondents expressed any difficulty for consumption of any of the standardized recipe. Incorporation of mushroom supplement does not hinder the acceptability of the dish.

Mane et al. (2000) pointed out that mushroom powder can be incorporated with wheat flour, maize and millet flour to make rotis and bread for daily consumption. They were also of the opinion that mushroom powder act as a good supplementary food item to cereal and millet preparations .

5.3.2.Case study on hyper glycemic subjects

Two middle aged subjects selected for the case study on diabetes, belonged to middle income family and were non vegetarians.

On account of the body measurements the both of them were having normal BMI while on account of the waist hip ratio, two of them were at risk group and exhibited gynoid obesity. Food consumption pattern indicated that consumption of meat products found to be less while fish consumption was found to be adequate.

Impact of mushroom supplement on the blood sugar levels

Figure 9 shows the changes in the blood sugar level of hyperglycemic subjects. The result indicated that the fasting blood glucose level of subject A and subject B initially was 186 mg/dl and 170 mg/dl respectively, decreased to 150 mg/dl and 140 mg/dl after 45th day of supplementation and again reduced to 115 and 110 mg/dl after 90th day of supplementation in both the subjects. The result confirmed that the substantial reduction in blood glucose level after administration of dried *Pleurotus florida* at five g/ day. The observation is in tune with earlier findings.

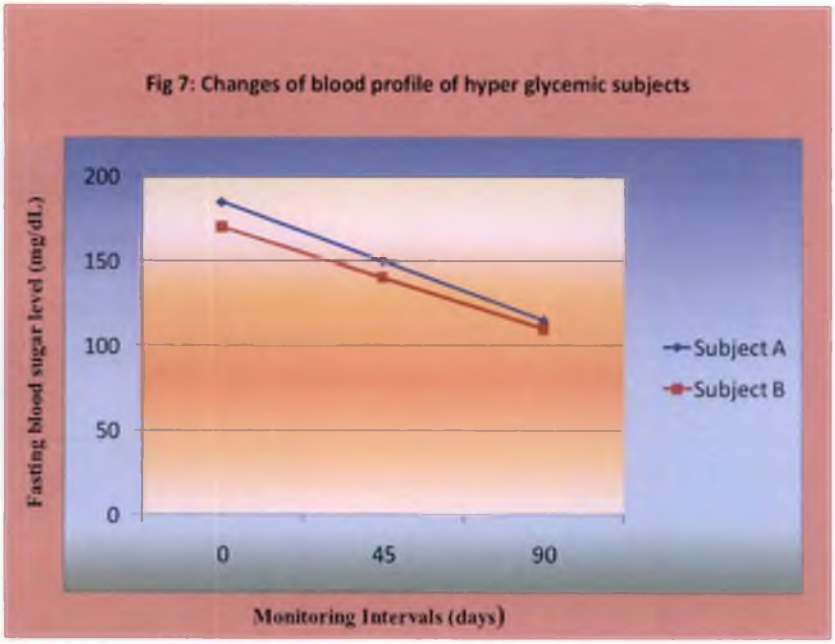


Fig 7: Changes of blood profile of hyper glycemic subjects
Fasting blood sugar level (mg/dL)
200
150
100
50
0
0
45
90
Monitoring Intervals (days)
Subject A
Subject B

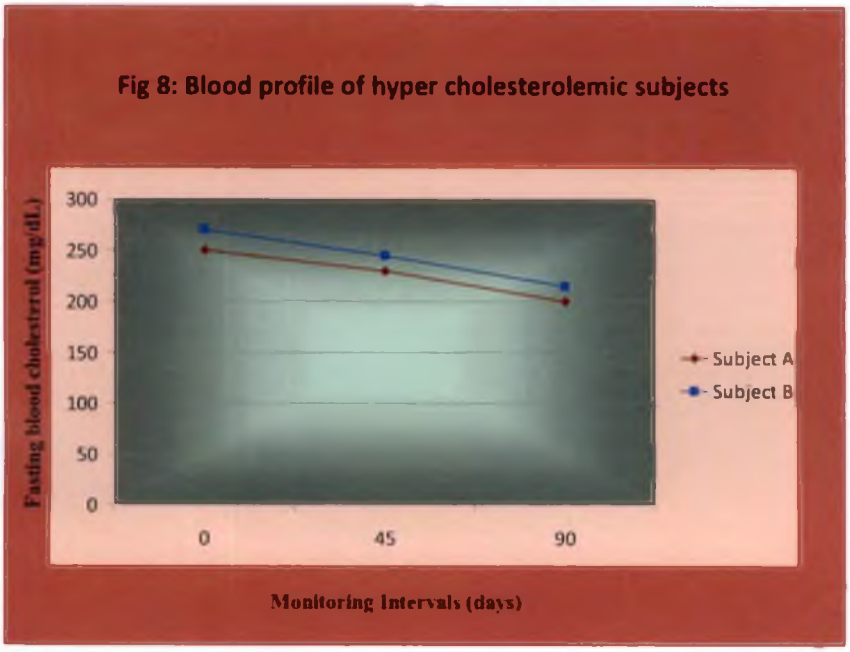


Fig 8: Blood profile of hyper cholesterolemic subjects
Fasting blood cholesterol (mg/dL)
300
250
200
150
100
50
0
0
45
90
Monitoring Intervals (days)
Subject A
Subject B

Nita (2009) reported that the combination of low fat, carbohydrate and zero cholesterol with high proteins, vitamins, minerals, water and fiber makes the mushroom ideal for diabetes. The author was also of the opinion that mushrooms contain natural insulin and enzyme which breaks down the starch and sugar in food. Apart from the above, certain compounds stimulate the endocrine glands form insulin, which helps to reduce glucose level.

Rai et al. (2003) reported that the high protein content associated with low starch sugar makes the mushroom delight of diabetic. Talpur et al. (2002) and Manohar et al. (2002) reported that maitake mushroom extract enhance the insulin sensitivity in rats and therefore reduce the blood glucose level.

Hyun et al. (2001) studied the hypoglycemic effect of a medicinal mushroom *Phellinus lenteus*. In his study he has developed dried mushroom powder and incorporated at 5 -1 per cent in daily diet of diabetic rats and observed in lower plasma glucose level as much as 28 per cent in rats.

P.ostreatus posses hypoglycemic effects in human subjects (Khatun et al. 2007). Study conducted by Kress (1991) indicated that mushrooms contain more mannitol and hence highly suitable for diabetics.

5.3.3. Case study on hyper cholesterolemic subjects

Two subjects selected for the case study were middle aged females. Both of them belonged to Hindu community and from middle income family. Both of them follow non vegetarian diet and consume four meals a day. No special diet was followed for their disease condition.

On account of the body measurements, both the subjects do not maintain ideal body weight, and as per BMI standard one subject was over weight. On account of the waist hip ratio two of them were at risk and depict gynoid obesity.

Impact of mushroom supplement on the cholesterol levels

Mushroom supplement was incorporated by the subjects through various dishes in the daily diet without much difficulty. The result of feeding trial showed a gradual decrease in the blood cholesterol level in the two subjects after supplementation.

The result showed that the initial blood cholesterol level of the respondents were 250mg/dl and 270mg/dl subject A and subject B respectively. It was reduced to 230mg/dl and 245 mg/dl after 45th day of supplementation and after 90th day of supplementation it was reduced to 200 and 215mg/dl in the subjects A and B respectively (Fig.8).

The result obtained in the present investigation indicated that *Pleurotus florida* dried powder act as an effective functional food for the control of elevated cholesterol level.

Schneider et al. (2010) conducted a study on the lipid lowering effect of oyster mushroom on humans and reported that 30 g dried oyster mushroom incorporated in tomato soup in hyper cholesterolemic diet resulted in lowering the tryacylglycerol concentration and low density lipoprotein levels even after 21 days of incorporation.

Bhandari et al. (1991) reported that dried *Pleurotus florida* incorporated at 5 per cent or 10 per cent level in hyper cholesterolemic diets in albino rats resulted in

lowering the lipids, cholesterol and glyceride levels in plasma without any effect on fatty acids and phospholipids.

Dill (2007) reported that the oyster mushroom helps to reduce cholesterol level. Natures Janitor (2010) concluded from the study that oyster mushroom have the most promising effect on cholesterol levels. Oyster mushroom naturally produce compounds called statins which is a drug to reduce bad cholesterol (LDL) by stimulating receptors in the liver to clear the cholesterol from the body. The findings of the present experiment, revealed highly promising results of *P.florida* as reported by earlier researchers.

5.3.4. Case study on hypertension subjects

Two females aged 50 and 51, belonged to Hindu and Christian religion were selected for the case study. Both of them were from middle income family and were non vegetarians, following three meals a day pattern. No special diet was followed for their disease condition.

On account of the body measurements, the two subjects were over weight and were at risk group based on waist hip ratio. On account of the waist hip ratio, the two subjects were at risk and were prone to develop degenerative diseases.

Impact of mushroom supplement on the blood pressure levels

The initial value obtained for blood pressure level for subjects A and B were found to be 139-89 mmHg for systolic pressure and 140-90 mmHg for diastolic pressure.

There was no noticeable changes in the blood pressure level of the two subjects after 45 days of supplementation. However marginal decrease was noticed in blood pressure level, 130-85 mmHg systolic and pressure in the subject (A) below 125-85 for systolic pressure and diastolic pressure for the subject (B) after 90^{th} days of supplementation.

Preuss et al. (2010) reported that incorporation of maitake extract for 120 days in daily diet of hypertensive rats showed a positive effect on the systolic and diastolic pressure. At 35 days there is a decrease in systolic pressure from 138 to 120-125 mmHg. The author also reported that by the end of 4^{th} months after introduction of maitake extract in the diet, the diastolic pressure and mean BP were also reduced.

The impact of the mushroom supplement, on hypertension is to be studied further to obtain positive and confirmative results.

Summary

SUMMARY

The present study entitled "Evaluation of nutritional quality and health benefits of oyster mushroom" (*Pleurotus florida*) is a comprehensive study carried out with an objective to determine the nutritional quality, nutrient losses during processing and also to investigate the impact of mushroom supplement on the blood profile of the subjects with specific disease condition.

The popular and most versatile commercially cultivated and consumer preferred oyster mushroom(*Pleurotus florida*) was selected for the study. Chemical and nutritional composition of the fresh and processed oyster mushrooms were assessed with regard to macro nutrients, vitamins, minerals and other chemical constituents.

The energy value of oyster mushroom was 453.0 kcal/100 g on dry weight basis and that of carbohydrate, protein and fat content were 4.7g, 5.6 g and 0.8 per cent respectively in the fresh mushroom. As reported earlier by researchers oyster mushrooms are low in calories, with low carbohydrate and fat content.

Quality of protein present in the oyster mushroom was determined in detail. Eighteen amino acids including eight essential amino acids were analyzed, which yielded more precise data on the quality aspects of mushroom protein. Oyster mushroom contains all the essential amino acids, and the content of phenyl alanine was exceptionally high when compared to the reference protein. Similarly leucine, lysine and threonine content were also found to be higher than the reference protein.

Among the other amino acids present, glutamic acid content was remarkably high (17.2 g) followed by aspartic acid and tyrosine. Amino acid content of the *P.florida* when compared to *P.citrinopeleatus* and *P.sajor caju*, it was observed that glutamic acid content was higher than the other two species.

Determination of amino acid score - an index to evaluate protein quality, indicated that the essential amino acids viz threonine recorded the highest amino acid score (208) followed by leucine (113.46) and lysine (111.36). Limiting amino acid sequence in *P.florida* was methionine, valine and isoleucine.

Amino acid content and amino acid score (AAS) clearly confirmed that *P.florida* superior in protein quality with respect to amino acid composition and essential amino acid content when compared to *p.citrinopeleatus* and *P.sajor caju*. EAA index of oyster mushroom computed was found to be 119 while nutritional index based on protein quality was ascertained as 6.42.

Oyster mushroom contains B complex vitamins viz thiamine, riboflavin and niacin as 5.43 mg, 8.7 mg and 55.9 mg respectively which is fairly very high when compared to other plant foods. However vitamin C content of oyster mushroom was found to be comparatively low (12.4 mg)/100 g.

Investigation clearly revealed that oyster mushrooms are rich sources of various minerals. Calcium content was recorded as 12.46 mg/100 g. While sodium, potassium and phosphorus were found to be 125 mg, 623 mg and 477 mg per 100 g respectively. Oyster mushroom also found to have fairly good amount of iron (7.63 mg/100 g). Trace elements analyzed viz copper and zinc were estimated as 1.9 mg and 1.47 mg/100 g respectively.

Moisture content of oyster mushroom was 90.3 per cent which promote its susceptibility to deterioration. As observed in other mushrooms fiber content of oyster mushroom was 3.2 g/100 g. Tannin and polyphenol which are considered as antioxidants were determined as 1.4 mg and 4.3 mg /100 gm respectively.

Anti inflammatory factors (IF positives) and antioxidant analyzed in the mushroom were vitamin C, zinc, copper, polyphenols, tannin and fibre which also account for its medicinal properties.

On assessing the loss of nutrients in the oyster mushroom when subjected to various processing methods, it was revealed that as expected, all the macro nutrients decreased during processing such as boiling, blanching and steaming while dried mushroom depicted enhanced values with respect to calories (453.0 kcal), carbohydrate (39.43

g), protein (20.43 g) and fat (2.85 per cent). All the nutrients were found to depict significant variation when subjected to different processing methods.

The present investigation indicated that the nutrient loss was maximum in boiled mushroom followed by blanched and steamed samples. While it was observed that all the vitamins were higher in T_4 treatment (dried mushroom).

The principal minerals in foods that may be lost during cooking or processing are the salts of calcium, sodium and potassium. The mineral content of oyster mushroom treated with different processing treatments indicated that the mean value for minerals significantly vary with processing treatments. It was noticed that the dried mushrooms (T_4) depicted higher values with regard to all minerals. As the moisture is lost from the mushroom, nutrient concentration increases and hence dried mushroom recorded higher values for all the nutrients.

Health benefits of oyster mushroom was ascertained through supplementation study on the selected human volunteers, with three specific disease condition viz. hyperglycemia, hypercholesterolemia and hypertension. Dried mushroom powder formulated without adding any chemicals was distributed to the subjects under case study on the basis of 5g/ person/ day for a period up to three months. Incorporation of mushroom supplement in the dietaries of subjects was accomplished without any difficulties.

Various recipes were standardized in laboratory with incorporation of mushroom supplement, which helps the subjects to incorporate the supplement in the daily dietary. Diet counseling was imparted to the subjects along with the supplement.

The impact of mushroom supplement on the disease condition was assessed by monitoring blood profile of the subjects at periodical intervals.

The result of the blood profile of the subjects showed a significant decrease in the blood glucose, blood cholesterol levels in the subjects over a period of three months. Impact of the supplement on the blood pressure was not very much apparent with in the short spell of supplementation. However slight decrease in blood pressure was noticed at the end of the 90^{th} day.

Based on the findings of the in-depth investigation on oyster mushroom, it could be concluded that oyster mushroom is superior in nutritional quality and highly suitable and beneficial for promoting and maintaining health. Oyster mushroom proved to bring desired positive changes in the hyperglycemic and hypercholesterolemic subjects. The study also recommend that cultivation and

consumption of oyster mushroom should be popularized and promoted with the motto "mushroom for nutrition, health and income".

References

7. REFERENCES

Adejumo, T.O. and Awosanya, D.B. 2005. Proximate and mineral composition of four edible mushroom species from South Western Nigeria. African Journal of Biotechnology 4(10): 1084-1088

Agarwala, K.C. and Jandaik, C.L. 1989. Amino acid composition of pleurotus species in comparison with other species of mushrooms. Mushroom Journal (4) :110

Ajith T.A. and Janardhanan K.K. 2001. Anti oxidant and anti inflammatory activity of methanol extract of phellinus rimosuspilat. Indian J. Exp Biol. 38(11): 1166-1169.

Alam, N., Amin, A, Khan, A., Ara, I., Shim, M., Lee, M.W. and Lee, T.S. (2008). Nutritional analysis of cultivated mushrooms in Bangladesh- P.ostreatus, P. sajor caju, P.florida and Calocybe indica. Bangladesh. J. Mushroom. 36(4):228-232. The Korean society of mycology.

Alam, N., Hossain, S., Khair, A., Amin, A. and Khan, A. (2007). Comparitive effects of oyster mushrooms on plasma lipid profile of hyper cholesterolemic rats. Bangladesh. J. Mushroom. 1:15-22.

Aletor, V.A. (1995). Food chemistry.54:265-268.

Alvi, S., Khan, M.K., Munir, A.S. and Shahid, M. 2003. Effect of peeling and cooking on nutrients in vegetables. Pakistan. J. Nutrition. 2 (3): 189-191

Anderson, E.E. and Fellers, C.R. 1982. The food value of mushrooms. Horticultural Abstarct 44: 221,

AOAC. 1990. Official and tendative methods for analysis. 13th ed. Association of Officical Analytical Chemists, Washingtom in D.C., USA, pp. 10-18

Arrora, A. 1991. The Women Elite in India. Sangam Books Ltd., London : 40

Arumuganathan, T., R.D. Rai, C. Indurani and A.K. Hemkar. 2003., Rehydration characteristics of button mushroom (*Agaricus bisporus*) dried by different drying methods. *Mushroom Res* 12:121-123.

Banik. S and Nandi, R. 2004. Effects of supplementation of rice straw with biogas residual slury mature on the yield, protein and mineral contents of oyster mushroom crops and .Industrial crops and products. 20: 311-319.

Bano Z, Rajarathnam S, Shashirekha, M.N.1992. Mushroom uncoventional single cell protein for a conventional consumption. Indian fd pak. 46(5):20-27.

Bano, Z. and Rajarathnam, S. 1982. Pleurotus mushroom as a nutritious food .Tropical mushroom –Biological nature and cultivation methods.pp,363-380.

Bano, Z. and Rajarathnam,S. 1988. Vitamin content of mushrooms. Food technology Abstract.51:22.

Barros, L., Baptista, P., Daniela, M., Susana, C.C., Betriz O., Isabel C.F.R., Ferria (2007). Fatty acid and sugar composition and nutritional value of five edible mushrooms from Northeast Portugal. Science direct .Food chemistry.105:140-145.

Bawa, S., Singh, H. 1998. Preparation, nutritional improvement, packaging and storage of mutter : a traditional Indian snack. J. Food Sci. Technol 35:537-539.

Beetz, A. and Kustudia, M. 2004. Mushroom production. Mushroom Cultivation and Marketing, Horticulture Production Guide. www.attra. NCAT. Org.

Benefield, H. 1997. Medicinal mushrooms .Help yourself to a serving of health. Natures impact:40.

Bertholle, J., Child, J., Beck, S. 2001. Mastering the art of French cooking. Alfred A. Knoof

Bhabdari, R., Khanna, P.K., Soni, G.L., Garcha, H.S. and Mittar, D. 1991. Studies on hypocholesterolemic/ hyporlipidemic actions of pleurotus florida in albino rats. Indian Mushrooms. 207-210

Bisaria R, Madan M, Bisaria, V.S., Mukhopavhyay, V.S. (1987). Amino acid composition of the mushroom *P.sajor-caju* cultivated on different agro residues. Biological wastes 209:251-259

Bisaria, R. Madan, M. and Bisaria,V.S., 1987.Mineral content of mushroom *Pleurotus sajor* caju ,cultivated on different agro wastes. Mushroom journal of tropics,7: 53-60

Boa, E. 2004. Wild edible fungi: A global overview of their use and importance to people. Food and agriculture organization of the united nations. ISBN 92-5-105-157-7.

Borchers A.T, Krishnamurthy, A., Keen, C.L., Meyers, F.J., Gershwin, M.E. 2008. The immune biology of mushrooms. Exp Biol Med 223(3):259-76.

Borchers, A.T., Stern, J.S., Hackeman, R.M., Keen C.L., Gershwin M.E, 1999. Proc soc exp boil med. 22 (4). pp 281-293.

Bowerman and Susan. 2008. mushrooms are see the light. The Los Angels Times. http://articles.latimes.com.

Bray, G.A. 1991. Pathophysiology of obesity. Am. J. Clin. Nutr, 55: 448-449

Buigut. 2002 Mushroom production in sustainable small scale farming system opportunities and constrains: a survey of Jasin Gishu district. In: proceedings of the Horticulture seminar on sustainable horticulture production in the tropic at Jomo Kenya university of agriculture and technology, Juja, Kenya 3rd -6th .

Caglarimark, N. (2007). The nutrients of exotic mushrooms Lentinula edodes and p. species and an estimated approach to the volatile compounds. Food chemistry, 105 (3): 118-1194.

Chaliha, M.K. 2007. Assam Agriculture University.

Chanda, S.L., Gopinath, N., Katyal, I. and Shekhawat, S. 1995. Dietary profile of adults in an urban and a rural community. Indian J. Med. Res. 101: 258-267

Chandra, S. and Smasher. 2002. Studies on quality of dehydrated oyster mushroom as influenced by various pretreatments and drying methods. Mushroom research vol:11:107-112.

Chang, R. 1996. Functional properties of edible mushrooms. Nutrition Review 54 (11): 591-593

Chang, S.T. 1992. Mushrooms as therapeutic material. Journal of Food Science 52 (6) : 613

Chang, S.T. and Hayes, W.A. 1988. Mineral content of mushrooms. Mushroom Science: 633-634

Chang, ST.(1980).Mushrooms as human food ,Bioscience 30:399-401.

Chihara, G. 1993. Medicinal aspects of Lentinan isolated from Lentinus edode Hong Kong, Chinese university press. pp 261-266.

Chilton, J. 1993. What are the health benefits of mushrooms? Let's Live : 24-29

Choi, K.W. 2004. Shelf cultivation of oyster mushrooms. http:// www.mushworld. com.

Chu. K.K, Hoss, and Chow A.H. 2002. Coriolus versicolor:a medicinal mmushroom with promising immune therapeutic values.J clin pharmacol.vol:42(9):976-984.

Cicil, M.J. 2000. Impact of nutrition education on mushrooms consumption. M.Sc Home science (FS&N) Thesis. Kerala Agricultural University. Thrissur, p. 130

Cohen, Periyassamy, K and Natarajan, 2002. Selection cultivation and Nutritive value of improved strains of Pleurotus spp. Mushroom Research 11(2): 81-84.

Craig, W. 2003. MPH, phD, RD. Health benefits of oyster mushrooms. http://www.livestrong.com/article/294007.nutrition.facts on oyster mushrooms.

Dabour IR, Taruri, H.R. (2002).Protein quality of four types of edible mushrooms found in Jordan. Plant foods for human nutrition. l:57.pp.1-11

Dake, B. 2009. Boiling water for tea: Bubbles and steam. October 13th . Mighty leaf tea blog.

Das N. 2005. Determination of lead ,arsenic ,cadmium ,iron ,copper and nickel in wide mushroom samples in South West Bengal *Mushroom Res* 14(2):80-83,2005.

Deepak, R.R., Masuda. R. and Saito, M. (2000). Effect of modified atmospheric packaging on low molecular weight carbohydrate of oyster mushroom. J.food sci. Technol.37(4):384-387.

Demirbas, A. 2000. Accumulation of heavy metals in some edible mushroom from Turkey. Food chemistry. 68 (4): 415-419

Deng, G., Ling, H., Seidman, A. (2009). A phase I/II trial of a polysaccharide extract from Grifola frondosa (Maitake mushroom) in breast cancer patients: immunological effects. J. of Cancer Research and Clinical Oncology 135 (9): 1215-21

Depluch, F. 1992. Paper presented at a meeting "Functional Sihnificance of Low Body Mass Index (BMI)". Rome.

Dharmandra, S. 1996. Medicinal mushrooms. Best Ways Magazine : 54-58

Dikie, A. 1989. Dietary fibre and medicinal value of mushrooms. Mushroom Journal 152: 304

Dill J. (2007). http:// okwild crafting wikia.com/wiki/oyster_ mushroom.

Dunkwal, V and Jood, S. 2009. Effects of substrates on nutrient composition of oyster mushroom. J. Dairying foods and HS.28(2):132-136.

Dunkwal, V., Jood, S. and Khetarpaul, N. 2006. Sensory and nutritional evaluation of oyster mushroom products. Abstract, ss-05. In: ICFOST 2006: 18th Indian Convention of Food Scientist & Technologists.

Ekanem if E.O. and Ubengama, VS(2002). J. Fd Sci. Technol.36:81-83.

Ereifj, K.I. and AL-Raddad, A. 2000. Identification and quality evaluation of two wild mushrooms in relation to Agaricus bisporus from Jordan. In L. Van Griensven, ed. Science and cultivation of edible fungi, pp. 721-724.

Flatt, K. (2010) oyster mushroom facts. Nutrition/ herbs/ species/ supplement

Flickety, W.R.M. 2011. How to sundry fruit. www.wikiHow.com

Fukushima et al.(2000). Mushrooms and macro fungi. www. Mushroomcouncil.com

Fullerton S.A, Samadi A.A, Tortorelis D.G, Choudhury M.S, Mallouh.C, Tazaki.H, Konno.S. (2000) Induction of apopotosis in human ptotrait cancer cells with betaglucan (Maitake mushroom polysaccharide) Mol Vrol 2000. Spring:4(1).7-13.

Garcha, H. S. and Khanna, P.K. (2003) Mushroom cultivation. Sixth edition Punjab Agricultural University. Ludhiana

Geetha, D. and Suharban, M. 1997. Koon oru poshakakalavara. Kerala Karshakan 10:28

Ghosh N, Chakravarthy, D.K. (1990) predictive analysis of protein quality of Pleurotus citrinopileatus. J.Food Sci. Technol., 27:236-23.

Gopalan, C. 1988. Dietary guidelines for affluent Indians. Bull. Nutr. Found. Ind. 9: 1-4

Gopalan, C., Ramsastri ,B.V .and Balasubramanyan ,S.C.1991.Nutritive value of Indian foods :2-5.

Gopalan, G., Ramasastri, BV. and S.C. Balasubrahmanyan (2010) published by Institute of nutrition, ICMR, Hydrabad-500007.

Goyal R.(2002) phD Thesis, CCS Haryana Agricultural university. Hisar India.

Grieger (2010). Do mushrooms have nutritional value?. http://www.ivillage.com

Gunde-Cimerman, N.(1999). Medicinal value of the genus Pleurots. Int J. Medi. Mushrooms.1:69-80.

Gunde-Cimerman, N., Cimerman, A. (1995). Pleurotus fruiting bodies contain the inhibitor of 3-hydroxy-3-methylglutaryl-coenzyme A reductase lovastatin. Exp Mycol. 19(1):1-6.

Gupta, M., Sarmah R. and Gupta, S. (2004). Nutrient composition of *Pleurotus sjor-caju* Grown on different substrates .J. Food Sci.Technol.,2004,vol.41,No.5,584-586

Guthalu, N.P., Upparahalli, S.V., Mallaiah, S.D., Shashirekha, M.N. and Somasundaram, R. 2006. Antioxidant activity of indigenous edible mushroom. J. Agri. Food chemistry. 54 (26): 9764-9772

Hadwan, H.A., Al- Jaboury, M.H. and Hassan, A.A. 1997. Suitability of different substrate and amendments on the cultivation of oyster mushroom. Collection of Thesis materials S & T, Development, Environment and Resource Proc. 96 (FUZHOU) International Symposium on the development of Junco industry. pp 215-221

Halpern, George, M., Miller and Andrew. 2002. Medicinal mushrooms: ancient remedies for modern ailments. New York: M. Evans and Co. pp. 64-5

Harsh, N.S.K., and Joshi, K. 2008. Mushrooms: The vegetable of the future. India Science and Technology. 2008

Hayes,VA. and Haddad, N.(1976). The food value of the cultivated mushroom and its m importance to the mushroom industry .Mushroom journal.40:104-110.

Henze, R.B. 1991. Preservation of oyster mushroom by light CO2 concentration. Mushroom Science 8: 663-671

Hetland, G., Johnson, E., Lyberg, T., Bernardshaw, S., Tryggestad, A.M., Grinde, B. 2008. Effects of medicinal mushroom Agaricus bazeli Murill on immunity, infection and cancer. Scandinavian Journal of Immunology 68 (4): 363-70

Hobbs,1995. Medicinal mushroom. Published by Santa cruz, CA Botanical press,110-115.

Hobbs,1997.Medicinal mushrooms .Herbs for health:52-53.

Huseyin, G., Yusuf, U., Yusuf, T and Demirel, K. (2008). Determination of mineral contents of wild grown edible mushrooms. Food chemistry vol:113(4):1033-1036.

Hyman. 2006." Ultra- Metabolism" p.137.

Hyun,D.K., Byung-Kun., Jung, N., Surajiit., Won, J., Young, S and Nam, J. (2001).Hypoglycemic effects of mycelia produced from a submerged culture of Phellinus linleus in streptozotozin induced diabetic rats. Int. J.med. mush.3(1).

Indian Agriculture (2003). Indian Economic data research centre, New Delhi.

Indian food industry. (1998) Mushroom biscuits .Vol.16(6)pp.371.

Jain and Singh. 2003. A study on the nutritional status of women I the age group of 25- 50 years working in sedentary job in Jaipur city. Ind. J. Nutr. Diet. 40

Jandaik, C.L. 1988. Study on oyster mushroom species. Journal of Food Science 54: 20-22

Jedinak, A. and Sliva, D. 2008. Pleurotus ostreatus inhibits proliferation of human and colon cancer cells through p53-dependent as well as p53 independent pathway. International Journal of Oncology 33 (6): 1307-13

Jegtvig, S. 2010. Anti inflammatory foods. About.com

Jiskani, M.M. (2001).Energy potential of mushrooms. The DAWA Economic and Business review.Oct.15-21.p-iv.

Jones, K. 1997. Shitake: medicine in a mushroom. Herbs for health: 48-54

Jose ,N., Ajith, T.A and Janardhanan, K. (2002). Anti oxidant anti inflammatory and anti tumour activity of P.pulmonarious. International Journal of Medicinal Mushroom.Vol.4,pp.329-335.

Joshi, V.K, Seth, P.K., Sharma, R.C and Sharma, R. (1991) Indian fd pak,4:39-43.

Kamal, A.S.M., Khair, A., Farhad, S.F.U., Zaman, N.A. and Fauziya. 2009. Mechanical detection of minerals, heavy metals and trace elements in processed mushroom in relation to toxicological aspects. Bangladesh. J. Mushrooms. 3 (1): 53-65

Kelvin, R. 1991. Crude fibre content in mushroom. Nutrition Abstract 58 (5) : 162

Khader, V. and Padmavathi. 1991. Studies on Oyster mushrooms at different stages of maturity and standardization of three recipes from matured mushrooms.Pp:63-66.

Khader, V. and Padmavathy. R. 1991. Mushrooms in human nutrition. Indian Mushrooms-Proceedings of the National Symposium on Mushrooms. 223

Khan, A.S.M., Amin, R., M.D. Nazim, U., Mousumi, T. and Alam, A. (2008). Comparitive study of the nutritional composition of oyster mushroom cultivated in Bangladesh. Bangladesh. J. Mush.2(1):9-14.

Khatun, K., Magtab, H., Khanam, P.A., Sayeed, M.A. and Khan, K.A.(2007). Oyster mushroom reduced blood glucose and cholesterol in diabetic subjects. *Mymensingh Med. J.* 16:94-99.

Kim. M.Y., Min Chung, Sun Joo Lee, Joung-Kuk-Ahn, Eun- Hye Kim, Mi-Jung Kim, Sun Lim Kim, Hyung-In moon, Hee Myong Ro, Eun- Young Kang, Su- Hyun Seo and Hong Keun(2009).Comparison of free amino acid, carbohydrates concentration in korean edible mushrooms.food chem. .113(2)386-393.

King, T.A. 1993.Mushrooms the ultimate food . Mushroom News 41(2)-29-26

Kodaman, N., Asakawa, A., Inui, A., Masuda, Y., Nanba, H. 2005. Enhancement of cytotoxicity of NK cell by D-fraction, a polysaccharide from Grifola frondosa. Oncology Report 13 (3): 497-502

Kodaman, N., Murata, Y., Nanba, H. 2004. Administration of a polysaccharide from Grifola frondosa stimulates immune function of normal mice. Journal of Medicinal Food 7 (2): 141-5

Konno, S. 2004. Potential growth inhibitory effects of maitake D- fraction on canine cancer cells. Veterinary Therapeutics 5 (4): 263-71

Koyyalamudi, S.R., Jeong, S.C., Song, C.H., Cho, K.Y., Pang, G. 2009. Vitamin D2 formation and bioavailability from agaricus bisporus button mushrooms treated with ultraviolet irradiation. J.Agric. Food Chem.57(8):3351-5.

Kress, M. 1991. The role of edible mushrooms in the diet. In Lelly (Ed) Mushroom growing. The biotechnology of cultivated mushrooms.

Krumm, S. 2009. Mushrooms packed with nutrients. LJworld.com

Kumar ,K. and Barmanrai, A. 2007. Studies on drying characteristics of White button mushroom dried by different drying techniques. Mushroom research .16(1):37-40.

Kumar, S., Nath, N and Tyagi ,R.K. 2006. Development and evaluation of *Pleurotus* mathri. J Food Sci Technol,4(5),501-504.

Kumary, R.V. and Murthy, K.N.K. 2002. Nutritive value of mushroom. Agro industry.vol :4 (2): 17.

Kurner,Y. and Ozdemir,Y. 2000. Acid and EDTA blanching effects on the essential element content of mushrooms. J Sci Food agric 80:2074-2076.

Kushalappa, P. 2010. Mushrooms can keep the doctor far away 1ST BA, SDM college UJIRE.

Lamacraft, B. 2007. The nutritional value of raw carrots. www. Helium. Com

Lean, M.E.J., Han, T.S. and Morrison, C.E. 1995. Waist circumference as a measure for indicating need for weight management. Brt. Med. J. 11: 638-641

Lee, G.S., Byun, H.S., Yoon, K.H., (2009). Dietary calcium and vitamin D2 supplementation with enhanced Lentinula edodes improves osteoporosis-like symptoms and induces duodenal and renal active calcium transport gene expression in mice. Eur J Nutr.48 (2): 75-83.

Lelly, J. (2007). Healthy aspects of eating mushrooms. GAMU Ltd. Institute of mushroom research.

Li, L., Ng, T.B., Song, M., Yuan, F., Liu, Z.K., Wang, Jiang, Y., Fu, M., and Liu, F.(2007). A polyshacharide –peptide complex from abalone mushroom(*pleurotus abalones*) fruiting bodies increases activities and gene expression of antioxidant enzymes and reduces lipid peroxidation in senescence- accelerated mice. *Appl. Microbiol. & Biotechnol.*75:863-869.

Lindequist, V., Neidermeyer, T.H. and Julinch, W.D.(2005). The pharmacological potential of mushrooms. evidence based complementary and alternative medicine.2:285-299.

Lintzel, W. 1990. Nutritive value of mushrooms. Food Science and Technology Abstract 43(13): 23

Losato, O.H. 1988. Mineral contents in mushrooms. Biological Abstracts 95 (3) : 120

Losato, O.H. 1990. Selenium content in mushrooms .Biological Abstract .95(3) : 120

Lowe, B. 2009. Chapter IV. Fruits and vegetables losses in cooking vegetables. Experimental cookery from the chemical and physical standpoint

Lowry, O.H., Rosebrough, N.J., Farr, A.L., Randall, R.J. 1951. Protein measurement with the Folin phenol reagent. J. Biol. Chem. 193 (1): 265-75

Luthra, S.K., Soni, G.L., Garcha, H.S., Singh, C.K., Singh, R if. 1991. Role of mushrooms as hypochlesterolemic and hypolipidemic agent. Indian mushrooms. 211-212

Maier, K. 2010. www. Good morning heart.com.

Mane, A., Nilima, W., Archana A.,GK. Mane. 2003. Oyster powder and: an effective supplement for saily bread of Indians. Current vista in mushroom Biology and product. Mushroom society of India.

Mane, A.S. and deshmukh. 2000. Acceptability and protein quality of supplimentary foods davaloped out of mushroom powder.Science and cultivation of edible fungi.Vol.11.pp.753-755.

Manohar, V., Talpur, N., Echard, B.W., Liberman, S.and Preuss, H.G. 2002. Effects of a water soluble extract of a mushroom on insulating glucose/insulin concentrations in mice. Diabetes, obesity and metabolism.4:43-49.

Manpreet, K., Giridhar,S. and Khanna, P.K. 2004. In vitro and in vivo antioxidants potentials of P. florida in experimental animals. Mushroom research 13:21-26.

Manzi ,P. and Marconi ,S. 2004. Commercial mushrooms: Nutritional quality and effect of cooking. Science Direct. Vol .84,Pp 201-2006.

Manzi, P. 2000. Beta glucans in edible mushroom. Food chemistry.vol:68 (3):315-318.

Manzi, P., Altero aguzzi, Pizzoferrato, L. 2001. Nutritional value of mushrooms widely consumed in Italy. J. of Food chemistry, vol:73. Issue-3.pp.321-325.

Marion, R.B. 2006. Nutrient data on mushroom update. www. Ars.usda. gov/ nutrient database

Mattila P, Suonpaa K, Piironen V (2000). Functional properties of edible mushrooms. J. Agri food chemistry. 16 (7-8): 694-6.doi:10.1016/S0899-9007(00) 00341-5 PMID 10906601.

Mattila.P, konkok, Euroia.M, Pihlava.J.m, (2001) Contents of vitamins, minerals and some phenol compounds in cultivated mushrooms. J. Agri food chemistry vol:49(5)pp 2343-2348.

Mau, J.L., Lin. HC., Chen. C.C (2002) Antioxidant properties of several medicinal mushrooms. J. agri food chemistry.vol:50(21)pp 6072-6077

Mayuri, K. 2009. Mushroom nutritional value. www.buzzle.com

Ming, D., Song, X. S., Guanghua, Z., Cong, W. 2010. Mechanism underlying the antitumour activity of proteins from the Ling Zhi or Reishi medicinal mushroom, Ganoderma lucidum. Int. J Med. Mushr. 12 (2): 114

Mizuno T, (1991). The extraction and development of antitumour active polysaccharides from medicinal mushrooms in Japan. Int J Med Mush.vol:1.

Mori, K., Kobayashi, C., Takkakko, T., Inatomi, S. and Ikeda, M. (2008). Antecholesterolemic effect of the edible mushroom pleurotus eryngi, Grifola frondosa and hypsizygus marmoreus in apolipoprotein E- deficient mice. Nutrition research, vol:28, issue, pp 335-342.

Moriarty, K. 2007. Enjoying healthy mushrooms. Suite 101.com

Moss, .W.R. (2004) phD. Weekly cancer decisions.com. Newsletter.

Murakav, K., Fukunaga, K., Tanouchi, M., Hosokawa, M., Hossain, Z., Takahashi, K. 2007. Therapy of myeloma in vivo using marine phospholipid in combination with Agaricus bazeli Murill as an immune respond activator. Journal of Oleo Science 56 (4): 179-88

Nair (1991). Medicinal musrooms. Indian Mushrooms 27-29

Narayanaswamy, P., Suganthavel, P., Sabari, D., Divya, J., Vanchinathan and M.S. Kumar. 2009. Cultivation of mushroom by using two different agricultural wastes in laboratory condition. The Inter Journal of Microbilogy. 7 (2)

Nayana Jose, T.A .Ajith and K.K. Janardhanan. 2002. Antioxidant, anti-inflammatory and antitumor activities of culinary medicinal mushroom pleurotus pulmonarious. Inter J Med Mushrooms.vol:4.pp.329-335.

Nayana,J., Ajith, T.A. and Janardhanan, K. 2004. Methanol extract of the oyster mushroom, pleurotus florida inhibits inflammation and platelet aggregation. Phytotherapy research.18:43-46.

Nicoli, C.M., Calligaris, S., Manzoco, L. 2000. Effect of enzymatic and chemical oxidation on the antioxidant capacity of calichin model system and apple derivatives. J. Agric. Fd. Chem., 48: 4576-4580

Nina and Ana. 2001. Hypocholesterolemic activity of the genus pleurotus(jacq:fr) P.kunm(Agaricales S.I, Basidiomycetes).Int. J. med.mush.3(4).

Nita, M. 2009. Composition and health benefits of mushroom: A rich source of nutrient Source with medicinal properties. http://www.suile.101.com/ content/composition and health benefits of mushroom.

Nozaki, H., Itonory, S., Sugita, M. 2008. M ushroom acidic glycophinglipid induction of cytokine secretion from murine T cells and proliferation of NK1.1 alpha/beta TCR-double positive cells in vivo. Biochemical and Biophysical Research Communicatios 373 (3): 435-9

Oatman, G.S. 2000. An alternative to synthetic drugs, Medicinal mushroom.

Oei, P. 2003. Mushroom cultivation. Appropriate Technology for Mushroom Growers. 3rd edition. Backhuys pub., Leiden. Netherlands. 426

Ogawa, W. 1993. Amino acid content of pleurotus species. J.of Food Science 72 (9) : 116

Omisore, S. 2010. Benefits of mushrooms in checking cancer, hypertension. Nigereian compass, 5 March.

Oser, B.L. 1959. An integrated essential amino acid index for predicting the biological value of proteins, in Protein and Amino acid Nutrition by Albanese AA, (Ed) Accademic press, Newyork, 1959, 281.

Paraskevi, K, Odzouni, Petridis, D., Koller, W.D. and Kyriakos, A., Rignakos. 2009. Nutritional value and metal content of wild edible mushrooms collected from west Macedonia and Epirus, Gruce. Food chemistry, vol:115(4):1575-1580.

Park, K. and wnag-ho. 2001. Nutritional value of a variety of mushrooms. January, 5

Periyassamy and K. Natarajan. 2002. Selection cultivation and nutritive value of wild and improved starins of pleurotus djamor. Int J Mush Research 11(2):81-84.

Preuss, H., Konno, S. 2002. Maitake magic. USA Freedom press,2002:1-160.

Preuss,H.G., Echard, B.W., Bagchi,D.,Nocholas,V. and Perricone. 2010. Maitake mushroom extracts ameliorate progressive hypertension and other chronic metabolic perturbations in aging female rats. Int. J. med sci.37:169-180.

Qutila. 1999. Mushrooms and macro fungi. www. Mushroomcouncil.com

Rai R.D., Chandrasekhar, V. and Arumughanathan, T. 2003. .Postharvest technology of mushrooms. *Mushroom Res (*2003).

Rai, R.D . and Saxena, S. 1989. Suitability of methods of estimation for critical assessment of the vitamin C content in mushrooms. Mushroom Journal of Tropics 9: 43-46

Rai, R.D. 1995. Nuritional value and medicinal significance of mushrooms .Advances in Horticulture.13:543.

Rai, R.D., Saxena, S. and Upadhyay, R.C. 1988. Comparitive nutritional value of various pleurotus species grown under identical conditions. Mushroom Journal of Tropics 8: 93-98

Rama, V. and P.J. John. 2000 .Effects of methods of drying and pre treatments on quality of dehydrated mushroom. *Indian Fd Pack.* 54: 59-64

Randhawa, G.K and Ranote, P.S. 2004. Storage stability of processed Oyster Mushroom *(Pleurotus hspp.)*into soup Powder .J .Food Sci. Technol., 2004.Vol.41, No.5, 525-529.

Ranganathan, G. and Somasundaram, S. 1998. Knowledge on mushroom cultivation technologies. Journal of Extension Education 9 (4) : 2257

Ranganna, S. 2001. Hand book of analysis and quality of fruit and vegetable products. Second edition. Tata Mc Graw Hill, Publishing company Ltd, India, p. 112

Ranote S.P., Bawa A.S. and Chawla, R. 2007. Edible Mushrooms-Nutrition and health attributes .Indian Food Industry, July-Aug 2007

Ranote, S.P. and Randhawa, G.K. 2004. Storage stability of processed Oyster Mushroom (*Pleurotus* spp.)into soup powder. *J.Food Sci. Technol* ., Vol. 41, No.5, 525-529.

Richardson, M. 2010. Nutritional value of mushrooms/ eHow.com.

Robinson, A. 2010. Nutrition facts on oyster mushrooms.

Sadashivam, S. and Manikkam, A. 1992. Biochemical Methods for Agricultural Science.

Sadler, M 2003. Nutritional properties of edible fungi. Br. Nutrition.Found.Nutri.Bull.28:305-308.

Sanmee, B., Dell, P. and Lumyog. 2003. Nutritive value of popular wild edible mushrooms from northern Thailand. Food chemistry vol:82(4):527-532.

Sarker, N.C., Hossain, N., Sultana, I.H., Main, A.J.M., karim, S. and S.M., Amin, R. 2007. Effect of watering on the growth yield of oyster mushroom. Bangladesh. J of Mushroom. 1 (1): 29-37

Schneider, I., Gaby Kressel., Meyer, A., Krings, U., Ralf, G. Berger and Hahn, A. 2010. Lipid lowering effects of oyster mushroom in humans. J. functional foods.

Schultz, T. 2010. Loss of nutrients when vegetables are cooked. http//www.brighthub.com/health/diet-nutrition/articles/44825.

Shanmukham, N. 1989. New species of *Pleurotus* Food abstract 35:20.

Shanmukham, N. and Jayarajan, R. 1990. Starch content in mushroom. Mushroom science 991):232-234. Science Dily .(2005).

Sharma RC, Jandaik, C.L, and Bharadway, S.K. 1991. In advance in mushroom science.pp:102.

Shashirekha, M.N., Rajarathnam, S. and Bano, Z. 2005. Effects of supplementary rice straw growth substrate with cotton seeds on the analytical characterstics of the mushroom. Food chemistry.92:255-259.

Shelly, N.J., S.M. Amin, A., M.M. Nuruddin., K.U. Ahmed. and Khandakar. J. 2008. Comparitive study on the nutritional composition of P.ostreatus and some strains of P.cystidiosus. 2 (2): 589- 594

Shin, C.K., Yee. C.F., Lee, J.S and Atong, M. 2007. Nutritional properties of some edible mushrooms in Sabah. J.Appl.Sci.7:2216-2221.

Shouji, N., Takada,K., Fukushima, K. and Hirrasawa. 2004. Anti caries component fro Shiitake mushroom. Caries Res .Vol.34(1):94-8.

Singh, S. 1994. Mushroom consumption patterns. Indian Food Packer. 48-91

Singh, S.K., M. Narain. and B.K. Kumbhar. 2001. Effect of drying air temperatures and standard pre treatments on the quality of fluidized bed dried Button mushroom(*Agaricus bisporus*) *Indian Food Packer* 55:82-86

Sivaprakasham, K. 1986. Energy value of mushrooms. Food Science and Technology Abstract 64 (7): 130

Sliva, D. (2003). Ganoderma lucidum (Reishi) in cancer treatment. Integrative Cancer Therapies 2 (4): 358- 64

Sohi, H.S. 1986. Mushrooms as food and their nutritive value. Mushroom Science 9 (1): 550

Somsub, W., Kongka, R C., Sangpuag, P and Charoensiri, R. 2008. Effects of three conventional cooking methods on vitamin C, tannin, myoinsitol phosphatase contents in selected Thai vegetables.J of food composition and analysis, vol:21(2): 187-197.

Sones,1992.Medicinal value of mushrooms. Mushroom journal3(1):48-51.

Sourav. 2010. Foods high in antioxidants. www. Healthmad.com

Srilekshmi, B. 2003. Nutrition Science. New Age International. Pvt. Ltd., New Delhi p. 383

Stanislaus, C. 1996. Ling zhi- medicine of kings. New Editions Health World : 38- 41

Starton,L.1990.Carbohydrate content of mushroom. Journal of food science .7298):691.

Stephanie, I. 2002. The real nutritional value of fungi. Mushroom council.com

Stroller, P. and Hall, N.S. 1988. Time of harvest and method of analysis affecting the amount of niacin content in mushroom. Science Today :52

Svoboda, L., Kalac, P., Spicka, J. and Janauskova, D. 2002. Food Chemistry. 79 (1): 41-45

Swaminathan, M. 1993. Principles of Nutrition and Dietetics. The Bangalore printing and publishing company Ltd., Bangalore : 334

Talpur, N.A., Echard, B.W., Fan, A.Y., Jaffari, O., Bagchi, D., Preuss, H.G. 2002. Antihypertensive and anti diabetic effects of whole maitake mushroom powder and its fractions in two rat strains Molec pharmacol and Biol.237:129-136.

Tam, S.C., Fund, K.P. and Chang ,S.T. 1986. Hypotensive and renal effect of the edible mushroom pleurotus sajor caju. Life science.38:1115.

Tewari, R.P. and Pandey, M. 1991. Mushroom trade. Idian mushrooms: 268

Tsang, G.R.D. 2005. Antioxidants 101. Health castle.com

Turner, L. 1993. Nutritive value and biological efficiency of pleurotus species. Biological Abstract 90 (1): 135

Tyagi RK. And Nath, N. (2005) Effect of addition of pleurotus mushroom powder on quality of papad. J. Food scie. Technol 42:404-410.

Ude, U.D., A.E.N. Ezenwugo and R.C. Agu (2001) Composition and food value of sclerotinum and edible mushroom. J.Food Sci. Technol.vol:38(6):612-614.

USDA. National nutritional nutrient database for standard deference, release 22(2009).Oyster mushroom nutrition , the nutritional value of oyster mushrooms and full oyster mushroom nutrition information.

Vallejo, F.(2003). Phenolic compound contents in edible parts of broccoli inflorescence after domestic cooking. Journal of the Science of Food and Agriculture 83(14):1511-1516.

Vaz, J.S., Barros, L., Martins, A., Jorge, S.C., Morais, M., Helna, V and Issabel C., F.R., Ferreira (2011). Phenolic profile of seventeen portugese wild mushrooms. Food science and technology, vol: 44 (1): 343-346.

Verma, R.N. 1999. National and international scenario of mushroom production and trade. Paper presented at Conference on Mushroom Industry in India and- A decade of achievements and future perspective on 3rd December, pp 5-8

Verma,R.D.1995. The tribune (news paper),August 7,Chandigarh.

Vetter, J. (2002) Data on sodium content of common edible mushrooms. Food chemistry vol:81(4):589-593.

Volantao, P., Andrade, P.B., Rangel, J., Ribeiro, B., Silva, B.M., Baptista, P. 2005. Effect of the conservation procedure on the content of polyphenolic compound and organic acids in chanterelle mushroom. J. Agri and food chemistry.53:4925-493

Vyas, N. L. 1999. Mushroom as a cheaper source of nutrition. The Hindu, August 19: 24

Watanabee,T., Tsue Hihasi.M., Takai,Y., Tanka, K. and Suziki,A. 1994. Effects of ozone exposure during cultivation of oyster mushroom (p.ostreatus) on chemical components of the fruit bodies. J .Jpn .Soc.Food. Sci.T echnol:41:705-708.

Weber, C.M.D. 2007. What are antioxidants?. About.com

Whitcomb, A.(2008) An introduction to mushrooms oyster . Aug 5-2008. www.wikipedia.encyclopidia.com.

Wiley,C.1995.The medicinal side of mushrooms. Vegetarian Times:22-30.

Wittingerova, 1991. Nutritive value of mushroom. Food science and Technology abstract.56:101.

Young,V.R.(2000) Diet as a modulator of aging and longevity. Food proc.38.

Zaman, M.A. 2004. Effect of growth regulators and organic and inorganic amendments on growth and yield of oyster mushroom. M.Sc. Thesis. Bangabandhur Sheikh Mujibur Rahman Agri University. Gazipus.

Zhang, M., Huang, J., Xie, X., Holma, C.D. (2009). Dietary intakes of mushrooms and green tea combine the reduce the risk of breast cancer in Chinese women. International Journal of Cancer 124 (6): 1404-8

Net references

Wh foods.com(2010) cooking and nutrient loss. http://www.wh foods .com.

www.dried mushrooms. US/ oyster mushrooms. html

www.lifeplusvitamins.com/mushrooms

Natures Janitor. 2010. Oyster mushrooms. http://wordpress.com.

Mushroomapplication.com. 2010.

Fresh plaza.com(2008) Haryana rank third in mushroom production

Appendices

APPENDIX – I

KERALA AGRICULTURAL UNIVERSITY
COLLEGE OF AGRICULTURE, VELLAYANI
DEPARTMENT OF HOME SCIENCE

Questionnaire to elicit information on the socio economic background of the selected respondents

1. Name of the respondent
2. Age :
3. Sex :
4. Religion :
5. Caste :
6. Adress : .....
   .....
   .....
7. Type of family : Nuclear/Joint
8. Size of family :Small/Medium/Large
9. Educational qualification:
10. Occupation :
11. Monthly income :
12. Monthly expenditure for food :
13. Monthly expenditure for health care :

14.-Do you have a family history for :

Diabetes
Hperlipidemia
Cardiac problem
Hypertention
Arthritis
Any other

15. Do you have any of the above disease :

16. If yes, how long you have been affected :

17. Clinical pictures :

Height
Weight
BMI
Waist hip ratio

18.What was your blood profile last recorded for

Hyperglycemia
Hyper cholesterolemia
Hypertension

19. Are you under any medicine : Yes/ No

20. Do you consume any medicine : Yes/ No

APPENDIX- I CONTINUED

Questionnaire to elicit information on the life style pattern of the selected respondents

1. Do you have any stress and strain in your day-to-day life : Yes/ No

2. If yes, type

   Occupational\Family problem
   Health problem
   Financial problem
   Old age problem
   Any other

3. Do you practice any relaxation technique : Yes/ No

   If yes what is it?

4. Do you have the habit of doing exercise : Yes/ No

   If yes, specify

   Time :
   Duration :
   Type :

5. Do you smoke : Yes/No

6. Particulars about smoking: Cigarette/Beedi

7. Do you have the habit of pan/beetle chewing

8. Do you take alcohol drinks : Yes/ No

9. Frequency of alcohol consumption
   Regular
   Most days
   Weekends
   Occasionally
   Never

APPENDIX- I CONTINUED

Questionnaire to elicit information on the dietary intake of the selected respondents

1. Food habit : Veg/Non veg

2.No:of meals taken per day

Two times	Three times	Four times

3.Are you following any special diet : Yes/No

If yes give details

4.Frequency of use of various food items in the diet by the respondent

Food items	Daily	Alternate days	Twice in a week	Once in a week	Occasionally
Cereals					
Pulses					
Vegetables					
Meat					
Fish					
Fruits					
Milk&Milk Products					
Coffee/Tea					
Beverages					
Bakery items					

Abstract

EVALUATION OF NUTRITIONAL QUALITY AND HEALTH BENEFITS OF OYSTER MUSHROOM

JAZIYA.S

Abstract of the

Thesis submitted in partial fulfillment of the requirement

for the degree of

Master of Science in Home Science

(Food Science and Nutrition)

Faculty of Agriculture

Kerala Agricultural University, Thrissur

2011

Department of Home Science

COLLEGE OF AGRICULTURE

THIRUVANATHAPURAM -695 522

ABSTRACT

"Evaluation of nutritional quality and health benefits of oyster mushroom" (Pleurotus florida) was a comprehensive study undertaken to determine the nutritional quality, nutrient losses during processing and also to investigate the impact of mushroom supplement on the blood profile of the subjects with specific disease condition.

The energy value of oyster mushroom was 453.0 kcal/100 gm on dry weight basis and that of carbohydrate, protein and fat content were 4.7 g, 5.6 g and 0.8 per cent respectively in fresh weight basis. As reported by earlier researchers oyster mushrooms are low in calories, with low carbohydrate and fat content.

Oyster mushroom contains all the essential amino acids, and the content of phenyl alanine was exceptionally high when compared to the reference protein. Similarly leucine, lysine and threonine content were also found to be higher than the reference protein. Among the other amino acids present, glutamic acid was remarkably high (17.2) followed by aspartic acid and tyrosine.

Amino acid content and amino acid score (AAS) clearly confirmed that oyster mushroom is superior in protein quality with respect to amino acid composition and essential amino acid content when compared to *P.citrinopeleatus* and *P.sajor caju*. Essential amino acid (EAA) index of oyster mushroom determined was found to be 119 while the nutritional index based on protein quality was estimated as 6.42.

Oyster mushroom contains, B complex vitamins viz thiamine, riboflavin and niacin as 5.43 mg, 8.7 mg and 55.9 mg per 100 g respectively which is fairly very

high when compared to other plant foods. However vitamin C content of oyster mushroom was found to be comparatively low(12.4 mg/100 gm).

Investigation clearly revealed that oyster mushrooms are rich source of various minerals. Calcium content was recorded as 12.46 mg/100 gm. While sodium, potassium and phosphorus were found to be 125mg, 623 mg and 477 mg per 100 gm respectively. Oyster mushroom also contains fairly good amount of iron(7.63 mg/100 gm). Trace elements analyzed viz copper and zinc was estimated as 1.9mg and 1.47 mg/100 gm of oyster mushroom.

Oyster mushroom contain 90.3 percent moisture which promote its susceptibility to deterioration. As observed in other mushrooms fiber content of oyster mushroom was 3.2 g/ 100 gm. Tannin and polyphenol which are considered as antioxidants were determined as 1.4mg and 4.3 mg /100 gm respectively.

Vitamin C and zinc are considered as IF positives present in oyster mushroom. Anti oxidants such as polyphenols, tannins and fibre were also present in oyster mushroom studied which account for their medicinal value.

On assessing the loss of nutrients in oyster mushroom when subjected to various methods of processing it was revealed that as expected all the macro nutrients decreased during processing such as boiling, blanching and steaming while dried mushroom depicted enhanced values. It was noticed that the dried mushroom (T4) was superior to all the other processing treatments, with respect to various nutrients. As the moisture is lost from the mushroom, nutrient concentration increases and hence dried mushroom recorded higher values for nutrients per100 grams. Boiling method recorded the maximum nutrient loss while steaming, the lowest.

Health benefits of oyster mushroom was ascertained through supplementation study on human volunteers with specific disease condition. Dried mushroom powder formulated was distributed to the subjects under case study on the basis of 5gm/person/day for a period of three months. Incorporation of mushroom supplement was accomplished without any difficulty in the subjects. The result of the blood profile of those subjects showed a significant decrease in the blood glucose and blood cholesterol levels in the subjects over a period of three months. Impact of the supplement on the blood pressure was not very much apparent with a short spell of supplementation.

To conclude, oyster mushroom is superior in nutritional quality and highly suitable and beneficial for promoting and maintaining health. The study also recommend that cultivation and consumption of oyster mushroom should be popularized and promoted with the motto "mushroom for nutrition health and income".