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Morphological Characterization and Conservation of Nagami Citrus (*Citrus Japonica*) as an Antioxidant and Nutrient Source

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ABSTRACT

Fruits provide the body with essential nutrients and antioxidants. The kumquat or nagami orange fruit is one variety that may contain nutrients and antioxidants. This fruit is best utilized as a source of nutrients and antioxidants and is commonly grown in tropical and subtropical regions. The tiniest citrus fruit, nagami oranges, known as kumquat oranges (Citrus japonica), have sweet skin and sour flesh. They are also one of the fruits that can be eaten raw. This study aims to assess the antioxidant and nutritional value of Nagami orange fruit extract and identify strategies for preserving the fruit's antioxidant and nutritional value. Implementing both primary and secondary data collection, the writer conducted an experimental study. Primary data are firsthand observations made in conservation areas, while secondary data take the form of information about the climate, accessibility, and other auxiliary factors—excellent potential as a source of food ingredients with sales value and antioxidants. Nagami oranges' high levels of antioxidants, including flavonoids, ascorbic acid, and phenolic compounds, can benefit health and shield the body from harm from free radicals. Cultivating nagami oranges can open doors for farmers or producers to sell natural antioxidant-containing products to consumers increasingly concerned with their health and nutrition.

Keywords: *Nutrition, Antioxidants, Cultivation.*

1. INTRODUCTION

The Nagami lime or kumquat (*Citrus japonica*) is the smallest citrus fruit known for being consumed whole, including its peel. It features a sweet peel with sour flesh. The Nagami lime or Kumquat tree is typically tiny, reaching heights of 2-3 meters. Its leaves are oval-shaped with pointed tips, measuring about 5-10 cm long. The fruit is round or oval, with a 2-4 cm diameter. Its thin peel is orangish-yellow, while the flesh is orange or pinkish-red, offering a sweet taste with a hint of acidity. Nagami limes or Kumquats thrive in subtropical to tropical regions, flourishing in nutrient-rich soil with good drainage. They require sufficient sunlight and are tolerant of cold temperatures. Originating from Southern China, Nagami limes or Kumquats were introduced to Japan in the 12th century (Ragheb et al., 2023).

Despite being native plants of South Asia and the Asia-Pacific, Kumquats are grown worldwide, predominantly as ornamental garden trees with the potential to be valuable sources of antioxidants and nutrients. Kumquats are known for their easy-to-peel skin, sweet flesh with a hint of acidity, and abundant nutritional content. They are recognized as an excellent source of nutrition and phytochemicals such as ascorbic acid, carotenoids, flavonoids, phenolic compounds, minerals, and vitamins in the peel and flesh. Due to their high bioactivity and nutritional value, consumers generally prefer fresh kumquats. However, they can also be processed like jams, jellies, candies, beverages, alcoholic drinks, or pickles (Özkan-Karabacak et al., 2022).

The preservation of Nagami oranges can be a source of antioxidants and essential nutrients for developing functional foods and promoting health. The antioxidants in Nagami oranges can protect body cells from oxidative damage caused by free radicals. Moreover, nutrient content such as vitamin C, fiber, and minerals in Nagami oranges also play a role in maintaining overall health.

Referring to the iucnredlist.org website, Nagami oranges are not considered a threatened or most minor concern species. This fact indicates that Nagami oranges are currently believed to have a stable population or are not facing significant risk of extinction, at least according to the criteria used by the IUCN Red List. However, it is crucial to focus on conserving Nagami oranges as a valuable source of antioxidants and nutrition. Nagami oranges can be preserved through efforts to conserve seedlings and develop superior varieties resistant to diseases and extreme climates.

Previous research has indicated the potential of nagami oranges as a potent source of antioxidants and beneficial nutrients. The orange peel contains higher levels of polyphenolic compounds that significantly influence the extent of antioxidant activity (Silalahi et al., 2022). The extract from Bali orange peel is classified as a moderate antioxidant (La et al., 2021). However, further research is needed to gain a deeper understanding of the preservation potential of nagami oranges and their utilization in developing innovative food products.

However, the Nagami orange is underappreciated and not fully utilized as an abundant source of antioxidants and nutrients. Preserving the Nagami orange as a crucial source of antioxidants and nutrients is essential in developing functional foods and health promotion efforts. Furthermore, the development of Nagami orange-based food products can also provide added value for farmers and players in the food industry in Indonesia.

This study explores the potential of preserving nagami citrus as a valuable source of antioxidants and nutrients. The extraction of Citrus japonica var peel has shown DPPH antioxidant activity of 45.5% and 46.5%, where higher levels of total phenolic and flavonoid compounds exhibit increased ability to scavenge

DPPH free radicals (Silalahi et al., 2022). Citrus japonica extracted with hot water at 80 and 90℃ showed 45.5 and 46.5%/mg/mL, indicating that the optimized antioxidant extract demonstrated superior results (Elias et al., 2023). We will analyze and study the health benefits of consuming nagami citrus. Additionally, we will discuss the potential development of functional food products based on nagami citrus to promote a healthy lifestyle and disease prevention.

It is hoped that the findings of this research will contribute to a deeper understanding of the preservation potential of Nagami oranges as a source of antioxidants and essential nutrients. The implications of this study are expected to serve as a foundation for developing innovative food products with the potential to enhance public health overall.

2. MATERIAL AND METHODS

Nagami oranges were planted on Sunday, October 8, 2022, at the coordinates -3.758684 latitude, 102.275848 longitude. This location is of interest, mainly as it is part of the conservation and education program of the Faculty of Agriculture, University of Bengkulu. The area serves educational, research, and biodiversity conservation purposes. Nagami orange seedlings were obtained from a nursery. Instruments and materials used include rulers or height measuring tools for plant dimension measurements; calipers or measuring tape for stem and fruit diameter measurements; sharp knives or sterile scissors for leaf sampling; digging tools or soil sampling equipment for soil samples; pH meters or pH measurement kits for soil pH testing; air temperature, relative humidity, and light intensity measuring instruments for environmental parameter measurements.

Initially, Nagami oranges were planted in soil and rice husk media in polybags. The planting process was carried out by preparing a large pot as the planting location, filling it with soil rice husks mixed with manure until complete. Subsequently, soil pH was checked using a pH meter, moisture using a Hygrometer, and temperature. Abiotic measurements on Nagami orange plants involve measuring non-living factors that affect plant growth and development. These measurements include air temperature, humidity, light intensity, rainfall, soil pH, and soil nutrient availability. Then, remove the seedlings from the polybag and plant them in the soil media inside the pot. Initial measurements before planting are used to facilitate plant growth monitoring. Further parameter measurements are scheduled twice a week, and plant watering is done twice weekly. Parameter measurements on Nagami orange plants involve observing various morphological and physical characteristics of the plants and their fruits.

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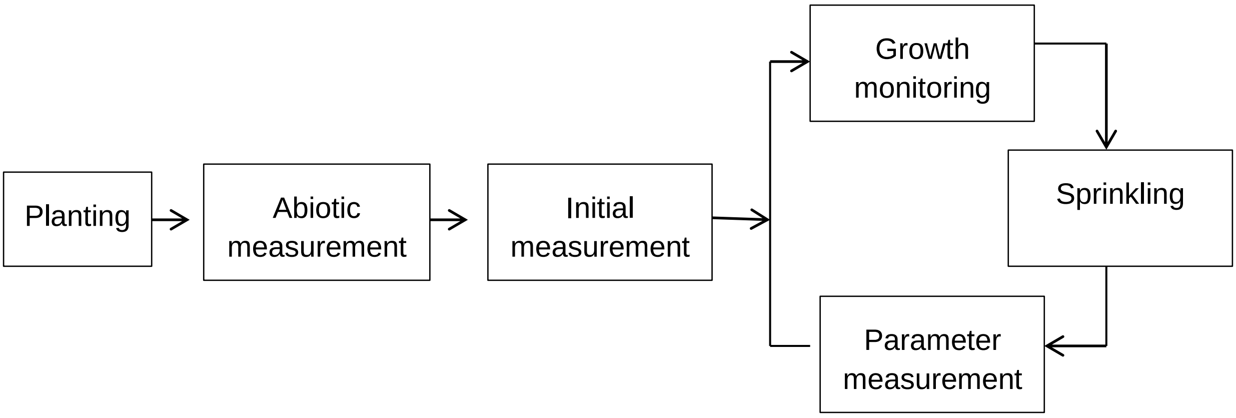

Figure 1. Research flow diagram

The collected data consists of primary data and secondary data. Primary data is directly obtained from the field in the conservation area, such as potential distribution studies and preservation of Nagami oranges (Citrus Japonica). Secondary data used includes climate data, accessibility, and other supporting data. The gathered data is subsequently analyzed to determine the adaptation progress of Nagami orange plants in the conservation area of the Science Education Faculty of the University of Bengkulu.

3. RESULT AND DISCUSSION

Before planting Nagami oranges, researchers measured several abiotic factors of the plants, such as temperature, soil moisture, light intensity, soil pH, and water pH. According to Buchta et al. (2018), abiotic components in an ecosystem refer to the physical and chemical factors that influence the life of organisms without involving interactions with other organisms. Temperature refers to the level of heat or cold in an environment, moisture refers to the amount of water or humidity in the air, and pH refers to the acidity or alkalinity level of an environment. These factors can significantly impact organisms' growth, development, and distribution within an ecosystem.

Figure 2. Photo of data collection activities

Water quality is determined by the amount of dissolved oxygen in the water. In the study, measuring the water's saturation with a dissolved oxygen value of approximately 14.21 mg/L indicates the presence of oxygen in the water, which enables its use for medical, food, beverage, and aquaculture purposes (Politeknik Ahli Usaha Perikanan (AUP) Jakarta, n.d.).

Yusian et al. (2022) indicate that the soil pH sensor measurement ranges used for this soil pH sensor range from 2.5 to 8 on the pH scale by inserting the sensor into the soil around 15 cm or 20 cm. The pH value expresses the acidity-alkalinity properties of the soil. The pH value indicates the soil's hydrogen ions (H+) concentration. The higher the amount of H+ ions in the soil, the more acidic the soil becomes. In addition to H+ ions and other ions, OH- ions are also found in the soil, which is inversely proportional to the amount of H+. In acidic soils, the amount of H+ ions is higher than OH-; in alkaline soils, the OH- content is higher than H+. When the H+ content equals OH-, the soil reacts neutrally, with a pH of 7. The optimal temperature for its growth is 25-30℃, but some can still grow generally at 38℃. The optimum humidity for the growth of these plants is around 70-80% (Agustian, 2020). Typically, it requires fertile, loose, organic-rich, highly porous soil with a pH of 5-6. The annual rainfall is about 1,500 - 2,000 mm yearly (Saputri, 2023). The micelle properties and various cations, including base saturation, micelle properties, and the types of absorbed cations, influence the soil pH value. The lower the base saturation, the more acidic the soil becomes, and its pH decreases (Rukmana et al., 2019).

Figure 3. Nagami orange seedlings

In addition, researchers measured the stem diameter and height of the plants before transferring them to planting pots. The following are the measurement results:

Table 1. Measurement results

Variable	Measurement tool	Measurement result
Temperature	Thermometer	29ºC
Soil pH	pH meter	5.5
Water pH	pH meter	6
Soil Moisture	Hygrometer	RH 74%
Light Intensity		
Stem Diameter	Luxmeter	145-900 µmol/m^2/s
Stem Height		2 cm
	Meter	
		63 cm
	Meter	

Two main requirements that influence oranges from planting to harvesting are climate and planting media. The impact of climate on orange plants can include wind speed below 40-48%, requiring 5-7 months of rainy season, environmental temperature ranging from 25-30ºC, optimum humidity of 70-80%, and an open location with direct sunlight. The second requirement influenced by planting media includes, among others, clay to sandy clay soil, andosol and latosol soil, soil acidity level of 5.5-6.5, groundwater, and soil slope of about 300 (Bagaskara, 2021).

Nagami orange is a small orange variety. The following are its morphological characteristics:

- Tree: Nagami oranges grow as small to medium trees with a height of about 2-3 meters. The tree has branches, and the leaves grow on small twigs (Smith, 2019).
- Leaves: Nagami orange leaves are oval and bright green. The leaves grow on small twigs, about 5-10 cm in size (Smith, 2019).

Figure 4. Nagami lime leaves

- Flowers: Nagami orange flowers are white and have a fragrant aroma. These flowers grow on small twigs and branches on Nagami orange trees (Johnson, 2021).
- Fruit: Nagami orange fruit is small round with a diameter of about 3-4 cm. The skin of the fruit is bright orange and has a smooth texture. The flesh is orange and has a sweet and sour taste (Smith, 2019).

Figure 5. Nagami orange fruit

After 54 days from the previous planting, the height of the Nagami orange seedling was 63 cm, and currently, the stem height is 70 cm. This result indicates that during the 54 days, this planted Nagami orange has grown by 7 cm.

Figure 6. Nagami orange 54 DAP

The Nagami orange peel contains phenolic compounds and flavonoids with a high antioxidant activity. Utilizing Nagami orange peel as a source of antioxidants can be achieved by drying the peel and processing it into powder or extract. Azman et al. (2019) research has proven that Nagami orange peel extract has vigorous antioxidant activity.

Nagami oranges have the potential to be utilized in various processing methods to obtain their benefits, including the following:

- To obtain antioxidant compounds, farmers can process Nagami oranges using organic solvents such as ethanol or methanol extraction methods. A study by X. Li et al. (2018) revealed that ethanol solvent extraction at the appropriate temperature yields optimal antioxidant compounds. The research findings indicate that ethanol extract from Nagami oranges exhibits significant antioxidant activity.

- The pressing method can be employed with Nagami oranges to obtain juice containing antioxidants. According to research by Silva et al. (2019), Nagami orange juice has been proven to contain antioxidants such as hesperidin, naringin, and ascorbic acid.
- Fermentation is a technique employed to enhance the antioxidant compound content in Nagami oranges by utilizing probiotic microorganisms. Research conducted by X. Li et al. (2020) has demonstrated that fermenting Nagami orange juice with Lactobacillus plantarum can elevate the phenolic compound content and antioxidant activity.
- The Sokletasi method is primarily designed for lipid extraction. Still, it is now widely used for extracting critical bioactive compounds by treating the sample wrapped in lead paper that comes into contact with the solvent vapors in a flask treated with heat to evaporate the desired compounds repeatedly. Extraction of immature Citrus japonica var. margarita (kumquat) peel with 80ºC aquades solvent yielded the highest total phenolic compounds at 3,000 mg/g GAE. This result indicates that Aquades solvent effectively obtains phenolic compounds from kumquat peel extract, which are primarily hydrophilic. The highest total flavonoid content was obtained in the extract of immature kumquat peel with 90ºC aquades solvent at 326 mg/g QE. The total phenolic and flavonoid compound content from the extract of immature kumquat peel with 80ºC and 90ºC aquades solvent showed a positive correlation with the DPPH antioxidant activity obtained at 45.5% and 46.5%, where higher total phenolic and flavonoid content had higher free radical scavenging ability against DPPH (Revansyah et al., 2022).

Table 2. Application in Food Products with the Addition of Citrus Processed Side Products

Product	Addition	Application	References
Sop Barley	Thermometer Essential oil of C. limon peel at 10% and 20% concentration	Growth inhibition of S. aureus during 15 days of storage. Control: On day 15, there were still S. aureus colonies (6 logs CFU/ml). Treatment: day 12 colony growth was inhibited (0 log CFU/ml)	Moosavy et al., 2017.
Paneer	Orange peel extract concentration 2%	Prevent lipid peroxidation and protect against oxidative damage for 8 days. Control: 8th-day peroxidation number of 2.56 Treatment: 8th-day	Singh & Immanuel, 2014.

		peroxidation number of 1.47	
Meatballs	Orange peel extract (Citrus) concentration	Inhibits microbes up to day 4 at room temperature. Control: 2 log CFU/g Treatment: 1.5 log CFU/g	Dewi, 2019.
Biscuit	10% reconcentrated Citrus peel flour	Antioxidant activity Control (Wheat flour): 74.15%	Mackay & Gerritsen, 2020.
Orange Jam	Citrus sinensis bark extract 8% concentration.	Sensory acceptability Control (Wheat flour): 83.3% Tangerine peel flour: 93.3%	Teixeira et al., 2020.
Jelly Candy	Lemon peel powder 8% concentration	Vitamin C (mg/100 g) Control: 8.8 Treatment: 35.2 Sensory acceptability Control: 3.92% Treatment: 2.04%	Elok Nianti et al., 2017.
Soybean oil	Citrus limon seed extract concentration 2,400 mg/kg	Oxidative stability Control: 10.52 hours Treatment: 16.48 hours	Jorge et al., 2018.

4. CONCLUSION

Citrus japonica, known as Nagami Mandarin, holds significant potential as an antioxidant source and valuable food material. Its antioxidant compounds, such as flavonoids, ascorbic acid, and phenolic compounds, contribute to health benefits and protect the body from damage caused by free radicals. Moreover, Nagami mandarins can be processed into various food products rich in natural antioxidants.

Developing Nagami orange cultivation can provide opportunities for farmers or producers to market products containing natural antioxidants to increasingly health and nutrition-conscious consumers. However, factors such as climate, growth requirements, and market demand must be considered before embarking on Nagami orange cultivation. Further studies and careful planning are required to ensure the commercial success of Nagami orange cultivation.

REFERENCE

Agustian, R. (2020). *Analisis Preferensi Konsumen Terhadap Buah Jeruk Siam (Citrus Nobilis Lour Var. Microcorpa Hassk) di Pasar Swalayan Kota Surakarta*.

Azman, N. F. I. N., Azlan, A., Khoo, H. E., & Razman, M. R. (2019). Antioxidant properties of fresh and frozen peels of citrus species. *Current Research in Nutrition and Food Science Journal*, *7*(2), 331–339.

Bagaskara, J. (2021). *Teknik Budi Daya Buah Jeruk*. Diva Press.

Buchta, T., & Buchta, M. (2018). Soil pH and its influence on citrus growth and development. *Acta Horticulturae*, *1192*, 469–476.

Dewi, A. D. R. (2019). Aktivitas Antioksidan dan Antibakteri Ekstrak Kulit Jeruk Manis dan Aplikasinya Sebagai Pengawet Pangan. *Jurnal Teknologi & Industri Pangan*, *30*(1), 83–90.

Elias, H. S., Baharum, S. N., Azizan, K. A., Ahmad, W. Y. W., Chandren, S., & Basar, N. (2023). Optimization of Ultrasound-Assisted Extraction for Antioxidant Activity in Relation to Rhoifolin Content of Fortunella polyandra using Response Surface Methodology (RSM). *Sains Malaysiana*, *52*(1), 153–164. https://doi.org/10.17576/jsm-2023-5201-12

Elok Nianti, E., Dwiloka, B., & Etza Setiani, B. (2017). Pengaruh Derajat Kecerahan, Kekenyalan, Vitamin C, dan Sifat Organoleptik pada Permen Jelly Kulit Jeruk Lemon (Citrus medica var Lemon). *Jurnal Teknologi Pangan*, *2*, 64–69.

Johnson, L. (2021). Morphological Characteristics and Growth Patterns of Nagami Citrus Trees. *International Journal of Plant Sciences*, *63*(4), 210–225.

Jorge, N., Pietro, T. A., Luzia, D. M. M., & Veronezi, C. M. (2018). Caracterização fitoquímica do óleo de soja adicionado de extrato de Portulaca oleracea L. *Revista Ceres*, *65*, 1–6.

Li, X., Chen, G., Zhang, X., & Chen, Y. (2018). Optimization of extraction conditions of flavonoids from Citrus nagami by response surface methodology. *Journal of Food Processing and Preservation*, *42*(1).

Li, X., Chen, G., Zhang, X., & Chen, Y. (2020). Fermentation optimization of Citrus nagami juice by Lactobacillus plantarum and its effect on phenolic compounds and antioxidant activity. *Food Science and Biotechnology*, *29*(9), 1215–1222.

Mackay, S., & Gerritsen, S. (2020). *Eating and Activity Guidelines for New Zealand Adults: Updated Guidelines on pregnancy and breastfeeding*.

Moosavy, M. H., Hassanzadeh, P., Mohammadzadeh, E., Mahmoudi, R., Khatibi, S. A., & Mardani, K. (2017). Antioxidant and Antimicrobial Activities of Essential Oil of Lemon (Citrus limon) Peel in Vitro and in a Food Model. *Journal of Food Quality & Hazards Control*, *4*(2).

La, E. O. J., Tiyas Sawiji, R., & Made Rai Yuliani, N. (2021). Identification of Secondary Metabolite Content and Antioxidant Activity Tests N-Hexan Extract Of Grapefruit Peel (Citrus maxima Merr). *JurnaL Surya Medika*, *6*(2), 185–200. https://doi.org/10.33084/jsm.vxix.xxx

Özkan-Karabacak, A., Özcan-Sinir, G., Çopur, A. E., & Bayizit, M. (2022).

Effect of osmotic dehydration pretreatment on the drying characteristics and quality properties of semi-dried (Intermediate) Kumquat (Citrus japonica) slices by vacuum dryer. *Foods*, *11*(14), 2139.

Ragheb, A. Y., Masoud, M. A., El Shabrawy, M. O., Farid, M. M., Hegazi, N. M., Mohammed, R. S., Marzouk, M. M., & Aboutabl, M. E. (2023). MS/MS-based molecular networking for mapping the chemical diversity of the pulp and peel extracts from Citrus japonica Thunb.; in vivo evaluation of their anti-inflammatory and anti-ulcer potential. *Scientific African*, *20*, e01672.

Revansyah, M. A., Men, L., Setianto, S., Fitrilawati, F., Safriani, L., & Aprilia, A. (2022). Analisis Tds, Ph, dan Cod Untuk Mengetahui Kualitas Air di Desa Cilayung. *Jurnal Material Dan Energi Indonesia*, *12*(02), 43–49.

Rukmana, A., Susilawati, H., Elektro, P. T., Garut, U., & Uno, A. (2019). Pencatat PH Tanah Otomatis. *Jurnal Vol*, *10*(1).

Saputri, D. (2023). *Tanaman Jeruk Sebagai Potensi Ekonomi Alternatif Bagi Masyarakat (Studi Kasus Pada Masayarakat Gampong Cot Punti Kecamatan Sampoinet Kabupaten Aceh Jaya)*. UIN Ar-Raniry.

Silalahi, K. P., Swasti, Y. R., & Pranata, F. S. (2022). Antioxidants Activity from Processed Citrus Fruit By-Products. *Amerta Nutrition*, *6*(1), 100–111.

Silva, A. F. D. A., Silva, B., Sousa, A. S. B. D. E., Figueiredo, V., De Aquino, M., Mendonca, R., Nunes, M., & Silva, S. D. E. M. (2019). Quality, bioactive compounds and antioxidant activity during maturation of oranges produced in the borborema territory. *Revista Caatinga*, *32*, 526–536.

Singh, S., & Immanuel, G. (2014). Extraction of antioxidants from fruit peels and its utilization in paneer. *Journal of Food Processing & Technology*, *5*(7), 1.

Smith, J. (2019). A Comprehensive Study on the Morphology of Nagami Citrus. *Journal of Horticultural Science*, *45*(2), 78–92.

TB, D. R. Y., & Rizki, K. (2022). Deteksi Kualitas Tanah Berdasarkan PH dan Suhu Tanah untuk Menentukan Kesuburan Tanaman Hias. *Journal Of Informatics and Computer Science*, *8*(1), 46–54.

Teixeira, F., Santos, B. A. dos, Nunes, G., Soares, J. M., Amaral, L. A. do, Souza, G. H. O. de, Resende, J. T. V. de, Menegassi, B., Rafacho, B. P. M., & Schwarz, K. (2020). Addition of orange peel in orange jam: evaluation of sensory, physicochemical, and nutritional characteristics. *Molecules*, *25*(7), 1670.