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# 学位論文全文に代わる要約
# Extended Summary in Lieu of Dissertation

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学位論文題目：
Title of Dissertation　Study and development of biological activity from edible mushrooms and *Citrus macroptera*
（食用キノコと*Citrus macroptera*の生物活性の研究と開発）

学位論文要約：
Dissertation Summary

Diabetes mellitus is a serious metabolic disease and has been viewed as a major risk of health in the world (Liu et al., 2012). One approach to diabetes prevention is to control glucose absorption to reduce postprandial blood glucose levels (Suzuki et al., 2017). $\alpha$-Glucosidase is a key enzyme that hydrolyzes oligosaccharides and disaccharides to $\alpha$-D-glucose and increases postprandial blood glucose levels. In order to suppress the postprandial blood glucose levels, $\alpha$-glucosidase inhibitors can delay the carbohydrate absorption by inhibiting the $\alpha$-glucosidase (Lebovitz, 1997). In addition, hyperglycemia is a risk factor for the development of diabetes, which is responsible for the generation of reactive oxygen species (ROS), causes a greater production of free radicals, and results in a reduction of the antioxidant defense, which also mediates the complications of the disease. Antioxidants are bioactive reducing agents capable of preventing harmful effects of reactive oxygen species (ROS) and other free radicals. Thus, antioxidants protect against numerous chronic diseases such as cancer, heart disease, autoimmune diseases, diabetes, sclerosis, atherosclerosis, cataracts, and chronic inflammation (Willcox et al., 2004). On the other hand, antibiotics have proven to be an important tool in the fight against microbial infections and have significantly improved health-related qualities of human life. Since the discovery of antibiotics and their uses as chemotherapy agents, there has been the impression in the health sector that this would lead to the possible eradication of infectious diseases. However, in the past few decades, misuse of antibacterial agents has led to the emergence and spread of multi-drug resistant strains of different groups of microorganisms (Khan et al., 2009; Bhalodia and Shukla, 2011). In clinical practice, various synthetic agents are used to control diabetes, oxidative damages and bacterial infections. Therefore, it is very important to find active substances that will lead to the development of antidiabetic, antioxidant, and antibacterial drugs with minimal side effects and relatively low cost in the clinic. For this reason, the use of biomolecules of natural resources is the best option. Edible mushrooms and *Citrus macroptera* have been recognized as a source of natural phytochemicals with promising biological activities that can protect us from different chronic diseases. This research, therefore, has focused to study and development of biological activity from edible mushrooms and *Citrus macroptera* fruit.

Mushrooms are macrofungi (Basidiomycetes and Ascomycetes) with a characteristic fruiting body which can be either epigeous (above ground) or hypogeous (below ground) and large enough to be seen with the naked eye and to be picked by hand. (Elsayed et al., 2014; Chang and Miles, 2008). They are environmentally friendly, biosynthesize their food from residues of agricultural crop, which would otherwise result in health risks

(Chang and Wasser, 2012). Mushroom edibility can be described by criteria including lack of toxic effects on humans and desirable for its taste and aroma (Chang and Miles, 2008).

For a long time edible mushrooms were admired for their flavor and texture. They are now recognized as a nutritious food and as an important source of biologically active compounds with medicinal value. A daily consumption of mushrooms can make us healthier, fitter, and happier, and enable us to live longer (Breene, 1990). There are more than 150000 different types of mushrooms in existence, but only 10 percent are recognized and named. However, for nutritional purpose only about 2000 species are grown and cultivated (Alispahic et al., 2015). A total of 126 medicinal functions, including antitumor, immune modulating, antioxidant, radical scavenging, cardiovascular, anti-hypercholesterolemia, antiviral, antibacterial, anti-parasitic, antifungal, detoxification, hepato protective, and anti-diabetic effects are thought to be produced by mushrooms (Chang and Wasser, 2012).

*Citrus macroptera* (family, Rutaceae) is a semi-wild species of the *citrus* genus (Dreyer and Huey, 1973). It is commonly known as ‘Satkara’ in Bangladesh and generally found in the division Sylhet in the northeastern part of the country. Though a type of true fruit like orange, it is commonly regarded as a vegetable by the locals. The whole fruit is used as an ingredient in various curries, as well as in pickle preparation (Rahmatullah et al., 2010). *C. macroptera* is a potential source of natural nutrients, phenolic compounds and antioxidants (Islam et al., 2015). Moreover, several bioactive compounds with different biological activities were reported from *C. macportera* (Aktar and Foyzun, 2017). Traditionally, the fruit has been used for the treatment of several diseases. However, *C. macroptera* has demonstrated several biological activities, such as the antioxidant activity (Islam et al., 2015; Paul et al., 2015; Chowdhury et al., 2008), antiparasitic activity (Desrivot et al., 2007), thrombolytic activity (Karim et al., 2015), neuropharmalogical activities (Rahman et al., 2014), the antimicrobial activity (Waikedre et al., 2010), the $\alpha$-amylase inhibitory activity, hypoglycemic activity, cardioprotective and hepatoprotective activities (Uddin et al., 2014).

This research consisted of three chapters (Chapters 2, 3, and 4). The objective of Chapter 2 was to examine the antioxidant activity and $\alpha$-glucosidase-inhibitory activity of seven edible mushroom species, namely, Enokitake (*Flammulina velutipes*), Hiratake (*Pleurotus ostreatus*), Aragekikurage (*Auricularia polytricha*), Maitake (*Grifola frondosa*), Porcini (Yamadoritake) (*Boletus edulis*), Mannentake (*Ganoderma lucidum*), and Shiitake (*Lentinula edodes*), and to determine $\alpha$-glucosidase-inhibitory active compounds from *B. edulis*. The objective of Chapter 3 was to explore the antibacterial activity of the above mentioned edible mushroom species, using a resazurin-based 96-well plate microdilution method. The objective of Chapter 4 was to isolate and identify the compounds from the whole fruit of *Citrus macroptera* and investigate their antioxidant activities.

Chapter 2 was carried out to examine the antioxidant activity and $\alpha$-glucosidase inhibitory activity of the seven species of edible mushroom species. Edible mushrooms are one of the most common foods in many areas of the world, not only for their taste but also for their chemical and medicinal properties. Moreover, some edible mushrooms contain antioxidant and antihyperglycemic activities (Zavastin et al., 2016). In this regard, seven species of edible mushrooms commercially available [Enokitake (*Flammulina velutipes*, Hiratake (*Pleurotus ostreatus*), Aragekikurage (*Auricularia polytricha*), Maitake (*Grifola frondosa*), Porcini (Yamadoritake) (*Boletus edulis*), Mannentake (*Ganoderma lucidum*), and Shiitake (*Lentinula edodes*)] were used, and their methanolic and water extracts were prepared and investigated.

**Table 1.** Yield, total phenolic content, DPPH radical scavenging activity, and $\alpha$-glucosidase inhibitory activity of extracts from seven species of edible mushrooms

| Samples and positive controls | Extracts | Yield (% dry weight of mushroom) | Total phenolic content (mg GAE/g sample extract) | DPPH radical scavenging activity $IC_{50}$ (mg/mL) | $\alpha$-Glucosidase inhibitory activity $IC_{50}$ (mg/mL) | |
|---|---|---|---|---|---|---|
| | | | | | *Saccharomyces cerevisiae* | Rat small intestine |
| *F. velutipes* | MeOH Extract | 40.0 | 6.56 ± 0.08 | 3.81 ± 0.01 | ND | ND |
| | Water Extract | 35.0 | 6.49 ± 0.19 | 1.89 ± 0.63 | ND | ND |
| *P. ostreatus* | MeOH Extract | 34.2 | 6.83 ± 0.08 | ND | ND | ND |
| | Water Extract | 30.5 | 13.3 ± 0.02 | 2.75 ± 0.56 | ND | ND |
| *A. polytricha* | MeOH Extract | 3.32 | 6.24 ± 0.31 | 0.54 ± 0.03 | ND | ND |
| | Water Extract | 8.00 | 9.5 ± 0.06 | 1.89 ± 0.24 | ND | ND |
| *G. frondosa* | MeOH Extract | 29.0 | 5.19 ± 0.08 | ND | 7.05 ± 0.18 | ND |
| | Water Extract | 16.0 | 18.6 ± 0.42 | 1.43 ± 0.18 | ND | ND |
| *B. edulis* | MeOH Extract | 31.1 | 9.35 ± 0.25 | 1.50 ± 0.19 | 1.27 ± 0.02 | ND |
| | Water Extract | 29.8 | 30.8 ± 0.44 | 0.33 ± 0.00 | ND | ND |
| *G. lucidum* | MeOH Extract | 4.80 | 13.0 ± 0.67 | 0.53 ± 0.02 | 1.30 ± 0.04 | ND |
| | Water Extract | 5.27 | 8.87 ± 0.19 | 1.37 ± 0.13 | ND | ND |
| *L. edodes* | MeOH Extract | 20.0 | 4.12 ± 0.02 | ND | ND | ND |
| | Water Extract | 20.0 | 7.82 ± 0.06 | 1.20 ± 0.12 | ND | ND |
| Trolox | - | - | - | $6.64 \times 10^{-3} \pm 0.31 \times 10^{-3}$ | - | - |
| (-)-Epicatechin | - | - | - | - | 0.53 ± 0.01 | ND |
| Acarbose | - | - | - | - | ND | 0.12 ± 0.00 |

Each value is expressed as the mean ± SE (n = 3). ND: not detected.

The water extract of *B. edulis* showed the highest total phenolic content (30.8 ± 0.44 mg/g), followed by the water extract of *G. frondosa* with 18.6 ± 0.42 mg/g (Table 1). In addition, the water extract of *B. edulis* exhibited significant antioxidative activity (DPPH radical scavenging activity) ($IC_{50}$: 0.33 ± 0.00 mg/mL), followed by MeOH extract of *G. lucidum* ($IC_{50}$: 0.53 ± 0.02 mg/mL) and MeOH extract of *A. polytricha* ($IC_{50}$: 0.54 ± 0.03 mg/mL). The other mushroom extracts had less activity.

With respect to inhibition activity of the $\alpha$-glucosidase from *Saccharomyces cerevisiae*, the MeOH extract of *B. edulis* was exhibited the strongest activity with $IC_{50}$: 1.27 ± 0.02 mg/mL, followed by the MeOH extract of *G. lucidum* with $IC_{50}$: 1.30 ± 0.04 mg/mL at 10 mg/mL sample concentration. In this study, on the other hand, in the case of the $\alpha$-glucosidase from rat small intestine, all the selected mushroom extracts exhibited less inhibitory activity. (-)-Epicatechin showed inhibitory activity on $\alpha$-glucosidase from *S. cerevisiae*, but no inhibitory activity on $\alpha$-glucosidase of the rat small intestine. In contrast, acarbose showed a high inhibitory activity for the rat small intestine $\alpha$-glucosidase but had no effect on the $\alpha$-glucosidase from *S. cerevisiae*.

Furthermore, MeOH extract of *B. edulis* was separated to identify the $\alpha$-glucosidase inhibitory compounds. The *n*-butanol-organic fraction showed inhibitory activity against the $\alpha$-glucosidase from *S. cerevisiae*, and its separation was carried out. Finally, the presence of four fatty acids with the $\alpha$-glucosidase

inhibitory activity were found. They were identified as methyl ester derivatives [methyl palmitate ($M^+$: *m*/*z* 270), methyl stearate ($M^+$: *m*/*z* 298), methyl oleate ($M^+$: *m*/*z* 296), and methyl linoleate ($M^+$: *m*/*z* 294)] by GC-MS. Those structures were confirmed by comparison with GC-MS of the standard compounds. To the best of our knowledge, this is the first report showing inhibitory effects of *Boletus edulis* fatty acids on *α*-glucosidase.

**Table 2.** *α*-Glucosidase (*S. cerevisiae* and rat small intestine) inhibitory activity of different saturated and unsaturated fatty acids

| Samples and positive controls | Numerical symbols of fatty acids | *α*-Glucosidase inhibitory activity, $IC_{50}$ | | |
|---|---|---|---|---|
| | | (*S. cerevisiae*) μg/mL | (*S. cerevisiae*) nmol/mL | (Rat small intestine) μg/mL |
| Palmitic acid | 16:0 | 79.98 ± 2.98 | 311.89 ± 11.62 | ND |
| Stearic acid | 18:0 | 6.13 ± 0.27 | 21.5 ± 0.94 | ND |
| Oleic acid | 18:1 ($\Delta^9$) | 9.63 ± 0.02 | 34.09 ± 0.00 | ND |
| Linoleic acid | 18:2 ($\Delta^{9,12}$) | 34.06 ± 0.39 | 121.44 ± 1.40 | ND |
| Arachidic acid | 20:0 | 6.19 ± 0.07 | 19.80 ± 0.22 | ND |
| Behenic acid | 22:0 | 0.99 ± 0.03 | 2.90 ± 0.00 | ND |
| α-Linolenic acid | 18:3 ($\Delta^{9,12,15}$) | 7.48 ± 0.08 | 26.86 ± 0.28 | ND |
| (-)-Epicatechin | | 530.00 ± 14.46 | 1825 ± 49.8 | ND |
| Acarbose | | ND | ND | 115.73 ± 1.66 |

Each value is expressed as the mean ± SE (n = 3). ND: not detected.

The inhibitory active compounds were evaluated in the inhibition assay of *α*-glucosidase (*S. cerevisiae*) along with other standard compounds. The *α*-glucosidase inhibitory activity of these compounds are shown in Table 2. Stearic acid showed the strongest inhibitory activity with $IC_{50}$: 6.13 ± 0.27 μg/mL (21.5 ± 0.94 nmol/mL), followed by oleic acid with $IC_{50}$: 9.63 ± 0.02 μg/mL, linoleic acid with $IC_{50}$: 34.06 ± 0.39 μg/mL, and palmitic acid with $IC_{50}$: 79.98 ± 2.98 μg/mL at 100 μg/mL sample concentration. To elucidate the structure-activity relationship, arachidic acid, behenic acid, and α-linolenic acid were also assayed. Among them, behenic acid was exhibited the strongest inhibitory activity with $IC_{50}$: 0.99 ± 0.03 μg/mL (2.90 ± 0.00 nmol/mL), followed by arachidic acid and α-linolenic acid at 100 μg/mL sample concentration. However, in the case of *α*-glucosidase (rat small intestine) inhibition activity, no activity was detected from all compounds. This result suggested that *B. edulis* could potentially be used to develop *α*-glucosidase (*S. cerevisiae*) inhibitory activity and antioxidant activity.

Chapter 3 was carried out to explore the antibacterial activity of the seven species of edible mushroom species. In this study, the antibacterial activity of methanol (MeOH) and water extracts of seven species of edible mushroom was studied, using a resazurin-based 96-well plate microdilution method. Based on our knowledge, the seven edible mushrooms (*F. velutipes*, *P. ostreatus*, *A. polytricha*, *G. frondosa*, *B. edulis*, *G. lucidum*, and *L. edodes*) have rarely been studied for its antibacterial activity, using the resazurin-based 96-well plate microdilution method. The results of MIC and MBC using resazurin-based 96-well plate microdilution method are shown in Table 3. The result demonstrated that both gram-positive (+ve) and gram-negative (−ve)

bacteria examined were susceptible to the MeOH and water extracts from the seven edible mushrooms. The MIC values ranged from 0.31 mg/mL to >5 mg/mL for *E. coli* and 0.16 mg/mL to >5 mg/mL for *S. aureus*. The MBC values ranged from 0.625 mg/mL to >5 mg/mL for *E. coli* and 0.31 mg/mL to >5 mg/mL for *S. aureus.* The standard drug (Ampicillin) showed great antibacterial activity for both MIC and MBC values 4 $\mu$g/mL (the least concentration tested).

The MeOH extract of *G. lucidum* showed the highest activity with MIC (0.31 mg/mL) and MBC (0.625 mg/mL) values against *E. coli*. Likewise, the MeOH extract of *G. lucidum* showed the highest activity with MIC (0.16 mg/mL) and MBC (0.31 mg/mL) values against *S. aureus*. On the other hand, the MeOH extract of *G. frondosa* showed moderate activity in both gram-positive (+ve) and gram-negative (−ve) bacteria. The present study shows that MeOH extract of *G. lucidium* and *G. frondosa* demonstrated antibacterial activity against *E. coli* and *S. aureus*. It suggests that these mushrooms may be used as good sources of antibacterial agents.

**Table 3.** Determination of the minimum inhibitory concentrations (MIC) and minimum bactericidal concentrations (MBC) values of the sample extracts against two standard bacterial strains, using a resazurin-based 96-well plate microdilution method.

| Samples and Control | Extracts | *Escherichia coli* (−ve) | | *Staphylococcus aureus* (+ve) | |
|---|---|---|---|---|---|
| | | MIC (mg/mL) | MBC (mg/mL) | MIC (mg/mL) | MBC (mg/mL) |
| Enokitake (*Flammulina velutipes*) | MeOH Extract | 1.25 | 5 | 1.25 | 1.25 |
| | Water Extract | 1.25 | 2.5 | 1.25 | 2.5 |
| Hiratake (*Pleurotus ostreatus*) | MeOH Extract | 1.25 | 5 | 1.25 | 1.25 |
| | Water Extract | >5 | >5 | >5 | >5 |
| Aragekikurage (*Auricularia polytricha)* | MeOH Extract | 1.25 | 1.25 | 1.25 | 1.25 |
| | Water Extract | >5 | >5 | 5 | >5 |
| Maitake (*Grifola frondosa)* | MeOH Extract | 0.625 | 1.25 | 0.625 | 2.5 |
| | Water Extract | >5 | >5 | >5 | >5 |
| Porcini (Yamadoritake) (*Boletus edulis*) | MeOH Extract | 1.25 | 5 | 1.25 | 1.25 |
| | Water Extract | >5 | >5 | 0.625 | >5 |
| Mannentake (*Ganoderma lucidum*) | MeOH Extract | 0.31 | 0.625 | 0.16 | 0.31 |
| | Water Extract | >5 | >5 | >5 | >5 |
| Shiitake (*Lentinula edodes)* | MeOH Extract | 1.25 | 5 | 1.25 | 2.5 |
| | Water Extract | 5 | >5 | 5 | >5 |
| Ampicillin (positive control) | - | <0.004 | <0.004 | <0.004 | <0.004 |

">" (value greater than the highest concentration tested), and "<" (value lesser than the lowest concentration tested)

Chapter 4 was carried out to identify the compounds isolated from the whole fruit of *Citrus macroptera* and investigate their antioxidant activities. *Citrus macroptera* (family Rutaceae), locally known as Satkara in Bangladesh, is a pharmacologically diverse medicinal plant. The whole fruit powder of *C. macroptera* was extracted with MeOH. The resulting MeOH extract was partitioned between EtOAc and water. The EtOAc fraction was subjected to a series of chromatographic-separation giving seven isolated compounds, namely, xanthotoxol (**1**), isomeranzin (**2**), limonin (**3**), scopoletin (**4**), scoparone (**5**),

5-[(6',7'-dihydroxy-3',7'-dimethyl-2'-octenyl)oxy]psoralen (**6**), and meranzin hydrate (**7**) (Figure 1), which were identified by comparing their NMR spectroscopic data with those in the literature. Based on our knowledge, among the identified seven compounds, **1**, **2**, **4**, **5**, and **7** were isolated and identified for the first time from this plant.

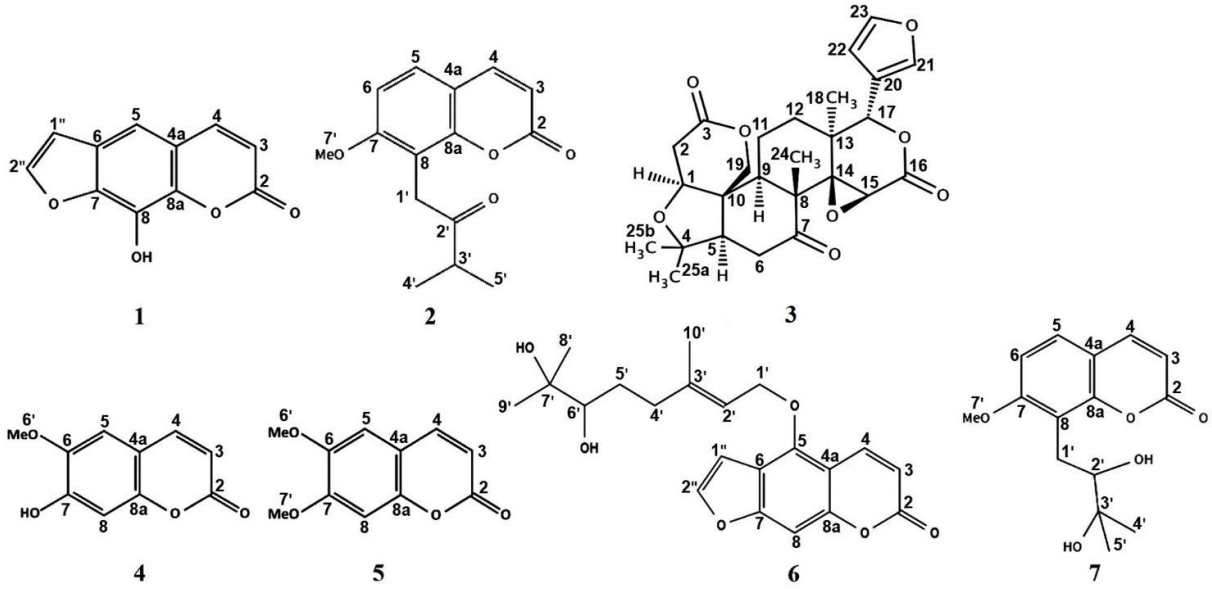

**Figure 1.** Structures of the isolated and identified compounds from the whole fruit of *Citrus macroptera*

**Table 4.** DPPH free radical scavenging activity of compounds from the whole fruit of *Citrus macroptera*

| Compounds | $IC_{50}$ µg/mL | $IC_{50}$ nmol/mL |
|---|---|---|
| Xanthotoxol (**1**) | 10.7 ± 0.05 | 52.7 ± 0.25 |
| Isomeranzin (**2**) | 75.8 ± 0.00 | 291.1 ± 0.00 |
| Limonin (**3**) | 581.6 ± 0.08 | 1236.1 ± 0.16 |
| Scopoletin (**4**) | 113.5 ± 0.01 | 590.7 ± 0.00 |
| Scoparone (**5**) | 215.9 ± 0.01 | 1046.8 ± 0.00 |
| 5-[(6',7'-Dihydroxy-3',7'-dimethyl-2'-octenyl)oxy]psoralen (**6**) | 380.7 ± 0.02 | 1022.3 ± 0.00 |
| Meranzin hydrate (**7**) | 344.0 ± 0.00 | 1236.2 ± 0.00 |
| Trolox (Positive control) | 6.64 ± 0.31 | 26.6 ± 1.25 |

The seven compounds were examined for antioxidant activity using the DPPH free radical scavenging assay (Table 4). Among them, xantotoxol (**1**) ($IC_{50}$: 52.7 ± 0.25 nmol/mL) exhibited strong activity, and isomeranzin (**2**) (291.1 ± 0.00 nmol/mL) and scopoletin (**4**) (590.7± 0.00 nmol/mL) showed moderate activity compared with the known antioxidant, trolox. A few researchers reported on antioxidant activity of xanthotoxol (Prasad et al., 2010; Bai et al., 2016). Xantotoxol (**1**) is a phenolic furanocoumarin. Prasad et al. (Prasad et al., 2010), documented that **1** has DPPH radical scavenging activity due to its ability to donate electrons. It can be concluded that the coumarins are the major contributors of the antioxidative property of *C. macroptera*.

**References**

Liu, Y.T., Sun, J., Luo, Z.Y., Rao, S.Q., Su, Y.J., Xu, R.R., Yang, Y.J. 2012. Chemical composition of five wild

edible mushrooms collected from Southwest China and their antihyperglycemic and antioxidant activity. *Food Chem. Toxicol.* **50**, 1238–1244.

Suzuki, T., Matsuno, F., Katayama, T., Andrianto, D. 2017. *α*-Glucosidase inhibition and DPPH free radical-scavenging activities of underutilized fruits from Java Island Indonesia. *J. Forest Biomass Util. Soc*. **12,** 59–62.

Lebovitz, H.E. 1997. *α*-Glucosidase inhibitors. *Endocrinol Metab. Clin. North Am.* **26,** 539–551.

Willcox, J.K., Ash, S.L., Catignani, G.L. 2004. Antioxidants and prevention of chronic disease. Review. *Crit. Rev. Food Sci. Nutri.* **44**, 275–295.

Khan, R., Islam, B., Akram, M., Shakil, S., Ahmad, A.A., Ali, S.M., Siddiqui, M., Khan, A.U. 2009. Antimicrobial activity of five herbal extracts against multi drug resistant (MDR) strains of bacteria and fungus of clinical origin. *Molecules* **14 (2)**, 586–597.

Bhalodia, N.R., Shukla, V.J. 2011. Antibacterial and antifungal activities from leaf extracts of *Cassia fistula* l.: An ethnomedicinal plant. *J. Adv. Phar. Technol. Res.* **2 (2)**, 104–109.

Elsayed, E.A., Enshasy, H. E., Wadaan, M.A.M., Aziz, R. 2014. Mushrooms: A potential natural source of anti-inflammatory compounds for medical applications. *Mediat. Inflamm.* **2014**.

Chang, S.T., Miles, P.G. 2008. Mushrooms: Cultivation, Nutritional Value, Medicinal Effect, and Environmental Impact, 2nd ed. CRC Press: Boca Raton, FL, USA.

Chang, S.T., Wasser, S.P. 2012. The role of culinary-medicinal mushrooms on human welfare with a pyramid model for human health. *Int. J. Med. Mushrooms* **14**, 95–134.

Breene, W. M. 1990. Nutritional and medicinal value of specialty mushrooms. *J. Food Prot.* **3**, 883–894.

Alispahic, A., Sapcanin, A., Salihovic, M., Ramic, E., Dedic, A., Pazalja, M. 2015. Phenolic content and antioxidant activity of mushroom extracts from Bosnian market. *Bull. Chem. Technol. Bosnia Herzegovina* **44**, 5–8.

Dreyer, D.L., and Huey, P.F. 1973. Coumarins of *Citrus macroptera*. *Phytochemistry* **12 (12)**, 3011–3013.

Rahmatullah, M., Khatun, M.A., Morshed, N., Neogi, P.K., Khan, S.U.A., Hossan, S.A., Mahal, M.J., Jahan, R. 2010. A randomized survey of medicinal plants used by folk medicinal healers of Sylhet Division, Bangladesh. *Adv. Nat. Applied Sci.* **4**, 52–62.

Islam, M.Z., Hoque, M.M., Asif-Ul-Alam, S.M., Monalisa, K. 2015. Chemical composition, Antioxidant capacities and storage stability of *Citrus macroptera* and *Garcinia pedunculata* fruits. *Emir. J. Food Agric.* **27 (3)**, 275–282.

Aktar, K., Foyzun, T. 2017. Phytochemistry and Pharmacological Studies of *Citrus macroptera*: A Medicinal Plant Review. *Evid. Based Complem. Altern. Med.* **2017**, 1–7.

Paul, S., Hossen, M.S., Tanvir, E.M., Islam, M.A., Afroz, R., Ahmmed, I., Saha, M., Gan, S.H., Khalil, M.I. 2015. Antioxidant properties of *Citrus macroptera* fruit and it's *in vivo* effects on the liver, kidney and pancreas in

Wistar Rats. *Int. J. Pharmacol.* **11**, 899–909.

Chowdhury, S.A., Sohrab, M.H., Datta, B.K., Hasan, C.M. 2008. Chemical and Antioxidant Studies of *Citrus macroptera*. *Bangladesh J. Sci. Ind. Res.* **43 (4)**, 449–454.

Desrivot, J., Waikedre, J., Cabalion, P., Herrenknecht, C., Bories, C., Hocquemiller, R., Fournet, A. 2007. Anti-parasitic activity of some New Caledonian medicinal plants. *J. Ethnopharmacol.* **112 (1)**, 7–12.

Karim, N., Sakib, A.H., Sarkar, M.Y., Hossain, M.S., Ansari, M.A., Dhar, R. 2015. Study on in-vitro cytotoxic and thrombolytic activity of methanolic extract of *Citrus macroptera* (Fruit). *J. Sci. Res. Adv.* **2 (2)**, 90–94.

Rahman, H., Eswaraiah, M.C., Dutta, A.M. 2014. Neuropharmacological activities of ethanolic extract of *Citrus macroptera* (Varannamensis) fruit peels. *Global J. Pharmacol*. **8 (4)**, 609–616.

Waikedre, J., Dugay, A., Barrachina, I., Herrenknecht, C., Cabalion, P., Fournet, A. 2010. Chemical composition and antimicrobial activity of the essential oils from New Caledonian *Citrus macroptera* and *Citrus hystrix*. *Chem. Biodivers.* **7 (4)**, 871–877.

Uddin, N., Hasan, M.R., Hossain, M.M., Sarker, A., Hasan, A.H.M.N., Islam, A.F.M.M., Chowdhury, M.M.H., Rana, M.S. 2014. In vitro $\alpha$-amylase inhibitory activity and in vivo hypoglycemic effect of methanol extract of *Citrus macroptera* Montr. Fruit. *Asian Pac. J. Trop. Biomed.* **4 (6)**, 473–479.

Zavastin, D.E., Bujor, A., Tuchilus, C., Mircea, C.G., Gherman, S.P., Aprotosoaie, A.C., Miron, A. 2016. Studies on antioxidant, antihyperglycemic and antimicrobial effects of edible mushrooms *Boletus edulis* and *Cantharellus cibarius*. *J. Plant Develop* **23**, 87–95.

Prasad, K.N., Xie, H., Yang, B., Qiu, B., Wei, X. 2010. Antioxidant and anticancer activities of 8-hydroxy psoralen isolated from Wampee (*Clausena lansium* (Lour.) Skeels) peel. *Food Chem.* **118**, 62–66.

Bai, Y., Li, D.H., Zhou, T.T., Qin, N.B., Li, Z.L., Yu, Z.G., Hua, H.M. 2016. Coumarins from the roots of Angelica dahurica with antioxidant and antiproliferative activities. *J. Funct. Foods* **20**, 453–462.