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# The Medicinal *Agaricus* Cultivated in Brazil, a Versatile Multiple-Use Mushroom, in the Context of the Recent Brazilian Economic Growth

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## Abstract

The well-known medicinal *Agaricus* cultivated in Brazil is an important player in the research and development of the country's mushroom business. Here we attempt to contextualize the Brazilian new economic growth scenario as a great opportunity for this business upgrading. The multiple uses of the mushroom are discussed. A paradigm shift in order to prioritize the domestic market, while keeping in mind the export opportunities, is proposed. We also draw attention to the establishment of international partnerships as a way of leveraging the mushroom industry development in Brazil.

**Keywords.** *Agaricus blazei*, *Agaricus brasiliensis*, *Agaricus subrufescens*, Medicinal Use, Non-medicinal Use, Cosmetic Industry, Functional Food, Food Safety, Obesity, Marketing

## The New Brazilian Economic Growth Scenario

Brazil's economy is based on large and well-developed agricultural, mining, manufacturing, and service sectors. Although facing many drawbacks, the country is experiencing a strong economic growth. According to the Global Competitiveness Index-GCI 2011 – 2012 (World Economic Forum, 2011), Brazil, at the 53<sup>rd</sup> position out of 133 countries, benefits from several competitive strengths, including one of the world's largest internal markets (10<sup>th</sup>) and a sophisticated business environment (31<sup>st</sup>). Moreover, the country has one of the most efficient financial markets (40<sup>th</sup>) and one of the highest rates of technological adoption (47<sup>th</sup>) and innovation (44<sup>th</sup>) in Latin American and Caribbean. On a less positive note, Brazil still suffers from weaknesses that hinder its capacity to fulfil its tremendous competitive potential. The lagging quality of its overall infrastructure (104<sup>th</sup>) despite its Growth Acceleration Programme (PAC), its macroeconomic imbalances (115<sup>th</sup>), the poor overall quality of its education system (115<sup>th</sup>), the rigidities in its labour market (121<sup>st</sup>), and insufficient progress to boost competition (132<sup>nd</sup>) are areas of increasing concern.

According to the US Central Intelligence Agency (CIA, 2012a), since 2003, Brazil has steadily improved its macroeconomic stability. After strong growth in 2007 and 2008, the onset of the global financial crisis hit the country. However, it was one of the first emerging markets to begin a recovery. In 2010, consumer and investor confidence revived and GDP growth reached 7.5%, the highest growth rate in the past 25 years. Rising inflation led the authorities to take measures to cool the economy; these actions and the deteriorating international economic situation slowed growth to 2.7% in 2011, though forecasts for 2012 growth are somewhat higher. Despite slower growth in 2011, Brazil overtook the United Kingdom as the world's



seventh largest economy in terms of the Gross Domestic Product index (GDP index). Urban unemployment is at the historic low of 4.7% (December 2011), and Brazil's traditionally high level of income inequality has declined. Brazil's high interest rates make it an attractive destination for foreign investors. Large capital inflows over the past several years have contributed to the appreciation of the currency, hurting the competitiveness of Brazilian manufacturing and leading the government to intervene in foreign exchange markets and raise taxes on some foreign capital inflows.

## **Mushrooms as Functional Foods & Obesity as a Health Concern in Brazil**

The concept of "functional foods" has evolved from the awareness of the relationship between diet and disease. A food may be considered to be functional if it contains a component (whether a nutrient or not) that affects one or more identified functions in the body in a positive manner. The US Academy of Science has defined functional foods as those that "encompass potentially healthful products" including "any modified or food ingredient that may provide a health benefit beyond the traditional nutrients it contains".

Nutrition is essential to support life but, paradoxically, can also be associated to many chronic diseases, as diabetes, hypertension, heart diseases and cancer. Nutrition Science has progressed from being largely epidemiologically-based on the greater understanding of the physiological and genetic mechanisms by which diet and individual food components influence health and disease. It is now largely recognized that the correct diet modulates many human body functions, participating in the maintenance of the state of good health (homeostasis), and so reducing the risk of many diseases.

Obesity is a serious health concern in many nations. Great efforts to improve dietary habits of their populace are a wise way to improve health quality and reduce medical expenditure. As the weight rises, so do the secondary risks associated with obesity, including cardiovascular disease, high blood pressure and type 2 diabetes. Also many types of cancer can now be linked to inappropriate diets. In contrast, regular consumption of fruits and vegetables - classical examples of functional foods - are considered as essential ingredients in cancer prevention programs.

The situation in Brazil is not so bad, but concern is due because the figures are growing up, especially among children and teenagers. Based on data of 2003, Brazil appears in the 52<sup>th</sup> position (11.1% of the population) in a ranking of 70 countries, when compared for obesity adult prevalence rate by the US Central Intelligence Agency (CIA 2012b). In a survey by the Brazilian Institute of Geography and Statistics in partnership with the Ministry of Health (Instituto Brasileiro de Geografia e Estatística-IBGE, 2010), data from more than 188 000 people of all ages and all over the country were analysed. Weight above the level considered healthy by the World Health Organization-WHO and obesity were found with great frequency, from 5 years old, in all income groups and regions of the country. Overweight reached 33% of children aged five to nine years, 21% of teenagers and 49% of adults. The figures for obesity were: 14%, 5% and 15% of children, teenagers and adults, respectively. Comparing the data with previous studies (1974/1975), it was shown a jump in the number of overweight and obese people in all groups: 3.4 ×, 3.6 × and 2.1 × for overweight and 6.0 ×, 9.0 × and 2.7 × for obesity among children, teenagers and adults, respectively.

To prevent obesity in Brazil, the Ministry of Health launched this year (March 5 - 9, 2012) the first edition of the Week Health at School (*Semana Saúde na Escola*), with main focus in the prevention of obesity in childhood and adolescence. This campaign is part of the governmental Health at School Program (*Programa Saúde na Escola*), which is in process since 2007 under the coordination of the Ministries of Health and Education. Students aged 5 - 19 years, from 22 000 public schools, in 1 938 municipalities, were



nutritionally evaluated and oriented by professionals from the team of the Family Health Program (*Programa Saúde da Família*). The overweight ones were sent to the Basic Health Units (*Unidades Básicas de Saúde*). This initiative aims to prevent an “epidemic” of young adults with hypertension and diabetes type 2, and must be extended to private schools, where the figures are even worse. (<http://www.abeso.org.br/lenoticia/852/para-combater-a-obesidade-nas-escolas.shtml>).

In this scenario, mushrooms can well be introduced as health food and encouraged to be included in the normal diet of the Brazilians. Their nutritional qualities, as well as tonic and medicinal attributes, have long been recognized. Diet therapy—the use of food to sustain or improve health or treat illness—was used by ordinary people and in the imperial court of China 2 000 years ago. Chang (2009) presents a good illustrative pyramid model for the mushroom industry—fully conforms to the ancient Chinese motto “Medicines and food have a common origin”—where mushrooms as a food (functional food) forms the base of the pyramid, as a tonic (traditional medicine/nutraceuticals) stands in the middle, and as a medicine, in the top.

There is increasing experimentally-based evidence to support centuries of observations regarding the nutritional and medicinal benefits of mushrooms. Generally, edible mushrooms fulfil all three levels of food function in diet: primary (nutrition), secondary (flavour, aroma and texture), and tertiary (physiological functions). Regarding to nutritional value, mushrooms are rich in high quality proteins (all nine essential amino acids are present), fibers (chitin,  $\beta$ -glucans and heteroglucans), vitamins (particularly B and D), and special minerals such as potassium, phosphorus and selenium (an excellent antioxidant). Furthermore, they are low in fat (and even better, with high proportions of unsaturated fatty acids, mainly linoleic acid), low in calories and cholesterol, as well as low in sodium. Edible mushrooms have a distinct flavour and aroma and good texture feature which make them suitable as a delicious foodstuff and also as a source of food flavouring substances. Regarding to the physiological functions, mushrooms produce several bioactive substances, including high molecular weight polysaccharides (mainly  $\beta$ -glucans), heteroglucans, chitinous substances, peptidoglucans, proteoglucans, lectins, dietary fibers, and low molecular weight organic substances such as terpenoids, sterols, and novel phenols. Therefore, one can say that mushrooms are a valuable health food in modern society (Chang, 2009).

Nowadays, a substantial amount of information on the health benefits of mushrooms can easily be found online, either as scientific papers or all kind of propaganda and advertises. Although claims on the efficacy and functions are frequently untrue or at least exaggerated by advertisement, in a broad sense, one can say that mushrooms are of good value in the following diet programs:

- low-glucose diet (prevention and treatment of diabetes)
- low-energy dense (low-calorie) diet (prevention and treatment of obesity and associated morbidity)
- low-cholesterol diet (prevention and treatment of cardiovascular diseases)
- low-sodium diet (prevention and treatment of hypertension)
- low-purine diet (prevention and treatment of gout)
- high-fiber diet (prevention and treatment of colitis and cancer of the colon)
- ovolactovegetarian and vegan diets (particularly as a source of high quality protein and vitamin D).

### **The Mushrooms and Health Global Initiative**

Developing the mushroom industry by increasing the demand for mushrooms is the desired goal for many growers, supply chains, politicians, health authorities, and the scientific community around the world. Key benefits include: increased gross value production via increased consumption and/or price; improved



community health and reduced healthcare costs; and increased scientific activity and research investment (Seymour, 2008). On the other hand, in the Western world, due to strong expectation, bulk production has taken the lead and overproduction of the most consumed mushroom (*Agaricus bisporus*, the button mushroom) occurs regularly. Low pricing is harmful to the socio-economical structure of the industry and, therefore, measures have to be taken to introduce mushrooms as a true health food (van Griensven, 2009).

An international collaborative project that provides the scientific underpinning of global mushrooms and health communication efforts and local marketing strategies designed to increase the demand for mushrooms was launched by a partnership between USA and Australia. Then, other countries joined the consortium: Canada, United Kingdom, Ireland, Netherlands, Belgium, France, Germany, Denmark, Spain, Italy and Poland. The project, called 'The Mushrooms and Health Global Initiative - MHGI', is a key component of the International Society for Mushroom Science (ISMS) effort and was launched during the 4<sup>th</sup> International Medicinal Mushroom Conference (Slovenia, 2007), following a meeting of the Australian Mushroom Growers Association and the U. S. Mushroom Council. The 2010 report and the MHGI Bulletin are excellent sources for updated literature and are available for free download at <http://www.mushroomsandhealth.com/>.

### **The Gourmet and Medicinal Champignon do Brasil and its Multiple-uses**

There is no official statistics on mushroom production and commercialization in Brazil. It can be observed, however, that it is rapidly expanding. Dias (2010) gives a good review on mushroom cultivation in Brazil, its challenges and potential for growth. In the world ranking, the country has a small and insignificant participation, but being the fifth biggest population of the world (more than 190 million inhabitants)-behind only China, India, United States and Indonesia-Brazil is an obvious great potential market. An increasing interest is going on due to the efforts of the mushroom community, the good moment of the country economy in recent years, and the fact that consumers are more and more aware of the benefits of health foods. Besides, as the production increases, the prices become more attractive.

The most promising cultivated mushroom in Brazil is *Agaricus brasiliensis*. The mushroom has reached the uppermost ranks among the best of all gourmet and medicinal mushrooms (Largeteau et al., 2011). It is an interesting alternative to developing countries because of its versatility being useful both in the medicine, as in the cosmetic and food sectors (Mendonça et al., 2005). Other potential uses worthwhile to be explored are discussed by Largeteau et al. (2011): industrial production of lignocellulolytic enzymes in solid-state fermentation or by extraction from spent cultivation substrates; application of extracts of the mushroom and its spent compost in organic agriculture for the control of plant pathogens; use of spent compost as an alternative to chemicals to promote plant growth when considering organic production of horticultural crops and Eucalyptus growing in artificial forests; remediation of biocides; and substitution of antibiotics in chicken farming. Moreover, like for mushrooms in general, its cultivation also contributes to sustainable agriculture efforts by making use of agricultural residues.

The mushroom is known in Brazil under many vernacular names such as Piedade mushroom (in allusion to the village where it was first found in the country and sent to Japan for its medicinal properties study), medicinal mushroom, sun mushroom (Cogumelo do Sol<sup>®</sup>), the Almond Portobello (due to its fragrance and taste) and Champignon do Brasil (proposed by Amazonas and Siqueira, 2003, in allusion to its congener *Agaricus bisporus*, the Champignon de Paris). In Japan, it is called Himematsutake, Agarikusutake and Kawariharatake; in China, Ji Song Rong; and, in other countries, Royal Sun Agaricus<sup>®</sup>. Among its medicinal properties allegations, the immunomodulator and anti-tumour effects are the most widely



documented, besides the glucose and cholesterol reduction actions. Its high content of ergosterol, vitamin D precursor, also gives him important attributes in the fight of bone diseases, as rachitis and osteoporosis. Many reports in literature also point the mushroom as nutritionally valuable, with a large gastronomic potential, combining peculiar characteristics of taste, almond flavour and excellent texture (Stamets, 2000; Stijve et al., 2001, 2002, 2003, 2004; Amazonas and Siqueira, 2003; Amazonas, 2005; Escouto et al., 2005). Moreover, it has been used in cosmetics by some Brazilian initiatives as, for instance, Vitamega Cosmetic (<http://www.alibaba.com/member/vita10.html>) and Aproconova-Associação dos Produtores de Cogumelo do Norte de Minas e Vale do Jequitinhonha (Sebrae-MG, 2007). It is worth to highlight that Brazil is an ideal market for cosmetic products taking into account its large population and its culture of self-image. Brazil's per capita spending on cosmetics and toiletries is roughly 1.7% of GDP-more than double of that in France (0.7%), triple of that in Britain (0.5%), and quadruple in the United States (0.4%) (Casanova and Fraser, 2008).

Some good reviews have been recently published indicating a worldwide interest in the Brazilian medicinal mushroom. One of them, from Norway, focus on its medicinal effects on tumour, infection, allergy and inflammation (Hetland et al., 2011). Another, from France, deals with its biological characteristics, cultivation and non-medicinal valorisation (Largeteau et al., 2011). And a third one, from Thailand, China and France, summarizes its taxonomy, phylogeny, distribution, health benefits and current status of scientific research (Wisitrassameewong et al., 2012).

Food safety studies have shown that the human trials carried out to date suggest that the mushrooms and mushroom extracts of the *Agaricus* species tested are safe and generally well tolerated. Agaritine in cultivated *A. bisporus* has been reported in some animal model studies to be associated with potential carcinogenic effects, although this has been contradicted by other studies in the same animal models. A recent study has demonstrated that agaritine purified from *A. blazei* has direct anti-tumour activity against leukemic tumour cells *in vitro*, which is in contrast to the carcinogenic activity previously ascribed to this compound. These data provide support for the conclusion of a recently published scientific critique of studies on agaritine, which concluded that there is no scientifically substantiated data linking consumption of mushrooms to carcinogenicity in either animal models or humans. (Roupas et al., 2010).

From the nomenclatural point of view, taxonomists agree that the species has been incorrectly referred to as *Agaricus blazei* Murrill, a species originally described from Florida. The improper use of this species name is due to misidentification by the Belgium botanist Paul Heinemann who studied the fungus sent from the small village Piedade, located in the Brazilian State of São Paulo, to Japan in 1965. Heinemann only communicated his identification to the scientific community in a paper published in 1993. The fungus was again found in nature in Brazil in 2001 and, in a detailed comparative morphological study, Solomom Wasser and coll. demonstrated that the North American endemic species *A. blazei* ss. Murrill and the widely cultivated medicinal *A. blazei* ss. Heinem. are two different species. A new species, *Agaricus brasiliensis* Wasser, Didukh, Amazonas & Stamets, was proposed (Wasser et al., 2002) and then synonymised by Kerrigan (2005), based on genetic and interfertility testing, with *A. subrufescens* Peck, a species first described by the American botanist Charles Horton Peck, in 1893, and cultivated for the table in the eastern United States during the late 19<sup>th</sup> and early 20<sup>th</sup> centuries. Two years later, Philippe Callac noted that the nomination of *A. brasiliensis* for this fungus was illegitimate because it is a later homonym of *A. brasiliensis* Fr. 1830. In this context, Wisitrassameewong et al. (2012) refer to the mushroom as *Agaricus subrufescens* Peck and, accordingly, attribute to this species the results of studies on mushrooms named as *A. blazei* and *A. brasiliensis*. However, as they declare, all the data concerning the medicinal properties reported are based on



studies of a limited number of isolates, all or nearly all of them from the local population in Brazil. It is believed that the majority of the strains spread over the world most probably come from the culture originally sent from Piedade to Japan.

As for the mushroom business, changes in a species name pose a big problem because the entrepreneurs have to submit their products to the legislation of the country in order to get permission for commercialization. In Brazil, according to the legislation, foods presented as capsules, pills, and tablets, consisting of edible parts of fruits and vegetables submitted to process of drying or dehydration, must be evaluated as new foods. So far, under this category, only the names *Agaricus blazei* and *Agaricus sylvaticus* Schaeffer have already been approved (ANVISA, 2008). This is the main reason why most products from Brazil are commercialized under the name *Agaricus blazei*. Only the company Cogumelo do Sol® uses the name *Agaricus sylvaticus* Schaeffer, another example of misidentification problem (Amazonas, 2005).

Thanks to a great marketing strategy in Japan, the mushroom reached a high status among the medicinal natural products. Japan has become the greatest importer of the Brazilian production. Many farmers and people with no previous agricultural activity experience have realized the promise of high profits and a rapid expansion of the mushroom cultivation took place in different regions of the country. This had a positive effect on changing the perception of the Brazilians towards mushrooms. Poisonous and hallucinogenic mushrooms are usually what first come to the mind of most Brazilians when approached by someone talking about mushrooms. Gradually, the Brazilian medicinal mushroom and other edible mushroom species are becoming more and more popular in the country especially due to the claims of their health benefits (Dias, 2010).

The euphoria of the early times, however, was broken in 2006, when three cases of severe hepatic dysfunction in cancer patients were reported in Japan supposedly associated with the use of *Agaricus blazei* extract products, although it was impossible to confirm this suspicion because other causative factors such as cancer chemotherapy and hepatitis virus could not be completely ruled out (Mukai et al., 2006). According to the Brazilian Embassy in Tokyo (SECOM, 2010), as a precaution measure, the Japanese Ministry of Health, Labour and Welfare (MHLW) recommended to the manufacturers the suspension of sales and voluntary withdrawal of products from the market. Three products under suspicion were analysed for toxicity by the Japanese National Institute of Health Science and one of them showed cancer stimulatory effect. Although the product in question did not utilize mushrooms from Brazil origin, the Brazilian suppliers were hit hard. From 2006 to 2008, there was a cut of about 76% of the Japanese importation. Brazil, being responsible for about 80% of the total Japanese importation, was the country most affected by the new Japanese consumers perception about the benefits of the mushroom. This drastic declination caused a great impact on the vulnerable Brazilian mushroom growers, because 90% of their production was destined for export, almost all of it to Japan. Many growers failed to run their business and had to suffer big losses. In 2009, the export market to Japan stabilized, with a slight recover. Although it is early to predict whether it will return to the levels of 2004, a new wave of optimism due to the Brazilian economically favourable conditions is in the air among the growers that managed to maintain the business directing their products to the domestic market and exporting whenever possible.

## Opportunities and Further Prospects

In The Global Competitiveness Report 2009 – 2010, World Economic Forum, Sala-I-Martin et al. (2009) highlight that, together with Mexico, Brazil has been at the forefront of the new Latin American-based multinationals (*Multilatinas*) phenomenon by which, thanks to superior technology and organization, local



companies have successfully turned global, while others are in the way to. These companies are making this transition notably by investing massively abroad, in the region and beyond, and thus realizing an increasing portion of their revenues internationally.

In mushroom business, however, Brazil is still in its early childhood. In the particular case of the Champignon do Brasil, to face a demand of the Japanese market, interested only in the medicine use of the mushroom, the country had to learn by trial and error all the steps involved in the cultivation, processing and commercialization, without a previous solid activity experience target to its own home market. All went very well until the crisis triggered by Japan import declination in 2006, when most growers were crushed. The situation is reverting from 2009, but hopefully, the growers have learnt the lesson. There is a huge domestic potential market to be explored, which could guarantee the success of the business on a steadier basis, instead of trusting only on the high prices offered by export business.

Besides the recent Brazilian economic growth, the fact that Brazil will be the site of the 2014 World Cup and the 2016 Olympic Games has attracted the investment of many multinational companies that are now making commitments to set up offices in the country. Mushroom entrepreneurs thinking in expanding their business through international partnership should consider Brazil as a good deal opportunity. And the Brazilian mushroom entrepreneurs, instead of taking this as a threat, could well hold the especial moment to learn about global market dynamics. I believe that international scientists and entrepreneurs partnership for the establishment of strong mushroom cultivation and processing plants, based on fair mutual benefit projections and solid partners confidence, could well be a good deal for foreign investors and the Brazilian mushroom industry development. Beyond the use of the medicinal and cosmetic mushroom products, with a regular supply of fresh and dried mushroom to supermarkets and restaurants throughout the year and good marketing campaigns soon the mushroom could well become much popular in the country. In this context, the expertise of the Mushrooms and Health Global Initiative could be of great help. The first approach in this direction was done by Greg Seymour - president of the ISMS - during the Fourth International Symposium on Mushrooms in Brazil, held in Caxias do Sul, State of Rio Grande do Sul, in 2008 (Seymour, 2008). It is time to go forward!

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