Chapter 8

Mushroom for a Living

AGARICUS BLAZEI[1] CULTIVATION FOR A LIVING IN BRAZIL

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Introduction

The unemployment crisis in many countries and the opportunity to establish a new source of income are motivating a great number of small farmers around the world to consider mushroom production. The main reason for their interest is that mushroom crops enjoy higher profit margins and quicker returns than most other agricultural crops. Mushroom is also a healthy and nutritious food product that has become an important alternative source of dietary protein. Mushroom growing operations can be established as small family businesses and all together they can bring in important foreign currency when exported. For these and many other reasons mushroom production has become a very interesting activity in the rural areas of most developing countries.

Excellent conditions for mushroom production exist in Brazil, including a wide range of climates and a great diversity and availability of agro-industrial residues that can be used in the production of mushroom substrates. The major activities in the country are agro-industrial and residues are frequently wasted. Wasted materials include coffee residues, cereal straws, sugarcane bagasse, native and fast growing grasses, cotton plant leaves and stems and several types of industrial residues such as sawdust and manure. Most of these materials have already been tested and approved in other countries as suitable ingredients for mushroom substrates.

Several species of specialty mushrooms, *Lentinula edodes* and *Pleutorus* spp., have been recently introduced into Brazil by Asian immigrants. Even though *A. blazei* is a native Brazilian species, it was not until the 80's that cultivation of this species was established in the interior of the State of São Paulo from whence it has been extended to other states in the last decade.

This expansion of cultivation was stimulated by the high price of mushrooms on the international markets. The *A. blazei* species is also, at present, the most popular medicinal mushroom in Brazil.

History of Agaricus blazei in Brazil

Agaricus blazei (Murrill) ss.Heinemann is known in Brazil as the medicinal mushroom, Cogumelo do Sol®, Cogumelo Piedade, ABM (from *Agaricus* ***b****lazei* **M**urrill) or Cogumelo Blazei. Farmers from Piedade (interior of the São Paulo State) reported that the mushroom was sent to Japan in the 60´s for research on its medicinal properties and after the benefits were known, the Japanese brought to Brazil the knowledge concerning the culture of the mushroom and established commercial mushroom farms in Brazil. Production for exportation to Japan was feasible because the climatic conditions in Brazil were favorable and because the commercial interactions with immigrant farmers were easy. At that time the commercial product of ABM mushroom farms was mostly dried mushrooms consumed as a health promoter with immuno-modulatory proper-

[1] *Agaricus blazei* (Murrill) ss. Heinemann, widely cultivated nowadays, was lately described as *Agaricus brasiliensis* by S. Wasser *et al.*

ties.

At present, the production areas have expanded to other states such as Minas Gerais (Southeast), Paraná, Santa Catarina and Rio Grande do Sul (South) as well as to some of the Northeast States such as Bahia and Ceará (Fig. 1).

Exportations of ABM sharply increased from 1996 to 1998, were steady until 2001, but in the last two years these exportations have decreased due to competition with other producers and the economic crisis in Japan (Fig. 2).

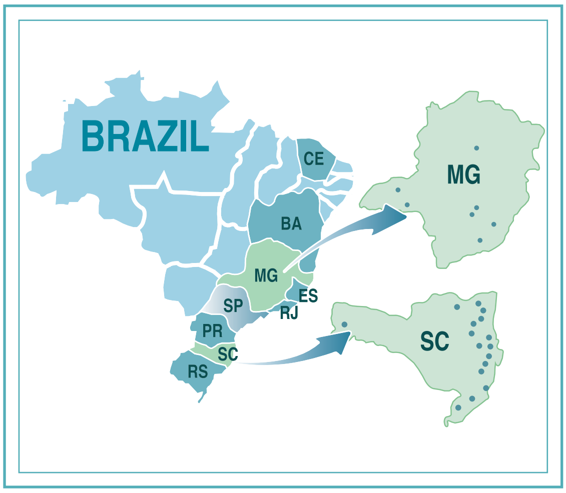

Figure 1. Regions in Brazil where Agaricus blazei has been cultivated. **SP**- State of São Paulo main national producer; **MG** and **SC**- detail showing farming localities in states of Minas Gerais (MG) and Santa Catarina (SC); **RS**-Rio Grande do Sul; PR-Paraná; RJ-Rio de Janeiro; ES-Espirito Santo; BA-Bahia; CE-Ceará

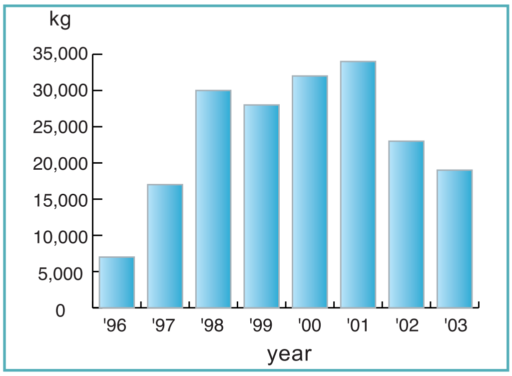

Figure 2. Brazilian exportation of Agaricus blazei from 1996 to 2003

Brazilian ABM mushroom growers export to a variety of countries including Australia, Bolivia, Germany, South Africa, Thailand, the USA, India and Korea. At the same time as exportations have decreased there has been noticed an improvement of the local market, as the Brazilian population has became more aware of the mushroom's benefits.

Mushroom consumption in Brazil is low, at about 30g/year/*capita*, when compared to other countries such as France and Italy which have consumption values of 2.0kg and 1.3 kg/year/*capita*, respectively. The first species cultivated in Brazil was *Agaricus brunnescens*, the champignon. Sixty percent of the national champignon crop is consumed fresh.

Cultivation Technology of Agaricus blazei

Locations and climate

In Brazil, ABM has been cultivated in regions close to the Atlantic coast, of moderate to warm temperatures and of high humidity, from September to April. It is cultivated mostly as a seasonal crop in farms with a low to medium technology profile. Average farmers cultivate 3-5 tons of compost any growing season.

Temperature is a very important ecological factor in ABM growth and fruiting. Optimal temperatures are higher than those maintained for champignon cultivation. ABM is a subtropical species and requires temperatures of 25-28℃ for optimal mycelial growth and 22-25℃ for fruiting. The species is very sensitive to extreme temperatures out of the optimal range, which is a factor contributing to the regional and seasonal restrictions on cultivation. Farmers in regions where summer temperatures are higher than those in the optimal range have a tendency to have lowered yields due to the faster development of pathogens. In regions of low temperatures, productivity has a tendency to be lower, with a frequent absence of fruit body production, unless environmental controls are used.

Strains

Strains in Brazil vary in characteristics such as mycelial growth rate, optimal temperature for mycelial growth, optimal pH of substrate, fruiting body morphology and productivity. However, low genetic variability may, in a short period of time, make the crop susceptible to the pathogens and pests that are the common causes of low productivity. A frequent exchange of compost and spawn among different states has also facilitated the rapid spread of diseases and pests. A degenerated strain with low productivity was identified by Neves (2003), and even though variability among strains was low, important traits may have been involved in genetic changes.

Selection experiments performed under laboratory and greenhouse conditions have been recently performed in commercial scale experiments. The strains UFSC 51 (Figs. 3) and 52 are in the experimental phase in several farms in the State of Santa Catarina for an evaluation of their productivity under different seasonal productive systems.

Spawn

Figure 3. Strain being tested in farmers houses **A**: UFSC 51 strain under commercial growing conditions **B**: UFSC 51 grade A mushrooms produced in growing house without climate control equipment

Spawn may either be produced commercially by private enterprises or be available from government or educational intuitions.

Several spawn production technologies (solid-state fermentation or liquid fermentation) are being tested as well as different storage conditions, culture preservation methods and also containers for spawn production and storage (Figs. 4A and C). Mother spawn is available at the university laboratory for spawn manufacturers (Fig. 4B)

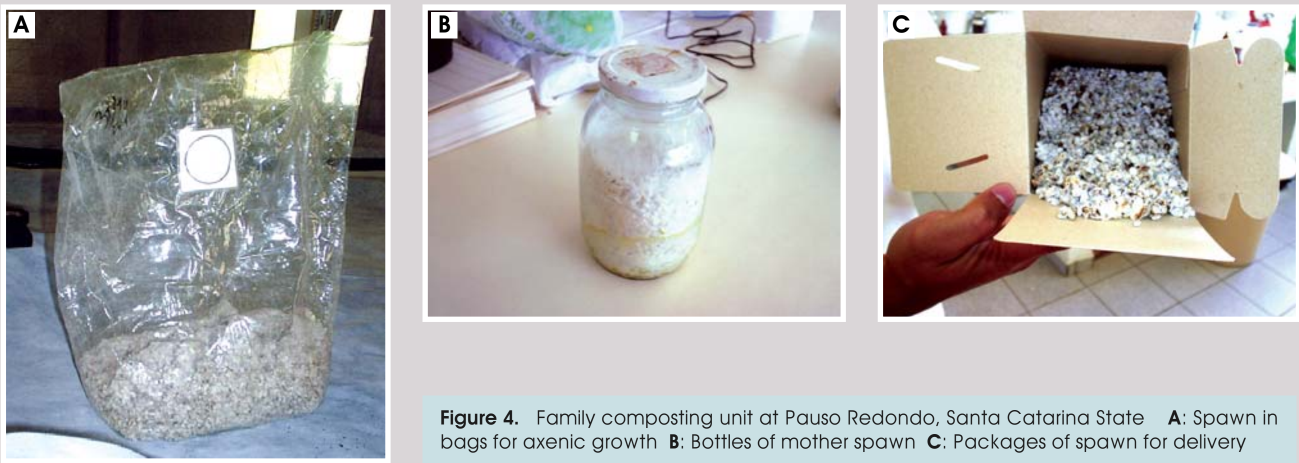

Figure 4. Family composting unit at Pauso Redondo, Santa Catarina State **A**: Spawn in bags for axenic growth **B**: Bottles of mother spawn **C**: Packages of spawn for delivery

Substrates

A small number of compost production units are established in Santa Catarina. Most of the substrate formulations used in the state are composed of corncobs, wheat and rice straws, or one of several other grasses.

Table 1 shows the substrate formulations used in Brazil – *A. brasiliensis*. In São Paulo State (sugarcane bagasse based). There are several compost production units at São Paulo State where the same compost for champignon is also used for *A. blazei*. The composting process involves a traditional fermentation (Phase I) followed by a pasteurization operation (Phase II) (Figs 5A, B and C).

Table 1. Sugarcane bagasse compost[2] formulation for A. brasiliensis

INGREDIENTS	WET WT(kg)
Sugarcane bagasse	3,000
Brachiaria sp. (grass)	1,500
Panicum sp.	1,500
Soybean bran	150
Urea	75
Ammonium sulphate	50
Phospahte	13
Gypsum	200
Calcarium	200
Water	7,700

Source: Eira, 2003

Compost is sold commercially either already inoculated and colonized or non-inoculated. Most farmers prefer the non-inoculated system and they inoculate with their own selected strains. Inoculation and spawn run is usually performed by the farmers at their growing houses as observed in Figure 5D. Spawn run usually takes 15-20 days depending on climate conditions. During the mycelial growth ventilation is minimal and the growing houses are maintained at temperatures of around 25-30℃, with a humidity 80-85%.

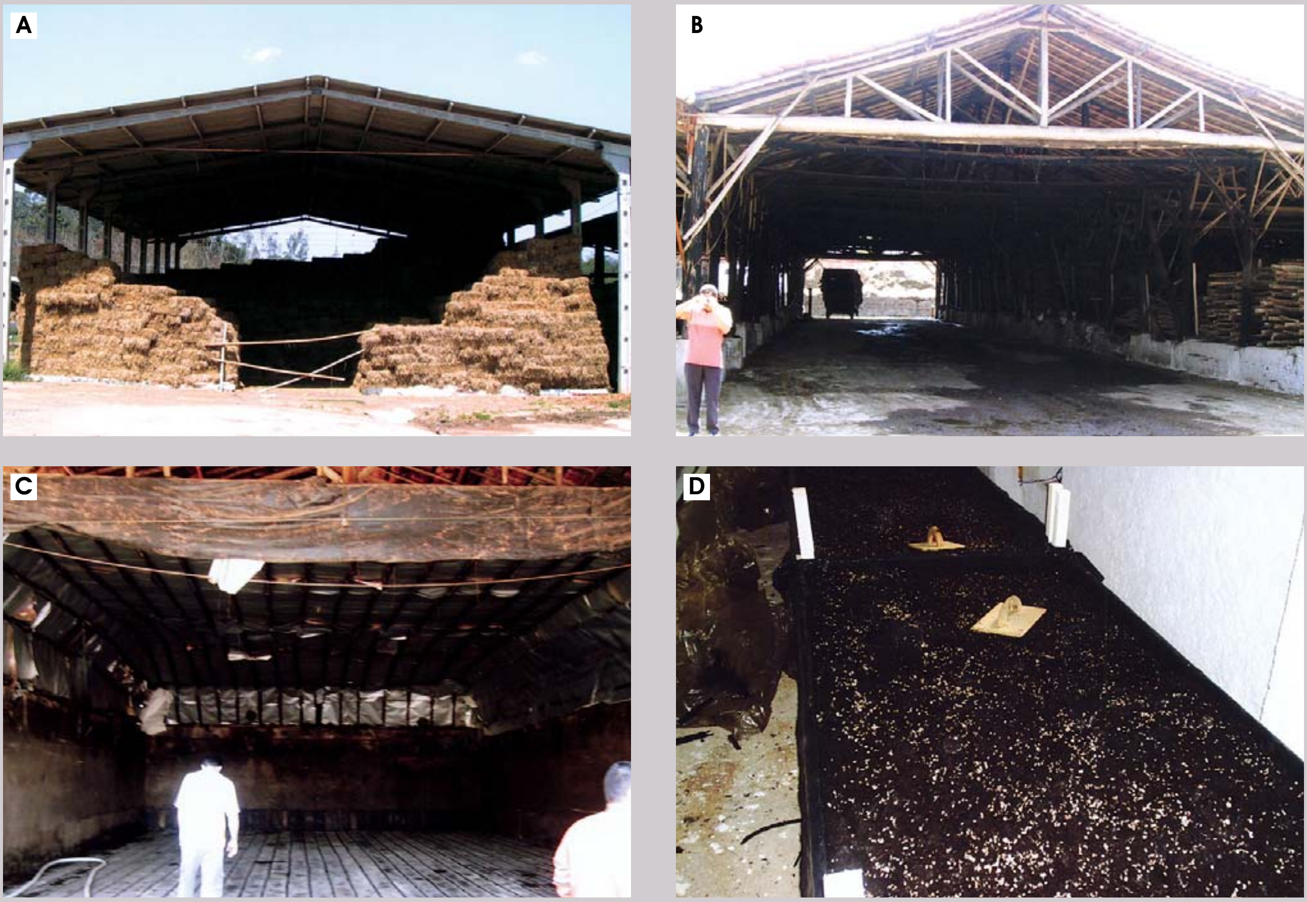

Figure 5. Composting unit in State of São Paulo **A**: Storage area of composting materials **B**: Fermentation area (phase I) **C**: Pasteurization room **D**: Compost inoculated at farmers growing house

[2] C/N=37/1

Casing

The different casing mixtures used include soil and sand, that are solarized or pasteurized for 6 hours in steam at 60-65℃, and peat based mixtures. The high incidence of soil borne contaminants, particularly nematodes and fungal pathogens has made clear the need to avoid soil and find substitute non soil-based mixtures. The State of Santa Catarina has an extensive area of peat and the university is involved in a research project to define a better peat based substrate for casing. Several mixtures are being tested involving different degradation stages of peat. Casing is applied when the mycelium spreads into 75% of the compost. Depth of the casing ranges from 3 to 5cm, depending on the environmental variability of the growing house. Mycelium spreads within the casing layer in about 15 days. The whole growing cycle requires around 20-21 days from casing to the first harvest. The subsequent harvesting periods (usually 2-3 flushes) may require an additional 30-60 days depending on environmental conditions.

Fruiting

Fruiting is induced by providing fresh air or ventilation (opening windows, use of exhausting equipments), lowering the temperature below 25℃, and providing enough air humidity (use of evaporative cooling, irrigation of growing houses floor and walls) and performing heavy irrigation of the substrate. The elimination of CO_2 (ventilation+substrate irrigation) is then an important factor in successful induction. In rare cases, growers have sophisticated climate control systems. Between flushes the mycelia are left to recover for some days and during this resting period irrigation is maintained at a minimum level.

Harvesting and processing

Figure 6. Harvesting and processing steps **A**: Collected mushrooms and eliminating soil particles **B**: Washing and brushing to eliminate cap pigment **C**: White mushrooms before drying process **D**: Introduced into the dryer

Mushrooms are harvested when they reaches their highest biomass, which occurs during the immature stage (button stage with veil membrane enclosing the gills intact) as seen in Figure 3B. Several processing phases follow the harvest, such as washing, brushing, selection, sanitization, sectioning, anti-oxidant treatment, drying, packing, selecting and storage (Figs. 6). Mushrooms are finally classified according to market standards as grade A, B or C, using as criteria the mushroom color (straw color, pale yellow), morphology and size.

Growing conditions

Seasonal cultivation in Santa Catarina is mostly done indoors, and undertaken either in plastic, wooden or brick houses (Figs. 7). Most of the farmers have no equipment for climate control. However a few have simple cooling systems (evaporative systems) or simple heating systems built by the farmer. The average size of a house ranges from 90 to 120m² ranging from 6 × 15 × 3.5m to 8 × 15 × 3.5m.

Figure 7. Growing conditions: under growing room conditions **A-D**: Different types of growing houses **E**: Outdoor **F,G**: A growing house made by plastic **H**: Beds and **I**: Trays

Pests and Diseases

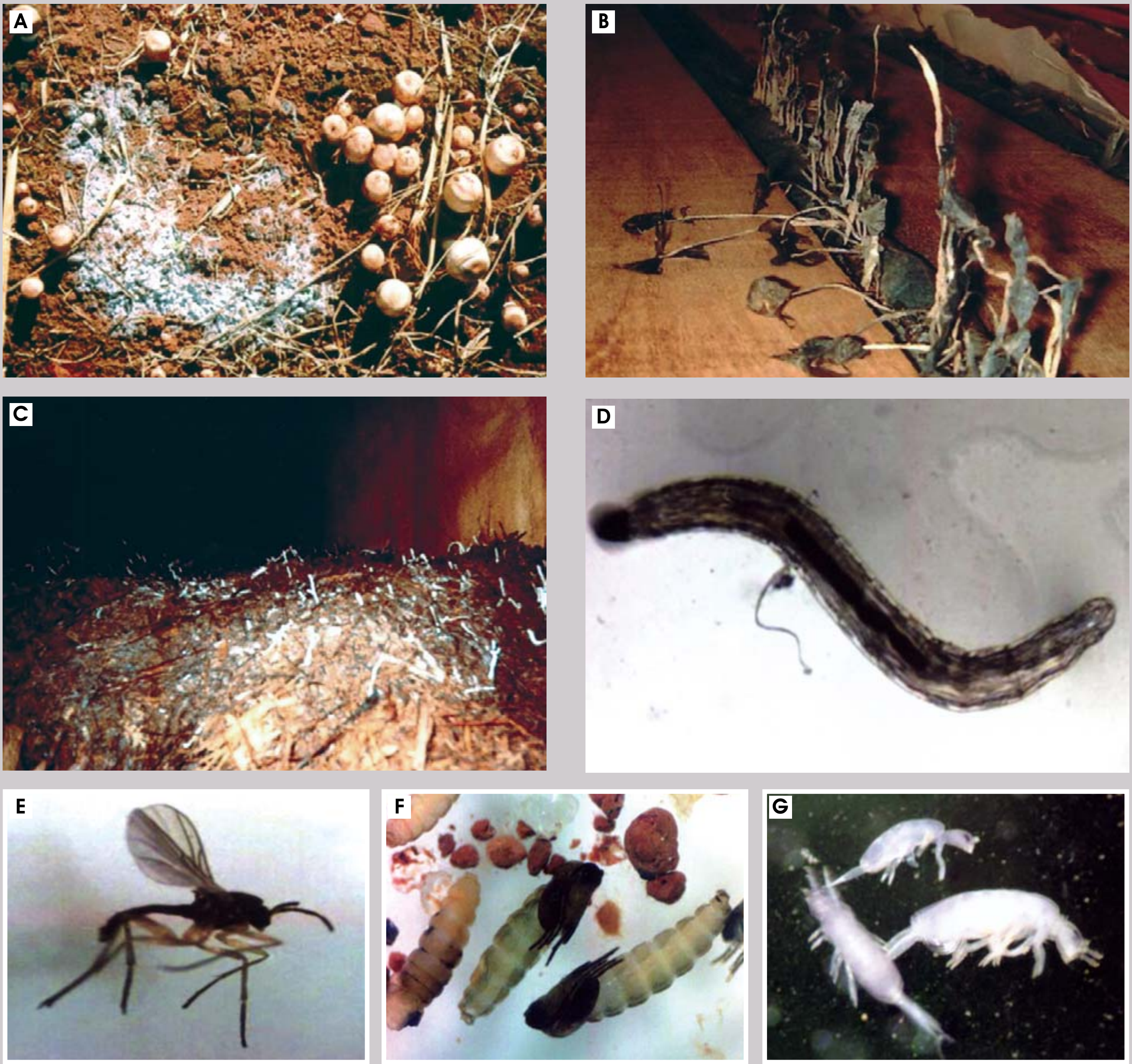

Figure 8. Important diseases and pests in the State of Santa Catarina **A**: Trichoderma sp. **B**: Coprinus sp. (bellow substrate bed) **C**: Coprinus sp. on the substrate **D**: Lycoriella larvae **E**: Lycoriella sp. **F**: Lycoriella pupae stage **G**: Collembola

Main problems in cultivation of *Agaricus blazei* are caused by insects (*Lycoriella* sp.) and fungus contamination (as the "false truffle" (*Diehliomyces* sp.), *Coprinus comatus*, *Trichoderma* sp., *Chaetomium* sp. and *Papulospora* sp.), indicators of low quality compost.

Parasitic fungi occur often in farms with inadequate management techniques. Non-disinfected casing layers and other poor hygiene and non existent prevention practices lead to many parasitic fungi problems.

The most serious fungal disease diagnosed in SC was the "false truffle" in 1999, that was responsible for heavy losses (50-80% loss of production) in several farms in the regions of Jaraguá do Sul and Benedito Novo, in the northern region. The source of contamination was inadequately composted substrate introduced from another State.

Pests are often responsible for even heavier losses. Sciaridae flies frequently infest most farms. Phoridae have been present less frequently than *Lycoriella*, and *Collembola* was found in several farms but losses were reduced after the introduction of controlling measures. Mites and nematodes may occur after the first flush if the farmer does not use preventative measures.

Since this mushroom cultivation is still a recent phenomenon in the state, it is possible that the incidence of diseases will increase in the future. However, farmers are being educated in programs that teach them how to prevent serious problems and avoid the need for of pesticides.

Few pesticides have been used in the mushroom farms in Santa Catarina because most farmers sell their dried mushrooms for higher prices to consumers who are concerned about the use of pesticides. The most commonly used pesticides, for the control of flies, are Decis (deltamethrin) and Dimilin (diflubenzuron).

Production and Products of A. blazei

There are no official statistics on the country's mushroom production but it is estimated that total production is around 3,000 tons per year (0.12% of world production), involving around BRL[3] 10 million (USD3.6 millions). The State of São Paulo, Região do Alto Tietê, is the biggest producer of mushrooms in the country, and accounts for 70-80% of the national production.

Brazil is not a significant participant in the world mushroom market because the national production so low. Part of the local demand, mostly for champignon, is supplied by importations from different countries, such as Chile, China, India and Indonesia. From 1997 to 2000 the exportation volume was significantly inferior to the volume of importations. However, whereas importations involved species of consumed fresh, as the champignon, with low economical value, exportations involve dried, sliced or powdered mushrooms, mostly *A. blazei*, that is a high valued product in the market. As a result, the commercial balance of mushroom activity in Brazil has been extremely positive due to the production of *A. blazei* for export.

Figure 9. Biotecnological products made with Agaricus blazei mushrooms commercialized in Brazil **A**: Supplements **B**: Cosmetic products (Photo courtesy of Renata May)

[3] BRL (Brazilian Real, USD1 ≒ BRL 2.8 in March, 2005)

Cost and benefit of Agaricus blazei

Productivity as measured as a wet weight of mushrooms compared to the wet weight of the substrate used varies between 5 and 20%. Most farmers average a ratio of 10%. Mushroom prices are quite variable, depending on the region, the season and the production technology, with values ranging from BRL80.00 (USD28.57) to BRL200.00 (USD71.43)/kg of dried mushrooms {average price type A is BRL140.00 (USD50)}. Farmers' profits are also quite variable, particularly if external marketers are used, and may reach values from 42.6% to 74.8% .

Cost and benefit of *A. blazei* mushroom production (for 3 months up to 3 flushes) in a farm with a seasonal production in a simple 120m² growing house, with 5,000kg of compost.

Based on 1% productivity (average)				
Content	**Unit**	**Quantity**	**Unit value**	**Amount in BRL**
Mushroom Type A	Kg	25	200.00	5,000.00
Mushroom Type B	kg	25	120.00	3,000.00
Re-sale of compost	kg	5,000	0.12	600.00
Total revenue (A)				**8,600.00 (USD3,071.43)**
Variable costs				
Compost	kg	5,000	0.65	3,250.00
Silica gel	bags 25g	100	1.20	120.00
PPL bags	kg	1	10.00	10.00
Pit casing layer	bags 25kg	50	7.00	350.00
Cleaning chemicals	1	4	2.50	10.00
Electricity	kw/h	700	0.50	350.00
Water	m³	2.5	2.50	6.25
Labour	days	72	25.00	1,800.00
Freight	unit	3	100.00	300.00
Tax (2.3% on A)	%	2.3	8,600.00	197.80
Total variable costs (B)				**6,394.05 (USD2,283.59)**
Gross margin (A-B)				**2,205.95 (USD787.84)**
Fixed costs				
(based on na investment of BRL 18.422.00 for 120m² growing house a dryer and washing facilities)				
Repairs and maintenance	%	1	18,422.00	46.06
Depreciation on buildings	%	4	18,422.00	184.22
Depreciation on machines	%	10	18,422.00	460.55
Interest on capital (6%/yr)	%	6	18,422.00	276.33
Total fixed costs (C)				**967.16 (USD345.41)**
Total cost of production (B+C)				**7,361.21 (USD2,629.00)**
Net profit				**1,238.80 (USD442.43)**

Sensitivity analysis	**Total revenue**	**Variable cost**	**Gros Margin**	**Fixed cost**	**Profit**
1% productivity	8,600.00	6,394.05	2,205.95	967.16	1,238.79
1.5% productivity	12,600.00	7,345.43	5,254.57	967.16	4,287.41
2% productivity	16,600.00	8,069.30	8,530.70	967.16	7,563.54

Benefit / Cost analysis	**Benefit**	**Cost**	**B / C**
1% productivity	8,600.00	7,361.21	1.17
1.5% productivity	12,600.00	8,312.59	1.52
2% productivity	16,600.00	9,036.46	1.84

Perspectives for Low Income Farms in Developing Countries

Good profits are usually obtained when farmers have access to good quality spawn and compost and also have the basic knowledge of culture management. There is no need for sophisticated growing houses or technologies in order to generate a profit with seasonal production systems. However, the availability of these basic ingredients for success occurs only when cooperative relationships between governmental institutions and farmers are established.

As Brazil is an extensive and diverse country with different agro-climatic regions, with great differences in the types of residues available for substrate production, cultivation technologies must be selected regionally. Furthermore, each state has its own priorities that are defined by governmental programs which are established periodically. The State of Santa Catarina, in South Brazil, has defined mushroom cultivation as one of the priority crops in the agricultural program of the State in 2004. A previous successful experience in the cultivation of ABM mushrooms occurred in 1999, in Garuva, Northern of Santa Catarina and the model for the present governmental project was set up. At present the project has been extended to several regions of the State and was improved with the participation of an association of farmers.

Based upon the program, technologies and research should be developed at universities and extended to the farmers through competent extension services. Knowledge should be transferred in programmed educational processes which should integrate scientists, extension experts and farmers. Successful cultivation should depend upon permanent organizations of support, such as a clinic for the diagnosis of problems, particularly pests and diseases, and a model farm to perform educational courses, where key production steps should be performed.

Farmers should be organized (in associations or cooperatives) and linked to governmental institutions (universities, extension services) so they can have competent support and apply efficiently to governmental funds.

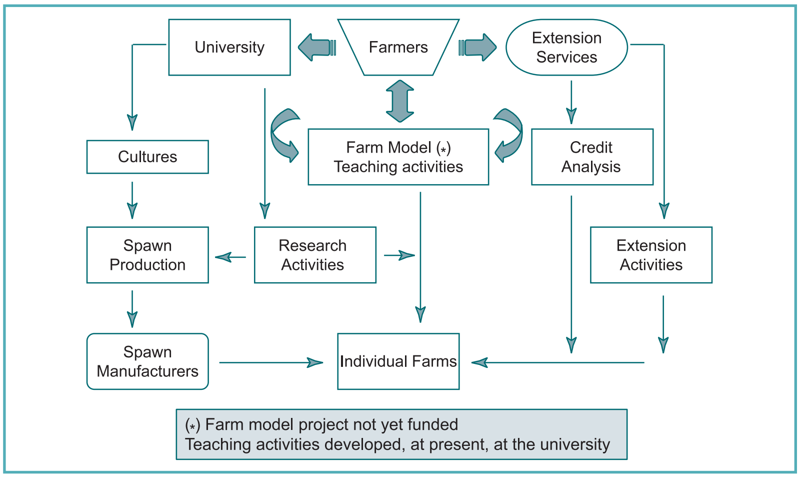

Figure 10. Interactions between farmers and governamental institutions in the State of Santa Catarina

As scientific and technological research on ABM improves, profitability will increase and risks on cultivation will be reduced. The species, being adapted to high temperatures, is very interesting as an alternative for developing countries, to improve the amount of protein in the diet (mushroom has around 49% protein, high protein content) and also to reduce poverty (high price in the international market).

If seasonal cultivation is selected, low investments on infrastructure are required. However, success is dependant upon some type of technical support for cultivation and marketing particularly if foreign markets are targeted.

According to Eira (2003) attention should be paid to avoiding the main causes responsible for a decrease in farm profits. The causes include:

- Low quality compost, spawn and casing layers
- High incidence of pests, diseases and contaminants
- Environmental factors not managed according to the species requirement
- Late harvesting that results in low quality products
- Low market prices due to lack of good marketing strategies

Conclusion

Agaricus blazei is an interesting alternative to developing countries because:

It is a versatile mushroom and has multiple uses including medicinal, cosmetic and food use. It has a high level of protein so it may be used as a nutraceutic (functional food). Consumption and cultivation promotes health in the population. Cultivation of ABM contributes to sustainable agriculture efforts by making use of agricultural residues. Has relatively high price in the international market. It is economically viable to cultivate ABM if three basic factors are considered: use of quality spawn, compost and good culture management. As the mushroom is mostly consumed dried it may be stored for long periods and there is no need to immediately commercialize the product.

REFERENCES

- Chen, A. 2001. Cultivation of *Agaricus blazei* Murrill, a mushroom of culinary and biomedical importance. *International Journal of Medicinal Mushrooms* 1: 291-301.
- Cogumelos :mercado e comercialização. available at *http://www.faemg.org.br/*
- Eira, A.F. 2003. Cultivo do Cogumelo Medicinal, *Agaricus blazei* (Murrill) ss. Heinemann ou *Agaricus brasiliensis* (Wasser *et al*.). *Editora Aprenda Fácil*. Viçosa, MG. 395.
- Kopytowski Fo, J. 2002. Relação C/N e proporção de fontes de nitrogenadas na produtividade de *Agaricus blazei* Murrill e poder calorífico do composto. Dissertação de Mestrado, Universidade Estadual Paulista Julio de Mesquita Filho, Campus Botucatu. 96p.
- Nascimento, J.S. 2003. Etiologia, controle e demanda de energia na prevenção da falsa trufa Diehliomyces microsporum) em cultivos de *Agaricus blazei*. Tese de Doutorado, Universidade Estadual Paulista Julio de Mesquita Filho, Campus Botucatu. 114p.
- Neves, M.A. 2000. Caracterização ecológica, fisiológica e genética de *Agaricus balzei* Murrill através de estirpes provenientes de diferentes empresas de produção de cogumelos. Dissertação de Mestrado, Universidade Federal de Santa Catarina. 69p.
- Wasser, S.P., Didukh, M.Y., Amazonas, M.A. de A., Nevo, E., P. Stamets, and Eira, A.F. 2003. Is a widely cultivated culinary-medicinal Royal Sun Agaricus (the Himematsutake mushroom) indeed *Agaricus blazei* Murrill? MushWorld website. available at http://www.mushworld.com)