Science Get Journal
Vol. 01, No. 2, July 2024, 30-40
***e*-ISSN: 3062-6595**

Bioactivity and Benefits of the Okra Plant (*Abelmoschus esculentus* (L.) Moench.) : Literature Review

Tri Putri Wahyuni [1]*, & Atyka Trianisa[2]
[1]*Universitas Negeri Padang Indonesia, [2]Universitas Negeri Padang Indonesia
*e-mail: triputriyuni@gmail.com

Article Information
Received: July 29, 2024
Revised: July 31, 2024
Online: August 07, 2024

Keywords
Bioactivity okra, Abelmoschus esculentus L, Composition and Benefits

ABSTRACT
Abelmoschus esculentus L., commonly known as okra, is a flowering plant belonging to the Malvaceae family. Okra is a versatile plant due to the various uses of its fresh leaves, buds, flowers, pods, stems, and seeds. Okra is a popular health food because of its high content of fiber, vitamin C, and folate, as well as being a good source of calcium and potassium. Additionally, this plant has been used medicinally in the treatment of several disorders, demonstrating anti-cancer, antimicrobial, hypoglycemic, and anti-ulcer activities. Okra is a vegetable crop with diverse nutritional qualities and potential health benefits. This plant is also known to be high in antioxidants. The purpose of this research is to investigate bioactivities such as antioxidant, anti-cancer, antibacterial, and antidiabetic activities, as well as to determine the benefits of okra.

Keywords: *Bioactivity okra, Abelmoschus esculentus L, Composition and Benefits*

INTRODUCTION

Okra (*Abelmoschus esculentus*) has long been recognized in agriculture and culinary circles. Originating from Africa, it is now widely cultivated across various warm regions of the world This plant is relatively easy to grow and adapts well to tropical and subtropical environments, making it a popular choice for farmers of all scales. The Abelmoschus genus encompasses 11 species, including wild, semi-wild, and cultivated varieties, exhibiting significant variation in chromosome numbers among different species. The okra plant, belonging to the genus Abelmoschus, shares a close relationship with the genus Hibiscus.

Taxonomy of Okra:

Kingdom : Plantae
Divisio : Magnoliophyta
Class : Magnoliopsida
Ordo : Malvales

http://dx.doi.org/10.69855/science.v1i3.48
https://gpijournal.com/index.php/science
PUBLISHED BY : GPress Indonesia

Familia : Malvaceae
Genus : Abelmoschus
Species : *Abelmoschus esculentus* (L.) Moench.

Figure 1. Okra (*Abelmoschus esculentus*)

Originating from Africa, okra (*Abelmoschus esculentus*) is now widely cultivated across various warm regions of the world. This plant adapts well to tropical and subtropical environments, making it a popular choice for farmers of all scales. While generally cultivated, okra can also grow wild in suitable areas. The most commonly used part is its young fruit, but recent research has explored the potential of other plant parts. Studies have investigated the antioxidant properties of okra leaves and the feasibility of using okra seeds as a raw material for biodiesel production.

While generally cultivated, okra can also grow wild in areas suitable to its needs. The most commonly used part is its young fruit, but recent research has shown potential in utilizing other parts of the plant. The genetic diversity of okra has also been a focus of research, with various cultivars being developed to enhance resistance to pests and diseases.

Anatomically, the fruit, stem, and leaves of okra are covered with minute soft, hairy structures. Although the flowering of the okra plant is perennial, its growth is highly dependent on various biotic and abiotic factors. The leaves of okra are polymorphous, characterized by hairy upper and lower surfaces, while the petioles are about 15 cm long. The flowers of okra can be recognized by their slight yellowish color with a crimson center. The edible part of okra, or its capsule (pod), measures approximately 15–20 cm in length and has a pyramidal-oblong, pentagonal, and hispid appearance. Historically, okra pods were used for various purposes, such as in food, appetite boosters, astringents, and as an aphrodisiac.

Okra is known for its long, slender, and fleshy fruit that is commonly consumed as a vegetable. Currently, okra cultivation has been widely developed in various tropical and subtropical countries, including Indonesia as a tropical country. Okra is an economical natural source rich in carbohydrates, proteins, fatty acids, vitamins, fiber, minerals, and bioactive phytochemicals important for human well-being.

Okra (*Abelmoschus esculentus* L.) is known for its diverse nutritional and therapeutic benefits. It contains a range of essential nutrients, including vitamins C, A, and folate, which contribute to its antioxidant, vision, and immune-boosting properties. The fruit is rich in minerals such as potassium,

calcium, and magnesium, essential for maintaining blood pressure and bone health, respectively [5],[6]. Additionally, okra provides dietary fiber, including mucilage, which supports digestive health and blood sugar regulation (Mosa & Mujib, 2021). Its antioxidant capacity is attributed to various bioactive compounds, including flavonoids, polyphenols, and oligomeric catechins, which play a role in neutralizing free radicals and reducing oxidative stress. Okra also contains phytochemicals like saponins and tannins, known for their anti-inflammatory and anticancer activities. These attributes make okra a valuable vegetable with potential applications in nutrition and health.

METHODS

The collection of references and data related to Okra was conducted using a literature review method, both online and offline in libraries. Online information searches were performed on several important websites such as Google Scholar, ResearchGate, and Scopus. Information obtained from books, journal publications, and proceedings used keywords such as Okra, Abelmoschus esculentus, Bioactivity, antioxidant, antidiabetic, and Okra benefits.

RESULTS

Bioactive compounds or secondary metabolites can be identified by conducting phytochemical screening with ethanol extracts obtained from okra fruit. The results of the phytochemical screening show that the ethanol extract of okra fruit contains phenolic compounds, alkaloids, flavonoids, saponins, terpenoids, and steroids.

Table 1. Results of phytochemical screening of okra fruit ethanol extract [8]

Number	Phytochemical Test	Explanation
1	Phenolic	+
2	Alkaloids	+
3	Flavonoids	+
4	Saponins	+
5	Steroids/Terpenoids	+

Secondary metabolite compounds, such as flavonoids, phenolics, alkaloids, tannins, terpenoids, steroids, and saponins, all of which are beneficial to health, include preventing diabetes, lowering cholesterol, acting as antioxidants, serving as antibacterials, preventing cancer development, and being good for the digestive system. The benefits of okra are likely due to okra containing secondary metabolite components such as alkaloids, terpenoids, flavonoids, and others. This finding is consistent with the report by Syam et al., which indicates that both green and red okra fruits are rich in various bioactive compounds, including alkaloids, flavonoids, polyphenols, tannins, quinones, steroid-triterpenoids, and monoterpenoid-sesquiterpenes. The flavonoid content in red okra fruit is higher compared to green okra fruit. This is due to the influence of anthocyanins contained in red okra, where anthocyanins are a class of flavonoids characterized by their red color, visible in the skin of red okra. The content of 100 g of young okra fruit consists of 90.17 g water; 31

kcal energy; 2.00 g protein; 0.10 g total fat; 0.70 g ash; 7.03 g carbohydrates; 3.2 g total fiber; 1.2 g total sugar; 81 mg Ca; 0.8 mg Fe; 57 mg Mg; 0.60 mg Zn; 0.990 mg Mn; 303 mg K; 375 IU Vitamin A; 21.2 mg Vitamin C; 0.36 Vitamin E; 53 mg Vitamin K; 0.02 mg Thiamin; 0.06 mg Riboflavin.

Okra is known to have different compounds in each of its parts. The okra skin contains polyphenols, folic acid, carotene, thiamin, vitamin B2, niacin, ascorbic acid, oxalic acid, and amino acids. Okra seeds contain polyphenolic compounds, particularly catechin oligomers and flavonol derivatives such as quercetin, high-level lysine proteins, and oil components rich in palmitic acid, oleic acid, and linoleic acid. Okra roots primarily consist of carbohydrates and flavonol glycosides. Fresh fruits are rich in pectin and mucilage, oxalic acid, proteins, fats, minerals, carbohydrates, calcium, and phosphorus. The fruit mucilage includes flavonoids, d-galactose, l-rhamnose, and d-galacturonic acid. Okra leaves contain tannins, minerals, and okra flavonol glycosides.

Table 2. Activity Tests of Okra Extract (Abelmoschus esculentus)

Activity Test	Result	References
Antioxidant	Studies on the antioxidant properties of okra (Abelmoschus esculentus) have yielded varied results. While the DPPH method revealed that the ethanol extract of okra fruit exhibits weak antioxidant activity (IC50 151-200), capable of neutralizing 50% of free radicals.	[8]
	Acid-soluble okra pectin (AOP) and crude acid-soluble okra pectin (CAOP) demonstrate good antioxidant activity against free radicals.	[11]
Antidiabetic	Research has indicated that aqueous okra extract has potential as a functional food that regulates intestinal microecological balance in diabetic patients.	[12]
	In an animal study, diabetic rats treated with okra maintained stable blood glucose levels, while untreated diabetic rats experienced increased blood glucose levels. After twelve days, the untreated diabetic group reached a peak level of 399.33 ± 198.05 mg/dl, significantly higher than the okra-treated diabetic group (p=0.023).	[13]
Anti-inflammatory	The anti-inflammatory properties of okra have also been investigated. Acid-soluble okra pectin (AOP) has been found to significantly reduce NO content, thereby inhibiting LPS-induced inflammation in RAW 264.7 macrophages.	[11]
Anti-cancer	Studies on cholesterol reduction have shown promising results. Research has demonstrated a	[14]

Activity Test	Result	References
	decrease in total cholesterol levels in positive control, extract, and nanoparticle groups by 48.68%, 32.44%, and 42.95%, respectively. Notably, nanoparticles were found to enhance the activity of the extract.	
	The immunomodulatory and anti-cancer potential of okra has been explored in several studies. Ethanol extract of red okra fruit (EEROP) has been shown to modulate immune response by (1) down-regulating IL-1, IL-6, TNF-A, IFN-C, TGF-B, and IL-10 to prevent overexpression of pro-inflammatory cytokines, (2) increasing CD4+ and CD8+ T cell activity to enhance immune response against cancer, and (3) protecting mammary gland epithelium from thickening due to cancer cell proliferation. These findings suggest that EEROP may act as an anti-cancer agent by modulating immune response.	[15]
	Significant anti-cancer activity has been observed at different sample solution concentrations. *Abelmoschus esculentus* flowers were tested for anti-cancer activity against the HePG2 liver cancer cell line using the MTT assay. The CTC50 value of the sample was found to be 444.22 μg/ml against the HePG2 liver cancer cell line.	[16]
Antibacterial	Okra has demonstrated antibacterial activity against E. coli at various concentrations. A study aimed at determining the antibacterial activity of okra fruit extract against E. coli found that the best inhibition occurred at concentrations of 40%, 50%, and 60%, as evidenced by the size of the inhibition zones.	[17]
	The antibacterial activity of okra flowers has been tested against four bacteria: S. typhi, E. coli, E. faecalis, and B. cereus. At an extract concentration of 40 mg/mL, inhibition zones ranged from 17-18 mm for all test bacteria, while at 50 mg/mL, the range increased to 24-26 mm. These results were comparable to or better than the standard chloramphenicol, which showed inhibition zones of 17-19 mm against the test bacteria.	[18]

DISCUSSION

1. Antioxidant Activity

Okra (*Abelmoschus esculentus*) has gained increasing attention in recent years due to its rich antioxidant profile. Various parts of the plant, including the pods, seeds, leaves, and flowers, contain significant amounts of antioxidants, with polyphenols and flavonoids being particularly abundant [19]. These compounds play a crucial role in protecting the body against oxidative stress and related diseases, making okra a potential functional food ingredient. To extract these valuable antioxidants, researchers have employed a range of methods, each with its own advantages. While traditional solvent extraction remains common, more advanced techniques have shown promising results. To extract these antioxidant compounds, various methods have been developed and optimized. Zhang et al. [21] applied ultrasound-assisted extraction (UAE) and found that "UAE significantly increased the extraction yield of polyphenols from okra pods compared to conventional methods, while maintaining their antioxidant activity. Meanwhile, Alam et al. [3] explored the potential of enzyme-assisted extraction, stating that "enzymatic pretreatment before extraction enhanced the release of bound phenolic compounds from the okra cell matrix, resulting in extracts with higher antioxidant activity." Additionally, environmentally friendly extraction approaches have gained momentum. Advanced extraction techniques, such as Microwave-Assisted Extraction (MAE) and Ultrasound-Assisted Extraction (UAE), have shown improved efficiency in isolating these antioxidant compounds from okra compared to traditional methods. Furthermore, the optimized extracts from okra demonstrate potent antioxidant capacities, evidenced by low IC50 values in DPPH radical scavenging assays and significant Ferric Reducing Antioxidant Power. The selection of appropriate extraction methods is crucial in maximizing the antioxidant potential of okra. With the growing interest in functional foods and nutraceuticals, further research on optimizing extraction and characterizing antioxidant compounds from various parts of the okra plant could pave the way for the development of antioxidant-rich okra-based products to support health.

2. Antidiabetic

Okra (Abelmoschus esculentus (L.) Moench) has been traditionally used for the prevention and management of diabetes, even alongside pharmaceutical drugs. Studies have shown that okra contains a unique fiber that helps stabilize blood sugar by limiting sugar absorption in the intestinal tract.

Abelmoschus esculentus, commonly known as okra, has shown significant potential in stabilizing blood sugar levels by reducing glucose diffusion and enhancing insulin resistance. Research indicates that both the peel and seeds of okra are effective in normalizing blood glucose and lipid profiles in diabetic conditions. Okra significantly impacts glucose and lipid metabolism, contributing to improved glycemic control. Research has revealed that okra fruit contains secondary metabolites including triterpenoids, phenolics, and flavonoids. The flavonoid quercetin, present in okra, functions as a hypoglycemic agent. Sabita reported anti-diabetic and anti-hyperlipidemic activities of okra peel and seeds in streptozotocin-induced diabetic rats.

The aqueous fraction of okra seeds contains two types of flavonol glycosides: isoquercitrin and quercetin-3-O-beta-glucopyranosyl-glucoside, which act as α-glucosidase inhibitors, thus inhibiting maltase and sucrose absorption in the intestine.

The fiber in okra has been found to help stabilize blood sugar by regulating the rate of sugar absorption from the intestinal tract. Nutritional analysis has shown that the edible part of the fruit contains 1.9g protein, 0.2g dietary fiber, 6.4g starch, 66mg calcium, 56mg phosphorus, 0.35mg iron, 6.98mg sodium, 103mg potassium, 0.19mg copper, 30mg sulfur, 88IU Vitamin A, 0.7mg thiamine, 0.1mg riboflavin, 0.6mg nicotinic acid, 13mg Vitamin C, and 89.6g moisture. These findings suggest that okra may be beneficial for patients with asthma and could help normalize blood sugar and cholesterol levels. Additionally, it has been used to address various health issues such as ulcers, lung inflammation, sore throat, and intestinal irritation.

3. Anti-cancer

Cancer is characterized by abnormal tissue growth where cells exhibit uncontrolled division, leading to a progressive increase in the number of dividing cells. MTT assays conducted on compounds isolated from the ethyl acetate fraction of Abelmoschus esculentus flowers have demonstrated anti-cancer activity across all tested concentrations. These findings suggest that these compounds have potential as a source of anti-cancer drugs and could be used to improve health outcomes.

Okra (*Abelmoschus esculentus*), a nutritious vegetable widely cultivated in tropical and subtropical regions, is gaining attention in the scientific community for its potential anticancer properties. This green, finger-shaped pod is rich in bioactive compounds, including flavonoids, tannins, sterols, and terpenoids, which have shown promising anticancer potential.

Recent studies have particularly focused on the flavonoids extracted from okra flowers. These purified compounds have demonstrated robust antitumor effects against colorectal cancer, both in vitro and in vivo. The flavonoids exhibit substantial antioxidant activity and significant antiproliferative effects, suggesting a dual mechanism of action in combating cancer cells.

4. Anti-Inflammatory

Regarding anti-inflammatory properties, nitric oxide (NO) has been identified as a signaling molecule that provides anti-inflammatory effects under normal physiological conditions. However, excessive pro-inflammatory mediators can exacerbate inflammation. In Asian traditional medicine, okra has been prepared as a dietary remedy for gastric irritation. Okra fruit is rich in mucilage, primarily composed of pectic polysaccharides and high carbohydrate content, making it a potential source of natural and healthy functional ingredients.

In recent studies, okra polysaccharides were found to significantly reduce the production of pro-inflammatory cytokines such as TNF-α and IL-6 in lipopolysaccharide-stimulated macrophages. Additionally, these polysaccharides activated the Nrf2/HO-1 pathway, which plays a crucial role in regulating cellular antioxidant and anti-inflammatory responses.

In a comprehensive review, Uwiringiyimana et al. highlighted the diverse bioactive compounds present in okra, including flavonoids, phenolic compounds, and polysaccharides, all of which contribute to its anti-inflammatory properties. The review emphasized okra's potential in managing inflammatory bowel diseases and other gastrointestinal disorders.

5. Antibacterial

Studies have shown that the okra plant contains polysaccharides and phenolic compounds as its main active constituents. Various research findings have demonstrated that extracts from different parts of the okra plant, including flowers, leaves, seeds, and fruits, exhibit effective antibacterial activity. The okra plant has been found to contain secondary metabolites such as alkaloids, saponins, cardenolides, and anthraquinones, which are known to possess antibacterial properties.

Khan et al. reported in their research that aqueous extracts of okra fruit contain numerous active compounds. Using GC-MS analysis, they identified 35 compounds in the okra fruit extract, with the main compounds being (E)-anethole (6.7%), limonene (6.65%), β-caryophyllene (5.2%), decanal (4.45%), and carvone (4.35%), all of which are known to have antimicrobial activity.

In addition to its high nutritional content, the fruit's mucilage has been found to be beneficial for maintaining blood pressure. Okra seeds have been utilized for their anti-fatigue properties, attributed to their polyphenol and flavonoid content (Xia et al., 2015). These findings highlight the potential of okra as a natural source of antibacterial compounds and its diverse health benefits, supporting its traditional use in various applications (Xia et al., 2015).

Research has revealed several beneficial effects of okra (Abelmoschus esculentus) on human health. Studies have shown that okra contains a specific type of fiber that helps regulate blood sugar levels. The mucilage found in okra has been demonstrated to play a role in eliminating toxins and harmful cholesterol that burden the liver. Additionally, okra's laxative properties have been found to be beneficial for cleansing the intestines.

Investigations into okra's nutritional profile have indicated that its fiber content serves as a nutrient source for intestinal microorganisms, potentially supporting gut health. Okra has also been reported to be an effective remedy for gastric issues and joint health. Its alkaline nature has been observed to counteract acidity, while its mucilaginous properties have been shown to protect the mucous membranes of the digestive system by forming an additional protective layer.

Furthermore, okra has been traditionally used to address various health conditions, including lung inflammation, intestinal irritation, and sore throat. Notably, research conducted in India has suggested that okra may have potential as a complex human blood plasma substitute, although further studies are needed to confirm this finding.

These diverse health benefits highlight okra's potential as a functional food and its possible applications in various areas of health and nutrition. However, it is important to note that while these findings are promising, more comprehensive clinical trials are necessary to fully establish the efficacy and safety of okra in treating specific health conditions.

Research has demonstrated that okra (Abelmoschus esculentus) has diverse applications beyond its medicinal uses. Studies have shown that okra leaves are valuable as animal feed due to their nutritional content. According to analyses, 100 g of okra leaves contain 56 calories, 11 g of carbohydrates, and 4.4 g of protein. Investigations into the utilization of various parts of the okra plant have revealed that its stems can be used as fuel and as a source of fiber for paper pulp production. Ikrarwati and Rokhmah noted that young okra leaves can be consumed as a vegetable, while the seeds can be processed into cereal.

Rukmana and Yudirachman highlighted the rich folic acid content in okra, which is crucial for fetal neural tube formation between 4-12 weeks of pregnancy. Yasin et al. also reported that okra exhibits significant anti-ulcer and anti-inflammatory properties, particularly in the context of gastric lesions. Higher concentrations of okra extract (500 mg/kg) demonstrated protective effects against aspirin-induced gastric ulcers, suggesting that okra may function as a natural remedy with antibacterial potential, similar to the protective effects observed in previous studies involving famotidine and quercetin.

Additionally, Susanto reported that okra fruit contains glutathione, an antioxidant component beneficial for maintaining cell vitality and countering free radicals that can lead to cancer [32]. These findings underscore the potential of okra as a versatile crop with applications in agriculture, nutrition, and health. These diverse applications of okra demonstrate its potential as a multi-purpose crop with significance in various sectors, including agriculture, nutrition, and health. However, further research may be necessary to fully explore and validate these applications in different contexts.

CONCLUSIONS

Okra has potential as an antioxidant, antidiabetic, anticancer, antibacterial agent, and can potentially be used as a source of natural and healthy functional ingredients. This is due to okra containing secondary metabolite compounds, such as flavonoids, phenolics, alkaloids, tannins, terpenoids, steroids, and saponins, all of which are beneficial for health. These compounds can help prevent diabetes, lower cholesterol, act as antioxidants, serve as antibacterial agents, inhibit cancer development, and are good for the digestive system.

ACKNOWLEDGMENT

The authors extend their sincere gratitude to the providers of literature who have greatly facilitated the citation of existing articles. Furthermore, the authors wish to express their appreciation to the various parties who have contributed to the publication of this article.

REFERENCES

Bangsawan, C. C., & Kurniati, I. (2019). Antidiabetes Effects of Okra Plant (Abelmoschus esculentus).

Chaemsawang, W., Prasongchean, W., Papadopoulos, K. I., Ritthidej, G., Sukrong, S., & Wattanaarsakit, P. (2019). The Effect of Okra (Abelmoschus esculentus (L.) Moench) Seed Extract on Human Cancer Cell Lines Delivered in Its Native Form and Loaded in Polymeric

Micelles. Int. J. Biomater., 2019. doi:10.1155/2019/9404383.

Deng, Y., et al. (2020). Flavonoid-rich extracts from okra flowers exert antitumor activity in colorectal cancer. Food Funct., 11(12), 10448–10466. doi:10.1039/d0fo02081h.

Djamil, R., Rahmat, D., Zaidan, S., & Latifah, M. N. (2020). Anticholesterol Activity of Okra Fruit Extract (Abelmoschus esculentus (L) Moench) and Its Nanoemulsion in Vivo. Pharmacogn. J., 12(2), 316–320. doi:10.5530/pj.2020.12.50.

Durazzo, A., Lucarini, M., Novellino, E., Souto, E. B., Daliu, P., & Santini, A. (2019). Abelmoschus esculentus (L.): Bioactive components' beneficial properties-focused on antidiabetic role. doi:10.3390/molecules24010038.

Elkhalifa, A. E. O., et al. (2021). Okra (Abelmoschus esculentus) as a potential dietary medicine. Molecules, 26(3), 1–21. doi:10.3390/MOLECULES26030696.

Fekadu Gemede, H. (2015). Nutritional Quality and Health Benefits of 'Okra' (Abelmoschus esculentus): A Review. Int. J. Nutr. Food Sci., 4(2), 208. doi:10.11648/j.ijnfs.20150402.22.

Guebebia, S., Espinosa-Ruiz, C., Zourgui, L., Cuesta, A., Romdhane, M., & Esteban, M. Á. (2023). Effects of okra leaves, fruits and seeds extracts on European sea bass leukocytes. Fish Shellfish Immunol., 138. doi:10.1016/j.fsi.2023.108799.

Hafeez, M., Hassan, S. M., Mughal, S. S., Munir, M., & Khan, M. K. (2020). Antioxidant, Antimicrobial and Cytotoxic Potential of Abelmoschus esculentus. Chem. Biomol. Eng., 5(4), 69. doi:10.11648/j.cbe.20200504.11.

Islam, M. T. (2019). Phytochemical information and pharmacological activities of Okra (Abelmoschus esculentus): A literature-based review. Phyther. Res., 33(1), 72–80. doi:10.1002/ptr.6212.

Khan, S., et al. (2022). Phytochemical Screening, Nutritional Value, Anti-Diabetic, Anti-Cancer, and Anti-Bacterial Assessment of Aqueous Extract from Abelmoschus esculentus Pods. Processes, 10(2). doi:10.3390/pr10020183.

Liao, H., Dong, W., Shi, X., Liu, H., & Yuan, K. (2019). Analysis and comparison of the active components and antioxidant activities of okra extracts. Pharmacogn. Mag., 8(30), 156–161. doi:10.4103/0973-1296.96570.

Lisnawati, N., Astuti Handayani, I., & Fajrianti, M. (2016). Analysis of Flavonoids from 96% Ethanol Extract of Red Okra Fruit Skin. [Online]. Available: https://e-jurnal.stikes-isfi.ac.id/index.php/JIIS/article/view/36/31

Mariem Haj Romdhane, L. B., Chahdoura, H., Dias, P. M. I., Corrêa, R. C. G., Ciudad-Mulero, H. M., Flamini, G. (2020). Biological Evaluation of Tunisian Okra Pods. Article, 24(3), 3–4.

Oyaizu, M. (1986). Studies on products of browning reaction. Antioxidative activities. Japanese J. Nutr. Diet., 44(6), 307–315. doi:10.5264/eiyogakuzashi.44.307.

Pramudya, M., Dewi, F. R. P., Wong, R. W., Anggraini, D. W., Winarni, D., & Wahyuningsih, S. P. A. (2022). Anti-cancer activity of ethanolic extract of red okra pods. Vet. World, 15(5), 1177–1184. doi:10.14202/vetworld.2022.1177-1184.

Rukmana, R., & Yudirachman, H. (2016). BLocal Vegetable Cultivation. Bandung: Nuansa Cendikia Publishing & Printing. [Online]. Available: https://nuansa.co/product/budidaya-sayuran-

lokal-2/

Sabrina, N., Pujilestari, S., Nurul Azni, I., Amelia, J. R., Surbakti, F. H., & Rismawati, A. (2021). Anti Diabetic and Anti Hypercholesterolemia Potential of Abelmoschus Esculentus Functional Beverage with Ginger Extract.

Singh, B., et al. (2023). Okra: Breeding and Genomics. Veg. Sci., 50(02), 261–273. doi:10.61180/vegsci.2023.v50.i2.01.

Solomon, S., Muruganantham, N., & Senthamilselvi, M. M. (2016). Anticancer Activity of Abelmoschus esculentus Flowers Against Human Liver Cancer. [Online]. Available: www.ijpbs.com or www.ijpbsonline.com

Solomon, S., Muruganantham, N., & Senthamilselvi, M. M. (2016). Antimicrobial activity of Abelmoschus esculentus (flowers). Int. J. Herb. Med., 46(6), 46–49.

Susanto, H. B. (2016). Organic Urban Farming Minimalist Organic Yard. Yogyakarta: Andi Publisher. [Online]. Available: https://andipublisher.com/produk/detail/organic-urban-farming-halaman-organik-minimalis-sehat-dengan-menyulap-taman-sempit-rumah-jadi-taman-sayuran-organik

Syam, A. K., Riyanti, S., & Armypa, U. W. (2019). Determination of Flavonoid and Polyphenol Levels of Red Okra and Green Okra Fruit. Semin. Nas. Farm. 4 UNJANI. [Online]. Available: http://repository.unjani.ac.id/index.php?p=show_detail&id=4215

Uwiringiyimana, T., et al. (2024). Review on Okra (Abelmoschus esculentus) Production, Nutrition and Health Benefits. Rwanda J. Agric. Sci., 3(1), 71–87.

Wulandari, A., Kusuma, D., 1b, W., Kh, U. A. W., Hasbullah, J., & Timur, I. (2019). Antimicrobial inhibition zone test of purple okra extract on growth of gram-negative bacteria.

Wu, L., et al. (2022). Analysis of the effect of okra extract on intestinal flora diversity in diabetic based on 16S rRNA sequence. Food Sci. Technol., 42. doi:10.1590/fst.00121.

Xiong, B., et al. (2021). Preparation, characterization, antioxidant and anti-inflammatory activities of acid-soluble pectin from okra. Int. J. Biol. Macromol., 181, 824–834. doi:10.1016/j.ijbiomac.2021.03.202.

Yasin, H., et al. (2020). Ethanolic extract of okra has a potential gastroprotective effect. Food Sci. Nutr., 8(12), 6691–6698. doi:10.1002/fsn3.1963.

Zainuddin, A., Sabilu, Y., Majid, R., Pratiwi, A. D., & Jafriati. (2022). Analysis of Phytochemical Compounds, Total Phenolic Content, and Antioxidant Activity Test of Ethanol Extract of Okra from Traditional Market of Kendari. Hunan Daxue Xuebao/Journal Hunan Univ. Nat. Sci., 49(7), 89–95. doi:10.55463/issn.1674-2974.49.7.10.

Zhang, L., et al. (2022). Hybrid techniques of pre and assisted processing modify characteristics of okra pectin. Ultrason. Sonochem., 88, 106080. doi:10.1016/j.ultsonch.2022.106080.

Zhu, X. M., Xu, R., Wang, H., Chen, J. Y., & Tu, Z. C. (2020). Structural Properties, Bioactivities, and Applications of Polysaccharides from Okra. J. Agric. Food Chem., 68(48), 14091–14103. doi:10.1021/acs.jafc.0c04475.

Ikrarwati & Rokhmah, N. A. (2018). Cultivating Okra and Moringa in Pots. J. Artik., 3–4.