Efficacy of Black Tea Extracts on Inhibition of Herpes Simplex Virus Type 2

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Abstract. Herpes simplex viruses (HSV) are divided into two types: HSV-1 and HSV-2. HSV-1 typically causes infections in the oral and ocular regions, whereas HSV-2 is mainly transmitted sexually and predominantly affects the genital area. Current antiviral drugs, such as acyclovir, valacyclovir, and famciclovir may cause undesirable side effects. Therefore, natural extracts should be used as an anti-viral agent for the treatment of HSV infections. *Camellia sinensis,* or tea, is globally consumed as a beverage that is rich in bioactive compounds, including polyphenols, catechins, and theaflavins. These bioactive compounds exhibit strong antioxidants and anti-inflammatory properties. In this study, black tea leaves were extracted using distilled water and 95% ethanol, yielding aqueous and ethanolic extracts. Cytotoxicity on Vero cells was assessed by MTT assay. The CC_{50} values of black tea leaf aqueous and ethanolic extracts were 70.5 and 237.97 μg/mL, respectively. Antioxidant activities of aqueous and ethanolic extracts of black tea leaves were 271.07 and 85.47 mg gallic acid equivalent/g extract when determined by DPPH assay. Non-toxic concentrations of black tea aqueous extract (30 μg/mL) and ethanolic extract (120 μg/mL) inhibited HSV-2 when treatment after viral infection by 97.79% and 96.62%, respectively. Therefore, both extracts were potent against HSV-2. The ethanolic extract exhibited a remarkably high SI value of 72.99 and aqueous extract showed SI value of 18.70. These findings suggest that black tea extracts possess potent antioxidants and antiviral activities and could serve as promising natural alternatives for managing HSV infections.

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1 Introduction

Herpes simplex virus (HSV) infection is characterized by skin lesions and blister formation. The term "herpes" means "to creep," referring to the spread of skin infection [1]. HSV, a member of the *Herpesviridae* family, is classified into two types: HSV-1 and HSV-2. In particular, HSV-1 typically causes infections around lips, eyes, along with other upper

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body areas, whereas HSV-2 is an established sexually transmitted pathogen causing genital and perianal disease [1, 2]. Following initial infection—which presents with localized pruritus, burning, vesicle formation, erythema, and edema—the virus establishes latency within sensory nerve ganglia. Subsequent reactivation may occur endogenously when host immunity is compromised, or exogenously upon re-exposure to the virus [2].

Existing pharmacological management for HSV infections utilize synthetic medicines, including acyclovir, valacyclovir, famciclovir, and other nucleoside analog drugs. These medications inhibit the growth of the virus once it enters the body and heal lesions quickly, but they do not completely eradicate the virus. Additionally, these drugs often have some side effects such as nausea, vomiting, stomach pain, and frequent urination. Injectable forms of synthetic drugs can cause swelling, redness, and inflammation at the injection site[3, 4]. Therefore, studying natural extracts, such as tea extracts, is of interest for their potential to inhibit viruses and promote wound healing from viral infections.

Tea (*Camellia sinensis*) belongs to the Family *Theaceae*. The majority of commercial tea production is derived from two botanical varieties: *Camellia sinensis* var. *assamica* (Assam tea) and *Camellia sinensis* var. *sinensis* (Chinese tea). Chinese tea have smaller and narrower leaves, and the plants are more tolerant against cold weather when compared to Assam tea[5]. This diversity is beneficial for tea breeding, allowing the development of tea plants with different physical traits, leaf sizes, and unique flavors. Chinese tea varieties from Taiwan have also been improved in the highlands of Chiang Rai province, Thailand [6]. Tea leaves contain several important pharmacological compounds, including catechin, theaflavin, caffeine, xanthine, theobromine, and theophylline [7], as well as flavanols and phenolic acids including epicatechin (EC), epigallocatechin gallate (EGCG), and epicatechin gallate (ECG) [8]. Catechins have been reported to suppress replication of human immunodeficiency virus type 1 [9]. Additionally, catechins impact the DNA of viruses such as the hepatitis B virus, herpes simplex virus, Epstein-Barr virus, and adenovirus, and affect the viral RNA including HIV, hepatitis C virus, and influenza virus [10]. The flavonoids and polyphenols in tea also possess antibacterial and antifungal properties. These antioxidants demonstrated wound healing activity by increasing collagen volume and keratinocytes reproduction [11]. Therefore, black tea will be extracted and investigated for its inhibitory activity against HSV-2.

2 Method

2.1 Production of Aqueous and Ethanolic Extracts of Black Tea

Black tea leaves were extracted using distilled water as a solvent at a ratio of 1:10. The mixture was incubated in a water bath at 45ºC for 2 hours and the extraction process was repeated twice. For ethanolic extraction, the tea was soaked in 95% ethanol for 72 hours, and the extraction process was repeated twice. Filtration was performed using Whatman No. 1 filter paper, and the solvents were evaporated under reduced pressure with a rotary evaporator. The extracts were freeze-dried using a lyophilizer to obtain crude extracts, which were stored at -20ºC. Before evaluation, the extracts were dissolved in DMSO and stored at −20 °C[12].

2.2 Evaluation of Antioxidant Activity by DPPH Assay

DPPH solution was prepared by 2 mg of DPPH in 100 mL of methanol. Subsequently, the sample (0.75 mL) at various concentrations were mixed with DPPH solution (1.5 mL). After incubation in the dark for 15 minutes at 25°C, absorbance was measured at 517 nm by

comparing with a gallic acid standard solution, and percentage of radical inhibition was calculated [6].

2.3 Determination of Total Phenolic Content

Extracts from black tea leaves were prepared in methanol. The tea extracts were mixed with 50% folin-ciocalteu reagent, 95% ethanol, and deionized water. The solution was incubated in the dark for 5 min, followed by the addition of 5% Na_2CO_3 and further incubation in the dark for 1 hour. The absorbance at 725 nm was evaluated. A calibration curve was generated using gallic acid as the reference standard [13].

2.4 Determination of Total Flavonoid Content

The black tea leaf extracts were prepared using methanol. Then 10% aluminiucm chloride, 1M potassium acetate, and deionized water were mixed. Further, incubated in the dark for 30 mm. The absorbance was measured at 415nm. In addition, methanol served as blank, while quercetin was used as the standard for the calibration curve [14].

2.5 Cytotoxicity Evaluation on Vero Cells by MTT Assay

Vero cells were cultivated in a 96-well plate until a cell monolayer was formed. The black tea leaf extracts were diluted with DMEM in various concentrations. The extracts were added to the wells and incubated at 37°C with 5% CO2 for 48 hours. MTT solution was added and incubated for another 4 hours. The formazan crystals were dissolved with DMSO, and the absorbance was measured at 540 nm and 630 nm. Cell viability was calculated, and the toxic concentration of the extracts was determined for subsequent antiviral testing[15].

2.6 Evaluation of Antiviral Activity of Black Tea Leaf Extracts Against Herpes Simplex Virus After Viral Attachment to Vero Vells by Plaque Reduction Assay

Vero cells at 10,000 cells/well were seeded in a 24-well plate and incubated for 24 hours. The cell culture medium was removed, and HSV was added to each well and incubated at room temperature for 1 hour on a rocking platform. Non-toxic doses of the tea leaf extracts were added to the wells. Overlay medium was added and incubated at 37°C in a 5% CO2 incubator for 2-4 days. The infected cells were stained with 0.1% crystal violet in 1% ethanol, and the viral plaques were counted. The number of plaques were counted, and the percentage of virus inhibition was calculated [16]

2.7 Statistical Analysis

All experimental determinations were conducted in triplicate, and the data were analyzed using one-way analysis of variance (ANOVA) at a significance level of $p < 0.05$ using IBM SPSS and GraphPad Prism10 software.

3. Result and Discussion

3.1 Extract Yield of Aqueous and Ethanolic Black Tea Preparations

Black tea leaf extracts were prepared using two different solvents yielded aqueous and ethanolic extracts (Table 1). The aqueous extract produced a markedly higher yield of 15.59% (23.81 g) comparing with only 6.10% (9.15 g) for the ethanolic fraction. This outcome is attributable to the polar character of water, which facilitates efficient extraction of water-soluble constituents such as carbohydrates, caffeine, and tannins that predominate in black tea[17]. Conversely, ethanol is a less polar solvent and preferentially for extraction of moderate-polarity compounds such as phenolic and flavonoid compounds, leading to a lower overall yield. Although the aqueous extraction method is superior for obtaining the maximum amount of extractable material, further analyses are essential to determine the solvent that efficiently concentrates the bioactive compounds and responsible for the desired antioxidant and antiviral properties.

Table 1 Percentage yield of black tea leaf aqueous and ethanolic extracts

Solvent	Net weight (g)	Yield (%)
Aqueous	23.81	15.59
Ethanol	9.15	6.1

3.2 Determination of Antioxidant Activity by the DPPH Assay

The antioxidant capacity of the black tea leaf extracts was evaluated using the DPPH radical scavenging assay. The aqueous extract of black tea leaves demonstrated significantly superior antioxidant activity with antioxidant activity of 271.07 ± 91.68 mg GAE/g extract. In contrast, the ethanolic extract showed a markedly lower antioxidant activity of 85.47 ± 35.33 mg GAE/g extract (Table 2).

The higher concentration of antioxidant of aqueous extract indicated that water, a highly polar solvent, is more efficient for extracting the primary chemical components responsible for radical scavenging in black tea leaves. These components are generally large, complex, and highly polar phenolic polymers, such as thearubigins, which are abundant in oxidized black tea[14, 18]. The aqueous extract showed a higher extracted yield since it naturally concentrated on a greater total amount of antioxidant components and resulting in higher antioxidant activity by DPPH assay. In contrast, the ethanolic extract has intermediate polarity and may be specific to less polar components, but unable to capture the dominant antioxidant compounds in the tea[18].

Table 2. Antioxidant activity, total phenolic content and total flavonoid content of black tea leaf extract.

Extracts of black tea leaves	Antioxidant activity (mg Galic/g extract)	Total Phenolic contents (mg Galic/g extract)	Total Flavonoid contents (mg QUE/g extract)
Aqueous	271.07 ± 91.68^{a}	558.36 ± 8.45^{a}	2.954 ± 0.362^{b}
Ethanol	85.47 ± 35.33^{b}	171.74 ± 8.94^{b}	13.622 ± 1.212^{a}

*All values are mean ± SEM of triplicate samples. Different superscript letters denote significant differences (ANOVA, $p < 0.05$).

3.3 Total Phenolic and Flavonoid Content

The effect of solvent on extract phytochemistry is summarized in Table 2. The aqueous extract contained a significantly higher total phenolic content (TPC: 558.36 ± 8.45 mg GAE/g extract) compared to the ethanolic fraction (TPC: 171.74 ± 8.94 mg GAE/g extract)This result aligns with the overall extract yield (Table 1) and further supporting the ability of water to mobilize polar polymerized phenolics, such as thearubigins and high-molecular-weight tannins[18]. The strong positive correlation between TPC and antioxidant activity confirms that the overall radical scavenging capacity of black tea is principally determined by polar phenolic macromolecules [19-22].

In contrast, the ethanolic extract was significantly enriched in flavonoids (TFC: 13.622 ± 1.212 mg QUE/g extract) compared to the aqueous preparation (TFC: 2.954 ± 0.362 mg QUE/g extract), consistent with the preferential solubility of semi-polar flavonoid aglycones and glycosides in organic solvents [22]. Despite this selective enrichment, the overall antioxidant capacity of the ethanolic extract remained lower, indicating that DPPH scavenging in black tea is driven predominantly by the polymeric phenolics rather than the monomeric flavonoid fraction.

3.4 Cytotoxicity Test of Extracts on Vero Cells using MTT Assay

The cytotoxicity of the black tea leaf extracts on Vero cells was evaluated using the MTT assay to determine the safe concentration of the extracts for subsequent antiviral testing. The study showed a dose-dependent reduction on Vero cell viability (Fig.1A and 1B). The comparative analysis in Fig. 1C confirmed that the ethanolic extract of the black tea leaves was significantly less toxic on the Vero cells. The survival rate of the cells treated with the ethanolic extract remained higher than that of the aqueous extract by calculating the CC_{50} values. The aqueous extract showed higher cytotoxicity with a CC_{50} value of 70.50 ± 26.82 μg/ml whereas the ethanolic extract exhibited markedly lower toxicity with a CC_{50} value of 237.97 ± 108.74 μg/ml

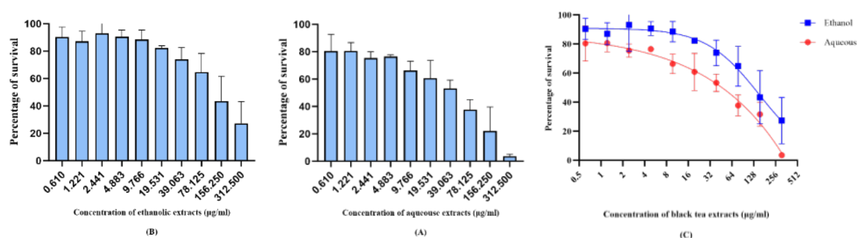

Figure 1. The dose-response relationship shows the percentage of Vero cell survival against extract concentrations. The percentage of cell survival of the aqueous extract (A) and the ethanolic extract of the black tea leaves (B). A comparative dose-response relationship between the aqueous and ethanolic extracts of the black tea leaves (C).

3.5 Antiviral Activity of Black Tea Extracts Against HSV using Plaque Reduction Assay

3.5.1 Inhibition of HSV After Viral Attachment to Vero Cells

Antiviral efficacy was evaluated by quantifying plaque reduction following application of extract after viral attachment to Vero cells. Both preparations exhibited concentration-dependent suppression of HSV-2 plaque formation (Fig. 2). The IC_{50} for the aqueous extract was 3.77 ± 0.55 µg/mL, while the ethanolic extract yielded an IC_{50} of 3.26 ± 0.15 µg/mL, indicating comparably potent antiviral activities at low concentrations.

The physical evidence from the plaque reduction assay is visually represented in Figure 3. Infected cells were treated with the extracts, especially at higher concentrations (e.g., 30 µg/ml for aqueous extract and 120 µg/ml for ethanolic extract). The results showed dramatic reduction in plaque formation (Fig. 3F and 3I) compared to the untreated virus control (Fig. 3A), confirming the high efficacy of black tea leaf extracts. 96.62%

It should be noted that the inhibition of HSV-2 for the aqueous extract at 30 µg/ml showed a maximum inhibition of approximately 97.79% (Fig. 2A) and the ethanolic extract at 120 µg/mL inhibited HSV-2 by 96.62% (Fig. 2B) resulting in effective plaque elimination comparable to that observed as the positive control after treatment with acyclovir (ACV) at 10 µg/ml.

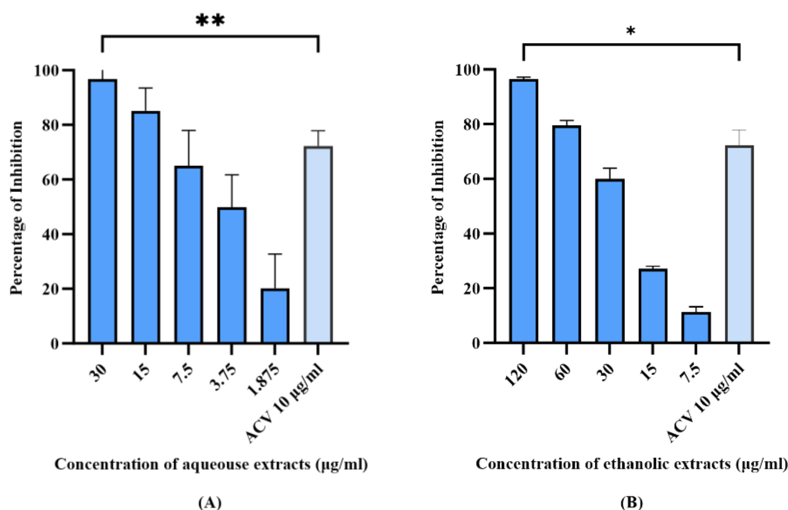

Figure 2. Percentage of HSV-2 inhibition on Vero cells after treatment with aqueous black tea leaf extract at concentrations of 30, 15, 7.5, 3.75, and 1.875 µg/ml (A) and treatment with ethanolic black tea leaf extract at concentrations of 120, 60, 30, 15, and 7.5 µg/ml (B).

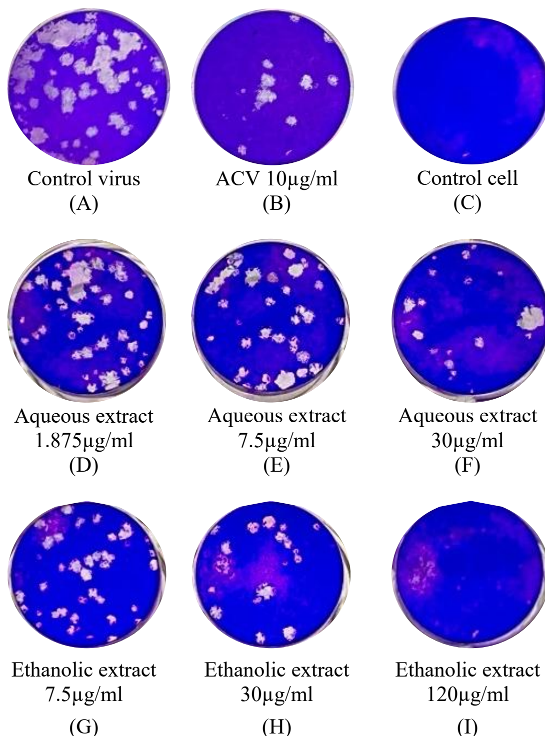

Figure. 3. Plaque reduction assay of HSV-2 treated and untreated with different concentrations of aqueous and ethanolic black tea leaf extract. (A) Control virus (untreated), (B) Control acyclovir drug at 10µg/ml, (C) Control Vero cell, (D-F). HSV-2 treated with aqueous black tea leaf extract at concentrations of 1.875, 7.5, 30 µg/ml, (G-I) HSV-2 treated with ethanolic black tea leaf extract at concentrations of 1.875, 7.5, 30 µg/ml.

Table 3. The summary data of 50% cytotoxicity concentration, 50% inhibitory concentration and selectivity index values.

Solvent	50% Cytotoxicity Concentration (CC_{50})	50% Inhibitory Concentration (IC_{50})	Selectivity Index ($SI = CC_{50}/IC_{50}$)
Aqueous	70.50 µg/ml	3.77 ± 0.55 µg/ml	18.70
Ethanol	237.97 µg/ml	3.26 ± 0.15 µg/ml	72.99

The selectivity index (SI), described as the ratio of cytotoxicity to antiviral activity ($SI = CC_{50}/IC_{50}$) and serves as a critical indicator of therapeutic potential since higher values denote greater safety and specificity [23]. The aqueous extract of black tea leaves exhibited an SI of 18.70, whereas the ethanolic extract of black tea leaves displayed a markedly higher SI of 72.99, indicating superior antiviral selectivity and a broader safety margin. The high antiviral potency demonstrated in the plaque reduction assay suggests that the black tea leaf extracts, particularly the ethanolic extract, may disrupt the later stages of life cycle, including viral replication, assembly or release after successful infection on Vero cells. The enhanced therapeutic effectiveness of the ethanolic extract (SI = 72.99) correlated strongly with its higher total flavonoid content.

Therefore, this assay evaluated post-infection activity and flavonoids are likely acting as intracellular inhibitors [24, 25]. This proposed mechanism implies that the bioactive constituents can penetrate the Vero cell membrane and disrupt key viral processes within the host cell, such as inhibiting viral enzymes (e.g., DNA polymerase) or interfering with the synthesis of viral proteins essential for replication and assembly [26, 27]. The high SI value further supports that the ethanolic extract possesses the safety and potency required to serve as an effective therapeutic candidate against HSV-2 infection, offering a distinct and potentially complementary mechanism to agents that primarily inhibit viral entry.

4 Conclusion

This study demonstrates that solvent selection profoundly influences the phytochemical composition and antiviral efficacy of black tea extracts against HSV-2. Although the aqueous extract yielded greater total biomass and higher antioxidant activity attributable to abundant polar phenolic polymers (TPC: 558.36 mg GAE/g), the ethanolic extract proved superior for therapeutic application despite its lower mass yield (6.10%). Ethanol selectively enriched the extract with flavonoid compounds (TFC: 6.590 mg QUE/g extract). In addition, the ethanolic extract demonstrated a significantly better safety profile (CC_{50} 237.97µg/ml) than the aqueous extract showed toxicity on Vero cells (CC_{50} 70.50 µg/ml). In the antiviral assessment, both extracts inhibited HSV-2 replication with comparable potency (IC_{50} approximately 3.3–3.8 µg/mL), achieving near-complete plaque suppression (>96%) at non-toxic concentrations. Notably, the ethanolic extract exhibited a markedly higher selectivity index (SI = 72.99) compared to the aqueous extract (SI = 18.70). This high SI value confirms its efficacy and safety of black tea leaf extracts. Furthermore, the demonstrated antiviral activity in the assay condition which evaluated inhibition after viral attachment strongly suggested that the enriched flavonoid components act as intracellular inhibitors, interfering with the viral replication cycle. In conclusion, the ethanolic black tea leaf extract possesses the best combination of safety and efficacy, making it a highly promising source to support the development of novel, and safe natural antiviral therapies against HSV-2 infection.

References

1. D.Z. Rechenchoski, L.C. Faccin-Galhardi, R.E.C. Linhares, C. Nozawa, Herpesvirus: an underestimated virus, Folia microbiologica 62(2) (2017) 151-156. https://doi.org/10.1007/s12223-016-0482-7
2. Y. Lee, Y.-J. Kim, Y.-J. Jung, K.-H. Kim, Y.-M. Kwon, S.I. Kim, S.-M. Kang, Systems biology from virus to humans, Journal of analytical science and technology 6(1) (2015) 3. https://doi.org/10.1186/s40543-015-0047-4
3. M.S.A. Khan, I. Ahmad, Herbal medicine: current trends and future prospects, New look to phytomedicine, Elsevier2019, pp. 3-13.
4. K. Kłysik, A. Pietraszek, A. Karewicz, M. Nowakowska, Acyclovir in the treatment of herpes viruses–a review, Current medicinal chemistry 27(24) (2020) 4118-4137. https://doi.org/10.2174/0929867325666180309105519
5. S.-Y. Pan, Q. Nie, H.-C. Tai, X.-L. Song, Y.-F. Tong, L.-J.-F. Zhang, X.-W. Wu, Z.-H. Lin, Y.-Y. Zhang, D.-Y. Ye, Tea and tea drinking: China's outstanding contributions to the mankind, Chinese medicine 17(1) (2022) 27. https://doi.org/10.1186/s13020-022-00571-1
6. P. Wongvas, & Rungiwon, E, Bioactive and Active Ingredients Content That are Beneficial to health in assam tea products, Ban Na Jok, Nakhon Phenom

Provic, Journal of the Greater Mekhong Subregion Research and Development 1(3) (2022) 37-44.
7. T. Tanaka, Y. Matsuo, Production mechanisms of black tea polyphenols, Chemical and Pharmaceutical Bulletin 68(12) (2020) 1131-1142.
8. H. Zhang, R. Qi, Y. Mine, The impact of oolong and black tea polyphenols on human health, Food Bioscience 29 (2019) 55-61. https://doi.org/10.1016/j.fbio.2019.03.009
9. V.D. Kharisma, M.H. Widyananda, A.N.M. Ansori, A.S. Nege, S.W. Naw, A.P. Nugraha, Tea catechin as antiviral agent via apoptosis agonist and triple inhibitor mechanism against HIV-1 infection: A bioinformatics approach, J Pharm Pharmacogn Res 9(4) (2021) 435-445. https://doi.org/10.56499/jppres18.424_6.6.458
10. X. Xu, Y. Zhang, Q. Li, Characteristics of herpes simplex virus infection and pathogenesis suggest a strategy for vaccine development, Reviews in medical virology 29(4) (2019) e2054. https://doi.org/10.1002/rmv.2054
11. G. Kouhihabibidehkordi, S. Kheiri, I. Karimi, F. Taheri, E. Bijad, M. Bahadoram, Z. Alibabaie, S. Asgharian, H. Zamani, M. Rafieian-Kopaei, Effect of white tea (Camellia sinensis) extract on skin wound healing process in rats, World journal of plastic surgery 10(1) (2021) 85. https://doi.org/10.29252/wjps.10.1.85
12. C.D. Fernando, P. Soysa, Extraction Kinetics of phytochemicals and antioxidant activity during black tea (Camellia sinensis L.) brewing, Nutrition journal 14(1) (2015) 74. https://doi.org/10.1186/s12937-015-0060-x
13. M. Kopjar, M. Tadić, V. Piližota, Phenol content and antioxidant activity of green, yellow and black tea leaves, Chemical and Biological Technologies in Agriculture 2(1) (2015) 1. https://doi.org/10.1186/s40538-014-0028-7
14. T. Kaewkod, S. Bovonsombut, Y. Tragoolpua, Efficacy of kombucha obtained from green, oolong, and black teas on inhibition of pathogenic bacteria, antioxidation, and toxicity on colorectal cancer cell line, Microorganisms 7(12) (2019) 700. https://doi.org/10.3390/microorganisms7120700
15. P. Kumar, A. Nagarajan, P.D. Uchil, Analysis of cell viability by the MTT assay, Cold spring harbor protocols 2018(6) (2018) pdb. prot095505. https://doi.org/10.1101/pdb.prot095505
16. Y. Tragoolpua, A. Deethae, Y. Peerapornpisal, J. Pekkoh, P. Sangthong, Inhibitory effect of Spirogyra spp. algal extracts against herpes simplex virus type 1 and 2 infection, journal of applied microbiology 124(6) (2018) 1441-1453. https://doi.org/10.1111/jam.13729
17. J. Li, A. Sobańtka, A systematic analysis of the effect of extraction solvents on the chemical composition of extraction solutions and the analytical implications in extractables and leachables studies, Journal of Pharmaceutical and Biomedical Analysis 222 (2023) 115081. https://doi.org/10.1016/j.jpba.2022.115081
18. W. Koch, Theaflavins, thearubigins, and theasinensins, Handbook of dietary phytochemicals, Springer2019, pp. 1-29.
19. C. Vieito, É. Fernandes, M.V. Velho, P. Pires, The effect of different solvents on extraction yield, total phenolic content and antioxidant activity of extracts from pine bark (Pinus pinaster subsp. atlantica), Chemical Engineering Transactions 64 (2018) 127-132. https://doi.org/10.3303/CET1864022
20. M. Bhebhe, T.N. Füller, B. Chipurura, M. Muchuweti, Effect of solvent type on total phenolic content and free radical scavenging activity of black tea and herbal infusions, Food Analytical Methods 9(4) (2016) 1060-1067. https://doi.org/10.1007/s12161-015-0270-z
21. S. Abdullah, Determination of phenolic and antioxidant properties in tea and spent tea under various extraction method and determination of catechins, caffeine and gallic acid by

HPLC, International Journal on Advanced Science, Engineering and Information Technology (2015). https://doi.org/10.18517/ijaseit.5.3.520
22. D.J. Bhuyan, A. Basu, Phenolic compounds potential health benefits and toxicity, Utilisation of bioactive compounds from agricultural and food production waste, CRC Press2017, pp. 27-59.
23. A.E. Al-Snafi, Medicinal plants with antiviral effect: A review, GSC Biological and Pharmaceutical Sciences 37 (2023) 38. https://doi.org/10.30574/gscbps.2023.24.1.0275
24. J.B. Hudson, Antiviral Compounds From Plants, CRC press1989.
25. M. Musarra-Pizzo, R. Pennisi, I. Ben-Amor, G. Mandalari, M.T. Sciortino, Antiviral activity exerted by natural products against human viruses, Viruses 13(5) (2021) 828. https://doi.org/10.3390/v13050828
26. S.L. Badshah, S. Faisal, A. Muhammad, B.G. Poulson, A.H. Emwas, M. Jaremko, Antiviral activities of flavonoids, Biomedicine & pharmacotherapy 140 (2021) 111596. https://doi.org/10.1016/j.biopha.2021.111596
27. R. Ghildiyal, V. Prakash, V.K. Chaudhary, V. Gupta, R. Gabrani, Phytochemicals as Antiviral Agents: Recent Updates, Springer Singapore2020, pp. 279-295.