2 REVIEW OF LITERATURE
CHAPTER 2
REVIEW OF LITERATURE

Review of literature is a continuous process and starts even before the finalization of the research topic. Review of literature means identification, reading, comprehension and understanding, subsequently taking notes and use of literature, relevant to the aspects to be dealt in the research study. Before writing the thesis, all possible available references on the topics, books, reviews, scientific papers, etc., are referred. Information collected is put in the correct order. Nutritional potential of oyster mushroom is discussed under the following subheads:

2.1 Nutritional contribution
2.2 Hypotensive, hypolipidemic and hypocholesterolemic effects
2.3 Hypoglycemic effects
2.4 Antioxidant activity
2.5 Antitumor effects
2.6 Processing of mushroom
2.7 Mushroom products
2.8 Hypotheses of the study
2.9 Conceptual model of study

2.1 Nutritional contribution

Nutrition contribution of mushrooms is discussed under the following subheads.

2.1.1 Proximate composition

Mushrooms are considered as a good source of protein, vitamins, fats, carbohydrates, amino acids and minerals (Jiskani, 2001). *P. ostreatus* and *Pleurotus sajor-caju* are found to have high protein (27.4% and 26.9% respectively), carbohydrate (40.75%) and lipid levels 5.4 per cent and 6.2 per cent on dry weight basis (Dhonda et al., 1996; Rai et al. 1988) study showed that fresh *Pleurotus sajor-caju* contains 90.2 per cent moisture, 2.5 per cent protein, 0.2 per cent fat, 5.2 per cent carbohydrate, 1.3 per cent fibre, 0.6 per cent ash and 35 per cent calorie. *Pleurotus*
florida contains 1.6 per cent protein, 3.09 per cent carbohydrate, 0.09 per cent fat, 0.52 per cent ash, 0.7 per cent fibre and 16 per cent calorie at fresh weight. Ogundana and Fogade (1981) study indicated that mushroom has about 16.5 per cent dry matter out of which 7.4 per cent crude fibre, 14.6 per cent crude protein and 4.48 per cent fat. The mushrooms are low in fat (2%) however, 70 per cent of the total content are unsaturated of fatty acids (Daraismy et al., 1991). Proximate composition of four edible species of mushroom indicated that Termitomyces manmiformis is a very good source of crude protein (37%), crude fibre (7%) and ash (10%). Russula vesca was found richest in carbohydrate (71%), while Lactarius triviralis was richest in moisture content (37%). It is also a good source of carbohydrate (64%). Lentinus tigrinus was, however found the richest in dry matter (94%) and is also rich in carbohydrate (62%) (Adejumo et al., 2005). Chang and Miles (1989) have suggested that the protein in mushrooms, in general, is about twice that in asparagus and cabbage, and 4 and 12 times those in oranges and apples, respectively. On a dry basis, 9.35 per cent protein in mushrooms compares well with 7.3 per cent in rice, 13.2 per cent in wheat and 25.2 per cent in milk powder.

2.1.2 Protein

Mushroom contains protein, which consists of various amino acids. All the essential amino acids required by an adult are present in mushroom. Tryptophan and lysine are present in high concentrations as compared to cystein and methionine. These amino acids are absent in vegetable proteins. According to Chang (1993) amino acid composition of Pleurotus sajor-caju and Pleurotus florida as leucine 7.5 per cent and 7.0 per cent, isoleucine 5.2 per cent and 4.4 per cent, valine 6.9 per cent and 5.3 per cent, tryptophan 1.1 per cent and 1.2 per cent, lysine 9.9 per cent and 5.7 per cent, threonine 6.1 per cent and 5.0 per cent, phenylalamine 3.5 per cent and 5.0 per cent, histidine 2.8 per cent and 2.2 per cent, methionine 3.0 per cent and 1.8 per cent for Pleurotus sajor-caju and Pleurotus florida, respectively. Mushrooms are rich in high quality protein, so these can be utilized to supplement daily diet, which is primarily based on millets. Millets are deficient in two essential amino acids namely lysine and tryptophan while mushrooms are rich in these two (Bisaria et al., 1987a). When assessing the nutritive value of the protein account must also be taken of the quality of the protein. In this context, the proteins of commonly cultivated mushrooms contain
all the essential amino acids as well as most commonly occurring non essential amino acids and amides and are especially rich in lysine and leucine, which are lacking in most staple cereal foods (Chang et al., 1980). Gopalan et al. (1984) also suggested that millets, the staple constituents of Indian diet, are deficient in two essential amino acids namely lysine and tryptophan. Mushrooms which are rich in lysine and tryptophan, can effectively supplement the millet in term of protein quality. The digestibility of mushroom protein is also high. Memona Haque (1987) studied on the quantitative analysis of essential amino acids and found that Pleurotus sajor-caju and Pleurotus flabulatus contain all essential amino acids in appreciable amount. The experimental evidence showed positive nitrogen balance in mushroom fed diets. The digestibility of mushroom diets was found more than casein diet. The Net Protein Utilization (NPU) of mushroom diets were 73.99 and 76.42 per cent for Pleurotus sajor-caju and Pleurotus flabulatus respectively and Protein Efficiency Ratio (PER) of the experimental mushroom fed diets were also comparable to that of casein diet i.e. 3.45, 3.50 and 3.80, respectively. Lintgel et al. (1994) reported the digestibility of mushroom protein to be as high as 72-83 per cent. Sugimori et al. (1971) studied that the digestibility of Pleurotus astreatlus is 90 per cent. According to Nawange et al. (2006) the amino acid, protein profile and NPR values of Lentinus squarrosatus and Psathyrella atrorubronata is quite encouraging and suggested that they provide enough protein for maintenance. Biological value of Pleurotus sajor-caju and P. florida is 84.47 per cent and 93.30 per cent, digestibility co-efficient 86.75 per cent and 87.08 per cent, NPU 69.85 per cent and 80.37 per cent respectively. Pleurotus florida is more effective than Pleurotus sajor-caju (Nilima Bhoge, 2002). Quality of mushroom protein is far superior to the vegetable proteins and in as good as or just inferior to animal protein because of presence of essential amino acids (Crisan and Sands, 1978; Bano and Rajaratnam, 1982; Chang and Miles, 1989).

To meet the demands of protein, one alternative marketed as "Quorn" was produced by – Marlow Foods Ltd. Quorn is a product obtained by the growth of mycelium of Fusarium venenatum on food grade glucose. The mycelium has meat like texture and now it is considered to be a meat alternative. Its NPU is 75/100, comparable to those of beef (80) and cow milk (75). It has minimum of 44 per cent protein and contains all the essential amino acids.
2.1.3 Polysaccharide

Fungal polysaccharides are represented by glycogen and such indigestible forms as dietary fibre, cellulose, chitin, mannans and glucans (Grochowski, 1978; Manzi and Pizzoferrato, 2000; Pizzoferrato et al., 2000; Manzi et al., 2001), which are important in the proper functioning of the alimentary tract. Mushroom contains 42 per cent soluble carbohydrates, 1.66 per cent pentoses and 32.26 per cent hexoses on dry weight basis. Since mushrooms are devoid of starch, the food is stored in the form of glycogen (Bano, Z., 1967). Carbohydrate components consist of a wide variety of compounds including pentoses, methyl pentoses, hexoses, disaccharide etc. (Crisan et al., 1978). Fibre has long been recognized as an important component of a balanced and healthy diet and epidemiological data indicate that population on a fibre deficient diet had a higher incidence of colonic cancer, coronary heart disease and other illness than populations eating high fibre diets. Fibre content of edible mushrooms is chitin, a polymer component of the fungal cell wall (Burkitt et al., 1972).

2.1.4 Vitamins

Edible mushrooms are good source of several vitamins including thiamine, riboflavin, niacin, biotin and ascorbic acid (Chang & Buswell, 1996 and Crisan et al., 1978). The vitamin ‘C’ content in several Pleurotus species was found to range between 2.2 to 4.4 on fresh weight basis (Rai et al., 1995). Mushroom supplies vitamin B complex significantly. This composite vitamin is not lost due to cooking. Mushroom is an important source of folic acid. Though in traces mushroom contains vitamin A, C, D and K. The vitamin of group B are abundant (Breene, 1990; Zrodowski, 1995; Mattila et al. 2000, 2001), particularly thiamine, riboflavin, pyridoxine, pantothenic acid, nicotinic acid, nicotinamid, folic acid and cobalamin, as well as other vitamins, such as eryosterol, biotin, phytochinon and tocophenols. Vitamin in Pleurotus species as reported by Bano and Shrinivasan (1979) are thiamine range from 1.16mg to 4.80mg/100g and niacin 780 to 108.7mg/100g. Vitamin B12 is 1.4mg/100g (dry weight). Folic acid and vitamin B12, which are generally absent in the plant foods, are present in mushroom, although in small quantities. As little as 3g of fresh mushrooms may provide the recommended daily intake of vitamin B12 (Hayes and Hadded, 1976). Australian Mushroom Growers Association, in their recent mushroom promotion campaign, has concentrated on
importance of vitamin B₁₂ for vegetarians; the poster reads ‘This delicious dose of vitamin B₁₂ contains no cholesterol’ (Miller, 1993). Li and Chang (1985) assessed the vitamin C content of some mushrooms by differential pulse polarography and found 2-3mg in *P. ostreatus* and 4-5mg in *P. sajor-caju*. Rai and Saxena (1989) studied the suitability of the methods of estimation for critical assessment of vitamin C in mushrooms and found that dinitrophenyl hydrazine method was most suitable as it takes into account the dehydro ascorbic acid, which also exhibits vitamin C activity. By this method, vitamin C content in *A. bisporous*, *P. sajor-caju* and *P. astreatus* were found to be 8, 4 and 3mg respectively per 100g fresh weight. Vitamin C content on seven *Pleurotus* spp. was found to range between 2.2 and 4.4mg on fresh weight basis (Rai *et al.*, 1988).

### 2.1.5 Minerals

Mushrooms are a good source of minerals which are taken up from the substrate by the growing mycelium and translocated to the spores. The major mineral elements present are potassium, which is particularly abundant, phosphorus, sodium, calcium and magnesium. Together these elements constitute between 56-70 per cent of the total ash content (Chang *et al.*, 1989). Phosphorus and calcium essential for human nutrition, is often higher in mushroom than in many fruits and vegetables (Kattan *et al.* 1991). Mineral composition of four edible species of mushrooms indicate that *Ternitomyces manniiformis* contains 21.6g calcium, 13.6mg manganese, *Russula vesca* 1.4g/100g magnesium, 123mg/100g iron, 0.8mg/100g copper, 210g/100g calcium and 12.0mg/100g manganese. *Lentinus tigrinus* content 1.1g/100g magnesium and 0.6mg/100g copper. It was observed that four species are low in phosphorus (Adejumọ *et al.*, 2005). The presence of copper in *Pleurotus* mushrooms is a bit higher (12.2 to 21.9 ppm) as compared to other mushrooms. Bano *et al.* (1981) and Bisaria *et al.* (1987b) have assessed the minerals and heavy metals content in *Pleurotus* spp.

### 2.2 Hypotensive, hypolipidemic and hypocholesterolemic effects

Oyster mushroom (*Pleurotus ostreatus*) is extremely delicious as well as conferring various health giving properties and benefits. Traditionally it has been used to strengthen veins and relax tendon. In China oyster mushroom is indicated for joint
and muscle relaxation (Yan et al., 1989). A product containing oyster mushroom, called tendon-easing powder, is effective in the treatment of discomfort. A dried oyster mushroom are said to be high builders (Opletal, 1993). Cochran (1978) and Cheng and miles (1989) have reviewed the literature on antibiotic activities (antiviral, antifungal and antibacterial) antitumor and hypolipidemic effects of mushrooms but most important and significant medicinal effects having recently attracted the attention of researchers and publicity are the antitumor, hypcholesterolemic and hypolipidemic, antihypertention and hypoglycemic effects. An aqueous extract from the popularly cultivated oyster mushroom, *Pleurotus sajor-caju* has been shown to exhibit hypotensive and reduce the rate of nephron deterioration which may extend the life span of chronic renal failure patients (Tam et al., 1986). Mushroom in general an *Pleurotus*, *Lentinus* and *Grifola* in particular because of their high fibre content, starch, proteins, micronutrients and a low calorific value are almost ideal for diets designed to prevent cardiovascular diseases as first suggested by traditional Chinese medicine (Breene, 1990; Hobbs, 1995).

Reactive oxygen species and increased levels of blood lipids are key elements in the pathogenesis of atherosclerosis, one of the main causes of death in industrial countries. The control of blood lipids, especially cholesterol, is important for reducing the risk of the development or progression of atherosclerosis. A pronounced hypcholesterolemic effect of oyster mushroom (*P. ostreatus*), combined with inhibition of lipid peroxidation was shown in rats and rabbits. Oyster mushroom diet (10% dried fruiting bodies) significantly reduced the incidence and size of atherosclerotic plaques in rabbits (Bobek et al., 1999). Lovastatin, the lead compound for the statine, (HMG-CoA reductase inhibitors), detected in this species and is jointly responsible for the observed effects (Gunde et al., 1993). *Pleurotus* spp. modulate the immune system, have hypoglycemic activity, antithrombotic effect, inhibit tumor growth, inflammation and microbiolaction and lower blood pressure and plasma lipid concentration. In addition, they effectively reduce lipids in generals, specifically low density lipoprotein cholesterol (Gunde et al., 2001) and suggested that *Pleurotus* mushrooms could be recommended as a natural cholesterol lowering substance (Gunde et al., 1999). Bobek et al. (1990) reported a hypocholesterolemic effect of oyster mushroom (*P. ostreatus*) in rats with hereditary increased sensitivity to dietary cholesterol.
Significant hypolipidemic and hypocholesterolemic effects of mushrooms have been reported in many mushrooms especially in *L. edodes* which has been shown to lower plasma cholesterol level in animals and man (Koneda et al., 1966; Suzuki et al., 1976 and Rai, 1995) and the effect was attributed to acceleration of cholesterol metabolism and increased cholesterol execution (Tokuda et al., 1976). An active hypolipidemic principle in *L. edodes* has been identified as critadenine which gives rise to a general response, affecting cholesterol, triglyceride and phospholipids levels (Tokuda et al., 1976). The mushroom significantly increased the activity of lecithin cholesterol acyltransferase and decreased the activity of lipoprotein lipase in abdominal adipose tissue. Hypercholesterolemia is one of the pathogenic factors in atherosclerosis, lowering plasma lipids by consumption of certain mushrooms. On the basis of review it is assume that oyster mushroom works to show lipid lowering effect.

### 2.3 Hypoglycemic effects

Diabetes mellitus is a metabolic disorder affecting 250 million people worldwide. Medicinal mushrooms have been help to balance blood sugar levels. *Pleurotus* species modulate the immune system and have hypoglycemic activity (Gunde et al., 2001). Badole et al. (2007) investigated the administration of aqueous extract of *Pleurotus pulmonarius* (500mg/kg) and its combination with glyburide (10mg/kg) significantly decreased serum glucose level in diabetic mice. *Pleurotus pulmonarius* showed potent and synergistic antihyperglycemic effect in combination with glyburide. The submerged culture of the mushroom *Phellinus linteus* decreased plasma glucose, total cholesterol and triglyceride concentration by 49 per cent, 32 per cent and 28 per cent respectively, Kim et al. (2001) opined that polysaccharide prevent hyperglycemia in diabetic patients.

Ganodermin A and B, glucons from *G. lucidum* fruiting bodies (Hikino et al., 1985), Coriolin, a β-glucan-protein complex obtained from submerged grown *T. versicolor* biomass (Ikuzawa et al., 1985) and an acidic glucoronoxylomannen from the fruiting bodies of *Tremella aurantiaschwein* (Kiho et al., 2000) exhibited hypoglycemic effects in several test systems and ameliorated the symptoms of diabetes. According to Windholg (1983) guanide, a known hypoglycemic substance related to biguanide class of oral antidiabetic drugs, has been detected in edible
mushrooms of *Pleurotus* species and might be responsible for the antidiabetic effect. The review demonstrates that mushrooms, especially oyster mushroom have antidiabetic activity.

### 2.4 Antioxidant activity

Potentially harmful Reactive Oxygen Species (ROS) are produced as a consequence of normal aerobic metabolism. The reactive species is usually inactivated *in vivo* by a variety of antioxidant. Antioxidant are deployed to prevent generation of ROS or to scavenge those formed. Thus, oxidatively induced tissue damage is minimized. However, deficiency of antioxidant defences may lead to oxidative stress, which might be associated with a variety of disorders, diabetes, arthritis and cancer (Yoshikawa *et al.*, 2000; Spiteller *et al.*, 2001). Chinese herbs have been used for diet therapy for several millennia. Some of them are alleged to exhibit significant antioxidant activity (Su *et al.*, 1992; Kim *et al.*, 1994; Weng and Chen, 1996 and Yun, 1999). Mushrooms are traditionally used in Chinese medicine and are commonly used for pharmaceutical purpose and health foods. A number of medicinal mushrooms have recently been reported to possess significant antioxidant activity (Jose *et al.*, 2002; Jones and Janardhanan, 2000; Ajith and Janardhanan, 2001; Ekonem and Ubengama, 2002). Lakshmi *et al.* (2004) observed the antioxidant activity of *Pleurotus florda*, *Pleurotus sajor-caju*, *Ganoderma lucidum* and *P. rimosus*. All mushroom showed significant antioxidant activity. among four species *Pleurotus rimosus* extract seems to be the more effective antioxidant. The role of free radicals has been implicated in a large number of diseases. The antioxidant activity of the mushrooms is of significant importance in exploiting their therapeutic potential.

### 2.5 Antitumor effects

Several edible fungi have been reported to exhibit antitumor activity including *L. edodes*, *F. velutipes*, *P. iostreatus*, *A. bisporum*, *P. nameko*, *Tricholoma mastutata* and *A. auricular* (Ikekawa *et al.*, 1969; Vogel *et al.*, 1974) reported the shiitake mushroom (*Lentinula edodes*) is known to be effective against many symptoms. Particularly a active constituent is the polysaccharide lentinon, which is already being used in clinical treatment. Another constitute is GI-PS, a beta glucan of similar structure, which has shown similar effects in comparative clinical studies.
Haematological and immunological effects of GI-PS and antitumor effects of both compounds are outlined. As isolation of these active structures is very costly, extraction conditions were individually optimized for maximum yield of each active compound from the powdered fungus. Jose et al. (2002) reported that methanolic extract of Pleurotus pulmonarius fruiting bodies reduced carrageen – induced colon cancer in rats but did not influence significantly the incidence of tumor. This effect is explained by the antitumor properties of mushroom and by its fibre content (Bobek et al., 1998).

Tumor diseases are one of the main causes of death worldwide. Experiences from Asian and Eastern Europe countries show that mushrooms could play an important role in prevention and treatment of cancer. Piptoporus betulinus was used traditionally in Bohemia for the treatment of rectal cancer and stomach diseases. Currently available data from numerous in vitro and in vivo studies suggest that the cancer preventing and tumoricidal properties of Ganoderma might be ascribed to its antioxidative and radical scavenging effects, enhancement of host immune function, induction of cell cycle arrest and apoptosis, and other biological effects. Isolated beta-glucan type non starch polysaccharide of tuber-regium showed antitumoral effect (Zhang et al., 2001). A significant decrease in the number of tumor foci observed in animals supplemented with 5 per cent dried oyster mushroom (Pleurotus ostreatus) in the diet on colon carcinogenesis induced by dimethylhydrazine rats (Bobek et al., 1998). The antitumour activity present in many other mushrooms which need to be studied in detail (Nanba, 1993). Considerable attention has focused on Lentinus, a polysaccharide extracted from L. edodes, the anticancer activity of which is reported to extend to cancer of the bowel, pancreas, gastrointestinal tract, liver, lung and ovaries. Ohno et al. (2003) reported that so called immunomodulators (biological response modifier, immunopotentiators and immunostimutants) are the most important medicinal mushroom drugs used especially in Japan, China, Korea and other East Asian countries today. In a small clinical trial, powder of S. crispus (300mg/day) was given orally to several cancer patients after one course of lymphocyte transfer immunotherapy. Performance status of 14 cases were monitored after several months, and 9 cases were improved.
2.6 Processing of mushrooms

Mushrooms for its long-term preservation can be dried and further be processed as powder. Mushroom may be dried by sun drying, air drying, fluidized bed drying or freeze-drying. Quality of freeze-dried product is much better than any other technique but at the same tie, product costs 10 times more than air-dried product. Sun drying is appropriate technology for our country because of free source energy and minimum investment at cottage level but at commercial level, air-drying is best. Mushrooms after sorting, washing and trimming can be sliced into halves or in quarters according to the size. Mushroom pieces are blanched in water containing 2 per cent salt and 1 per cent citric acid for 30 minutes. Blanched mushrooms are dipped in solution containing 0.5 per cent potassium meta-bisulfite and 0.25 per cent citric acid for 15 minutes. Drain the solution and dry the mushrooms at 50±2° C for 5 to 6 hours or at 55±2° C till moisture level reaches 8-9 per cent. Then after sweating as such or mushrooms after grinding in powder form can be packed in polyethylene bags and can be stored at ambient temperature.

Alternatively, for effective drying multi layer-infra red drier can be employed but this has only disadvantage that product with an uneven moisture content is obtained (Wang and Sheng, 2004). Similarly osmosis is done to bring the moisture content to a desired level. Air drying of Osmosed button mushroom is recommended because drying osmosed button mushroom at 65°C yields a product highly acceptable particularly for mushroom soup preparation (Kaul and Gupta, 2003).

2.7 Mushroom products

Mushrooms have been traditionally used in China and Japan for their medicinal and tonic properties. Several pharmaceuticals have been developed from mushrooms in Japan and their active components identified. Cosmetic products and some healthful beverages have also been produced in China from mushrooms (Chang,1999). Smith et al. (2000) discussed on ‘Functional foods’ which prepared by particularly medicinal mushrooms. The immunomodulatory and anticancer glucan and polysaccharide effects of mushroom and the regulatory aspects of functional foods are also discussed. Mushroom dietary supplements and nutraceuticals possess particular physiological effects, such as lowering of blood cholesterol, or hepatothromboprotective activity (Grienven, 2000).
Now in modern medicine few fungi are again gaining much more importance. In the recent past, a variety of medicinal preparations in the form of tablets, capsules and extracts of mushrooms have been produced and marketed (Rai et al., 2002). Mushroom can be used for the preparation of mushroom ketchup a high quality product. Mushrooms after sorting, washing and cooling with vinegar are allowed to stand for a week. Mushrooms are then made into fine pulp and ketchup is prepared following the procedure as for other ketchups. Like wise mushroom can be utilized for pickle and candy preparation, weaning foods and biscuits. Mushrooms have their potential to replace traditional items like potato from burger, hot dog, Patties, cheese sandwiches, stuffed dosa, biryani, fritters, omlette and poached eggs and also these products are gaining importance day by day. Canning of mushrooms also increases the shelf life of the produce manifolds. Canned mushroom with increased yield and improved colour can be obtained when mushrooms are stored at 2-4°C for 20 hours and then blanched in water containing 1 per cent citric acid (Zhimin et al., 2001). Apart from this technology mushroom can be minimally processed by trimming, washing in water, placing on support (to allow drainage) cooking on the support in liquid, drainage, packing under vacuum and preservation (Donnard, 1995). According to Chang et al. (1989) mycelium of edible mushrooms grown in liquid culture has been used in the making of soups and teas, a practice especially popular with edible fungi that are throughout to have medicinal or tonic qualities. In China, the mycelium of the golden era mushroom, Tremella aurantia, that is harvested from liquid culture is added to walnut cakes, biscuits and bread. It also put into drinks for older people and children and added to flour for making noodles. Preliminary studies have been undertaken on the formation of an acceptable food product (tentatively called ‘mycomeat’) prepared by growing edible fungi on waste soybean residue from tofu production. The product formed has good taste and texture, with the flavour determined by the edible mushrooms used.

The discussion on foregoing review of the past research studies reveals that mushrooms, similar to plants, have a great potential for the production of useful bioactive metabolites and that they are a prolific resource for drugs. Prerequisite for a use as drug, nutraceutical or other purpose in the continuous production of mushrooms (fruitsing bodies or mycelium) in high amounts and in a standardized quality. Chang (2001) opines that mycelial products are the ‘wave of the future’
because they ensure standardized quality and year around production. Keeping in view the nutritional potential of mushrooms following hypotheses were framed.

2.8 Hypotheses of the study

The hypotheses of the study were formulated on the basis of the assumed relationship of oyster mushroom and health benefits are presented in the null form (H₀) as below.

1: There is no significant difference between the means of nutritional contribution of fruiting and mycelium of oyster mushroom in terms of proximate compositions, nucleic acids, essential amino acids, and macro and micro minerals.

2: There is no significant difference between the means of gain weight of albino rats fed on doses of fruiting and mycelium of oyster mushroom.

3: There is no significant difference between the means of plasma lipid level of fruiting and mycelium of oyster mushroom.

4: There is no significant difference between the means of blood glucose level of fruiting and mycelium of oyster mushroom.

2.9 Conceptual model of study

Any systematic study should essentially be based on sound theoretical model. A researcher develops a model for the purpose of study since it helps in rational thinking about the research problem and represents the conceptualization of the concepts used in the investigation.

Based on the discussion of foregoing reviews of the past researches, a conceptual model has been developed for the present study and the same has been depicted in figure 1, 2, and 3.
**Independent Variables**
- Fruiting of oyster mushroom
- Mycelium of oyster mushroom

**Dependent Variables**
- **Nutritional contribution**
  - Proximate composition
  - Nucleic acid
  - Essential amino acid
  - Macro and Micro minerals

**Fig. 1 Conceptual model**
- 1g Mushroom fruiting dose
- 2g Mushroom fruiting dose
- 1g Mushroom mycelium dose
- 2g Mushroom mycelium dose

**Fig. 2 Conceptual model**
- **Effect on growth**
  - Body weight

**Fig. 3 Conceptual model**
- **Effect on plasma lipid level**
  - Total cholesterol, Triglyceride, HDL, LDL, HDL : LDL
- **Effect on blood glucose**
  - Weight loss
  - Fasting blood glucose level
  - Post meal blood glucose level