Proceedings of the Seminar

on

"Mushroom Consumption and Poisoning Risk"

14th January, 2014 (30th Paush, 2070)

Khumaltar, Nepal

Jointly Organized

By

Nepal Academy of Science and Technology (NAST)

and

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Cover Photographs (Front)

Amanita hemibapha (Edible) - Left
Amanita phalloides (Deadly poisonous)-Right

The views and interpretation in this proceeding are those of the author(s) and do not necessarily reflect the views of NAST.

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Preamble

Nepal has all the requisities of low cost labour, favourable climatic conditions, plentiful cheap supply of raw substrates, spawns and other inputs to become a leading mushroom producer. The mushroom industry is gradually taking root in Nepal but the pace is rather slow because of insufficient scientific research and discourse. Mushroom, a protein rich wonder food needs more publicity as it deserves. It is then this precious vegetable would solve the problem of protein malnutrition in our country. In future, the ever increasing population, depleting agricultural land, changes in environment, water shortage and need for quality food products are going to be the vital issues. To meet these challenges and to provide food and nutritional security to our people, it is important to diversify the agricultural activities in areas like horticulture. Mushrooms are one such component that not only uses vertical space but also help in addressing the issues of quality food, health and environmental sustainability. There is need to promote both mushroom production as well as consumption for meeting the changing needs of food items. The mushroom sector holds huge potentials to contribute significantly in nation's socio-economic transformation. The nation can grab this potentiality enforcing a concrete national mushroom policy. All concerned stakeholder organizations and individuals should go ahead as integrated for the holistic development of mushroom industry across the country. Taking these points into consideration, NAST has initiated few research and development programs on Mushroom (study of mushroom diversity, development of *in vitro* mycorrhization techniques for the cultivation of high value mycorrhizal mushrooms such as truffles, screening of bioactive compounds from highly prized mushrooms, etc.). I believe this document will be very useful for policy makers, mushroom researchers, growers, consumers, entrepreneurs and other concerned stakeholders.

Iswor Prasad Khanal
Chief
Faculty of Science
&
Member,
Seminar Organizing Committee

Acknowledgements

First of all on the behalf of organizing committee, I would like to express my sincerest thank to Ministry of Science, Technology and Environment for collaborating with us and making this seminar successful. I would also like to extend my utmost gratitude to Prof. Dr. Surendra Raj Kafle, Vice Chancellor of Nepal Academy of Science and Technology (NAST) for his full support and encouragement to organize the seminar. I am deeply indebted to senior mycologist Dr. Budhi Ratna Khadge for chairing the technical sessions with his enthusiasm, energy and excellent insight. My sincere thanks go to senior mycologist Dr. Keshari Laxmi Manandhar and Dr. Mahesh Kumar Adhikari for their thematic remarks on the program. I am very much thankful to members of technical committee for their critical comments and suggestions on the research papers of this proceeding. Dr. Deegendra Khadka is also highly acknowledged for his kind support in drawing the some chemical structures. I would also like to extend my heartfelt gratitude to all mushroom experts from various organizations, who actively participated and contributed their highly valuable papers in the seminar. Likewise, Dr. Bhoj Raj Pant is deeply acknowledged for sharing his experiences and valuable guidelines to organize the seminar properly. I am deeply indebted to Mr. Pawan Neupane, Mr Om Basukala, Ms Neel Kamal Kozu, Ms. Smita Shrestha, Ms Poonam Yadav, Mr. Agni Dhakal, Mr. Biswa Nath Yadav, Mr. Dev Raj Sapkota, Mr. Mahesh Adhikari, Mr. Pursottam Bhattarai, Mr. Priya Darshan Manandhar, Mr. Bhim Bahadur Thapa who worked extremely hard with various responsibilities to make the program grand success.

I would like to thank Mr. Mahendra Kapali for setting, layout design and his editorial inputs that helped us improving this document and bring the publication into its present shape. My heartfelt thanks also go to the Promotion Division of NAST for their kind cooperation and support in audiovisual recordings and others.

Finally, I would also like to acknowledge all those who have helped directly or indirectly to achieve the goal.

Thank you all and hope for similar cooperation in future as well.

Jay Kant Raut, PhD
Member Secretary
Organizing Committee

Executive Summary

Incidence of mushroom poisoning in various parts of the country is becoming more tragic, terrible and challenging in recent years. To overcome on this very burning issue, one day seminar on "Mushroom Consumption and Poisoning Risk" was organized. The primary goal of this seminar was to analyze the current situation of mushroom poisoning incidents in Nepal and sketch a roadmap for its mitigation. The seminar was conducted in two sessions namely Inaugural session and Technical session. The program was inaugurated by Prof. Dr. Surendra Raj Kafle, Vice Chancellor of NAST by picking the mushroom. Mr. Iswor Khanal, Chief Faculty of Science had highlighted the program. Thereafter, the senior mycologist Dr. Keshari Laxmi Manandhar and Dr. Mahesh Kumar Adhikari had remarked on the theme of the seminar. Likewise, in technical session altogether seven technical papers from different organizations were presented which was chaired by senior mycologist Dr. Budhi Ratna Khadge. There were more than 120 participants from various government & non-governmental organizations, universities, research institutes and individual mushroom grower, entrepreneur & consumer. During the technical session there was extensive and active discussion on various aspects of mushroom among the participants. This document which is the outcome of the seminar is a landmark endeavor to provide guiding light to government agencies and other concerned stakeholders for holistic development of mushrooms industry including mitigation of mushroom poisoning incidences across the country.

Opening Remarks

Mahesh Kumar Adhikari
Retired Deputy Director General, DPR

Namaste !!!

Vice Chancellor and chief guest, NAST

Secretary, Guest of the ceremony, NAST

Mr. I.P Khanal, Chairman and Chief, Faculty of Science, NAST

Dr. K. L. Manandhar, Senior mycologist

Senior scientists, senior mycologists, Officers from different organizations, senior mushroom growers, interested armatures and fungi lovers.

Today, I welcome you all in this august gathering for the seminar on *"Mushroom consumption and poisoning risks"* organized by NAST and Ministry of Science, Technology and Environment.

I do much appreciate for this kind effort and thank the organizers to conduct this seminar, which was thought much necessary since last few years, to create and or make aware the fungi lovers, ethnic groups, consumers, collectors, traders and mycophagous societies about the consequences of mushroom consumption and risk of poisoning.

Nepal the land of diverse geographical settings and phytodiversity, situated in the centre of globe, is well known to be the center of immense biological diversity. It is the Central Himalayan region, which is known to be the center for origin, adaptation, growth and dominance of different biotypes. Many biotypes are described as new species within this narrow belt from tropical to alpine zones. This region is also known as the store house of *Plant Resources.*

Regarding the mycobiota, the credit of first report goes to Llyod (1808). There after the reports were published by Berkeley (1854) and Balfour- Browne (1950). Since then, about 190 foreigners and 50 Nepalese have contributed their findings. Among these, most of the reports were on mushrooms of Nepal. Till now, 5 monotypic and 52 endemic species of mushrooms are described from Nepal. Near about 1150 species of mushrooms have been recorded. Among these 147 are said to be edible, while 100 species are poisonous and 73 have medicinal values. The annual mortality rate due to wild mushroom poisoning ranges in between 20 – 30. Among them, most of the victims age between 10 – 45 years.

The cultivation of mushroom started since 1976 and now it has been progressed into commercialized way. Eight exotic strains are in practice of farmers for cultivation. Among the 147 wild species found in Nepal none of the indigenous species are used as cultivars. At least 30 species can be immediately taken into consideration for cultivation.

So following points should be taken into consideration by related institutes to develop the

mycological researches in Nepal.

- Fungal legislation to assist collection and research activities
- Need of well equipped Mycological Institute acting as "*Germplasm Center for Mycological Studies*"
- Investigation of Nepalese myco-resources.
- Control for quality of edible species.
- DNA isolation or molecular or phylogenic studies
- Hybridization or breeding of good commercial species.

Lastly again , I thank NAST and MOSTE for organizing this valuable seminar (collection, consumption, cultivation and poisoning risk) for the benefit of Nepalese mycophilian societies.

Thank you all !

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An Overview of Mushroom Poisonings in Nepal

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Abstract

Incidence of mushroom poisoning in various parts of the country is becoming more tragic, terrible and challenging. It is emerging as a medical emergency representing both a diagnostic and treatment dilemma for physicians. Many physicians still consider all mushroom poisonings as similar, but actually based on the toxins contained, there are different groups of poisonous mushrooms. More than 95% of lethal mushroom poisoning occurs due to amanitin and misidentification of a toxic mushroom as an edible. Late hospitalization and conservative management of the incidences are major causes of higher mortality rate. Various types of community awareness programs about the dangers of poisonous mushrooms and management of well trained health workers, advanced technology such as liver transplantations or plasma exchange, facility to do high performance liquid chromatography (HPLC) or radioimmunoassay (RIA) for detection of amanitin and other toxins from plasma, feces, urine or vomitus seems to be the most effective way to tackle this problem. The purpose of this review paper is for informational and preventive.

Key words: Amanitin, Atropine, Mycetism, Mycophagous, Toxins

Detrimental effects appeared after ingestion of toxic substances present in a mushroom is called mushroom poisoning. It is also known as mycetism. The effects may vary from slight gastrointestinal discomfort to life-threatening organ failure resulting in death. The toxins present are secondary metabolites produced in specific biochemical pathways in the fungal cell. Mushroom poisoning is usually the result of ingestion of wild mushrooms due to misidentification of a toxic mushroom as an edible species. More than 95% of mushroom poisoning incidences around the world occur due to misidentification (Thomas 2008). Even though poisonous mushrooms represent less than 1% of the world's known mushrooms, we cannot ignore the existence of the relatively few dangerous and sometimes fatal species (Chang 2004). Death of several historical figures like Roman Emperor Claudius, Pope Clement VII, Tsaritsa Natalia Naryshkina, Holy Roman Emperor Charles VI and Siddharth Gautama are considered to be associated with mushroom poisoning (Stamets 2000, Marmion &Wiedemann 2002). Recently, incidence of mushroom poisoning is increasing as a result of the increasing popularity of wild mushroom consumption. The incidence is more frequent in Western Europe with 50-100 fatal cases reported annually. Likewise, the incidence is 0.005% in USA and 0.05% in Iran (Kavalci et al. 2010). True statistics for mushroom poisoning are hard to obtain for several reasons. Mushroom poisoning occurs during the same season and may exhibit the same symptoms as other food poisoning. A child probably will not admit eating mushrooms when he or she has been warned against such action. Those who experiment with possible hallucinogenic mushrooms and are poisoned may not admit it, fearing legal involvement. Wild mushroom eaters may not admit they made a wrong identification. The most deadly group of mushrooms, the Amanitas are the slowest to show onset of symptoms and the victim may truly forget that he/she had eaten wild mushrooms the night before. Tradition of collection & consumption of wild mushrooms are very old in Nepal as well. Various mycophagous community such as Sherpa, Chepang, Tamang, Gurung, Magar, Tharu, Danuwar, Newar, Kami, Damai, and Sarki are directly concerned with the collection and consumption of wild mushrooms. Due to poor socio-economic condition and ignorance the practice is very common in these communities. (Aryal 2009, Raut 2013). Though,

there is no exact data available due to lack of regular and well managed poison registry system in Nepal. Based on local & national media every year dozens of people die; hundreds are admitted to hospital, while hundreds more rely on local treatments. Moreover, most of members from the same family are wiping out every year by consuming wild mushroom. The real numbers of casualties may be much more than published ones because most of the incidences occur in remote areas which are out of any media coverage. Gordon Wasson, who researched the various cultural uses of mushrooms, divided societies into "mycophobic" and "mycophilic" (fearing and loving mushrooms). He considered the mycophobic cultures to include the Scandinavian countries, Great Britain, Canada and the United States. Countries considered mycophilic included France, Austria, Italy, Switzerland and the Slavic countries. In those countries, photographs and descriptions of both toxic and edible fungi often decorate the walls of primary schoolrooms.

Numerous myths/beliefs are in practice among the wild mushroom collectors to determine whether mushrooms are safe to eat. However, none is accurate. They are dangerous and can be deadly. Here are some examples

- If a clove of garlic turns black when cooked with mushrooms, this is supposed to mean the mushrooms are poisonous.
- A silver coin is supposed to blacken or a silver spoon tarnishes if placed in the cook pot with poisonous mushrooms.
- Poisonous mushrooms will lose their poison when cooked with some vinegar or timur (*Zanthoxylum alatum*).
- Mushrooms having a fruity smell are safe to eat.
- Mushrooms with bitter, acrid, or pungent taste are poisonous.
- Smooth-capped mushrooms are edible.
- Some use a rule of thumb that mushrooms that stain or secrete a milky fluid when bruised or have caps that do not peel are poisonous. Some edible mushrooms have these characteristics and more importantly, the highly poisonous amanitas do not.
- Some feel that no poisonous mushrooms grow on rotting wood. Some do!
- The fact that slugs, insects or animals feed on a species of mushroom does mean that it is safe for humans.
- Parboiling, salting, pickling or drying may detoxify some species, but one can't count on any of these methods for all mushrooms.
- An edible mushroom can become poisonous through some strange influence exercised by snakes or amphibians.
- The first picked mushroom should be offered to God so that subsequent mushrooms will be safe.
- Mushrooms growing in a cluster or group are edible, but those growing alone are not. (Arora 1988, Thomas 2008, Aryal 2009)

There are no general rules for safe mushroom collecting. One must learn to recognize the safe mushrooms species by species, then collect only those that he/she recognizes fully confidently. The wild mushroom collector must be aware of "look-alikes". Morel mushrooms are among the most desirable and tastiest species. The false morel closely resembles the true morels, but is included in one of the two deadly groups of mushrooms. It is said that all puffballs are edible; however, the poisonous earthball and immature Amanita buttons both resemble puffballs. There are many other "look-alikes".

Mushroom Toxins

Based on the toxins contained, there are eight recognized groups of mushroom poisonings.

Toxin Group

I – Amanitins (Cyclopeptides)

II – Gyromitrin (Monomethylhydrazine)

III – Orellanine

IV – Muscarine

V – Ibotenic acid and Muscimol

VI – Coprine

VII – Psilocybin (psilocin)

VIII – Gastrointestinal irritants

Based on physiological action these toxin groups are categorized into four classes

Class-1 Cellular /Protoplasmic Toxins

They are deadly toxic causing cell destruction and cell death. They mainly damage liver and kidney. This class includes

- Amanitins - Cyclopeptides
- Gyromitrin - Monomethylhydrazine
- Orellanine

Class-2 Toxins Affecting Autonomic Nervous System

- These toxins affect the autonomic nervous system which controls the involutary regulation of smooth and cardiac muscles, organs of the GI tract, endocrine system, and excretory system
- Not deadly unless large quantities eaten
- Some edible and sought after
- It includes two toxin groups (Muscarine and Coprine)

Class-3 Toxins Affecting the Central Nervous System

It includes

- Ibotenic Acid and Muscimol
- Psilocybin and Psilocin

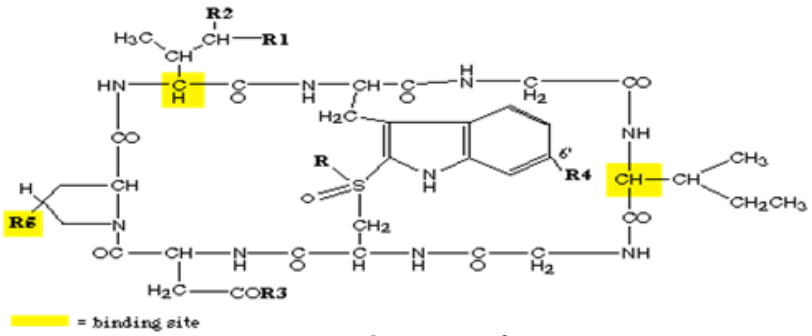
Remember these can be fatal if enough are ingested

Class-4 Gastrointestinal Irritants

- Large variety of mushrooms contain toxins that can cause gastrointestinal distress, including but not limited to nausea, vomiting, diarrhea, and abdominal cramps
- Symptoms similar to those caused by the deadly protoplasmic poisons - but usually have a rapid onset
- Some mushrooms may cause vomiting and/ or diarrhea which lasts for several days

Group I — Amanitin Poisoning

Amanitins are a group of complex cyclic polypeptides which damage tissues by inhibiting RNA synthesis within each individual cell. The toxin molecules are made up of amino-acids in a double ring, and so are called cyclic oligopeptides or cyclopeptides. They come in two varieties, known as amatoxins (amanitins), which contain 8 amino-acid molecules, and phallotoxins (phalloidins), which contain 7 amino-acid molecules. Phallotoxins are found ten times more lethal than cyanide when injected into mice: their LD_{50} is 2 mg/kg. But when taken by mouth, they have no effect. They may be neutralized or broken down by digestive juices, or may not be absorbed by the gut. In contrast, the much more deadly amatoxins are actively toxic when eaten (LD_{50} = 0.1 mg/kg). Amanitin poisoning is extremely serious with fatality rate of about 50% (Kendrick 2001). It is doubly dangerous due to the fact that the symptoms are delayed for 6 to 24 hours after ingestion, by which time the toxins have been completely absorbed by the body and after the initial state of gastric distress, the patient appears to recover and is sometimes sent back to home.



General Structure of Amatoxin

Distribution

Amanita bisporigera, A. phalloides, A. verna, A. virosa, Galerina autumnalis, G. *marginata, Lepiota* spp, *Conocybe filaris*

Symptoms

Amanitin poisoning usually manifests itself in four stages

- First stage is a latency period of 6 to 24 hours after ingestion, in which the toxins are actively destroying the victim's kidneys and liver, but the victim experiences no discomfort.
- Second stage is a period of about 24 hours characterized by violent vomiting, bloody diarrhea, and severe abdominal cramps.
- Third stage is a period of 24 hours during which the victim appears to recover (if hospitalized, the patient is sometimes released!)
- Fourth stage is a relapse, during which kidney and liver failure often occurs, leading to death. Patients may also "bleed out" and die due to the destruction of clotting factors in the blood. There may be more than one relapse.

Treatment

Even if the problem is correctly diagnosed, there is currently no antidote for amanitin. Treatment is largely supportive and symptomatic. Penicillin, kutkin, and silibinin/silymarin show promise as treatments, along with oral activated charcoal and electrolytes. Basically, treatment consists of attempts to: (1) remove toxin from the system; (2) increase the rate at which the patient excretes it; (3) support the patient's various systems.

(1) Removal of toxin. If the condition is diagnosed within an hour or two, it is obviously appropriate to empty the stomach by emesis and gastric lavage (getting the patient to throw up, and then washing out the stomach). If the usual latent period has elapsed, this approach would be pointless. Three blood-cleansing techniques have been applied to late-diagnosed amanitin poisoning. (A) Haemodialysis (circulating the blood through a semipermeable membrane bathed in an isotonic medium) is used in long-term treatment of kidney failure, or until a transplant becomes available. Its use in Amanita poisoning is questionable, since it removes substances of molecular weight 300 or less. Amanitin itself has a molecular weight of 900, and it may often become complexed with much larger molecules, such as proteins. (B) Haemoperfusion (circulating the blood over activated charcoal) is used to support the detoxifying function of ailing livers. It has been used experimentally to treat Amanita poisoning in recent years, and has been shown to remove some toxin from amanitin-spiked blood.

Unfortunately, the amounts of amanitin detected in the blood of poisoning victims are usually very low, especially if more than 12 hours have elapsed since the mushrooms were eaten. Keeping in mind the possible unfavourable effect of haemoperfusion on a blood coagulatory pattern already unbalanced by the effects of the toxin, this technique should be applied with caution. It may, of course, be indicated if the effects of the toxin cause liver failure. (C) Apheresis (centrifuging the blood to segregate its major components plasma, erythrocytes, leucocytes, platelets - then discarding and replacing the fraction containing the unwanted agent) is being increasingly used to treat many diseases of the immune system, and some kinds of poisoning. Again, the actual kinetics of amanitin in the body are not yet well-enough understood for us to be sure which blood fraction, if any, should be replaced. This technique may prove to be of value when the movements of amanitin in the body are better understood (Kendrick 2001).

(2) Increase excretion of toxin. Although the body's natural excretion of amanitin is obviously not efficient enough to prevent cell damage, a new and sensitive radioimmunoassay for amanitin in body fluids has shown that the toxin is present in the urine of patients at far higher levels than can be found in their blood. This suggests that attempts to increase urine production by giving intravenous fluids, and an appropriate diuretic, might be helpful.

(3) Supportive measures involve careful monitoring of electrolyte and fluid balance,

and blood sugar, with appropriate replacement therapy as required. Liver and kidney functions must be closely followed. If kidney and/or liver failure occur, haemodialysis and/or haemoperfusion may be necessary. In addition, various researchers have suggested several other strategies to support the damaged liver or kidneys: intravenous infusion of B vitamins, vitamin K, Penicillin-G, corticosteroids, and thioctic acid (a coenzyme in the Krebs cycle). The therapeutic value of some of these agents has not been firmly established, but in a potentially fatal condition, the shotgun approach is worth trying.

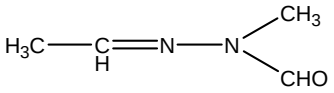
Meixner test- a qualitative test for amatoxins

Presence of amatoxins can be detected by Meixner test. It is a simple and fairly accurate test if performed correctly. Dr. Theodor Wieland first studied the test on high-lignin paper but later Dr. Axel Meixner showed that it would work on ordinary newspaper and the test is simply known as the "Meixner test"

Avoiding sunlight or high heat, a small circle is made on newspaper (or other high-lignin paper) with a pencil. A small amount of mushroom juice is then squeezed on to this and left to dry at room temperature. When dry, a single tiny drop of 8-16 concentrated hydrochloric acid is placed in the center of the circle. The grayed bluish-green that is typical of amatoxins slowly appears over 1-3 minutes, but the test sheet should be observed up to 20 minutes. The color on high lignin paper is usually 25B3-5 in the Methuen Handbook of Colour (Kornerup & Wanscher 1978) but may vary from 25B3-5 to 25B5-26B4. There has been considerable concern about false positives (Beutler &Vergeer 1980). However, if done with reasonable knowledge of colors seen with various genera, falsely positive tests are not of great concern

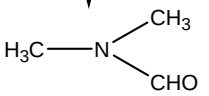
Group II — Gyromitrin (Monomethylhydrazine) Poisoning

After hydrolysis gyromitrin converted into monomethylhydrazine (MMH), which is a colorless, volatile, highly toxic, carcinogenic compound used as a rocket fuel. Gyromitrin poisoning has puzzled scientists for many years because of the very narrow threshold between safe and lethal dose. This is due to its volatile nature which is removed by cooking or drying.



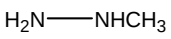
N-methyl N-formyl hydrazine actaldehyde (Gyromitrin)

Rapid decomposition if adequate stomach acid



N-methyl N-formylhydrazine (MFH) and actaldehyde

Slow hydrolysis



Monomethylhydrazine (MMH)

Hydrolysis of Gyromitrin to monomethylhydrazine (MMH)

Distribution

Several *Gyromitra* species (especially *G. esculenta, G. ambigua, G. infula. G. montanum, G. gigas, G. fastigiata* (=*brunnea*), *G. californica, G. sphaerospora* and also many related Ascomycetes, such as some species of *Helvella, Verpa,* and *Cudonia*

Symptoms

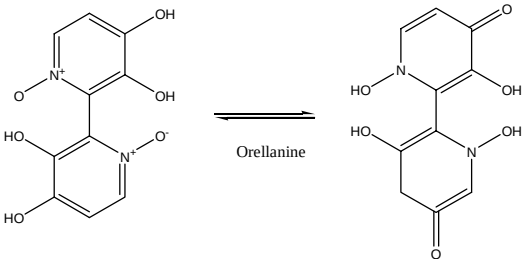
Gyromitrin poisoning resembles Amanita poisoning but is less severe. Very few fatalities are in USA while it is 2-4% in Europe from this type of poisoning. Symptoms appear within 2 to 24 hours and include headaches, abdominal distress, severe diarrhea, and vomiting. In severe cases, liver, kidney, and red blood cell damage may occur, possibly resulting in death.

Treatment

Treatment is largely supportive, and a physician should be consulted.

Group III — Orellanine Poisoning

An extract of *Cortinarius orellanus* has yielded a crystalline substance orellanine. Orellanine now appears to be a group of bipyridyl compounds (Antowiak & Gessner 1975, 1978). Dried specimens of *Cortinarius orellanus* have retained toxicity up to 60 years (Rapior et al. 1988). Orellanine poisoning is extremely serious. Onset of symptoms from orellanine poisoning can be very greatly delayed (as much as three weeks), the toxin isn't very well understood, and specific treatments are not available.



Distribution

Cortinarius orellanus and *C. rubellus* (=*C. orellanoides, C. speciosissimus, C. rainierensis*). *C. splendens, C. atrovirens, C. venenosus, C. gentilis* may possibly cause orellanine like poisoning.

Symptoms

Symptoms occur within 36 hours to 3 weeks of ingestion (average is about 8 days), and include nausea, vomiting, lethargy, anorexia, frequent urination, burning thirst, headache, sensations of coldness and shivering (fever generally absent), evidence or progressive kidney failure.

Treatment

Beyond the standard management of kidney failure, there is little but supportive treatment of use in cases of orellanine poisoning. Patients with severe, but not irreversible damage may begin to recover kidney function between two and four weeks after the onset of symptoms.

Qualitative tests for Orellanine

Test-1

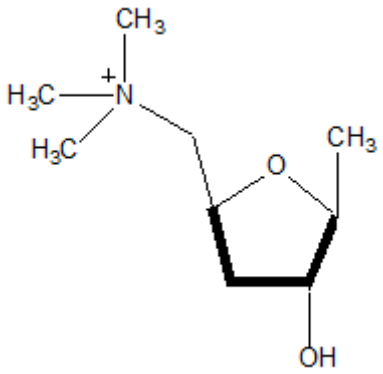
The fresh or dried mushroom is crushed in water and after 10 minutes the mixture is filtered. The filtered solution is mixed in equal portions with 3% ferric chloride hexahydrate dissolved in 0.5 N hydrochloric acid. A dark gray blue color suggests orellanine (Schumacher & Høiland 1983)

Test-2

The fresh, dried or even cooked specimen is added to a small amount of water, just enough to pound or grind to a pulp. The mixture is then centrifuged to obtain the liquid test material. A drop of this liquid is then placed onto previously prepared white blotting paper or laboratory "bibulous paper" (paper used to mop up excess fluid from microscope slides). The bibulous paper is pretreated by soaking with a 2% solution of ferric chloride in 0.5 N HCl acid and allowed to dry. A control spot is done on a second piece of non-treated bibulous paper. A positive test for orellanine is one showing a central reddish color with an encircling lilac halo (Pöder & Moser 1989).

Group IV — Muscarine Poisoning

Amanita muscaria and *Amanita pantherina* were previously thought to have contained primarily muscarine - but they contain insignificant amounts. Muscarine is an oxoheterocyclic quarternary salt, 2-methy-3-hydroxy-5-trimethyl-ammoniummethyl tetrahydrofuran chloride. Muscarine poisoning occurs primarily in the genera *Clitocybe* and *Inocybe*. This toxin produces muscarine poisoning by strongly attaching to muscarinic acetylcholine receptors in the parasympathetic nerves and initiating an acetylcholine effect on organs supplied by these nerves (part of the non-voluntary nervous system). The enzyme acetylcholinesterase, which breaks down acetylcholine, is not effective against muscarine.



Symptoms

Muscarine activates the parasympathetic nervous system. Symptoms of sweating, salivation, nausea, teary eyes, small pupils and/or pupils sluggishly reacting to light, slow heart rate, increased urination and sometimes diarrhea occur within 20-30 minutes. Severe poisonings may produce more serious symptoms, including bronchial constriction, slow heart rate with faster "escape rhythms" and pulmonary edema.

Treatment

The treatment for this symptom complex is atropine titrated to reduce symptoms, induce slight dryness of mouth and restore normal or nearly normal pupil size. The initial adult dose of atropine is 0.5 to 1.0 mg given very slowly intravenously. Repeat doses of 0.5-1.0 mg can be given at 10-20 minutes intervals to either of two endpoints:

A. 1 mg doses until bronchial hyper secretion, pulmonary edema and significant cardiac arrhythmias have cleared or

B. 0.5 mg of atropine until the pupils is normal or nearly so. The second end-point may take longer to achieve; its use requires increased diligence and slower administration of atropine to avoid over dosage. Usually no more than 2.5 mg of atropine is required.

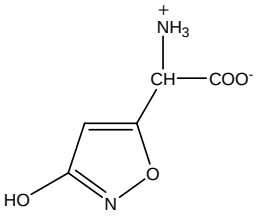
Group V — Ibotenic/Muscimol (isoxazole) Poisoning

Ibotenic acid (an amino acid in the form of an isoxazole ring) and muscimol are the major toxins of this type of poisoning. *Amanita muscaria* contains a substance that specifically affects the central nervous system. Regarding the principal toxins of *Amanita muscaria* and *A. pantherina* a lot of contradictions can be found in literatures. Needless to say, this was discovered long ago, and has been exploited by various peoples. The Soma hymns of the 3,000 years old sacred Indian book, the Rig Veda, have been interpreted as a glorification of *A. muscaria* and its effects. Moreover, R. Gordon Wasson in his book SOMA: The devine mushroom of immortality mentions for it being the mystical Soma plant of the RigVeda. It has been also linked to the origin of Christianity (The Sacred Mushroom and the Cross). Many tribes in Siberia used it for centuries as a religious or recreational intoxicant, and although it has now largely been replaced by vodka, some Siberians still prefer mushrooms. It may have been used throughout Eurasia in ancient times .

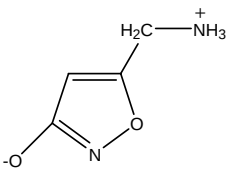
Drying and cooking convert most of the ibotenic acid in these amanitas to muscimol. Only blanching and throwing out the cooking water significantly lower the toxicity. Japanese found that muscimol in very small amounts was twenty times more effective in enhancing food flavors than sodium glutamate, the commonly used salt of glutamic acid (Thomas 2008).

Distribution

Amanita muscaria, A. pantherina, A. gemmata, Amanita multisquamosa (syn. *A. cothurnata*), *A. frostiana, A. crenulata, A. strobiliformus, Tricholoma muscarium.*



Ibotenic acid



Muscimol

Symptoms

Symptoms appear within 30 minutes to 2 hours after ingestion, and last for several hours. Nausea and vomiting are quite common, but the principle effects are on the central nervous system: confusion, visual distortion, a feeling of greater strength, delusions and convulsions. Drowsiness is a common symptom, and many who ingest these mushrooms fall asleep and cannot be roused. In rare cases the coma-like state can last for more than 24 hours. This facet of the syndrome can be particularly frightening for the attending physician, as most cases involve patients who arrive in this apparently comatose state

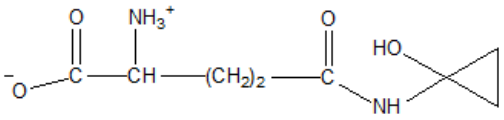
Treatment

Although fresh mushrooms contain ibotenic acid, which has some effect on the nervous system, dried mushrooms have been found to be much more potent. This is because ibotenic acid degrades to muscimol on drying. Muscimol is 5-10 times more psychoactive than ibotenic acid. Dried mushrooms retain their potency for 5-10 years. Although very few deaths have been reported from this kind of poisoning, 10 or more mushrooms can constitute a fatal dose.

Treatment of humans and animals is largely supportive — reassuring the patient that the effects are only temporary. Recovery is normally spontaneous. Atropine is not indicated.

Group VI - Coprine (Antabuse-like) Poisoning

This kind of poisoning can occur at any time for up to 5 days after Coprinus atramentarius has been eaten. The mushrooms by themselves are not toxic. They contain a protoxin "coprine" which is converted to 1-aminocyclopropanol— a compound with an antabuse-like reaction with alcohol. Symptoms appear 30-60 minutes after the mushroom-eater has a drink containing alcohol



Distribution

Coprinopsis atramentaria (=*Coprinus atramentarius*), *C. insignis, C. quadrifidus, C. variegatus*.

Symptoms

The symptoms are tachycardia (racing heart) and palpitations, tingling arms and legs, warmth and flushing, and sometimes headache, heavy limbs, salivation.

Treatment

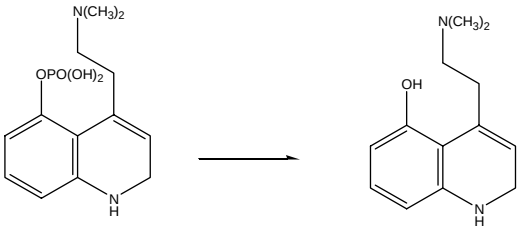
This is an unpleasant combination, but it isn't fatal. The only treatment necessary may be to control arrhythmia (irregular heartbeat). The syndrome will persist as long as there is any alcohol in the system usually 2-4 hours after which recovery is spontaneous, and the victim may well swear off booze.

Group VII - Psilocybin/Psilocin Poisoning

These indole derivatives are very popular for their psychedelic properties and psilocybin mushrooms are often consumed for recreational purposes. These mushrooms have played important roles in religion and medicine in some parts of the world, notably in South America. Many psilocybes blue with bruising or cutting, apparently a reaction catalyzed by cytochrome oxidase. This reaction in hallucinogenic genera corresponds roughly with the amount of psilocin. The exact compound producing this bluing

reaction remains to be isolated, although it appears to be a quinone derivative. Psilocin (a dephosphorylated version of psilocybin) is about ten times active as psilocybin. Most psilocybin-containing mushrooms have only a trace of psilocin, but the human body converts most of psilocybin into psilocin. A blueing reaction associated with the presence of psilocybin and psilocin is caused by an enzyme that oxidizes psilocin. However, not all mushroom that stain blue contain psilocybin or psilocin, and not all psilocybin mushrooms stain blue.

The psychoactive principles in these agarics are indole alkaloids called psilocybin and psilocin, hydroxyltryptamine derivatives related to the neurotransmitter, serotonin.



Psilocybin Psilocin

Distribution

About 20 *Psilocybe* species including *P. cyanescens, P. stuntzii, P. cubensis*, and *P. semilanceata,* several *Panaeolous* species including *P. cyanescens* and *P. subbalteatus,* at least three *Gymnopilus* species most notably *Gymnopilus spectabilis* plus at least one *Mycena*, one *Pluteus*, one *Conocybe* and one *Inocybe.*

Symptoms

Initial symptoms, starting around 20 minutes after ingestion, present with a variety of very individual responses—relaxation, anxiety, light-headedness, nausea and vague abdominal discomfort usually followed by a sharpness of outline or heightened color for objects and visual imagery with closed eyes

Treatment

An average effective dose of psilocybin is 4-8 mg, the amount contained in about 2 g of dried mushrooms. If larger quantities of mushrooms are eaten, the hallucinogenic effects may be rather overwhelming, but serious poisoning is unlikely unless huge numbers of mushrooms are consumed. Adults on 'bad trips' may become extremely anxious or even paranoid, and may need considerable reassurance or, more rarely, tranquilizers. Children who eat hallucinogenic mushrooms may develop a high fever or convulsions. They should not be given aspirin. Tepid baths or wet sheets should be used. Hallucinations may be suppressed by chlorpromazine, and convulsions by diazepam

Group VIII — Gastro-Intestinal Irritants

The most frequent form of mushroom poisoning is caused by a wide variety of gastrointestinal irritants. It is the largest and most prevalent group of mushroom toxins. Although a number of toxins are known to cause only GI symptoms, most of these are poorly understood. They are rarely fatal. Allergic reactions to edible mushrooms normally take the form of gastrointestinal upset.

Distribution

Agaricus hondensis, A. placomyces; Amanita brunnescens; Boletus luridus, other blueing *Boletus* spp.*; Chlorophyllum molybdites; Entoloma grande, E. lividum, E. sinuatum, E. strictius; Hebeloma crustuliniforme; Lactarius piperatus, L. rufus, L. uvidus, L. vellereus; Marasmius urens; Naematoloma fasciculare; Omphalotus olearius; Pholiota squarrosa; Ramaria formosa and relatives; Russula emetica; Scleroderma* spp.*; Tricholoma pardinum*; etc.

Symptoms

Symptoms usually appears shortly after ingestion (20 minutes-4 hours). They include include nausea, vomiting, cramps, and diarrhea, which normally pass after the irritant had been expelled. Severe cases may require hospitalization.

Treatment

Treatment is largely supportive - helping the patient's body to eliminate what it's not equipped to handle. Recovery is complete, though a bout with severe gastro-intestinal

distress may put one off ever eating mushrooms again! IMPORTANT: If the gastrointestinal distress begins 6 to 24 hours after ingestion of the mushrooms, there is a possibility of a very serious toxicity from Amatoxins. GI onset of 4-11 hours with impaired kidney function could be due to Allenic Norleucine (2-amino-4, 5-hexadienoic acid). GI onset greater than 24 hours and up to 21 days could be due to Orellanine

Besides above there is the danger of contamination by pesticides and other environmental poisons. So there is necessary always to be aware of this possibility, especially when picking mushrooms in towns, along well travelled roads, and in forests, fields, or range land where herbicides and pesticides are used. Mushroom poisoning has emerged as a medical emergency representing both a diagnostic and treatment dilemma for physicians. Diagnosis of mushroom poisoning is difficult. Because the suspect mushrooms have; probably been eaten, so that none remain available for identification. If a sample of the mushroom is available, a competent mycologist can be of great help in identifying the mushroom. Many physicians still consider all mushroom poisonings as similar, but actually, based on the toxins contained, there are different aforementioned groups of poisonous mushrooms. Among them amanitin group is the most lethal and cause more than 95% human casualty worldwide. Delay in onset of symptoms, individual susceptibility variation and lack of rapid and reliable identification have contributed to the significant morbidity and mortality of this type of poisoning.

The time between ingestion and onset of symptoms and the type of systemic involvement (for example, neurologic versus gastrointestinal) can be helpful indexes for characterizing the type of mushroom poisoning. Mushroom poisoning can be divided into cases in which symptoms appear within several minutes to six hours after ingestion and those in which symptoms develop much later. Most nonlethal poisonous mushrooms produce symptoms soon after ingestion, whereas A. phalloides-type mushrooms produce life-threatening reactions 6 to 24 hours after ingestion. However, since a mixture of wild mushrooms is often ingested; early onset of symptoms does not exclude the possibility of more serious poisoning. Poisoning with immediate onset of symptoms is further distinguishable by the type of symptoms; that is, gastrointestinal disturbance, parasympathetic stimulation and hallucinations. Such poisoning is rarely serious, and recovery usually occurs within 24 hours (Becker et al. 1976). Variations in clinical effects may depend on an individual's susceptibility and on the presence of confounding factors such as contamination and/or co-ingestion. In general, children, older persons, and persons with disabilities are at a higher risk of developing serious complications with mushroom poisoning than are healthy young adults. There are few studies on mushroom toxicology in Nepal (Prasad & Karki 1997, Rauniyar et al. 1999, Ghimire et al. 2004, Paudyal 2005, Das et al. 2007, Joshi et al. 2007, Adhikari 2008, Adhikari et al. 2008, 2012, Aryal 2009, Syed et al. 2009, Lohani et al. 2010, Patowary 2010, Raut 2012, 2013). Based on these studies it has been found that most of mushroom poisoning incidences in Nepal also occur due to misidentification of a toxic mushroom and majority of human casualty are due to amanitin group. Late hospitalization and conservative management of the cases are major causes of higher mortality rate within country. In Europe, early hospitalization, rapid diagnosis and aggressive management with charcoal hemoperfusion, thioctic acid, plasma exchange, extracorporeal liver assist device (ELAD) or orthotopic liver transplantation have shown to reduce mortality to 10% whereas 60-hour delay increases it to 50-90% (Das et al. 2007). Rate of mushroom poisoning has found different in different areas in Nepal. It has found 1-4% in the major leading tertiary hospital of Kathmandu while it is 4.89% in a tertiary care center in eastern Nepal and 1% in another urban district level hospital of Chitwan. In USA, It was <0.5% of all reported toxic exposures from 1979 to 1995 (Joshi et al. 2007). For the effective management of mushroom poisoning incidences within country immediate actions are necessary.

Mitigation

To tackle and mitigate the problem some recommendations are made here.

- Mushrooms from each part of country should

be extensively explored and documented

- Regional toxicology/poison centers should be established which would impart public education on dangers of wild mushroom consumption
- Nationwide awareness programs through national & local media (radio, television, newspaper) should be conducted. Miking, postering, mushroom exhibition, etc. about hazards of mushroom poisoning at the beginning of the rainy season might be more effective.
- Physicians and other health workers should be trained for the effective management of different types of mushroom poisoning. An appropriate protocol for each type should be launched to hospitals or poison centers.
- If there is suspicion about poisonous mushroom consumption, immediately nearby health institute or poison center should be contacted
- It is best and safe to avoid alcohol while consuming mushrooms
- It is worth remembering that there is no specific antidote for lethal mushroom poisoning and most lethal mushroom toxins are not destroyed or deactivated by cooking, canning, freezing, drying or other any means of food preparations.
- Amanita toxicity should be considered in differential diagnosis of acute hepatic and renal failure especially in high prevalent regions.
- Edible mushroom cultivation should be promoted throughout country to decrease the reliance of peoples on wild mushrooms.

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The Status of Collection and Utilization of Nepalese Mycobiota

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Abstract

Nepal, the land of diverse geographical settings and mycodiversity, is well known to be the center for origin, adaptation, growth and dominance of different mycobiota. First publication of mycoelements was done by Llyod (1808) and then followed by Berkeley (1854) and Balfour- Browne (1950). Since then, many researchers have contributed their findings. Among 1150 species of mushrooms 5 monotypic and 52 endemic species of mushrooms are recorded from Nepal. This mushroom biota embraces 147 edible, 100 poisonous and 73 medicinal species. The annual mortality rate due to mushroom poisoning ranges in between 20 – 30. The cultivation of mushroom started since 1976 and all are the exotic strains. There is now need of cultivation of indigenous species, fungal legislation to assist research activities, a center for mycological studies, quality control of edible species, DNA isolation or molecular or phylogenic studies, screening of mycochemicals and breeding of good commercial species.

Key words – Decoration, Endemic, Mycogeographic, Poisonous, Wild

Introduction

Nepal, the Himalayan kingdom, situated in the lap of well known high snow peaked Himalayan chain in the north and vast terrain of plain in the south, is famous as the centre for origin and house of immense biological diversity. Among the biotypes the Phanerogamic floral diversity has been studied immensely but the studies on cryptogamic especially myco diversity has got less attention in Nepal. While talking of other countries there are several institutes related to studies on mycological fields in Europe, America, Germany, Japan, India, China and Russia and they have contributed immensely as an authority for several taxa. Nepal has to undergo several challenges to meet the current advances seen in development of mycological field.

The credit of starting investigation on the Nepalese fungi goes back to the work of Lloyd (1808), Berkeley (1854) and Balfour-Browne (1955, 1968) from where the fungi of Nepal came to light. Since then more than 540 papers have been published by several researchers from abroad (more than 190 persons) and Nepal (more than 50 persons). The papers mostly embrace the studies related to taxonomy, ethnomycology, pathology, biogeographic or ecological distribution pattern, screening results and mycorrhizal mycobiota. The most well known compiled literature are "*Mushrooms of Nepal*" (Adhikari 2000), "*Researches on the Nepalese mycoflora*" 1 and 2 (Adhikari 2009 & 2012), "*Fungi of Nepa*l" (part 1, 2, 3) (Adhikari & Manandhar 1996, 1997, 2001) and '*Fungi of Nepal. IV, Basidiomycotina: Ustilagiales'* (Manandhar & Adhikari 2006)

Besides these, the other major literatures concerned with the mycoflora are '*Flora of Eastern Himalaya'* (Hara 1966), '*Expedition to Khumbu Himal'* (1976), *'Reports on the Cryptogamic study in Nepal'* (1982), '*Cryptogams of the Himalayas Vol. 1: The Kathmandu valley'* (1988), *"Cryptogams of the Himalayas. Vol. 2: Central and Eastern"* (1990), *'Research trends on Nepalese mycoflora'* (Adhikari 1991), *'Cryptogams of the Himalayas' vol. 3: Pakistan and Nepal'* (1995), *'The check references list of plant pathogen in Nepal'* (Pawsey 1989), *'Annotated check list of rust fungi (Uredinales) of Nepal'* (Ono, Adhikari & Kaneko, 1996), '*Gasteromycetes from Nepal'* (Adhikari, 1999d), *'The Clavarioid fungi of Nepal'* (Adhikari & Devkota 2007), *'The diversity of Cordycepioid fungi reported from Nepal'* (Adhikari 2008) *'The family Sclerodermataceae: ectomycorhizal fungi from*

Nepal' (Manandhar & Adhikari 2009). Some of these checklists now need revision as many species are added to the list of Nepalese mycobiota.

Taxa reported from Nepal

The glimpse to Nepalese mycobiota encompasses 608 genera and 2025 species with 5 monotypic species, 52 genera and 145 species of endemic fungi out of 177 species discovered by various mycologists in time to time (table no. 1). Thirty two (32) species are now reported from other countries; while near about 22 species have undergone the synonym or basionymes (Adhikari 2009, 2012).

Table 1. Mycodiversity

Class	Genus	Species	g. nov.	sp. nov.
Myxomycota	**34**	**150**	-	**19**
Mastigomycota	**27**	**70**	-	-
Zygomycota	**17**	**46**	**1**	**1**
Ascomycota	**171**	**372**	-	**32**
Basidiomycota				
Uredinales	**39**	**291**	-	**30**
Ustilaginales	**12**	**38**	-	**6**
Pragmobasidiomycetes	4	11	-	-
Transitional group	5	11	-	-
Homobsidiomycetes	**171**	**585**	**1**	**38**
Gasteromycetes	**20**	**68**	-	**12**
Deuteromycota	**108**	**383**	**3**	**54**
Total taxa	**608**	**2025**	**5**	**192**

While visualizing Nepal Himalaya as centre for origin, appearance and dominance of number of mycobiota and their distribution pattern between high and low altitude forms, the present number of species is 10 times smaller in comparison to India (Adhikari 1990, 2000, 2009). Yet the mycoflora Nepal serves as a connecting link with Sino-Japanese, Western and Central Asiatic, North East American, partly North African and mostly Indian subcontinent. The eastern sector shows some of the flora characteristic to South-East Asia, while the rest shows their affinity with the North-West Himalayan elements of India.

Adhikari (2000) also considered 3 mycogeographic regions on the basis of findings of *Amauroderma rugosum* in (Sanghu, Dhankuta) Eastern Himalaya and *Aecidium urticae* in (Bajhang) North-West Himalaya, which supports the view of Stearn (1960) to be divided into 3 phytogeographic regions.

Till now near about 270 genera and 1150 species of mushrooms have been investigated belonging to near about 100 families. Among them Ascomycota embraces 157 species, while Basidiomycota has 993 species (Adhikari 2012). About 52 species of mushrooms are described from Nepal among these 9 species are found in other countries. Thirty two (32) species are endemic to Nepal, while 10 species have turned into synonyms.

Utilization of mycoresources

(a) Wild edible and poisonous species

While talking of the wild edible species it encounters around 147 species and the poisonous species are recently recorded to reach near about 100 species (Adhikari 2008c; Adhikari et al. 2008, 2012). The medicinal are 73 species (Adhikari 2008a), while 20 species can be utilized in decoration.

The daily consumption of wild mushrooms is found in tropical forest areas, midlands, the temperate and subalpine region of Nepal, where the local inhabitants dwell near by the forest (Adhikari & Adhikari 1996-97, 2000). The high consumption is found in temperate region in comparison to others. This mishappening always occurs in the areas where there is nearness to forest and or scarcity of food. But till now the amount of collection and consumption is unknown. The mortality rate due to the consumption of wild mushrooms encircles around 20 to 25 persons annually, where there is poor facility of prompt communication and first aid services. The collectors are mostly traditional mycophagous society, herds of animals or wood collectors, which age between 10 to 45 years. Among them infants and old age persons are the victims. Their necessity to earn money for livelihood and serve hand to mouth invites the fatal cases. They are illiterate and ignorant to differentiate between edible and poisonous ones (Adhikari 2004).

In rainy season near about 30 species are sold in Kathmandu market and elsewhere in urban cities (Adhikari & Adhikari 19996- 97; Adhikari 2000, 2009). The cities like Kathmandu and Pokhara valley are no longer exception to this case especially during the raining season.

The wild delicious taxa like, *Hericium* (3 species), *Amanita* (3 species), *Laetiporus sulphureus, Pleurotus* (4 species), *Cantharellus* (3 species), *Morchella* (6 species: 6 – 10 tons annually), *Ophiocordyceps sinensis* (1 tons annually) and *Scleroderma texens* and *Termitomyces* (7 species) collected and sold in the market. Some of these are collected in huge amount and exported to other countries (Adhikari 2000a, b, 2008b, 2012; Adhikari & Adhikari 1996-97). The species of collection also depend up on the difference between the ethnic casts, their physiologic condition and the phyto or physiographic condition of the area. Chepangs are traditionally expert in collecting *Amanita chepangiana,* a species of subtropical region. The screening of nutrient present in some of these wild mushrooms has also been done. There are many literatures published on wild edible mushrooms of Nepal by different authors, which now is under revision based on FAO report and various literatures (Adhikari 2009).

So, to create awareness about the concept on the collection and the consequence produced by consumption of wild mushroom in the rural areas three posters of poisonous mushrooms were released. These three posters containing photographs of 30 poisonous species were published in the year 2008 along with their description in collaboration with DPR, DOA and JICA. The team was headed by me along with Japanese senior volunteer and other researchers of DOA. Recently later in 2012 a poster again was released embracing the photographs of 50 species in collaboration of PPD and JICA. It was also headed by me along with same Japanese senior volunteer and the staff of PPD.

(b) Cultivation of mushrooms

Nepalese farmers grow exotic cultivar and unknown strains of *Agaricus bisporus, Agaricus bitorquis, Pleurotus ostreatus, Coprinus comatus, Pleurotus eryngii, Pleurotus floridus, Lentinus sajor-caju, Lentinula edodes, Volvariella volvacea* and *Ganoderma lucidum.* The daily consumption is known to be between 25 – 35 tons in "*in season*", while the daily consumption in "*off season*" lies between 5 – 10 tons. But quality of production and sales are not good.

I have heard that many growers use powerful fungicides, insecticides or pesticides starting from the preparation for cultivation up to packing up their products for market. These chemicals though do not show their immediate hazard in human health, but are quite harmful, which are attached

in the human genetic material as covalent and carried to generation to generation. So, there is need of regular examination and visit of market, where both the wild and cultivated species are sold. It is visualized here necessary to formulate a law for both wild and cultivated edible species to standardize as quality product by *Food Research Laboratory* as *food security legislation* (Adhikari 2011).

(c) Other uses

Despite of fermentation, medicinal, lightening and dye yielding values, now a days some new aspects of utilization of fungi has been found. The masks are made out of several species of polypores. They are found selling in the market and cost price ranges between 25/- to 4000/-Rs. This is a new emerging industry in Nepal. One must think the pros and cons about it.

Nepal is rich in all these indigenous species and despite of these there several species which await their exploration, collection, breeding, producing cultures and cultivation. So, now the time has become necessary to use our own wealth of the country to enrich the kingdom.

Conclusion

Lastly, while looking backwards we see many things yet to be done in future as noted below.

- Nepal needs vivid exploration, investigation and studies on Nepalese mycobiota. Till now western and eastern regions are not well explored in comparison to central region. Many mycotaxa remains still to be discovered.
- Very few Nepalese are engaged in this field
- Not a single person or researcher has been awarded, despite of their enormous and noteworthy contributions in the field of mycology. And so, what country would expect from them for more contribution in future,
- A good and well equipped institute for investigation and studies on Nepalese mycology serving as "Center for Himalayan Mycological Studies",
- Provide or create posts for and or mycologists in the related institutes
- Provide free entrance for collection and investigation opportunities in any parts of Nepal to any Nepalese researchers.
- Provide well equipped labs for taxonomic, molecular, phylogenetic and pharmacological studies. The lab should be able to provide the opportunities for myco-chemical screening tests, nutrient analysis, breeding behavior studies and agrobased experiments.
- Provide joint collaborative works, exchange of materials and researchers with mycologists of other countries.
- There is a need of suitable legislation to facilitate the collection and study of fungi in Nepal
- Need of a sound and priority based teaching technology with special preference in mycological studies. Universities should give preferences on providing mycological studies.
- Utilization through cultivation practices of indigenous wild edible species and production of new cultivars for commercial production edible mushrooms.
- Facilities to be provided in trade and transit of mushrooms.
- Frequent cross check or examination of wild species sold in the market and standardization or quality control of cultivated species including chemical residue analysis (CRA, PRA or FRA) so on.
- Nepal also now needs a perfect "*Mycological Society*" under a dyanamic leadership, which would render the services related to mycology, publish a standard Journal and conduct various activities related to mycological field.

Lastly, my request to all persons working in the mycological filed to work very hard starting from the investigation of wild mushrooms up to their possible commercialization so that we can make steps and march ahead to uplift, develop and overcome the difficulties. In these areas specially the NAST along with Department of Plant Resources, MOFSC, DOA Mushroom Unit,

PPD, NARC, TU, PU and KU should play a vital role.

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Mushroom Research in Nepal: Current Status and Prospects

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Abstract

Organized research and production of mushroom in Nepal was started after the establishment of Mushroom Research Unit in Plant Pathology Division, Khumaltar, in 1974. Since then this division has been mainly concerned on research and production of five different mushrooms, namely Button Mushroom (*Agaricus bisporus*), Oyster mushroom (*Pleurotus* sp.), Shiitake mushroom (*Lentinula edodes*), Straw mushroom (*Volvariella volvacea*), Jelly ear mushroom (*Auricularia auriculata)* and Red mushroom (*Ganoderma lucidum*). Plant Pathology Division has been collecting and studying native mushrooms from different parts of the country under its new strategic plan. In this short period, a number of edible mushrooms were collected and many of them have been identified based on their morphology and made culture through tissue culture for domestication purpose. They include different species of *Pleurotus*, *Ganoderma*, *Shiitake*, *Pholiota*, *Grifola*, and many others. Attempts are being made to produce spawns of some of the collected species for their cultivation.

Key words: *Agaricus bisporous*, *Ganoderma lucidum*, Native mushroom, Nutritional, *Pleurotus* sp. *Volvariella volvacea*

History of mushroom research in Nepal

Mushroom research was initiated by Prof. S. C. Singh from Tribhuvan University in 1972. During that period, he started research work with collection of native edible mushrooms from forest. At the beginning, he did tissue culture of *Pleurotus* sp. and worked on the domestication mushroom on saw dust, *Quercus semicarpefolia* and *Euphorbia royliana*

Organized research and production of mushroom in Nepal started after the establishment of Mushroom Research Unit in Plant Pathology Division, Khumaltar, in 1974. At the beginning, many substrates of button mushroom were used for making the spawn to cultivate the button mushroom. At that time, many cereal grains were used as a substrate out of which wheat grain substrate were selected suitable for the button mushroom. Side by side, suitable substrate for cultivation purpose was also selected.

Button mushrooms (Gobre chyau) cultivation in Nepal

Cultivation technologies for the cultivation of button mushrooms(Gobre chyau) was recommended to farmers in 1977. Initially, cultivation technology was transferred in different locations of the Kathmandu valley like Balambu, Chapagaun, Harisiddhi, Koteshwor, etc and then to various places outside the Kathmandu valley including Chitwan, Illam, Sunsari, Jhapa, Dhankuta, Bara, Makawanpur, Nawalparasi, Pokhara, Kaski, Mustang, Dang, and Dhading districts.

The substrates developed by Plant Pathology Division were as follows:

Compost A: Straw: 1000 kg, Urea:5 kg, Ammonium sulphate:20 kg, Triple super phosphate: 7 kg, and Agri lime: 30 kg

Compost B: Straw: 1000 kg, Complexsal (20:20:0): 23 kg, Urea: 4 kg, Gypsum (Plaster of aris): 40 kg

Compost C: Straw: 1000 kg, Urea: 15 kg, Ammonium sulphate : 15 kg, Gypsum: 35 kg, Agri lime: 25 kg and Rice bran: 25 kg

Compost D: Straw: 1000 kg Or Straw- 500 kg and Wheat straw- 500 kg, Chicken manure-

150 kg, DAP (Diammonium phosphate)- 3 kg, Urea- 10 kg and Gypsum- 20 kg

However, during unavailability of Triple super phosphate, Complexsal and Ammonium sulphate in the market, research on alternatives ingredients has been carried out. Based on recent research, modified Compost A containing Rice straw (Taichung)(1000 kg) + Urea (5 kg), Ammonium sulphate (20 kg) + TSP (10 Kg) + Agri lime (30 kg); modified Compost B containing Rice straw (Taichung) (1000 kg) + Urea (3 kg) + Ammonium sulphate (15.6 kg) + DAP(9.78 Kg) + Agri lime (30 kg) were developed ingredients. The research findings showed that compost A was the best one, which was followed by Compost B. Based on the research outcomes, Compost A and Compost B have been recommended to farmers for the better production of button mushroom.

Oyster mushroom (Kanye chyau) cultivation in Nepal

Plant Pathology Division (PPD) introduced cultivation technology of Oyster mushrooms in 1981. Then, PPD started research on different substrates, sterilization process and climatic conditions, etc. In 1984, developed technology for cultivation of Oyster mushroom was recommended to the farmers in Kathmandu valley. At that time, *Pleurotus sajor-caju* was found better strain of Oyster mushroom for cultivation purpose. Later, the technology was extended to Kavrepalanchowk, Chitwan, Nawalparasi, Bhairahawa, Pokhara, Nepalgunj, Dang, Dhankuta and Sunsari districts. Gradually, other strain of Oyster mushrooms (*Pleurotus florid, Pleurotus ostreatus)* were also brought into cultivation.Among these, *Pleurotus ostreatus* is getting popularity among the farmers. Different substrates for the cultivation of Oyster mushrooms are: Paddy Straw, Wheat straw, Paddy straw (75%) + Wheat straw (25%), Saw dust (90%) + Rice bran (10%), and Wood log of Uttish (*Alnus nepalensis*). Among these paddy straw has been popular among the farmers of Kathmandu valley especially Taichung variety of paddy straw for winter as well as the summer cultivation. Masino variety of rice straw is good only for winter season.

King's Oyster mushroom (*Pleurotus eryngii*) cultivation in Nepal

From last two years, the author has been doing research on King's Oyster mushroom and on different substrates such as saw dust (90%) + rice bran (10%), paddy straw alone and combination of paddy straw and other supplements (compost). Results showed that both substrates can give better yield. Moreover, research on various substrates is ongoing. Cultivation of this mushroom in Nepal is suitable at 15-18°C for mycelia growth and 20-22°C for fruiting.

Straw mushroom (Parale chyau) cultivation in Nepal

In 1981, scientists of the Plant Pathology Division introduced the cultivation technology of straw mushroom and conducted research on different substrates for its cultivation. Based on their research, paddy straw + gram powder was found the best substrate for the cultivation of straw mushroom. It is also found out that cultivation of straw mushroom can be done only in summer season in Kathmandu valley and Terai also. Because of favorable climatic conditions of Terai region, demand of straw mushrooms is increasing, but due to the improper marketing system, cultivation of straw mushrooms could not flourish satisfactorily.

Shiitake mushrooms (Mirge chyau) cultivation in Nepal

Shiitake mushroom cultivation was introduced in 1979/1980. Some cultivated substrates were developed from the Plant Pathology Division. They were wood logs of Uttis (*Alnus nepalensis*), Katus (*Quercus tricofolia*) etc. Because of the restriction on cutting of the trees, cultivation of these mushrooms could not flourish properly. Dr. Keshari Laxmi Manandhar did some research work on different species of the trees (Manandhar 2002).

Substrate for Shiitake mushrooms are Saw dust (90%) + Rice bran (10%), Wood logs are as follows: *Alnus nepalensis* (Uttis), *Castanopsis hystris* (Dhale Katus), *C. indica* (Musure Katus),

Betula alnoides (Saur), *Faxinus floribunda* (Lakure), *Engelhardtia spicata* (Mauwa), *Quercus tricofolia* (Banja) . *Alnus* and *Betula,* suitable substrates for Shiitake cultivation are easily available in many places.

As compared to previous decade, cultivation of these mushrooms has been increasing gradually. Cultivated areas for this mushroom are Illam, Taplejung, Dhankuta, Sankhuwasabha, Sindhuli, Ramechhap, Dolakha, Sindupalchowk, Kavrepalanchowk, Nuwakot, Kathmandu valley, Dhading, Nawalparasi, Kaski, Makawanpur, Myagdi, Baglung, Syangja, Palpa districts etc.

Cultivation of Red Mushroom (Rato chyau) in Nepal

In Nepal cultivation Technology of this mushroom was introduced by PPD/NARC in 2004. Identified substrate for cultivation of this mushroom are; Saw dust (90%)+ Ricebran (10%), Saw dust (72%) + Corn flour (20%) + Rice bran(7.5%) + Calcium carbonate (0.2%), Saw dust (76%) + Millet flour (12%) + Rice bran (12%), Saw dust (90%) + Wheat bran (10%). Among these supplements, Saw dust(90%) + Rice bran (10%) and Saw dust (72%) + Corn flour (20%) + Ricebran(7.5%) + Calcium carbonate (0.2%) are found better substrate for cultivation of Red Mushrooms. More recently, wood disc (6 x 6 inch) of Uttish (*Alnus nepalensis*) is found the best substrate for Ganoderma. Besides these, sawdust of *Alnus nepalensis* supplemented with gram flour also showed higher yield.

Cultivation of Jelly ear mushroom in Nepal

In 1998, Jelly Mushroom (*Auricularia auriculata*) was recommended for commercial cultivation. However, only few farmers in some areas of Kathmandu valley have cultivated these mushrooms.

Native edible mushroom species cultivation in Nepal

Plant Pathology Division has recently initiated the research on native mushrooms and has been collecting the specimens from different parts of the country. A number of edible mushrooms have been collected and identified based on the morphological structures. For commercialization, many species of edible mushrooms have been cultivated through tissue culture technology. They include different species of *Pleurotus*, *Ganoderma*, *Lentinula*, *Pholiota*, *Grifola*, etc.

Spawn Production in Nepal

Plant pathology Division was the only sole sector to distribute spawn to farmers' all over Nepal. Later, Plant Pathology Division provided training to the interested farmers regarding spawn production. In 1991, some privates companies started the production of mushroom spawn, Now, more than 20 private spawn growers are producing spawn throughout the country. Till 2013, it is estimated that about 4,50,000 packets of spawn were sold and produced about 2,000-2,500 metric tons of fresh mushroom, among which about 1,200 metric tons is from the Kathmandu valley.

Recommendations and Suggestions

In general, mushroom farming is done at small scale, but now farmers are being encouraged to cultivate mushrooms at commercial scale. In order to develop mushroom farming in commercial way, good quality spawn and enough technical support should be provided to the farmers. Distribution network should be made in such a way that it facilitates marketing of products and mushroom processing plants should be installed with the resource centre. There should be support from government organizations in order to regulate the spawn quality and mushroom quality and coordinate marketing with national international level for various purposes. Crop insurance policy should be developed and implemented in order to minimize the risks associated in mushroom farming. Insect and disease are also creating a lot of problem especially on *Pleurotus* sp. and Dry Bubble disease on Button mushroom which needs a lot of research to find solution.

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Present Scenario and Prospects of Mushroom Cultivation in Nepal

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Abstract

The existing natural resources and raw materials' availability, unemployed and under-employed people's workforce, a wide range of diverse but suitable physiographic and environmental conditions in Nepal favour and make by default an excellent milieu for the promotion and up-scaling of mushroom production in Nepal. Biodiversity of Nepal is also remarkable with wide variety of species of flora and fauna, which gives opportunity for production of numerous high value products including mushroom. Due to this rich diversity, the potential for mushroom production for both food and medicinal purpose is enormous. For health, nutrition as well as economic condition of Nepalese people certainly needs to be improved and those can be addressed through the establishment of sustainable and stable mushroom industries at various levels. Although mushroom is increasingly taken as one of the important cash generating agriculture businesses, it could not get smooth momentum. There is a lack of adequate technologies and technicians, institutionalized marketing network, economy of scale of high quality mushroom production and adequate infrastructures including financial support. Thus, from the view point of improving the mushroom production, its quality and marketing systems, a good common thrust is required to subdue all of the constraints and issues related to mushroom. Diversified and wide variation range of climate across the country has gifted an enormous number of species and varieties of mushroom naturally. However, resources endowed by the diversified nature have yet to be captured and utilized. This paper deals with the review of current status of mushroom farming, its potentials and prospects.

Introduction

A mushroom is the fleshy, spore-bearing fruiting body of a fungus, typically produced above ground on soil or on its food source and characterized by heterotrophic mode of nutrition. Mushrooms are utilized for their nutritive and medicinal values. In Nepal, in some places owing to various superstitions, misbelieves and low level of understanding, mushroom is considered as religiously impure and is given a relatively low priority in traditional Nepalese food. However, interestingly now-a-days there is a growing trend of consumption of mushroom because of its health related benefits such as having very low cholesterol, low calorie and delicious taste. Mushrooms are nutritionally functional food and a source of physiologically beneficial and nontoxic medicines (Wasser & Weis 1999). 'Soma' the divine drink is supposed to be obtained from the mushrooms. RigVeda says Apamiva bhavatu rakshasa sah, 9:85, which means with the help of 'soma' we may be free from diseases, and demons. Mushrooms find their place in traditional folk medicine throughout the world since ancient times. Farmers in increasing number are being attracted for its higher production as well, in proportionate with its increasing consumption and demand. Due to rich diversity, the potential for mushroom production for both food and medicinal purposes is immense. However, resources endowed by the diversity have yet to be captured and utilized. Several thousands of mushroom species known worldwide, only around 2 thousands are considered edible, of which about 20 are cultured commercially, with only 4 to 5 under industrial production. At present, Oyster and Button mushrooms are easily available in the market but in future shiitake mushroom will also appear in Nepalese market. From the trends of past years, the demand and consumption of mushroom is expected to continue increasing.

Oyster mushrooms are identified as being both economically viable and suited for local cultivation. Nepal Agriculture Research Council (NARC) and a few private organizations are the major resource centers for supplying quality spawn to the farmer/growers. These days commercial cultivation of mushroom in Nepal is increasing rapidly. Mushroom is gaining popularity in Kathmandu valley and other parts of the country. At present, it is estimated to be about more than 9,000-10,000 mushroom farmers in Kathmandu valley alone, mostly small farmers, producing 300-500 kg per day. They have been able to meet mushroom local demand to some extent so far. The average mushroom production is about 8-10 MT per day. Pokhara and Chitwan are other major mushroom producing districts. Other districts also produce these two species but in increasing amount, hardly enough to meet local demand (Poudel & Bajracharya 2011).

Mushroom has been being used by the people as food and medicine in Nepal since a very long period of time. Commercially cultivated five species of mushrooms are *Agaricus bisporus* (Lange) Imbach, *Pleurotus* spp., *Lentinus edodes* (Berk.) Pegler, *Volvariella volvacea* (Bull Fries) Singer and *Ganoderma lucidum* (Curtis) P. Karst. Mushroom farming has been identified as one of the profitable agro-business these days with an annual production of 1900 MT (according to Directorate of Industrial Entomology Development). By the end of the fiscal year 2072/73, the production of mushroom has been targeted to be 3200 MT. The financial analysis of fresh mushroom production indicated more than 50% of internal rate of return. Mushroom farming is popular in urban and peri-urban areas where it has high market demand and now being established as profitable micro-enterprise. This enterprise is getting popularity among farmers and agriculture scientists due to nutritional value, medicinal as well as other properties such as small scale investment less labour consuming, short crop duration and growing demand in the market. There is high demand of regular supply of mushroom in big hotels, restaurants and departmental stores. Attempts has been made by various governmental and non-government organizations through research, training, spawn distribution, awareness raising and other promotional programs till these days proved to chalk out mushroom farming as profitable agri-business in the urban and peri-urban areas with focus on women and resource poor growers. The wild mushroom varieties with medicinal properties are also becoming known locally as well as in abroad. There are some wild mushroom species of very high medicinal importance and very high value, which are exported to abroad, however, in very small scale, without any institutional structure. The commercial cultivation of those wild mushroom species of medicinal importance has yet to be explored (Wasser & Weis 1999).

Diversified and wide variation range of climate across the country has gifted a lot of varieties of mushrooms naturally (760 species) in Nepal and some (170 species) of them have been proven as edible mushrooms (Poudel & Bajracharya 2011).

History of mushroom cultivation in Nepal

The mushroom related research commenced in 1974 under Nepal Agriculture Research Council (NARC), and the cultivation of white button mushroom began in 1977 as well as Oyster mushroom in 1984 by farmers. Small researches for Shiitake and *Ganoderma* have been being done since 2001 by NARC as well as some private organizations. Shiitake and straw mushrooms have also been being produced successfully.

Spawn production and distribution at the beginning was done by NARC. However, presently spawn is being produced by governmental sectors and private organizations /companies as well.

Mushroom found in Nepal

A large number of species as well as varieties of mushroom are found in Nepal because of the great range of geographic elevation and diversity. Wild mushrooms are still remaining unexplored and only few are domesticated. All the mushroom species cultivated here are not native of Nepal. In one project out of 114 species of wild mushrooms collected, 25 species were found

poisonous (Manadhar 2005). In another, out of 174 species found in the forest in wild condition 110 were edible, 13 medicinal, 45 toxic, and6 others (Adhikari 2005).

Mushrooms in Nepal can be broadly classified as: a) Cultivated mushrooms, b) Wild mushrooms.

Cultivated mushrooms in Nepal

1. White button mushroom, Gobre chyau *(Agaricus bisporus)* in Hilly region,
2. Oyster Mushroom, Kanye chyau *(Pleurotus ostreatus)* in Hilly regions, Terai region in winter,
3. Shiitake, Mirge chyau (*Lentinula edodes*) in Midhills,
4. Straw mushroom, Parale chyau (*Volvorielle volvacea*) in Terai region,
5. Ganoderma, Rato chyau in (*Ganoderma lucidum*) in Hilly Region.

Wild mushrooms in Nepal

There are lots of (Provide number of species) species of wild mushrooms found in various areas of Nepal. Villagers consume wild mushroom, but the harvest of wild mushroom is in very less amount. Various species have been placed under medicinal plant by the department of forest (Poudel & Bajracharya 2011).

Some important wild mushrooms of very high commercial value are:

1. *Boletus edulis* (Cep, or Bolete)
2. *Cantharellus cibarius* (Chantharelle)
3. *Ophiocordyceps sinensis* (Yarsagumba in Nepali)
4. *Craterellus connucopiodes* (Horn of plenty)
5. *Ganoderma lucidum* (Ganoderma, Rato chyau)
6. *Morchella conica* (Morel)
7. *Morchella esculenta* (Morel)
8. *Tricholoma matsutake* (Matsutake)

Among these wild mushrooms of very high commercial value, *Ophiocordyceps sinensis* has become significant source of income for a lot of people in the hilly regions. Most of morels, which are not yet cultivated artificially, are collected in the forest of Nepal and are exported abroad. Recognizing the medicinal importance of *Ganoderma lucidum*, various organizations and private sectors have been in efforts to cultivate it. The cultivation of *Ganoderma lucidum* is yet to be done in commercial scale by the farmers (Poudel & Bajracharya 2011).

Places where mushroom farming is concentrated

Mushroom cultivation is mostly concentrated in urban and peri-urban areas around major city centers such as Kathmandu valley, Pokhara and Narayanghat. The consumption is also found to be more in these areas. According to farmers these areas have highest demand. Kathmandu valley is the largest producer as well as largest consumer. Up to 8-10 MT of mushroom is consumed in Kathmandu valley alone (Manandhar 2005).

The two species of mushroom, white button mushroom, i.e., Gobre chyau *(Agaricus bisporus)* and oyster mushroom, i.e., Kanye chyau *(Pleurotus ostreatus)* are produced in the valley during winter when temperature is low. During summer, which is off-season for the mushroom cultivation, farmers shift their cultivation to higher altitude in hills surrounding the valley.

Mushroom cultivation areas

The main areas, where mushroom cultivation is being done are:

District Areas

Kathmandu	**:**	Balambu, Kakani, Thankot, Gokarna, Sundarijal, Budhanilkantha, Sankhu
Lalitpur	**:**	Chapagaun, Lamatar, Lakuri Bhanjyang, Lele, Godawari
Bhaktapur	**:**	Sirutar, Balkot, Janagal
Kavre	**:**	Dhulikhel, Panauti, Nala
Chitwan	**:**	Padampur
Kaski	**:**	Pokhara

Farmers produce white button mushroom

and oyster mushroom in tunnels made of bamboo framework and cover by plastic and straw, producing about 300-400 kilograms in a season and 150-250 kilograms during an off-season. The farmers choose mushroom farming because of the good profit within a short period of time. According to farmers, they could make profit up to 4 times their investment in average. The reason for not trying shiitake is because of its long gestation period for harvesting. The farmers get almost same price around the year. The retail price is fixed by the dealer according to demand and availability. Farmers have to carry mushroom in their motorcycles or rent transport vehicle.

Potential areas

The most feasible areas for mushroom farming would be in hills surrounding the valley or any other areas near urban centers. Since the market is concentrated in these areas, farming would be most appropriate in these areas. Important factor to be considered are:

i. Since these areas are near to cities, market access will not be problem. Most areas also have motorable roads, which makes transportation easier.

ii. These areas though near cities, are agriculture dominated. The farmers too, due to vicinity to cities are more open to new technology for farming, which is essential for introduction of any new crop.

iii. The poverty level of these areas also needs to be addressed. Though they are near to cities, they have been constantly overlooked by any form of development.

iv. Areas around Kathmandu valley also have good climatic condition for mushroom farming.

Mushroom cultivation is also one of popular activities for women targeted development programs. Lots of women are producing mushroom from the local resources, i.e., agricultural by-products, straw at their own home in small amount, giving them opportunity to generate income. Hence, mushroom cultivation is one of the most potential income generating activities. With the remarkable diversity, Nepal has immense potential for cultivation of many kinds of mushroom, which can contribute to poverty reduction.

Mushroom farming by small farmers

Mushroom farming is increasingly becoming attractive to small farmers in urban and peri-urban areas including Kathmandu valley. In remote areas, mushroom consumed are mostly wild mushroom brought from forest. Since there is lack of scientific technique to test the poisonous nature of wild mushroom, every year many people die due to its consumption.

The reasons behind popularity of mushroom farming among small farmers are:

- It requires relatively less time to grow and harvest mushroom. White button mushroom can be harvested within 3 months and oyster mushroom can be harvested within 1 to 2 months with profits within short time. It can also be grown in off-season providing income to farmers round the year. Shiitake takes about 8 months to grow, which diverts farmers towards the cultivation of mushrooms with short gestation period and quick profit.
- This farming can be done with less investment. The farmers can decide to cultivate mushroom according to the amount they can invest. Agriculture by-products or other local resources, which are easy for farmers to obtain, are used in this farming.
- The farming is concentrated around urban centers or peri-urban areas because of transportation and market access. Storage and preservation technology is not much developed.
- With lack of good transportation network, access to market becomes a challenge. Because of this, mushroom farming appears to be concentrated in villages near to cities.

Spawn production

Around 450,000 bottles of mushroom seed (Spawn) are produced annually by different governmental and non-governmental organizations in Nepal. Spawns are produced through propagating spores as well as through tissue culture (Singh 2011).

Marketing of mushroom

There is an enormous (3 times) demand of mushroom in the domestic market of Nepal and there is no marketing problem for mushroom for the time being in Nepal. However, there is a need of a strong institutionalized marketing network.

Existing challenges

Although mushroom is increasingly taken as one of the important cash generating agriculture businesses, it could not get smooth momentum. There is a lack of adequate technologies and technicians, institutionalized marketing network, economy of scale of high quality mushroom production and adequate infrastructures including financial support.

In Nepal, due to diverse but suitable physiographic, environmental conditions, and biological diversity, wide variety of mushroom can be produced for income generation of farmers. However, currently there are various obstacles on its development. The challenges are as follows:

i. There has been a lesser amount of study and research by government sectors or other private organization. No policy is yet in place for mushroom farming.

ii. Due to lack of good transportation network, market access is a big challenge. Production of any kind of mushroom will first require development of road network. Also the market is mainly limited to urban centers only and is dominated by two kinds of mushroom only.

iii. Currently, two varieties White button mushroom or Gobre chyau *(Agaricus bisporus)* and Oyster Mushroom or Kanye chyau *(Pleurotus ostreatus)*, which are produced by farmers, fail to compete at international market. The other species, which can be exported, are yet to be produced at large scale.

iv. Many farmers have no confidence to start mushroom farming because they do not have skill, knowledge about investment, profits and loss that may be required in this farming.

v. There is also lack of awareness among consumers regarding the nutritional and medicinal value of mushroom. Due to this, there is a negligible demand of high value mushrooms, and hence there is no supply.

vi. There is also good opportunity for collaboration between community forest and mushroom farming. Shiitake for example, since it is produced in wood logs, can be good source of income for community forestry user groups.

vii. Technology transfer is also a challenging issue considering the literacy level of farmer and long history of dependency on traditional method. Moreover, very less researchers are involved in this, making technology transfer a more difficult job.

viii. The mushroom export has not gained much interest from businessmen either.

Enhancing mushroom cultivation

It is important to incorporate JUNCAO technology

* JUNCAO technology refers to integrated techniques that use JUNCAO to cultivate edible and medicinal fungi, as well as produce myco-protein forage and fertilizer. JUNCAO industry is formed by the utilization of JUNCAO technology and other interrelated techniques.

  It is indispensable to

  - prepare skillful technicians and a cadre of workforce for mushroom cultivation.
  - facilitate for the spawn production.
  - build up adequate infrastructures, development units, marketing centres.
  - provide subsidies in transportation, spawns and and laboratory facilities.
  - increase peoples' awareness on nutritional value of cultivated mushroom and reduce the poisoning risk of uncultivated mushrooms in urban and peri-urban areas
  - strengthen and leverage mushroom value chain
  - share experience and scale up mushroom enterprise among neighboring countries

for mutual benefit and well-being of the region

- conserve and elicit benefit from valuable edible wild mushrooms of Nepal and neighboring countries.

Conclusions

- The existing natural resources and raw materials' availability, unemployed and under-employed people's workforce, variegated but suitable physiographic and environmental conditions in Nepal favour and make by default an excellent milieu for the promotion and up-scaling of mushroom production in Nepal.
- For Health, nutrition as well as economic condition of Nepalese people certainly needs to be improved and those can be addressed through the establishment of sustainable and stable mushroom industries at various levels.
- Thus, from the view point of improving the mushroom production, its quality and marketing systems, a good common thrust is required to subdue all of the constraints and issues related to mushroom.
- The overall objective of the mushroom production should be to commercialize it as industries and increase income of the entrepreneurs thereby increasing their standard of living and reduce national poverty.
- The specific objectives should be as follows:
  - Increase production and quality of mushroom;
  - Establish well equipped quality testing accredited laboratory;
  - Provide employment to rural farmers.

Mushroom farming can be good opportunity for farmers to earn decent income. So far farmers have found it to be profitable, requiring less investment. With more research, there is possibility to produce numerous high value mushrooms, from which local people can be benefited economically. The main challenge lies in carrying out thorough research. The few private agencies involved and government sector are toether required to give much importance to this area with concrete action plans. There is however growing optimism among farmers to try and grow new varieties. They however need assurance that they will not have to bear loss.

There is also need to promote marketing of mushroom along with production. The consumers should be made aware about different kinds of mushroom, their nutritional and medicinal values to create further demand of mushroom. Moreover, the farmers need to have easier access to loan at reasonable rate of interest. With subsidies, farmers may be encouraged to take risks too. With Nepal's successful community forestry, Community Forest User Groups can utilize the forest resources and take forestry and mushroom farming together, which can be a way for the species of wild mushroom that cannot be cultivated.

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Grass Based Mushroom Production Technology

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Abstract

Grass based mushroom production technology is a technology in which fresh as well as dry grass powder with wheat / rice /maize bran in the appropriate combination is used as a substrate to grow the mushroom. The healthy mycelium that is grown in the grass substrate gives a fruiting body at the definite environmental condition. Experiment has shown that the mushroom that is grown in this substrate is much more nutritious rather than grown in conventional substrate. Because of abundant and easily availability of different grasses in rainy season the technology will be cost effective, sustainable and environmental friendly in Nepal. The conventional technology is rather straw based labor consuming and competent with animal feed. Even though the traditional technology is adopting quite a long time but it has not developed as big industry in Nepal. This will be the good pathway to industrialize mushroom production in Nepal.

Key words: Fruiting, Sterilization, Inoculation, JUNCAO Technology

Introduction

Mushroom is a higher class fungus which is chlorophyll less and rich in nutrient that serves as almost balance diet for human being. Mushrooms with other fungi are something special in the living world, being neither plants nor animals. They have been placed in a kingdom of their own called the kingdom of Myceteae. Like in the other countries, its production technology is being popular day by day in Nepal as well. Mushroom production is nowadays being emerging business across the country. It is a short return agricultural business and can be of immediate benefit to the community. It will provide the people with an additional vegetable of high quality, and enrich the diet with high quality proteins, minerals and vitamins which can be of direct benefit to the human health and fitness. The extractable bioactive compounds from medicinal mushrooms would enhance human's immune systems and improve their quality of life (Chang 2004). Mushroom cultivation has great scope in Nepal because of the cheap and easily available raw materials needed for this activity.

Substrates for mushroom

The species grown in Nepal are *Agaricus bisporus, Pleurotus ostreatus, Volvariella volvacea*. In small amount *Lentinula edodes Ganoderma* are also grown. Up to now Nepal is practicing *Agaricus bisporus, Pleurotus* species and *Volvariella volvacea* in rice straw and *Lentinula edodes*, and *Ganoderma* sp. either in wood log or saw dust.

The widely used substrate that is used in Nepal is rice straw which is scarce in the mushroom production site and also using as the main constituent of animal feed. There is thinking that, the use of rice straw in Nepalese community is animal feed but substrate for mushroom is its alternative use. Mushroom business is an emerging business but it has to compete with animal husbandry. To overcome such a problem use of grasses for mushroom production instead of straw and wood log will be the best way forward for the future. Because of abundant availability of seasonal grass, easiness of technology, sustainability and environmental friendly, introduction of grass based mushroom production technology is the best way in future for mushroom farmers.

What is grass based mushroom production technology?

This is the technology in which grinded grass powder (fresh as well as dry) is used as a

substrate to grow edible/medicinal mushroom instead of using wood log and straw. In this technology, a series of comprehensive techniques for cultivation are involved. In China, this technology is called JUNCAO Technology (Lin 2000).

Invention of technology:

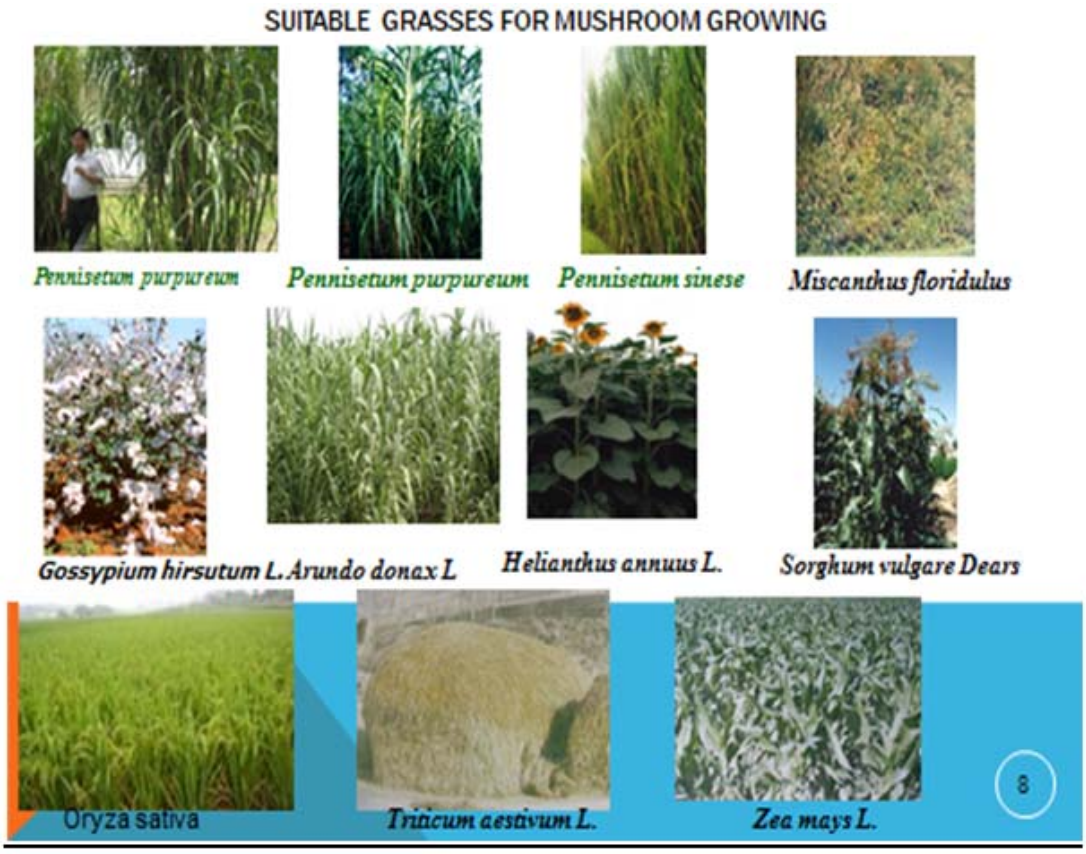
- The concept of grass based technology was innovated in 1980 in China and disseminated to all over the World.
- According to the experience of China this technology is considered as new way in resolving the word-wide problem of unemployment, poverty, food security and environment protection.
- Nepal has great potentiality of this technology to incorporate in our cultivation system.
- China has already set up JUNCAO technology in Japan, Papua New Guinea, South Africa, Rwanda, Malaysia and Fiji.
- In China this technology has been used as a tool for the poverty alleviation in their Ningxia and Tibet provinces.
- This technology is quite new in Nepal but it can be adopted and disseminated

Some of the common edible and medicinal mushroom that can be grown in grass based substrate:

S. N.	Mushroom Species	Use
1.	*Agrocybe cylindracea*	Edible
2.	*Auricularia auricula*	Edible and Medicinal
3.	*Auricularia polytricha*	Edible
4.	*Flammulina velutipes*	Edible
5.	*Lentinula edodes*	Edible and Medicinal
6.	*Poria cocos*	Medicinal
7	*Agaricus bisporus*	Edible and Medicinal
8	*Ganoderma* sp.	Medicinal
9	*Volvariella volvacea*	Edible
10.	*Tremella fuciformis*	Edible and Medicinal
11.	*Pleurotus ostreatus*	Edible and Medicinal
13.	*Pleurotus ferulae*	Edible
14.	*Pleurotus nebrodensis*	Edible
15.	*Pleurotus eryngii*	Edible
16.	*Pholiota nameko*	Edible
17.	*Hericium erinaceus*	Edibled Medicinal
18.	*Pleurotus* spp.	Edible
19.	*Tremella aurantialba*	Edible and Medicinal
20.	*Hypsizigus marmoreus*	Edible

21.	*Pleurotus citrinopileatus*	Edible
22.	*Dictyophora* spp.	Edible
23.	*Armillaria mellea*	Medicinal and Edible
24.	*Grifola frondosa*	Edible and Medicinal
25.	*Agaricus blazei*	Edible and Medicinal
26.	*Coprinus comatus*	Edible and Medicinal
27.	*Cordyceps militaris*	Medicinal and Edible
28.	*Ophiocordyceps sinensis*	Medicinal
29.	*Gloeostereum incarnatum*	Edible and Medicinal
30.	*Trametes versicolor*	Medicinal

Brief cultivation process of mushrooms in grass substrate



Preparation of Substrate

- The fresh or dry grass is grinded in the form of powder with the machine. If the grass is fresh there may be excess moisture but it should be maintained within the range of 60-70%.

- The grass powder is filled tightly in small poly bags.
- Arrange these bags in the tray.

Sterilization of Bags

- Cover the bags with a thick polyethylene and insert steam inside
- Kept it for about 24 hours with in appropriate temperature

Inoculation of fungus:

- The sterilized bags are inoculated inside the Laminar Bench
- Keeps the bags in the incubation room for mycelium growth

Fruiting

- The bags with well grown mycelium are stacked and kept for fruiting. The fruiting environment may be different according to the species

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नेपालमा च्याउ खेतीको वर्तमान स्थिति

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सारांश

नेपालमा व्यावसायिक रुपमा च्याउ खेतीको थालनी भएको करीब ४ दशक बितिसक्दा पनि अपेक्षित रुपमा यसको विकास र विस्तार हुन सकेको छैन । राज्यको प्राथमिकता सूचिबाट च्याउ खेती बाहिर रहनु, यसको विकास र विस्तारको लागि आवश्यक नीति नबन्नु, देशमा च्याउ खेती प्रविधिको अध्ययन र अनुसन्धान कम हुनु, च्याउमा प्राविधिक दक्ष जनशक्तिको कमी आदि यसका केही प्रमुख कारणहरु हुन् । यिनै कारणहरुले गर्दा शायद विगतमा खुलेका केही ठूला च्याउ उद्योगहरु (स्नो ह्वाइट मसरुम, हिमालयन हेल्थ फुड, हिमालय मसरुम सोसायटी) छोटो समयभित्र बन्द हुन पुगे । अहिले मुलुकमा कृषकस्तरमा मात्र च्याउ उत्पादन भईरहेका छन् । च्याउ खेती कृषकको मुख्य पेशा बन्न सकेको छैन् । वर्ष भरिमा केही समय मात्र च्याउ खेती गर्दछन् र बाँकी समय अन्य पेशा अँगाल्नु पर्ने बाध्यता छ । च्याउ विज्ञान एउटा बृहत क्षेत्र भएको हुनाले यसको अध्ययन, अनुसन्धान र विकासको लागि स्तरीय प्रयोगशालासहितको राष्ट्रिय स्तरमा छुट्टै निकायको स्थापना हुनु पर्दछ । यसले अध्ययन र अनुसन्धानबाट विकास गरिएको प्रविधि समय समयमा गोष्ठी, कार्यशाला, प्रशिक्षक तालिम आदिको माध्यमबाट मुलुकमा आवश्यक दक्ष प्राविधिक तयार गर्दछ जसले च्याउ व्यवसायलाई उचित तरीकाले संचालन र व्यवस्थापन गर्न मदत गर्दछ । यसरी दक्ष प्रशिक्षकको माध्यमबाट उत्पादक वा कृषकसम्म प्रविधि सही तरीकाले पुऱ्याउन सकिन्छ ।

पृष्ठभूमी

नेपालमा २०३१ सालमा नेपाल कृषि अनुसन्धान परिषद्, खुमलटारबाट गोब्रे च्याउ खेतीको अनुसन्धान सुरु गरी २०३७ साल देखि किसानहरुलाई तालिम दिई च्याउ खेती सुरु भएको हो । त्यस्तै कन्ये च्याउको खेती पनि २०३७ सालदेखि नै अनुसन्धान तथा खेती गर्न सुरु गरेका थिए (Singh 2007, Raut 2013) । त्यस बेला काठमाण्डौंको बलम्बु लगायत नेपालका धेरै जिल्लाहरुमा खेती भएको थियो । तर बलम्बुका किसानहरुको निरन्तर प्रयासबाट च्याउ खेतीको विकास आजको स्थिति सम्म आई पुगेको हो । किनभने अरु जिल्लाका किसानहरु त्यसबेला सफल हुन नसकि निरुत्साहित भएका थिए । पछि बलम्बुबाट च्याउ उत्पादन भएको देखेर अन्य जिल्लाका किसानहरु पनि प्रभावित भई हाल नेपालका धेरै जिल्लाहरुमा च्याउ खेतीको विकास हुँदै गएको हो । सुरुमा नार्कबाट च्याउका बीउ विजनहरु विक्री वितरण भएको थियो । पछि विस्तारै निजी क्षेत्रबाट वीउ उत्पादन हुन थाल्यो । अहिले सबै वीउहरु निजी स्तरबाट उत्पादन भइरहेको छ । च्याउ खेती प्रणाली पहिले भन्दा केही सुधार भए पनि त्यति राम्रो तथा व्यवस्थित हुन सकेको छैन । त्यस्तै च्याउको माग राम्रो भए पनि बजार व्यवस्थित हुन सकेको छैन । हाल च्याउ खेतीमा शिक्षित युवाहरु धेरै आकर्षित भइरहेको छ । तर परम्परागत प्रणालीमै खेती भइरहेकोले तिनीहरु

सबैले यसलाइ निरन्तरता दिन सकेको छैन। त्यसैले नेपाल सरकारले च्याउ खेतीको आधुनिक प्रविधि विकास गर्न तालिम तथा अनुसन्धानको राम्रो व्यवस्था गर्नु पर्ने देखिन्छ। यसरी व्यवस्थित बजार, पोष्ट हार्भेष्ट प्रणालीको विकास आदि गर्न सके च्याउ निर्यात सम्म गरी देशको समग्र आर्थिक विकासमा उलेख्यनीय योगदान पुऱ्याउन सकिन्छ।

नेपालमा खेती हुने च्याउ

क्र.सं.	च्याउको प्रकार	उत्पादन	मूल्य
१.	कन्ये च्याउ	२१,९०,०००	२१,९०,००,०००।-
२.	गोब्रे च्याउ	३,६५,०००	७,३०,००,०००।-
३.	सिताके च्याउ		
४.	रातो च्याउ		

च्याउ तथा च्याउ खेतीको महत्व

भनिन्छ, १९औं शताब्दीमा मानिसहरु खानकोलागि मात्र उत्पादन (कृषि) गरिन्थ्यो। तर पछि २०औं शताब्दीतिर आई पुगदा खानकोलागि मात्रनभइकन मिठो स्वादकोलागि राम्रो मिठो अन्न तथा तरकारीहरु उत्पादन गर्थे र अहिले २१औं शताब्दीमा आई पुगदा उपभोक्ताहरुले पौष्टिक तथा गुणस्तरीय खाना खोज्न थालेका छन्। च्याउ अत्यन्तै स्वस्थ्य र पोषिलो खाद्यपदार्थको रुपमा सर्वत्र मान्यता पाइसकेको छ। खेती गरिएका च्याउमा प्रोटिनको मात्रा १.७५-५.९ प्रतिशत (ताजा तौलको आधार मा) पाईएको छ। सामान्य रुपमा यसको औसतमान ३.५-४.० प्रतिशत रहेको अनुमान छ जुन प्याज (१.४ प्रतिशत) र बन्दागोभी (१.४ प्रतिशत) को दुई गुणा बढी, सुन्तला (१.० प्रतिशत) को चार गुणा बढी र स्याउ (०.३ प्रतिशत) को बाह्र गुणा बढी रहेको छ। सामान्यतया: सुँगुरको मासुमा ९-१६, कुखराको मासुमा १८-२०, माछामा १८-२० र दूधमा २.९-३.३ प्रतिशत प्रोटिनको मात्रा रहेको हुन्छ। सुखा तौलको आधारमा च्याउमा प्रोटिनको मात्रा सामान्यतया: १९-३५ प्रतिशत रहेको हुन्छ जबकि चामलमा ७.३, गँहुमा १२.७, भटमासमा ३८.१ र मकैमा ९.४ प्रतिशत पाइन्छ। यसरी च्याउमा प्रोटिनको मात्रा माछामासु भन्दा कम र प्राय: दूधसहित अरु खाद्य वस्तुभन्दा बढी पाइएको छ। यसमा हरेक प्रकारका भिटामिनहरु जस्तै भिटामिन बी. (Thiamine, Riboflavin, Niacin, Folic acid, Vitamin B_{12}) का साथै भिटामिन D पनि पाइन्छ। त्यस्तै हाम्रो शरिरलाई आवश्यक खनिज तत्त्वहरुमा फस्फोरस, सोडीयम, आइरन, पोटासियमका साथै अन्य खनिज तत्त्वहरु प्रशस्त मात्रामा पाइन्छ र यो सजिलैसँग पचाउन पनि सकिन्छ (Raut 2013)।

च्याउ खेतीको अर्को महत्त्व भनेको खेर जाने कृषि उपजहरुको प्रयोग हो। प्राय च्याउ परालमा उत्पादन हुने भएकोले धान उत्पादन गर्ने किसानहरुले सितैमा खेरजाने परालको पनि मूल्य पाउछ। हाल नेपालमा पाइने परालको जम्मा ५-६ प्रतिशत पराल मात्र च्याउ खेतीमा प्रयोग भएको पाइन्छ। त्यस्तै अर्को खेर जाने गहुँको छ्वाली पनि च्याउ खेतीमा प्रयोग गर्न सकिन्छ। यस प्रकार च्याउको लागि आवश्यक प्रमुख कच्चा पदार्थ नेपालमा प्रशस्त मात्रामा पाइने भएकोले च्याउ खेतीको सम्भावना धेरै छ।

नेपालका यूवाहरु विदेशिने क्रम बढेको बेलामा च्याउ खेतीको प्रवर्द्धन तथा विकास गर्न सके स्वदेशमै प्रचुरमात्रामा रोजगार सृजना गर्न सकिन्छ । हाल च्याउ खेतीमा ५ हजार भन्दा बढी रोजगार भएको अनुमान छ र च्याउ खेतीको अर्को महत्त्वपूर्ण पक्ष आय पनि हो । यसमा अन्य व्यवसायको तुलनामा थोरै लगानी गरेर मनग्य आम्दानी गर्न सकिन्छ ।

वर्तमान स्थिति

नेपालमा हाल परम्परागत प्रविधिबाट खेती भईरहेको छ जुन अन्य मुलुका किसानहरुले धेरै पहिले गरिन्थ्यो । प्रविधी विकास नहुँदा व्यवस्थित टहरा वा बिल्डीङ्ग प्रणालीमा जान सकेको छैन । उपयुक्त पाश्चराइजेशन प्रविधिमा हामी जान सकेका छैनौं जसले गर्दा खेतीमा रोग लागेर धेरै नोक्सान हुने गरेका छन् । मौसम, भौगोलिक स्थिति अनुसारको खेतीलाई नेपालमा विस्तार गर्न सकेको छैन । जसले गर्दा एकै ठाउँमा एकै प्रजातिका च्याउ मात्र लगाउनु पर्ने स्थिति छ । नयाँ प्रजातिका च्याउहरु, मौसम र भौगोलिक स्थिति अनुसार लगाउन सके निरन्तर च्याउ उत्पादन गर्न सकिन्थ्यो । प्लास्टिक र परालको टहरामा खेती हुँदा मौसम अनुसार उत्पादनमा बृद्धि तथा कमि हुने भएकोले धेरै उत्पादन हुँदा बजारमा सस्तोमा च्याउ बिक्री गर्नु पर्ने बाध्यताको सृजना हुन्छ । उत्पादित च्याउको उचित मुल्य नपाउने अवस्थामा कृषकहरुले उपयुक्त पोष्ट हार्भेष्ट प्रविधि पाउन सकेको छैन ।

बीउ

नेपालमा प्रयाप्त मात्रामा गुणस्तरिय बीउ उत्पादन भईरहेको छैन । जसले गर्दाखेरि समय समयमा बीउको कारण खेतीमा संक्रमण भइरहेको पाइन्छ । प्राय गोब्रे च्याउको बीउ प्रयाप्त मात्रामा नपाएको गुनासो किसानहरुबाट पटक पटक आइरहेका छन् । अहिलसम्म पनि च्याउका कल्चरहरु बाहिरबाट ल्याउनु पर्ने बाध्यता छ । प्राय बीउ उत्पादकहरुले भारतबाट कल्चर ल्याएर बीउ उत्पादन गरिरहेका छन् । यसरी ल्याएको कल्चरलाई पनि राम्रोसँग लामो समयसम्म भण्डार गर्ने प्रविधि छैन । त्यसैले बीउको गुणस्तर कायम गर्न सकेको छैन ।

कच्चा पदार्थ

अन्य खेतीमा जस्तै च्याउ खेतीको लागि चाहिने आवश्यक सामाग्रीहरु पनि धेरै महँगो हुँदै गईरहेको छ । पराल धेरै टाढाबाट ल्याउनु पर्ने भएकाले काठमाडौं उपत्यकामा परालको मूल्य बढेको छ । च्याउ खेतीलाई आवश्यक रासायनिक मल तथा कृषि चुन लगायत किटनाशक विषादि, ढुसी नाशक विषादिहरु गुणस्तरीय नहुनुको साथै महँगो हुँदै गईरहेको छ । त्यस्तै प्लास्टिक, स्प्रे मेसिनहरु तथा बीउ पनि दिन प्रतिदिन महँगो हुँदै गईरहेकोले लगानीमा धेरै बृद्धि भएको छ ।

खेती गर्ने स्थल

च्याउ खेती प्लास्टिक, बाँस र परालबाट निर्मित टहराभित्र गर्ने भएकोले भुइ सहित टहरा दुषित हुँदै जाने र एकै स्थानमा खेती गरिरहँदा च्याउ बिग्रने सम्भावना धेरै बढी हुन्छ । त्यसैले प्रत्येक वर्ष जस्तो ठाउँ परिवर्तन गरिरहनु पर्ने बाध्यता छ । त्यसरी ठाउँ परिवर्तन गर्दै जाँदा पनि पुरै एरिया संक्रमण हुँदैजाने भएकोले हाल बलम्बु एरियामा उत्पादनमै कमि आएको महशुस गर्न थालिएको छ । त्यस्तै काठमाडौं लगायत शहरी क्षेत्रमा वस्ती बढ्दै गईरहेकोले च्याउ खेतीको लागि आवश्यक खुल्ला जग्गा कम हुँदै गइरहेको छ ।

बजार

मौसम अनुसार च्याउ उत्पादनमा कमी तथा बढी हुने भएकोले बजार मूल्यमा स्थिरता आउन सकेको छैन । उत्पादन कमि भयो भने उपभोक्ताले खरिद गर्न नसक्ने मूल्य लगाई दिन्छ व्यापारीहरुले ।

त्यस्तै मागभन्दा बढी उत्पादन भयो भने किसानलाई नोक्सानी हुने मूल्यमा च्याउ बेच्नु पर्ने बाध्यता छ । यसरी किसानहरुले मूल्य नपाउँदा च्याउमा बढी पानी हाल्ने काम पनि केही किसानहरुले गरेको पाइन्छ जसले गर्दा च्याउको गुणस्तरमा कमि हुन सक्ने सम्भावना बढेको छ। च्याउसम्बन्धी आवश्यक जनचेतना तथा प्रचार-प्रसारको कमिले गर्दा पनि प्रयाप्त मात्रामा बजार विस्तार हुन सकेकौ छैन । काठमाडौं बाहेक अन्य जिल्लामा च्याउको खपत निकै कम रहेको पाइन्छ ।

राज्यका च्याउ विज्ञ, प्राविधिक र किसानहरुको सम्बन्ध

राज्यको अन्य क्षेत्रमा जस्तो च्याउमा त्यति लगानी तथा कार्यक्रमहरु रहेको देखिँदैन । च्याउ विज्ञ, र प्राविधिकको अभावले कृषकहरुमाझ नयाँ सरल तथा उन्नत प्रविधि पुग्न सकेको छैन । राज्यले कृषकहरुकोलागि आवश्यक तालिम तथा उचित प्राविधिक सेवाको व्यवस्था गर्न सकेको छैन। कृषि कार्यालयहरुमा पनि छुटै च्याउ विज्ञ वा प्राविधिकको व्यवस्था भएको पाइँदैन ।

निजि क्षेत्रको योगदान

नेपालमा च्याउ खेतीको विकास र विस्तारमा निजीक्षेत्रको भुमिका अग्रणी रहेको छ । विभिन्न समस्याहरुको वावजुद पनि उत्पादकहरुले आफ्नो निजी प्रयास र लगानीमा देश वा विदेशबाट समेत तालिम प्राप्त गरी निरन्तर रुपमा च्याउ खेतीलाई अगाडी बढाइरहेका छन् । किसानहरुकै प्रयासबाट च्याउको प्रचार-प्रसार तथा बजारसमेत विस्तार हुँदै अहिलेको अवस्थामा पुगेको हो । किसान तथा च्याउ व्यवसायीहरु अझै स्वअध्ययन तथा अनुसन्धानमा पनि लागिरहेका छन्। च्याउको बीउ उत्पादनमा निजी क्षेत्रले ठूलो भूमिका खेलेको छ। यसले कुल उत्पादनको ८५ प्रतिशत भाग ओगटेको छ ।

यसरी किसान आफ्नो अनुभव, स्वअध्ययन तथा देश विदेशबाट तालिमहरु प्राप्त गरी निरन्तर रुपमा च्याउ उत्पादन गर्न सफल भइहेका छन् । जसले गर्दा बजारमा कुनै पनि दिन प्रयाप्त मात्रामा नभएपनि आपूर्ति भने गरिरहेका छन् । अर्कोतिर यसले निरन्तररुपमा रोजगारीको पनि बृद्धि भइरहेको छ । त्यति मात्र नभई निरन्तर रुपमा नेपाल भरिका किसानहरुलाई बलम्बु च्याउ सहकारी लगायत अन्य निजी संघ/संस्थाहरुले आवश्यक परामर्श तथा तालिमहरु पनि सञ्चालन गरिहेका छन्। काठमाडौंको बलम्बु गाविस नेपालको सबैभन्दा बढी च्याउखेती हुने स्थान हो। बलम्बुलाई 'च्याउ हब' का रूपमा पनि लिइन्छ (Raut 2013)।

च्याउ विकासका लागि बलम्बुले गरेका कार्य र योजना

क. च्याउ सहकारीको स्थापना

ख. च्याउ अध्ययन तथा तालिम केन्द्रको स्थापना

ग. च्याउ सम्बन्धी पुस्तकालयको स्थापना

घ. च्याउ खेती सामाग्रीसम्बन्धी सुपथ मुल्य पसल संचालन

ङ. च्याउ खेतीमा लगानी

च. च्याउ खेतीसम्बन्धी परामर्श तथा अवलोकनको व्यवस्था ।

च्याउ उद्योगको विकासकोलागि गर्नु पर्ने कार्यहरु

च्याउ खेती प्रणालीलाई व्यावसायिकरण गर्न अत्यन्त जरुरी भइसकेको छ। यसकोलागि वर्तमान खेती प्रणालीलाई आधुनिकीकरण गर्नु पर्ने आवश्यक छ। खेती प्रणालीको आधुनिकीकरण सँगै गुणस्तरीय कल्चर विकास गर्ने, नयाँ प्रजातीको खेती विकास गर्नु पर्ने जरुरी छ। त्यस्तै किसानहरुलाई संगठित गरी, सहकार्य र समन्वयको संस्कृतिको

विकासकोलागि पहल गर्नु पर्दछ। कृषकहरुको समय समयमा देश तथा विदेशमा भएका आधुनिक च्याउ फार्महरुको भ्रमणको व्यवस्था मिलाउनु पर्दछ । अध्ययन, अनुसन्धान र विकासकोलागि स्तरीय प्रयोगशालासहितको राष्ट्रिय स्तरमा छुट्टै निकायको स्थापना हुनु पर्दछ। यसले अध्ययन र अनुसन्धानबाट विकास गरिएको प्रविधि समय समयमा गोष्ठी, कार्यशाला, प्रशिक्षक तालिम आदिको माध्यमबाट मुलुकमा आवश्यक दक्ष प्राविधिक तयार गर्दछ जसले च्याउ व्यवसायलाई उचित तरीकाले सञ्चालन र व्यवस्थापन गर्न मद्दत गर्दछ। यसरी दक्ष प्रशिक्षकको माध्यमबाट उत्पादक वा कृषकसम्म प्रविधि सही तरीकाले पुऱ्याउन सकिन्छ। उत्पादनको सहज बजारीकरणको लागि राम्रो बजार सञ्जालको व्यवस्था मिलाउनु पर्दछ साथै गुणस्तर नियन्त्रण र प्रमाणीकरणकोलागि पनि उचित व्यवस्था हुनु पर्दछ । च्याउको विविध पक्षबारे स्थानीय तथा राष्ट्रिय सञ्चार माध्यमहरुबाट जनतामा चेतना अभिबृद्धि गर्ने कार्यक्रमहरु नियमित रुपमा प्रकाशन तथा प्रसारण गर्नु पर्ने आवश्यकता देखिन्छ ।

सन्दर्भ सूची

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Raut, J.K. 2013. "*Adhunik Chyau Kheti Prabidhi*" (=Modern Mushroom Cultivation Technology) 1st ed. Heritage Publisher and Distributor Pvt. Ltd. Kathmandu, Nepal.

Singh, S.C. 2007. Status of mushroom cultivation in Nepal with reference to world production and consumption trends. In: *Mycological Research and Mushroom production in Nepal* (Eds. Singh S.C., M.K. Adhikari & R.D. Tiwari). The Mycological and Phytopathological Society, Nepal (MAPSON).

Annex-I

Recommendations

Substantial discourses among the mushroom experts, entrepreneurs, growers, collectors, consumers & other active participants during the seminar following recommendations are made here for the mitigation of mushroom poisoning incidences as well as gross development of mushroom industry in the country.

- To overcome the fear of poisoning and to standardize the product for national and international marketing, a separate unit for quality control and certification should be established.
- Regional toxicology/poison centers should be established which would also impart public education on dangers of wild mushroom consumption
- Physicians and other health workers should be trained for the effective management of different types of mushroom poisoning. An appropriate protocol for each type should be launched to hospitals or poison centers.
- Local experts of mushrooms are identified, examined and provided a license. Later, they can issue certificates of valid identification of wild mushrooms for sale.
- Nationwide extensive various types of public awareness programs about both hazards & benefits of mushroom should be conducted. Miking, postering, street theatre, mushroom exhibition, etc., about hazards of mushroom poisoning at the beginning of the rainy season might be more effective.
- Mushrooms from each part of country should be extensively explored and documented
- Adequate mushroom courses should be included in school & university curriculum
- For the innovative research & development of mushroom based on local needs, a separate unit at national level with well equipped laboratory and human resources should be established that produce technical manpower to operate and manage the mushroom farming venture by periodically organizing seminars, workshops and trainers training on mushroom. In this way technology can be properly and perfectly extended to villagers or growers.
- All kinds of technical advices/services on mushroom and fresh spawn should be timely available to all needy peoples
- Well organized market channels should be established that facilitates the marketing of products.
- To promote the domestic mushroom production crop insurance policy should be easily available to each grower for potential risk management in mushroom farming.

Annex-II

Program of the Seminar

Seminar on

Mushroom Consumption and Poisoning Risk

Tuesday, 30th Poush, 2070 (14th Jan, 2014)

NAST Auditorium Hall, Khumaltar, Lalitpur

Program Schedule

Registration : 9:30 am - 10:30 am

Inaugural Session : 10:30 am - 11:30 am

Master of Ceremony : Mr. Pawan Kumar Neupane

Inaugural Session

10:30	Welcome speech	:	Mr. Iswor Prasad Khanal, Chief, Faculty of Science, NAST
10:40	Remarks	:	Dr. Mahesh Kumar Adhikari, Senior Mycologist
10:50	Remarks	:	Dr. Keshari Laxmi Manandhar, Senior Mycologist
11:00	Remarks	:	Prof. Dr. Prakash Chandra Adhikari, Secretary, NAST
11:10	Remarks	:	Prof. Dr. Surendra Raj Kafle, Vice Chancellor, NAST
11:20	Vote of thanks	:	Dr. Jay Kant Raut, Senior Scientific Officer, NAST

Refreshment : 11:30 am - 12:00 pm

Technical Session

(12:00 pm – 16:10 pm)

Chair Person : **Dr. Budhi Ratna Khadge**

Rapporteurs : Ms. Neel Kamal Koju, Mr. Om Basukala

Presentation & Discussion

Session I : 12:00 pm - 13:15 pm

12:00 – 12:25 **Problems and prospects of mushroom cultivation**
Mr. Jagdish Bhakta Shrestha, Directorate of Industrial Entomology Development

12:25 - 12:50 **An overview of mushroom poisoning in Nepal**
Dr. Jay Kant Raut, Senior Scientific Officer, NAST

12:50 – 13:15 **Poisonous mushrooms of Nepal**
Dr. Mahesh Kumar Adhikari, Former Director General, DPR

Lunch Break: 13:15 pm - 14:15 pm

Presentation & Discussion

Session II : 14:15 pm -16:10 pm

14:15 – 14:40 **Mushroom research in Nepal**
Mr. Gopal Prasad Parajuli, Plant Pathology Division, NARC

14:40 - 15:05 **Cultivation of Oyster mushroom: A sustainable approach of rural development in Nepal**
Dr. **Chandra Prasad Pokharel,** CDB, T.U

15:05 – 15:30 **Appropriate substrate for mushroom production**
Mr. Padam Devkota, MoSTE

15:30 – 15:55 **Current trends of mushroom production & consumption in Nepal**
Mr. Dharmendra Maharjan, Balambu Mushroom Cooperative Pvt. Ltd.

Concluding Remarks: 15:55 pm – 16:10 pm

Annex-III

Committees for the Seminar

Organizing Committee

Prof. Dr. Prakash Chandra Adhikari, **Chairperson**

Mr. Iswor Prasad Khanal, **Member**

Dr. Anjana Giri, Member, **Member**

Mr. Hari Bahadur Bhandari, **Member**

Dr. Jay Kant Raut, **Member -Secretary**

Technical Committee

Dr. Jay Kant Raut- **Coordinator**

Dr. Mahesh Kumar Adhikari -**Member**

Dr. Lok Ranjan Bhatt- **Member**

Ms. Prabina Rana- **Member**

Annex-IV

Glimpses of the Seminar