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SHORT NOTE [NOTA CORTA]

ECONOMIC VIABILITY OF MUSHROOMS CULTIVATION TO POVERTY REDUCTION IN BANGLADESH

[VIABILIDAD ECONÓMICA DEL CULTIVO DE HONGOS COMESTIBLES PARA LA REDUCCIÓN DE LA POBREZA EN BANGLADESH]

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SUMMARY

Mushroom is an important vegetable usually grows in the forest with its nutritive and medicinal value. It can also be cultivated domestically in a small scale by landless people. The climate of Bangladesh is highly favourable for high volume of mushroom production. The cultivation of mushroom is one of the lucrative agricultural job. In our study the profitability of mushroom cultivation was found comparatively higher than that of rice and wheat, the most popular cash earning crops in Bangladesh. As funding to promote the production and consumption of mushrooms is limited, local government and NGOs can play vital role to develop mushroom agriculture to arise at industrial level which can create ample employment opportunities both in semi-urban and rural areas. This result suggests that the potential of mushroom cultivation could be a possible offer to alleviate poverty and develop the life style of the vulnerable people in Bangladesh.

Keywords: Economic analysis, Employment, Food value, Mushroom cultivation, Poverty

RESUMEN

Los hongos comestibles son un product comestible que generalmente crece en los bisques y cuenta con valor medicinal y nutritive. También pueden ser cultivados domestivamente a pequeña escala por gente sin acceso a tierras de cultivo. El clima de Bangladesh es favorable para la producción a escala de hongos. Su cultivo es una actividad agrícola lucrativa. Este estudio encontró que la rentabilidad del cultivo de hongos es mayor que el cultivo de arroz y trigo (cultivos con alta rentabilidad en Bangladesh). Debido a que los fondos para la promoción de la producción y consumo de hongos son limitados, la participación de los gobiernos locales y ONG's es vital para desarrollar la producción de hongos a escala industrial, lo que crearía mayores oportunidades de empleo tanto en área rurales como peri-urbanas. Los resultados sugieren que el cultivo de hongos es una oferta potencial para reducir la pobreza y mejorar el nivel de vida de la población vulnerable en Bangladesh.

Palabras clave: Análisis económico, empleo, valor del alimento, cultivo de hongos comestibles, pobreza.

INTRODUCTION

Bangladesh is an agriculture based developing country and about 84% of the population is directly or indirectly engaged in a wide range of agricultural activities (GOB, 2007). Population density of this country is the highest in the world is suffering from protein malnutrition with high proportion of poverty. According to recent estimates, 49.8 percent population lives under the poverty line (UNDP, 2006). Population of Bangladesh may increase from 158.66 million in 2006 to 206.02 million in 2025 and annual growth rate is 1.7 percent (ESCAP, 2007). Reduced income coupled with increased expenditure on healthcare in a country already facing stiff economic challenges has worsened the poverty situation. Due to the frequency of natural calamities and livestock diseases in this part of the world as well as the high cost of conventional agricultural production, the people of Bangladesh are anxious to develop an alternative source of protein with

a high potential income generation. In this situation mushroom cultivation could be the potential offer of solution to poverty reduction. Although knowledge and production level are still limited in Bangladesh, yet mushroom has focused much interest in the past few years. One might say that the different NGO's and farms have literally cultivated mushrooms here recently. It is hoped that the new hut industry of mushroom cultivation in Bangladesh will soon provide an important tool for income generation and the creation of food security for thousands of households. Unlike other agronomic crops, the set-up, costs-benefits and space for mushroom cultivation are recommendable. Fertilizers, machinery and pesticides are not much used, the market price is relatively high and profit margins for mushroom crops can be considerably higher than traditional crops. In general the project takes very little space and can produce returns within a short period of time. Bangladeshi farmers who are using local varieties of seed can grow rice and wheat crops that take an average of four months to reach harvest maturity. This time period is equivalent to at least two crops of mushrooms cultivation. Considering this scenario, the relative profitability of these three crops can be compared even the input costs of mushrooms enterprise were to be doubled and would still remain more profitable than that of either rice or wheat. Therefore, potential mushrooms cultivation may play an active role to employment generation and thus alleviate poverty. The main objective of this study is to focus on alternative job opportunities which could be potential income source as well as to prove the economic viability of mushroom cultivation and how does it may play to alleviate poverty in Bangladesh.

MATERIALS AND METHODS

Mushroom

Mushroom is any of various fleshy fungi, characteristically having an umbrella-shaped cap borne on a stalk grows usually in the forest. 'Mushroom' is not a taxonomic category. The term 'mushroom' is 'a macro-fungus with a distinctive fruiting body, which can be either hypogeous or epigeous, large enough to be seen with the naked eye and to be picked by hand' (Chang and Miles, 1992). From a biological taxonomic point of view, mainly basidiomycetes but also some species of mushrooms belong to ascomycetes. The number of mushroom species on the earth is estimated to be 140000 and only 10% are known. The proportion of useful mushrooms among the undiscovered and unexamined mushrooms may be 5%, which can be of possible benefit to mankind (Hawksworth, 2001).

Important factors of mushroom cultivation

Spawn: The spawn of mushroom is like seed is to crop. Unlike spore, spawn is already at its mycelial stage growing on its own substrate such as sawdust. The life cycle of mushroom starts from spores, but growers inoculate mycelial origin spawn rather than spore origin spawn because of possible variations and mutations. The quality of spawn is one of the most critical factors for successful crop. Therefore, growers need to use qualified spawn for commercial production. Spawn maintains the strain characteristics and is propagated by subcultures. The various types of mushroom spawn include grain, sawdust, plug and liquid.

Substrate: Mushrooms can be classified as 3 categories by their tropic pattern; saprophytes, parasites or mycorrhizae. The most commonly grown mushrooms are saprophytes, decomposers in an ecosystem growing on organic matters like wood, leaves and straw in nature. Raw materials can be used as substrate for primary decomposers such as oyster mushroom which have lignocellulosic enzymes. On the other hand, secondary decomposers like button mushroom or straw mushroom require substrate degraded by bacteria or other fungi. Mushroom requires carbon, nitrogen and inorganic compounds as its nutritional sources and the main nutrients are carbon sources such as cellulose, hemicellulose and lignin. Thus, most organic matters containing cellulose, hemicellulose or lignin can be used as mushroom substrate. Examples are cotton, cottonseed hull, corncob, sugarcane waste, sawdust, and so on. However, demanded amount of each nutritional source differs according to mushroom species. For example, oyster mushroom and shiitake require less nitrogen and more carbon source but button mushroom (*Agaricus bisporus*) requires relatively high nitrogen source. Mushroom mycelia secrete digestive enzymes into the substrate and absorb the dissolved nutrients. Cellulose, the main nutritional source of mushroom is one of the most abundant organic matters on earth, but its digestive enzyme, cellulase is owned by several microorganisms including fungi. Mushroom is also influenced by acidity of substrate. The optimal pH value of substrate ranges from 6 to 8, varying with mushroom species.

Environment: The last important factor for mushroom growing is providing an appropriate environment both for vegetative and reproductive growth. Not being protected by a skin layer, fungi are easily affected by their growing conditions. So it can be said that the success or failure of mushroom cultivation depends on the control of growing conditions. Environmental factors affecting mushroom

cultivation include temperature, humidity, light and ventilation. Optimal levels of them at vegetative stage differ from those at reproductive stage. Mushroom mycelia can survive between 5 and 40°C depending on the species. Mushroom mycelia grow well with the temperature range between 20 and 30 °C. Substrate moisture content should be 60-75% and log moisture content, 35-45%. During fruiting, different relative humidity levels, ranging from 80-95%, are needed at the early, mid and latter stage. Though mycelia like dark to grow but some species require light for fruiting body formation. Being aerobic fungi, mushrooms need fresh air during growing and ventilation is more required for reproductive stage. In conclusion, among the three factors, the most important is environmental control. By maintaining optimal conditions at each growing stage and for each species, growers can produce the desired yield of quality mushrooms.

Mushroom cultivation method in Bangladesh

There are many methods of mushroom cultivation but bag cultivation, bottle cultivation, log cultivation and shelf cultivation are usually common. Rice straw, wheat straw, sugarcane waste, banana leaves, grass and sawdust are the major fibrous residues important for mushroom cultivation substrates. The pasteurized substrate is usually spawned and packed into polythene bags of about 30cm wide and 60~90cm long for the bag culture of the oyster mushroom. The growing rooms are maintained at between 18 °C ~ 25 °C, with a relative humidity of about 75%. Although up to 6 flushes may be obtained from each bag, the first three are the most important in commercial production. For every 10kg of dry substrate used, as much as 20kg of mushroom can be harvested from the first 3~4 flushes. At least 2~3kg are usually harvested per bag. During the cooler winter season, *Pleurotus ostreatus* is cultivated while the more heat tolerant *P. sajor-caju* is produced in summer. The button mushroom, most often grown by well-financed growers, is the main export mushroom. For button mushroom cultivation, wheat straw and cow manure are mixed and used as substrate. Some farmers add inorganic fertilizers and/or peat. Cultivation is carried out in trays. Lower temperatures of about 18 °C need to be maintained and diseases and pests must be closely monitored. The expenses and requirements for strict management of the growing room have restricted the number of newcomers going into button mushroom production.

Data collection

Research methods were used as structured interviews of 60 households focused especially on experiences and actual costs and benefits of mushroom, rice and wheat cultivation. Focus group discussion (FGD) and observation were also carried out in order to determine the motivation and capacities of both cultivation practices. Other data were gathered by way of interviews with key informants (Government, non-government, public organizations, books and daily newspaper) and market prospecting. The secondary data were used from statistical yearbooks, local administrative and various related sources. For many elements of the study (cultivation practices, actual cost and benefit etc.), semi-quantitative analysis was carried out for mushroom and other crops (rice and wheat) cultivation at the household level.

RESULTS AND DISCUSSION

The economic analysis of mushroom production was calculated. The production cost of first and second round was tk. 20,000.00 (including house cost) and tk.10,700.00 (excluding house cost), respectively. Average net profit of first and second round was measured tk. 10,000.00 and tk. 19,300.00, respectively. After 4 months, average net profit was tk. 29,300.00 where total investment was tk. 20,000.00 because the income earned from first round can be used to cultivate second round (Table 1). The profitability of rice, wheat and mushroom was also evaluated and found that mushroom cultivation is the lucrative one. We considered one acre of land for rice and wheat cultivation, and 30′×18′ in size growing house for mushroom cultivation. After four months, the net income of rice and wheat were tk.12,240.00 and tk.24,360.00 where total cost were tk.11,760.00 and tk.7,640.00, respectively. Within the same time the cost and benefit of mushroom was tk. 30,700.00 and tk.29,300.00, respectively. Interestingly within this four months period mushroom was cultivated two times where average production cost and benefit was tk.20,000.00 and tk.10,000.00 for the first round (costs including house), and tk.10,700.00 and tk.19,300.00 for the second round (costs excluding house), respectively (Table 1 and 2). The relative profitability of these three crops can be focused as the mushroom cultivation is more profitable. In Zimbabwe farmers have been benefited more by growing mushroom than maize and wheat. The net income of mushroom, maize and wheat are ZWD 1703000.00, ZWD 518500.00 and ZWD 1140000.00, respectively (MushWorld, 2004). This result is quite similar to our findings. To the aim of poverty reduction in Bangladesh, mushroom cultivation could be potential job. Because Bangladesh is located in a tropical monsoon climate which is ideally considered for high elevation of mushroom production. Mushroom cultivation can be popular to income generation among the women in Bangladesh because of its suitability to

their works and life style. As they are especially responsible for household works and taking care of their children, thus they can easily accommodate their time for mushroom cultivation. This product is highly nutritious and a good food for their children and the older as well. They also obtain some money from this product because of its high economic value. They can utilize the agricultural waste, and thus mushroom cultivation can improve the life of many poor families in Bangladesh. Cultivation of mushrooms is labor-intensive for the countries where jobs are rare. In fact, some technologies can use family labor thus providing employment for all of the family members.

Unfortunately, funding to promote the production and consumption of mushrooms is limited in Bangladesh. But the potential of mushroom cultivation to poverty reduction among the vulnerable groups like women are especially encouraged. In this context, an assistance of the local government is important for the development of mushroom industry which can create job opportunities both in semi-urban and rural areas. Here we assumed a project how farmers will pay their loan. Our findings indicate that the growing set-up, costs-benefits and space for mushroom cultivation are recommendable as well as pay back of loan is easier than other crops. According to estimate of Table 3, the loan tk. 20,000.00 with interest will be fully paid after four months which is difficult for other crops. In the estimated project, one mushroom grower can produce about 5~6 crops, 3 tons per year on average. Therefore, he can earn tk. 73,250.00~87,900.00 (USD 1098.70 ~ 1318.14) per year.

Table 1. Economic analysis of mushroom production (USD 1= BDT 66.67)

Item	Quantity	Cost in BDT	Cost in USD
Straw for 200 bags	800 kg (4 kg/bag)	2,000.00	30.00
Spawn (250g/bottle)	100 bottles (BDT 25/bottle)	2,500.00	37.50
Plastic bags	large and small in size	1,000.00	15.00
Chemicals		1,000.00	15.00
Labor (30 days)	BDT 80/day	2,400.00	36.00
Miscellaneous	10% of total cost	1,800.00	27.00
House	30 feet × 18 feet	9,300.00	139.50
Total Production Cost (1st round*, with house cost)		20,000.00	300.00
Total Production Cost (2nd round, without house cost)		1,0700.00	160.00
Total Income (each round)		24,000.00-36,000.00	360.00-540.00
Net Profit (1st round)		4,000.00-16,000.00	60.00-240.00
Net Profit (2nd round)		13,300.00-25,300.00	200.00-380.00
Average Net Profit/4 months		29,300.00	440.00

Production cost in BDT is calculated based on the highest round figure of money, *Each round takes 2 months, one month for growing and another month for harvest. Total Production: 400-600 kg/2 months (2-3 kg/bag). Price: BDT 60.00/kg

Table 2. Compared profitability of rice, wheat and oyster mushroom in Bangladesh

Item	Rice	Wheat	Oyster Mushroom
Expected yield/ 4 months	2.4 ton /acre	1.6 ton /acre	1 ton (500 kg/2 months)
Average price	24,000.00	32,000.00	60,000.00
Total costs	11,760.00	7,640.00	30,700.00
Net income	12,240.00	24,360.00	29,300.00
Labor (BDT 80/day)	4,160.00	2,040.00	
Land preparation	1,800.00	1,500.00	
Seed (rice 30 and wheat 40 kg)	600.00	1,200.00	
Fertilizer/Lime	1,000.00	1,200.00	(Production cost is shown in
Insecticides	500.00	300.00	Table 1)
Transport	200.00	200.00	
Irrigation	3,000.00	700.00	
Miscellaneous	500.00	500.00	

Compared profitability of rice, wheat (1 acre land/4 months) and oyster mushroom (30′ × 18′ size house/4 months) is considered in BDT

Table 3. Financial aspect of the project for mushroom cultivation (USD1= BDT 66.67)

Total amount of loan	BDT 20,000.00	$ 300.00
1. Total cost		
- Growing house (made up of local materials, wooden shelves)	BDT 9,300.00	$ 140.00
-Production cost	BDT 10,700.00	$ 160.00
2. Estimated income per 2 month (average)		
-Total production per 2 month 500 kg (total production - loss during handling, storage and delivery)	500 kg (excluding damage)	
-Net sales per 2 month (total production × price per kg)	BDT 30,000.00 (500 kg × BDT 60)	$ 450.00
3. Pay back of loan (for 4 months)		
-Collection per 2 month to pay back loan (33.34% of income)	BDT 10,000.00 (BDT 30,000.00/3)	$ 150.00
If 35~40% of 2nd round's income is collected the loan and interest will be fully paid back for 4 months		

Su Decheng, a mushroom scientist, who lived in poverty during 16 years of his life in China, committed to help his countrymen out of poverty trap by studying mushroom. In 1989, he started a project to help people how they grow mushrooms for self–sufficiency in the poverty-stricken areas of China. Using his knowledge and experience he involved 20 students from mushroom science to train the local people how to grow mushroom on sawdust. They established a mushroom farm to demonstrate the local people how mushrooms could be cultivated. In another location in China there were 70,000 people in 14,000 rural families living below the poverty line with annual income of less than CNY15300 (USD 36.01). The land here was unfertile, producing only scrub wood and little grain. In 1989, Su and his students trained them how to grow mushrooms, resulting average annual income per capita increased CNY 1800.00 (USD 216.09) in 1993, six times higher than 1989 when the project was first started. Three quarters of their income came from mushroom cultivation. This interesting report demonstrates the incredible impact of mushroom cultivation may have in China. More than a dozen such successful story of mushroom cultivation in China are quoted by Wu (2000).

Mushrooms have long been favored by Asian people as food stuff in soup. Now a day mushrooms are found in markets throughout America, Europe, Asia as well as Africa. Popularity of mushrooms is ever increasing throughout every part of the world because of its exotic flavor and their culinary properties whether eaten alone or in combination with other foods. But until now, it is not well known that mushrooms are full of nutrients and can therefore make a very important contribution to human nutrition. Based on this theme we presented here a comparative chart of nutritional value between shiitake mushroom (*Lentinula edodes*) and other foods taken from MushWorld 2005. The caloric value of 100g of dried shiitake is higher than 100g of raw potatoes (66 kcal) and beef loin (224 kcal), but lower than that of whole wheat and brown rice (328 and 350 kcal). The protein content of dried shiitake is comparable to that of chicken and beef but the fat count is much lower and the dietary fiber count is considerably higher than those meats. It contains enough sugar (59 mg) that is the nearest of rice and wheat. In addition to dietary fiber, dried shiitake contains higher contents of calcium (Ca), iron (Fe), vitamins B_1 (thiamin), B_2 (riboflavin) and B_3 (niacin). But it does not contain vitamins A and C (Table 4).

Mushroom is used as delicious item of our food menu containing both nutritive and medicinal values (Agrahar-Murugkar *et al.,* 2005; Cheung and Cheung, 2005). Shiitake contains almost all the essential amino acids, with lysine and arginine being particularly abundant (Liu and Bau, 1980), and methionine and phenylalanine less abundant (Lasota and Sylwestrzak, 1989). In laboratory analysis it was found that amino acids, protein, glycogen, lipids, ascorbic acid, and total ash contents increased as the fruiting body developed. Based on these findings, it may be desirable to consume fully mature fruiting bodies for maximum nutritional value. Shiitake contains dietary fiber in the ratio of 6.7g per 100g of dried shiitake, which is a figure much higher than that for brown rice (0.2g), and sweet potatoes (0.9g).

Table 4. Constituents of shiitake mushroom (Oak) and other food sources (*Dry, **Fresh).

Food source	Energy (Kcal)	Protein (g)	Fat (g)	Carbo. (mg)		Minerals (mg)		Vitamins (mg)		
				sugar	fiber	Ca	Fe	B_1	B_2	B_3
Shiitake*	272	18.1	3.1	57	6.7	19	3.3	0.48	1.57	19
Shiitake**	27	2	0.3	5.4	0.7	6	0.6	0.08	0.23	4.0
Chicken	180	19.0	10.6	0.1	-	11	1.1	0.20	0.21	2.7
Beef	224	17.5	15.9	0.2	-	15	1.6	0.07	0.23	4.3
Potato	66	2.5	-	14.4	0.2	04	0.6	0.20	0.06	1.0
Rice	350	7.6	2.1	74.4	2.7	06	0.7	0.23	0.008	3.6
Wheat	328	12	2.9	69	2.5	71	3.2	0.34	0.11	5.0

Source: Mushroom growers handbook-2, MushWorld 2005 (table is modified)
100g edible portion of dried/fresh shiitake mushroom and same amount of other food sources.

Dietary fiber prevents constipation, obesity, diabetes, hypertension, colon cancer and arteriosclerosis by lowering cholesterol level. The high amount of ergo-sterol in fresh shiitake makes dried shiitake an important vitamin D source because ergo-sterol converts to vitamin D_2 in the presence of sunlight. Exposure of shiitake to direct sunlight for 3 hours/day increases the vitamin D_2 content up to 5 times. Sunlight exposure also increases the free amino acid content which is about 2,180 mg/dl in the dry fruiting bodies, and it makes them sweeter and less bitter (Kiribuchi, 1991).

Eating mushroom can prevent various vitamin B and D deficiencies including beri-beri$_2$ (thiamin); cheilosis$_3$, glossitis$_4$, corneal vascularization$_5$, Seborrheic dermatitis$_6$, nerve tissue damage (riboflavin); abnormal growth in infants and children (niacin); and rickets$_7$ (vitamin D). Vitamin D boosts calcium absorption and thus plays an important role in bone formation. Mushrooms are not only sources of nutrients but have also been reported as therapeutic foods, useful in preventing diseases such as hypertension, hypercholesterolemia and cancer (Bobek and Galbavy, 1999 and Bobek *et al.,* 1995). Some recently isolated and identified compounds, originating from mushrooms, show other quite significant medical properties, such as immuno-modulatory, cardiovascular, liver protective, anti-fibrotic, anti-inflammatory, anti-diabetic, anti-viral and anti-microbial activities (Wasser and Weis, 1999a; Gunde-Cimerman, 1999; Ooi, 2000; Wasser and Weis, 1999b). Some atiifungal protein are also recognized which shows the inhibiting activity of HIV-1 reverse transcriptase (Ngai *et al*., 2005; Ngai and Ng, 2003), possible being used for healing AIDS disorder. The scientific evidences of mushrooms as multi-purpose medicines on different human diseases have been accumulated. So mushrooms can be used to combat human diseases.

CONCLUSION

Mushroom production is the most appropriate job for the poor landless both men and women farmers in Bangladesh. Mushrooms can be grown in the small space of a farmer's own house for small scale production and generate income that aids in the family support. Mushroom cultivation is a most popular activity for development programs targeting income generation among women in Bangladesh because it is suitable for the women's life style. The product is highly nutritive and a good food for their children and old parents, and because of its high economic value they can also earn some income from the production. In many areas of Bangladesh farmers have grown mushrooms in a small scale and have benefited directly. They have managed to adopt the technology in a simpler way whereby they can afford to invest in a small scale. They are mainly utilizing the agricultural waste mainly wheat and paddy straw. Thus, mushroom cultivation may reduce poverty and improved the life style of many poor farmers in Bangladesh.

REFERENCES

Agrahar-Murugkar, D. and Subbulakshmi, G. 2005. Nutritional value of edible wild mushrooms collected from the Khasi hills of Meghalaya. Food Chemistry 89: 599–603.

Bobek, P. and Galbavy, S. 1999. Hypocholesterolemic and anti-atherogenic effect of oyster mushroom (*Pleurotus ostreatus*) in rabbit. Nahrung 43(5): 339–342.

Bobek, P., Ozdyn, L. and Kuniak, L. 1995. The effect of oyster (*Pleurotus ostreatus*) its ethanolic extracts and extraction residues on

cholesterol levels in serum lipoproteins and liver of rat. Hypocholesterolemic and anti-atherogenic effect of oyster mushroom (*Pleurotus ostreatus*) in rabbit. Nahrung 39: 98–99.

Chang, S.T. and Miles, P.G. 1992. Mushroom biology–a new discipline. Mycologist 6: 64–65.

Cheung, L.M. and Cheung, P.C.K. 2005. Mushroom extracts with antioxidant activity against lipid peroxidation. Food Chemistry 89: 403–409.

ESCAP (Economic and Social Commission for Asia and the Pacific) 2007. ESCAP Population Data Sheet 2007. United Nations, New York.

GOB (Government of the Peoples Republic of Bangladesh) 2007. Ministry of Agriculture, Bangladesh. (http://www.bangladeshgov.org/moa/moa.html).

Gunde-Cimerman, N. 1999. Medicinal value of the genus pleurotus (Fr) P. Karst. (Agaricles S. R., Basidiomycetes). International Journal of Medicinal Mushrooms 1: 69–70.

Hawksworth, D.L. 2001. Mushrooms: the extent of the unexplored potential. International Journal of Medicinal Mushrooms 3: 333–340.

Kiribuchi, T. 1991. Effective uses of fungi by UV irradiation. 3. Change of free amino acid composition in fungi by suli or ultraviolet light irradiation. Nippon Kasei Gakkaishl 42: 415-421.

Lasota, W. and Sylwestrzak, J. 1989. Chemical composition of cultivated mushrooms. Part. shiitake *Lentinus edodes* (Berk.) Sing. Bromatologia i Chemia Toksykologiczna 22: 167-171.

Liu, B. and Bau, Y.S. 1980. Fungi Pharmacopoeia. Kinoko Press, CA, Oakland.

MushWorld 2004. Oyster Mushroom Cultivation: Mushroom Grower's Handbook-1., Korea, pp. 20-23. (http://www.MushWorld.com).

MushWorld 2005. Shiitake Cultivation: Mushroom Grower's Handbook-2., Korea, pp. 18-20. (http://www.MushWorld.com).

Ngai, P.H. and Ng, T.B. 2003. Lentin, a novel and potent antifungal protein from shitake mushroom with inhibitory effects on activity of human immunodeficiency virus-1 reverse transcriptase and proliferation of leukemia cells. Life Sciences 73: 3363-3374.

Ngai, P.H., Zhao, Z. and Ng, T.B. 2005. Agrocybin, an antifungal peptide from the edible mushroom *Agrocybe cylindracea*. Peptides 26: 191–196.

Ooi, V.E.C. 2000. Medicinally important fungi. In: Van, G. (Edt). Science and cultivation of edible fungi, Balkema 41–51.

UNDP (United Nations Development Programme) 2006. Human Development Report 2006. UNDP, New York.

Wasser, S.P. and Weis, A.L. 1999a. Medicinal properties of substances occurring in higher basidiomycete mushrooms: Current perspective. International Journal of Medicinal Mushrooms 1: 31–62.

Wasser, S.P. and Weis, A.L. 1999b. Therapeutic properties of substances occurring in higher basidiomycete mushrooms: a modern perspective. Critical Review of Immunology 19: 65–96.

Wu, J.L. 2000. Shiitake Production in China. Agricultural press in Chinese, Beijing, China.

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