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NUTRITIONAL AND ANTIOXIDATIVE PROPERTIES OF UNDERUTILIZED Ziziphus mauritiana L. (BIDARA) FOR NUTRACEUTICAL POTENTIAL

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By

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Faculty: Biotechnology and Biomolecular Sciences

Nowadays, researchers around the globe are extensively searching for potential safe alternative drugs and antioxidant. The need for this alternative natural resource is due to the harmful side effects of current commercial synthetic drugs and antioxidant. The underutilized plant might be the key to discovering the presence of potential bioactive compounds for medicinal purposes or nutraceutical products. However, due to the scarcity of information and lack of study on many underutilized plants, the potential antioxidants compound remains undiscovered. *Ziziphus mauritiana* is one of Malaysian underutilized plant which had been used locally as traditional treatments and also for Islamic practises. This plant is believed to have good nutritional content and carries antioxidative properties. Thus, this study is carried out to investigate the nutritional composition and physicochemical value of *Z. mauritiana* extracts associated with the antioxidant capacity of the different extraction solvents. The nutritional composition of *Z. mauritiana* leaves, fruit and seed were determined using proximate analysis. The physicochemical properties of *Z. mauritiana* leaves and fruit were measured based on their pH value, total acidity (TA) and total soluble solid content (TSS) while antioxidant capacity was analyzed using TPC, TFC, FRAP and DPPH assays. Based on the results, leaves showed the highest percentage of ash (9.06%) and crude protein (14.59%) while the moisture content (88.32%) was found the highest in fruit. The crude fiber (48.12%), fat (1.89%), carbohydrate (63.24%) and energy (411.61 kJ) were the highest in the seed. The results also showed that *Z. mauritiana* fruit had a higher value of TSS (11.70°Brix) and TA (0.32%) than the leaves while the pH of the leaves (5.47) was higher than fruit (4.77). The phytochemical compound of squalene (46.69%) in leaves, 5-hydroxymethylfurfural (35.04%) in fruit and conipheryl alcohol (21.45%) in seed were the major compounds found using GC-MS analysis. The antioxidant capacity of *Z. mauritiana* in different

solvent extracts showed that the highest TPC, TFC and FRAP value was found in leaves water extract (287.71 mgGAE/g), in fruit water extracts (119.75 mgQAE/g) and leaves acetone extract (10.06 mgFe/g) respectively. While the strongest free radical scavenging activity against DPPH was shown in the leaves water extract (4.02 µg/ml). According to principal component analysis (PCA), flavonoid compound has shown a significant positive correlation with ferric reducing power by 0.760 while the extracts can be classified into three distinctive groups of potential phenolic, flavonoid and weak scavenging activity against DPPH. Thus, the underutilized plant of Malaysian *Z. mauritiana* has the potential to be used as an alternative source of nutraceutical product.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains

NILAI PEMAKANAN DAN SIFAT ANTIPENGOKSIDA TUMBUHAN NADIR *Ziziphus mauritiana* L. (*BIDARA*) UNTUK KEUPAYAAN NUTRASUTIKAL

Oleh

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Pada masa kini, para penyelidik di seluruh dunia giat memperluaskan pencarian alternatif ubatan dan antioksidan yang selamat. Keperluan untuk mencari sumber alternatif semula jadi ini disebabkan oleh kesan sampingan yang berbahaya daripada ubatan dan antioksidan tiruan komersial. Tumbuhan nadir mungkin menjadi kunci untuk menemukan sebatian yang mempunyai potensi bagi tujuan perubatan atau produk nutraseutikal. Namun, disebabkan kekurangan maklumat dan kajian mengenai tumbuhan nadir ini, potensi sebatian antioksidan kekal tersembunyi. Ziziphus mauritiana adalah salah satu tumbuhan nadir di Malaysia yang sering digunakan secara tempatan untuk perubatan tradisi dan juga untuk amalan dalam agama Islam. Tumbuhan ini dipercayai mempunyai kandungan nutrisi yang baik dan sifat antipengoksida. Oleh itu, kajian ini telah dijalankan untuk mengkaji komposisi nutrisi dan nilai fizikokimia ekstrak Z. mauritiana berhubung kait dengan keupayaan antioksidan di dalam pelarut ekstrak yang berbeza. Komposisi pemakanan daun, buah dan biji Z. mauritiana telah ditentukan menggunakan analisa terhampir. Sifat fizikokimia yang terdapat pada daun dan buah Z. mauritiana diukur berdasarkan nilai pH, jumlah keasidan (TA) dan jumlah pepejal terlarut (TSS) manakala keupayaan antioksidan telah dianalisa menggunakan kaedah TPC, TFC, FRAP dan DPPH. Berdasarkan keputusan kajian, daun telah menunjukkan peratusan tertinggi abu (9.06%) dan protein (14.59%) manakala kandungan lembapan (88.32%) didapati paling tinggi di dalam buah. Serat (48.12%), lemak (1.89%), karbohidrat (63.24%) dan tenaga (411.61 kJ) adalah yang tertinggi di dalam benih. Hasil kajian menunjukkan bahawa buah Z. mauritiana mempunyai nilai TSS (11.70 °Brix) dan TA (0.32%) yang lebih tinggi berbanding daun manakala pH daun (5.47) adalah lebih tinggi daripada buah (4.77). Kompaun fitokimia squalene (46.69%) di dalam daun, 5-hydroxymethylfurfural (35.04%) di dalam buah dan alkohol koniferil (21.45%) di dalam benih adalah kompaun utama yang telah

ditemui menggunakan analisis GC-MS. Keupayaan antioksidan ekstrak Z. mauritiana di dalam pelarut yang berbeza telah menunjukkan nilai tertinggi iaitu TPC, TFC dan FRAP dalam ekstrak air daripada daun (287.71 mgGAE/g), ekstrak air daripada buah (119.75 mgQAE/g) dan dalam ekstrak aseton daripada daun (10.06 mgFe/g). Selain itu, aktivti perencatan radikal bebas yang terkuat terhadap DPPH telah ditunjukkan dalam ekstrak air daripada daun (4.02 µg/ml). Berdasarkan analisa komponen utama (PCA), sebatian flavonoid mempengaruhi kuasa penurunan ferric disebabkan oleh hubung kait positif yang ketara (0.760) dan juga kesemua estrak dapat diklasifikasikan kepada tiga kumpulan khas yang mempunyai potensi fenolik, flavonoid dan aktiviti perencatan terhadap DPPH yang lemah. Oleh itu, tumbuhan nadir di Malaysia iaitu Z. mauritiana mempunyai potensi untuk digunakan sebagai sumber alternatif produk nutraseutikal.

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LIST OF ABBREVIATIONS

ANOVA	Analysis of variance
AOAC	Association of Analytical Chemist
°C	degree celcius
cm	centimeter
DNA	deoxyribonucleic acid
E	East
Fe	ferrous
g	gram
GAE	gallic acid equivalent
GC-MS	gas chromatography-mass spectrometry
IC50	50% inhibition concentration
kJ	kilojoules
µl	microliter
µm	micrometer
m	meter
M	molar
mg	milligram
ml	milliliter
mM	millimolar
mm	millimeter
min	minute
N	North

NaOH	Sodium hydroxide
nm	nanometer
NIST	National Institute of Standards and Technology
QAE	quercetin equivalent
rpm	revolution per minute
RT	retention time
TA	Total acidity
TFC	Total flavonoid content
TPC	Total phenolic content
TSS	Total soluble solid
TPTZ	2,4,6-Tripyridyl-s-triazne
UV-vis	ultra violet-visible
w/v	Weight per volume

CHAPTER 1

INTRODUCTION

1.1 Research Background

Globally, researchers are avidly studying the phytochemicals from various plant species due to their great interest on discovering new plant phytochemical compound that have the potential to be developed as a source of active ingredient in nutraceutical products. Many of this promising plant species are known to fall under category of underutilized plant which defines as neglected plant species of indigenous ancient crop that had been used by local with many undiscovered potentials. In addition, underutilized plant plays many important roles such as enhancing the agrobiodiversity in agricultural development, maintaining the ecosystem stability due to the underutilized plant ability to cope with environmental changes, securing food resource, replenishing nutrition deficit and opening up new market opportunities to local community (International Plant Genetic Resources Institute (IPGRI), 1999). However, the main reason for the underutilized plant to remain undiscovered is due to the scarcity of knowledge on this plant health benefit properties that restraining its potential to be utilized as a promising material for nutraceutical product. The underutilized plant such as Ceri Terengganu (*Lepisanthes fruitocosa*), Dabai (*Canarium odontophyllum*), Kebayau (*Dacryodes rostrata*), Sentul (*Sandoricum macropodum*), Kuini (*Mangifera odonata*) and Bidara (*Ziziphus mauritiana)* are indigenous to Malaysia (Ikram *et. al*., 2009; Mohd Shukri *et. al*., 2013) and these underutilized plant were found to have a remarkable nutritive value (phytochemicals and antioxidant) which carry many health benefits. *Ziziphus mauritiana* is one of the promising underutilized plants that come from the family of *Rhamnaceae* and has a common name of Indian jujube or better known as Bidara by local people in Malaysia. This fruit-bearing tree of *Z. mauritiana* is a prominent native plant of Malaysia and also other South East Asia countries such as Thailand, Indonesia and Vietnam (Orwa *et. al.,* 2009) which was found distributed in warm climate region throughout Africa and Asia. Moreover, *Z. mauritiana* plant is commonly found grew in the wild forest of Malaysia apart from being planted as an ornamental plant for residential area and mosque compound. This underutilized plant is known to this date for only being used in traditional home remedies and being consumed as food source due to its nutritive value for many generations.

Bidara leaves are popular among Muslim community in Malaysia for the usage as material for Islamic spiritual treatment and tools during the process of cleansing dead bodies. It is a common material used in Islamic therapeutic centres in Malaysia as a treatment for the patients that are affected with evil spells in which the patients will be bathed with the mixture of water and Bidara leaves (Ahmad, 2012). Furthermore, during the funeral of deceased Muslim, the Bidara leaves is used in the cleansing rituals as it helps soften the dead body, strengthen the skin and delays the decaying process (Muhammad Yusri *et. al.,* 2017). Accordingly, the Bidara leaves had showed anti-inflammatory and antibacterial activities due to the

phytochemicals constituents present in which can become a potential source of topical treatment for wound healing (Sumanth and Bhargavi, 2014). Meanwhile, Bidara fruit is commonly being consumed fresh, dried or pickled among Malaysian. Pickled Bidara is only known to be produced by the locals in Kelantan which the fresh fruit being mostly imported from Thailand (Ismail, 2015). In other part of the world, for example in Nigeria, the fruit is being consumed during drought season in order to replenish their nutrients and energy (Lockett *et. al*., 2000). Thus, *Z. mauritiana* should be considered as one of the Crop for Future (CFF) that can serve as an important food source due to their nutritive value.

The underutilized plant carries many potentials due to their ethnomedicinal properties that can help preventing chronic diseases related to the present of phytochemical constituents that have physiological role as antioxidant. Antioxidant is an important chemical compound that helps in reducing the adverse effect of free radicals related to degenerative diseases such as aging, cancer, asthma and diabetes. Current studies on *Z. mauritiana* showed that in the leaves, it has numerous properties including antioxidant, antiviral, antibacterial, anti-inflammatory actions (Batool *et. al*., 2018; Jain *et.* al., 2019). Meanwhile, the fruit of *Z. mauritiana* showed an antioxidant, antibacterial and anticancer potential which can be used for therapeutic application (Okala *et. al*., 2014; Beg *et. al*., 2016). The seed extract of *Z. mauritiana* had shown a hypnotic effect that can be used for insomnia treatment and it also carries anticancer potential against cancer cell lines and carcinoma cells (Mishra *et. al*., 2010; Moh *et. al*., 2013). Thus, it was hypothesized that the phytochemical compound present in leaves, fruit and seed of *Z. mauritiana* have associated with their potential as nutraceutical product.

1.2 Problem Statement

Nowadays, synthetic antioxidants and drugs had been known to be used in modern medicine that resulted in many harmful long-term side effects. This problem had arisen a concern and the need for the alternative natural resource. Underutilized plant of *Z. mauritiana* was used to treat common diseases such as constipation (Khan *et. al*., 2015), asthma (Jan *et. al*., 2018) and wound (Patel *et. al*., 2018) that proven to possess medicinal benefits. Moreover, this plant can be found easily grown in Malaysian tropical climate and soil which has the potential to be cultivated on a large scale. Although the awareness of many potential health benefits of plants are increasing, the availability of scientific evidence associated with nutraceutical value of different plant parts and extracts from underutilized *Z. mauritiana* are still lacking and in ascent stage, especially in Malaysia.

1.3 Objectives

The main objective of this present study was to investigate the nutritional composition and physicochemical value of *Z. mauritiana* extracts associated with antioxidant capacity of the different extraction solvents. Thus, the study was performed corresponding to the following specific approaches:

1. To determine the nutritional composition and the physicochemical properties of *Z. mauritiana* leaves, fruit and seed.
2. To investigate the phenolic (TPC) and flavonoid (TFC) contents of different plant parts of *Z. mauritiana*.
3. To evaluate the antioxidant activity of different plant parts of *Z. mautritiana* and their significant correlation using Principal Component Analysis (PCA).

REFERENCES

Abbas, M. F., & Fandi, B. S. (2002). Respiration Rate, Ethylene Production and Biochemical Changes During Fruit Development and Maturation of Jujube *(Ziziphus mauritiana* Lamk*). Journal of the Science of Food and Agriculture,* 82(13), 1472–1476.

Abd El-Mawla, A. M. A., Farag, S. F., & Beuerle, T. (2011). Cinnamyl Alcohols and Methyl Esters of Fatty Acids from *Wedelia prostrata* Callus Cultures. *Natural Product Research*, 25(1), 45–52.

Abd-Alrahman, S. H., Salem-Bekhit, M. M., & Elhalwagy, M. E. A. (2013). Chemical Composition and Antimicrobial Activity of *Ziziphus jujuba* Seeds Extract. *Journal of Pure and Applied Microbiology*, 7, 379–385.

Abdel-Sattar, M., Almutairi, K. F., Al-Saif, A. M., & Ahmed, K. A. (2021). Fruit Properties During The Harvest Period of Eleven Indian Jujube (*Ziziphus mauritiana* Lamk.) Cultivars. *Saudi Journal of Biological Sciences*, 1 – 9.

Aberoumand, A. (2011). Screening of Less known Two Food Plants for Comparison of Nutrient Contents: Iranian and Indian Vegetables. *Functional Foods in Health and Disease*, *1*(10), 416–423.

Abubakar, S., Osuji, C., Etim, V. A., & Gbolahan, G. M. (2017). Proximate, Minerals and Antioxidant Prospective of Sub–Saharan Processed Local Biscuit (Akuri) from Wild Edible Fruit *Ziziphus mauritiana* (Lam). *Journal of Environment and Life Sciences*, *2*(1), 1–6.

Abubakar, S. M., Umar, S. A., Alexander, I., Abubakar, N., Abdulazeez, M. A., & Sule, M. S. (2018). Evaluation of Hypoglycaemic, Hypolipidaemic and Non Toxic Effect of Hydro-Methanolic Extracts of *Ziziphus mauritiana*, *Ziziphus spina christi* Fruit and Glibenclamide on Alloxan Induced Diabetic Rats. *Journal of Drug Delivery and Therapeutics*, *8*(3), 82-92.

Achgill, R. K., & Call, L. W. (1991). Process For Preparing Herbicidal Ureas And Insectcdal Carbamates and Carbamate Dervatives. *United States Patent*. United States Patent.

Ahmad, K. (2012). A Study on Sorcery Theraphy Methods at Islamic Therapeutic Centres in Malaysia. *Perspektif Journal*, *4*(1), 82–111.

Ahmad, I., Nafees, M., Ashraf, I., Maryam, M. Al-Khayri, J., Muhammad Yousaf, M., … Qureshi, R. (2016). Fruit Morphological Attributes to Assess Genetic Diversity in Jujube (*Ziziphus mauritiana*L.) Germplasm of Bahawalpur. *Pure and Applied Biology*, *5*(4), 921–926.

Akhtar, N., Ijaz, S., Khan, H. M. S., Uzair, B., Khan, B. A., & Khan, B. A. (2016). *Ziziphus mauritiana* Leaf Extract Emulsion for Skin Rejuvenation. *Tropical Journal of Pharmaceutical Research*, *15*(5), 929–936.

Alasalvar, C., Grigor, J. M., Zhang, D., Quantick, P. C., & Shahidi, F. (2001).

Comparison of Volatiles, Phenolics, Sugars, Antioxidant Vitamins, and Sensory Quality of Different Colored Carrot Varieties. *Journal of Agricultural and Food Chemistry*, 49(3), 1410–1416.

Alawode, A.R., Iyaka, A.Y., Ndamitso, M., & Anuonye, J.C. (2020). *Ziziphus mauritiana* (Jujube) Seed as a Protein Source in the Diet Promote Growth Performance and Stabilized Hematology, Lipid Profile and Serum Chemistry Profile of Rattus norvergicus. *Advanced Research in Life Sciences*, 4, 1 - 10.

Amoo, I.A., & Atasie, V.N. (2012). Nutritional and functional properties of Tamarindus indica pulp and Zizyphus spina- christi fruit and seed. *Journal of Food Agriculture and Environment,* 10(1), 16 -19.

Amin, W., Sajjad, H., Anjum, M. A., & Ejaz, S., Saqib, Khalid, M. F., Sezai, E., & Shakeel, A. (2018). Genetic Giversity of Jujube (*Ziziphus mauritiana*) Cultivars. *Genetika*. 50. 483-494.

Anjum, M., Rauf, A., Bashir, M., & Ahmad, R. (2018). The Evaluation of Biodiversity in Some Indigenous Indian Jujube (*Zizyphus mauritiana*) Germplasm Through Physico-Chemical Analysis. *Acta Scientiarum Polonorum-hortorum Cultus*, 17, 39-52.

Anjum, M.A., Haram, A., & Ahmad, R. (2020). Physico-Chemical Attributes of Fresh and Dried Indian Jujube (*Zizyphus mauritiana*) fruits. *Pakistan Journal of Agricultural Sciences*, 57(1), 165-176.

Association of Official Analytical Chemists (AOAC). (1995). Official Methods of Analysis, vol. 4, 16th ed. Association of Official Analytical Chemists, Arlington, VA.

Association of Official Analytical Chemists (AOAC). (2000). Official Methods of Analysis. 17th ed. Association of Official Analytical Chemists, Arlington, VA.

Aoki, T., Akashi, T., & Ayabe, S. I. (2000). Flavonoids of Leguminous Plants: Structure, Biological Activity, and Biosynthesis. *Journal of Plant Research*, *113*(1112), 475–488.

Ara, R., Jahan, S., Abdullah, A. T. M., Fakhruddin, A. N. M., & Saha, B. K. (2014). Physico-Chemical Properties and Mineral Content of Selected Tropical Fruits in Bangladesh. *Bangladesh Journal of Scientific and Industrial Research*, *49*(3), 131–136.

Arndt, S. K., Clifford, S. C., & Popp, M. (2001). Ziziphus — a Multipurpose Fruit Tree for Arid Regions. *Sustainable Land Use in Deserts*, (Cherfas 1989), 388–399.

Ashraf, A., Sarfraz, R. A., Anwar, F., Shahid, S. A., & Alkharfy, K. M. (2015). Chemical Composition and Biological Activities of Leaves of *Ziziphus mauritiana* L. Native to Pakistan. *Pakistan Journal of Botany*, 47(1), 367–376.

Azim, A., Ghazanfar, S., Latif, A., & Nadeem, M. A. (2011). Nutritional Evaluation of Some Top Fodder Tree Leaves and Shrubs of District Chakwal, Pakistan in Relation to Ruminants Requirements. *Pakistan Journal of Nutrition*, *10*(1), 54–59.

Bakker, R., & Elbersen, H. (2005). Managing Ash Content and Quality in Herbaceous Biomass: An Analysis From Plant to Product. *14th European Biomass Conference and Exhibition, Paris, France*, (December), 1–4.

Balamurugan, R., Duraipandiyan, V., & Ignacimuthu, S. (2011). Antidiabetic Activity of γ-sitosterol Isolated from *Lippia nodiflora* L. in Streptozotocin Induced Diabetic Rats. *European Journal of Pharmacology*, *667*, 410–418.

Ban, J. O., Hwang, I. G., Kim, T. M., Hwang, B. Y., Lee, U. S., Jeong, H.-S., … Hong, J. T. (2007). Anti-proliferate and Pro-apoptotic Effects of 2,3-dihydro-3,5-dihydroxy-6-methyl-4H-pyranone through Inactivation of NF-κB in Human Colon Cancer Cells. *Archives of Pharmacal Research*, *30*(11), 1455–1463.

Barneix, A. J., & Causin, H. F. (1996). The Central Role of Amino Acids on Nitrogen Utilization and Plant Growth. *Journal of Plant Physiology*, *149*(3–4), 358–362.

Barry, B. W. (1968). The Self Bodying Action of The Mixed Emulsifier Sodium Dodecyl Sulfate/Cetyl Alcohol. *Journal of Colloid and Interface Science*, *28*(1), 82–91.

Batool, R., Aziz, E., Mahmood, T., Tan, B. K., & Chow, V. T. (2018). Inhibitory Activities of Extracts of *Rumex dentatus*, *Commelina benghalensis*, *Ajuga bracteosa*, *Ziziphus mauritiana* as well as their Compounds of Gallic Acid and Emodin Against Dengue Virus. *Asian Pacific Journal of Tropical Medicine*, *11*(4), 265–271.

Bednarski, M. D., Knox, S., Cannizzo, L., Warner, K., Wardle, R., Velarde, S., … Ning, S. (2016). Cyclic Nitro Compounds, Pharmaceutical Compositions Thereof and Uses Thereof. United States Patent Application Publication.

Beg, M. A., Teotia, U. V. S., & Farooq, S. (2016). In Vitro Antibacterial and Anticancer Activity of *Ziziphus*. *Journal of Medicinal Plants Studies*, *4*(5), 230–233.

Benzie, I. F. F., & Strain, J. J. (1996). TheFerric Reducing Ability of Plasma (FRAP) as a Measure of "Antioxidant Power": The FRAP assay. *Analytical Biochemistry*, *239*(1), 70–76.

Bhatia, A., & Mishra, T. (2010). Hypoglycemic Activity of *Ziziphus mauritiana* Aqueous Ethanol Seed Extract in Alloxan-Induced Diabetic Mice. *Pharmaceutical Biology*, *48*(6), 604–610.

Bhattarai, D. R., & Gautam, D. M. (2006). Effect of Harvesting Method and Calcium on Post Harvest Physiology of Tomato. *Nepal Agriculture*

Research Journal, *7*, 37–41

Bhuiyan, M. A. R., Hoque, M. Z., & Hossain, S. J. (2009). Free Radical Scavenging Activities of *Zizyphus mauritiana*. *World Journal of Agricultural Sciences*, *5*(3), 318–322.

Biyanzi, P., Ndjouenkeu, R., Mbofung, C. M. F., Kamga, R., & Pallet, D. (2018). Physicochemical Characteristics, Nutritional Value and Antioxidant Activity of *Ziziphus mauritiana* Fruit and Processing Product in Savannah Region of Cameroon. *International Journal of Food Nutrition and Safety*, 9(1), 75-99.

Blunden, C. A., & Wilson, M. F. (1985). A Specific Method for The Determination of Soluble Sugars in Plant Extracts using Enzymatic Analysis and Its Application to The Sugar Content of Developing Pear Fruit Buds. *Analytical Biochemistry*, *151*(2), 403–408.

Boulton, R. (1980). The Relationships Between Total Acidity, Titratable Acidity and pH in Grape Tissue. *Vitis*, *19*, 113–120.

Bradstreet, R. B. (1954). Kjeldahl Method for Organic Nitrogen. *Analytic Chemistry*, 185-187.

Brand-Williams, W., Cuvelier, M. E., & Berset, C. (1995). Use of a Free Radical Method to Evaluate Antioxidant Activity. *Food Science Technology*, *28*, 25–30

Bravo L. (1998) Polyphenols: Chemistry, Dietary Sources, Metabolism, and Nutritional Significance. *Nutrition Reviews*, 56(11), 317-333.

Carnovale, E., & Marletta, L. (2000). *Tabelle di composi- zione degli alimenti.* EDRA, Milan: Istituto Nazionale di Ricerca per gli Alimenti e la Nutrizione.

Cheema, J., Yadav, K., Sharma, N., Saini, I., & Aggarwal, A. (2017). Nutritional Quality Characteristics of Different Wild and Underutilized Fruits of Terai Region, Uttarakhand (India). *International Journal of Fruit Science*, *17*(1), 72–81.

Choi, M. S., Lee, M. K., Jung, U. J., Kim, H. J., Do, G. M., Park, Y. B., & Jeon, S. M. (2009). Metabolic Response of Soy Pinitol on Lipid-lowering, Antioxidant and Hepatoprotective Action in Hamsters Fed-high Fat and High Cholesterol Diet. *Molecular Nutrition and Food Research*, *53*(6), 751–759.

Chow, P. S., & Landhäusser, S. M. (2004). A Method for Routine Measurements of Total Sugar and Starch Content in Woody Plant Tissues.*Tree Physiology*, *24*(10), 1129–1136.

Cornelissen, J. H. C., Sibma, F., Van Logtestijn, R. S. P., Broekman, R. A., & Thompson, K. (2011). Leaf pH as a Plant Trait: Species-Driven rather than Soil-Driven Variation. *Functional Ecology*, *25*(3), 449–455.

Coseteng, M. Y., Mclellan, M. R., & Downing, D. L. (1989). Influence of Titratable Acidity and pH on Intensity of Sourness of Citric, Malic, Tartaric, Lactic and Acetic Acids Solutions and on The Overall Acceptability of Imitation Apple Juice. *Canadian Institute of Food Science Technology Journal*, *22*(1), 46–51.

Dam, J. v., & Gorshkova, T. (2003). Cell Walls and Fiber: Fiber Formation. In *Encyclopedia of Applied Plant Sciences* (pp. 87-96). Academic Press.

Derengowski, L. S., De-Souza-Silva, C., Braz, S. V., Mello-De-Sousa, T. M., Báo, S. N., Kyaw, C. M., & Silva-Pereira, I. (2009). Antimicrobial Effect of Farnesol, a *Candida albicans* Quorum Sensing Molecule, on *Paracoccidioides brasiliensis* Growth and Morphogenesis. *Annals of Clinical Microbiology and Antimicrobials*, *8*, 1–9.

Dureja, A., & Dhiman, K. (2012). Free Radical Scavenging Potential And Total Phenolic And Flavonoid Content Of *Ziziphus mauritiana* and *Ziziphus nummularia* Fruit Extracts. *International Journal of Green Pharmacy*, *6*(3), 187-192.

Elagbar, Z. A., Naik, R. R., Shakya, A. K., & Bardaweel, S. K. (2016). Fatty Acids Analysis, Antioxidant and Biological Activity of Fixed Oil of *Annona muricata* L. Seeds. *Journal of Chemistry*, 1–6.

El-ishaq, A. A. R. O., & Nangere, Z. A. (2016). Proximate and Phytochemical Analysis of *Ziziphus mauritania* Lam Leaves. *Frontiers in Biomedical Sciences*, *1*(2), 45–49.

El-Nahhal, Y., Nir, S., Polubesova, T., Margulies, L., & Rubin, B. (1998). Leaching, Phytotoxicity, and Weed Control of New Formulations of Alachlor. *Journal of Agricultural and Food Chemistry*, *46*(8), 3305–3313.

Esmaillzadeh, A., Kimiagar, M., Mehrabi, Y., Azadbakht, L., Hu, F. B., & Willett, W. C. (2006). Fruit and Vegetable Intakes, C-reactive Protein, and The Metabolic Syndrome. *American Journal of Clinical Nutrition*, *84*(6), 1489–1497.

Fakhar-ud-Din Razi, M., Anwar, R., Basra, S. M. A., Mumtaz Khan, M., & Khan, I. A. (2013). Morphological Characterization of Leaves and Fruit of Jujube (*Ziziphus mauritiana* Lamk.) Germplasm in Faisalabad, Pakistan. *Pakistan Journal of Agricultural Sciences*, *50*(2), 211–216.

FAO. (2002). Food Energy - Methods of Analysis and Coversion Factors. FAO

Fischer, U., Men, S., & Grebe, M. (2004). Lipid Function in Plant Cell Polarity. *Journal of Plant Biology*, *7*, 670–676.

Fitzgerald, D. J., Stratford, M., Gasson, M. J., Ueckert, J., Bos, A., & Narbad, A. (2004). Mode of Antimicrobial of Vanillin against *Escherichia coli*, *Lactobacillus plantarum* and *Listeria innocua*. J*ournal of Applied Microbiology*, 97(1), 104–113.

Garcia-Salas, P., Morales-Soto, A., Segura-Carretero, A., & Fernández-Gutiérrez, A. (2010). Phenolic-compound-extraction Systems for Fruit and Vegetable Samples. *Molecules*, *15*(12), 8813–8826.

Gerendás, J., & Schurr, U. (1999). Physicochemical Aspects of Ion Relations and pH Regulation in Plants - A Quantitative Approach. *Journal of Experimental Botany*, *50*(336), 1101–1114.

Ghasham, A. Al, Muzaini, M. Al, Qureshi, K. A., Elhassan, G. O., Khan, R. A., Farhana, S. A., … Abdallah, W. E. (2017). Phytochemical Screening , Antioxidant and Antimicrobial Activities of Methanolic Extract of *Ziziphus mauritiana* Lam. Leaves Collected from Unaizah , Saudi Arabia. *International Journal of Pharmaceutical Research & Allied Sciences*, *6*(3), 33–46.

Gogavekar, S. S., Rokade, S. A., Ranveer, R. C., Ghosh, J. S., Kalyani, D. C., &Sahoo, A. K. (2014). Important Nutritional Constituents, Flavour Components, Antioxidant and Antibacterial Properties of *Pleurotus sajor-caju*. *Journal of Food Science and Technology*, *51*(8), 1483–1491.

Goyal, M., Sasmal, D., & Nagori, B. (2012). Review on Ethnomedicinal Uses, Pharmacological Activity and Phytochemical Constituents of *Ziziphus mauritiana*. *Journal on Complementary Medicine and Drug Discovery*, *2*(2), 101–116.

Gupta, M. K., Bhandari, A. K., & Singh, R. K. (2012). Pharmacognostical Evaluations of the Leaves of *Ziziphus mauritiana*. *International Journal of Pharmaceutical Sciences and Research*, *3*(3), 818-821.

Haminiuk, C. W. I., Plata-Oviedo, M. S. V., de Mattos, G., Carpes, S. T., & Branco, I. G. (2014). Extraction and Quantification of Phenolic Acids and Flavonols from *Eugenia pyriformis* using Different Solvents. *Journal of Food Science and Technology*, 51(10), 2862–

Hecker, M., Sommer, N., Voigtmann, H., Pak, O., Mohr, A., Wolf, M., … Mayer, K. (2014). Impact of Short- and Medium-Chain Fatty Acids on Mitochondrial Function in Severe Inflammation. *Journal of Parenteral and Enteral Nutrition*, *38*(5), 587–594.

Herbani, M. & Bintari, Y. R. (2017). In Silico Studies on Bidara (*Ziziphus mauritiana*) Leaves Ethanol Extract Bioactive Ligands Compared to Acarbose toward α-glucosidase Enzyme. J*ournal of Islamic Medicine Research*. 1. 1-9.

Hidalgo, M., Sánchez-Moreno, C., & de Pascual-Teresa, S. (2010). Flavonoid-flavonoid Interaction and its Effect on Their Antioxidant Activity. *Food Chemistry*, 121(3), 691–696.

Huang, B., Wang, Z., Park, J. H., Ryu, O. H., Choi, M. K., Lee, J. Y., … Lim, S. S. (2015). Anti-Diabetic Effect of Purple Corn Extract on C57BL/KsJ db/db Mice. *Nutrition Research and Practice*, *9*(1), 22–29.

Ibrahim, M., Shafique, M., Helali, M., Rahman, M., Biswas, S., & Islam (2009). Studies on The Physiological and Biochemical Composition of Different Ber (*Zizyphus mauritiana* Lamk.) Cultivars at Rajshahi. *Bangladesh Journal of Scientific and Industrial Research, 44*, 229-232.

Iglesias, I., Echeverría, G., & Soria, Y. (2008). Differences in Fruit Colour Development, Anthocyanin Content, Fruit Quality and Consumer Acceptability of Eight "Gala" Apple Strains. *Scientia Horticulturae*, *119*(1), 32–40.

Ikram, E. H. K., Khoo, H. E., Mhd Jalil, A. M., Ismail, A., Idris, S., Azlan, A., … Mohd Mokhtar, R. A. (2009). Antioxidant Capacity and Total Phenolic Content of Malaysian Underutilized Fruits. *Journal of Food Composition and Analysis*, *22*, 388–393.

Imamura, F., Micha, R., Wu, J. H. Y., de Oliveira Otto, M. C., Otite, F. O., Abioye, A. I., & Mozaffarian, D. (2016). Effects of Saturated Fat, Polyunsaturated Fat, Monounsaturated Fat, and Carbohydrate on Glucose-Insulin Homeostasis: A Systematic Review and Meta-analysis of Randomised Controlled Feeding Trials. *PLoS Medicine*, 13(7), 1–18.

International Plant Genetic Resources Institute (IPGRI), I. P. G. R. I. (1999). The Role of Underutilized Plant Species in The 21st Century. In *Global Forum on Agricultural Research* (pp.1–7). Retrieved from http://www.fao.org/docs/eims/upload/207051/gfar0089.pdf

Islam, M., Molla, M., Nasrin, T., Uddin, A. M., & Kobra, K. (2015). Determination of Maturity Indices of BER *(Zizyphus mauritiana* Lam.) Var. BARI Kul-2. *Bangladesh Journal of Agricultural Research,* 40(1), 163–176.

Ismail, N. (2015). Preliminary Study on The Marketing of Pickles in Malaysia. *Journal of Agribusiness Market.ing*, *7*, 60–82.

Jahangir, T., Khan, T. H., Prasad, L., & Sultana, S. (2005). Alleviation of Free Radical Mediated Oxidative and Genotoxic Effects of Cadmium by Farnesol in Swiss Albino Mice. *Redox Report*, *10*(6), 303–310.

Jain, P., Haque, A., Islam, T., Alam, M. A., & Reza, H. M. (2019). Comparative Evaluation of *Ziziphus mauritiana* Leaf Extracts for Phenolic Content, Antioxidant and Antibacterial Activities. *Journal of Herbs, Spices and Medicinal Plants*, *25*(3), 236–258.

Jamil, N., Jabeen, R., Khan, M., Riaz, M., Naeem, T., Khan, A., … Fahmid, S. (2015). Quantitative Assessment of Juice Content, Citric Acid and Sugar Content in Oranges, Sweet Lime, Lemon and Grapes Available in Fresh Fruit Market of Quetta City. I*nternational Journal of Basic & Applied Sciences IJBAS-IJENS*, 15(01), 21–24.

Jan, I., Mukhtar, M., Hazrat, A., Amir, M., Nisar, M., Hussain, A., … Jan, T. (2018). The Ethnobotanical Study of Medicinal Plants in Rawalakot Used for Asthma. *FUUAST Journal of Biology*, *8*(1), 157–160.

Jannok, P., Kamitani, Y., & Kawano, S. (2014). Development of a Common Calibration Model for Determining the Brix value of Intact Apple, Pear and Persimmon Fruits by Near Infrared Spectroscopy. *Journal of Near Infrared Spectroscopy*, 22(5), 367–373.

Jung, Y. Y., Hwang, S. T., Sethi, G., Fan, L., Arfuso, F., & Ahn, K. S. (2018). Potential Anti-inflammatory and Anti-cancer Properties of Farnesol. *Molecules*, *23*(11), 1–15.

Kankara, S. S., Ibrahim, M. H., Mustafa, M., & Go, R. (2015). Ethnobotanical Survey of Medicinal Plants used for Traditional Maternal Healthcare in Katsina State, Nigeria. *South African Journal of Botany*, *97*, 165–175.

Keta, J. N. (2017). Proximate and Mineral Elements Analysis of *Ziziphus mauritiana* Fruits. *UMYU Journal of Microbiology Research*, 2(1), 247-250.

Ketsa, S. (1988). Effects of Fruit Size on Juice Content and Chemical Composition of Tangerine. *Journal of Horticultural Science*, *63*(1), 171–174.

Khan Marwa, S., Aslam Khan, M., ur-Rehman, F.-, & Ullah Bhat, I. (2009). Aromatic Plant Species Mentioned in the Holy Qura'n and Ahadith and Their Ethnomedicinal Importance. *Pakistan Journal of Nutrition*, *8*(9), 1472–1479.

Khan, M. P. Z., Ahmad, M., Zafar, M., Sultana, S., Ali, M. I., & Sun, H. (2015). Ethnomedicinal Uses of Edible Wild Fruits (EWFs) in Swat Valley, Northern Pakistan. *Journal of Et.hnopharmacology*, *173*, 191–203.

Khilari, V. J. & Sharma, P. P. (2016). Determination of Total Lipids from Five Underutilized Wild Edible Fruits in Ahmednagar District, Maharashtra (India). *International Journal of Advanced Research in Biological Sciences*, 3(7), 14-20.

Kim, H. S. (2002). Efects of The*Zizyphus jujuba* Seed Extract on The Lipid Components in Hyperlipidemic Rats. *Journal of Food Science Nutrition*, *7 (1)*, 72–77.

Kim, K. H., Moon, E., Kim, H. K., Oh, J. Y., Kim, S. Y., Choi, S. U., & Lee, K. R. (2012). Phenolic Constituents from The Rhizomes of *Acorus gramineus* and Their Biological Evaluation on Antitumor and Anti-Inflammatory Activities. *Bioorganic and Medicinal Chemistry Let.ters*, *22*(19), 6155–6159.

Kirkwood, R. N., Brandon, S. C. E., Souza Moreira, B. de, & Deluzio, K. J. (2013). Searching for Stability as we Age: The PCA-Biplot Approach. *International Journal of Statistics in Medical Research*, *2*, 255–262.

Kleinhenz, M. D., & Bumgarner, N. R. (2012). Using °Brix as an Indicator of Vegetable Quality: An Overview of The Practice. *The Ohio State University Extension, Department of Horticulture and Crop Science*, 4. Retrieved from https://ohioline.osu.edu/factsheet/HYG-1651

Koley, T. K., Kaur, C., Nagal, S., Walia, S., Jaggi, S.,& Sarika. (2016). Antioxidant Activity and Phenolic Content in Genotypes of Indian jujube (*Zizyphus mauritiana* Lamk.). *Arabian Journal of Chemistry*, *9*, S1044–S1052.

Kongkachuichai, R., Charoensiri, R., Yakoh, K., Kringkasemsee, A., & Insung, P. (2015). Nutrients Value and Antioxidant Content of Indigenous Vegetables from Southern Thailand. *Food chemistry*, *173*, 838-846.

Krishna, H., & Parashar, A. (2013). Phytochemical Constituents and Antioxidant Activities of Some Indian Jujube (*Ziziphus mauritiana* Lamk.) Cultivars. *Journal of Food Biochemistry*, *37*(5), 571-577.

Kumar, V. R., Monika, P., Sushil, S., Rambir, S., & Manish, I. (2018). Phytochemical Investigation and Pharmacological Evaluation of Leaves of *Ziziphus Mauritiana* for Wound Healing Activity in Albino Rats. *Tropical Journal of Pharmaceutical and Life Sciences*, *5*, 8–18.

Kumar, C.S., Ali, A., & Manickavasagan, A. (2020). Health Benefits of Substituting Added Sugars with Fruits in Developing Value-Added Food Products: A Review. *International Journal of Nutrition, Pharmacology, Neurological Diseases*, 10, 75-90.

Kushwaha, P., Yadav, S. S., Singh, V., & Dwivedi, L. K. (2018). GC-MSAnalysis of Bio-Active Compounds in Methanolic Extract of *Ziziphus mauritiana* Fruit. *International Journal of Pharmaceutical Sciences and Research*, *10(6)*, 2911–2916.

Li, Y. O., & Komarek, A. R. (2017). Dietary Fibre Basics: Health, Nutrition, Analysis and Applications. *Food Quality and Safet.y*, 1(1), 47–59.

Liu, M. J., & Cheng, C. Y. (1995). A Taxonomic Study on The Genus *Ziziphus*. *Acta Horticulturae*, (390), 161–165.

Lockett, C. T., Calvert, C. C., & Grivetti, L. E. (2000). Energy and Micronutrient Composition of Dietary and Medicinal Wild Plants Consumed During Drought. Study of Rural Fulani, Northeastern Nigeria. *International Journal of Food Sciences and Nutrition*, *51*, 195–208.

Lou-Bonafonte, J. M., Martínez-Beamonte, R., Sanclemente, T., Surra, J. C., Herrera-Marcos, L. V., Sanchez-Marco, J., … Osada, J. (2018). Current Insights into The Biological Action of Squalene. *Molecular Nutrition and Food Research*, *62*(15), 1–16.

Lozano-Grande, M. A., Gorinstein, S., Espitia-Rangel, E., Dávila-Ortiz, G., & Martínez-Ayala, A. L. (2018). Plant Sources, Extraction Methods, and Uses of Squalene. *International Journal of Agronomy*, 1–13.

Ludwig, D. S., Hu, F. B., Tappy, L., & Brand-Miller, J. (2018). Dietary Carbohydrates: Role of Quality and Quantity in Chronic Disease. *BMJ*, 361, 1–6.

Makni, M., Chtourou, Y., Fetoui, H., Garoui, E. M., Boudawara, T., & Zeghal, N.

(2011). Evaluation of The Antioxidant, Anti-inflammatory and Hepatoprotective Properties of Vanillin in Carbon Tetrachloride-treated Rats. *European Journal of Pharmacology*, *668*(1–2), 133–139.

Manach, C., Williamson, G., Morand, C., Scalbert, A., & Rémésy, C. (2005). Bioavailability and Bioefficacy of Polyphenols in Humans. I. Review of 97 Bioavailability Studies. *The American Journal of Clinical Nutrition*, *81*(1 Suppl), 230S–242S.

Martin, S. W., Glover, B. J., & Davies, J. M. (2005). Lipid Microdomains – Plant Membranes get Organized. *TRENDS in Plant Science*, *10*(6), 263–265.

Memon, A. A., Memon, N., Luthria, D. L., Pitafi, A. A., & Bhanger, M. I. (2012). Phenolic Compounds and Seed Oil Composition of *Ziziphus mauritiana* L. Fruit. *Polish Journal of Food and Nutrition Sciences*, *62*(1), 15–21.

Mishra, T., Khullar, M., & Bhatia, A. (2011). Anticancer Potential of Aqueous Ethanol Seed Extract of *Ziziphus mauritiana* against Cancer Cell Lines and Ehrlich Ascites Carcinoma. *Evidence-based complementary and alternative medicine*: *eCAM*, 2011, 765029.

Mishra, R., & Kar, A. (2014). Effect of Storage on The Physicochemical and Flavour Attributes of Two Cultivars of Strawberry Cultivated in Northern India. *The Scientific World Journal*, *2014*, 1–7.

Moh, A., San, M., Thongpraditchote, S., Sithisarn, P., & Gritsanapan, W. (2013). Total Phenolics and Total Flavonoids Contents and Hypnotic Effect in Mice of *Ziziphus mauritiana* Lam. Seed Extract. *Evidence-Based Complementary and Alternative Medicine*, *2013*, 1–4.

Mohd Shukri, M. A., Mirfat, A. H. S., Erny Sabrina, M. N., Razali, M., & Salma, I. (2013). Nutritional Value and Potential of Malaysian Underutilised Fruits and Traditional Vegetables. In *2nd International Symposium on Underutilized Plants Species "Crops for the Future - Beyond Food Security"* (Vol. 979, pp. 173–186).

Mokrani, A., & Madani, K. (2016). Effect of Solvent, Time and Temperature on the Extraction of Phenolic Compounds and Antioxidant Capacity of Peach (*Prunus persica* L.) fruit. *Separation and Purification Technology*, *162*, 68-76.

Muchuweti, M., Zenda, G., Ndhlala, A. R., & Kasiyamhuru, A. (2005). Sugars, Organic Acid and Phenolic Compounds of *Ziziphus mauritiana* Fruit. *European Food Research and Technology*, 221(3-4), 570–574.

Muhammad Yusri, Y. @ S., Rahimin Affandi, A. R., Faridah, Y., Paiz, H., Abd Munir, M. N., & Mohd Zahirwan Halim, Z. A. (2017). Funeral Management in The Malay World : Local Knowledge and Practices. *Journal of Applied Environmental and Biological Scoences*, *7*, 72–77.

Nenadis, N., Zhang, H. Y., & Tsimidou, M. Z. (2003). Structure-antioxidant activity Relationship of Ferulic Acid Derivatives: Effect of Carbon Side

Chain Characteristic Groups. *Journal of Agricultural and Food Chemistry*, *51*(7), 1874–1879.

Njidda, A. A., & Ikhimioya, L. (2010). Nutritional Evaluation of Some Semi-arid Browse Forages Leaves as Feed for Goats. *European Journal of Applied Sciences*, *2*(3), 108–115.

Nunes, C. N., & Emond, J.-P. (2007). Relationship Between Weight Loss and Visual Quality of Fruits and Vegetables. *Proceeding of the Florida State Horticultural Societ.y*, *120*, 235–245.

Nursakinah, I., Zulkhairi, H. A., Norhafizah, M., Hasnah, B., Zamree, M. S., Farrah Shafeera, I., … Hamzah Fansuri, H. (2012). Nutritional Content and In Vitro Antioxidant Potential of *Garcinia atroviridis* (Asam gelugor) Leaves and Fruits. *Malaysian Journal of Nutrition*, 18(3), 363–371.

O'Leary, K. A., De Pascual-Tereasa, S., Needs, P. W., Bao, Y. P., O'Brien, N. M., & Williamson, G. (2004). Effect of Flavonoids and Vitamin E on Cyclooxygenase-2 (COX-2) Transcription. J*ournal of Mutation Research*, 551(1–2), 245–254.

Obeed, R. S., Harhash, M. M., & Abdel-Mawgood, A. L. (2008). Fruit Properties and Genetic Diversity of Five Ber (*Ziziphus mauritiana* Lamk) Cultivars. *Pakistan Journal of Biological Sciences*, *11*(6), 888–893.

Okala, A., Ladan, M. J., Wasagu, R. S. U., & Shehu, K. (2014). Phytochemical Studies and In Vitro Antioxidant Properties of *Ziziphus mauritiana* Fruit Extract. *International Journal of Pharmacognosy and Phytochemical Research*, *6*(4), 885–888.

Okazaki, Y., Otsuki, H., Narisawa, T., Kobayashi, M., Sawai, S., Kamide, Y., … Saito, K. (2013). A New Class of Plant Lipid is Essential for Protection Against Phosphorus Depletion. *Nature Communications*. 4, 1-5.

Orwa, C., Mutua, A., Kindt, R., Jamnadass, R., & Anthony, S. (2009). *Ziziphus mauritiana. World Agroforest Database, 1-6.*

Osman, M. A., & Ahmed, M. A. (2009). Chemical and Proximate Composition of *(Zizyphus spina-christi)* Nabag Fruit*. Nutrition and Food Science,* 39(1), 70-75*.*

Owolarafe, T. A., Wudil, M. A., Alhassan, A. J., & Imam, A. A. (2018). Nutritional Evaluation and Effect of Varying Fortified Feeds of *Ziziphus mauritina* Fruit (Mesocarp) on Growth Performance of Albino Rats. *Biokemistri,* 30(2), 42-52.

Packer, L. (1991). Role of Vitamin E in Biological Systems. *The American Journal of Clinical Nutrition*, *53*(1050S-5S).

Palomer, X., Pizarro-Delgado, J., Barroso, E., & Vázquez-Carrera, M. (2018). Palmitic and Oleic Acid: The Yin and Yang of Fatty Acids in Type 2 Diabetes Mellitus. *Trends in Endocrinology and Met.abolism*, *29*(3), 178–

190.

Pandey, S. & Poonia, A. (2018). Bioactive Compounds, Medicinal Benefits and Value Added Products of Ber Fruit: A review. *Journal of Pharmacognosy and Phytochemistry,* 7(4), 1460-1466.

Parmar, P., Bhatt, S., Dhyani, S., & Jain. (2012). Phytochemical Studies of The Secondary Metabolites of *Ziziphus mauritiana* Lam. Leaves. *International Journal of Current Pharmaceutical Research*, *4*(3), 153–155.

Parr, A. J., & Bolwell, G. P. (2000). Phenols in the Plant and in Man. The Potential for Possible Nutritional Enhancement of the Diet by Modifying the Phenols Content or Profile. *Journal of the Science of Food and Agriculture*, *80*(7), 985-1012.

Patel, H. R., Maru, R. N., & Patel, R. S. (2018). Ethnomedicinal Plants Traditionally Used by The Tribals of R.D.F. Poshina Range of Sabarkantha District , North Gujarat , India. *International Journal of Scientific Research in Science and Technology*, *4*(5), 582–589.

Pejin, B., Savic, A., Sokovic, M., Glamoclija, J., Ciric, A., Nikolic, M., … Mojovic, M. (2014). Further In Vitro Evaluation of Antiradical and Antimicrobial Activities of Phytol. *Natural Product Research*, *28*(6), 372–376.

Pereira, L. M., Hatanaka, E., Martins, E. F., Olivera, F., Liberti, E. A., Farsky, S. H., … Pithon-Curi, T. C. (2007). Effect of Oleic and Linoleic Acids on the Inflammatory Phase of Wound Healing in Rats. *Cell Biochemistry and Function*, *26*, 197–204.

Popping, B., & Diaz-Amigo, C. (2014). pH and Tritable Acidity. In *Food Analysis* (Vol. 25, pp. 219–238). Poulos, P. G., Critchley, J., & Diaz, R. E. (2000). *6132786*. *United States Patent*.

Poulos, P. G., Critchley, J., & Diaz, R. E. (2000). Long-Term Mold Inhibition in Intermediate Moisture Food Products Stored at Room Temperature. 6132786. *United States Patent*.

Prakash, O., Usmani, S., Singh, R., Singh, N., Gupta, A. & Ved, A. (2021). A Panoramic View on Phytochemical, Nutritional, and Therapeutic Attributes of *Ziziphus mauritiana* Lam.: A Comprehensive Review. *Phytotherapy Research*. 35(1):63-77.

Ræbild, A., Larsen, A. S., Jensen, J. S., Ouedraogo, M., de Groote, S., van Damme, P., … Kjaer, E. D. (2011). Advances in Domestication of Indigenous Fruit Trees in The West African Sahel. *New Forests*, *41*(3), 297–315.

Ranade-Malvi, U. (2011). Interaction of Micronutrients with Major Nutrients with Special Reference to Potassium. *Karnataka Journal of Agriculture Science*, *24*(1), 106–109.

Rashid, Z. M., Mohd Nasir, N. A., & Aziz, N. (2018). Biochemical Analysis and α-Glucosidase Inhibition of *Ziziphus mauritiana* (Bidara) Immature Leaves

Extracts. *Journal Of Agrobiotechnology*, *9*(1S), 43–53.

Rathore, S. K., Bhatt, S., Dhyani, S., & Jain, A. (2012). Preliminary Phytochemical Screening of Medicinal Plant *Ziziphus mauritiana* Lam. Fruits. *International Journal of Current Pharmaceutical Research*, *4*(3), 160–162.

Rodrigo, M. J., Alquézar, B., Alós, E., Lado, J., & Zacarías, L. (2013). Biochemical Bases and Molecular Regulation of Pigmentation in ThePeel of Citrus Fruit. *Scientia Horticulturae*, *163*, 46–62.

Rolland, F., Moore, B., & Sheen, J. (2002). Sugar Sensing and Signaling in Plants. *The Plant Cell*, 185–205.

Rui, H. L. (2013). Health-Promoting Components of Fruits and Vegetables in Human Health. *Advance in Nutrition*, *4*(3), 384S-392S.

Ruzic-Muslic, D., Petrovic, M. P., Petrovic, M. M., Bijelic, Z., Caro-Petrovic, V., Maksimovic, N., & Mandic, V. (2014). Protein Source in Diets for Ruminant Nutrition. *Biotechnology in Animal Husbandry*, 30(2), 175–184.

Salem, M. Z. M., Ali, H. M., & Mansour, M. M. (2014). Fatty Acid Methyl Esters from Air-dried Wood, Bark, and Leaves of B*rachychiton diversifolius* R. Br: Antibacterial, Antifungal, and Antioxidant Activities. *BioResources*, *9*(3), 3835–3845.

Saran, P. L., Godara, A. K., & Sehrawat, S. K. (2006). Characterization of Ber (*Ziziphus mauritiana* Lamk.) Genotypes. *Haryana Journal of Horticultural Science*, *35*, 215–218.

Sareen, A., Gupta, R. C., Bansal, G., & Singh, V. (2020): Comparison of Key Mineral Elements in Wild Edible Fruits of *Ziziphus mauritiana* and *Z. nummularia* Using Atomic Absorption Spectrophotometer (AAS) and Flame Photometer, *International Journal of Fruit Science*, 1-8.

Schwalfenberg G. K. (2012). The Alkaline Diet: is there Evidence that an Alkaline pH Diet Benefits Health?. *Journal of Environmental and Public Health*, 2012, 727630.

Schwertner, H. A., & Biale, J. B. (1973). Lipid Composition of Plant Mitochondria and of Chloroplasts. *Journal of Lipid Research*, *14*, 235–242.

Sena, L. P., Vanderjagt, D. J., Rivera, C., Tsin, A. T. C., Muhamadu, I., Mahamadou, O., … Glew, R. H. (1998). Analysis of Nutritional Components of Eight Famine Foods of The Republic of Niger. *Journal of Plant Foods for Human Nutrition*, *7*(1), 17–30.

Shams, Z. A., & Wadhawan, N. (2019). Development and Shelf Life Assessment of a Carbonated RTS Beverage from Ber Fruit (*Ziziphus mauritiana*). *International Journal of Science, Environment and Technology*, 8(1), 193 – 200.

Sharif, N., Jaskani, M. J., Abbas Naqvi, S., & Awan, F. S. (2019). Exploitation of

Diversity in Domesticated and Wild Ber (*Ziziphus mauritiana* Lam.) Germplasm for Conservation and Breeding in Pakistan. *Scientia Horticulturae*, 249, 228–239.

Sheeja, L., Lakshmi, D., Bharadwaj, S., & Sajidha Parveen, K. (2016). Anticancer Activity of Phytol Purified from *Gracilaria edulis* Against Human Breast Cancer Cell Line (MCF-7). *International Journal of Current Science*, *19*(4), 36–46.

Shivakumar, S. S., & Mohana, K. N. S. (2012). *Ziziphus mauritiana* Leaves Extracts as Corrosion Inhibitor for Mild Steel in H_2SO_4 and HCl Solutions. *European Journal of Chemistry*, *3*(4), 426–432.

Silva, J., & Uchida, R. (2000). Essential Nutrients for Plant Growth : Nutrient Functions and Deficiency Symptoms. In *Plant Nutrient Management in Hawaii's Soils, Approaches for Tropical and Subtropical Agriculture*, 31–55.

Silva, R. O., Sousa, F. B. M., Damasceno, S. R. B., Carvalho, N. S., Silva, V. G., Oliveira, F. R. M. A., … Medeiros, J. V. R. (2014). Phytol, a Diterpene Alcohol, Inhibits the Inflammatory Response by Reducing Cytokine Production and Oxidative Stress. *Fundamental and Clinical Pharmacology*, *28*(4), 455–464.

Singleton, V. L., Orthofer, R., & Lamuela-Raventos, R. M. (1999). [14] Analysis of Total Phenols and Other Oxidation Substrates and Antioxidants by Means of Folin-Ciocalteu Reagent. *Met.hods in Enzymology*, *299*, 152–177.

Sumanth, M., & Bhargavi, Y. (2014). Evaluation of Wound-Healing Effect of *Ziziphus mauritiana* L. Leaf Extract in Rats. *International Journal of Green Pharmacy*, *8*(4), 263–266.

Sundarraj, S., Thangam, R., Sreevani, V., Kaveri, K., Gunasekaran, P., Achiraman, S., & Kannan, S. (2012). γ-Sitosterol from *Acacia nilotica* L. Induces G2/M Cell Cycle Arrest and Apoptosis through C-Myc Suppression in MCF-7 and A549 Cells. *Journal of Et.hnopharmacology*, *141*(3), 803–809.

Vangdal, E. (1985). Quality Criteria for Fruit for Fresh Consumption. *Acta Agriculturae Scandinavica*, *35(1)*, 41–47.

Ward, G. M., & Miller, M. J. (1970). Relationship Between Fruit Sizes and Nutrient Content of Greenhouse Tomatoes and Cucumbers. *Canadian Journal of Plant Science*, *50*(4), 451–455.

Wickens, A. P. (2001). Ageing and The Free Radical Theory. *Respiration Physiology*, *128*(3), 379–391.

Yahia Y, Benabderrahim MA, Tlili N, Bagues M, Nagaz K. (2020). Bioactive Compounds, Antioxidant and Antimicrobial Activities of Extracts from Different Plant Parts of Two *Ziziphus* Mill. Species. PLoS ONE 15(5): e0232599.

Yu, X., Zhao, M., Liu, F., Zeng, S., & Hu, J. (2013). Identification of 2,3-dihydro-3,5-dihydroxy-6-methyl-4H-pyran-4-one as a Strong Antioxidant in Glucose-histidine Maillard Reaction Products. *Food Research International*, *51*, 397–403.

Zahari, N. S., Zaidan, U. H., Hanizam, M. B., Abd Gani, S. S & Effendi, M. I. (2020). Biofunctional Characteristics of Dietary Fibre from Malaysian *Ziziphus mauritiana* Leaves. *Akademi Sains Malaysia Science Journal*, 13(6), 53-59.

Zaidan, U. H., Mohamad Zen, N. I., Amran, N. A., Shamsi, S., & Gani, S. S. A. (2019). Biochemical Evaluation of Phenolic Compounds and Steviol Glycoside from *Stevia rebaudiana* Extracts Associated with In Vitro Antidiabetic Potential. *Biocatalysis and Agricultural Biotechnology*, *18*(November 2018), 101049.

Zhao, L., Chen, J., Su, J., Li, L., Hu, S., Li, B., … Chen, T. (2013). In vitro Antioxidant and Antiproliferative Activities of 5-hydroxymethylfurfural. *Journal of Agricultural and Food Chemistry*, *61*(44), 10604–10611.

Zheng, K., Zhao, Z., Lin, N., Wu, Y., Xu, Y., & Zhang, W. (2017). Protective Affect of Pinitol Against Inflammatory Mediators of Rheumatoid Arthritis via Inhibition of Protein Tyrosine Phosphatase Non-receptor Type 22 (PTPN22). *Medical Science Monitor*, *23*, 1923–1932.

Zhishen, J., Mengcheng, T., & Jianming, W. (1999). The Determination of Flavonoid Contents in Mulberry and their Scavenging Effects on Superoxide Radicals. *Food Chemistry*, *64*(4), 555–559.

Zoué, L. T., Bédikou, M. E., Gonnety, J. T., Faulet, B. M., & Niamké, S. L. (2012). Two Novel Non-conventional Seed Oil Extracts with Antioxidant and Antimicrobial Activities. *Tropical Journal of Pharmaceutical Research*, *11*(3), 469–475.

Zozio, S., Servant, A., Hiol, A., , Mbeguie-A-Mbeguie, D, Cosmidis, L., Lucien, J. M., & Pallet, D. (2015). Processed Z. Mauritiana Lamk in the Formula of High Nutritional Value Cake. *Journal of Food Processing & Technology*, 6(5), 1-6.

Zulkifli, N., Hashim, N., Abdan, K., & Hanafi, M. (2016). Evaluation of Physicochemical Properties of *Musa acuminate* cv. Berangan at Different Ripening Stages. *International Food Research Journal*, *23*, S97–S100.