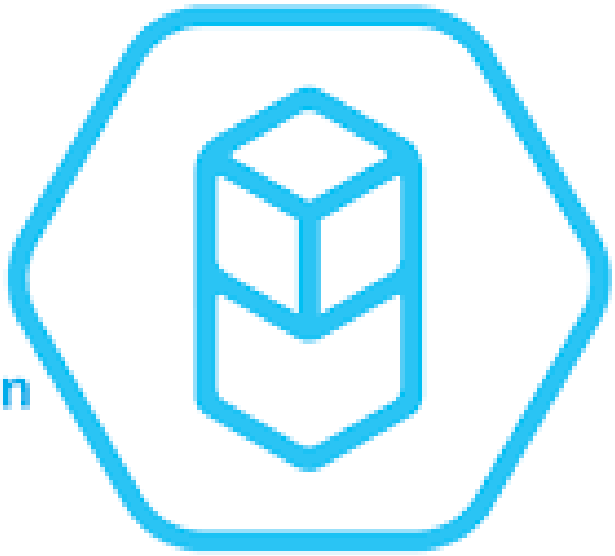
International Pharmaceutical Federation

FIP Education (FIPEd)



Pharmacy Education

an international peer review journal

Vol. 22 No. 2 (2022): IAI Special Edition

Published: 2022-03-31

Special Edition

IAI SPECIAL EDITION: Determinant factors of narcotics, psychotropic, and addictive substances abuse relapse in a drug rehabilitation centre in Indonesia

Raharni Raharni, Siti Isfandari, Telly Purnamasari, Andi Leny Susianti, Mujiati Mujiati (Author)

p. 207-212

PDF

IAI SPECIAL EDITION: The development of a medication safety module for healthcare professionals: Results of a Delphi technique

Desak Ketut Ernawati , Ika Widi Astuti, Luh Kadek Pande Ary Susilawati, I Wayan Sumardika (Author)

p. 70-73

PDF

IAI SPECIAL EDITION: Comparison and validation of EuroQol-5 Dimension level and Short Form-6 Dimension in cataract patients

Tri Murti Andayani, Susi Ari Kristina, Rizky Hidayaturahmah (Author)

p. 236-241

PDF

IAI SPECIAL EDITION: Development of novel curcumin nanoemulgel: Optimisation, characterisation, and ex vivo permeation

Ferdy Firmansyah, Wildan Khairi Muhtadi, Sepfira Indriani, Maulana Dziya Ulhaq, Suci Rizki Auliya, Benni Iskandar, Nesa Agistia, Lutfi Chabib (Author)

p. 98-103

PDF

IAI SPECIAL EDITION: Pharmaceutical care model for antituberculosis drug therapy in tuberculosis patients at a primary healthcare centre in Surabaya, East Java, Indonesia

Yuni Priyandani, Abdul Rahem, Umi Athiyah, M. B. Qomaruddin, Kuntoro (Author)

p. 263-266

PDF

IAI SPECIAL EDITION: Medication adherence and quality of life among asthmatic patients in primary care in Indonesia

Gesnita Nugraheni, Ayu N. A. Santoso, Dian Puspitasari, Catur D. Setiawan, Yunita Nita (Author)

p. 123-128

PDF

IAI SPECIAL EDITION: Molecular docking study of vemurafenib derivatives on melanoma inhibitory activity (MIA) as anti-melanoma

Fauzan Zein Muttaqin , Anita Pramudya Ratna Sari, Fransiska Kurniawan (Author)

p. 284-288

PDF

IAI SPECIAL EDITION: Cytotoxic activity of Cantigi leaf extract (Vaccinium varingiaefolium Blume Miq.) on HeLa cervical cancer cells and A549 lung cancer cells

Kosasih Kosasih, Hasna Nurfitriyati, Reza Hafidz (Author)

p. 147-150

PDF

IAI SPECIAL EDITION: Effects of a combination of Sauropus androgynus L. leaf and Zingiber Ottensii rhizome on fatty acid profile and liver damage in rats

Agus Sulaeman, Annisa Mardianni , Ary Yuniarto , Masteria Yunovilsa Putra, Bustanussalam, Asep Bayu (Author)

p. 9-15

PDF

IAI SPECIAL EDITION: The effect of astaxanthin gel and zeaxanthin combination on wound healing in diabetic rats

Lusi Nurdianti, Renaldi Eka Mufti Rosyidi, Keni Idacahyati, Fajar Setiawan (Author)

p. 169-173

PDF

IAI SPECIAL EDITION: The impact of mobile application: "Friends of Heart" in knowledge and compliance of patients with coronary heart disease

Riyan Pratama Putra, Ike Dhiah Rochmawati, Delta Ardy Prima (Author)

p. 36-40

PDF

IAI SPECIAL EDITION: Evaluation of pharmacist-led structured counselling on glycemic control and clinical outcomes of Type 2 diabetes mellitus patients at a health centre in East Jakarta, Indonesia

Muhammad Rahmat Masdin, Ratu Ayu Dewi Sartika, Rani Sauriasari (Author)

p. 194-199

PDF

IAI SPECIAL EDITION: Mapping of pharmaceutical service facilities (pharmacy) based on geographic information in Surabaya

Catur Dian Setiawan, Arief Wibowo, Umi Athiyah (Author)

p. 60-65

PDF

IAI SPECIAL EDITION: An exploratory study of pharmacists' views on the development of a professional recognition system in Indonesia

Sherly Meilianti, Felicity Smith, Roy Himawan, Franciscus Kristianto, Rasta Naya, Ian Bates (Author)

p. 225-229

PDF

IAI SPECIAL EDITION: Optimal scenario of antihypertension's cost-effectiveness in Prolanis hypertension patients: A case study of Pandeglang District, Indonesia

Yusransyah, Eli Halimah, Auliya A. Suwantika (Author)

p. 85-91

PDF

IAI SPECIAL EDITION: Cost of illness analysis of diabetes mellitus with complications in one hospital in Surabaya

Yohana Febriani Putri Peu Patty, Yunita Nita, Libriansyah (Author)

p. 160-164

PDF

IAI SPECIAL EDITION: Antioxidant activity assay of Agarwood leaf extract cream (Aquilaria malaccensis L.) using free radical scavenging method

Abdul Rahman Wahid, Yuli Fitriana, Alvi Kusuma Wardani, Lisa Apriana Heru Listari (Author)

p. 24-29

PDF

IAI SPECIAL EDITION: Prescription of medicine for outpatients of gynaecology obstetric poly at a private hospital in Semarang, Indonesia

Didik Apriyanto, Maria Caecilia Nanny Setiawati (Author)

p. 184-187

PDF

IAI SPECIAL EDITION: Development of Sumbawa honey as tonic to stimulate stamina during the COVID-19 pandemic in West Nusa Tenggara

Baiq Leny Nopitasari, Shah Iqbal Ikraman Akbar, Alvi Kusuma Wardani (Author)

p. 50-54

PDF

IAI SPECIAL EDITION: Pancreatic histological studies in mice induced by alloxan and steeping okra coffee (Abelmoschus esculentus [L.] Moench)

Indiana Gita Anggraeni, Rahmat A Hi Wahid, Nurul Marfu'ah (Author)

p. 213-217

PDF

IAI SPECIAL EDITION: Influence of dispersing solvent on curcumin dissolution from solid dispersions prepared using hydroxypropyl methylcellulose-polyvinylpyrrolidone K30

Dewi Setyaningsih, Dyah Roro Palupi, Yustina Sri Hartini (Author)

p. 74-78

PDF

IAI SPECIAL EDITION: Adverse drug reaction of antiepileptic monotherapy on epileptic paediatric patients in Dr Sardjito Hospital, Yogyakarta, Indonesia

Woro Harjaningsih, Emma Rahmania, Sheila Nabila Firdha (Author)

p. 242-247

PDF

IAI SPECIAL EDITION: Theobroma cacao L. (Cocoa) pod husk as a new therapy for transient receptor protein vanilloid-1 (TRPV1)-targeted diabetic neuropathy: An in silico study

Pungky Azarotul Nisa, Alviyani Mahdalina Adzani, Sinta Noor Amalia, Risa Maulidiana, Eka Yuniar, Fania Mufti Mufidah, Fifteen Aprila Fajrin (Author)

p. 104-108

PDF

IAI SPECIAL EDITION: Relationship between family support and compliance in diabetes mellitus patients

Devi Nur Zafirah, Liza Pristianty, Abdul Rahem, Yuni Priyandani (Author)

p. 267-269

PDF

IAI SPECIAL EDITION: Validation of stress assessment instruments related to the COVID-19 pandemic in pregnant women

Mazhar Ardhina Silmi, Gusti Noorrizka Veronika Achmad, Hanni Prihhastuti Puspitasari (Author)

p. 129-131

PDF

IAI SPECIAL EDITION: Relationship between knowledge and attitude towards COVID-19 prevention behaviour among west jakarta residents

Đ…tĐµfĐ°nÕ½Ñ• LÕ½kĐ°Ñ•, Diana Laila Ramatillah, Nina Jusnita, Đ…Đ°lÑ•Đ° FĐ°dhÑ–lla, Yufri Aldi, Fatma Sri Wahyuni (Author)

p. 289-291

PDF

IAI SPECIAL EDITION: In vitro anti-ageing activity of ethanol extract of Cantigi (Vaccinium varingiaefolium Blume Miq.) leaf and the extract loaded gelatin nanoparticles

Kosasih Kosasih, I Wayan Redja, Yunahara Farida (Author)

p. 151-155

PDF

IAI SPECIAL EDITION: Antioxidant and α-Glucosidase inhibition of Pyrrosia longifolia extracts

Rohimatul Khodijah, Hilwan Yuda Teruna, Rudi Hendra (Author)

p. 16-19

PDF

IAI SPECIAL EDITION: Stevia rebaudiana as a nutraceutical for COVID-19 patients with no sugar diet during recovery and its nanoparticle application

Lutfi Chabib, Arman Suryani, Sherina Nabila Putri Hakim, Muhammad Ikhwan Rizki, Ferdy Firmansyah, Yulianto, Fitra Romadhonsyah (Author)

p. 174-179

PDF

IAI SPECIAL EDITION: The effect of advertising on the decision to purchase facial wash during the COVID-19 pandemic

Anna Pradiningsih, Baiq Leny Nopitasari, Ida Ayu Melian, Resi Sukmaningsih, Mahacita Andanalusia (Author)

p. 41-44

PDF

IAI SPECIAL EDITION: Study of potential interactions of oral antidiabetic drugs in patients with type 2 diabetes mellitus with comorbidities: A retrospective study

Primanitha Ria Utami, Devi Ristian Octavia (Author)

p. 200-206

PDF

IAI SPECIAL EDITION: Cost of illness for COVID-19 inpatients in West Nusa Tenggara, Indonesia

Cyntiya Rahmawati, Baiq Nurbaety, Nurul Qiyaam, Sulton Dini, Laelatul Maftuhah (Author)

p. 66-69

PDF

IAI SPECIAL EDITION: Regulatory compliance of skincare product advertisements on Instagram

Sinta Rachmawati, Afriza Amalia, Ema Rachmawati (Author)

p. 230-235

PDF

IAI SPECIAL EDITION: Plant tissue culture of cat whiskers (Orthosiphon aristatus Blume Miq): A review of secondary metabolite production and micropropagation

Fahrauk Faramayuda, Totik Sri Mariani, Elfahmi, Sukrasno (Author)

p. 92-97

PDF

IAI SPECIAL EDITION: Tocilizumab therapy in COVID-19 patients

Yulistiani, Humaira Izka A, Mareta Rindang A, Prastuti A W (Author)

p. 259-262

PDF

IAI SPECIAL EDITION: Comparison of antipyretic activities of ethanol and ethyl acetate extracts of Bandotan herb (Ageratum conyzoides L.) in hyperpyrexia mice

Fransiska Maria Christianty, Diana Holidah, Junita Haulani, Lady Refrina Fitriasaria, Fifteen Aprila Fajrin (Author)

p. 118-122

PDF

IAI SPECIAL EDITION: Evaluation of clinical pharmacy services in community health centres to support Indonesian health programme in West Java Indonesia

Zaenal Komar, Keri Lestari, Anna Meiliana, Ali Gufron Mukti (Author)

p. 278-283

PDF

IAI SPECIAL EDITION: Lung histopathological profile of male albino Wistar rats exposed to tobacco smoke administered ethanolic extract of red spinach

Keni Idacahyati, Rani Agustiani, Vera Nurviana, Winda Trisna Wulandari, Firman Gustaman (Author)

p. 142-146

PDF

IAI SPECIAL EDITION: α-Glucosidase inhibitory activities of Loranthus ferrugineus and Peperomia pellucida extracts

Hilwan Yuda Teruna, Rudi Hendra, Muhammad Almurdani (Author)

p. 5-8

PDF

IAI SPECIAL EDITION: Phytochemical screening and antidiabetic activities test of ethanol extract from Syzygium cumini L. seeds in male Wistar rats induced by alloxan

Lia Puspitasari, Made Asmarani Dira (Author)

p. 165-168

PDF

IAI SPECIAL EDITION: Effects of health supplement self-medication learning media on health student behaviours during the COVID-19 pandemic

Adin Hakim Kurniawan, Yusmaniar, Safitri, Alvi Nur (Author)

p. 30-35

PDF

IAI SPECIAL EDITION: Medication adherence of diabetes mellitus patients in Indonesia: A systematic review

Maria Vini Pertiwi, Riza Alfian, Yunita Nita, Umi Athiyah (Author)

p. 188-193

PDF

IAI SPECIAL EDITION: Effect of gelling agent and penetration enhancer on the release rate of ibuprofen-PEG 6000 solid dispersion from gel preparations

Budipratiwi Wisudyaningsih, Lidya Ameliana (Author)

p. 55-59

PDF

IAI SPECIAL EDITION: The potential of citronella grass to inhibit growth of Escherichia coli and Staphylococcus aureus bacteria

Reynelda Juliani Sagala, Pretty Falena Atmanda Kambira, Untung Gunawan, Grafty Pollin (Author)

p. 218-224

PDF

IAI SPECIAL EDITION: White Turmeric (Kaempferia rotunda L.) extract liquid soap preparation for feminine hygiene and effectiveness against Candida albicans

Sofi Nurmay Stiani, Lila Ardiani Putri, Yusransyah, Dimas Danang Indriatmoko (Author)

p. 74-84

PDF

IAI SPECIAL EDITION: Effectiveness of telemedicine use to improve patient outcome in cancer patients: A narrative review

Angela Judhia Arkandhi, Woro Harjaningsih (Author)

p. 248-253

PDF

IAI SPECIAL EDITION: Formulation and effectivity testing of pining fruit extract gel (Hornstedtia alliacea) for healing burns

Firman Gustaman, Fajar Setiawan, Nida Nur Fadhilah, Keni Idacahyati, Winda Trisna Wulandari, Indra Indra (Author)

p. 109-112

PDF

IAI SPECIAL EDITION: Signal detection of adverse drug reaction to first line anti tuberculosis drugs using the Indonesian pharmacovigilance database

Setyo Utami, Umi Athiyah, Yunita Nita (Author)

p. 270-274

PDF

IAI SPECIAL EDITION: Development and validation of dissolution testing of Flunarizine dihydrochloride in tablet dosage form

Fitra Yelli , Harrizul Rivai , Henny Lucida (Author)

p. 132-137

PDF

IAI SPECIAL EDITION: The potential role of pharmacists in counteracting health misinformation in social media

Anila Impian Sukorini, Titik Puji Rahayu, Kandi Aryani Suwito, Andi Hermansyah (Author)

p. 292-296

PDF

IAI SPECIAL EDITION: Solubility improvement of gallic acid in water through cocrystal formation with the solvent-drop grinding method and tartaric acid as co-former

Ledianasari, Sohadi Warya, Sri Nurjayanti (Author)

p. 156-159

PDF

ISSN: 1477-2701

Pharmacy Education (2022) 22(2) 275 - 277
https://doi.org/10.46542/pe.2022.222.275277

IAI SPECIAL EDITION

RESEARCH ARTICLE

Brotowali (*Tinospora crispa L.*) stem extract activity as an α-Amylase enzyme inhibitor

Yustina Sri Hartini, Dewi Setyaningsih, Fetiana Chrismaurin, Fila Delfia
Faculty of pharmacy, Sanata Dharma University, Yogyakarta, Indonesia

Keywords
α-amylase enzyme
Aqueous extract
Ethanolic extract
Tinospora crispa L. stem

Correspondence
Yustina Sri Hartini
Faculty of pharmacy
Sanata Dharma University
Yogyakarta
Indonesia
yustinahartini@usd.ac.id

Abstract

Introduction: Reducing glucose absorption in the gastrointestinal tract is one of the strategies for treating diabetes mellitus. The condition of treating diabetes mellitus can be achieved by inhibiting the activity of the α-amylase enzyme. Brotowali (Tinospora crispa L.)/Tc has antihyperglycemic activity; compounds contained in the Tc stem can inhibit the activity of the α-amylase enzyme. The extraction of the Tc stem used for treatment was done with water and/or ethanol. **Aim:** This study aimed to measure the inhibitory activity of the α-amylase enzyme in both aqueous and ethanolic extract Tc stem. **Methods:** The inhibitory activity test of the α-amylase enzyme was carried out using the UV-visible spectrophotometric method. **Results:** The aqueous extract and ethanolic extract of Tc stem had α-amylase enzyme inhibitory activity with IC_{50} values of 11.660 ± 0.310 mg/mL and 10.348 ± 0.313 mg/mL, respectively. The Tc stem extracted with water or ethanol can be used as an antidiabetic drug.

Introduction

Since ancient times, people have used plants as medicinal ingredients for the treatment of various conditions. Traditionally, diabetes mellitus was among the diseases that can be treated with the stems of brotowali (*Tinospora crispa L.)*/**Tc**. Managing blood sugar levels is a way to prevent diabetes mellitus. The α-amylase enzyme plays a role in converting carbohydrates into sugar; the inhibition of α-amylase enzyme activity can suppress the formation of blood sugar (Hilallzaid & Slemannkadan, n.d.). **Tc** stem is famous as a medicinal ingredient characterised by a very bitter taste. **Tc** contains more than 65 compounds isolated from various groups of compounds, such as furano-diterpenes, lactones, steroids, flavonoids, lignans, and alkaloids (Ahmad *et al.,* 2016). People use medicinal plants by boiling them in water. This statement goes along with the making or the use methods of **Tc** stems, as stated in the Formulary of Indonesian Traditional Medicines (Keputusan Menteri kesehatan Republik Indonesia, n.d.). Aqueous extracts from several plants exhibited the α-amylase enzyme inhibiting activity (Bhutkar & Bhise, 2012). The antidiabetic activity was tested using an *in vitro* method in the form of an α-amylase enzyme inhibition activity test (Patil *et al.* 2012, Antidiabetic, n.d.). This study aimed to compare the activity of aqueous and ethanolic extracts of **Tc** stems against α-amylase enzymes *in vitro*.

Material and method

Brotowali stem (*Tinospora crispa* L.) was received from PT HRL Internasional, East Java. The maceration method was used in the compound extraction of **Tc** leaf. The identification of **Tc** leaf methanolic extract compounds was carried out using Thin Layer Chromatography/TLC. The materials used were α-amylase enzyme (SIGMA Aldrich), Quercetin (E. Merck), ethanol pro analysis (E. Merck), double-distilled water, dimethyl sulfoxide pro analysis (E. Merck), iodine iodide reagent, potato starch, 1N HCL, acarbose tablets (PT Dexa Medica). The α-amylase enzyme (from porcine pancreas-type VI-B, CAS A3176, SIGMA Aldrich)

inhibitory activity test was carried out according to Ononamadu and colleagues (Ononamadu *et al.,* 2020) with few modifications. The following ingredients were mixed: potato starch (1% w/v), 1ml of test material (**Tc** extract, acarbose), 1 ml of the α-amylase enzyme (1% w/v), and 2 ml of acetate buffer (0,1M, 7,2 pH). The measurement of the inhibitory effect of the sample blank solution was carried out by taking 1 ml of 0.5% potato starch solution into a test tube. The mixture was incubated for one hour, then a 0.1 ml iodine-iodide indicator was added to the mixture. The absorbance measurement used a UV-Vis spectrophotometer using a wavelength of 536 nm. The percentage of inhibition was calculated as follows:

$$\% \text{ inhibition} = (As\text{-}Ac/As) \times 100$$

*Ac is the absorbance of the control; As is the absorbance of the sample.

The inhibitory concentration (IC_{50}) calculation was obtained from the linear regression equation after calculating the percentage of inhibition of α-amylase enzyme activity of the test material with a concentration range of 4 mg/ml, 8 mg/ml, 15 mg/ml, and 20 mg/mL. This research used the analysis of variance (ANOVA) to compare the treatment. A value of $p < 0.05$ was considered statistically significant, alongside the Tukey Post-Hoc Test significance and a 95% confidence interval. Linear regression measured the median IC_{50} to determine the inhibitory activities of α-amylase. This research used IBM SPSS statistics version 22 for statistical analysis.

Results

The addition of the concentrations of the three test materials (aqueous extract of **Tc** stem, ethanolic extract of **Tc** stem, acarbose tablet) increased the percentage of inhibition of α-amylase enzyme activity (Figure 1). The inhibitory activity of the α-amylase enzyme from acarbose was higher than that of the aqueous extract and the ethanol extract of the **Tc** stem. At concentrAntituberculosisAntituberculosisations of 4 mg/mL and 8 mg/mL, **Tc** stem aqueous extract showed higher inhibition of α-amylase enzyme activity than ethanolic extract, but at a concentration of 20 mg/mL, it occurred otherwise. At the same concentration of 15 mg/mL, **Tc** stem aqueous extract and **Tc** stem ethanolic extract showed the same percentage of inhibition of α-amylase enzyme activity. Statistical tests ($P<0.05$) showed a significant difference between the percentage of inhibition of α-amylase enzyme activity of aqueous extract **Tc** stem, ethanolic extract **Tc** stem, and acarbose tablets. The TLC of the **Tc** did not show a spot similar to the quercetin spot (Figure 2).

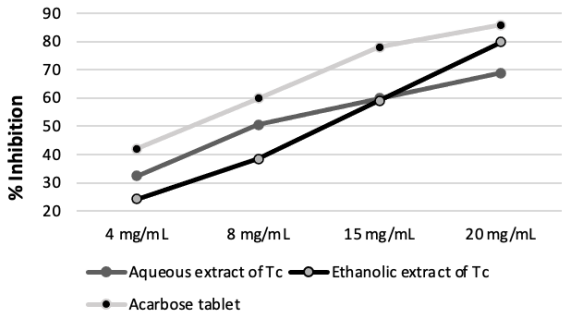
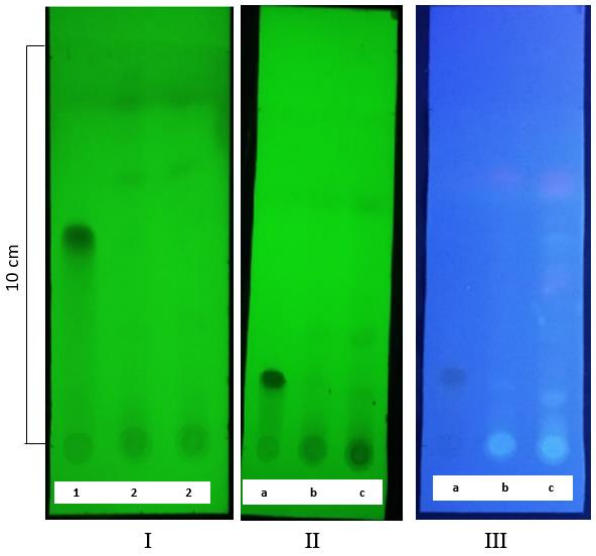


Figure 1: Percent inhibition of aqueous extract, ethanolic extract, and acarbose tablet



Note: (1) Quercetin, (2) Tc stem powder, (a) Quercetin, (b) Aqueous extract of Tc stem, (c) Ethanolic extract of Tc stem, (I-II) UV_{254} nm detection, (III) UV_{365} nm detection.

Figure 2: Thin Layer Chromatogram

Discussion

The inhibitory activity of aqueous and ethanol extracts of bitter leaf on α-amylase enzyme activity was tested *in vitro*. As shown in Figure 1, the higher concentration of the material tests increased the percentage inhibition of α-amylase enzyme activity. The level of inhibitory activity against the α-amylase enzyme is expressed as 50% inhibition concentration (IC_{50}). The IC_{50} value were 11.660 ± 0.310 mg/ml, 0.348 ± 0.313 mg/mL, and 5.554 ± 0.380 mg/mL for **Tc** stem aqueous extract, **Tc** stem ethanolic extract, and acarbose tablets, respectively. The antidiabetic drug acarbose was chosen as a positive control because of its chemical structure, similar to that of starch that acts as a substrate. Both compounds have a benzene ring

and a hydroxyl group that play a role in binding the enzyme's active site. This activity occurred so that a competitive inhibition mechanism of enzyme activity could happen (Takahama & Hirota, 2018). *In vivo* antidiabetic activity of **Tc** stem has been reported. *Tinospora crispa L.* stems contain alkaloids, flavonoids, glycosides, and terpenoids (Elya *et al*., 2015). In this study, a reference standard compound used flavonoid quercetin. The presence of quercetin in aqueous extract and ethanol extract of **Tc** stems could not show with the TLC. Even though there are faint spots in the same Rf region, the presence of the same compound with quercetin cannot be asserted. TLC did not detect the presence of quercetin at the same RF value (Figure 2).

Several studies reported the presence of quercetin in **Tc** stems. Methods other than TLC are recommended to detect the presence of quercetin in aqueous extracts and ethanolic extracts of **Tc** stems. Borapetoside C is the compound most commonly found in **Tc** plants and can inhibit the α-amylase enzyme (Hamid et al., 2015). Compounds in the aqueous extract and ethanol extract of **Tc** stems showed α-amylase enzyme inhibitory activity, which could be due to borapetoside C or several compounds, either singly or in a combination of the compounds in the extract. Several studies have shown that the overall activity of botanical extracts can result from mixtures of compounds with synergistic, additive, or antagonistic activity. Proponents of the medicinal use of natural product mixtures often claim that they are more effective than purified compounds due to beneficial “synergistic” interactions (Caesar & Cech, 2019). The active compound that functions as an inhibitor of the α-amylase enzyme can be in **Tc** stems aqueous or the ethanolic extracts, so both can be used as antidiabetic drugs. Further studies need to focus on the compounds or combinations of compounds in both aqueous extracts and ethanolic extracts of **Tc** stems responsible for the antidiabetic activity through the inhibition of the α-amylase enzyme.

Conclusion

In conclusion, *in vitro,* aqueous extract and ethanolic extract of brotowali (*Tinospora crispa* L.) stem showed α-amylase inhibitory activity with IC_{50} values of 11.660 ± 0.310 mg/mL and 10.348 ± 0.313 mg/mL, respectively.

Acknowledgements

The researchers would like to thank PT HRL Internasional and LPPM Sanata Dharma University for the materials and funds support for this research.

References

Ahmad, W., Jantan, I., & Bukhari, S. N. A. (2016). *Tinospora crispa* (L.) Hook. f. & Thomson: A review of its ethnobotanical, phytochemical, and pharmacological aspects. In *Frontiers in Pharmacology* (Vol. **7**, Issue MAR). Frontiers Media S.A. https://doi.org/10.3389/fphar.2016.00059

Bhutkar, M. A., & Bhise, S. B. (2012). In vitro assay of alpha amylase inhibitory activity of some indigenous plants. In *Int. J. Chem. Sci* (Vol. **10**, Issue 1). www.sadgurupublications.com

Caesar, L. K., & Cech, N. B. (2019). Synergy and antagonism in natural product extracts: When 1 + 1 does not equal 2. In *Natural Product Reports* (Vol. **36**, Issue 6, pp. 869–888). Royal Society of Chemistry. https://doi.org/10.1039/c9np00011a

Elya, B., Handayani, R., Sauriasari, R., Azizahwati, Hasyyati, U. S., Permana, I. T., & Permatasari, Y. I. (2015). Antidiabetic activity and phytochemical screening of extracts from indonesian plants by inhibition of alpha amylase, alpha glucosidase and dipeptidyl peptidase IV. *Pakistan Journal of Biological Sciences*, **18**(6), 273–278. https://doi.org/10.3923/pjbs.2015.279.284

Hamid, H. A., Yusoff, M. M., Liu, M., & Karim, M. R. (2015). α-Glucosidase and α-amylase inhibitory constituents of Tinospora crispa: Isolation and chemical profile confirmation by ultra-high performance liquid chromatography-quadrupole time-of-flight/mass spectrometry. *Journal of Functional Foods*, **16**, 74–80. https://doi.org/10.1016/j.jff.2015.04.011

Hilallzaid, B., Zaid, H., Shanak, S., and Kadan, S. (2017). Anti-diabetes and Anti-obesity Medicinal Plants and Phytochemicals Safety, EE cacy, and Action Mechanisms. Springer International Publishing. Switzerland

Ministry of Health Republic of Indonesia, (2017). Formulary of Indonesian Traditional Medicines. Ministry of Health Republic of Indonesia, Jakarta

Ononamadu, C. J., Ezeigwe, O. C., Owolarafe, T. A., Ihegboro, G. O., Lawal, T. A., Salawu, K., Umeoguaju, U. F., & Aminu, I. (2020). Starch-iodine assay method underestimates α-amylase inhibitory potential of antioxidative compounds and extracts. *Biotechnologia*, **101**(1), 45–54. https://doi.org/10.5114/bta.2020.93103

Patil A., Nirmal, S., Pattan, S., Tambe, V., and Tare, M. (2012). Antidiabetic Effect of Polyherbal Combination in STZ Induced Diabetes Involve Inhibition of Amylase and Glocosidase with Amelioration of Lipid Profile. *Phytopharmacology*, **2**(1):46-57

Takahama, U., & Hirota, S. (2018). Interactions of flavonoids with α-amylase and starch slowing down its digestion. In *Food and Function*. **9** (2), pp. 677–687). Royal Society of Chemistry. https://doi.org/10.1039/c7fo01539a