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ASSESSMENT OF THE PHARMACOLOGICAL ACTIVITY OF NONI PLANT (*Morindacitifolia*) SEED

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ABSTRACT

The pharmacological potential of noni plant seed was evaluated using its ethanol extract's anti-inflammatory, antidiabetic, and antioxidant effects. Heat-induced haemolysis and albumin denaturation were used to assess the anti-inflammatory effects of the extract. In contrast, its inhibition against α-amylase and α-glucosidase activities was used to evaluate its antidiabetic prospects. The Antioxidant abilities were determined using DPPH radical scavenging capacity and ferric reducing antioxidant power (FRAP). All the analyses were done using standard analytical procedures, and results are presented in mean±SD. From the results of the anti-inflammatory and antidiabetic capabilities, the effect of the extract appears to be dose-dependent amongst the various concentrations, though significantly ($p<0.05$) lower than the corresponding doses of the standards used. The different concentrations of the extract exhibited varying degrees of scavenging abilities against DPPH radical, which are significantly ($p<0.05$) lower when compared with Butylated hydroxytoluene (BHT). Moreover, the extract showed dose-dependent progressive inhibitory potentials across the graded concentrations for FRAP. This was significantly ($p<0.05$) lower when compared with corresponding concentrations of the standard (gallic acid). These pharmacological potentials could be attributed to the phytoconstituents of noni plants, which, if explored and harnessed, could aid in the treatment cum management of an array of life-threatening diseases.

Keywords: Anti-inflammatory, Antidiabetic, Antioxidant, Noni plant, seed

INTRODUCTION

The use of various parts of plants in the prevention and treatment of many ailments is now experiencing positive awareness, especially amongst rural dwellers, because of their availability, lower prices, effectiveness, and resistance to diseases caused by the organisms (Arowosegbe *et al*., 2020). Numerous active drugs are developed from plants against ailments and diseases such as diabetes, hypertension, pain, cancer, and many human diseases (Harvey, 2008; Patwardhan *et al*., 2014). Oxidative stress-

induced tissue damage is implicated as a cause and consequence of ageing, coronary heart disease, diabetes, cancer, gastric ulcer, inflammatory disease, and many other human diseases (Nita and Grzybowski, 2016; Adwas *et al*., 2019). Agnihotri *et al., (2016) asserted that inflammations are natural biological complex reactions, typically of mammals,* to a wide range of harmful agents such as pathogens, parasites and physical tissue injury. Inflammatory disease has become a primary global health concern affecting millions of people. It has a significant socioeconomic impact aside from being one of the most relevant areas of medical research (Joshua *et al*., 2019). Recently, the search for potent antidiabetic agents has been shifted to plants because of fewer side effects. (Shori, 2015). Noni (*Morindacitrifolia L*.) is native to Polynesia and is grown in tropical and subtropical countries as a sustainable crop (Jahurul *et al*., 2021). It grows widely throughout the Pacific and is one of the most significant sources of traditional medicines among Pacific island societies. Noni plant has been widely implicated as a surrogate and complementary therapeutic agent in many countries due to its antioxidant potency and health attributes (Pandiselvi *et al*., 2019). Tradomedically, it has been used as a therapeutic agent for various diseases as an antihelminthic, antibacterial, antitumor, anti-inflammatory, antidiabetic, and immunostimulant (Pandiselvi*et al*., 2019). Several studies have implicated the Noni plant to have significant inhibitory effects on cancer cells (Lv*et al*., 2011; Stoner *et al*., 2011, Wang *et al*., 2013; Gupta *et al*., 2013). According to Kamiya *et al.,* **(**2004), arteriosclerosis disease can be prevented by Noni fruit because it is related to the oxidation of low-density lipoprotein (LDLs). Wang *et al.,* (2008) reported that carbon tetrachloride (CCL4) induced acute liver injury in female rats of Sprague-Dawley (SD) was reversed by Noni juice. Despite the growing interest in noni fruits and their derivatives, there is still a gap in the scientific knowledge and applications regarding the pharmacological attributes of noni plant seeds, as these are being overlooked. Addressing this lacuna is essential for understanding and utilizing noni plants' therapeutic potential.

MATERIALS AND METHODS

Sample preparation

Sample collection: Noni plant seeds were collected from Martins Flowers Garden, UmuruNnobi, Idemmili South L.G.A. of Anambra State. Dr. S.I. Okeke, a botanist at Science Laboratory Technology, Federal Polytechnic, Oko, identified the fruit/seeds. The samples were washed, air-dried under a shade, and pulverized using a mechanical grinder.

Extraction: The 500 g pulverized sample was macerated in 1 litre of ethanol for 24 hours. The mixture was sieved using porcelain cloth and further filtered using No 1 Whatman filter paper. The filtrate was concentrated using a rotary evaporator, and the crude concentrate was stored at 4°C until it was required for further experiment.

Methods

Inhibition of albumin denaturation

The anti-inflammatory activity of the seeds of Morindacitrofolia was studied by using the inhibition of albumin denaturation technique, which was conducted according to Mizushima and Kobayashi (1968) and Sakat *et al.,* (2010), followed by minor modifications. The reaction mixture consisted of test extracts and a 1% aqueous solution of bovine albumin fraction. The pH of the reaction mixture was adjusted using a small amount of 1 NHCl. Aspirin was used as a standard drug. The sample extracts were incubated at 37 ºC for 20 min and then heated to 51 º C for 20 min; after cooling the samples, the turbidity was measured at 660nm. (UV-visible Spectrophotometer Model 371, Elico India Ltd) The experiment was performed in triplicate. The Percentage inhibition of protein denaturation was calculated as follows:

$$\text{Percentage inhibition} = \frac{(Abs\ Control - Abs\ Sample)\ X\ 100}{Abs\ control}$$

Heat-induced haemolysis, as described by Sakat *et al*., (2010)

The reaction mixture (2ml) consisted of 1 ml test sample of different concentrations (100 - 500 µg/ml) and 1 ml of 10% RBCs suspension; instead of the test sample, only saline was added to the control test tube. Aspirin was used as a standard drug. All the centrifuge tubes containing the reaction mixture were incubated in a water bath at 56 ºC for 30 minutes. At the end of the incubation, the tubes were cooled under running tap water. The reaction mixture was centrifuged at 2500 rpm for 5 min, and the absorbance of the supernatants was taken at 560 nm. The experiment was performed in triplicates for all the test samples. The Percentage inhibition of Haemolysis was calculated as follows:

$$Percentage\ inhibition = \frac{(Abs\ control - Abs\ sample)\ X\ 100}{Abs\ control}$$

α-Amylase Inhibitory Test.

The alpha-amylase inhibitory test was performed using a modified procedure by McCue and Shetty (2004). Morindacitrifolia seeds extract at various concentrations were placed in test tubes and mixed with 250 µl of 0.02 M sodium phosphate buffer (pH 6.9) containing α-amylase at a concentration of 0.5 mg/ml. The mixture was preincubated at 25°C for 10 minutes. Then, 250 µl of 1% starch solution in 0.02 M sodium phosphate buffer (pH 6.9) was added and incubated at 25° C for another 10 minutes. The reaction was stopped by adding 500 µl of dinitrosalicylic acid (DNS). The tubes were then incubated in a water bath at 95° C for 5 minutes, cooled at room temperature, then diluted with 5 ml distilled water. The optical density was measured at 540 nm. The same procedure was followed for ascarbose as the standard. The inhibitory activity on alpha-amylase was calculated as percent inhibition using the following formula:

$$\%inhibition = \frac{(OD\ control\ -\ OD\ extracts)\ x\ 100}{OD\ control}$$

α-Glucosidase Inhibitory Test.

The ability of the extracts to inhibit the activity of α-glucosidase was assessed according to Kim *et al* (2006) protocol. α-glucosidase (1U/ml) from Saccharomyces cerevisiae was preincubated with 250 µl extracts for 10 minutes. Pnitrophenylglucopyranoside substrate solution (pNPG, 3 mM) prepared in 20 mM phosphate buffer (pH 6.9) containing 2 mg/ml BSA was added to start the reaction. The reaction mixture was incubated at 37° C for 20 minutes and stopped with 1 ml of Na_2CO_3 (1M). α-Glucosidase activity was determined by measuring para nitrophenol released from pNPG at 405 nm. The percent inhibition was calculated as follows:

$$\%inhibition = \frac{(OD\ control\ -\ OD\ sample)\ x\ 100}{OD\ control}$$

DPPH Spectrophotometric Assay

The scavenging ability of the natural antioxidants of *Morinda citrifolia* seeds towards the stable free radical DPPH was measured by the method of Mensor *et al*., (2001). The seed extracts (20µl) were added to 0.5ml of 0.1mMmethanolic solution of DPPH and 0.48ml of methanol. The mixture was allowed to react at room temperature for 30 minutes. Methanol served as the blank, and DPPH in methanol, without the seed extracts, served as the positive control, while butylated hydroxytoluene (BHT) served as a reference. After 30 minutes of incubation, the discolouration of the purple colour was measured at 518nm in a spectrophotometer (Genesys 10-S, USA). The radical scavenging activity was calculated as follows:

$$Scavenging\ activity\ \% = \frac{100 - A518\ (sample)\ -\ A518\ (blank)\ \times\ 100}{A518\ (blank)}$$

Ferric Reducing Antioxidant Power

The assay's principle quantifies ferric degradation products by condensation with the extract. The reducing property of the extracts was determined as described by Pulido et al. (2000). 0.25 ml of the extracts were mixed with 0.25 ml of 200mM sodium phosphate buffer, pH 6.6, and 0.25 ml of 1% potassium ferrocyanide. The mixture will be incubated at 50°C for 20 min, thereafter 0.25 ml of 10% trichloroacetic acid will be added and centrifuged at 2000 rpm for 10 min, 1 ml of the supernatant will be mixed with 1 ml of distilled water, and 0.2 ml of ferric chloride and the absorbance was measured at 700 nm.

Extraction of phytochemicals

The sample (0.2g) was weighed and transferred in a test tube and 15ml ethanol and 10ml of 50%m/v potassium hydroxide was added. The test tube was allowed to react in a water bath 60^0c for 3 hours. After the reaction time, the reaction product in the test tube was transferred to a separatory funnel. The tube was washed successfully with 20ml of ethanol, 10ml of cold water, 10ml of hot water, and 3ml of hexane, all transferred to the funnel. These extracts were combined and washed three times with 10ml of 10%v/v ethanol aqueous solution. The ethanol solvent was evaporated. The sample was solubilized in 1000ul of pyridine, and 200ul was transferred to a vial for analysis.

Quantification of phytochemicals by Gas-Chromatography-Flame Ionisation Detector

The phytochemical analysis was performed on an Agilent 6890 Gas chromatography equipped with a flame ionization detector. A RESTEK 15-meter MXT-1 column (15m x 250um x 0.15um) was used. The injector temperature was 280°C with a splitless injection of 2ul of sample and a linear velocity of 30cms-1; Helium 5.0pa.s was the carrier gas with a flow rate of 40 ml min-1. The oven operated initially at 200^{0}C; it was heated to 330^{0}C at a rate of 3^{0}C min^{-1} and was kept at this temperature for 5min. The detector operated at a temperature of 320^{0}C. The ratio between the area and mass of internal standard and the area of the identified phytochemicals determined phytochemicals. The concentration of the different phytochemicals is expressed in ug/g.

RESULTS

The results of the anti-inflammatory potentials of the noni plant seeds are presented in Table 1. The effects of the extracts on albumin denaturation and heat-induced haemolysis appear to be dose-dependent amongst the various concentrations, though significantly ($p<0.05$) lower than the corresponding doses of the standard used.

Table 1: Showing the anti-inflammatory efficacy of noni plant seed

Concentration (mg/ml)	% Inhibition of the Extracts	% Inhibition of Aspirin
	Albumin Denaturation	
100	67.05 ± 1.62	69.16 ± 1.62
200	70.21 ± 0.67**	76.24 ± 0.81
300	73.57 ± 1.35**	79.02 ± 1.76
	Heat Induced Haemolysis	
100	49.66 ± 0.29**	70.99 ±0.73
200	55.27 ± 0.59**	74.36 ± 2.57
300	58.73 ± 0.39**	75.35 ± 1.41

*Data are represented in means ± SD. Values with ** as superscripts are significantly different at p < 0.05*

The results of the antidiabetic capabilities of the extract, as presented in Table 2, were assessed using α-amylase and α –α-glucosidase activities. The extract also exhibited a dose-dependent inhibitory capacity on the two enzyme activities. The standard (ascarbose) showed significantly ($p<0.05$) higher inhibitory abilities when compared with the corresponding concentrations of the extracts.

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Table 2: showing the antidiabetic effects of noni plant seed

Concentration (mg/ml)	% Inhibition of the Extracts	% Inhibition of ascarbose
	α-amylase	
5	60.27 ± 0.63**	79.30 ± 0.50
10	58.89 ± 1.00**	79.59 ± 0.29
50	61.82 ± 0.90**	82.39 ± 1.04
100	69.79 ± 0.60**	84.79 ± 0.45
	α-glucosidase	
5	48.50 ± 0.79**	80.53 ± 1.05
10	60.87 ± 2.38**	81.56 ± 0.40
50	64.98 ± 1.85**	84.37 ± 0.93
100	72.38 ± 0.40**	92.14 ± 9.00

*Data are represented in means ± SD. Values with ** as superscripts are significantly different at p < 0.05*

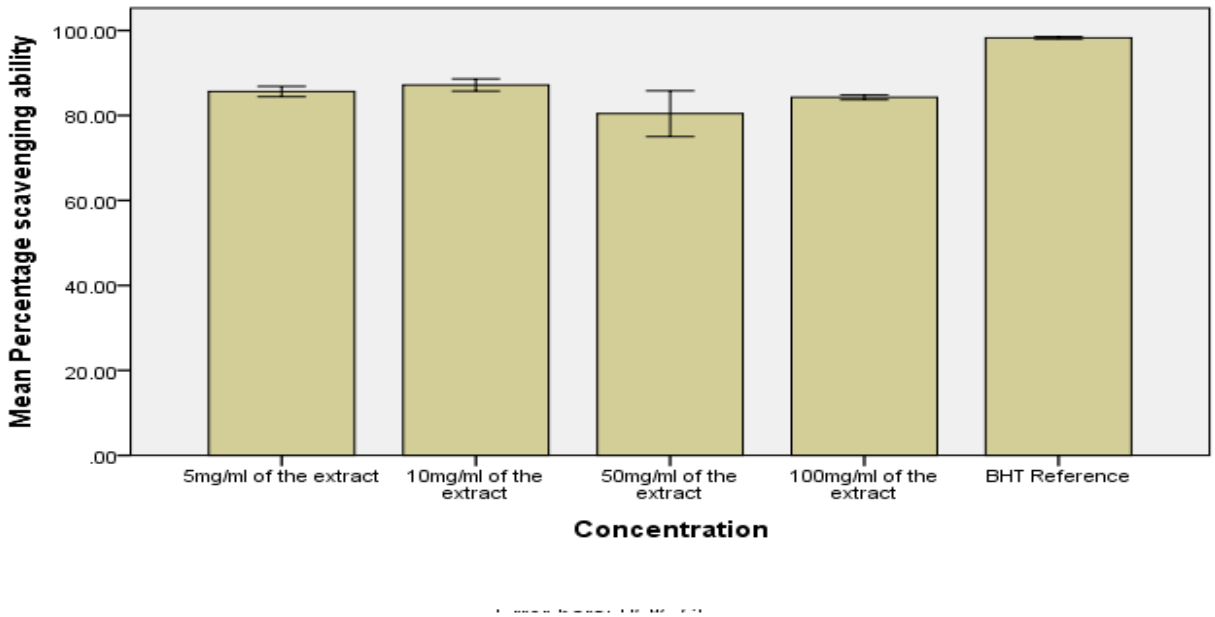

Figure 1: Showing the mean DPPH radical scavenging ability of noni seed extract compared with standard.

The different concentrations of the extract exhibited varying degrees of scavenging abilities against DPPH radical, which are significantly ($p<0.05$) lower when compared with Butylated hydroxytoluene (BHT).

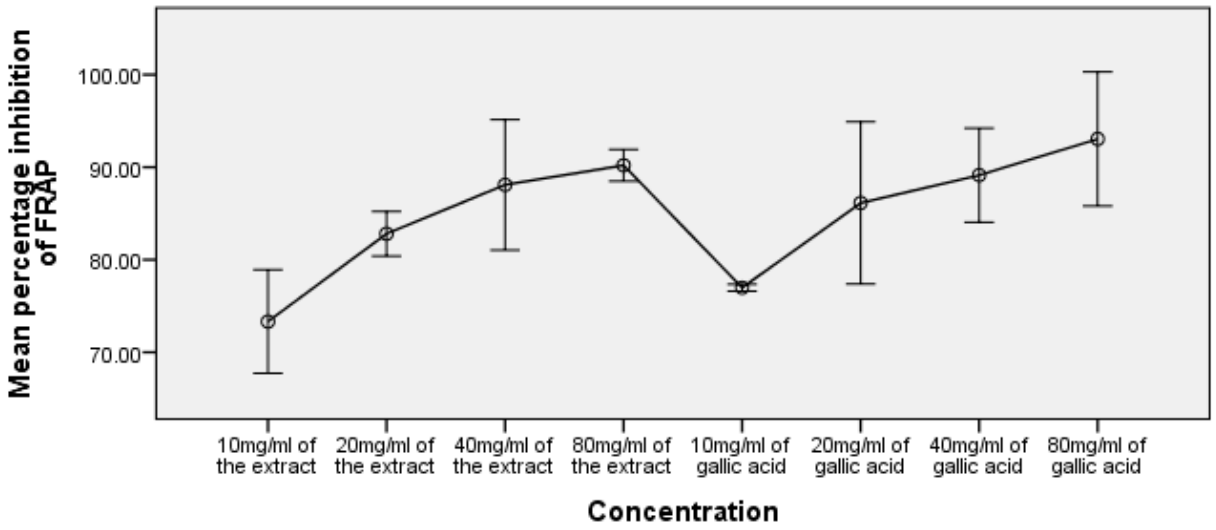

Figure 2: showing the percentage inhibitory effects presented in mean ± standard deviation of the extracts and standard on FRAP

The noni seed extract showed dose-dependent progressive inhibitory potentials across the graded concentrations. This was significantly ($p<0.05$) lower when compared with corresponding concentrations of the standard (gallic acid).

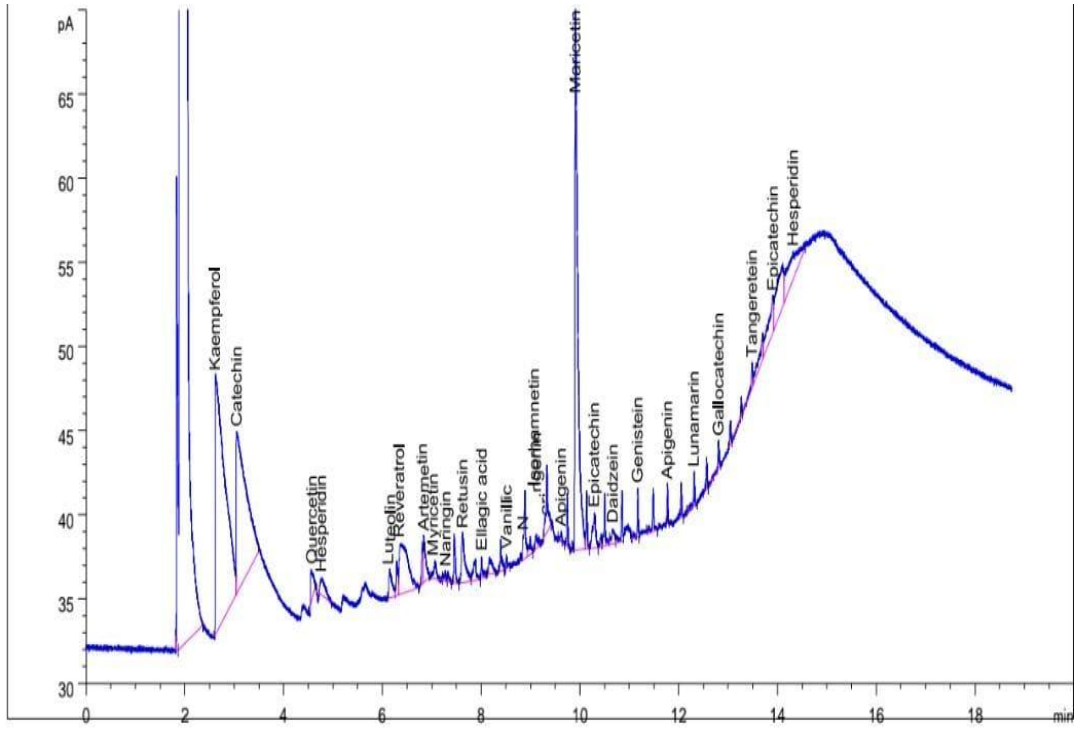

Figure 3: The result of the Gas Chromatography Flame Ionization Detector analysis of the phytoconstituents of the noni plant seed

DISCUSSION

According to Sumathi and Anuradha (2016), Inflammation is among the fastest-growing metabolic diseases in the world, making it essential to seek better approaches to controlling the disease, aided by the increasing awareness of its heterogeneous nature. The commonly used medications for the management/treatment of inflammatory conditions are non-steroidal anti-inflammatory drugs (NSAIDs), which have been associated with many adverse effects and possible reappearance of symptoms after discontinuation. Stabilization of the lysosomal membrane during inflammation is essential to prevent activated leukocytes from causing increased inflammatory damage in tissues through the release of their constituents, such as proteases and bactericidal enzymes (Oyekachukwu *et al*., 2017; Kosala *et al*., 2018). Deyet *et al.*, (2011) reported that tissue protein denaturation is a marker for inflammatory and arthritic diseases. Therefore, any substance that could prevent protein denaturation can be a potential anti-inflammatory agent. This study assessed the effects of noni plant seeds on heat-induced haemolysis and albumin denaturation as in vitro parameters to assess its anti-inflammatory potential. The result showed dose-dependent inhibitory capacities on heat-induced haemolysis and albumin denaturation, which indicates noni plant seed's anti-inflammatory benefits. The standard drug (Aspirin) used exhibited significantly ($p<0.05$) higher inhibition when compared with the corresponding doses of the extracts. The ability of the extracts to inhibit the release of haemoglobin corresponds to its effectiveness in preventing the release of inflammatory mediators and the lysosomal contents of activated leukocytes during inflammatory response (Joshua *et al*., 2019). Furthermore, the extract's effectiveness in inhibiting protein denaturation also buttresses its potential as a prospective anti-inflammatory agent. This study's results agree with Banerjee *et al.*, (2014) on the leaves and stems of *M. scandens* and Joshua *et al.*, (2019) on *Daturastramonium* leaves and seeds.

Uncontrolled diabetes mellitus is accompanied by high mortality and morbidity due to its concomitant microvascular complications, such as nephropathy, neuropathy, and retinopathy, as well as macrovascular complications, which include cardiovascular diseases leading to myocardial infarction and stroke (Kitada *et al*., 2010: Forbes and Cooper, 2013). Complex starches, oligosaccharides, and disaccharides must be broken down into monosaccharides by α-amylase and α-glucosidases before they are absorbed in the duodenum and upper jejunum (Mohamed *et al*., 2012). Inhibition of the activities of these enzymes will translate to a reduction in postprandial hyperglycemia. Current knowledge of the activity of intestinal enzymes could aid in the development of better antidiabetic agents. From the result (Table 2), both the extract and the standard (ascarbose) showed a dose-dependent increase in inhibition against the activities of the two enzymes. The standard exhibited significant inhibitory effects when compared with the extract of the same concentration.

The inhibitory benefits may benefit insulin resistance and glycemic index control in people with diabetes.

Recent investigations suggest that plant-origin antioxidants with free-radical scavenging properties may be therapeutic in free-radical-mediated diseases (Sharma and Kumar, 2011). Many synthetic antioxidant compounds have shown toxic and/or mutagenic effects, while relatively plant-based medicines confer fewer side effects than synthetic drugs in some instances (Nagulendran *et al*., 2007). DPPH antioxidant assay and ferric antioxidant reducing power assay were used to evaluate the antioxidant potential of noni plant seed extract. The DPPH antioxidant assay is based on the ability of DPPH, a stable free radical, to decolorize in the presence of antioxidants, which can be quantitatively measured from the changes in absorbance. The extract showed varying scavenging ability against DPPH radical. Butylated hydroxytoluene (BHT) exhibited a significant ($p<0.05$) higher scavenging ability when compared with the various doses of the extract. FRAP of a compound generally depends on the presence of reductants, which have exhibited antioxidative potential by breaking the free radical chain and donating a hydrogen atom (Sharma and Kumar, 2011). From the result of the study, both the noni plant seed extract and gallic acid (standard) showed dose-dependent progressive FRAP potentials. The standard showed a significant increase ($p<0.05$) in the FRAP compared to the extract. These findings indicate that this plant extract is an essential source of natural antioxidants, which might help prevent the progress of various oxidative stresses.

CONCLUSION

These pharmacological potentials of noni plant seeds could be attributed to the phytoconstituents of the plant parts. Hence, it is evident that if this crude extract is harnessed and purified, the pharmacological activity may increase significantly and might even surpass that of the standard drug. Furthermore, in vivo investigations must be carried out before clinical use.

REFERENCES

Adwas, A.A., Elsayed, A.S.I., Azab, A.E. & Quwaydir, F.A. (2019). Oxidative stress and antioxidant mechanisms in the human body. *Journal of Applied Biotechnology and Bioengineering* 6: 43–47.

Agnihotri, S., Wakode, S.R., & Agnihotri, A. (2010). An overview of anti-inflammatory properties and chemo-profiles of plants used in traditional medicine. *Indian Journal of Natural Products and Resources, 1*, 150-167.

Arowosegbe, S., Olanipekun, M.K. & Olowoyeye, O.J. (2020). Influence of location on the phytochemical, Nutritional, and Mineral Composition of the leaves of Moringaoleifera (LAM) grown in Ekiti State. *Bulletin of pure and Applied Sciences;* 39(10): 40-50.

Banerjee, S., Chanda, A., Adhikari, A., Das, A. & Biswas, S. (2014). Evaluation of Phytochemical Screening and Anti Inflammatory Activity of Leaves and Stem of Mikaniascandens (L.) Wild. *Ann Med Health SciRes*;4(4):532-6. doi: 10.4103/2141-9248.139302. PMID: 25221699; PMCID: PMC4160675.

Dey, P., Chatterjee, P., Chandra, S. & Bhattacharya, S. (2011). Comparative in

vitro evaluation of anti-inflammatory effects of aerial parts and roots from Mikaniascandens. *J Adv Pharm EducRes*;1:271–7.

Forbes, J.M. & Cooper, M.E. (2013). Mechanisms of diabetic complications. *Physiological Review*; 93:137-88.

Gupta, R.K., Banerjee, A., Pathak, S., Sharma, C. & Singh, N. (2023). Induction of mitonchondrial-mediated apoptosis by Morindacitrifolia (noni) in human cervical cancer cells. *Asian Pacific Journal of Cancer Prevention*; 14(1): 237

Harvey, A.L. (2008). Natural products in drug discovery. *Drug Discov Today*; 13(19-20): 894-901. doi: 10.1016/j.drudis.2008.07.004.

Jahurul, M. H. A., Patricia, M., Shihabul, A., Norazlina, M. R., Ramlah George, M. R., Noorakmar, A. W., Lee, J. S., Jumardi, R., Jinap, S., & Zaidul, I. S. M. (2021). A review on functional and nutritional properties of noni fruit seed (Morindacitrifolia L.) and its oil. *Food Bioscience*; 41:101000 https://doi.org/10.1016/j.fbio.2021.101000.

Joshua, P.E., Abonyi, U.C., Eze, C.S., Asomadu, R.O., Obeta, J.N., Nnamani, I.V., Patrick, B.U., Eze, K.C. & Obialor, O.F. (2019). Comparative Effects of Daturastramonium Leaf and Seed Extracts on Membrane Stabilization and Platelet Aggregation In-vitro. *Afr. J. Biomed. Res*; 22: 363- 368

Kamiya, K., Tanaka, Y., Endang, H., Umar, M. & Satake, T. (2004). Chemical constituents of Mrindacitrifolia fruits inhibit copper induced low-density lipoprotein oxidation. *Journal of Agriculture and Food Chemistry*; 52(19):5843-5848.

Kitada, M., Zhang, Z., Mima, A. & King, G.L. (2010). Molecular mechanisms of diabetic vascular complications. *Journal of Diabetes Investigation*;1(3):77-89.

Kosala, K., Widodo, M.A., Santoso, S. & Karyono S. (2018). *In vitro* and *in vivo* anti-inflammatory activities of *Coptosapeltaflavescens*Korth root's methanol extract. *J. Appl. Pharm. Sci*. 8(9), 42-48

Lv, L., Chen, H., Ho, C.T. & Sang, S. (2011). Chemical components of the roots of noni (Morindacitrifolia) and their cytotoxic effects. *Fitoterapia*; 82(4): 704-708.

McCue, P.P. & Shetty, K. (2004). Inhibitory effects of rosmarinic acid extracts on porcine pancreatic amylase *in vitro. Asia Pacific. Journal of Clinical Nutrition*; 13:101-106.

Mensor, L.L., Menezes, F.S., Leitao, G.G., Reis, A.S., Dos Santos, T.C., Coube, C.S. & Leitão, S.G. (2001). Screening of Brazilian plant extracts for antioxidant activity by the use of DPPH free radical method. *Phytotherapy research*; 15(2): 127-130.

Mizushima, Y. & Kobayashi, M. (1968). Interaction of anti-inflammatory drugs with serum proteins, especially with same biologically active proteins. *J. Pharm. Pharmacol*; 20(1): 169-173

Mohamed, E.A., Siddiqui, M.J., Ang, L.F., Sadikun, A., Chan, S.H. & Tan, S.C. (2012). Potent α-glucosidase and a-amylase inhibitory activities of standardized 50% ethanolic extracts and sinensetin from OrthosiphonstamineusBenth as anti-diabetic mechanism. *BMC Complement Altern Med.* 2012;12:176

Nagulendran, K.R., Velavan, S., Mahesh, R. & Begum, V.H. (2007). In vitro antioxidant activity and total polyphenolic content of Cyperusrotundus rhizomes. *E J Chem*; 4:440–449.

Narkhede, M.B., Ajimire, P.V., Wagh, A.E., Mohan, M. & Shivashanmugam, A.T. (2011). In vitro antidiabetic activity of Caesalpinadigyna (R.) Methanol root extract. *Asian J Plant Sci Res*; 1(2):101-6.

Nita, M. & Grzybowski, A. (2016). The Role of the Reactive Oxygen Species and Oxidative Stress in the Pathomechanism of the Age-Related Ocular Diseases and Other Pathologies of the Anterior and Posterior Eye Segments in Adults. *Oxidative Medicine and Cellular Longevity*. 2016; Article ID 3164734, 23 pages. http://dx.doi.org/10.1155/2016/3164734

Oyekachukwu, A.R., Elijah, J.P., Eshu, O.V. & Nwodo, O.F.C. (2017). Anti-inflammatory effects of the chloroform extract of *Annonamuricata*leaves on phospholipase A2 and prostaglandin synthase activities. *Transl. Biomed*. 8(4), 137.

Pandiselvi, P., Manohar, M., Thaila, M. & Sudha, A. (2019). Pharmacological Benefits of Natural Products. 1st Edition. JPS Scientific publications, India. Pp; 213 – 237.

Patwardhan, B., Vaidya, A.D., & Chorghade, M.S. (2004). Ayurveda and natural products drug discovery. *Current Science*;86*:789-799*.

Pulido, R., Bravo, L. & Saura-Calixto, F. (2000). Antioxidant activity of dietary polyphenols as determined by a modified ferric reducing/antioxidant power assay. *J Agric Food Chem*; 48(8):3396-402. doi: 10.1021/jf9913458. PMID: 10956123.

Sakat, S., Juvekar, A.R. & Gambhire, M.N. (2010). In vitro antioxidant and anti-inflammatory activity of methanol extract of Oxalis corniculata Linn. *Int J Pharma and Pharm Sci* ; 2(1): 146—155.

Sharma, U.S. & Kumar, A. (2011). In vitro antioxidant activity of Rubusellipticus fruits. *J Adv Pharm Technol Res;* 2(1):47-50. doi: 10.4103/2231-4040.79805. PMID: 22171292; PMCID: PMC3217685.

Shori, A.B. (2015). Screening of antidiabetic and antioxidant activities of medicinal plants. *J Integr Med*; 13(5):297-305. doi: 10.1016/S2095-4964(15)60193-5. PMID: 26343100.

Stoner, G.D., Li, S., Claire, S., Claudio, Kristen, S. & Steven, C. (2010). Multiple berry types prevent n-nitrosomethylbenzylamine induced esophageal cancer in rats. *Pharmaceutical Research*; 27(6): 1138-1145.

Sumathi, S. & Anuradha, R. (2016). *In vitro* anti-inflammatory activity of flower extract of *Couroupitaguianensis*Aubl. *Int. J. Herb Med*. 4(5), 5-8.

Wang, M.Y., Diane, N., Gary, A., Jarakae, J. & West, B. (2008). Liver protective effects of Morindacitrifolia (noni). *Plant Foods for Human Nutrition*; 63(20: 59-63.

Wang, M.Y., Lin, P., Gary, A. & Diane, N. (2013). Breast cancer prevention with Morindacitrifolia (noni) at the initiation stage. *Functional Foods in Health and Disease*; 3(6): 203-222.