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Exotic Mushroom Cultivation in Alberta

Workshop Report

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EXOTIC MUSHROOM CULTIVATION IN ALBERTA WORKSHOP REPORT

**October 30, 1987
Alberta Environmental Centre
Vegreville, Alberta**

**by
J. S. DAVIES, Ph.D.
Head, Biotechnology Section
Environmental Technology Division
AEC, Vegreville**

and

**LU JUNSHAN, B.Sc.
Bacterial and Fungal Preservation Department
Institute of Applied Microbiology
Harbin
Heilongjiang
People's Republic of China**

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SUMMARY

The production of "exotic" mushrooms such as Shiitake or Oyster mushrooms is a small but growing industry in North America. In Alberta it represents an opportunity to convert wastes from agriculture and forestry into high value products with domestic and export markets. Recently under the Alberta-Asia Exchange a Scientific Exchange took place involving scientists of the Alberta Environmental Centre (AEC), Vegreville and the Institute of Applied Microbiology, Harbin, Province of Heilongjiang, People's Republic of China. The subject of this exchange was exotic mushroom cultivation; the visiting scientist from China worked at AEC for one year demonstrating Chinese techniques of cultivation after an initial visit to China by the senior author.

A telephone survey of interested parties indicated considerable interest in a workshop in this field. Accordingly, a workshop was held at AEC with the following objectives:

- a) Education/technology transfer.
- b) Information gathering - who is growing exotic mushrooms in Alberta and what kind of help they would like to see from the government.
- c) Communication - an opportunity for growers to get together and talk about common problems.

Despite very limited advertising (virtually by invitation only), attendance was in excess of 40. The program included presentations on mushroom cultivation in China, the biology of mushrooms, cultivation methods and a discussion of the business side of mushroom farming, led by a marketing officer from Alberta Agriculture. A presentation was also made on the work carried out at AEC during the Chinese exchange; six different species were cultivated at AEC in growth chambers; success was also achieved with cultivation of Oyster mushrooms outdoors in field plots.

The workshop attracted coverage from an Edmonton TV News crew; this feature was later aired by CTV affiliates across Canada.

The main recommendation of the workshop was that there is a definite need for technical support from the provincial government for mushroom growers and for this reason work on exotic mushroom cultivation at AEC should continue.

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1. PREAMBLE

In North America, "mushroom" has, for many years, been synonymous with the white button mushroom *Agaricus bisporus* in the mind of most consumers. It is readily available year round in grocery stores in fresh, frozen or canned form. In fact, to many people it is the only edible mushroom; others found growing wild are widely believed to be poisonous and are often referred to as "toadstools" particularly amongst people of anglo-saxon origin.

However, there is a significant proportion of the population, especially in Canada, not too many generations removed from European or Oriental roots for whom the word "mushroom" does not have such a narrow meaning. There is a well established tradition throughout Europe (outside the British Isles) of collecting edible wild mushrooms in the forest. The King Bolete, Chanterelle, Morel, Truffle and many others are justly prized as epicurean treasures. In the Orient, the robust flavoured Shiitake, the aromatic Matsutake or the delicate Enoke are what spring to mind when "mushroom" is mentioned; the button mushroom was virtually unknown in the Orient until quite recently.

In western (especially North American) parlance, cultivated or wild mushrooms, other than *Agaricus*, are usually referred to as "exotic". There has, for some time now, been a growing market in North America for exotic mushrooms, wild and cultivated. There has been a boom in ethnic and specialty restaurants in recent years, many of which feature novel mushrooms in their menus. Many people have been initially exposed to exotics in restaurants and, as a result, are willing to buy them to cook at home.

Up until a few years ago, the market for exotics in North America was largely filled by processed mushrooms, mainly from the Orient. However, in recent years domestic cultivation of exotics has seen significant growth concentrating on supplying

fresh mushrooms to a growing market. Growth has been particularly vigorous on the West Coast from California all the way to British Columbia.

In Alberta, exotic mushroom cultivation is a fledgling industry at present but it is growing in step with expanding market demand. In addition to several growers, Alberta has the largest wholesale dealer in wild exotic mushrooms in Canada. Alberta is ideally suited to this industry, having an abundance of the agricultural and forestry waste products (eg. straw and sawdust) on which exotic mushrooms are usually grown.

Until comparatively recently there has been little available in the way of technical support from the government for Alberta's exotic mushroom growers; there has been little need for such services in the past. In the past year, however, research into exotic mushroom cultivation was initiated at the Alberta Environmental Centre (AEC) in co-operation with Alberta Agriculture as part of the Waste Management Research Program. The initial impetus for this activity was a scientific exchange agreement between Alberta and the Province of Heilongjiang, Peoples' Republic of China in the area of exotic mushroom cultivation. Heilongjiang, in the northeast corner of China, has much in common with Alberta with respect to climate and natural resources. Heilongjiang, however, has a large industry in the cultivation of exotic mushrooms supported by a significant government effort in research and extension under the umbrella of the Heilongjiang Academy of Sciences (HAS).

The Alberta-Heilongjiang exchange offered an opportunity to effect technology transfer of Chinese experience in mushroom cultivation to the Alberta industry. With this objective, Dr. Davies of the Biotechnology Section, AEC visited Heilongjiang for one month in 1986. Upon his return, Mr. Lu Junshan of the Institute of Applied Microbiology, worked at AEC for a period of one year: November 1st, 1986 to October 30th, 1987.

The objectives of the exotic mushroom research program at AEC are as follows:

- a) Value added processing of agricultural and forestry wastes. Wastes such as straw or sawdust with a low or even negative value can be converted into a cash crop worth anywhere from \$5 - \$20 per kg.
- b) Import replacement. Exotic mushrooms are presently imported from out-of-province and out-of-country; replacement by domestic production keeps jobs and revenue in-province.
- c) Practical research related to problems of existing growers under local conditions.
- d) Technology transfer. Finding new products and/or cultivation methods for Alberta growers either by research, introduction of ideas from elsewhere or a combination thereof.
- e) To work with Alberta Agriculture to provide a source of current technical information on exotic mushrooms including cultivation techniques and pest management within the provincial government. Only by being involved in an active research program can adequate current awareness be maintained to serve this function.

Towards the end of the stay of Mr. Lu at AEC, it was decided to hold a one-day workshop on exotic mushroom cultivation, primarily for growers and serious would-be growers. A preliminary telephone poll of interested parties in the province had indicated that this would be well received. The workshop was intended to serve three main purposes:

a) Education

From conversations with growers and would-be growers a need was apparent for providing some basic information on both the technical and business side of mushroom cultivation especially for beginners, although in a one-day workshop there was obviously a limit to what could be covered. With this in mind, a program of short talks was scheduled.

b) Information Gathering

Getting people together in this way was seen as an ideal way to get an appreciation of the present state of exotic mushroom cultivation in Alberta and where it is going. The workshop also offered an opportunity to find out what support growers would like the government to provide in the way of research, extension services, business advice, financial support, etc.

c) Communication

Exotic mushroom producers tend to be highly motivated independent risk takers of very diverse backgrounds. This very independence, however, can be a drawback. There is often a reluctance to share information for fear of losing a perceived competitive advantage. This can lead to repeated reinvention of the wheel. It was hoped that bringing individuals with common interests together under one roof would stimulate a useful dialogue between them.

2. PROGRAM

A tentative program was distributed to participants at registration. The schedule of time allocated for individual topics was not intended to be rigidly followed. A loose informal session which would stimulate dialogue was planned and in fact this was what occurred. The topics listed were covered but interruptions were encouraged and occurred frequently. The net result was a blend of presentations and discussions which stretched well into the afternoon.

The speakers were:

Dr. R.S. Weaver, Executive Director, Alberta Environmental Centre, Bag 4000, Vegreville, Alberta T0B 4L0.

***Dr. Steve Davies**, Head, Biotechnology Section, Environmental Technology Division, Alberta Environmental Centre, Vegreville, Alberta T0B 4L0 (403) 632-6761.

Mr. Lu Junshan (Jason), Visiting Scientist (Alberta-Asia Exchange) Bacterial and Fungal Preservation Department, Institute of Applied Microbiology, 32 Zhao Lin St., Harbin, Peoples' Republic of China.

Ms. Carol Love-Rolheiser, B.Sc., M.Ed., Agri-Food and Processing Development Branch, Marketing Services Division, Alberta Agriculture, 7000 - 113 St., Edmonton, Alberta T6H 5T6.

*Enquiries should be directed to the above.

2.1 Executive Director's Remarks - Dr. R.S. Weaver

Dr. Weaver welcomed the participants and gave them a brief introduction to the Alberta Environmental Centre.

2.2 Introduction - Dr. J. S. Davies

Dr. Davies presented a brief introduction covering the exotic mushroom industry in Alberta and Canada, the AEC/Chinese exchange and the reasons for the workshop. He stated the objectives and then discussed most of the material covered in the preamble of this report.

2.3 Mushroom Cultivation in China - Mr. Lu Junshan (Jason)

Mr. Lu discussed the mushroom industry in China particularly in his home province of Heilongjiang. He pointed out the differences in mushroom cultivation between Alberta and China. In China, the white button mushroom (*Agaricus spp.*) is virtually unknown but many other species are cultivated which, in the West, are referred to as exotics. The presentation was supplemented by slides taken in Heilongjiang illustrating a wide variety of mushroom cultivation practices in that province.

Mr. Lu also explained the role of his government in support of mushroom growers. He is employed as a scientist in the Institute of Applied Microbiology, part of the Heilongjiang Academy of Sciences. The Bacterial and Fungal Culture Preservation Department of the Institute, as its name suggests, maintains cultures of mushroom fungi for distribution to growers and spawn producers. In addition, they conduct applied research on mushroom cultivation, isolate new cultures from wild mushrooms, provide an extension service to growers and provide training courses in cultivation techniques at the Institute.

Having pointed out the differences in cultivation practices between Heilongjiang and Alberta, Mr. Lu went on to point out the areas we had in common. Both provinces have similar climates and are well endowed with agricultural and forestry wastes suitable for mushroom cultivation.

2.4 Biology of Mushrooms - Dr. J. S. Davies

A brief account of the nature of mushroom fungi, their morphology, life cycle and physiology was given, illustrated with transparencies and slides.

The mushroom or fruiting body is only a small part of the total cell mass of the organism. Mushroom fungi are in reality microorganisms in which the total biomass is made up of many long microscopic threads called *hyphae* or collectively, the *mycelium*.

Fungi, together with other microbes such as bacteria and actinomycetes, are responsible for the decomposition of organic matter in nature, that is (usually) dead plant and animal remains. They constitute an important part of the carbon cycle in nature. Fungal hyphae, like any other living cells, are made up of carbohydrates, proteins, fats, minerals and trace biochemicals. Fungi, including those producing mushrooms, are not true plants; they lack chlorophyll and cannot photosynthesize. Fungi do not derive energy directly from the sun nor can they rely upon carbon

dioxide from the air as a source of raw materials for increase of cell mass. They break down complex organic compounds (the growth substrate) to simpler compounds by means of biological catalysts called enzymes. Some of these compounds are oxidized to yield energy; others are used as "building blocks" to synthesize new cell components or *biomass* which, in the case of mushroom fungi, takes the form of a dense network of hyphae growing over and through the growth substrate, of straw, wood or other related materials.

Decomposers like mushroom fungi, in order to survive in competition with other organisms in the natural environment, need to colonize new substrates far and near. Locally, this can be done by simple vegetative growth of hyphae outward from the point of origin. The fairy ring mushroom found on many lawns is a good example. For dispersal over greater distances most fungi rely upon small resistant propagules called spores which can be carried to new habitats by such agencies as air, wind, water or insects. Many fungi, like the common blue bread mould *Penicillium*, produce spores on simple modified hyphae; others like the mushroom fungi produce relatively large fruiting bodies to release spores into the air. These fruiting bodies or mushrooms as they are usually known, appear at first glance to have much in common with the organized tissues of plants or animals. In fact, they are constructed of relatively simple assemblages of hyphae.

In nature, the "success" of a decomposer such as a mushroom species can be measured in terms of the extent of its colonization of available substrates (the spawn run) or the total biomass it is able to produce; production of fruiting bodies is only a means to this end. To the mushroom grower, however, "success" means producing more mushrooms from less raw material in less time in the least possible space at the lowest possible cost.

Like any other living organism, mushroom fungi are profoundly influenced by their physical and chemical environment. With respect to a given physical or chemical parameter, each species will have a definite range with upper and lower limits and

within that range a much narrower optimum range which is preferred. A partial listing of these parameters is as follows:

Temperature

pH

Oxygen

Carbon dioxide

Moisture

Chemical make up of the substrate including

- carbohydrate (eg. cellulose, starch, sugar)
- nitrogen
- minerals
- vitamins

These are by no means mutually exclusive. The moisture content of the substrate determines the "void volume" available to be occupied by a gas phase which affects ventilation and therefore oxygen availability and carbon dioxide accumulation.

Conditions which favour mycelial growth or "spawn running" do not necessarily promote fruit body formation. When sufficient biomass has been produced in the substrate fruiting can take place; it usually needs to be triggered by a certain combination of environmental conditions specific to the particular species. In some species a cold shock is necessary, eg. *Pleurotus ostreatus*. Increased ventilation to reduce carbon dioxide concentration in the air is usually necessary. Light is often a factor. Different factors affect initial "pinning" or primordium formation and subsequent development and maturation of the fruiting body.

2.5 Cultivation Methods - Dr. J. S. Davies

Methods adopted for cultivation of exotic mushrooms are many and various. They are normally a compromise between what is known of the optimal conditions for the

particular species and what is technically and/or economically feasible in the way of environmental control.

2.5.1 Spawn

Mushroom cultures are usually maintained in the laboratory on a relatively small scale as agar slant cultures. Mushroom fungi are not normally transferred from agar slants or petri plates to bulk substrates for mushroom production; usually there is an intermediate stage, **S-P-A-W-N**, not to be confused with **S-P-O-R-E-S**, which are rarely used in commercial mushroom cultivation.

Spawn is the inoculum or seed culture of the fungus added to the bulk substrate the act of which is known as spawning. The growth of the mushroom mycelium through the substrate is the spawn-run. Spawn essentially consist of a bulk culture of the mycelium of the mushroom fungus usually growing on a solid but friable substrate. To guard against all too frequent genetic changes in mushroom cultures spawn is usually no more than 2 or 3 generations removed from agar stock cultures. Spawn is, except under very primitive conditions, almost always a pure culture of the mushroom fungus culture alone and contains no other microbes. It is normally grown in glass jars or, more recently, autoclavable plastic bags.

The method and rate of spawn application vary in different situations. It is normally broken into small pieces then spread over the surface of the substrate or mixed intimately with it. Application rates usually range from 1-10% by weight. Application rates at the high end are often found in relatively primitive operations where, due to inefficient pasteurization and/or unsanitary conditions, contamination is a problem.

Some of the common types of spawn are as follows:

a) Grain

Normally cooked sterilized grain, such as rye or hard wheat though millet is sometimes used. Often chalk (calcium carbonate) and/or gypsum (calcium sulphate) is added before sterilization; the former as buffer against acid production, the latter to keep grains from sticking together.

b) Sawdust

This or other pulverized cellulosic residue (eg. corn cobs) should be fairly coarse and is usually amended with a nitrogen supplement such as wheat bran or rice bran. A typical recipe on a dry weight basis would be 79% sawdust, 20% wheat bran, 1% chalk.

Moisture content would be adjusted to 65-75% w/w before sterilization.

c) Plug Spawn

Normally used in traditional Japanese Shiitake culture. The fungus is allowed to colonize sterilized plugs of wood which are then hammered into holes drilled into logs.

d) Liquid Spawn

This is largely experimental. It involves growing large quantities of mycelium in submerged culture using shake flasks and/or stirred tank fermenters. The macerated mycelium can then be mixed with the bulk substrate very efficiently. The equipment and expertise required are, however, outside the scope of most growers or spawn producers.

Most commercial growers tend to buy spawn from a supplier rather than produce their own. Spawn production demands close attention to cleanliness and sterility and great vigilance for signs of genetic variation in stock cultures.

2.5.2 Spawn-Run or Colonization of Substrate

a) *Round Wood (logs)*

- Shiitake (*Lentinula edodes*)
- Wood Ear or Black Jelly Mushroom (*Auricularia spp*)
- Oyster Mushroom (*Pleurotus spp*)

This is a traditional low-tech cultivation method. Spawn, usually plug or sawdust, is applied to a freshly cut surface often a hole or notch. Incubation is usually, but not always, outdoors. This approach is very susceptible to environmental extremes.

b) *Composted/Pasteurized Substrates*

- Paddy Straw Mushroom (*Volvariella spp*)
- Oyster Mushrooms (*Pleurotus spp*)
- Button Mushrooms (*Agaricus spp*)

Mixtures of manure, straw, agricultural products or other suitable biomass are allowed to undergo a process of solid-state fermentation or "composting" by the agency of a mixed population of bacteria, fungi and actinomycetes over a period of time. This process changes the chemical make-up of the substrate to a form more suitable for growth of the mushroom fungus. Usually a period of high temperature (60°C) is employed at some stage to kill harmful fungi and various pests but the compost is still well-colonized by "useful" microorganisms when finally spawned.

c) *Pasteurized/Sterilized Substrates*

- Oysters (*Pleurotus spp*)
- Shiitake (*Lentinula edodes*)
- Enoke (*Flammulina velutipes*)
- Wood Ear (*Auricularia spp*)
- *Stropharia rugoso-annulata*
- Others

Many mushroom species are cultivated on a variety of cellulosic wastes including cereal straws, sawdust, corn cobs and cottonseed hulls, which are often amended by a nitrogen supplement such as wheat or rice bran. These species are more often than not wood-rotting fungi with well developed capabilities for degradation of cellulose and lignin; they do not require prior composting of raw materials.

Culture or "spawn running" on a completely sterile substrate is both expensive (requiring, for example, high pressure steam) and technically demanding. Certain species, however, such as Shiitake or Enoke do not compete well in the presence of "weed species" of other fungi and bacteria. They demand sterile or aseptic culture techniques, usually in jars or autoclavable plastic "space bags" up until fruiting.

More robust species such as Oysters can compete quite well with weed species; in fact the presence of certain bacteria is thought to be beneficial. In such cases pasteurization rather than sterilization of growth substrate is sufficient prior to spawning. Approaches vary from raising the temperature to 65°C for 20 - 30 minutes to steaming at 80 - 100°C for 1 - 4 hours.

2.5.3 Fruiting

Conditions for fruiting are often quite different to those required for the spawn run and vary considerably from species to species. For many exotics, induction of fruiting

involves exposure of all or part of the surface of the colonized substrate to ventilation with or without light at a suitable temperature and high relative humidity to prevent drying of primordia. In certain cases such as *Enoke*, temperature and humidity are varied as fruiting bodies develop to give the desired form and quality.

Other species such as *Agaricus* or *Stropharia* require "casing". This involves covering the surface of the colonized substrate with a 3 - 5 cm layer of moist material, usually peat/limestone based. Casing is believed to serve two main functions:

- a) To supply moisture and humidity during development of fruiting bodies.
- b) To support growth of beneficial microorganisms which enhance and stimulate fruiting.

2.6 Research at AEC - Dr. J.S. Davies

Prior to the arrival of Lu Junshan in November 1986, activity in the area of mushroom cultivation at AEC was of low intensity. Oyster mushrooms had been cultivated outdoors on poplar logs and wheat straw. Serious work on mushroom cultivation requires a certain degree of environmental control with regard to such parameters as temperature, humidity, ventilation, light intensity, illumination period, etc. In addition, such control must be applied to relatively large confined spaces since mushroom trials normally involve significant quantities of raw materials; 0.5 kg is about the minimum mass of a single unit for cultivating mushrooms.

Early work relied on a relatively crude homemade growth chamber in which some degree of environmental control could be achieved. However, only one set of conditions could be achieved for a given period of time. The ideal equipment for this kind of work is the controlled environment chamber designed for research involving plant growth. Precise control of all the parameters mentioned above can be achieved with such equipment. The Plant Sciences Division at AEC is very well equipped with state-of-the-art growth chambers and we had access to such a unit for most of the

year. In the Spring of 1987, we were fortunate enough to acquire six used growth chambers, four of which were put into operation by May of 1987 with full control of temperature, light, ventilation and humidity enabling us to maintain several different environments simultaneously.

A relatively short time was available to complete an extensive research program during the visit of Mr. Lu, November 1, 1986 to October 31, 1987 since capabilities were somewhat limited until the growth chambers became operational in May 1987. It was decided to spend the time available capitalizing on the presence of Mr. Lu. Attempts were made to apply Chinese methods to local raw materials and conditions. Since we were, to a certain extent, entering (for the Province) relatively uncharted waters, we felt a need to adopt a "show and tell" approach to this work initially. We tried, whenever possible, to adopt a high profile, producing mushrooms for people to see (and taste) on local raw materials. Our work was split into two parts: a) cultivation under controlled conditions indoors; b) mushrooms cultivation in field plots outdoors.

2.6.1 Indoor Cultivation

Four different species of Oyster mushrooms were cultivated successfully; *Pleurotus ostreatus*, *P. sajor-caju*, *P. florida* and *P. citrinopileatus*. Success was also obtained with "Enoke" (*Flammulina velutipes*) and the "Monkey's Head Mushroom" (*Hericium erinaceus*).

In some cases different strains of individual species were compared.

All four Oyster mushroom species were cultivated on unamended wheat straw and on aspen sawdust, usually amended with wheat bran. A mixture of oak shavings and sawdust from a local furniture factory could be used in place of aspen. In the case of straw, 1.5 to 2 kg wet weight of soaked steamed straw was spawned in small plastic bags. After colonization, the bags were opened up and allowed to fruit under

Figure 1. "Golden Oyster Mushroom", *Pleurotus citrinopileatus* growing on wheat straw.

Figure 2. "Phoenix Oyster Mushroom", *Pleurotus sajor-caju* growing on cellulosic pulping wastes.

Figure 3. "Enoki", Flammulina velutipes growing on
Aspen sawdust.

Figure 4. "Shiitake", Lentinula edodes growing on
Oak log.

appropriate conditions. For sawdust culture, we used the Chinese approach. Mixtures of sawdust, bran and calcium carbonate were pasteurized or sterilized in jars (0.5 kg) or plastic-wrapped blocks (5.0 or 12.0 kg). Sawdust spawn was spread over the surface and placed in wells cut into the blocks. After colonization (anywhere from 2 - 4 weeks), fruiting was induced.

Pleurotus citrinopileatus is a very attractive vivid yellow Oyster mushroom which is very popular in China but as far as we are aware has not been cultivated commercially in North America. Believing this species to have very definite commercial possibilities, we decided to study it in more detail. Jar studies were performed using aspen sawdust amended with bran, alfalfa meal, soy bean meal and Canola meal to supply nitrogen. All amendments supported growth but the alfalfa produced a markedly more intense yellow colour over other amendments.

The Japanese "Enoke" mushroom *Flammulina velutipes*, also known as the winter mushroom or snow mushroom, is very popular in Japan and has a growing following in North America. We were able to cultivate this species using the same sawdust/bran media used for Oysters. Initial colonization of the substrate occurs at 25°C quite readily but induction of fruiting requires low temperatures, 11 - 12°C and lower.

A very popular, expensive mushroom in China is the so-called "Monkey's Head Mushroom", *Hericium erinaceus*, which is unknown commercially in the West. Again, we were successful in cultivating this species on sawdust media though it is rather slow compared with Oysters or even Enoke. Because of its unique appearance and delicious flavour, we believe this mushroom has definite commercial potential.

2.6.2 Field Plots

In China, Oyster mushrooms, notably *Pleurotus sapidus* and *P. citrinopileatus*, are cultivated successfully outdoors during the summer using very simple "low tech" procedures. Summers in Alberta are not as long as those in the Harbin area nor as

warm but trials were undertaken to test the practicality of such cultivation here in Alberta.

Two test plots were set up, one on the AEC site in Vegreville at approximately 53° 30' N and another at approximately 50° 30' N at the Alberta Horticultural Research Centre at Brooks with the co-operation of Dr. Ron Howard. Summers at the latter site are much longer, warmer and drier than those at the more northerly site. It was felt that these sites fairly represented the extremes in the major populated zone of the province.

The approach at each site was essentially the same. A mixture of aspen sawdust and wheat bran was pasteurized with steam and formed into plastic-wrapped blocks set in shallow trenches in the ground. Individual beds were 100 x 50 cm, 12 cm deep. Once cooled, beds were spawned with sawdust-spawn. The spawn was laid on the surface, at the sides and in wells bored into the blocks. After spawning, the surface of the beds were covered with perforated black plastic to exclude light and left until the substrate was fully colonized; shade panels protected the beds from direct sunlight. After colonization, the beds were uncovered and exposed to the air beneath perforated transparent plastic tunnels (under the shade panels) equipped with misting devices for the development of fruiting bodies. Air temperatures and bed temperatures at both sites were monitored with automatic data loggers.

The Vegreville site was set up June 1; that in Brooks two weeks later. Each site was identical. Five strains were used: *Pleurotus florida*, *P. sajor-caju*, *P. citrinopileatus* and two strains of *P. ostreatus*; each strain was spawned to 3 blocks at both sites.

The Vegreville trial was not successful; low temperatures early in the summer and flooding from heavy rains prevented successful colonization of the substrate and heavy contamination occurred. At Brooks, however, successful fruiting was achieved in 4 out of 5 strains. The exception was *P. citrinopileatus*; this species colonized the

substrate well but would not fruit. It is believed that the later start and generally warmer temperatures in Brooks were responsible for success there. *P. citrinopileatus* is essentially a warm-temperate/sub-tropical species native to central Asia. It is believed that lower night-time temperatures in Brooks prevented fruiting. Paradoxically, *P. sajor-caju*, a tropical species native to India and Pakistan, fruited vigorously under the same conditions.

Pre-colonized blocks of *P. sajor-caju* and *P. ostreatus* when placed outside at Vegreville fruited readily; *P. citrinopileatus*, however, did not under the same conditions. The latter fruits successfully outdoors in NE China but overnight temperatures in mid-summer are much milder than Alberta.

Probably due to the unseasonably mild fall of 1987, blocks in Brooks were still fruiting when the plots were dismantled November 9.

2.7 The Mushroom Business - Ms. Carol Love-Rolheiser

Ms. Love-Rolheiser, a Crop Marketing Officer of Alberta Agriculture's Marketing Services Division, made a presentation on business aspects of mushroom cultivation. Included below is an outline of this presentation:

Mushroom Industry Profile

- Alberta Profile (1986)
- Statistics Canada - Mushroom Growers Survey (1986)

Getting Into the Mushroom Business

- It's an "*Agaricus* market"
- Pioneering exotic mushrooms into the marketplace
- The competition

What Should You Know Before Going Into a Food Production Business?

- Gather information - do your homework by doing research
- Ask basic questions?
 - a) What is the market potential?
 - b) Is the market growing or contracting?
 - c) Who are the potential customers and what location, advertising and sales force can serve them best?
 - d) Can I guarantee quality and supply - can I deliver to meet client needs?
 - e) What kind of facilities and equipment are needed? Should I purchase new, second-hand or lease?
 - f) What costs are involved in production?
 - g) How can I finance?
 - h) What prices will the market bear?
 - i) What regulations govern the business?
 - j) Who are the competitors? Where are they targeting their markets?
What about their products, prices and promotion and advertising profiles?
 - k) Where can I get assistance - technical, financial or consultative?

Ms. Love-Rolheiser also distributed an Alberta Agriculture publication, "The Packaged Goods on Food Processing", a precis of which is included below:

A. Checklist

- target your product
- customers and marketplace
- who will buy your products
- market trends
- market size and growth potential
- pricing
- distribution

- competition
- operations
- equipment
- facility
- labour
- operational time frames
- advertising/marketing

B. The Business of Business

- management skills
- assess your skills
- profit - the return on your investment
- legal forms of business
- work closely with professional advisors
- financing
- small business loan program
- other sources of financing
- business plans

C. Regulations

- licenses
- development/building permits
- packaging and labelling
- food safety
- retail

D. Assistance

- marketing sector - Alberta Agriculture
- Agriculture Development Corporation
- Alberta Economic Development - Small Business Assistance Branch
- Alberta Opportunity Company

- Alberta Research Council program
- Federal Business Development Branch
- Other information sources

Ms. Love-Rolheiser in her presentation not only welcomed interruptions but continually stimulated audience participation resulting in a very lively, interactive session. She gave a brief profile of the mushroom industry in Alberta and Canada as a whole. Among the significant points which were raised were:

a) At the present time, the mushroom market in Canada is essentially "the *Agaricus* market"; exotic mushrooms must be "pioneered" into the marketplace.

b) To what degree exotics represented competition for the *Agaricus* industry. How much of the *Agaricus* market could potentially be displaced by exotics. This point was the subject of some disagreement. Some of those present considered exotics to be no more competition for *Agaricus* than artichokes are for potatoes.

c) The exotic market in North America is essentially a market for a premium quality fresh product. As a general rule, processed product - canned, dried, etc. - can be imported much more cheaply from the Orient.

It was pointed out that in general assistance from Alberta Agriculture was normally delivered to a particular segment of the industry as a whole. The Department would be reluctant to devote time and resources to an individual producer and then do the same at later dates for others. She suggested that a growers' association would speak with a louder voice and would be more likely to elicit a favourable response from the Department when assistance was requested.

3. DISCUSSION AND RECOMMENDATIONS

Attendance of the workshop was initially limited to invitees who were known to have a particular interest in mushroom cultivation. In a very short time after the initial notice went out, numerous requests from interested parties were received. Final attendance was close to fifty people; any serious attempt to advertise more widely would have brought serious problems of overcrowding.

Further evidence of the degree of interest in exotic mushroom was found in the response to television coverage of the proceedings. The workshop was covered by CFRN TV, the Edmonton CTV affiliate. A short feature was produced on exotic mushrooms for the evening news which included footage of AEC and a cooking demonstration at an Edmonton Chinese restaurant with Mr. Lu. This show was originally aired in Edmonton December 28th, 1987 but interest was such that it has since been shown across Canada. Television exposure has resulted in requests for information on exotic mushrooms from inside and outside Alberta including Saskatchewan, Quebec and Nova Scotia.

Popular interest in the subject of mushroom cultivation, however gratifying, is not a valid reason for devoting valuable resources on research. There is however, ample evidence that exotic mushroom cultivation has a bright future as a viable commercial enterprise in Alberta. A recent business report entitled "Tomorrow's Customers" by Woods Gordon identifies future market trends in Canada. "Growth markets" now and in the future are predicted to be in the area of "luxuries of life" rather than necessities. Amongst the "Winning Products for the Coming Decade" identified are "Exotic and Gourmet Foods".

This trend can already be seen in Alberta. Mona Mushrooms of Edmonton sell wild and cultivated exotic mushrooms; they cannot meet the demand for fresh oyster mushrooms with produce from Alberta growers. Large grocery stores such as Superstore regularly carry several different kinds of fresh exotic mushrooms including

Shiitake, Enoke, Oysters and Wood-Ear. With the exception of Oysters such mushrooms are imported, usually from California, but often from Japan. Not only could these imports be replaced by locally-grown products but mushrooms could be exported to other provinces and abroad.

At present there are three commercial growers of exotic mushrooms in Alberta and one broker who sells wild and cultivated exotic mushrooms wholesale and retail. Venture capital for novel enterprises of this kind is not easy to obtain; as a result, existing growers are relatively small and undercapitalized. However, in the Fall of 1987, Sylvan Mushrooms of Vancouver completed a highly mechanized plant with a capacity of approximately 5,000 kg. per week, some of which is slated for the Japanese market. The same trend can be seen south of the border; a plant recently opened in California which is expected to produce approximately 20,000 kg. of mushrooms per week. Expected revenue is in the order of \$6 million (Cdn.) per year for an initial investment of \$5 million (Cdn.). However, even the latter plant is dwarfed by comparison with a plant which was recently commissioned in West Germany; this plant has a capacity of 18 metric tonnes of oysters per day.

The exotic mushroom business can realistically be split into two main divisions.

I. The low volume/high value market - mushrooms which because of technical demands of the cultivation process are likely to remain high-priced "gourmet" items (e.g. Shiitake, Enoke).

II. The high volume/low value market - mushrooms, the cultivation of which, are not technically demanding (e.g. oyster mushrooms).

The latter market from the European experience will probably grow at the expense of button mushrooms especially as production increases and prices stabilize. Oyster mushrooms are likely to develop into a regular item on grocery lists as button mushrooms have done in recent years. They will no longer be seen as "exotic" food

items but merely an alternative to *Agaricus* in the same way that chicken is an alternative to beef.

Market I, by contrast, is likely to remain exotic and relatively insensitive to price competition. This market is expanding both in volume and variety. At present fresh morels are available only as wild specimens collected in the spring. In June 1986, a company in Michigan received patent protection for a process for cultivation of morels. The process is due to be piloted shortly. Fresh morels currently sell anywhere from \$12 - 20 U.S. per kilo. Other species are known which can be cultivated quite readily but have not, as yet, been produced in commercial quantities in North America. The ultimate prize for mushroom cultivation research would have to be a process for artificial cultivation of the European truffle which has sold for as much as \$11 - 1,300 U.S. per kilo in recent years. In fact, quite recently a California company has claimed success with culture of biomass of the black truffle, *Tuber melanosporum*, for use as a flavoring agent in processed foods. They have recently signed a contract with a French company which is willing to buy 6 tonnes at in excess of \$330 U.S. per kilogram for the coming year.

The market for exotic mushrooms in the U.S. has enjoyed tremendous growth in recent years and is expected to continue. U.S. producers are expanding to meet this demand. The Canadian market is also expanding but demand is already outstripping supply. If domestic production does not develop in step, this demand is likely to be filled from the U.S. Currently fresh mushrooms entering Canada from the U.S. are subject to a 10% tariff; mushrooms entering the U.S. from Canada are subject to a 25% tariff. Under free trade, presumably these tariffs will disappear.

It should not be assumed that free trade will kill Canadian exotic mushroom production. Alberta, especially, enjoys many advantages for development of a viable exotic mushroom industry. It has a great abundance of the raw materials needed for this activity. Agriculture wastes such as cereal straw and high protein supplements such as bran and alfalfa are cheap and inexhaustible. Besides petroleum and

agricultural products, Alberta's other great natural resource is its forest. New pulp mills are now under construction to take advantage of this resource. Exploitation of forests always generates considerable quantities of cellulosic wastes. In many parts of the world such as China and Japan, such wastes are used to grow mushrooms.

Alberta could not only fill the increasing domestic demand for exotics thereby reducing the flow of dollars, and of course jobs, out of the Province but could develop a viable export business too. A rule of thumb in the button mushroom industry is that fresh mushrooms are not shipped more than 1000 miles to market (surface) and that shipping costs should not exceed \$0.15 per pound. However, this is for a product for which the grower (in Alberta) receives about \$1.55 per pound. Higher value produce such as exotics can often bear the cost of airfreight. Mona Mushrooms of Edmonton routinely airfreights exotic wild mushrooms to Japanese and European markets. Oyster mushrooms are currently being shipped by air from Vancouver to Japan.

Exotic mushrooms are produced in two basic kinds of operations:

I. Moderate to large-scale, mechanized, capital - intensive operations;
and

II. Small-scale family operations employing little in the way of expensive hardware, relying instead upon adapted farm equipment and buildings or greenhouses.

Businesses in the first category typified by the aforementioned factories in Vancouver, California or Germany would locate in or near large city markets and would produce on a large scale, selling far afield, often employing airfreight to reach distant markets. Such operations would make a significant contribution to the wealth of the community in which they located by creating new employment. They would also make a significant contribution to the Provincial agrifood industry by a) replacing imports; and b) generating revenue from exports out of the province.

The second category of mushroom producer can be looked upon as something of a cottage industry typically operated by a family in a rural area. Mushrooms would be produced as an income supplement alongside more conventional farm operations. Existing farm buildings and equipment can readily be adapted to this use. Several operations of this type exist already in Alberta. A good example of the use of existing facilities is the growing of mushrooms in greenhouses, widely practiced in Europe. In Alberta, many greenhouses are underutilized, standing empty for much of the year. Mushroom cultivation could represent an additional source of income for greenhouse operators either by producing mushrooms themselves or leasing the facilities to a third party for this purpose.

Traditional markets for prairie farmers have been eroding rapidly in recent years leading to much speculation on "new crops". Mushrooms are not going to replace wheat but could represent a significant extra source of income for our financially-stressed farm community.

The exotic mushroom business in North America is growing rapidly driven by a strong market demand. It is to be hoped that Alberta producers will not only supply a significant portion of this demand in the province but will generate additional revenue by sending Alberta-grown mushrooms beyond our provincial boundaries. However, mushroom growers, like any other sector of the agrifood industry, cannot exist in a vacuum; they need help with production, pest management, marketing and scientific and extension services.

This kind of help is already supplied by Alberta Agriculture to the mainstream of agriculture in the province: wheat, barley, canola, beef, pork, glasshouse crops, etc. Extension services supplied to producers is backed up by professional scientific support within the Department of Agriculture and also from the Alberta Environmental Centre which delivers research and diagnostic services to Agriculture as its client department. The exotic mushroom business, although growing rapidly, is still in its infancy or, at best, early adolescence; it does not have the sound foundation of

well-established principles of production, pest management, etc. that is the case with production of button mushrooms, for example. For this reason exotic mushroom producers have greater individual needs for advice and support than mainstream sectors of agribusiness; "mushroom husbandry" in the exotics area changes rapidly often in response to research advances mostly outside North America.

Since the inception of the exotic mushroom program at AEC with the Alberta-Heilongjiang exchange, the Centre has received numerous enquiries from growers seeking help with problems such as strain degeneration, environmental control, insect pest management, etc. Where possible, advice was provided and even laboratory investigations carried out where appropriate.

Although exotic mushroom cultivation can be carried out at both "High Tech" and "Low Tech" levels it is, in fact, a solid-state fermentation process and as such must be based on sound microbiological practices and principles. Effective technical support for exotic mushroom growers depends not only upon sound theoretical knowledge of the microbiological principles underlying the cultivation methods but also current awareness of the scientific literature and recent advances in the industry worldwide. In addition, the ability to perform laboratory investigations into growers' problems depends upon knowledge of appropriate techniques by the investigator and moreover, the specialized facilities to carry out such work. Maintenance of such a capacity is only possible realistically as part of an active research program in this field.

A good foundation has been laid at AEC with the Exotic Mushroom Project. Appropriate facilities have been established, techniques developed and good contact established with authorities in Canada and abroad. The need for this kind of support has been demonstrated by the response to the workshop and ongoing calls requesting advice on start-up and various problems. Unfortunately, competing priorities from other projects are threatening the cancellation of this project. Allocation of human and physical resources at AEC for any project depends very much upon support from a

client department. To date, excellent co-operation has been enjoyed with Alberta Agriculture in the work at Brooks and more recently with greenhouse trials at the Alberta Tree Nursery with Dr. Mirza Mohyuddin. Continued activity at AEC in this field is heavily dependent upon firm support from Alberta Agriculture and hopefully from Forestry, Lands and Wildlife.

It is therefore recommended that renewed commitment to this project be sought from the various client departments of the Alberta Environmental Centre and from the private sector. The minimum level of resources to continue a meaningful effort is 20% of a professional man year and 50% of a technical man year. This, plus a suitable operating budget, would amount to approximately \$50,000 annually. An initial period of three years is recommended.

APPENDIX I

Workshop Participants

J. Blayone
Box 1932
Peace River, Alberta
T0H 2X0
Calgary, Alberta
624-8493

Mr. Steve Nagy
Mycotech Laboratories Ltd.
3505 - 62 Avenue S.E.
Calgary, Alberta
T2C 1P5
236-3811

Mr. Walter Chipchar
Forest Mushrooms
Box 658
Smoky Lake, Alberta
656-4159

Mr. Dave Pedersen
Mountain Mushrooms
Box 1500
Airdrie, Alberta
T0M 0B0
948-3686

Mr. Tony Clements
General Delivery
Mundare, Alberta
T0B 3H0

Dr. S. Navratil
Acting Director
Forest Research Branch
Alberta Forest Service
9915 - 108 Street
Edmonton, Alberta
T5K 2C9
962 - 8700

Ms. Lucille Maskalyk
Box 6, Site 3, RR 1
Winterburn, Alberta
T0E 2N0
962-4533

Mr. Charles Montandon
Box 97
Beauvallon, Alberta
T0B 0K0
366-2548

Mr. Otto Holzbauer
Mona Enterprises
7312 - 84 Avenue
Edmonton, Alberta
T6B 0H8
466-1262

Mr. Raymond Kwan
#208, 2916-19 Street N.E.
Calgary, Alberta
T2E 6Y9
244-8994 (bus.)
239-8678 (res.)

Mr. John Kostelyk Jr.
Prairie Mushrooms Ltd.
53331 Range Road 232
Sherwood Park, Alberta
T8A 4Z2
467-3555

Ms. Carol Love-Rolheiser
Marketing Officer
Alberta Agriculture
3rd Floor, 7000 - 113 Street
Edmonton, Alberta
T6H 5T6
422-6317

Mr. Arnott Wilson
Chef's Choice Mushroom Farms Ltd.
Box 813
Onoway, Alberta

Mr. Sam Aardema
Prairie Mushrooms Ltd.
53331 Range Road 232
Sherwood Park, Alberta
T8A 4Z2
467-355

Mrs. Rose Solodzuk
8236 - 93A Avenue
Edmonton, Alberta
T6C 1V6

Mr. John Kostelyk Sr.
Prairie Mushrooms Ltd.
53331 Range Road 232
Sherwood Park, Alberta
T8A 4Z2
467-3555

Ms. Sheila Bebonang
General Delivery
Mundare, Alberta
T0B 3H0

Mr. Henry Fong
212 Ranchview Place N.W.
Calgary, Alberta
T3G 1R7
239-8678

Dr. Maria Neuwirth
AEC
Vegreville, Alberta
T0B 4L0
632-6761

Mr. Doug Schroeder
211 Maunsell Close N.E.
Calgary, Alberta
T2E 7C1
230-3706

Mr. Reinhard Hermesh
AEC
Vegreville, Alberta
T0B 4L0
632-6761

Ms. Rosemary Harris
AEC
Vegreville, Alberta
T0B 4L0
632-6761

Mr. Richard Johnson
AEC
Vegreville, Alberta
T0B 4L0
632-6761

Mr. Wm. Chalmers
Western Biologicals
Box 46466, Stn. G
Vancouver, B.C.
V6R 4G7
(604) 228-0986

Dr. Surya Acharya
AEC
Vegreville, Alberta
T0B 4L0
632-6761

Ms. Michelle Dalpe
4609 - 49A Street
Vegreville, Alberta
T0B 4L0
632-3231 (res.)
632-6761 (bus.)

Ms. Kim Soldan
AEC
Vegreville, Alberta
T0B 4L0
632-6761

Mr. John Vogrinetz
AEC
Vegreville, Alberta
T0B 4L0
632-6761

Ms. Cathy Pedersen
118 El Dorado Road
Airdrie, Alberta
T4B 1Y5
948-4292

Mr. Rob Hughes
AEC
Vegreville, Alberta
T0B 4L0
632-6761

Mr. Klaus Wittenburg
Mycotech Laboratories
3505 - 62 Avenue S.E.
Calgary, Alberta
T2C 1P5
236-3811

Ms. Christine Thomas
Box 3637
Airdrie, Alberta
T4B 2B8
948-5618

Mr. Vincent House
10936 - 82 Street
Edmonton, Alberta
T5H 1L8
429-3435

Mr. Thomas Thomas
Box 3637
Airdrie, Alberta
Vegreville, Alberta
948-5618

Dr. Albert Liem
AEC
Vegreville, Alberta
T0B 4L0
632-6761

Ms. Maggie Davidson
Box 5259
Airdrie, Alberta
T4B 2B3
948-3643

Mrs. Ollie Zeniuk
95 Westbrook Drive
Edmonton, Alberta
T6J 2C8
436-7933

Dr. R.S. Weaver
AEC
Vegreville, Alberta
T0B 4L0
632-6761

Dr. Jack Taylor
6703 Hardisty Drive
Edmonton, Alberta
T6A 3V2
466-9448

Dr. Steve Davies
AEC
Vegreville, Alberta
T0B 4L0
632-6761

Mr. Lu Junshan (Jason)
Bacterial and Fungal Culture Preservation Dept.
Institute of Applied Microbiology
Heilongjiang Academy of Sciences
32 Zhao Lin Street
Harbin, Peoples' Republic of China

Mr. Grant Burls
Burls Spawn Lab
Box 635
Medicine Hat, Alberta
T1A 7G6
527-0265

APPENDIX II

Recommended Reading

Books

Stamets, P. and J.S. Chilton 1983. The Mushroom Cultivator - A practical guide to growing mushrooms at home. Agarikon Press, Olympia, Washington. ISBN: 0-9610798-0-0. About \$30.00.

A "must" for the beginner, contains a wealth of practical information couched in non-technical language.

Chang, S.T. and W.A. Hayes 1978. The Biology and Cultivation of Edible Mushrooms. Academic Press, New York. ISBN: 0-12-168050-9. About \$100.00+.

A serious technical work for professionals, reviews scientific research papers on mushroom cultivation.

Chang, S.T. and T.H. Quimio 1982. Tropical Mushrooms. Biological Nature and Cultivation Methods. The Chinese University Press, Hong Kong. ISBN: 962-201-264-7. About \$100.00+.

Similar to Chang's 1978 title above but with emphasis on cultivation under tropical conditions, contains much information applicable to temperate latitudes.

Chang, S.T. and P.G. Miles 1988. Edible Mushrooms and Their Cultivation. CRC Press, Boca Raton, Florida. ISBN: 0-8493-6758-1. About \$270.00.

The latest of Chang's efforts, again mainly aimed at professionals.

Kaye, Geraldine C. 1984. Wild and Exotic Mushroom Cultivation in North America. A growers and gourmets' guide to the new edible species. Farlow Reference Library and Herbarium of Cryptogamic Botany, Harvard University,

Cambridge, Massachusetts 02138, U.S.A.

A small booklet listing many titles and suppliers of books, mushrooms and supplies.

Journals

The Mushroom Journal (monthly)
The Mushroom Growers Association
Agriculture House
Knightsbridge
London, SWIX 7NJ
U.K.

The Mushroom News (monthly)
American Mushroom Institute (AMI)
Box 373
Kennet Square, Pa. 19348
U.S.A.

Mushroom Journal for the Tropics (quarterly)
The International Mushroom Society for the Tropics
c/o Dept. of Biology
The Chinese University of Hong Kong
Shatin, N.T., Hong Kong

APPENDIX III

Suppliers/Businesses

Forest Mushrooms
Att. Walter Chipchar
Box 658
Smoky Lake, Alberta
T0A 3C0
656-4159

Mushroom spawn, culture bags,
consulting.

Mona Enterprises
Att. Otto or Rita Holzbauer
7312 - 84 Avenue
Edmonton, Alberta
T6H 0H8
466-1262

Buy and sell exotic mushrooms,
wild and cultivated, wholesale
and retail.

Western Biologicals Ltd.
Att. Bill Chalmers
P.O. Box 283
Aldergrove, B.C., Canada
V0X 1A0
(604) 856-3339

Mushroom spawn, cultures,
media, equipment, consulting.
Short courses available on
cultivation techniques.
Catalogue \$2.00.

Fungi Perfecti
Att. Paul Stamets
P.O. Box 7634
Olympia, Wa. 98507
U.S.A.
(206) 426-9292

Supplies, equipment, cultures,
spawn, consulting, courses.
Catalogue U.S. \$3.00.

N.L.C. - B.N.C.

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