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# HALALAN THAYYIBAN NATURAL ANTIDIABETIC FOR A HEALTHY LIFE

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**ABSTRACT**

*Type II diabetes is one of the types of Diabetes Mellitus (DM) that are commonly occurring in diabetic patients worldwide. It is a condition that happens due to the inability of the body to regulate and use simple sugar (glucose) as fuel or source of energy to the body and would later lead to an increase in blood sugar level. Citrus hystrix or also known as Kaffir lime, is one of the most common citrus fruits in the Southeast Asian region that is known to have an antidiabetic potential. Consequently, this research aims to investigate the usage of Kaffir lime as a natural as well as Halalan Thayyiban antidiabetic alternatives for patients suffering from Type II Diabetes in lowering their blood sugar content. In Brunei Darussalam, most cases of DM are related to Type II Diabetes. This can be caused by the unhealthy lifestyle and unbalanced diet of many of the local citizens which are already suffering from overweight and obesity. This study has been reviewing secondary data such as books, journals and articles of other researchers of the same or similar field of research or topic as a source of reference and data collection. The findings show that Kaffir lime can be a good source of antidiabetic alternatives for diabetic patients as it is naturally occurred and Halalan Thayyiban. The phytochemical contents of the Kaffir lime which include such as flavonoids is proved to have an effective impact towards inhibiting the activity of alpha-amylase enzyme, an enzyme that catalyses the digestion of starch into simple sugars such as glucose. This could help diabetic patients to regulate their blood glucose levels accordingly with the correct amount of Kaffir lime extract intake.*

***Keywords***: *Halalan, Thayyiban, Natural, Antidiabetic, Alpha-Amylase.*

## 1. INTRODUCTION

Diabetes Mellitus or can be simply called as DM is one of the major diseases and issues faced by countries all over the world. The number of patients suffering from DM increases annually that according to the World Health Organization

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(WHO), the number of people with diabetes exponentially rises from 108 million in 1980 to 422 million in 2014, four times increase in the span of 3 decades (WHO, 2023). Moreover, the number of deaths related to DM are usually in large numbers in which a report from 2019 stated that, a total of 1.5 million deaths were directly associated with diabetes, and 48% of those deaths happened under the age of 70 (Global Burden of Disease Study, 2020).

DM is a metabolic disease usually can be characterized by the elevated levels of blood glucose or sugar levels in the blood. It occurs due to the inability of the human body to regulate the usage of simple sugars such as glucose for the purpose of energy. The two main sub-categories of DM are the Type I Diabetes Mellitus (T1DM) and Type II Diabetes Mellitus (T2DM). T1DM often affects young people and adolescents, but T2DM is more likely to occur in middle age and older individuals who suffer from prolonged hyperglycemia because of unhealthy lifestyle and nutritional habits (Sapra et al., 2024).

T2DM is one of types of DM that commonly occurring in diabetic patients worldwide. It is a condition that usually happens due to the inability of the insulin, a hormone that regulates the content of glucose in the blood by changing it into useful source of energy for the body and leading to the increase in blood sugar content. Most of the cases that lead to T2DM are coming from patients that have already suffering from obesity and unhealthy diet that consists of fatty and sweetened food and drinks. Insulin resistance is caused by increased fatty acids as well as proinflammatory cytokines, that hinder glucose delivery and accelerate the breakdown of fat (Sapra et al., 2024).

In Brunei Darussalam, DM is the third greatest cause of death since 2012 (Muhammad Haskani et al., 2023). The number of patients suffering from DM have been increasing with the estimated prevalence of this condition in the country (13.3%) is higher than that of the worldwide prevalence (9.1%) with T2DM being the most common whereas the rate of diabetic retinopathy (DR), an eye condition among diabetic patients that causes vision loss and blindness, which mostly linked to T2DM has been increasing from 18% to 22.9% within the two decades in the country. In one of the articles published by one of the local newspapers, Borneo Bulletin, dated November 13, 2023, the Minister of Health Brunei Darussalam shared that most DM cases that are reported in Brunei Darussalam are T2DM with the cases often linked to lifestyle factors such as unhealthy diet, lack of physical activity and exercise as well as the increase in the obesity cases amongst the younger generations (Borneo Bulletin, 2023).

In the recent years, the study on the *Citrus hystrix* plant has seen it as a good alternative for antidiabetic due to the antidiabetic potential contents of the plant that is not just beneficial for the human health but is also Halalan Thayyiban for

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Muslim consumption due to its natural sources. Therefore, to further understand the antidiabetic ability of this plant as Halalan Thayyiban natural antidiabetic, this research aims to investigate the usage of *Citrus hystrix* as a natural as well as Halalan Thayyiban antidiabetic alternatives. The following research objectives are constructed to assist in achieving the aims of this research which is to study the Halalan Thayyiban aspect of *Citrus hystrix* plant, the antidiabetic potential of *Citrus hystrix* plant and once it has been identified this will lead to the next step in understanding the potential which is through studying the phytochemical effects of *Citrus hystrix* plant towards DM. Lastly the research will aim to find out ways of utilizing *Citrus hystrix* plant as part of healthy lifestyle diet for DM patients.

## 2. LITERATURE REVIEW

The principle of *Halalan Thayyiban* holds critical importance as it encompasses not only the permissibility of food in accordance with Islamic Law but also assuring the safety, hygiene, and nutritional value of the food, hence creating a sense of confidence among the consumers. This as mentioned by (Dewi & Agustina, 2021), that Halalan Thayyiban food sources should not just be focusing on the religious aspect (Halal) of the sources but also making sure that it contains the adequate and balanced nutrition needed to maintain spiritual and physical health. The failure in understanding the significance of Halalan Thayyiban will later lead to the endangerment of one's life and health as the idea of this concept incorporates with one of the *Maqasid Shariah* (Objectives of Islamic Law) which is the protection of life or *Hifz An-Nafs* (Anuar et al., 2024).

In the light of the increasing issues associated with DM, there are much research that have been done in finding the ways and solutions as continuous efforts to combat and tackle DM, preferably those that are coming from natural products that can reduce the digestion and absorption of carbohydrates (de la Garza et al., 2011), as well as sustainable sources and Halalan Thayyiban. This can be found from sources such as plants, herbs, fruits and vegetables that is naturally Halal for Muslim consumption and proven to have many health benefits to the human body. In addition, it has been theorized that patients with metabolic disorders such as diabetes, could benefit from plant extracts with antioxidant and anti-inflammatory properties (Siti et al., 2022).

One perfect example of a Halalan Thayyiban antidiabetic alternative is the *Citrus hystrix* plant. *Citrus hystrix* is a fruit coming from the Rutacae family of the *Citrus* species. *Citrus hystrix* is native tropical Southeast Asia plant from the Rutacae family which normally can be found and originated in countries such as Thailand, Vietnam, Laos, Malaysia as well as Indonesia (Le et al., 2020). Other names for *Citrus hystrix* such as kaffir lime, Makrut or Thai lime, leech lime, or in the Malay region usually known as "Limau Purut" (Budiarto et al., 2021). Moreover, the fruit

and leaves of *Citrus hystrix* or kaffir lime is said to have an effective result in treating patients with diabetic issues due to the ability of the extract coming from the plant in inhibiting the several types of enzymes that are directly involved in diabetes such as the alpha amylase and alpha glucosidase enzyme. Blood sugar levels can be lowered by inhibiting the activity of enzymes that hydrolyze carbohydrates, which lowers the uptake of glucose (Bhatia et al., 2019).

Moreover, previous studies made by (Umran et al., 2020), stated that the therapeutic potential of some of the plant extracts including *Citrus hystrix*, could have a beneficial effect towards metabolic disorders such as diabetes due to the presence of phytochemicals which show antioxidant and anti-inflammatory properties. In addition, the *Citrus hystrix* is also quite known for its benefits in terms of health and is usually used as herbal medicine. As mentioned by (Pattarachotanant & Tencomnao, 2020), *Citrus hystrix* is used for the treatments of headaches, inflammation, flu, fever, sore throat, bad breath, digestive disorders, hypertension, stomach pain, diarrhea, flavoring and eliminating body odors while the leaves are used in maintaining healthy teeth, gums as well as curing scurvy.

## 3. METHODOLOGY

Therefore, to achieve the research objectives of this study, the narrative review methodology has been adopted. Secondary data obtained from reviewing books, publications, journals and articles, published by previous researchers that are closely related to the study, are used as a source of data collection and reference. The literature search was conducted in local university library as well as in four electronic databases which were PubMed, ScienceDirect, ResearchGate and Google Scholar by using the following sets of search terms: "*Citrus hystrix*" OR "kaffir lime" AND "Halalan Thayyiban" OR "antidiabetic" OR "diabetes" OR "bioactive compound" OR "phytochemical" OR "healthy lifestyle". Original publications and reviews published in English or Malay were included in this review. Publications in other languages, not available full-text, studies with different *Citrus* species, and studies other than the metabolic disorder and Halalan Thayyiban aspect were excluded. Based on the inclusion and exclusion criteria, 30 publications from books, articles, journals and conference proceedings were finally included in the review.

## 4. RESULTS & DISCUSSION

### 4.1 *Halalan Thayyiban Aspect of Citrus hystrix Plant*

According to (Malboobi & Malboobi, 2012), it states that basic standards for distinguishing between what is Halal and Haram include being Thayyib (good), not Khabaith (filthy), reasonable, as well as not causing obvious or

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quantifiable adverse effects on the environment, people, or other animals. This is in line with the idea of (Al-Qurtubi, 2013), elucidated that in reading the verse in Surah Al-A'raf, verse 157:

*"…...He commands them to do good and forbids them from evil, permits for them what is lawful and forbids to them what is impure, and relieves them from their burdens and the shackles that bound them…."*

He used the opinions of Imam Malik, declaring that at-Thayyiban is something that is Halal based on its excellent character, whereas al-Khabaith is whatever is forbidden owing to its bad essence.

The most recent developments in the fields of food science and food manufacturing have raised questions about the wholesomeness (Thayyiban) of the food being produced as well as whether it is Halal, or legal under Islamic law. According to (Zaharudin et al., 2022), in applying the idea of Halalan Thayyiban to the matter of dietary selection, food must be not only Halal but also Thayyib (good), meaning it must be prepared in a way that does not cause harm for oneself or other people.

The *Citrus hystrix* plant can be considered as a source of Halalan Thayyiban alternative due to the nature of its kind. It is as mentioned in the Holy Quran in Surah Al-An'am, verse 141:

*"And He it is who causes gardens to grow, [both] trellised and untrellised, and palm trees and crops of different [kinds of] food and olives and pomegranates, similar and dissimilar. Eat of [each of] its fruit when it yields and give its due [zakāh] on the day of its harvest. And be not excessive. Indeed, He does not like those who commit excess."*

The verse shows that the *Citrus hystrix* plant, as part of the things that come from natural sources such as fruits and vegetables, is neither Haram nor prohibited in the context of the prohibition of things mentioned in the Holy Quran. Moreover, fruits and vegetables of natural sources contain many benefits and nutrients that are important for human health. This is mentioned by (Latif & Rahman, 2020), that it is well acknowledged that both fruits and vegetables are healthy to individuals, and there is now strong scientific evidence to show close connections between vegetable and fruit intake and better health, as the study made by (Mazzoni et al., 2021), stated that up until today, extensive research across diverse scientific disciplines have made significant efforts on the characterization of the phytochemical composition of numerous fruits and vegetables which have also elucidated key mechanisms of action and metabolic pathways underlying their health-promoting and disease-preventive properties. Furthermore, this can be supported by the one of the branches of Qawaid Al-Fiqhiyyah (Islamic Legal

Maxim), a methodology of determining Islamic law based on the science of Fiqh, which goes by "Al-Aslu Fil Ashyai Al-Ibahah Hatta Yadullu Ad-Dalil 'Ala At-Tahrim", which gives meaning to "Something remains in their original state until it is proven otherwise." (As-Suyuti, 1983; Ibn Nujaym, 1999).

### 4.2 *Antidiabetic Potential of Citrus hystrix Plant*

According to (Kumari et al., 2023), the medicinal properties of citrus fruits include antidiabetic and anti-hypercholesterolemic in addition to anti-microbial and antioxidant properties, this also includes *Citrus hystrix*. The *Citrus hystrix* plant is known for having defensive effects against DM due to its antidiabetic potential. This is possible due to the ability of the plant to moderately inhibit the enzyme activity, alpha amylase and alpha glucosidase, that are responsible for the breakdown of starch into glucose (Suttisansanee et al., 2021).

Alpha amylase and alpha glucosidase are two enzymes that are related to the digestion of starch into sugars. As mentioned by (Marghich et al., 2022), an essential component of the digestion of carbohydrates is the enzyme known as alpha amylase. Meanwhile (Pérez-Nájera et al., 2018) stated that alpha amylase inhibition decreases and slows the process of digestion of carbohydrates, while alpha glucosidase inhibition decreases the uptake of glucose. Figure 1 shows how the inhibition of *Citrus hystrix* extract on both alpha amylase and alpha glucosidase based on the study made by (Siti et al., 2022).

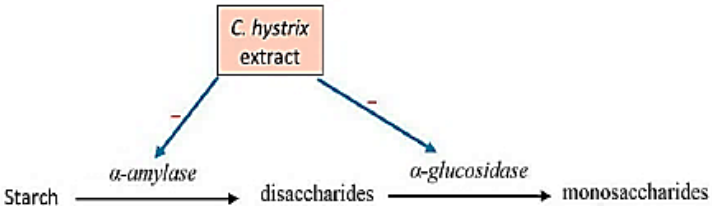


**Figure 1.** Inhibition of the *citrus hystrix* extract on alpha amylase and alpha glucosidase (Siti et al., 2022).

Moreover, in vitro studies made by (Abirani et al., 2014a, 2014b; Irawaty & Ayucitra 2018; Setyabudi et al., 2015 as cited in Siti et al. 2022), shows the extract of different parts of the *Citrus hystrix* plant shows a significant drop and decrease in alpha amylase activity. Table 1 below shows the overview of the results made by the studies.

**Table 1.** Overview of in vitro of *Citrus hystrix* plant parts studies on DM

| Studies | Model | Plant Extract | Outcomes/Results |
|---|---|---|---|
| **(Abirani et al., 2014a)** | In vitro | Rinds and pulps (Powdered form) | Increase in glucose adsorption capacity and decrease in glucose dialysis retardation index, starch |

| | | | |
|---|---|---|---|
| | | | digestibility and alpha amylase activity. |
| **(Irawaty & Ayucitra, 2018)** | In vitro | Rinds (Ethyl acetate fraction and water residue) | Decrease in alpha amylase and alpha glucosidase activity as well as starch digestibility. |
| **(Abirani et al., 2014b)** | In vitro | Fresh fruit juice | Decrease in alpha amylase and alpha glucosidase activity almost comparable to acarbose. |
| **(Setyabudi et al., 2015)** | In vitro | Rinds (ethanol) | Decrease in alpha amylase activity. |

However, to further understand the mechanism of the inhibition ability of the plant, it is also vital to study and understand the phytochemicals makeup that are present in the *Citrus hystrix* plant. As mentioned by (Umran et al., 2020), *Citrus hystrix* extract has shown protective effects against diabetes due to the presence of some phytochemicals in the extracts of the plant which include such as flavonoids which are known for their ability to inhibit the enzymes. Inhibiting important enzymes implicated in the development of illnesses is one of the many ways phytochemicals support human health benefits (Hinkaew et al., 2021).

### 4.3 *The Phytochemical Effects of Citrus hystrix Plant Towards DM*

According to (Palmer, 2021), there are over 25,000 phytochemicals present inside fruits, vegetables, as well as other plant foods consumed by humans. There are many plant extracts including *Citrus hystrix* plant that are being studied to assess the potential protective effects against diabetes, in particular, T2DM due to the knowledge of phytochemicals contents of the plant (Siti et al., 2022).

In a collective manner, nearly every portion of *Citrus hystrix* plant such as the leaves, fruits and peels have antidiabetic qualities, which are probably caused by the flavonoid concentration of the plant. Apart from their antioxidant and anti-inflammatory qualities, these chemicals can also function by inhibiting the activities of $\alpha$-amylase and $\alpha$-glucosidase (Siti et al., 2022). *Citrus hystrix* is said to have non-proteinaceous inhibitors due to the presence of naturally occurring properties such as flavonoids. According to (Lo Piparo et al., 2008), several polyphenolic substances and their derived compounds may inhibit the alpha-amylase enzyme. The primary phenolic class is called flavonoid, and it is further divided into six classes: isoflavones, flavonols, flavones, flavanones, and anthocynidins.

Flavonoids are believed to inhibit alpha-amylase activity and have antidiabetic characteristics. These characteristics include boosting insulin secretion, lowering glucose absorption, raising insulin sensitivity, enhancing glucose tolerance, and lowering the absorption of glucose in the breakdown of carbohydrates (Hasan et al., 2019). In a study made by (Suttisansanee et al., 2021), the results from the study showed that the flavonoids content such as quercetin and hesperidin played a huge role in the inhibition of enzymes, lipase and alpha amylase. Moreover, based on the study of (Amin et al., 2023), the *Citrus hystrix* plant was identified as one of the ingredients that has been used by traditional Malay therapy for cataract. The study was then further explained with the study by (Nakazawa et al., 2020) that stated an extract of alpha-glucosyl hesperidin that are present in citrus plant significantly reduced the severity of selenite-induced cataracts in a rat. This is supported by the study by (Umran et al., 2020), that stated, the formation of diabetic cataracts was significantly reduced by the hesperidin-standardized *Citrus hystrix* leaf flavonoids-rich extract (CLE). Hence, with this knowledge in hand, complications of DR which are closely linked to T2DM can be studied further to develop and create a sense of understanding in overcoming the condition as well as the possibility of producing medications that can be used to treat T2DM (Siti et al., 2022).

### 4.4 *Possible Application of Citrus hystrix Plant in Halal Industry*

The study made by (Budiarto et al., 2024), shows that *Citrus hystrix* has the potential to be a promising food ingredient or as functional food source due to the health benefits of associated to it. Utilizing the functional properties and the raw materials of the *Citrus hystrix* can be used in food productions. Pectin is a dietary fiber that can be found in the peels of *Citrus hystrix* plant and is often used as thickening agent or stabilizer in producing products such as jams, jellies, yogurts as well as edible films (Lubinska-Szczygeł et al., 2023). Based on the study made by (Mahmoud et al., 2024), pectin is reported to have reduced the risk and mitigate the effects of T2DM.

Moreover, *Citrus hystrix* plant is also well known in the form of essential oils (EO). It is one of the simplest forms that can be acquired due to the large amount of essential oil present in all parts of the plant (Md Othman et al., 2016). According to (Palazzolo et al., 2013; Wolffenbüttel et al., 2018), citrus essential oils (CEOs) exhibit antioxidant, antidiabetic, insecticidal, antifungal, and antibacterial properties, and have important applications in the pharmaceutical, sanitary, cosmetic, agricultural, and food industries. The study made by (Bora et al., 2020) have investigated the potential applications of CEOs especially in the field of food production and food safety such as food packaging, food preservation, edible films and coatings as well as CEO based microencapsulation and nanoemulsion. Despite that, many research and studies need to be done to further understand and take advantage of the

benefits that can be offered by the *Citrus hystrix* plant especially in producing products such as foodstuff and medications that can be benefited and taken advantage of by DM patients.

## 5. CONCLUSION

In conclusion, the *Citrus hystrix* plant is a good example of a Halalan Thayyiban natural antidiabetic as most plants are naturally Halal and Thayyiban meanwhile the flavonoid contents of the plant are proved to be a vital component for the antidiabetic potential of the plant. In addition, the plant is also used in food productions that can be catered according to the needs of patients suffering from DM through utilization of its functional properties. However, this study also has its limitations, namely that this study only reviews the work and research of previous literatures and publications, which could potentially minimise the accuracy and precision of the study. In addition, the previous studies that were made are mainly in laboratory analysis that might not reflect the actual situation. Therefore, future studies might consider including tests on real and actual DM patients to identify the true antidiabetic potential of *Citrus hystrix*.

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## 7. REFERENCES

Abirani, A., Nagarani, G., & Siddhuraju, P. (2014a). Measurement of functional properties and health promoting aspects-glucose retardation index of peel, pulp and peel fiber from *Citrus hystrix* and *Citrus maxima*. *Bioactive Carbohydrates and Dietary Fibre, 4*(1), 16–26.

Abirani, A., Nagarani, G., & Siddhuraju, P. (2014b). *In vitro* antioxidant, anti-diabetic, cholinesterase and tyrosinase inhibitory potential of fresh juice from *Citrus hystrix* and *C. maxima* fruits. *Food Science and Human Wellness, 3*(1), 16–25.

Al-Quran al-Kareem. (n.d.). Retrieved June 14, 2024, from https://quran.com/6/141?translations=20,83,84,17,85,18,95,101,41,31,19,22,28

Al-Quran al-Kareem. (n.d.). Retrieved September 15, 2024, from https://quran.com/en/al-araf/157

Al-Qurtubi, A. M. (2013). *Al-Jami' li ahkam al-Quran*.

Amin, N. S. S., Tusidan, N. A. M., & Badarudin, N. E. (2023). Exploring the traditional therapy for cataract based on the Malay medical manuscript: A scoping review. *International Journal on Integration of Knowledge, 1*(1), 12–26.

Anuar, F. N., Mamat, M. N., & Tumiran, M. A. (2024). The Importance Of Halalan Tayyiban In Food Consumption Among Adolescents: A Conceptual Analysis . *Al-Qanatir: International Journal of Islamic Studies*, *33*(4), 199–207. Retrieved from https://al-qanatir.com/aq/article/view/944

As-Suyuti, A. R. J. (1983). *Al-Ashbah wa an-nazair fi qawaid wa furu' fiqh Syafie*. Darul Kutub al-Ilmiyyah.

Bhatia, A., Singh, B., Arora, R., & Arora, S. (2019). *In vitro* evaluation of the $\alpha$-glucosidase inhibitory potential of methanolic extracts of traditionally used antidiabetic plants. *BMC Complementary and Alternative Medicine, 19*(1), 1–11. https://doi.org/10.1186/s12906-019-2482-z

Bora, H., Kamle, M., Mahato, D. K., Tiwari, P., & Kumar, P. (2020). Citrus essential oils (CEOs) and their applications in food: An overview. *Plants, 9*(3), 357. https://doi.org/10.3390/plants9030357

Borneo Bulletin. (2023). Diabetes a challenge for Brunei healthcare, economy. Retrieved June 15, 2024, from https://borneobulletin.com.bn/diabetes-a-challenge-for-brunei-healthcare-economy/

Budiarto, R., Poerwanto, R., Santosa, E., & Efendi, D. (2021). Morphological evaluation and determination keys of 21 citrus genotypes at seedling stage. *Biodiversitas Journal of Biological Diversity, 22*(3), 1570–1579.

Budiarto, R., Wathoni, N., Mubarok, S., Hamdani, J. S., Ujilestari, T., Darsih, C., ... & Sholikin, M. M. (2024). Recent overview of kaffir lime (*Citrus hystrix* DC) dual functionality in food and nutraceuticals. *Journal of Agriculture and Food*

*Research*, 101384. https://doi.org/10.1016/j.jafr.2024.101384

de la Garza, A. L., Milagro, F. I., Boque, N., Campión, J., & Martínez, J. A. (2011). Natural inhibitors of pancreatic lipase as new players in obesity treatment. *Planta Medica, 77*(8), 773–785. https://doi.org/10.1055/s-0030-1270924

Dewi, N. Y. S., & Agustina, A. (2021). Halalan Toyyiban: Theory and implementation of food products consumers. *Indonesian Interdisciplinary Journal of Sharia Economics (IIJSE), 4*(1), 179–189.

Global Burden of Disease Collaborative Network. (2020). *Global Burden of Disease Study 2019 results*. Retrieved June 14, 2024, from https://vizhub.healthdata.org/gbd-results/

Hasan, K., Setyawan, A. H., Abidin, M., Fathya, N. A., Handayani, D. R., Linasari, D., ... & Yusuf, M. (2023). Comparative assessment of human salivary $\alpha$-amylase inhibitor from Indonesian herbs. *Jurnal Pendidikan Kimia, 15*(3), 176–181. https://doi.org/10.24114/jpkim.v15i3.51153

Hinkaew, J., Aursalung, A., Sahasakul, Y., Tangsuphoom, N., & Suttisansanee, U. A. (2021). Comparison of the nutritional and biochemical quality of date palm fruits obtained using different planting techniques. *Molecules, 26*(8), 2217. https://doi.org/10.3390/molecules26082217

Ibn Nujaym, M. Z. I. (1999). *Al-Ashbah wa an-nazair 'ala madzhab Abi Hanifah an-Nu'man* (1st ed.). Darul Kutub al-Ilmiyyah.

International Diabetes Federation. (2020). *IDF Diabetes Atlas 2019*. Retrieved June 14, 2024, from https://diabetesatlas.org/resources/

Irawaty, W., & Ayucitra, A. (2018). Assessment on antioxidant and *in vitro* antidiabetes activities of different fractions of *Citrus hystrix* peel. *International Food Research Journal, 25*(6), 2467–2477.

Kumari, S., Bhowal, R., & Suprasanna, P. (2023). Sustainable approaches for biodiversity and bioprospecting of citrus. *Sustainability, 15*(9), 7731. https://doi.org/10.3390/su15097731

Latif, M. A., & Rahman, S. A. (2020). Knowledge and attitude on sunnah food and Islamic eating practices among students of Universiti Malaysia Sabah. *Journal of Halal Industry & Services, 3*(1), 1–7.

Le, X. T., Ha, P. T. H., Phong, H. X., Hien, T. T., & Ngan, T. T. K. (2020). Extraction of essential oils and volatile compounds of kaffir lime (*Citrus hystrix* DC) by hydrodistillation method. *IOP Conference Series: Materials Science and Engineering, 991*(1), 012024. https://doi.org/10.1088/1757-899X/991/1/012024

Lo Piparo, E., Scheib, H., Frei, N., Williamson, G., Grigorov, M., & Chou, C. J. (2008). Flavonoids for controlling starch digestion: Structural requirements for inhibiting human alpha-amylase. *Journal of Medicinal Chemistry, 51*(12), 3555–3561. https://doi.org/10.1021/jm800115x

Lubinska-Szczygeł, M., Kuczyńska-Łażewska, A., Rutkowska, M., Polkowska, Ż., Katrich, E., & Gorinstein, S. (2023). Determination of the major by-products of *Citrus hystrix* peel and their characteristics in the context of utilization in the industry. *Molecules, 28*(6), 2596. https://doi.org/10.3390/molecules28062596

Malboobi, M. T., & Malboobi, M. A. (2012). Halal concept and products derived from modern biotechnology. In *International workshop for Islamic scholars on agribiotechnology: Shariah compliance* (Vol. 22).

Marghich, M., Daoudi, N. E., Amrani, O., Addi, M., Hano, C., Chen, J.-T., Mekhfi, H., Ziyyat, A., Bnouham, M., & Aziz, M. (2022). Antioxidant activity and inhibition of carbohydrate digestive enzymes activities of *Artemisia campestris* L. *Frontiers in Bioscience-Scholar, 14*(4), 25. https://doi.org/10.31083/j.fbs1404025

Mazzoni, L., Ariza Fernández, M. T., & Capocasa, F. (2021). Potential health benefits of fruits and vegetables. *Applied Sciences, 11*(19), 8951. https://doi.org/10.3390/app11198951

Md Othman, S. N. A., Hassan, M. A., Nahar, L., Basar, N., Jamil, S., & Sarker, S. D. (2016). Essential oils from the Malaysian citrus (Rutaceae) medicinal plants. *Medicines, 3*(2), 13. https://doi.org/10.3390/medicines3020013

Mahmoud, H. M., Abdel-Razik, A. R. H., Elrehany, M. A., Othman, E. M., & Bekhit, A. A. (2024). Modified citrus pectin (MCP) confers a renoprotective effect on early-stage nephropathy in type-2 diabetic mice. *Chemistry & Biodiversity, 21*(7), e202400104. https://doi.org/10.1002/cbdv.202400104

Muhammad Haskani, N. H., Ming, L. C., Dhaliwal, J. S., Wee, D. V. T., Goh, B. H., Ali, M., ... & Goh, H. P. (2023). Diabetes mellitus and its therapy in Brunei Darussalam–A critical revisit. *Patient Preference and Adherence, 17*, 1131–1136. https://doi.org/10.2147/PPA.S411325

Nakazawa, Y., Aoki, M., Ishiwa, S., Morishita, N., Endo, S., Nagai, N., ... & Tamura, H. (2020). Oral intake of $\alpha$-glucosyl hesperidin ameliorates selenite-induced cataract formation. *Molecular Medicine Reports, 21*(3), 1258–1266. https://doi.org/10.3892/mmr.2020.10909

Palazzolo, E., Laudicina, V. A., & Germanà, M. A. (2013). Current and potential use of citrus essential oils. *Current Organic Chemistry, 17*(24), 3042–3049. https://doi.org/10.2174/13852728113179990054

Palmer, S. (2021). Phytochemicals fight disease. Retrieved June 19, 2024, from https://sharonpalmer.com/phytochemicals-fight-disease/

Pattarachotanant, N., & Tencomnao, T. (2020). *Citrus hystrix* extracts protect human neuronal cells against high glucose-induced toxicity. *Pharmaceuticals, 13*(10), 1–27. https://doi.org/10.3390/ph13100307

Pérez-Nájera, V. C., Gutiérrez-Uribe, J. A., Antunes-Ricardo, M., Hidalgo-Figueroa, S., Del-Toro-Sánchez, C. L., Salazar-Olivo, L. A., & Lugo-Cervantes, E. (2018). *Smilax aristolochiifolia* root extract and its compounds chlorogenic acid and astilbin inhibit the activity of $\alpha$-amylase and $\alpha$-glucosidase enzymes. *Evidence-Based Complementary and Alternative Medicine, 2018,* 1–12. https://doi.org/10.1155/2018/6247306

Sapra, A., Bhandari, P., & Wilhite, A. (2024). Diabetes (Nursing). In *StatPearls*. StatPearls Publishing. Retrieved June 14, 2024, from https://www.ncbi.nlm.nih.gov/books/NBK551501/

Setyabudi, C., Tanda, S., Santosa, W. I., & Soetaredjo, F. E. (2018). Studi *in vitro* ekstrak kulit jeruk purut untuk aplikasi terapi diabetes melitus. *Widya Teknik, 14*(1), 15–19.

Siti, H. N., Mohamed, S., & Kamisah, Y. (2022). Potential Therapeutic Effects of *Citrus hystrix* DC and Its Bioactive Compounds on Metabolic Disorders. *Pharmaceuticals*, *15*(2), 167. https://doi.org/10.3390/ph15020167

Suttisansanee, U., Thiyajai, P., Chalermchaiwat, P., Wongwathanarat, K., Pruesapan, K., Charoenkiatkul, S., & Temviriyanukul, P. (2021). Phytochemicals and *in vitro* bioactivities of aqueous ethanolic extracts from common vegetables in Thai food. *Plants, 10*(7), 1563. https://doi.org/10.3390/plants10081563

Umran, N. S. S., Mohamed, S., Lau, S. F., & Mohd Ishak, N. I. (2020). *Citrus hystrix* leaf extract attenuated diabetic-cataract in STZ-rats. *Journal of Food Biochemistry, 44*(11), e13477. https://doi.org/10.1111/jfbc.13477

Wolffenbüttel, A. N., Zamboni, A., Becker, G., Dos Santos, M. K., Borille, B. T., de Cássia Mariotti, K., ... & Limberger, R. P. (2018). Citrus essential oils inhalation by mice: Behavioral testing, GC-MS plasma analysis, corticosterone, and melatonin levels evaluation. *Phytotherapy Research, 32*(1), 160–169. https://doi.org/10.1002/ptr.5951

World Health Organization. (2023). *Diabetes*. Retrieved June 14, 2024, from https://www.who.int/news-room/fact-sheets/detail/diabetes

Zaharudin, W. M., Sungit, F., Azizan, N. I., & Mutalib, S. A. (2022). Parameter *halalan tayyiban* dari perspektif maqasid al-syariah dalam produk makanan enzim: The parameter of *halalan tayyiban* from maqasid al-syariah perspective in enzyme food products. *Journal of Muwafaqat, 5*(2), 16–32.