Borneo Journal of Pharmacy
Vol 6 Issue 3 August 2023
Pages 287 – 294

https://journal.umpr.ac.id/index.php/bjop/article/view/4239
DOI: https://doi.org/10.33084/bjop.v6i3.4239
e-ISSN: 2621-4814

Mini Review

Utilization, Phytochemistry and Biological Activity of *Hua gabonii* Pierre ex De Wild.

Clément Mutunda Mbadiko [1,2]
Gédéon Ngiala Bongo [1,2*]
Jean-Paul Koto-te-Nyiwa Ngbolua [1]
Marie Claire Dembo D'A Letshu Yandju [1]
Pius Tshimankinda Mpiana [3]
Théophile Fundu Mbemba [1,2]

[1] Department of Life Science, Université de Kinshasa, Kinshasa XI, Commune de Lemba, Democratic Republic of the Congo

[2] Research Laboratory of Food and Nutrition (LARAN), Université de Kinshasa, Kinshasa XI, Commune de Lemba, Democratic Republic of the Congo

[3] Department of Chemistry and Industry, Université de Kinshasa, Kinshasa XI, Commune de Lemba, Democratic Republic of the Congo

*email: gedeonbongo@gmail.com

Keywords:
Bioactivity
Hua gabonii
Phytochemistry

Abstract

Although few studies are reported, *Hua gabonii* remains scientifically unknown due to the lack of studies. However, this aromatic plant is used in developing countries as a condiment or in traditional medicine to treat various ailments. The literature reported that this species is rich in proteins, essential amino acids, and vitamins C and E. Its fruits would present an appreciable antioxidant power. Therefore, given its numerous uses in tropical countries, *H. gabonii* is a good candidate for further studies.

Received: January 26th, 2023
1st Revised: May 14th, 2023
2nd Revised: June 26th, 2023
Accepted: June 27th, 2023
Published: August 30th, 2023

INTRODUCTION

Aromatic plants are appreciated for their flavor in food seasoning or for their nutritive value and are used in traditional pharmacopeia because of their impressive therapeutic activities[1,2]. These plants are a potential natural source of bioactive molecules and are the subject of rigorous scientific studies for their possible use as drug alternatives. Furthermore, they are also used in cooking as preservatives or colorants, and others[3].

Among this arsenal of aromatic plants, *Hua gabonii* Pierre ex De Wild is one of the less studied species of this group. *Hua gabonii* is a small tree in the undergrowth of hygrophilic forests, quite common, having flowers that develop on the trunk and the large branches. The fruits contain big seeds, like a giant coffee cherry[4]. This aromatic plant is in the family of Huaceae, order Violales, and class Magnoliopsida. It is called a Garlic tree and *lofiongi*, *longowu* (dialect, Tshopo district, Democratic

How to cite: Mbadiko CM, Bongo GN, Ngbolua JPKtN, Yandju MCDDL, Mpiana PT, Mbemba TF. Utilization, Phytochemistry and Biological Activity of Hua gabonii Pierre ex De Wild. Borneo J Pharm. 2023;6(3):287-94. doi:10.33084/bjop.v6i3.4239

Republic of the Congo)[5]. Its various parts (barks, leaves, fruits, seeds, leaves) are used in traditional medicine and especially in food as condiments. *Hua gabonii*, like the other species of the Huacaceae family, is restricted to West and Central Africa[6]. The literature provides very little data on this plant and shows that the barks and fruits of this plant are rich in proteins and essential amino acids, showing that its fruits' extracts present an antioxidant activity[6-8]. Hence, the importance of conducting in-depth investigations on this plant species. The objective of this paper is to contribute to the valorization of *H. gabonii*, a little-studied plant, by succinctly presenting data on its uses, chemical composition, and pharmacological properties to generate interest for further scientific exploration.

LITERATURE SEARCH

The databases PubMed, PubMed Central, Science Direct, Scielo, DOAJ, Science Alert, and Google Scholar were used to identify data on the use, chemical composition, and biological activity of *H. gabonii*. The plant's scientific name (*Hua gabonii*) is used as a keyword to identify published data regarding the plant. **Figure 1** shows various images of plant parts of *H. gabonii*.

a **b** **c** **d**

Figure 1. Different parts of *H. gabonii*. (**a**) fruits, (**b**) leaves, (**c**) roots, and (**d**) wood.

USE IN TRADITIONAL MEDICINE

Different parts of *H. gabonii* (barks, leaves, fruits, seeds, leaves) are used in traditional medicine or food. **Table I** shows that different organs of *H. gabonii* are used mainly in food as condiments (leaves, seeds, and bark). This plant can be a source of flavorings or food additives for food, pharmaceutical, and other industries. Nowadays, the preference for natural flavors and colors over artificial ones is drawing attention because of the potential effects of artificial flavors[9-14]. Moreover, this plant is sometimes used as a substitute for garlic or other aromatic plants such as *Scorodophloeus zenkeri*[15].

Furthermore, the young leaves of this species are eaten as vegetables and might be considered a source of nutrients. Some studies have shown that vegetables are essential for a balanced diet as they can provide nutrients to the organism[16-18]. Singh *et al*.[19] reported that besides their nutrient intake, vegetables are essential in combating various health disorders such as cancer, heart disease, high blood pressure, high cholesterol, diabetes, prostate problems, and others. In addition to using *H. gabonii* in food, this plant is also used in traditional medicine, even among the most used medicinal plants in the Democratic Republic of Congo[20]. Its use in treating rheumatism and headaches predicts its anti-inflammatory or analgesic potential[21].

For several years, scientists from all over the world have primarily focused on the search for new anti-inflammatory molecules of natural origin. The risks of gastrointestinal toxicity of some classical anti-inflammatory drugs and the urgent need for new treatments or the poverty and high costs of classical anti-inflammatory drugs can explain this trend[22-24]. Indeed, medicinal plants have gained an increasing interest in treating specific human pathologies due to their easy geographical accessibility and lower treatment costs[25,26]. In 2002, the World Health Organisation (WHO) pointed out that traditional medicine is the primary means of care for more than 80% of the population in developing countries[27]. Besides, plants can produce a wide variety of compounds that do not participate in their basic metabolism but rather represent secondary metabolite compounds, which can be used as a source of drugs with anti-inflammatory properties[28].

Furthermore, it has been reported in **Table I** that the plant is used in the preparation of medicinal recipes to prevent abortion. Some sources in the literature mention infections as a cause of abortion[29-31]. This approach can be explored to show the action

of extracts of this plant on bacteria involved in infections. Furthermore, the emergence of antibiotic-resistant bacterial strains is becoming an increasing concern[32-34]. Therefore, further scientific study of this plant can contribute to discovering new antimicrobials. Moreover, the small branches or wood of *H. gabonii* are exploited in the Democratic Republic of Congo, particularly in the Tshopo district, to manufacture amenons in construction[35].

Table I. Different uses of *H. gabonii*.

Used parts	Uses	References
Bark	- Pieces of peel are added to vegetables and sauces; dried and crushed bark is added to sauces for seasoning - Their extracts are used in traditional medicine against gastrointestinal disorders; - The bark tea with added pigment and small bitter eggplants is used to fight colds; - Bark extracts are also used in fumigations against rheumatism or headaches; - Boil the bark in a pot with the bark of other trees, let it cool and give the decoction to the pregnant woman under threat of abortion to drink; - Bark extracts are also considered as fish poison	Nyakubwa *et al*.[36]; Bachiri *et al*.[37]; Nkeoua[38]; Termote & Van Damme[5]
Seeds	- The seeds are used in food to season dishes	Nyakubwa *et al*.[36]; Bachiri *et al*.[37]
Fruits	- In addition to their use as a condiment, the fruits (juice) are used for the treatment of amoebae; - They are also used as fish poison.	Termote & Van Damme[5]
Leaves	- The young leaves are eaten as vegetables or used as condiments; they are also used as a garlic substitute; - The leaves are added to the cooking vegetables; - The dried and crushed leaves and bark are prepared as tea; - In traditional medicine, these leaves are used for the treatment of cataract and intestinal disorders. - These leaves also stimulate dogs to hunt.	Nyakubwa *et al*.[36]; Bachiri *et al*.[37]; Termote & Van Damme[5]
Roots	- The roots are used against headaches or migraines	Termote & Van Damme[5]

CHEMICAL COMPOSITION

The chemical composition of this species is described in **Table II**. *Hua gabonii* is a source of nutrients. Abdou *et al*.[8] showed that *H. gabonii* fruits have valuable contents of protein and some essential amino acids (valine, leucine, phenylalanine, tyrosine, and lysine). However, having shown that the barks of *H. gabonii* have high contents of essential amino acids compared to fruits (41.31±0.1 g/100 g of proteins against 30.84±0.1/100 g) and that the amino acids as histidine, methionine, cysteine, threonine, and isoleucine are in great quantity in the barks compared to fruits.

Tchiégang and Mbougueng[40] reported that the fruits and peels of *H. gabonii* did not have the same macronutrient composition. Indeed, the fruits' lipid, protein, and carbohydrate content are 1.40±0.05 g/100 g of dry matter, 13.61±0.03 g/100 g, and 60.20±0.10/100 g, respectively. While the lipid, protein, and carbohydrate content in the barks are 1.26±0.02 g/100 g, 10.82±0.02 g/100 g, and 24.08±0.20 g/100 g of dry matter, respectively. As for macronutrients, it is well known that carbohydrates are the primary energy source in the diet. The daily carbohydrate requirement is 400-500 g. As far as proteins are concerned, they constitute an important part of the protoplasm and are essential for the proper functioning of the body. The daily protein requirement is 60-70 g[19]. Related to lipids, they are involved in the structure of the cell membrane or as calorie storage materials[39]. We believe that *H. gabonii* can be a source of essential amino acids and essential fatty acids mainly derived from the diet.

Tchiégang and Mbougueng[40] also showed *that H. gabonii* fruits and barks are a source of micronutrients such as phosphorus, iron, calcium, and magnesium. The content of phosphorus, iron, calcium, and magnesium in the fruits are 6.53±0.01 mg/100 g, 1.27±0.01 mg/100 g, 101.19±0.07 mg/g and 570.03±0.35 mg/g dry matter, respectively. At the same time, the content of phosphorus, iron, calcium, and magnesium in the barks is 0.60±0.01 mg/g, 9.59±0.85 mg/g, 2571.01±0.21 mg/g, and 2789.34±0.35 mg/g, respectively. Moreover, the barks and fruits of *H. gabonii* are a source of fiber. The content of this nutrient is 4.59±1.31 g/100 g and 56.00±2.44 g/100 g dry matter in the fruits and barks, respectively. Different parts of this plant used

mainly as a condiment can, given its nutrient composition, contribute to the improvement of the physiological conditions of the organism. As far as minerals are concerned, they provide the organism with essential elements for protection and functioning and participate in specific metabolic reactions[41]. Calcium and phosphorus play an essential role in the formation of the skeleton. Magnesium is involved in the composition of bones and neuromuscular functioning. Furthermore, the ionic balance of cells depends on the flow of sodium, calcium, potassium, and magnesium. On the other hand, iron makes up 33% of hemoglobin, which is involved in oxygen transport in the blood. In addition, fiber facilitates intestinal transit[42,43].
Bouba *et al.*[6-8] has also shown that the seeds of *H. gabonii* have a high number of total polyphenols, flavonoids, tannins, and vitamin E compared to the bark. However, the study showed that the concentration of vitamin C is high in the barks. Polyphenolic compounds are known for their biological properties, notably their antioxidant, anti-inflammatory, and antimicrobial activities[44]. Polyphenols, particularly flavonoids and tannins, are known to be toxic to micro-organisms[45]. Their mechanisms of toxicity are thought to be related to the inhibition of hydrolytic enzymes (proteases and carbohydrolases) or other interactions to inactivate microbial adhesins, transport, and cell envelope proteins. As for vitamins C and E, their role in the antioxidant defense system has been reported[46].

Table II. Phytochemical constituents of *H. gabonii*.

Used part	Chemical phytochemical	References
Bark	**Macronutrients and micronutrients**	Bouba *et al.*[7,8]
	- Proteins and essential amino acids (histidine, valine, methionine, cysteine, threonine, isoleucine, leucine, phenylalanine, tyrosine and lysine) and non-essential ones (aspartate, glutamine, serine, alanine, proline, arginine, glycine), fatty acids	
	- vitamins C and E	
	Other compounds	
	- Flavonoids, tannins	Bouba *et al.*[7]
Fruits	**Macronutrients and micronutrients**	
	- Essential proteins and amino acids (valine, methionine, cysteine, isoleucine, leucine, phenylalanine, tyrosine and lysine) and non-essential ones (aspartate, glutamine, serine, alanine, proline, arginine and glycine) and fatty acids	Bouba *et al.*[7,8]
	- Vitamins C and E.	
	Other compounds	
	- Flavonoids, tannins	Bouba *et al.*[7]

BIOLOGICAL ACTIVITIES

Poor literature characterizes the studies on the biological activities of *H. gabonii* extracts. Bouba *et al.*[6-8] showed that the extracts of fruits and barks present an antioxidant activity. Many studies have reported the involvement of oxidative stress in the pathophysiology of chronic non-communicable diseases (cardiovascular diseases, cancer, diabetes, obesity, and others) and other diseases, such as sickle cell disease[41,44]. Hence, the promotion of a diet that can provide antioxidants. Antioxidants are also known for their food-preserving properties. Several studies support using antioxidants from food and plant sources instead of synthetic antioxidants[47,48].

CONCLUSION

Certainly known for its medicinal or aromatic virtues, *H. gabonii* must be studied more. Studies highlighting its antimicrobial, anti-inflammatory, analgesic, and other properties are required, given the various uses of this plant in traditional medicine. It is also necessary to conduct in-depth studies to identify its active ingredients. In addition, the aromas derived from this plant also deserve to be studied and valorized. Lastly, toxicological studies to show the probable toxic effects of extracts from different parts of this plant used either in food or in traditional medicine are also essential.

ACKNOWLEDGMENT

None.

AUTHORS' CONTRIBUTION

All authors have an equal contribution in carrying out this study.

DATA AVAILABILITY

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

1. Novais, Pereira C, Molina AK, Liberal Â, Dias MI, Añibarro-Ortega M, Alves MJ, et al. Bioactive and Nutritional Potential of Medicinal and Aromatic Plant (MAP) Seasoning Mixtures. Molecules. 2021;26(6):1587. doi:10.3390/molecules26061587

2. Pereira C, Barros L, Ferreira ICFR. A Comparison of the Nutritional Contribution of Thirty-nine Aromatic Plants used as Condiments and/or Herbal Infusions. Plant Foods Hum Nutr. 2015;70(2):176-83. doi:10.1007/s11130-015-0476-7

3. Lourenço SC, Moldão-Martins M, Alves VD. Antioxidants of Natural Plant Origins: From Sources to Food Industry Applications. Molecules. 2019;24(22):4132. doi:10.3390/molecules24224132

4. Kimpouni V, Nzila JDD, Watha-Ndoudy N, Madzella-Mbiemo MI, Mouhamed SY, Kampe JP. Ethnobotanical indicator values of Non-Timber Forest Products from the Djoumouna peri-urban forest in Brazzaville, Republic of Congo. Heliyon. 2021;7(3):06579. doi:10.1016/j.heliyon.2021.e06579

5. Termote C, Van Damme P. Wild edible plant use in Tshopo District, Democratic Republic of Congo. Afr Focus. 2012;25(1):94-100. doi:10.1163/2031356X-02501014

6. Bouba AA, Njintang NY, Foyet HS, Scher J, Montet D, Mbofung CMF. Proximate Composition, Mineral and Vitamin Content of Some Wild Plants Used as Spices in Cameroon. Food Nutr Sci. 2012;3(4):423-32. doi:10.4236/fns.2012.34061

7. Bouba AA, Njintang NY, Scher J, Mbofung CMF. Phenolic compound and radical scavenging potential of twenty Cameroonian spices. Agr Biol J North Am. 2010;1(3):213-24.

8. Bouba AA, Ponka R, Augustin G, Yanou NN, El-Sayed MAH, Montet D, et al. Amino Acid and Fatty Acid Profile of Twenty Wild Plants Used as Spices in Cameroon. Am J Food Sci Technol. 2016;4(2):29-37. doi:10.12691/ajfst-4-2-1

9. Joute JR, Chawhan P, Rungsung S, Kirthika P. Food Additives and Their Associated Health Risks. Int J Vet Sci Anim Husb. 2016;1(1):1-5.

10. Ramesh M, Muthuraman A. Chapter 1 - Flavoring and Coloring Agents: Health Risks and Potential Problems. In: Grumezescu AM, Holban AM, editors. Natural and Artificial Flavoring Agents and Food Dyes. Cambridge; Academic Press: 2018. doi:10.1016/B978-0-12-811518-3.00001-6

11. Sales IMS, Silva JM, Moura ESR, Alves FDS, Silva FCC, Sousa JMC, et al. Toxicity of synthetic flavorings, nature identical and artificial, to hematopoietic tissue cells of rodents. Braz J Biol. 2018;78(2):306-10. doi:10.1590/1519-6984.07716

12. Elshama SS. Synthetic and Natural Food Additives: Toxicological Hazards and Health Benefits. Open Access J Toxicol. 2020;4(4):555643. doi:10.19080/OAJT.2020.04.5556343

13. Sambu S, Hemaram U, Murugan R, Alsofi AA. Toxicological and Teratogenic Effect of Various Food Additives: An Updated Review. Biomed Res Int. 2022;24:6829409. doi:10.1155/2022/6829409

14. Kraemer MVDS, Fernandes AC, Chaddad MCC, Uggioni PL, Rodrigues VM, Bernardo GL, et al. Food additives in childhood: a review of consumption and health consequences. Rev Saude Publica. 2022;56:32. doi:10.11606/s1518-8787.2022056004060

15. Djiazet S, Kenfack LBM, Linder M, Tchiégang C. An ethno-nutritional study on spices used in traditional foods of the Western Regions of Cameroon: the case of nah poh. J Ethnic Foods. 2019;6:31. doi:10.1186/s42779-019-0030-6

16. Hui YH, Culbertson JD, Duncan SE, Legarreta IG, Li-Chan ECY, Ma CY, et al. Handbook of food science, technology, and engineering. In Handbook of Food Science, Technology, and Engineering - 4 Volume Set. Boca Raton; CRC Press: 2006. p. 1-3497.

17. Dias JS. Nutritional Quality and Health Benefits of Vegetables: A Review. Food and Nutrition Sciences. Food Nutr Sci. 2012;3(10):1354-74. doi:10.4236/fns.2012.310179

18. Mintesnot HDA. Review on Contribution of Fruits and Vegetables on Food Security in Ethiopia. J Biol Agric Healthc. 2016;6(11):49-58.

19. Singh S, Gupta N, Saurabh A. Review: Vegetables an important source of nutrients. J Pharmacogn Phytochem. 2019;8(4S):78-80.

20. Betti JL. An ethnobotanical study of medicinal plants among the Baka Pygmies in the Dja Biosphere Reserve, Cameroon. Afr Study Monogr. 2003;25(1):1-27.

21. Bitew H, Hymete A. The Genus Echinops: Phytochemistry and Biological Activities: A Review. Front Pharmacol. 2019;10:1234. doi:10.3389/fphar.2019.01234

22. Rahman MM, Rahaman MS, Islam MR, Rahman F, Mithi FM, Alqahtani T, et al. Role of Phenolic Compounds in Human Disease: Current Knowledge and Future Prospects. Molecules. 2021;27(1):233. doi:10.3390/molecules27010233

23. McEvoy L, Carr DF, Pirmohamed M. Pharmacogenomics of NSAID-Induced Upper Gastrointestinal Toxicity. Front Pharmacol. 2021;12:684162. doi:10.3389/fphar.2021.684162

24. Bai J, Zhang Y, Tang C, Hou Y, Ai X, Chen X, et al. Gallic acid: Pharmacological activities and molecular mechanisms involved in inflammation-related diseases. Biomed Pharmacother. 2021;133:110985. doi:10.1016/j.biopha.2020.110985

25. Chaachouay N, Douira A, Zidane L. Herbal Medicine Used in the Treatment of Human Diseases in the Rif, Northern Morocco. Arab J Sci Eng. 2022;47(1):131-53. doi:10.1007/s13369-021-05501-1

26. Ekor M. The growing use of herbal medicines: issues relating to adverse reactions and challenges in monitoring safety. Front Pharmacol. 2014;4:177. doi:10.3389/fphar.2013.00177

27. Oyebode O, Kandala NB, Chilton PJ, Lilford RJ. Use of traditional medicine in middle-income countries: a WHO-SAGE study. Health Policy Plan. 2016;31(8):984-91. doi:10.1093/heapol/czw022

28. Nunes CDR, Arantes MB, Pereira SMdF, da Cruz LL, Passos MdS, de Moraes LP, et al. Plants as Sources of Anti-Inflammatory Agents. Molecules. 2020;25(16):3726. doi:10.3390/molecules25163726

29. Givens DM, Marley MSD. Infectious causes of embryonic and fetal mortality. Theriogenology. 2008;70(3):270–85. doi:10.1016/j.theriogenology.2008.04.018

30. Salmanov AG, Ishchak OM, Shostak MY, Kozachenko VV, Rud OV, Golyanovskiy OV, et al. Bacterial infection causes of pregnancy loss and premature birth in the women in ukraine. Wiad Lek. 2021;74(6):1355-9.

31. Wurdack KJ, Davis CC. Malpighiales phylogenetics: Gaining ground on one of the most recalcitrant clades in the angiosperm tree of life. Am J Bot. 2009;96(8):1551-70. doi:10.3732/ajb.0800207

32. Ventola LC. The Antibiotic Resistance Crisis. P T. 2015;40(4):277–83.

33. Serwecinska L. Review Antimicrobials and Antibiotic-Resistant Bacteria: A Risk to the Environment and to Public Health. Water 2020, 12, 3313; doi:10.3390/w1212331. Water. 2020;12(12):3313. doi:10.3390/w12123313

34. Nwobodo DC, Ugwu MC, Oliseloke AC, Al-Ouqaili MTS, Ikem JC, Chigozie UV, et al. Antibiotic resistance: The challenges and some emerging strategies for tackling a global menace. J Clin Lab Anal. 2022;36(9):e24655. doi:10.1002/jcla.24655

35. Dalglish SL, Straubinger S, Kavle JA, Gibson L, Mbombeshayi E, Anzolo J, et al. Who are the real community health workers in Tshopo Province, Democratic Republic of the Congo? BMJ Glob Health. 2019;4(4):e001529. doi:10.1136/bmjgh-2019-001529

36. Nyakubwa M, Bola M, Vasolene K. Plantes sauvages alimentaires chez les Kumu de Mosako à Kisangani (Zaire). Afr Study Monogr. 1990;11(2):75-86.

37. Bachiri M, Aguiar V, Mikala JK, Mbadinga S, Moussavou GM, Kialo K, et al. Pharmacopée et médecine traditionnelle chez les Pygmées du Gabon : Barimba et Baghama (Nyanga), Babongo (Ngounié, Ogooué Lolo et Haut Ogooué) et les Bakoya (Ogooué Ivindo). Libreville, Gabon; Bureau Multipays de l'UNESCO: 2009. p. 74.

38. Nkeoua G, Boundzanga GV. Données sur les produits forestiers non ligneux en République du Congo. Brazzaville, Congo Republic; Food and Agriculture Organization of the United Nations: 1999. p. 124.

39. Carvalho CCCR, Caramujo MJ. Review The Various Roles of Fatty Acids. Molecules. 2018;23(10):2583. doi:10.3390/molecules23102583

40. Tchiégang C, Mbougueng PD. Composition des épices utilisées dans la préparation du Nah poh et du Nkui de l'Ouest Cameroun. Tropicultura. 2005;23:193-200.

41. Fundu TM, Kapepula PM, Mbo JPN, Esimo JM, Kabamba NN. Congolese Traditional Foods as Sources of Antioxidant Nutrients for Disease Prevention. In: Fuertes PO, Corral MFC, editors. Recent Developments in Antioxidants from Natural Sources. London, UK: IntechOpen; 2023. doi:10.5772/intechopen.109319

42. Ponka R, Tchatchoua E, Tabot S, Fokou E. Composition nutritionnelle de quelques farines infantiles artisanales du Cameroun. Int J Innov Appl Stud. 2016;16(2):280-92.

43. Mbadiko CM, Inkoto CL, Gbolo BZ, Lengbiye EM, Kilembe JT, Matondo A, et al. A Mini Review on the Phytochemistry, Toxicology and Antiviral Activity of Some Medically Interesting Zingiberaceae Species. J Complement Altern Med Res. 2020;9(4):44-56. doi:10.9734/jocamr/2020/v9i430150

44. Mbadiko CM, Ngbolua KtN, Mpiana PT, Ngombe NK, Kapepula PM, Kemfine LL, et al. Antioxidant Potential and Anti-Sickling Activity of Different Organs of Curcuma longa: Correlation of the Antioxidant Capacity on Anti-Sickling Activity. South Asian Res J Nat Prod. 2019;2(2):1-16.

45. Makarewicz M, Drożdż I, Tarko T, Duda-Chodak A. The Interactions between Polyphenols and Microorganisms, Especially Gut Microbiota. Antioxidants. 2021;10(2):188. doi:10.3390/antiox10020188

46. Yan Z, Zhong Y, Duan Y, Chen Q, Li F. Antioxidant mechanism of tea polyphenols and its impact on health benefits. Anim Nutr. 2020;6(2):115-23. doi:10.1016/j.aninu.2020.01.001

47. Thorat ID, Jagtap DD, Mohapatra D, Joshib DC, Sutarb RF, Kapdi SS. Antioxidants, their properties, uses in food products and their legal implications. Int J Food Stud. 2013;2(1):81-104. doi:10.7455/ijfs/2.1.2013.a7

48. Badr AN, Youssef M, Abdel-Razek AG, Shehata MG, Hassanien MM, Amra H. Natural Antioxidants: Preservation Roles and Mycotoxicological Safety of Food. Egypt J Chem. 2021;64(1):285-98. doi:10.21608/ejchem.2020.51183.3048