Effect of Mushroom, Oat and Their Mixtures as Functional Food on Lipid Profile, Liver and Kidney Functions of Obese Rats

Tesby M. R. Lotfy[1], Hassan A. R. El-Hendy[2], Samar M. S. Shawir[1]

1 Home Economics Department, Faculty of Specific Education, Alexandria University, Alexandria, Egypt

2 Department of Home Economics, Faculty of Agriculture, Alexandria University, Alexandria, Egypt

كلية معتمدة

مجلة البحوث في مجالات التربية النوعية

معرف البحث الرقمي DOI: 10.21608/jedu.2021.73481.1330

المجلد السابع العدد 35 . يوليو 2021

الترقيم الدولي

P-ISSN: 1687-3424 E- ISSN: 2735-3346

موقع المجلة عبر بنك المعرفة المصري https://jedu.journals.ekb.eg/

موقع المجلة http://jrfse.minia.edu.eg/Hom

العنوان: كلية التربية النوعية . جامعة المنيا . جمهورية مصر العربية

كفاءة فطر عيش الغراب الصالح للأكل ، الشوفان وخليطهما كغذاء وظيفي على مستوى دهون الدم ، ووظائف الكبد والكلى في الفئران البدينة

د. تسبي لطفي، د. حسن الهندي، د. سمر شعير

تهدف الدراسة إلى تقييم تأثير فطر عيش الغراب (المشروم) والشوفان وخليطهما على دهون الدم ، نشاط انزيمات الكبد ووظائف الكلى في الفئران البدينة. استخدم في هذه الدراسة عدد ثمانية وأربعون من ذكور الفئران البيضاء البينو تم تقسيمهم إلى مجموعتين رئيسيتين. المجموعة الرئيسية الأولي عدد (6 فئران) تتغذى على نظام غذائي أساسي ،المجموعة الثانية عدد (42 فار) تتغذى علي غذاء مرتفع الدهون لمدة ثمانية أسابيع ثم قسمت الى 7 مجموعات كل مجموعة تحتوي على عدد (6 فار) ، في نهاية فترة التجربة (٨ أسابيع) تم حساب كل من نسبة الزيادة في وزن الجسم ومتوسط المتناول من الطعام والكفاءة الغذائية. تم تجميع الدم من كل المجاميع وتم فصل السيرم وتقدير معايير دهون الدم وانزيمات الكبد ووظائف الكلي بالاضافة الى تقدير سكر جلوكوز الدم . أشارت نتائج الدراسة إلي أن تغذية فئران التجارب علي غذاء مرتفع الدهون أدي إلي حدوث زيادة معنوية في (الكولسترول، الجلسريدات الثلاثية ، LDL) ومن ناحية أخرى أدت إلى انخفاض كولسترول الليبوبروتينات مرتفع الكثافة). بينما الفئران التي تم تغذيتها على نظام غذائي عالي الدهون مع مستويات من المشروم والشوفان وخليطهما أدي إلي حدوث انخفاض معنوي في مستويات دهون الدم (الكولسترول، و الجلسريدات الثلاثية ، LDL) وارتفاع مستوي كولسترول الليبوبروتينات مرتفع الكثافة واظهرت النتائج انخفاض نشاط انزيمات الكبد (ALP, ALT, AST and LDH) في المجموعة التي تغذت على وجبة عالية الدهون تحتوي على المشروم +الشوفان (40+20%) ، كما اظهرت النتائج ارتفاع مستوى اليوريا في المجموعة التي تغذت على وجبة عالية الدهون مقارنة بالمجموعة الضابطة السالبة. بينما في المجموعة التي تغذت على وجبة عالية الدهون تحتوي على المشروم +الشوفان (40+20%) كان مستوى اليوريا منخفض . لاتوجد اختلافات معنوية في مستوى الكريتنين بين المجاميع الاخرى كما حدث انخفاض في مستوى سكر الدم في المجموعة التي تغذت على وجبة عالية الدهون تحتوي على المشروم +الشوفان (40+20%) مقارنة بالمجاميع الاخرى . تشير الدراسة إلى إمكانية استخدام المشروم والشوفان كغذاء وظيفي للتحكم في السمنة وتحسين صحة الإنسان .

الكلمات الافتتاحية: الفئران البدينة – المشروم – الشوفان –دهون الدم – الكبد - الكلى

Effect of Mushroom, Oat and Their Mixtures as Functional Food on Lipid Profile, Liver and Kidney Functions of Obese Rats

Tesby M. R. Lotfy, Hassan A. R. El-Hendy, Samar M. S. Shawir

ABSTRACT

The present investigation aimed to evaluate the effect of mushroom, oat and their mixtures on lipid profile, liver and kidney functions of obese rats. Forty-eight male albino rats were used for the experiments, these rats divided into two main groups, first group (n=6 rats) fed on basal diet as a Control (group-ve). Second group (n=42 rats) received high fat diet (HFD) for 8 weeks to induce obesity in rats then divided into (7) subgroups each (n=6 rats). Eight weeks later, body weight gain, feed intake and feed efficiency ratio were estimated. Blood samples were collected from each rat to estimate lipid profile, liver enzymes, kidney function and of glucose level. The results of this study, showed that, the rats were feeding on (HFD) led to significant increase in serum cholesterol, triglycerides, LDL-c, and decreased HDL-c. treatment of rats group with mushroom plus oat (20+40%) improved the lipid profile compared with other treatments. this treatment also reduced the activity of liver enzymes (ALP, ALT, AST and LDH to the level close to the non-obese rats. Histological study of liver tissues supported the results. Mixtures of mushroom plus oat increased albumin close to non-obese. Concentration of urea in HFD rats was high compared with non-obese rats. The treatments of mushroom plus oat showed reduction in urea and glucose compared with other. Our results recommend that mushroom plus oat as functional foods could be used to manage obesity and improve human health.

Key words:

Mushroom, oat, Lipid profile, Liver enzymes, Kidney function, Obese rats.

INTRODUCTION:

Obesity, at the present time is an important health problem. Egypt considered one of the top adult obesity rates in the world. According to study of **Gregg and Shaw (2017)** about 19 million Egyptian are suffering from obesity representing 35% of the total adult population. In addition, 3.6 million Egyptian children 10.2% of Egyptian children are overweight and obese.

Obesity is a chronic disease that raises risk factors for metabolic syndrome, which include hypertension and hyperlipidaemia, potentially leading to type-2 diabetes, cardiovascular disease, and Kidney damage and fatty liver disease **(Hall *et al*., 2014)**.

Development of obesity is associated with the influence of genetic and environmental factors and activity. Diet plays an important role contributing to pathophysiology of obesity development. Frequent consumption of high energy density foods such as fat foods has role in obesity **(Davis, 2016)**.The relationship of obesity to blood lipids reflects a common dyslipidaemia pattern in obesity such as hyper triglyceride and hyper cholesterol and lower HDL-cholesterol. Moreover increase plasma triglyceride provides fatty acid for adipogenesis **(Liu *et al*., 2017)**.

Functional food can be very beneficial in reducing fat deposition and preventing obesity**. Bigliardi and Galati (2013),** demonstrated that functional food affects beneficially one or more target functions in the body, beyond adequate nutritional effects to improve state of health or reduce of risk disease. Functional food that retained in food form and not formed into pills or capsules has been grouped into conventional food, modified food and synthesized food ingredients **(Astray *et al*., 2009).**

Mushroom and oat are unique food abundant in essential macro and micronutrients, highest in dietary fiber and water, less calorie producing, low carbohydrate content, good sources of protein, low fat, vitamins, minerals and dietary fiber **(Cheung, 2010& Chi *et al*., 2017)**. Mushroom and oat have been grouped as functional foods they have β-glucan which is one of the most important components has potent biological function in increasing satiety **(Rop *et al*., 2009**

& Rathore *et al*., 2017), reducing cholesterol and fat deposition **(Kang *et al*., 2013).**

Also, β-glucan enhance the immune system and regulate blood sugar levels especially in cases of diabetes. Moreover, mushrooms can protect liver from toxins that damage liver **(Danan Jaya *et al*., 2017)**.

Several types of mushroom showed lowering effect of cholesterol synthesis or cholesterol absorption by enhancement of fecal cholesterol excretion **(Mori et al., 2008)**. Oyster mushroom the common type of mushroom in Egypt found to protect kidney from damage (**Jahan *et al*., 2017)**.

Oat and oat products have attracted attention for their considerable health benefits, such as weight-loss, reduction in postprandial glycaemia and reduction in serum low-density lipoprotein cholesterol **(Rasane *et al*., 2015 & Dong *et al*., 2016)**. These physiological benefits are generally attributed to β-glucan, which associated with functional properties including lipid lowering and reducing blood cholesterol levels, change histological (resulted from hypercholesterolemia) of kidney, liver, heart, and testes in male rats **(Rouhani *et al*., 2018)**. Also, reduce blood glucose after meals due to its effect on insulin and glycaemic **(Peng *et al*., 2013).** The objective of Study is to evaluate the effect of mushroom, oat and their mixtures in enriched diet on the lipid profile, liver and kidney functions of obese rats

MATERIALS AND METHODS

Materials:

Mushroom and Oat

The Oyster mushroom *"Pleurotus ostreatus"* and Oat "*Avena sativa*" Which were used in this investigation was purchased from local market in Alexandria, Egypt.

Chemicals and Kits

- All chemicals Which used in analytical and purified grade provided from Merck (Darmstadt, Germany), Sigma-Aldrich Sigma Chemical Co. (St. Louis, MO, USA).
- Commercial kits were obtained from Biosystems S.A. (Spain), Diamond (Germany) and Randox (United Kingdom).

Animals

Forty-eight male albino rats of Westar strain used in the present experiment, weighing 120-150gm were obtained from Institute of Graduate Studies and Research, Alexandria University. Rats were housed in wire cages under the normal laboratory conditions and were fed on basal diet for two weeks as an adaptation period. Food and water provided *ad-labitum* and checked daily.

Methods:

Preparation of dried Oyster Mushroom and Oat powder

Fresh Oyster mushroom, free of blemishes or obvious defects were washed and cut into pieces. Then dried in an electric oven at 40°C for completely dry. After drying, samples was grind in Grinder (Moulinex LM2428EG - 400 Watt, Germany) and then kept in Polyethylene bags in the refrigerator until used **(da Silva *et al.*, 2009)**.

The Oat grains were also grind in a Grinder (Moulinex LM2428EG - 400 Watt, Germany) for about 1 minutes until obtaining a fine, powdery flour and then kept in Polyethylene bags in the refrigerator until used.

Experimental design

The experiment was carried out at Graduate Studies and Research, Alexandria University. Rats were housed in wire cages in a room temperature 25°C and kept under normal healthy conditions. After two weeks' acclimatization period, rats were divided into two main groups. The first group (6 rats) were fed on basal diet, second group (42 rats) were fed on high fat diet HFD (basal diet plus animal fat 20%) for eight weeks after that samples of blood were taken from rats that fed on HFD confirm that obesity occurs through determine lipid profile ratio of triglycerides and cholesterol on the two groups; control (C-ve), fed on standard diet only and HFD which divided into 7 sub-groups (each 6 rats) which then fed for another 8 weeks as follows: **Group 2 :**(C+ve): fed on HFD (basal diet plus plant and animal fat 20%). **Group 3:** fed on HFD containing mushroom (10%). **Group4:** fed on HFD containing mushroom (20%). **Group 5:** fed on HFD containing oat (20%). **Group 6:** fed on HFD containing oat (40%). **Group7:** fed on HFD containing low levels of themixture of mushroom plus oat (10 + 20 %). **Group 8:** fed on HFD containing high levels of the mixture of mushroom plus oat (20 + 40 %).

Blood sampling:

At the end of experimental period rats were fasted over night before sacrificing. Blood collected and serum separated and used for measuring lipid profile (total cholesterol, triacylglycerol, high and low density lipoprotein-cholesterol (HDL-c and LDL-c), liver enzymes (aspartate transaminase (AST), alanine transaminase (ALT), Lactate dehydrogenase (LDH) and alkaline phosphates ALP); kidney function (Urea, creatinine and albumin). The level of glucose and histological of liver tissues are also considered.

Determination of lipid profile in serum

Triglyceride was determined as described by **Fossati and Prencipe (1982),** the enzymatic colorimetric GPO-PAP kit was used for the measurement of triglycerides after enzymatic hydrolysis with lipase. Total cholesterol was determined according to **Richmond (1973).** High density lipoprotein **(**HDL) was determined according to **Lopes-Virella *et al*. (1977),** Low density lipoprotein LDL-cholesterol was determined according to the method of **Jaye *et al*. (2009)**.

Determination of liver enzymes in serum

The liver enzymes includes alkaline phosphates was carried out according to ***Lavie et al*. (2018)**, Aspartate transaminase activity was measured according to method described **by Yagi *et al*. (1985).** Alanine transaminase (ALT) activity was measured according to method described by **Williamson (1974)**. Lactate dehydrogenase (LDH) activity was measured according to method described by **Bergmeyer and Bernt (1974)**

Determination of kidney functions

The kidney functions Include Urea and Creatinine. Urea was determined according to method of **Wuepper *et al*. (2003).** Creatinine was determined according to method of **Shlipak *et al*. (2013),** and albumin was measured according to method described by **Bergmeyer and Bernt (1974)**

Determination of glucose

Determination of glucose was carried out according to the method of **Lott and Turner (1975).**

Histology of liver tissues

Specimens from liver tissues were collected from all experimental groups, fixed in 10% phosphate buffered formalin for 10 h and excessively washed in 70% alcohol for further examination. Following fixation, specimens dehydrated in graded ethanol, embedded in wax, sectioned to 5 microns thickness and stained with Hematoxylin and Eosin according to **Bancroft and Gamble (2008)**, and examined under Olympus light microscope.

Statistical analysis

Data were analyzed using IBM SPSS software package version 20.0**. (**Armonk, NY: IBM Corp**)**. Quantitative data was described using mean, standard error. **F-test (ANOVA)** used for normally distributed quantitative variables, to compare between more than two groups, and Post Hoc test (LSD) for pairwise comparisons **(Kirkpatrick & Feeney, 2013)**.

RESULTS AND DISCUSSION

Body weight of rat feed on basal and high fat diet for eight weeks

Table (1) and Figure (1) showed the mean of body weight after feeding rat on basal diet and high fat diet (HFD) for eight weeks. The body weight increased with increasing feeding weeks, whether in rat fed on basal diet or rat feed on HFD. At the second week of feeding on the basal diet, the average of rat body weight was 170.30g with percent of increase (13.28%) corresponding to the mean body weight of rat at first week. While in HFD the average was 190.07g with increased percent (22.33%) of rat at first week. In the eighth and last week of feeding on the basal diet, the average of rat body weight was 232.2g with percent of increase (54.49%) corresponding to the mean body weight of rat at first week. While in HFD the average was 361.1g with increased percent (132.40%) of rat at first week. The data showed that the body weight of rat feeding on basal and HFD increased with increasing the weeks of feeding. The rate of increase of body weight of rat that fed on HFD was more compared with that fed on basal diet for all periods of feeding. The results in agreements with **Peng *et al*. (2013)**, they reported that body weight change of rats after 4 weeks, of the HFD-fed rats increased more than 30% of the body weight compared with the control. Our data showed that body weight change was 34.83% after 4 weeks of feeding while it was 132.40% after 8 weeks of feeding on HFD. Moreover, **Guo *et al*. (2018),** reported that HFD-fed rats dramatically increased in body weight compared to rats fed on basal diet . By week 8, the HFD-fed rats gained 54 g more weight than the control rats and showed characteristics of obesity.

Table (2): Mean of body weight after feeding rats on high fat diet (HFD) for eight weeks

weeks	Control (-)* (g) ± S.E	Body weight increased (%)	HFD treatments** (g) ± S.E	Body weight increased (%)	t	p
1st week	150.33 ± 1.34		155.38±0.95		1.964	0.056
2nd week	170.30 ± 3.08	**13.28**	190.07±2.77	**22.33**	4.764*	<0.001*
3rd week	175.00 ± 3.68	**16.43**	209.50±3.37	**27.87**	2.690*	0.010*
4th week	178.10 ± 5.69	**18.50**	216.50±3.37	**39.33**	3.407*	0.001*
5th week	184.00 ± 3.68	**22.49**	221.63±3.41	**42.64**	4.085*	<0.001*
6th week	191.40 ± 11.59	**27.35**	238.10±5.06	**53.24**	3.305*	0.002*
7th week	217.90 ± 14.62	**44.98**	334.73±5.48	**115.43**	7.528*	<0.001*
8th week	232.20 ± 17.06	**54.49**	361.10±7.75	**132.40**	5.980*	<0.001*

Data was expressed using Mean ± SE. *: Statistically significant at $p \leq 0.05$
Means in a column with same letters are not significant (and Means with Different letters are significant)
Each value is expressed as mean ± SE; [(week X - week 0)/week 0] X 100%.

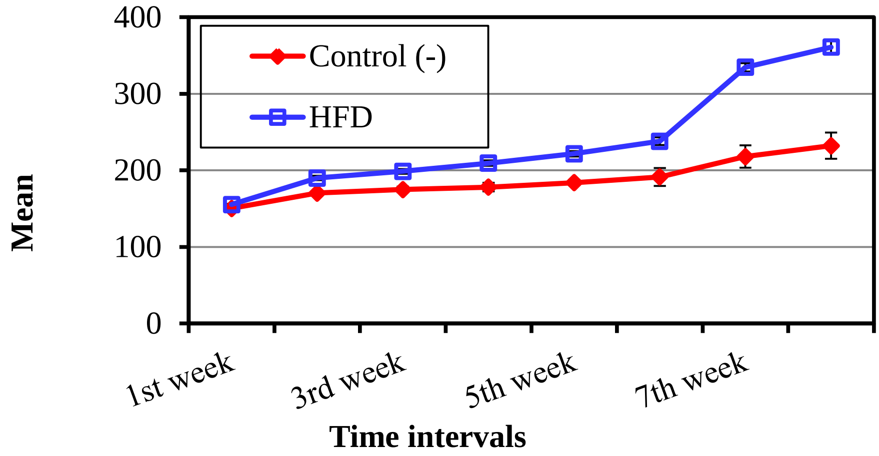


Figure (1): Mean of body weight after feeding rat on high fat diet (HFD) for eight weeks

Effect of mushroom and oat treatments on lipid profile of obese rats

Lipid profile most frequently induces measurements of total lipids, cholesterol, triglycerides and high and low density lipoprotein-cholesterol (HDL-c and LDL-c). The data in **Table (5)** showed that high fat diet significantly ($P<0.05$) increased the concentrations of serum lipid profile, while HDL-c decreased. On the other hand, treatment with mushroom (10%) and (20%), oat (20%) and (40%), mushroom plus oat (20+10%) and mushroom plus oat (20+40%) decreased serum lipid profile, while increased HDL-c compared to the HFD control group (control +). The presence of mushroom plus oat (20+40%) with high fat diet significantly decline the increase in the concentration of serum lipid profile, while HDL-c increased compared to high fat diet group. From the obtained results, it is clear that mushroom plus oat (20+40%) is more effective than other treatments on improving lipid. The current data showed lowering of lipid in serum that seems to be related to the effect of oat and mushroom β-glucan that increase viscosity which can lead to reduction of cholesterol absorption or in general decreased serum cholesterol and LDL-C, thereby improving the lipoprotein profiles. The results also concluded that the different treatments varied in their effect that showing significant reduction in serum TG concentrations and the lipoprotein profile mainly oat and /or mushroom and their mixture. The data matched with **Jia *et al*.**

(2013) they reported a significant decrease in the values of serum cholesterol, TG and LDL-c for all treated rat groups but showed a significant increase in the values of serum HDL-c comparing with HFD. Moreover, **Khatun *et al*. (2007)** demonstrated that mushroom significantly reduced TG and cholesterol of diabetic subjects without any deleterious effect on liver and kidney. **Alam *et al*. (2011),** reported that feeding on diet containing 5% powder of mushroom reduced plasma total cholesterol, triglyceride and low-density lipoprotein. **Schneider *et al*. 2011**, suggested that oyster mushrooms may improve blood lipid profile in humans. Oat products also have benefits in reducing weight and reduce low-density lipoprotein cholesterol and lipid in serum **(Rasane *et al*., 2015 & Dong *et al*., 2016).** Consumption of oat products can causes known positive effects, such as reduction of low-density lipoprotein cholesterol (LDL-C) in the serum. An inverse relationship was observed between consuming oat product and increasing body weight **(Othman *et al*., 2011).** Moreover, oat bran decreased the total cholesterol level in serum, and decreased cholesterol and TG contents in the liver. Whole-grain oat cereal decreased LDL in overweight and obese adults **(Chang *et al*., 2013)**.

Table (2): Effect of mushroom and oat treatments at different levels on lipid profile and lipoproteins of obese rats

groups	Treatments	Lipid profile			
		Cholesterol	Triglycerides	HDL-c	LDL-c
		(mg/dl)			
G1	Control (-)	$80.60^{g} \pm 0.93$	$66.80^{g} \pm 0.89$	$34.33^{a} \pm 0.67$	$32.90^{g} \pm 0.59$
G2	HFD (control +)	$165.2^{a} \pm 0.67$	$116.0^{a} \pm 0.58$	$16.0^{f} \pm 0.58$	$124.5^{a} \pm 0.44$
G3	HFD supplemented with Mushroom 10%	$142.0^{b} \pm 0.58$	$109.7^{b} \pm 0.88$	$23.0^{de} \pm 0.58$	$85.40^{b} \pm 0.72$
G4	HFD supplemented with Mushroom 20%	$135.3^{c} \pm 0.33$	$98.33^{c} \pm 0.88$	$27.0^{c} \pm 0.58$	$69.67^{d} \pm 0.88$
G5	HFD supplemented with Oat 20%	$141.0^{b} \pm 0.58$	$107.4^{b} \pm 0.81$	$21.27^{e} \pm 0.86$	$85.33^{b} \pm 0.33$
G6	HFD supplemented with Oat 40%	$126.3^{d} \pm 0.88$	$87.0^{d} \pm 0.58$	$24.47^{d} \pm 0.33$	$74.13^{c} \pm 0.58$
G7	HFD supplemented with Mushroom and Oat (10% +20%)	$102.0^{e} \pm 0.58$	$79.03^{e} \pm 0.61$	$29.0^{b} \pm 0.58$	$59.87^{e} \pm 0.61$
G8	HFD supplemented with Mushroom and Oat (20% + 40%)	$89.0^{f} \pm 0.58$	$72.38^{f} \pm 0.81$	$33.30^{a} \pm 0.85$	$38.87^{f} \pm 0.58$
F		1950.904^{*}	579.651^{*}	91.089^{*}	2253.953^{*}
p		$<0.001^{*}$	$<0.001^{*}$	$<0.001^{*}$	$<0.001^{*}$
LSD 5%		1.992	2.296	1.938	1.832

Data was expressed using Mean ± SE.
Means in a column with same letters are not significant (and Means with Different letters are significant)
*: Statistically significant at $p \leq 0.05$

Effect of mushroom and oat treatments on liver function in the serum of obese Rats

Table (3). represented the mean values of liver enzymes activities (AST, ALT, AlP and LDH) in serum of rat feed on basal diet (control -), rats fed on high fat diet (control +) and rat fed with HFD and supplemented with different levels of mushroom and oat beside their mixtures. Feeding on HFD increased the activities of serum ALP, ALT, AST and LDH compared to the control. The HFD rats showed the highest activity of the previous enzymes compared with the other treatment and control. Whereas the activity of ALP was 547.7 IU/L in HFD compared with 255.4, 300.2 and 280.0 IU/L in control (-), mushroom plus oat (20+10%) and mushroom plus oat (20+40%), respectively. The results showed that the mixtures of mushroom plus oat at the two levels reduced the activity of ALP to the level closed to the non-obese rats compared with the other treatments which showed moderate level of ALP reduction activity. Also, the HFD rats showed the highest activity of ALT compared with the other treatment and control. Whereas the activity of ALT was 66.83 U/ml in HFD compared with 34.63, 40.37 and 36.73 U/ml in control (-), mushroom plus oat (20+10%) and mushroom plus oat (20+40%), respectively. The results showed that the mixtures of mushroom plus oat at the two levels reduced the activity of ALT to the level closed to the non-obese rats compared with the other treatments which showed moderate level of ALT reduction activity. The HFD rats showed the highest activity of AST compared with the other treatment and control. Whereas the activity of AST was 80.40 U/ml in HFD compared with 49.87, 54.33 and 50.53 U/ml in control (-), mushroom plus oat (20+10%) and mushroom plus oat (20+40%), respectively. The results showed that the mixtures of mushroom plus oat at the two levels reduced the activity of AST to the level closed to the non-obese rats compared with the other treatments which showed moderate level of AST reduction activity. Moreover, the HFD rats showed the highest activity of LDH compared with the other treatment and control. Whereas the activity of LDH was 58.10 U/L in HFD compared with 28.67, 33.60 and 28.47 U/Lin control (), mushroom plus oat (20+10%) and mushroom plus oat (20+40%), respectively. The results showed that the mixtures of mushroom plus oat at the two levels reduced the activity of LDH to the level closed to the non-obese rats compared with the other treatments which showed moderate level of LDH reduction activity.

Our results showed feeding on high fat diet increased the activities of serum ALP, ALT, AST and LDH compared to the control. The HFD rats showed the highest activity of the previous enzymes compared with the other treatment and control. The results showed that the mixtures of mushroom plus oat at the two levels reduced the activity of ALP, ALT, AST and LDH to the level closed to the non-obese rats. Moreover, we can say that liver enzymes were improved by oat and/ or mushroom treatments, and thus the occurrence of fatty liver was avoided. Further, oat and/ or mushroom treatments showed that liver enzymes was significantly lowered compared with the high fat diet treatment, implicating that oat and /or mushroom are beneficial for preventing fatty liver. The obtained results in agreement with that reported by **Alam *et al*. (2009)** they found that feeding on high-fat diet for 6 weeks, serum levels of AST, ALT were significantly higher than those in the control group. Also, **Zeng *et al*. (2015)** reported that levels of ALT and AST in serum were clearly increased in response to high-fat diet compared with the control group. Furthermore, **Handayani *et al*. (2011)** reported That, HFD increased AST, ALT and ALP that that of the control group. The results of current study are in the same line with those reported by **Priya and Chellaram (2011)** they found that methonalic extract of mushroom reduced the liver enzymes , ALT , AST and ALP enzyme in obese group of albino rats. **Chen *et al*. 2018,** stated that consuming mushroom reduced liver and provided protection of liver enzymes**. Kim *et al*. (2016),** reported that HFD-induced obese rats showed increased levels of serum alanine aminotransferase, aspartate aminotransferase and lactate dehydrogenase compared to normal rats.

Table (3): Effect of mushroom and oat treatments at different levels on liver function in the serum of obese rats

Treatments groups	Parameters			
	ALP (IU/L)	ALT	AST	LDH (U/L)
		(U/mL)		
Control (-)	$255.4^{g} \pm 0.31$	$34.63^{e} \pm 0.33$	$49.87^{d} \pm 0.58$	$28.67^{e} \pm 0.27$
HFD(+)	$547.7^{a} \pm 0.91$	$66.83^{a} \pm 0.90$	$80.40^{a} \pm 0.89$	$58.10^{a} \pm 0.59$
HFD supplemented with Mushroom 10%	$320.7^{b} \pm 0.37$	$46.10^{b} \pm 0.55$	$61.07^{b} \pm 0.58$	$46.0^{b} \pm 0.58$
HFD supplemented with Mushroom 20%	$308.2^{d} \pm 0.60$	$41.73^{c} \pm 0.37$	$54.30^{c} \pm 0.35$	$38.40^{c} \pm 0.83$
HFD supplemented with Oat 20%	$319.1^{b} \pm 0.49$	$46.0^{b} \pm 0.58$	$60.67^{b} \pm 0.88$	$47.33^{b} \pm 0.88$
HFD supplemented with Oat 40%	$314.1^{c} \pm 0.64$	$44.33^{b} \pm 0.57$	$56.0^{c} \pm 0.58$	$37.73^{c} \pm 0.93$
HFD supplemented with Mushroom and Oat (10% +20%)	$300.2^{e} \pm 0.62$	$40.37^{c} \pm 0.86$	$54.33^{c} \pm 0.33$	$33.60^{d} \pm 0.67$
HFD supplemented with Mushroom and Oat (20% + 40%)	$280.0^{f} \pm 0.61$	$36.73^{d} \pm 0.44$	$50.53^{d} \pm 0.67$	$28.47^{e} \pm 0.86$
F	23275.027*	266.651*	235.223*	194.569*
P	<0.001*	<0.001*	<0.001*	<0.001*
LSD 5%	1.778	1.817	1.913	2.191

Data was expressed using Mean ± SE.
Means in a column with same letters are not significant (and Means with Different letters are significant)
*: Statistically significant at $p \leq 0.05$

Effect of mushroom and oat treatments on kidney function and glucose in the serum of obese rats

The mean values of urea, creatinine, albumin and glucose in the serum of rats feed on basal diet (control -), and rat fed with HFD and supplemented with different levels of mushroom and oat beside their mixtures are shown in **Table (4).** The data showed that the concentration of urea in HFD rats was high in serum compared with non-obese rats in which the concentration of urea was 51.07 mg/dl compared with 26.0 mg/dl in non-obese rat. The treatments of mushroom and oat showed reduction in urea concentration in which the treatment of mushroom plus oat (20+40%) gave the highest reduction in urea concentration that are closed to the concentration of urea in non-obese rats. The concentration of urea was 26.17, 28.53, 30.27 mg/dl, in mushroom plus oat (20+40%), oat (40%) and oat (20%) treatments, respectively. The data showed no significant variation in the creatinine concentration between the treatments of two levels of mushroom plus oat in obese or non-obese rats. The concentrations of creatinine ranged between 0.68 and 0.70 mg/dl for mushroom plus oat (20+40%) and mushroom (10%), respectively. The HFD rats showed the lowest level of the albumin compared with the other treatment and control. Whereas the concentration of albumin was 2.50 g/dl in HFD compared with 3.47, 3.63 and 3.50 g/dl in control (-), mushroom plus oat (20+10%) and mushroom plus oat (20+40%), respectively.

The level of glucose was significantly increased in HFD rats compared with non-obese rat. Whereas level of glucose was 104.7 mg/dl in HFD compared with 69.43 mg/dl in non-obese rats. The treatments of mushroom and/ or oat reduced the level of glucose which reached 76.90 and 70.10 mg/dl in mushroom plus oat (20+10%) and mushroom plus oat (20+40%), respectively. The current study indicated that oat and or mushroom treatments might have unique role that induce an improvement in the level of blood glucose that might be due to present of the soluble fiber (β-*glucan*) which considered a functional food component of oat and mushroom that can be incorporated into daily diet in different ways because its effect on induction insulin level. **Shanshan (2014),** reported non-significant differences between HFD group and obese groups which treated with mushroom in kidney creatinine Moreover, ***Alam et al*. (2011)** found that feeding on diet containing a 5% powder of *Pleurotus ostreatus* had no effects on creatinin, blood urea nitrogen and uric acid. **Shanshan (2014),** cleared that the highest blood glucose value was observed for HFD whereas the lowest blood glucose value was observed for negative control group C (-). On the other hand the obese rats treated with mushroom demonstrated a lower reduce the values of blood glucose as compared to HFD. Our results are in the same line with **Khatun *et al*. (2007)** and **Handayani *et al*. (2011)** they demonstrated that mushroom significantly reduced blood glucose in diabetic subjects. According to **Hsu *et al*. (2008)**, the urea, data of the different groups were statistically equal to each other, showing no influence by either the diet or mushroom. The effect of consuming oat has favorable effects on kidney function **(Rouhani *et al*., 2018). Peng *et al*. (2013)**, demonstrated that oat reduce serum glucose that enhanced by HFD. Moreover, **Andrade *et al*. (2015)** concluded that eating of β-glucans that present in oat was efficient in reducing the level of glucose in diabetic patients. Consumption more or less β-glucans for longer periods of time produced good results**.** Also, **Amin *et al*. (2012)** showed that β-glucans which is a component of the cell in mushroom regulate blood glucose level. Moreover, consuming oat β-glucans fiber after eating a meal regulate blood sugar and insulin level **(Andrade *et al*., 2015).** Furthermore **Li *et al*. (2016)** reported that intake of fifty to hundred grams daily of oat lowered blood glucose. Our results, demonstrated that the level of glucose was significantly increased in HFD rats compared with non-obese rat and mushroom and/ or oat treatments reduced the level of glucose. **Al-Sultan (2008),** stated that serum albumin is associated negatively with obesity in non-diabetic children and more recently in non-diabetic adults. Serum albumin correlated inversely with BMI suggesting an altered metabolism or handling of albumin in obesity. The current results showed that the mixtures of mushroom plus oat at the two levels increase the level of albumin close to the non-obese compared with the other treatments. The HFD rats showed the lowest level of the albumin compared with the other treatment and control.

Table (4): Effect of mushroom and oat treatments at different levels on kidney function and glucose in the serum of obese Rats

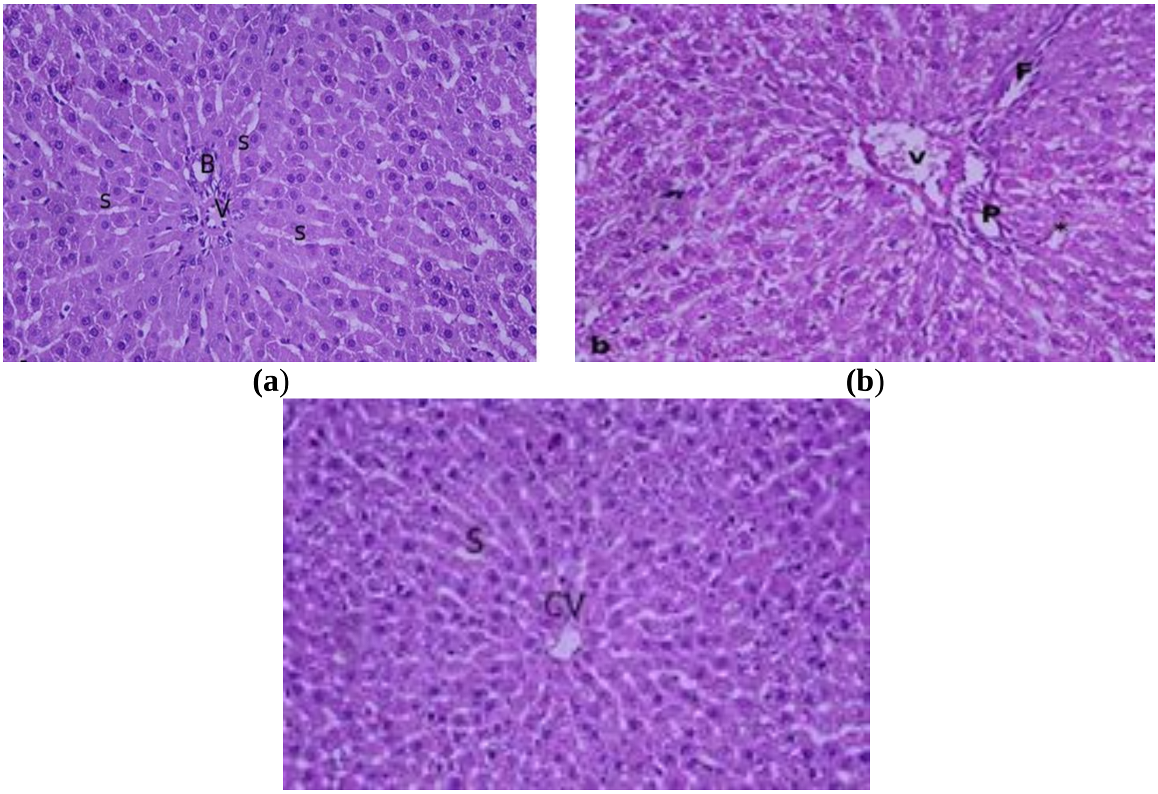
Treatments groups	Parameters			
	Urea	Creatinine	Albumin	Glucose
	(mg/dl)		(g/dl)	(mg/dl)
Control (-)	$26.0^{f} \pm 0.58$	$0.72^{a} \pm 0.05$	3.47abc ± 0.20	$69.43^{e} \pm 2.22$
HFD(+)	$51.07^{a} \pm 0.52$	$0.83^{a} \pm 0.14$	2.50d ± 0.35	$104.7^{a} \pm 0.82$
HFD supplemented with Mushroom 10%	$43.47^{b} \pm 0.90$	$0.70^{a} \pm 0.10$	2.83cd ± 0.35	$88.67^{b} \pm 0.88$
HFD supplemented with Mushroom 20%	$36.47^{c} \pm 0.68$	$0.71^{a} \pm 0.03$	2.97bcd ± 0.09	$80.0^{d} \pm 0.58$
HFD supplemented with Oat 20%	$30.27^{de} \pm 0.94$	$0.78^{a} \pm 0.09$	3.40abc ± 0.06	$88.0^{b} \pm 0.58$
HFD supplemented with Oat 40%	$28.53^{e} \pm 0.30$	$0.73^{a} \pm 0.02$	3.27abc ± 0.12	$83.33^{c} \pm 0.88$
HFD supplemented with Mushroom and Oat (10% +20%)	$30.93^{d} \pm 0.54$	$0.74^{a} \pm 0.02$	3.63a ± 0.09	$76.90^{d} \pm 0.95$
HFD supplemented with Mushroom and Oat (20% + 40%)	$26.17^{f} \pm 0.64$	$0.68^{a} \pm 0.03$	3.50ab ± 0.23	$70.10^{e} \pm 0.67$
F	182.841*	0.444	3.292*	115.507*
P	<0.001*	0.860	0.023*	<0.001*
LSD 5%	1.993	0.217	0.647	3.207

Data was expressed using Mean ± SE.
Means in a column with same letters are not significant (and Means with Different letters are significant)
*: Statistically significant at $p \leq 0.05$

Histology of liver tissues

Photomicrograph of liver rat from control group, fed on basal diet (**Photo 1a)** showed normal histological structure of hepatic lobule with normal portal vein **(V)**, bile ductile **(B)** around which the liver cells are organized in cell spans arranged in radial way. **Photo (1b)** present a liver sections of rat feed on HFD the photo showed fatty changes in sporadic hepatocytes that noticed only in liver tissues of rat fed HFD, also, showing apparently dilated and congested portal vein **(V)**, infiltrations around and in between the components of portal tract **(P)** with infiltrations between the hepatocytes **(F)**. Most of noticed hepatocytes are vacuolated and lipids pointed by **(*). Photo (1c),** represents a photomicrograph of rat liver fed on HFD and mushroom plus oat 20+40% the photo is showing normal architecture in central vein (c) and normal arrangement of blood sinusoids (S). In general, the control group of rat fed on basal diet showed a normal histological structure of hepatic while HFD group showed fatty changes in sporadic hepatocytes. However, photomicrograph of liver of HFD and mushroom plus oat 20+40% group showed normal architecture in central vein and normal arrangement of blood sinusoids which revealed that mushroom plus oat at the high level improved the structure of hepatic lobule, that might due to the present of Beta-glucans in both mushroom and oat which play role to stimulate macrophage and antioxidants effects thereby reduced the liver damage and oxidative stress in blockage the flow of bile out of the liver (**Liu *et al*., 2018)**. The results in agreement with **De Miranda *et al*. (2014)** in histology evaluation of liver, that showed mushroom diet had an effect on hepatocytes that noticed normal with homogeneous staining and reported a positive association between the dose of mushroom , liver TAG and liver ballooning histology. Also, **Peng *et al*., 2013** reported that supplement of oat reduced the hepatic lipids and decreased liver cholesterol and TG.

Further, **AL-Rawi (2007),** reported that the Histology examination of liver showed liver impairment was reduced markedly in the liver of oat soluble fiber fed rats.



(a) (b)

(c)

Photos (1): Photomicrograph of liver sections of obese rats fed on basal diet (a), HFD (b) and mushroom plus oat 20+40% (c). H&E stain X 400. (V) portal vein, (B) bile ductile, (p) portal tract, (F) infiltrations between the hepatocytes, (*) lipids pointed by, (c) central vein, (S) blood sinusoids

CONCLUSION

The results of this study reflect a positive influence of mushroom and oat on lipid profile, liver and kidney function moreover, improved level of glucose and liver tissues. A further study is needed to evaluate the effect of mushroom plus oat on some biochemical parameters in human beings. Our results recommend that mushroom, oat and their mixtures as functional foods could be used to manage obesity and improve human health.

REFERRENCES

Alam, N., Amin, R., Khan, A., Ara, I., Shim, M. J., Lee, M. W & Lee1, T. S. (2009). Comparative effects of oyster mushrooms on lipid profile, liver and kidney function in hypercholesterolemic rats. *Mycobiology*, *37*(1), 37-42. https://doi.org/10.4489/MYCO.2009.37.1.037

Alam, N., Yoon, K. N., Lee, T. S., & Lee, U. Y. (2011). Hypolipidemic activities of dietary Pleurotus ostreatus in hypercholesterolemic rats. *Mycobiology, 39*(1), 45-51. https://doi.org/10.4489/MYCO.2011.39.1.045

AL-Rawi, M. M. (2007). Efficacy of oat bran (Avena sativa L.) in comparison with atorvastatin in treatment of hypercholesterolemia in albino rat liver. *The Egyptian journal of hospital medicine*, *29*(1), 511-521. https://doi.org/10.12816/EJHM.2007.17696

Al-Sultan, A. I. (2008). Assessment of the relationship of hepatic enzymes with obesity and insulin resistance in adults in Saudi Arabia. *Sultan Qaboos university medical journal*, *8*(2), 185-192.

Amin, R., Islam, M. Z., Sen, M., Eva, S. N., Jesmin, S., and Nahar, S. (2012). Anti-obesity effect of mushroom (Ganoderma Lucidum) on experimentally induced obese rats. *Anwer khan Modern Medical College Journal*, 3(2), 11-14. https://doi.org/10.3329/akmmcj.v3i2.11687

Andrade, E. F., Lobato, R. V., de Araújo, T. V., Zangerônimo, M. G., de Sousa, R. V., and Pereira, L. J. (2015). Effect of beta-glucans in the control of blood glucose levels of diabetic patients: a systematic review. *Nutricion hospitalaria*, *31*(1), 170-177. https://doi.org/10.3305/nh.2015.31.1.7597

Association of Analytical Chemist [AOAC]. (2000). *Official methods of analysis of AOAC international* (17th ed.). Gaitherburg, USA: Association of Analytical Communities.

Astray, G., Gonzalez-Barreiro, C., Mejuto, J. C., Rial-Otero, R., & Simal-Gandara, J. (2009). A review on the use of cyclodextrins in foods. *Food Hydrocolloids, 23*(7), 1631-1640. https://doi.org/10.1016/j.foodhyd.2009.01.001

Bancroft, J. D., and Gamble, M. (2008). *Theory and practice of histological techniques*. London: Elsevier health sciences.

Bergmeyer, H. U., and Bernt, E. (1974). UV-assay with pyruvate and NADH. In H. U. Bergmeyer (Ed.), *Methods of enzymatic analysis* (p.p. 574-579). London: Elsevier.

Bigliardi, B., & Galati, F. (2013). Innovation trends in the food industry: the case of functional foods. *Trends in Food Science & Technology, 31*(2), 118-129. https://doi.org/10.1016/j.tifs.2013.03.006

Chang, H. C., Huang, C. N., Yeh, D. M., Wang, S. J., Peng, C. H., & Wang, C. J. (2013). Oat prevents obesity and abdominal fat distribution, and improves liver function in humans. *Plant foods for human nutrition, 68*(1), 18-23. https://doi.org/10.1007/s11130-013-0336-2

Chen, T. Q., Wu, J. G., Kan, Y. J., Yang, C., Wu, Y. B., and Wu, J. Z. (2018). Antioxidant and hepatoprotective activities of crude polysaccharide extracts from lingzhi or reishi medicinal mushroom, Ganoderma lucidum (Agaricomycetes), by ultrasonic-circulating extraction. *International journal of medicinal mushrooms, 20*(6), 581-593. https://doi.org/10.1615/IntJMedMushrooms.2018026536

Cheung, P. C. (2010). The nutritional and health benefits of mushrooms. *Nutrition Bulletin, 35*(4), 292-299. https://doi.org/10.1111/j.1467-3010.2010.01859.x

Chi, Q., Wang, G., Sheng, Y., Xu, W., Shi, P., Zhao, C., & Huang, K. (2017). Ethanolic extract of the Golden oyster mushroom, Pleurotus citrinopileatus (agaricomycetes), alleviates metabolic syndrome in diet-induced obese mice. *International journal of medicinal mushrooms, 19*(11), 1001-1008. https://doi.org/10.1615/IntJMedMushrooms.2017024486

da Silva, C. K. F., da Silva, Z. E., & Mariani, V. C. (2009). Determination of the diffusion coefficient of dry mushrooms using the inverse method. *Journal of food engineering*, *95*(1), 1-10. https://doi.org/10.1016/j.jfoodeng.2009.04.009

Danan Jaya, B. P., Widiastuti, E. L., Nurcahyani, E., and Sutyarso, S. (2017). Taurine and Oyster Mushroom (Pleurotus Ostreatus) Prevents Oxidative Damage in Liver of Mice Induced by Paraquat. *Biomedical and pharmacology journal*, *10*(4), 1993-2000. https://dx.doi.org/10.13005/bpj/1320

Davis, C. D. (2016). The gut microbiome and its role in obesity. *Nutrition today*, *51*(4), 167-174. https://doi.org/10.1097/NT.0000000000000167

De Miranda, A. M., Ribeiro, G. M., Cunha, A. C., Silva, L. S., dos Santos, R. C., Pedrosa, M. L., and Silva, M. E. (2014). Hypolipidemic effect of the edible mushroom Agaricus blazei in rats subjected to a hypercholesterolemic diet. *Journal of physiology and biochemistry*, *70*(1), 215-224. https://doi.org/10.1007/s13105-013-0295-y

Dong, J. L., Zhu, Y. Y., Ma, Y. L., Xiang, Q. S., Shen, R. L., & Liu, Y. Q. (2016). Oat products modulate the gut microbiota and produce anti-obesity effects in obese rats. *Journal of functional foods*, *25*, 408-420. https://doi.org/10.1016/j.jff.2016.06.025

Fossati, P., & Prencipe, L. (1982). Serum triglycerides determined colorimetrically with an enzyme that produces hydrogen peroxide. *Clinical chemistry*, *28*(10), 2077-2080. https://doi.org/10.1093/CLINCHEM/28.10.2077

Gregg, E. W., & Shaw, J. E. (2017). Global health effects of overweight and obesity: Mass Medical Soc.

Guo, X.-x., Wang, Y., Wang, K., Ji, B.-p., & Zhou, F. (2018). Stability of a type 2 diabetes rat model induced by high-fat diet feeding with low-dose streptozotocin injection. *Journal of Zhejiang University-Science B*, *19*(7), 559-569. https://doi.org/10.1631/jzus.B1700254

Hall, M. E., do Carmo, J. M., da Silva, A. A., Juncos, L. A., Wang, Z., & Hall, J. E. (2014). Obesity, hypertension, and chronic kidney disease. *International journal of nephrology and* *renovascular disease*, *7*, 75. https://doi.org/10.2147/IJNRD.S39739

Handayani, D., Meyer, B. J., Chen, J., Tang, P., Kwok, P. C. L., Chan, H.-K., & Huang, X.-F. (2012). The comparison of the effect of oat and shiitake mushroom powder to prevent body weight gain in rats fed high fat diet. *Food and Nutrition Sciences*, *3*(7), 1009-1019. https://doi.org/10.4236/fns.2012.37134

Hsu, C.-H., Hwang, K.-C., Chiang, Y.-H., and Chou, P. (2008). The mushroom Agaricus blazei Murill extract normalizes liver function in patients with chronic hepatitis B. *The Journal of Alternative and Complementary Medicine*, *14*(3), 299-301. https://doi.org/10.1089/acm.2006.6344

Jahan, N., Akhter, S., and Sultana, N. (2017). Effect of Oyster Mushroom on Kidney in Stress Induced Depressed Rats. *Journal of Bangladesh Society of Physiologist*, *12*(1), 33-40. https://doi.org/10.3329/jbsp.v12i1.33926

Jaye, M., Doan, K.-A. T., Krawiec, J. A., Lynch, K. J., Amin, D. V., South, V. J. . . . & Rader, D. J. (2009). *Compositions and Methods for Effecting the Levels of High Density Lipoprotein (HDL) Cholesterol and Apolipoprotein AI, Very Low Density Lipoprotein (VLDL) Cholesterol and Low Density Lipoprotein (LDL) Cholesterol*. Philadelphia: Patent Application Publication.

Jia, Y.-J., Liu, J., Guo, Y.-L., Xu, R.-X., Sun, J., & Li, J.-J. (2013). Dyslipidemia in rat fed with high-fat diet is not associated with PCSK9-LDL-receptor pathway but ageing. *Journal of geriatric cardiology: JGC*, *10*(4), 361-368. https://doi.org/10.3969/j.issn.1671-5411.2013.04.007

Kang, J.-H., Yun, S.-I., Park, M.-H., Park, J.-H., Jeong, S.-Y., & Park, H.-O. (2013). Anti-obesity effect of Lactobacillus gasseri BNR17 in high-sucrose diet-induced obese mice. *PloS one*, *8*(1), e54617. https://doi.org/10.1371/journal.pone.0054617

Khatun, K., Mahtab, H., Khanam, P., Sayeed, M., & Khan, K. (2007). Oyster mushroom reduced blood glucose and cholesterol in diabetic subjects. *Mymensingh medical journal*, *16*(1), 94. https://doi.org/10.3329/mmj.v16i1.261

Kim, G. W., Ahn, K. Y., Kim, Y. H., and Jeong, G. W. (2016). Time-course metabolic changes in high-fat diet-induced obesity rats: A pilot study using hyperpolarized (13)C dynamic MRS. *Magnetic resonance imaging*, *34*(8), 1199-1205. https://doi.org/10.1016/j.mri.2016.06.002

Kirkpatrick, L. A., & Feeney, B. C. (2013). *A simple guide to IBM SPSS statistics for version 20.0*. Belmont, Calif: Wadsworth, Cengage Learning.

Lavie, C. J., Laddu, D., Arena, R., Ortega, F. B., Alpert, M. A., and Kushner, R. F. (2018). Reprint of: healthy weight and obesity prevention: JACC health promotion series. *Journal of the American College of Cardiology*, *72*(23), 3027-3052. https://doi.org/10.1016/j.jacc.2018.10.024

Li, X., Cai, X., Ma, X., Jing, L., Gu, J., Bao, L & Li, Y. (2016). Short-and long-term effects of wholegrain oat intake on weight management and glucolipid metabolism in overweight type-2 diabetics: a randomized control trial. *Nutrients*, *8*(9), 549. https://doi.org/10.3390/nu8090549

Liu, B., Yang, T., Luo, Y., Zeng, L., Shi, L., Wei, Cand Luo, F. (2018). Oat β-glucan inhibits adipogenesis and hepatic steatosis in high fat diet-induced hyperlipidemic mice via AMPK signaling. *Journal of functional foods*, *41*, 72-82. https://doi.org/10.1016/j.jff.2017.12.045

Liu, R., Hong, J., Xu, X., Feng, Q., Zhang, D., Gu, Y & Wang, X. (2017). Gut microbiome and serum metabolome alterations in obesity and after weight-loss intervention. *Nature medicine*, *23*(7), 859-868. https://doi.org/10.1038/nm.4358

Lopes-Virella, M., Stone, P., & Colwell, J. (1977). Serum high density lipoprotein in diabetic patients. *Diabetologia*, *13*(4), 285-291. https://doi.org/10.1007/BF01223267

Lott, J. A., and Turner, K. (1975). Evaluation of Trinder's glucose oxidase method for measuring glucose in serum and urine. *Clinical chemistry*, *21*(12), 1754-1760. https://doi.org/10.1093/CLINCHEM/21.12.1754

Mori, K., Kobayashi, C., Tomita, T., Inatomi, S., & Ikeda, M. (2008). Antiatherosclerotic effect of the edible mushrooms Pleurotus eryngii (Eringi), Grifola frondosa (Maitake), and Hypsizygus marmoreus (Bunashimeji) in apolipoprotein E–deficient mice. *Nutrition Research*, *28*(5), 335-342. https://doi.org/10.1016/j.nutres.2008.03.010

Othman, R. A., Moghadasian, M. H., & Jones, P. J. (2011). Cholesterol-lowering effects of oat β-glucan. *Nutrition reviews*, *69*(6), 299-309. https://doi.org/10.1111/j.1753-4887.2011.00401.x

Peng, C.-H., Chang, H.-C., Yang, M.-Y., Huang, C.-N., Wang, S.-J., & Wang, C.-J. (2013). Oat attenuate non-alcoholic fatty liver and obesity via inhibiting lipogenesis in high fat-fed rat. *Journal of Functional Foods*, *5*(1), 53-61. https://doi.org/10.1016/j.jff.2012.08.003

Priya, G., and Chellaram , C. (2011). Anti–hyperlipidemic Effects of Edible Mushroom, Agaricus bisporus. *Advanced Biotech*, *10*(7), 71.

Rasane, P., Jha, A., Sabikhi, L., Kumar, A., & Unnikrishnan, V. (2015). Nutritional advantages of oats and opportunities for its processing as value added foods-a review. *Journal of food science and technology*, *52*(2), 662-675. https://doi.org/10.1007/s13197-013-1072-1

Rathore, H., Prasad, S., & Sharma, S. (2017). Mushroom nutraceuticals for improved nutrition and better human health: A review. *PharmaNutrition*, *5*(2), 35-46. https://doi.org/10.1016/j.phanu.2017.02.001

Richmond, W. (1973). Preparation and properties of a cholesterol oxidase from Nocardia sp. and its application to the enzymatic assay of total cholesterol in serum. *Clinical chemistry*, *19*(12), 1350-1356. https://doi.org/10.1093/clinchem/19.12.1350

Rop, O., Mlcek, J., & Jurikova, T. (2009). Beta-glucans in higher fungi and their health effects. *Nutrition reviews*, *67*(11), 624-631. https://doi.org/10.1111/j.1753-4887.2009.00230.x

Rouhani, M. H., Najafabadi, M. M., Surkan, P. J., Esmaillzadeh, A., Feizi, A., and Azadbakht, L. (2018). The impact of oat (Avena sativa) consumption on biomarkers of renal function in patients with chronic kidney disease: A parallel randomized clinical trial. *Clinical Nutrition, 37*(1), 78-84. https://doi.org/10.1016/j.clnu.2016.11.022

Schneider, I., Kressel, G., Meyer, A., Krings, U., Berger, R. G., and Hahn, A. (2011). Lipid lowering effects of oyster mushroom (Pleurotus ostreatus) in humans. *Journal of Functional Foods, 3*(1), 17-24. https://doi.org/10.1016/j.jff.2010.11.004

Shanshan, N. (2014). Biological effect of mushroom consumption on obese male rats. *Damietta University Publication*, *1*(2), 237-246. https://doi.org/10.21608/jfds.2012.75368

Shlipak, M. G., Matsushita, K., Ärnlöv, J., Inker, L. A., Katz, R., Polkinghorne, K. R. . . . and Coresh, J. (2013). Cystatin C versus creatinine in determining risk based on kidney function. *New England Journal of Medicine, 369*(10), 932-943. https://doi.org/10.1056/NEJMoa1214234

Williamson, D. H. (1974). L-Alanine determination with alanine dehydrogenase. In H. U. Bergmeyer (Ed.), *Methods of enzymatic analysis* (p.p. 1679-1685). New York: Elsevier.

Wuepper, A., Tattersall, J., Kraemer, M., Wilkie, M., and Edwards, L. (2003). Determination of urea distribution volume for Kt/V assessed by conductivity monitoring. *Kidney international*, *64*(6), 2262-2271. https://doi.org/10.1046/j.1523-1755.2003.00327.x

Yagi, T., Kagamiyama, H., Nozaki, M., and Soda, K. (1985). Glutamate-aspartate transaminase from microorganisms. In H. U. Bergmeyer (Ed.), *Methods in enzymology* (p.p. 83-89). New York: Elsevier.

Zeng, W., Shan, W., Gao, L., Gao, D., Hu, Y., Wang, G. . . . and Yao, J. (2015). Inhibition of HMGB1 release via salvianolic acid B-mediated SIRT1 up-regulation protects rats against non-alcoholic fatty liver disease. *Scientific reports, 5*, 16013. https://doi.org/10.1038/srep16013