ACTA SCIENTIARUM POLONORUM *Acta Sci. Pol., Hortorum Cultus 12(1) 2013, 27-40*

ALMOND MUSHROOM *Agaricus brasiliensis* (Wasser *et al.*) – PROPERTIES AND CULTURE CONDITIONS

Jolanta Lisiecka, Krzysztof Sobieralski, Marek Siwulski, Agnieszka Jasińska

Poznań University of Life Sciences

Abstract. Almond mushroom – *Agaricus brasiliensis* (Wasser *et al*.) was discovered and popularised as late as the 20th century. However, it has been known for its exceptional properties in the places of its origin for a long time. Studies have been conducted worldwide for several decades, aiming at the precise determination of these properties and their applicability in medicine. To date it has been proven that almond mushroom extracts exhibit anticancer and antibacterial action, and reduce blood cholesterol level. They are also useful in the treatment of AIDS, diabetes, hypertension and viral hepatitis. Almond mushroom is a very tasty mushroom with an almond aroma. This species is also characterised by high protein content and low fat content. For appropriate growth and development almond mushroom requires relatively high temperatures and air humidity as well as access of light. However, world literature sources contain limited data concerning the cultivation technology of almond mushroom. In Poland almond mushroom is practically unknown, while its considerable therapeutic properties should be an incentive to initiate more extensive studies.

Key words: *Agaricus blazei*, medicinal mushrooms, cultivation, substrate

INTRODUCTION

Almond mushroom – *Agaricus brasiliensis* (Wasser *et al*.), sometimes referred to as *A. blazei* (Murrill ss. Heinem.) or *A. subrufescens* (Peck) is an edible mushroom coming from southern Brazil [Wasser et al. 2002, Dias et al. 2004, Kerrigan 2005]. In Brazil it is called "Cogumelo do Sol", in Japan it is "Himematsutake", "Agarikusutake" and "Kawarihiratake", while in China it is known as "Ji Song Rong" [Stamets 2000, Dias et al. 2004, Firenzuoli et al. 2008, Largeteau et al. 2011]. According to Amazonas [2005] and Wasser et al. [2002], almond mushroom is a highly attractive mushroom both due to its medicinal properties and culinary value.

Corresponding author – Adres do korespondencji: Jolanta Lisiecka, Department of Vegetable Crops, Poznań University of Life Sciences, Dąbrowskiego 159, 60-594 Poznań, Poland, e-mail: lisica@up.poznan.pl

Studies on almond mushroom were initiated in mid-1960's in Japan, where its large-scale commercial cultivation was started, subsequently popularized in other Far East countries. For several years this species has been grown also in the United States, Denmark and Holland [Mizuno 2000, Stamets 2000, Stijve and Amazonas 2002, Stijve et al. 2002; 2004, Chen 2003, Largeteau et al. 2011]. As it was reported by Dias et al. [2004], in Brazil the large-scale cultivation of almond mushroom was started as late as 1990. At present Japan is the biggest producer and consumer of *A. brasiliensis* [Chen 2003, Dias et al. 2004].

In recent years this species has been the subject of numerous studies, concerning first of all its medicinal properties [Watanabe et al. 2002, Dias et al. 2004, Kimura et al. 2004, Souza-Paccola et al. 2004, Kim et al. 2005, Firenzuoli et al. 2008, Ueguchi et al. 2011], which in the opinion of Dias et al. [2004] and Stijve and Amazonas [2002] to a considerable degree have contributed to the popularization of cultivation of this mushroom. As it was reported by Ahn et al. [2004] and Yoshimura et al. [2005], fruiting bodies of *A. brasiliensis* are used in the prevention of cancer and as a complementary medication in chemotherapy.

CHARACTERISTICS OF THE SPECIES

Taxonomy and origin of almond mushroom for many years have raised controversies among researchers [Wasser et al. 2002, Kerrigan 2005, Wasser 2011]. This species is found under different names, most frequently being referred to as *Agaricus blazei* Murrill [*sensu* Heinemann], and recently *Agaricus brasiliensis* Wasser et al. [Kerrigan 2005, Wasser 2011]. Taxonomically this mushroom is classified to the kingdom *Fungi*, division *Basidiomycetes*, order *Agaricales*, family *Agaricaceae*, genus *Agaricus* [Wasser et al. 2002, Dias et al. 2004].

Almond mushroom is a medium-sized mushroom, forming caps of 7.5–12 (14) cm in diameter. Initially the cap is hemispherical, with a slightly undulating and squamulose surface, with the margins splitting with age, it is covered with white spots and its central part becomes slightly convex. While maturing the cap flattens and its margins fold upwards, forming a distinct hollow. A mature cap is dark brown and shaped like an inverted, truncated cone with a smooth surface. In the central part the cap is relatively thick [up to 1 cm]. Its margin is relatively thin, unfolded, with visible remnants of the partial veil. Gills are not attached to the stem, relatively dense, thin, of 0.7–0.9 cm in thickness. Initially they are white to pink in colour. With age they turn light-grey, and finally chocolate brown or grey-brown. Almond mushrooms form brown spores of 4.2 to 6.3 μm in size. They are oval to ellipsoid and have a smooth surface. The stipe is white and smooth, set centrally, initially solid it becomes hollow with age, and of 10–13.5 cm in length. It is distinctly bulbous at the base. After the rupture of the partial veil a membranous annulus is formed, slightly undulating at the margin, being of 1.5–3.5 cm in width. It is clearly visible in mature fruiting bodies. The body is fleshy, white and has a pleasant mushroomy aroma and a somewhat sweet taste [Wasser et al. 2002].

Almond mushroom is a saprophytic species, growing well on soils rich in lignocellulose residue [Stamets 2000]. As it was reported by Stamets [2000], Wasser et al. [2002] and Dias et al. [2004], natural habitats for this species include mixed forests, first of all their margins, as well as fields in upland and mountainous areas of Brazil and Peru.

NUTRITIVE VALUE AND MEDICINAL PROPERTIES

In recent years interest in macromycetes as sources of minerals, essential amino acids, vitamins and dietary fiber has increased significantly [Mattila et al. 2002, Bernaś et al. 2006]. Moreover, mushrooms supply specific substances with a unique health-promoting action [Wasser et al. 2000, Lindequist et al. 2005], thus they are frequently called nutraceutics or nutriceutics and are considered functional food or dietary supplements [Mattila et al. 2000, Camelini et al. 2005, Chang 2008].

Almond mushroom, apart from valuable medicinal properties, also have considerable contents of protein, carbohydrates, minerals and low fat contents [Largeteau et al. 2011]. Fruiting bodies of almond mushroom contain 38–45% protein, 38–45% carbohydrates, 3–4% fat and 5–7% minerals, mainly potassium (2.5%), phosphorus (1%) and magnesium (0.1%) in dry matter [Mizuno 1995, Amazonas 2005]. According to Liu et al. [2008], 100 g dry matter of fruiting bodies contains 38.5 g protein, 27.7 g carbohydrates, 2.6 g fat as well as 2920 mg potassium, 952 mg phosphorus and 96.5 mg magnesium. In the contrary, Tsai et al. [2008] found less protein (26%) and fat (2.6%). Studies showed that fruiting bodies contain also other minerals and vitamins, especially B_1, B_2, and niacin [Mizuno 1995, 2002; Amazonas 2005, Liu et al. 2008]. This species is also rich in amino acids, i.e. glutamic and aspartic acids, as well as alanine and sugars such as mannitol, trehalose, glucose, fructose and arabitol [Huang 1997, Stamets 2000, Stijve et al. 2002, Tsai et al. 2008]. Stijve et al. [2002] and Gyorfi et al. [2010] stated that caps of fruiting bodies have a greater nutritive value than the stipe and mycelium. According to Mizuno [1995] water accounts for 85–87% fresh fruiting bodies of almond mushroom. Gyorfi [2007] reported that fruiting bodies of almond mushroom contain less water than those of white button mushroom (*Agaricus bisporus*).

Since 1991 almond mushroom has become a very popular dietary supplement among the Japanese. At present on the Japanese market approx. 100 producers offer around 20 different supplements, which annual consumption is estimated at 15–20 ton [Ohno et al. 2011]. As it was reported by Takaku et al. [2001], annual production of dried fruiting bodies in that country amounts to 100–300 ton, consumed for medicinal purposes by 300–500 thousand people. In Japan almond mushroom is commonly used in alternative medicine for its anticancer properties [Takeda and Okumura 2004, Yuminamochi et al. 2007].

Compounds exhibiting anticancer action were extracted for the first time from fruiting bodies of almond mushroom by Kawagishi et al. [1989]. Bioactive substances obtained from almond mushroom include e.g. polysaccharides, steroids and lectins [Gonzaga et al. 2005, Kimura et al. 2004]. As it was reported by Gyorfi [2007], almond mushroom contains higher amount of soluble polysaccharides than white button mush-

room. Studies conducted by Smiderle et al. [2011] showed that polysaccharides of white button mushroom include first of all mannogalactan, while almond mushroom contains particularly β-glucans. Moreover, it was found that the amount and diversity of α- and β-glucans contained in almond mushroom increase with the maturation of fruiting bodies [Camelini et al. 2005, Firenzuoli et al. 2008]. The anticancer activity of polysaccharides contained in fruiting bodies of almond mushroom was confirmed by numerous researchers [Fujimiya et al. 1998, Mizuno et al. 1999, Novaes et al. 2007, Firenzuoli et al. 2008, Angeli et al. 2009, Gonzaga et al. 2009]. Moreover, it was shown that polysaccharides contained in fruiting bodies promote the production of interferon and interleukines [Yuminamochi et al. 2007]. Ergosterol, inhibiting the development of cancer cells, was detected in almond mushroom [Takaku et al. 2001], along with sodium pyruvate, preventing metastasis, and further development of sarcoma-180 [Kimura et al. 2004], as well as agaritine killing leukemia cells [Endo et al. 2010].

As studies have shown, apart from their anticancer properties, extract from fruiting bodies of almond mushroom also exhibit antibacterial [Bernardshaw et al. 2005], antiviral [Sorimachi et al. 2001] and antiallergenic properties [Ellertsen and Hetland 2009, Mizuno 2010]. Moreover, it reduces blood cholesterol level, stimulates the immune system and it is effective in AIDS treatment [Mizuno 2010, Liu et al. 2008, Lima et al. 2011]. It may also be used in the treatment of diabetes, arterial hypertension and viral hepatitis [Watanabe et al. 2002, Kim et al. 2005, Liu et al. 2008]. Chen and Shao [2006] showed that extract from fruiting bodies of almond mushroom may be applied as an adjuvant in different types of vaccines. Numerous studies have shown that it has antioxidant properties [Oliveira et al. 2007, Soares et al. 2009], which do not change under the influence of gamma radiation [Huang and Mau 2006]. Antimutagenic activity of extract of this mushroom was confirmed by studies conducted by Menoli et al. [2001] and Souza-Paccola et al. [2004].

Results of analyses indicate that extract from almond mushroom may be applied in plant protection against some pathogens [Di Piero et al. 2010] or used in the production of cosmetics [Hyde et al. 2010]. Ribas et al. [2009] stated the applicability of extract from the spent substrate of almond mushroom in bioremediation of soil and as a plant growth biostimulator.

Almond mushroom is a rich source of laccase [Largeteau et al. 2011]. According to Polak and Jarosz-Wilkołazka [2007], this enzyme participates in the synthesis of new or transformation of existing chemical compounds. Investigations conducted by D'Agostini et al. [2011] showed that the content of laccase in almond mushroom depends on the mutual proportions of carbon and nitrogen in the substrate.

Camelini et al. [2005] and Firenzuoli et al. [2008] reported that fruiting bodies of almond mushroom with open caps are characterised by a greater biological value, since they contain more glucans and proteins. However, it was not confirmed by other researchers [Bellini et al. 2003, Mourao et al. 2009]. Studies conducted by Mourao et al. [2011] showed a greater antioxidant activity of fruiting bodies with closed caps.

Fruiting bodies of almond mushroom have an almond aroma, provided by the presence of benzaldehyde and benzoic acid [Stamets 2000, Stijve et al. 2002, 2004]. As it was shown by Stijve et al. [2002, 2004] and Amazonas [2005], the content of benzoic acid in fruiting bodies enhances their post-harvest stability. Fruiting bodies of this *Aga-*

ricus contain sodium glutamate, which is responsible for their specific taste defined as umami [Tsai et al. 2008]. The term 'umami' is used to signify a unique and savory taste sensation that should be ranked as the fifth basic taste along with the four classical basic taste modalities: sour, sweet, salty and bitter [Marcus 2005]. As it was reported by Chen [2003], very tasty dishes may be prepared from almond mushroom. According to Escouto et al. [2005], almond mushroom is a species with a very high culinary potential.

CULTIVATION

Almond mushroom is the so-called secondary saprophyte, developing on partially processed substrate, in which microorganisms reduced complex ligno-cellulose compounds [Chen 2003]. Numerous authors have shown that due to the similar life cycle in the cultivation of almond mushroom technologies developed for white button mushroom may be applied. However, almond mushroom requires high temperature and high humidity as well as access to light to form fruiting bodies [Chen 2003, Dias et al. 2004, Siwulski and Sobieralski 2004, Mantovani et al. 2007, Dias 2010]. In Brazil, due to the advantageous climatic conditions this species is frequently grown outdoors; however, in other countries – mainly due to its high temperature requirements – such cultivation system is risky and may only be successful during very warm summers [Stamets 2000, Siwulski and Sobieralski 2004, Largeteau et al. 2011].

The results of *Agaricus* cultivation to a considerable degree are determined by the composition of the substrate. Unfortunately, there is a limited body of data concerning growing media for almond mushroom cultivation. Frequently producers, particularly in Brazil and Japan, use substrate with the composition developed for white button mushroom [Mantovani et al. 2007]. However, both species may respond differently to an identical substrate composition. For this reason it is essential to develop a substrate meeting requirements of almond mushroom [Zied et al. 2011]. The primary components in such a substrate are most frequently locally available materials, subjected to composting, e.g. agricultural waste rich in ligno-cellulose complexes, i.e. straw, cotton burrs, grasses, sawdust, enriched with animal manure, poultry dung, wheat or rice bran and calcium [Iwade and Mizuno 1997, Oei 2003, Pokhrel and Ohga 2007, Horm and Ohga 2008, Siqueira et al. 2009, Largeteau et al. 2011]. Wang et al. [2010] stated the applicability of asparagus post-harvest residue in the cultivation of almond mushroom. In turn, Gern et al. [2010] successfully applied substrate left after the growing of *Pleurotus* sp. with an addition of rice bran. It is fermented during composting, with microbiological changes and changes in the C:N ratio occurring in the course of the process [Chen 2003]. As it was reported by the same author, during fermentation, typically lasting for 23–25 days, temperature should not exceed 60ºC. A study by Gonzalez Matute et al. [2011] showed that uncomposted substrate may also be used in the cultivation of almond mushroom.

As it was stated by Siqueira et al. [2011], an adequate addition of nitrogen to the substrate rich in C considerably improves mycelium growth and quality of fruiting bodies. According to Andrade et al. [2007] and Siqueira et al. [2011], the optimal initial nitrogen content in the substrate should be 1–1.5%. The selection of the nitrogen source

is essential, since mushrooms from the division *Basidiomycetes* do not produce nitrate-reducing enzymes [Gerrits 1998]. For almond mushroom urea is the best source of nitrogen and the most advantageous C:N ratio ranges from 10:1 up to as much as 50:1 [Mantovani et al. 2007]. Table 1 presents examples of different substrates for almond mushroom growing.

Table 1. Composition of substrate for almond mushroom (composted)
Tabela 1. Skład podłoża uprawowego dla pieczarki brazylijskiej (kompostowane)

Iwade and Mizuno [1997] Huang [1997]	Huang [1997]	Huang [1997]	Oei [2003] Taiwan	Oei [2003] Korea
Rice or wheat straw (357 kg)	wheat straw (700 kg)	wheat straw (750 kg)	rice chaff (850 kg)	rice chaff (850 kg)
Rice bran (10 kg)	cotton burrs (125 kg)	sawdust (700 kg)	urea (10 kg)	urea (0.5 kg)
Poultry dung (15 kg)	dried cattle manure (150 kg)	ammonium sulfate (10 kg)	ammonium sulfate (20 kg)	poultry dung (63 kg)
Calcium carbonate (8 kg)	calcium sulfate (10 kg)	calcium sulfate (30 kg)	calcium phosphate (30 kg)	calcium sulfate (3 kg)
Ammonium sulfate (10 kg)	calcium phosphate (10 kg)	calcium phosphate (10 kg)	potassium sulfate (8 kg)	calcium phosphate (2 kg)
Calcium phosphate (5 kg)	urea (5 kg)	urea (5 kg)	calcium carbonate (25 kg)	—

Substrates, particularly those comprising industrial and agricultural waste, contain considerable amounts of microorganisms [Silva et al. 2009]. In order to eliminate pathogen infestation the fermented substrate is pasteurised at a temperature of 55–60ºC [Iwade and Mizuno 1997, Chen 2003]. Pasteurisation lasts for 8–10 h, after which the substrate is conditioned for 8–12 days at approx. 48ºC [Kopytowski Filho et al. 2006]. As it was reported by Chen [2003], when the substrate temperature drops to 25–35ºC it is spawned with granular mycelium, placed in the substrate in clusters at every 20 cm at a depth of approx. 10 cm [Chen 2003]. The amount of granular mycelium used per 1 m^2 culture ranges from 0.75 to 1 kg [Chen 2003, Park 2001]. Siqueira et al. [2009] and Wang et al. [2010] stated that mycelium should comprise from 1 to 2% substrate.

After spawning the substrate needs to be covered by with transparent perforated plastic film for a period of 7–10 days [Largeteau et al. [2011], which provides adequately high moisture content and access of light [Siwulski and Sobieralski 2004]. In the incubation period temperature needs to be controlled on a regular basis, as it should be 25–27°C. Care has to be taken to prevent damage to the culture as a result of excessive heating of the substrate by heat released by the growing mycelium [Chen 2003, Siwulski and Sobieralski 2004]. Mycelium completely overgrows the substrate after 15–20 days [Park 2001, Chen 2003, Siwulski and Sobieralski 2004, Mendonca et al. 2005]. After the substrate has been overgrown with the mycelium the plastic film needs

to be removed and a 2.5–5 cm casing layer needs to be spread [Chen 2003, Mendonca et al. 2005]. Mendonca et al. [2005] reported that the casing layer is spread when the 75% substrate is overgrown with mycelium. This typically occurs 20 days after spawning [Chen 2003]. According to Mendonca et al. [2005] and Stamets [2000] peat is the optimal casing layer. In turn, according to Chen [2003] the best casing layer is provided by fresh soil collected from deeper horizons, free from contaminants, with a high water holding capacity, friable, with a moisture content of 70–75%. Results of numerous studies indicate that the composition of the casing layer has a significant effect on the volume and earliness of yielding [Siqueira et al. 2009, Zied et al. 2010, 2011, Colauto et al. 2010, 2011]. The casing layer surface should be leveled, flat or with furrows of 10 cm in width, approx. 5 cm in height, spaced at 10–15 cm [Iwade and Mizuno 1997, Chen 2003, Siwulski and Sobieralski 2004]. According to Siwulski and Sobieralski [2004], the furrowed casing layer surface promotes the formation of a greater number of fruiting bodies. The first mycelium hyphae are visible on the casing layer surface after 7–10 days [Park 2001], and sometimes after 14 days [Siwulski and Sobieralski 2004] from casing. After the appearance of hyphae in the cultivation chamber temperature needs to be lowered by 2–3ºC, which has a positive effect on the formation of fruiting body primordia, which typically appear after 13–15 days [Park 2001, Siwulski and Sobieralski 2004]. Mendonca et al. [2005] reported that 15 to 20 days pass from casing to the first harvest. According to Chen [2003], approx. 10 days pass from the moment of setting of fruiting bodies to the consumption stage, with the entire production cycle lasting for 40 to 60 days.

FACTORS AFFECTING GROWTH AND YIELDING

Almond mushroom has high temperature, lighting and humidity requirements [Park 2001, Chen 2003, Siwulski and Sobieralski 2004]. According to Chang [2008], mycelium of this species grows over a relatively wide range of temperatures, i.e. from 15 to 35ºC, while according to Colauto et al. [2008] it is from 22 to 34ºC. In turn, data concerning optimal temperatures are relatively divergent and fall within the following ranges: 28–31ºC [Colauto et al. 2008], 28–30ºC [Neves et al. 2005], 25–30ºC [Siwulski and Sobieralski 2004], 25–28ºC [Mendonca et al. 2005], 23–27ºC [Chang 2008] and 20–33ºC [Huang 1997].

As it was reported by Siwulski and Sobieralski [2004], temperature below 20ºC and above 35ºC inhibits mycelium growth of almond mushroom, while at a temperature of 45ºC the mycelium dies. Largeteau et al. [2011] claimed that a temperature of 4ºC maintained over a longer period may also destroy mycelium.

In the period of mycelium incubation, i.e. the first stage of cultivation, the temperature should range from 23 to 27ºC [Huang 1997, Iwade and Mizuno 1997]. In turn, Stamets [2000] recommended a slightly wider range of temperatures, i.e. from 21 to 27ºC. Mendonca et al. [2005] stated that in the period of mycelium growth temperature should be maintained within the range of 25–30ºC.

Primordia of fruiting bodies in almond mushroom are formed at 21–25ºC [Huang 1997, Stamets 2000, Mendonca et al. 2005], while fruiting bodies for development

require a temperature of 23–27°C [Stamets 2000]. Largeteau et al. [2011] reported that providing changing temperatures promotes an increased yielding.

According to Iwade and Mizuno [1997] and Chang [2008], relative humidity during mycelium growth should be 60–75%. Mendonca et al. [2005] recommended maintenance of humidity within a range of 80 to 85%. In turn, Stamets [2000] and Siwulski and Sobieralski [2004] suggested 90–100%.

As it was reported by Mendonca et al. [2005], fruiting is induced by increased aeration and increased humidity and substrate moisture content. During the formation of primordia humidity should remain at 80–90% [Huang 1997, Stamets 2000, Largeteau et al. 2011], while during the development of fruiting bodies it should be 75–85% [Iwade and Mizuno 1997, Stamets 2000]. In turn, Chang [2008] recommended, both in the period of formation and growth of fruiting bodies, humidity at 70–85%.

The concentration of CO_2 during mycelium growth in the substrate is not significant. According to Stamets [2000], it should not exceed 5000 ppm. In the later cultivation period, particularly during the formation of fruiting body primordia, when as a result of intensive respiration great amounts of CO_2 are formed, its excess should be removed by regular ventilation [Chen 2003]. Stamets [2000] reported that during primordia formation the level of CO_2 should not exceed 800 ppm, while during the formation of fruiting bodies – 2000 ppm, respectively.

Mycelium in the period of substrate overgrowing does not require light; however, studies conducted by Park [2001] showed that at access of light mycelium grows faster. As it was reported by Stamets [2000], lighting is necessary during the formation of primordia and growth of fruiting bodies. Horm and Ohga [2008] in the period of fruiting applied light with an intensity of 500 lux for 12 h, but mushrooms developed equally well with no access of light.

Table 2. Factors affecting growth and yielding of almond mushroom
Tabela 2. Czynniki wpływające na wzrost grzybni i plonowanie pieczarki brazylijskiej

Factor – Czynnik	Mycelium growth Wzrost grzybni	Primordia formation Formowanie zawiązków	Fruiting bodies development Rozwój owocników
Temperature Temperatura, °C	21–27[7] 23–27[2, 3] 25–30[5]	21–25[2, 5, 7]	23–27[7]
Relative air humidity Względna wilgotność powietrza, %	60–75 [1, 3] 80–85[5] 90–100[6, 7]	70–85[1] 80–90[2, 4, 7]	70–85[1] 75–85[3, 7]
CO_2 concentration Stężenie CO_2, ppm	< 5000[7]	< 800[7]	< 2000[7]

1 – [Chang 2008], 2 – [Huang 1997], 3 – [Iwade and Mizuno 1997], 4 – [Largeteau et al. 2011], 5 – [Mendonca et al. 2005], 6 – [Siwulski and Sobieralski 2004], 7 – [Stamets 2000]

Substrate reaction should be pH 6–7, while too acid or too basic media inhibit mycelium growth [Park 2001]. According to Colauto et al. [2008], mycelium development in almond mushroom is distinctly inhibited at pH below 3 and above 8. As it was reported

by Kopytowski Filho et al. [2008], the application of substrate and casing layer at pH 7.0–7.5 contributes to growth of fruiting bodies in almond mushroom and at the same time inhibits the development of competitive mushrooms, particularly *Trichoderma* spp.

Table 2 presents some factors affecting growth and yielding of almond mushroom.

In Brazil the greatest losses in the cultivation of almond mushroom are caused by pests, particularly from the genus *Lycoriella*, as well as pathogens from the genera *Diehliomyces*, *Trichoderma*, *Chaetomium* and *Papulospora*, as well as a species *Coprinus comatus*. They originate first of all from an inappropriately prepared substrate and a lack of adequate hygiene during cultivation [Mendonca et al. 2005].

HARVEST OF FRUITING BODIES AND YIELD VOLUME

Harvest of fruiting bodies in almond mushroom is started when the partial veil is still unbroken and the cap is convex [Park 2001, Chen 2003, Siwulski and Sobieralski 2004]. Breaking of the partial veil and spilling of maturing spores deteriorate the quality of fruiting bodies [Chen 2003].

After harvest fruiting bodies of almond mushroom, whole or sliced, are dried for approx. 40 h [Chen 2003]. Initially the temperature of 40–50ºC is maintained for 1–2 h and next it is increased every hour by 1–2ºC [Park 2001]. Kopytowski Filho et al. [2006] reported high weight loss of fruiting bodies after drying – from 10 kg to approx. 1 kg. Stamets [2000], in order to extend shelf life of fruiting bodies, recommended their immediate cooling after harvest.

In comparison to other species from the genus *Agaricus*, yielding of almond mushroom is relatively low [Largeteau et al. 2011]. Zhou et al. [2010] from 1 m^2 culture obtained the amount of 9 kg fresh fruiting bodies. Kopytowski Filho et al. [2006] reported that the yield of this *Agaricus* species is 8–17 kg $\cdot$ m^{-2}. Yielding may last as long as 3–4 mouths, in 4–5 flushes [Chen 2003, Siwulski and Sobieralski 2004], within the intervals of approx. 10 days [Chen 2003]. In a study conducted by Mendonca et al. [2005] almond mushroom yielded for 50–80 days, in 2–3 flushes, while the entire culture cycle was 90–120 days. The cultivation cycle in a study by Zied et al. [2010] lasted from 70 to 100 days. Kopytowski Filho et al. [2006] stated that under controlled cultivation conditions the culture cycle of almond mushroom may be reduced to 70–90 days.

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PIECZARKA BRAZYLIJSKA *Agaricus brasiliensis* (Wasser *et al.*) – WŁAŚCIWOŚCI ORAZ WARUNKI UPRAWY

Streszczenie. Pieczarka brazylijska – *Agaricus brasiliensis* (Wasser *et al*.) została odkryta i spopularyzowana dopiero w XX w. Jednak od dawna znana była w miejscu swego pochodzenia z niezwykłych właściwości. Na świecie od kilkudziesięciu lat prowadzone są badania, których celem jest pełne poznanie tych własności i możliwość ich wykorzystania w medycynie. Do tej pory udowodniono, że wyciągi z pieczarki brazylijskiej wykazują działanie antynowotworowe, antybakteryjne, redukują poziom cholesterolu we krwi. Pomocne są także w leczeniu AIDS, cukrzycy, nadciśnienia i wirusowego zapalenia wątroby. Pieczarka brazylijska jest bardzo smacznym grzybem o migdałowym aromacie. Charakteryzuje się między innymi wysoką zawartością białka oraz niską zawartością tłuszczu. Dla prawidłowego wzrostu oraz rozwoju gatunek ten wymaga stosunkowo wysokiej temperatury i wilgotności powietrza oraz dostępu światła. Literatura światowa zawiera jednak niewiele danych dotyczących technologii uprawy pieczarki brazylijskiej. W Polsce pieczarka brazylijska jest praktycznie grzybem nieznanym, którego znaczące właściwości lecznicze powinny skłonić do podjęcia szerszych badań.

Słowa kluczowe: *Agaricus blazei*, grzyby lecznicze, uprawa, podłoże

Accepted for print – Zaakceptowano do druku: 20.06.2012