

Effect of Edible Mushroom (*Pleurotus ostreatus*) on Type-2 Diabetics

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Abstract

The prevalence of non-communicable diseases (NCD) like diabetes, hypertension, dyslipidemia and atherosclerotic cardiovascular diseases (CVD) are on the increase globally and predominantly in the South East Asian Region (SEAR). The increasing NCD and its complications burdened the health cost of Bangladesh. The available literatures suggest that edible mushrooms are effective in controlling metabolic risks like hyperglycemia and hypercholesterolemia.

The study addressed the metabolic effects of edible oyster mushroom (*Pleurotus ostreatus*) in diabetic individuals and to assess the undesirable effects of mushroom.

A total of 5000 newly registered diabetic women were screened for eligible participants (urban housewives, age 30 – 50y, BMI 22 – 27, FBG 8 – 12 mmol/l; free from complications or systemic illnesses and agreed to adhere to the study for 360 days). The investigations included weight and height for BMI, waist- and hip-girth for WHR, BP, FBG, 2ABF, T-chol, TG, HDL, LDL, ALT and Creatinine starting from the day 0 (baseline) and each subsequent follow-up days: 60, 120, 180, 240, 300 and 360 for comparison between placebo and mushroom groups and also within group (baseline vs. follow up days), individually for placebo and mushroom. The daily intake of mushroom was 200g for the mushroom group and an equivalent calorie of vegetables for the placebo group.

Overall, 73 diabetic housewives (mushroom / placebo = 43 /30) volunteered. The mean (with SEM) values of BMI, WHR, BP, FBG, 2ABF, T-chol, TG, HDL, LDL, ALT and Creatinine of the placebo group were compared with the mushroom group. Compared with the placebo, the mushroom group showed significant reductions of FBG ($p < 0.001$), 2ABF ($p < 0.001$), T-chol ($p < 0.001$), TG ($p = 0.03$) and LDL ($p < 0.001$); whereas, no difference was observed for BMI, SBP, DBP, HDL, Hb, creatinine and ALT. The comparison within groups (baseline vs. follow-up) there were significant reduction of these variables in mushroom but not in the placebo group.

Mushroom was found to have significant effect in reducing blood glucose, T-chol, TG and LDL. No impaired function was observed for liver, kidney and hemopoietic tissue in taking mushroom for 360 days of the study period.

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Acronyms –

ALT – alanine amino transferase; BMI – body mass index (weight in kg / height in met sq.); BP – blood pressure (SBP, DBP); FBG – fasting blood glucose; glucose 2ABF – 2h after breakfast; Hb – hemoglobin; HDL – high-density lipoproteins; LDL – low-density lipoproteins; NCD – non-communicable diseases; T-Chol – total cholesterol; TG – Triglycerides; WHR – waist-to-hip ratio.

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Introduction

The prevalence of non-communicable diseases (NCD) are increasing globally and most alarmingly in the south-east Asian region (SEAR).¹⁻³ In Bangladesh, the prevalence of diabetes, hypertension and coronary heart diseases have been found higher compared to any other Asian population.⁴⁻⁶

Bangladesh is one of the least developing countries with the highest population density of the world. And the brunt of NCD is overwhelming considering its poor economy, which is already overburdened with population explosion and communicable diseases. Very few of the NCD population can afford the cost of lifelong treatment. Only 1.4% of GDP is allocated to health and 43.3% of its population are below international poverty line (\leq US\$1.25 per day).⁷ The NCD patients need lifelong follow up treatment. A diabetic patient needs medication either oral hypoglycemic agent (OHA) or insulin for life. Likewise, lifelong antihypertensive medications are essential for a hypertensive subject. The dyslipidemic patients need lipid lowering agent(s) to prevent atherosclerosis. For lifelong maintenance of these medication is expensive and hardly feasible or affordable for most of the NCD patients. Considering the increasing NCD population at the face of poor affordability of treatment one has to explore alternative approach. And we have edible mushroom, popularly known and consumed as “Beneficial for Health” though exactly not known what the true benefit is. There are cumulative evidences that some edible mushroom, particularly, oyster mushroom (OM) rich in digestible proteins and bioactive compounds like vitamins, minerals, β -glucans (or immuno-modulants) that have effects in combating NCDs.⁸ The metabolic effects have been reported by many investigators, but these were observed in animal models.⁹⁻¹¹ Very few studies have been carried out in human subjects.^{12,13} Based on some important considerations this study was undertaken: a) an increasing trend of NCDs in Bangladesh; b) the suffering individuals can not afford lifelong treatment and frequently develop disabling complications; c) the oyster mushroom is popularly accepted and taken as beneficial vegetables for health; d) if this proved to be effective in reducing hypertension, hyperglycemia and hyperlipidemia without adverse outcomes then it would create immense economic possibilities – reducing import of medicine that required for millions of NCD patients in the country and saving

hard earn foreign currency, increasing mushroom production by generating employment to such an extent that result in cultivating and exporting it to the increasing global need of rising NCD population. Thus, the aims of this study were to determine the metabolic effects of edible (*Pleurotus ostreatus*) mushroom in diabetic subjects and to assess any undesirable effect among subjects who were familiar with mushroom.

Study Population and Methods

This study was conducted at the Bangladesh Institute of Research and Rehabilitation in Diabetes, Endocrine and Metabolic Disorders (BIRDEM). It is the largest referral hospital registering ~ 17000 diabetic patients annually. The participants of the study were selected from the BIRDEM registry. Regarding eligibility, housewives of Dhaka City aged 30 – 50 years with body mass index (BMI) 22 – 27, fasting plasma glucose being 8 – 12mmol/L; taking oral hypoglycemic agent (OHA); and free from diabetic complication(s) or systemic illness or pregnancy, were considered eligible. It was ensured that the participant would readily accept home visit by the field workers to monitor whether regularly taking mushroom or vegetables according to the decision made in consultation with dietician and diabetologist. She would also visit BIRDEM every two months interval for follow up. The baseline data (socio-demography, height, weight, blood pressure, blood glucose [2-sample OGTT], bilirubin, ALT, urea, creatinine, complete blood picture [Hb, TC DC, MCV, MCHC, and ESR], ECG and Ophthalmoscopy) were taken from the registry. The follow up investigations included anthropometry (weight, waist- and hip-girth, blood pressure (SBP, DBP), blood glucose fasting (FBG) and 2-h after breakfast (2ABF), total cholesterol (T-Chol), triglycerides (TG), high-density lipoproteins (HDL), low-density lipoproteins (LDL), urea, creatinine, bilirubin, alanine amino transferase (ALT), hemoglobin, total WBC and differential counts. The follow up were maintained on day 0 (baseline), 60, 120, 180, 240, 300 and 360.

From the BIRDEM Registry, a total of 5000 newly registered female diabetic subjects were screened for the selection of eligible participants. Of them, 300 women satisfied the eligible criteria as mentioned above. They were enrolled for the study. The protocol was discussed and they were informed about the procedural details. Of the 300 eligible participants,

173 agreed to volunteer the study. These subjects were reinvestigated for baseline data and to assess whether there was any complication. Microproteinuria was found in 15, background retinopathy in 19, proliferative retinopathy 2 and maculopathy in 1. Neurological assessment revealed peripheral neuropathy in 17, and autonomic neuropathy in 21. Oral hypoglycemic agent failed to control in 25, who were prescribed insulin and were excluded from the study. So, the remaining 73 were finally selected as eligible participants. Of these 73, 43 women were familiar with the mushroom as they used to take the mushroom occasionally, and 30 women never tasted the mushroom. So, the former group was assigned to mushroom (n=43) and the later assigned to placebo group (n=30). The stepwise selection of the study participants based on eligibility criteria is depicted in Figure-1. The daily mushroom intake was prescribed 200g and the placebo group was prescribed equivalent calorie of locally available vegetables exchange. The mushroom packets, each containing 200g, were supplied twice a week from the "Govt. Mushroom Farm" at Savar near Dhaka city. The field workers maintained home-visit twice a week, distributing mushroom and checking whether the participants were consuming it daily, and reporting to the physician if there was any irregularities in continuing mushroom intake. Home visit was also maintained to the placebo participants twice weekly. The follow up was strictly maintained for each participant as long as she was residing in the Dhaka City Corporation (DCC) area and was lost to follow up only if she left DCC area or withdrew from the study. The mushroom and the placebo groups were followed up from the day 0 (baseline) through the day 360 (Figure 2). The investigations in each visit on day 0, 60, 120, 180, 240, 300 and 360 included BMI, SBP, DBP, FBG, 2ABF, T-chol, HDL, TG, Hb, creatinine and ALT for both mushroom and placebo group.

Statistical analyses –There were three comparisons of the characteristics (BMI, BP, FBG, glucose 2ABF, T-chol, HDL, TG, Hb, creatinine and ALT). First comparison was between mushroom and placebo group. In this comparison, the values (mean with SEM) of mushroom and placebo groups were compared on baseline (day0) and then on the subsequent follow-up visits (day 60, 120, 180, 240, 300 and 360). The second comparison was made within the mushroom group taking the baseline values as reference and then compared with the subsequent follow-up visits (day

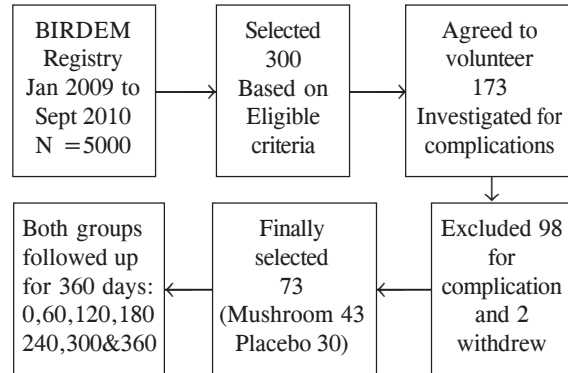


Fig.1: Stepwise selection of the female diabetic study participants based on eligibility criteria and their consent

60, 120, 180, 240, 300 and 360) to determine changes. Likewise, the third comparison was made within the placebo group taking the baseline (day 0) as the reference and then compared with follow up visits (day 60, 120, 180, 240, 300 and 360) to assess changes.

The study protocol was duly approved by the Ethical Review Committee of Diabetes Association of Bangladesh (DAB).

Results

After 360 days, 28 out of 43 and 12 out of 30 in mushroom and placebo groups respectively completed the follow up (Table-1)

- Comparison between mushroom and placebo group:** The mean (with SEM) values of BMI, SBP, DBP, FBG, 2ABF, T-chol, HDL, TG, Hb, creatinine and ALT of the placebo group were compared with that of the mushroom group on day 0 (baseline) and then on each subsequent follow-up visits. Compared to the placebo, the mushroom group showed significantly lower values for FBG ($p < 0.001$), 2ABF ($p < 0.001$) [Fig (2a), (2b)], T-chol ($p < 0.001$), TG ($p = 0.03$) and LDL ($p < 0.001$)

Table-1: The trend of retention of study participants from day 0 through day 360

Group	Number at Baseline	Number of participants maintained follow up at day					
		60	120	180	240	300	360
Mushroom	43	43	43	41	41	35	28
Placebo	30	30	29	26	21	18	12

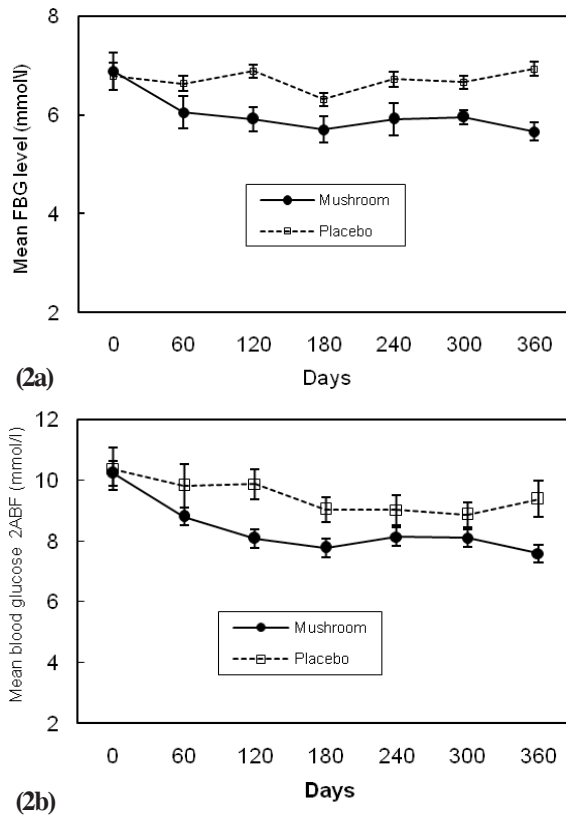


Fig. 2: Comparison of mushroom and placebo groups for fasting blood glucose (2a) and glucose 2ABF (2b) at day 0, 60, 120, 180, 240, 300 and 360. Compared to placebo the mushroom group showed significant reduction ($p < 0.01$) in FBG levels at day 120 to 360 and for 2ABF level at day 120, 180 and 360.

FBG: Fasting blood glucose, 2ABF: 2hrs after breakfast

[Fig-(3a), (3b), (3c)]; whereas, the differences were not significant for BMI, SBP, DBP, HDL, Hb, creatinine and ALT (data not shown).

- ii. *Comparison within mushroom group:* The mean (\pm SEM) baseline (day 0) values of BMI, SBP, DBP, FBG, glucose 2ABF, T-chol, HDL, TG and ALT were compared with that of the subsequent follow up values at defined interval (e.g. day 0 vs. day 60, day 0 vs. d120, day 0 vs. d180, day 0 vs. d 240, day 0 vs. d300 and day 0 vs. d360). Compared to the baseline values there were significant reduction of FBG ($p < 0.001$), glucose 2ABF ($p < 0.001$), T-chol ($p < 0.001$) and TG ($p < 0.001$) [Table-2] over 60 to 360 days; whereas, there was no such reduction for WHR, DBP, LDL, Hb, creatinine and HDL.

- iii. *Comparison within placebo group:* Comparisons were made within the placebo group as mentioned above for mushroom group. The mean (\pm SEM) baseline (day0) values of BMI, SBP, DBP, FBG,

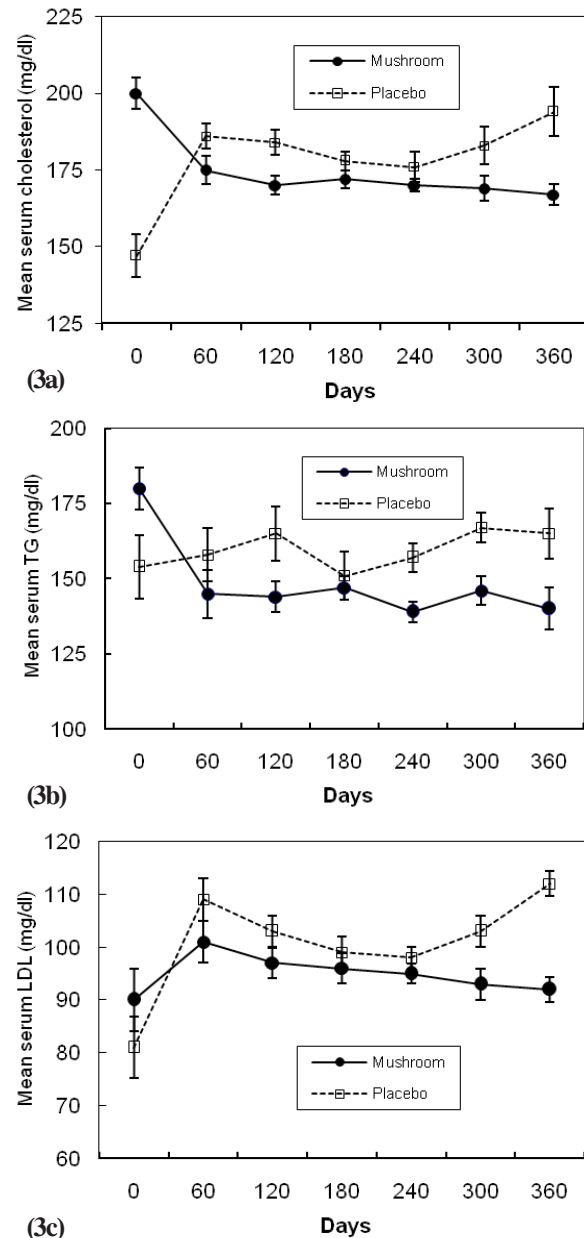


Fig. 3: Comparison of serum total cholesterol (3a), triglycerides (3b) and LDL (3c) levels of mushroom and placebo groups at day 0, 60, 120, 180, 240, 300 and 360. For total cholesterol $p < 0.01$ at day 120, 300 and 360; For triglyceride $p < 0.03$ at day 120, 240, 300 and 360; For LDL $p < 0.001$ at day 300 and 360.

Table-2: Comparison of FBG, glucose 2ABF, T-cholesterol and TG levels between baseline and that of follow up values at day 60, 120, 180, 240, 300 and 360 of mushroom group

Test at	Number	Mean (\pm SEM) values in mmol/l		Mean (\pm SEM) values in mg/dl	
		FBG	Glucose 2ABF	T-Chol	TG
Baseline	43	6.9 (0.3)	10.2 (0.4)	200.2 (5.2)	180.4 (7.2)
Day 60		6.1 (0.2)	8.8 (0.3)	175.4 (4.7)	145.7 (8.8)
P value		<0.001	<0.002	<0.001	<0.001
Baseline	43	6.9 (0.3)	10.2 (0.4)	200.2 (5.2)	180.4 (7.2)
Day 120		5.9 (0.1)	8.1 (0.2)	170.9 (3.0)	144.4 (5.1)
P value		<0.001	<0.001	<0.001	<0.001
Baseline	41	6.9 (0.3)	10.4 (0.4)	200.7 (5.3)	181.3 (7.5)
Day180		5.7 (0.1)	7.8 (0.2)	172.7 (3.1)	147.7 (4.3)
P value		<0.001	<0.001	<0.001	<0.001
Baseline	41	6.9(0.3)	10.4 (0.4)	200.7 (5.3)	181.3 (7.5)
Day 240		5.9(0.2)	8.1 (0.2)	170.8 (2.2)	139.9 (3.7)
P value		<0.001	<0.001	<0.001	<0.001
Baseline	35	6.9 (0.3)	10.3 (0.4)	200.0 (5.8)	183.5 (8.6)
Day 300		5.9 (0.1)	8.1 (0.3)	169.6 (4.3)	147.3 (4.8)
P value		<0.009	<0.001	<0.001	<0.001
Baseline	28	7.1(0.4)	10.5 (0.5)	208.8 (6.5)	179.9 (10.0)
Day 360		5.7(0.1)	7.6 (0.2)	167.5 (3.5)	143.1 (6.9)
P value		<0.001	<0.001	<0.001	<0.002

Note: FBG – Fasting blood glucose; 2ABF – 2hrs after breakfast; T-Chol – Total cholesterol; TG – Triglycerides; P values after paired t-test.

2ABF, T-chol, HDL, TG and ALT were compared with those of the subsequent follow up visits (e.g. day 0 vs. day 60, day 0 vs. d120, day 0 vs. d180, day 0 vs. d 240, day 0 vs. d300 and day 0 vs. d360). In contrast to the mushroom, the placebo group did not show any significant reduction of these variables (data not shown).

- iv. The mushroom showed no significant effect on hemoglobin, creatinine and alanine amino transferase (ALT).

Discussion

This is one of the pioneering studies to investigate the effect of mushroom for 360days on the south-east Asian population most prone to develop NCDs (hypertension, diabetes, dyslipidemia). This study also did attempt to

examine whether there were adverse effects on liver, kidney or bone-marrow. To explore the effects ALT (for liver), Hb (for bone-marrow) and creatinine (for kidney) were estimated and no adverse outcomes were observed in 360 days among those who regularly maintained mushroom intake. It could have been better if the duration of consumption had been investigated for a longer period. The other limitation is that the number of dropped off subjects were 15 in the mushroom and 18 in the placebo arms at the end. Had all the subjects volunteered for 360 days the study could have better conclusions.

This study clearly demonstrated that Oyster mushroom (OM) had anti-hyperglycemic and anti-lipids effects which are consistent with other studies.⁸⁻¹⁰ In India, Bajaj et al made similar conclusions that mushroom had hypocholesterolemic effect.¹³ These evidences are

consistent with other studies.^{14,15} Though some other studies claimed that mushroom had anti-obesity effect¹⁶ this study showed no such effect. Again this study found that edible mushroom did not reduce blood pressure significantly as claimed by other though in rat model.¹⁷

Conclusions

Mushroom was found to have significant effect in reducing blood glucose (FBG and 2ABF), T-chol, TG and LDL; whereas, no significant effect was found in reducing obesity (BMI and WHR) and reducing blood pressure (SBP, DBP). Neither there was any effect in improving HDL nor any changes in hemoglobin, creatinine and liver enzymes (ALT). The latter findings indicated that there were no deleterious effect(s) on liver, kidney and hemopoietic tissue in taking mushroom for at least 360 days.

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References

1. S. Wild, G. Roglic, A. Green, S. Sicree, H. King, Global prevalence of diabetes: estimates for the year 2000 and projections for 2030. *Diabetes Care* 2004; **27**: 1047-53.
2. McKeigue PM, Marmot MG, Syndercombe Court YD, Cottier DE, Rahman S, Riemersma RA. Diabetes hyperinsulinemia and coronary risk factors in Bangladeshis in East London. *Br Heart J* 1988; **60**: 390-396.
3. Colosia AD, Palencia R, and Khan S. Prevalence of hypertension and obesity in patients with type 2 diabetes mellitus in observational studies: a systematic literature review. *Diabetes Metab Syndr Obes* 2013; **6**: 327-338.
4. Sayeed MA, Mahtab H, Sayeed S, Begum T, Khanam PA and Banu A. Prevalence and risk factors of coronary heart disease in a rural population of Bangladesh. *Ibrahim Med Coll J* 2010; **4**(2): 37-43.
5. Sayeed MA, Mahtab H, Khanam PA, Latif ZA, Banu A and Azad Khan AK. Prevalence of diabetes and impaired fasting glucose in urban population of Bangladesh. *Bangladesh Med. Res. Counc. Bull.* 2007; **33**(1): 1-12.
6. Rahim MA, Hussain A, Azad Khan AK, Sayeed MA, Keramat Ali SM, Vaaler S. Rising prevalence of type 2 diabetes in rural Bangladesh: a population based study. *Diabetes Res Clin Pract* 2007; **77**(2): 300-5.
7. Bangladesh Bureau of Statistics. Statistical Pocket Book of Bangladesh. Ed: Mollah MSA, Statistical Division, Ministry of Planning, Government of The People’s Republic of Bangladesh 2013.
8. Lo HC, Wasser SP. Medicinal mushrooms for glycemic control in diabetes mellitus: history, current status, future perspectives, and unsolved problems (review). *Int J Med Mushrooms* 2011; **13**(5): 401-26.
9. Alam N, Yoon KN, Lee JS, Cho HJ, Shim MJ and Lee TS. Dietary effect of *Pleurotus eryngii* on biochemical function and histology in hypercholesterolemic rats. *Saudi J Biol Sci* 2011; **18**(4): 403-409.
10. Kanagasabapathy G, Kuppusamy UR, Malek SNA, Abdulla MA, Chua KH and Sabaratnam V. Glucan-rich polysaccharides from *Pleurotus sajor-caju* (Fr.) Singer prevents glucose intolerance, insulin resistance and inflammation in C57BL/6J mice fed a high-fat diet. *BMC Complement: Altern Med* 2012; **12**: 261.
11. Wasser SP. Current findings, future trends, and unsolved problems in studies of medicinal mushrooms. *App Microbiol Biotechnol* 2011; **89**: 1323-1332. doi: 10.1007/s00253-010-3067-4. [PubMed] [Cross Ref].
12. Khatun K, Mahtab H, Khanam PA, Sayeed MA and Azad Khan AK. Oyster Mushroom reduced blood glucose and cholesterol in diabetic subjects. *Mymensingh Med J* 2007; **16**(1): 94-99.
13. Bajaj M, Vadhera S, Brar AP, Soni GL. Role of oyster mushroom (*Pleurotus florida*) as hypocholesterolemic/ antiatherogenic agent. *Indian J Exp Biol* 1997; **35**(10): 1070-5.
13. Hossain S, Hashimoto M, Choudhury EK, Alam N, Hussain S, Hasan M, Choudhury SK, Mahmud I. Dietary mushroom (*Pleurotus ostreatus*) ameliorates atherogenic lipid in hypercholesterolaemic rats. *Clin Exp Pharmacol Physiol* 2003; **30**(7): 470-5.
15. Rajewska J, Balasinska B. Biologically active compounds of edible mushrooms and their beneficial impact on health. *Postepy Hig Med Dosw* (Article in Polish) 2004; **58**: 352-7.
16. Jeon BS, Park JW, Kim BK, Kim HK, Jung TS, Hahm JR, Kim DR, Cho YS, Cha JY. Fermented mushroom milk-supplemented dietary fibre prevents the onset of obesity and hypertriglyceridaemia in Otsuka Long-Evans Tokushima fatty rats. *Diabetes Obes Metab* 2005; **7**(6): 709-15.
17. Miyazawa N, Okazaki M, Ohga S. Antihypertensive effect of *Pleurotus nebrodensis* in spontaneously hypertensive rats. *J Oleo Sci* 2008; **57**(12): 675-81.