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Morphology characteristic and tuber content of yard cultivated *Canna indica* (*ganyong*) in Cibinong, West Java, Indonesia

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Abstract. *Noriko N, Sasaerila YH, Anisah S. 2024. Morphology characteristic and tuber content of yard cultivated* Canna indica *(ganyong) in Cibinong, West Java, Indonesia. Biodiversitas 25: 2586-2593. Canna indica* L. (*ganyong*) tubers have the potential to be an alternative food and functional food. This study aims to obtain morphology characteristics, including the content of white tubers of *C. indica* planted in yards in the Cibinong; research methodology by conducting surveys and laboratory analysis. The results showed *C. indica* can grow in the yard without special treatment. At the age of 8 months, the average 59.8 cm of plant height, 10.8 numbers of leaves, 0.80 mm leaf thickness, 9.14 cm stem diameter, 24.51 cm^2 leaf area, 112.64 g dry weight of tuber, 6.9 g dry weight of stem, 6.81 g dry weight of leaves at 34.3°C temperature, 59% humidity, 20086 lux light intensity, 4.85 soil pH, 2.3% organic C, 0.62% total N, 32.13% P_2O_5, 6.08% K_2O, 0.51 me Ca, 0.36 me Mg, 0.31 me K, 0.5 me Na, 5.44 me/100 gr CEC, 3.71 (mg FDA g^{-1}soil d.w. h^{-1}) soil enzyme activity and 1.66 (g/cm^3) bulk density. The flour from tubers contains 0.58% ash, 0.15% lipid, 1.01% protein, 1.11% crude fiber, 12.78% carbohydrates, 56.51 kcal calories, alkaloid, saponin, flavonoid, triterpenoid, and low antioxidant. Planting in the yard is recommended in the shade of sunlight. Watering and fertilizing including microelements are also required.

Keywords: Content, environment, food, morphology, tuber, yard

INTRODUCTION

Many efforts to maintain food security in Indonesia can be significantly bolstered through the availability of diverse food sources. One such promising alternative is *Canna indica* L. (*ganyong*, edible canna) tubers, which hold immense potential as a functional food. *Canna indica* found in Indonesia, exhibits two phenotypic variations: green and red; green *C. indica* boasts white tubers, while red *C. indica* features red tubers (Sari et al. 2016). The content of white tubers, a rich source of nutrition, includes 25.10% fiber, 28.50% starch, 4.72% crude protein, 5.75% lipid, 423 Kcal/100 g dry weight, and antioxidants such as 21 DPPH, 23 ABTS, and 170 ug/mL O_2-radical (Ayusman et al. 2020). These tubers can be processed into flour and further utilized to produce various processed foods, such as cookies and meatballs, thereby diversifying the food landscape (Noriko et al. 2023).

Canna indica is considered an easily cultivated food plant in various environmental conditions and has the potential to be developed. *Canna indica* plants can thrive in open spaces and under shade (Sasaerila et al. 2019). It can grow at altitudes from 0 to 2500 meters above sea level with an average rainfall of 500 mm/year and adapt to Indonesia's environmental climate (Luziatelli et al. 2023). *Canna indica* can also adapt under 25% sunlight exposure based on height, leaf area, and root dry weight (Sasaerila et al. 2021). Generally, *C. indica* grows wild in rice fields, gardens, and yards. Thus, *C. indica* has the potential opportunity as an alternative food source easily accessible to the community. *Canna indica* observed in the community yards in the Cibinong area are generally planted without any maintenance. Cibinong subdistrict is a rural area with rice fields, gardens, and yards that produce vegetables, herbs, and local fruits, including jackfruit, rambutan, and mango. The population increase and urbanization led to converting agricultural land into housing, malls and industrial complexes. This condition decreased public attention to the use of yard land, and therefore, some agricultural production decreased.

The yard is defined as land areas around the house that are individually owned with a small scale planted with mixed perennials and annual plants with low capital inputs and small technology so that production is low. The yard can be planted with plants that humans and animals can consume. The domestication of plants in yards used for food sources provides several advantages, including changing extreme ecological conditions such as drought due to climate change into a specific stable ecology through decreasing temperature and optimizing decomposition. The design of plant structures in yards is generally a multi-layer of woody plants, fruits, herbs, vegetables, and grasses with biodiversity (Korpelainen 2023).

The world's population in 2050 is expected to reach 9 billion requiring adequate food supply to avoid malnutrition and hunger. Therefore, undernourishment and nutrition deficiency are major global public health issues. Plant cultivation in the yard is a practice carried out in Asian, African, and Latin American communities on a declining basis. At the same time, it provides socioeconomic benefits, ecological services, food availability, and diverse diets. Therefore, yards can fulfill food insecurity and hunger (Dissanayake and Maredia 2021). Food availability faces several issues, such as climate change, urbanization, and land degradation, which require solutions through various approaches (Lenaerts et al. 2019).

However, research on the conditions of *C. indica* growing in the yard without maintenance is still limited. Therefore, this research aimed to obtain data on plant morphology characteristics and the content of *C. indica* white tubers planted in community yards in Cibinong. Morphology characteristics assessment including plant length, number of leaves in clumps, leaf thickness, leaf area, and stem diameter. At the same time, the tuber's content analyzed were moisture content, ash, fat, protein, crude fiber, carbohydrates, calories, substances of the metabolic seconder, and antioxidants; the environmental assessment includes temperature, humidity, solar intensity averages, physics, chemistry of soil, and enzymes contained in soil. The research findings will reference innovation in cultivating *C. indica* yards to develop alternative foods for the people of Indonesia.

Backyard science and technology (STB) innovation in rural areas is needed for sustainable intensification, especially in developing countries (Jiao et al. 2019).

MATERIALS AND METHODS

Study area

The research method was a survey on the condition of *C. indica* and laboratory analysis of tubers. This research was carried out from February to November 2018 in an open area covering 160 m^2 in a residential area located at Jalan Kampung Pajeleran Gunung, Sukahati, Cibinong, Bogor, West Java, Indonesia (6.492° S and 106.819° E). Various laboratory analyses were conducted in different facilities for enzyme soil analysis: (i) Chemistry Laboratory of UAI, South Jakarta; (ii) PT. Sucofindo Laboratory for proximate testing of tubers; (iii) Environmental and Calibration Laboratory (PT. UNILAB Perdana) for soil chemistry analysis; (iv) Indonesian Spice and Medicinal Crops Research Institute (Balitro) for flour content antioxidant analysis.

Preparation of *ganyong* seedlings

White tubers of *C. indica* were used for seedlings propagation, measuring 3-3.5 cm with 1-2 sprouting buds, and were planted without fertilizer. Soil preparation in the yard involved clearing weeds, loosening soil, and digging holes ±20 cm deep a week before planting. Each hole received one seedling spaced approximately 50 cm apart. Daily watering was conducted, except during rainy periods, and continued until leaves emerged. Parameters observed included environmental data such as temperature, humidity, light intensity, and soil conditions such as biology, physics, and chemistry. Light intensity was measured thrice at 09.00 am using a lux meter. Soil conditions were assessed using a soil tester in *C. indica* planted and surrounding soil, once for enzymes and once for physics analysis.

Measurement of morphology characteristics

The cultivated population of *C. indica* plants in the yard of 150 white plants and five white samples were randomly chosen at the planting site. Measurements were taken when the plants were 8 months aged. Parameters assessed included plant length, leaf count, thickness, stem diameter, leaf area, and dry weight. Samples were separated into leaves, stems, and rhizomes, weighed, and stored for analysis at the UAI chemistry laboratory. The length of *C. indica* stems was measured from the base to the tip of the highest leaf for five plant samples. Leaf count relied on fully expanded morphology, while leaf thickness was gauged with a digital caliper 5-6 cm from the midrib, measured thrice, averaging each result. Stem diameter was measured similarly at the stem's base, middle, and top. Leaf samples were processed, scanned, and analyzed for surface area, while plant dry weight was obtained by drying samples at 80°C until stabilized that were post-wrapped in the newspaper sheets when wet.

Soil analysis

Physical and chemical properties of soil

Soil sampling was conducted when the *C. indica* plants reached 5 months old, and samples were collected from 5 randomly selected points in the planting area. Milk cans with 7.4 cm in diameter and 7.5 cm in height were used for collection. Samples were wrapped in aluminum foil, labeled, and sent to the UAI chemistry laboratory for oven drying and subsequent dry weight measurement. Physical testing followed the Reynolds method (1970), involving soil heating at 105°C for 48 hours, cooling, and successive weighing until a constant weight was reached; chemical analysis conducted at PT. UNILAB Perdana, including pH, organic C, Nitrogen P_2O_5, Cation Exchange Capacity (CEC), K_2O, cation composition (Ca, Mg, K, Na) determined by saturation using ammonium acetate 1, and soil texture assessment.

Soil enzymes

Soil samples were collected from five locations, including *C. indica* planted soil (DG) and soil surrounding *C. indica* (TG), and collected using 322 cm^3 milk cans. Samples were stored in sealed plastic bags in cool boxes with ice (±4°C) and transported to the UAI chemistry laboratory. Following a modified method by Adam and Duncan (2001), soil enzyme analysis was conducted. After refrigerating for one day and avoiding light exposure, the labeled soil samples were sieved to remove debris, weighed, and distributed into 14 vials containing 0.3 g of soil for standards and duplicates. Soil samples in vials received the appropriate standard solution (Table 1), with FDA solution added to duplicate labels at 1 mL volume.

Table 1. List of labeling of 14 soil samples for enzyme analysis

Label	Type of solution	
	Mother solution (mL)	Buffer (mL)
Blanko	0	6.1
Standard 1	0.5	5.6
Standard 2	1	5.1
Standard 3	2	4.1
Standard 4	3	3.1
Standard 5	4	2.1
Standard 6	5	1.1

Reagents for soil enzyme analysis included Solution A, Solution B, Buffer solution, fluorescein diacetate (FDA) solution, and Mother solution. Solution A (0.827 g $NaH_2PO_4.H_2O$ in 100 mL distilled water) and Solution B (4.26 g NaH_2PO_4 in 500 mL distilled water) were prepared. Buffer solution (pH 7.6) was obtained by mixing 65 mL Solution A with 435 mL Solution B. FDA solution (30.25 mg FDA in 50 mL acetone) was used as a microbial activity measurement. Mother Solution was made by blending 12.5 mL FDA solution with 237.5 mL Buffer solution, heated at 97°C for 30 minutes. Samples, with a standard solution, were incubated at 25°C and centrifuged at 110 rpm for 30 mins; then, 6 mL acetone was added to stop FDA hydrolysis. Suspensions were transferred to 12 mL Falcon tubes, centrifuged at 5,000 rpm for 5 mins, and filtered with Whatman 42 paper. Next, the absorbance levels were read at 490 nm wavelength using a spectrophotometer.

Proximate analysis

The parameters tested and the methods of measuring the tubers were as follows: water content (following SNI 01-2891-1992), ash content (following SNI 01-2891-1992), fat content (following SNI 01-2891-1992), protein content (following SNI 01-2891-1992), fiber content (following SNI 01-2891-1992), carbohydrates (by difference), and calorie measurement used predictions from calories contained in carbohydrates, proteins and fats.

Secondary metabolites and antioxidants in *C. indica* flour

Therefore, *C. indica* tuber samples, around ±600 g, were harvested in open areas in Cibinong and stored in plastic containers. These samples were transported to the UAI chemistry laboratory for cleaning and separation from soil and roots. Next, the cleaned tubers underwent antioxidant analysis.

Data analysis

The data obtained from observations were processed by Microsoft Excel and analyzed using SPSS Statistics 24 software. An Independent T-test with a significance level of 5% was utilized to analyze enzyme activity in soil-planted DG and TG.

RESULTS AND DISCUSSION

Environmental condition

Canna indica was harvested for eight months in October 2018, and the climate data for the region were collected from the Indonesia Board of Meteorology Climatology and Geophysics (BMKG). The minimum temperature was 22.17°C, the maximum temperature was 32.73°C, and the average temperature was 26.09°C. The average humidity was 76.48%, with a total rainfall of 278.73 mm and an average sunlight duration of 7.78 hours daily. Data on environmental conditions at harvest time are shown in Table 2.

Morphological characteristic

Moreover, under local environmental conditions, the *C. indica* exhibited suboptimal height and growth (Figure 1.A). Table 3 shows the *C. indica* plant characteristics evaluations in October 2018 at the age of eight months.

Soil physics

Table 4 revealed the physics soil measurements tested in this study include volumetric water content, bulk density, water content, and soil texture. This physical test assists in determining soil potential closely related to plant growth and, therefore, is crucial to supporting soil and environmental management.

Table 3. Characteristics of *Canna indica* (Mean ± SE, n=5)

Components of growth	Measurement results	Reference sample (Sasaerila et al. 2021)
Plant length (cm)	59.8 ± 8.74	38.7±1.4
Number of leaves/clumps	10.8 ± 2.33	
Leaf thickness (mm)	0.80 ± 0.2	0.25±0.02
Stem diameter (cm)	9.14 ± 2.78	
Leaf area (cm^2)	24.51 ± 4.75	36.00±12
Dry weight of tuber (g)	112.64 ± 29.24	
Dry weight of stem (g)	6.9 ± 2.09	
Dry weight of leaves (g)	6.81 ± 2.81	

Table 2. Environmental conditions data at the research site in October 2018 (Mean value ± SE, n=3)

Month	Temperature (°C)	Relative humidity (%)	Light intensity (lux)	Total rainfall (mm)	Daily average sunlight duration (hours)
October	34.3 ± 0.41	59 ± 0.55	20086 ± 27.95	278.73	7.78

Figure 1. A. *Canna indica* growth in the local environment, B. Tuber harvest, C. Cleaned tubers

Table 4. Soil physics test measurements from five soil locations planted with *Canna indica*

Parameter	Mean rate
VWC (g/cm^3)	0.44
GWC (gH_2O/g soil)	0.27
Bulk Density (g/cm^3)	1.66
Water content (kg/ha)	4425.08
Texture: silty clay	
Sand (%)	10.7
Clay (%)	49.04
Silt (%)	40.26

Note: *VWC: Volumetric soil Water Content, GWC: Gravimetric Water Content, BD: Bulk Density

Table 5. Chemical compound from soil planted *Canna indica*

Parameter	Measurements
pH (H_2O)	4.85
Organic C (%)	2.3
Total N (%)	0.62
P_2O_5 (HCl 25%) mg/100 gr	32.13
K_2O (HCl 25%) mg/100 gr	6.08
Cation composition	
Ca (me)	0.51
Mg (me)	0.36
K (me)	0.31
Na (me)	0.5
Cation Exchange Capacity (me/100 g)	5.44

Soil chemicals

Table 5 shows the chemical compound content analysis results in the *C. indica* soil samples. The soil chemical compounds tested show soil acidity (pH 4.85) and several essential nutrient parameters. Furthermore, the *C. indica* can still adapt and produce tubers, as shown in Figures 1.B and 1.C, several tubers are produced within 1 clump.

Soil enzymes

Table 6 shows the values of soil enzyme activity in the planting site and around *C. indica* cultivation.

Proximate content of tubers

Table 7 shows the study's approximate content of tuber compositions compared to other research. The protein, lipid and crude fiber found in *C. indica* tubers are smaller than data from reference sample (Okonwu and Ariaga 2016). But the carbohydrate and moisture content of *C. indica* are higher than reference sample.

Secondary metabolites and antioxidants in *C. indica* flour from tubers

This chemical analysis aims to examine the bioactive compounds present in *C. indica* tubers after being processed into flour. The compounds tested include alkaloids, saponins, tannins, flavonoids, triterpenoids, and steroids (Table 8).

Table 6. Soil enzyme activity

Sample	Mean rate (mg FDA g^{-1}soil d.w. h^{-1})
Soil from the planting site of *C. indica*	3.71
Soil around of *C. indica*	3.38

Table 7. Proximate analysis results per 100 g of *Canna indica* tubers and sample

Parameter	Test sample	Reference sample (Okonwu and Ariaga 2016)
Moisture content (%)	84.36	50.66
Ash (%)	0.58	2.85
Lipid (%)	0.15	4.35
Protein (%)	1.01	4.81
Crude fiber (%)	1.11	33.16
Carbohydrate (%)	12.78	4.17
Calories (kcal)	56.51	-

Table 8. Qualitative analysis of secondary metabolites *Canna indica* flour

Sample	Secondary metabolites	Test result
C. indica flour	Alkaloid	+
	Saponin	+
	Tannin	-
	Flavonoid	+
	Triterpenoid	+
	Steroid	-

Red-orange precipitates form alkaloids, while saponin compounds are characterized by stable foam in the test samples. A color change to red marks flavonoid compounds formed, while triterpenoids are indicated by red or purple coloration in the tested solutions. The flour antioxidant compound was analyzed to test the antioxidant activity using the DPPH method and measured using spectrophotometry at a wavelength of 517 nm. This analysis showed an IC_{50} value of 8,379.57 ppm, and the obtained absorbance value was y=0.0051x+7.2642.

Discussion

The higher temperatures and lower humidity in yard gardens compared to BMKG data are due to the open nature and the absence of canopy trees; this condition increases the intensity of sunlight. Environmental conditions such as temperature, humidity, and sunlight intensity influence the morphology of plants (Chiang et al. 2020). Temperature is crucial to shaping plant growth and metabolic processes; higher temperatures from sunlight exposure can cause plant stress, leading to cell disturbances (Ding and Yang 2022). The morphology characteristics of *C. indica* showed a height of 59.8±8.74 cm, a leaf area of 24.51±4.74 cm^2, and a dry weight of tuber 112.64±29.24 g. The characteristics of *C. indica* showed a suboptimal height of 59.8±8.74 cm compared to the typical height of 2 meters (Sultana et al. 2019). The increased plant height is more influenced by optimal auxin response in shaded areas (Küpers et al. 2020). Leaf area exposed to 100% sunlight, temperature of 27±0.5°C, and humidity of 74±2,3% without fertilizer in the study by Sasaerila et al. (2021) showed a wider size of 36.00±12 cm^2 compared to 24.51±4.74 cm^2, but thicker leaf size of 0.80±0.2 mm compared to 0.25±0.02 mm (Table 3). This condition may represent a physiological response of the leaf to reduce evapotranspiration due to higher environmental temperatures of 34.3±0.41°C. Additionally, leaf thickness is influenced by sunlight intensity, which enhances photosynthesis rates; this condition represents the plant's adaptation response to changes in sunlight intensity (Yustiningsih 2019). Light exposure of 26000 and 18000 lux was able to stimulate an increase in leaf area and yield of *Dioscorea sparsiflora* tubers. A light intensity of 14000 lux shows no correlation with leaf area and tuber yield (Santacruz et al. 2020). Interestingly, *C. indica* plants under a sunlight intensity of 20086±27.95 lux showed tubers with a dry weight of 112.64±29.24 g, stems of 6.9±2.09 g, and leaves of 6.81±2.81. In temperate climates with a temperature of 25-28°C, the growth of *C. indica* can reach a plant height of 2.5 m, a leaf area of 55 x 18-30 cm, and a tuber diameter of 1-3 cm (De Las Mercedes Ciciarelli 2012).

This study revealed the average VWC value of 0.44 g/cm^3 (Table 4), which was lower than the reference value (0.9-1.60) g/cm^3 (Kravchuk et al. 2023). GWC was 0.27 gH_2O/g soil, while the soil density or BD on *C. indica* planted soil obtained a value exceeding the normal range (1.10-1.60 g/cm3). Those results indicate soil compaction that makes it increasingly difficult for water to penetrate and for plant roots to penetrate (Wang et al. 2020). Furthermore, the BD above 1.60 g/cm^3 reduces soil fertility and is related to the ecology of earthworms (Capowiez et al. 2021); it means a problem in the root's ability to penetrate deeper soil layers, making it difficult to absorb nutrients and affecting plant height. The compactness of the soil reduces its ability to absorb nutrients for soil and plants. *Canna indica* soil conditions have a soil BD value of 1.66 g/cm^3, higher than the density reference value of *C. indica* soil, which is 1.32 g/cm^3 (Qian et al. 2017). *Canna indica* planted soil samples were also tested for their texture type, and the results showed a 10.7% sand texture, 49.04% clay, and 40.26% silt. The soil texture type in the yard is considered suitable for cultivation due to its composition, with a higher proportion of sand than clay and silt. Organic Carbon and Nitrogen, sourced from various organic matter components like plant residues and animal waste, are crucial for photosynthesis. In addition, low pH levels indicate organic material accumulation (Zhou et al. 2019).

According to soil property criteria (Pusat Penelitian Tanah 1983), the soil exhibited moderate organic carbon and high total nitrogen levels with an acidic pH of 4.85. Soil organic matter compounds influence soil physical properties and contribute to denser soil (Hussain et al. 2023). The study revealed the P_2O_5 content was moderate at 32.13 mg/100 g, K_2O content was very low at 6.08 mg/100 g, and Cation Exchange capacity (CEC) was very low at 5.44 me/100 gr; the low CEC hinders nutrient exchangeability and availability (Nel et al. 2023). The cation composition indicated low levels of Ca and Mg but moderate levels of Potassium (K) and Sodium (Na). Based on environmental conditions, the growth inhibition of *C. indica* is caused by temperature, pH acidic soil, and low CEC. Optimal growth of *C. indica* requires 24-29°C (Sasaerila et al. 2024) and pH 6.9 (Sasaerila et al. 2021).

Testing enzyme activity is crucial, with one of its objectives being an index of soil fertility and microbial activity in agricultural practices (Attademo et al. 2021). The differing average values of soil enzyme activity are likely due to the presence of *C. indica* directly. The presence of *C. indica* grown alongside rubber plants in the study has contributed to soil microbial abundance (Effendi et al. 2019). Soil microbial abundance is influenced by root exudates, supported by an experiment with *C. indica* and *Cyperus flabelliformis* plants grown in constructed wetlands. These plants affect microbial abundance and structure in the rhizosphere (Chen et al. 2016). The presence of *C. indica* can improve soil fertility, evidenced by increased soil enzymes and the proximity of soil microbes to their roots.

The carbohydrate content found by Okonwu and Ariaga (2016) is 4.17%, with a moisture content of 50.66%. Differences in carbohydrate content, specifically starch, are found in various sources such as Banyuwangi at 15.01%, and in Kuningan, Bantul, and Cilacap, where it exceeds 9.5%, with a moisture content of over 75% (Diantina et al. 2022). The starch from tubers can be used as alternative food sources for prebiotics to support health and dietary diversity. The protein found in *C. indica* tubers is smaller, 1.01%, compared to 4.81%, based on data from (Okonwu and Ariaga 2016). The protein content of *C. indica* is generally <5%, carbohydrate 56-77%, fat <1%, and fiber can be more than 10% (Salazar et al. 2021). The ash abundance content values are suspected to be due to the influence of minerals that can enhance their nutritional values.

Analysis of the chemical compounds present in flour shows positive results for alkaloid, saponin, flavonoid, and triterpenoid content (Table 8); those chemical compounds in *C. indica* are antioxidants and anticancer agents (Ifandari et al. 2018). Terpenoid, alkaloid, and flavonoid content can play a role in pharmacological fields and is used in medicinal sources as antibacterial (Huang et al. 2022), antiviral, anthelmintic, anti-inflammatory, molluscicide, cytotoxic, hepatoprotective, analgesic, immunomodulator, hemostatic and antidiarrhea (Kanase and Vishwakarma 2018; Sarje et al. 2019). In addition, flavonoids as antioxidants can inhibit Reactive Oxygen Species (ROS) (Chen et al. 2023); therefore, they can become a nutraceutical and functional food (Swain 2023). Alkaloids are an antioxidant neurogenerative disease caused by oxidative stress (Sirin et al. 2023). However, human alkaloids can have a pro-oxidation effect dependent on the condition by inhibiting NADPH oxidase (Macáková et al. 2019). Furthermore, triterpenoids are bioactive and function as antioxidants (Cai et al. 2019); likewise, the case with Saponins, which include antioxidants (Lim et al. 2020).

Based on the research results of antioxidant containing, the tubers in this study have a higher IC_{50} value. A compound was classified as having high antioxidant activity if a sample has a small IC_{50} value, i.e., less than 50 µg/mL or 50 ppm (Molyneux 2004). The antioxidant content analyzed in white tuber extract has a concentration of 593 ppm (Ifandari et al. 2018). The IC_{50} concentration of flour tested *C. indica* has lower antioxidant activity than Solanum nigrum, Elephantopus scaber, and *Amorphophallus campanulatus* (Mahesh et al. 2014). Low antioxidant content indicates that stress in *C. indica* triggers ROS formation. Short light and stress temperatures influence low antioxidant production response and correlate with increased ROS (Szymańska et al. 2017). An increase in ROS extrinsically and intrinsically can have pathological effects due to an imbalance in the antioxidant defense system. Pathological effects such as cellular biomolecular damage including lipids, proteins, and DNA (Andrés Juan et al. 2021). ROS can accumulate in intra-and extra-cellular compartments (Ganganelli et al. 2024). ROS can stimulate degenerative diseases such as cancer and neurogenerative diseases (Liu et al. 2018).

Antioxidant compounds result from processes and contributions from secondary metabolites, and their activity is closely related to the environmental factors in which the plant grows. Environmental factors where the plant lives include temperature and sunlight intensity, which causes stress. The correlation of antioxidant activity with secondary metabolite compounds, phenolics in *Celosia argentea* Linn. plant samples, is very closely related to the environment (Wardani et al. 2020). In contrast to stress caused by soil pollution, Cr shows an increase in antioxidants and the dominance of bacteria such as Actinobacteria and Proteobacteria Chloroflexy as much as 75.16%. Secret metabolites produced by roots are related to the presence of Actinobacteriota, Proteobacteria, and Bacteroides (Mao et al. 2023). Microbionts in plants affect plant metabolism and metabolic seconder production (Pang et al. 2021). The tuber powder extract of *C. indica* produced steroid, tannin, and flavonoid compounds (Kumbhar et al. 2018), in contrast to the data from the results of this study. Additionally, microelements such as Boron and Silicon will optimize the production of secondary metabolites (Guerriero et al. 2018). The application of microelements to tomato plants can increase their antioxidant capacity (Homayoonzadeh et al. 2022), so it is necessary to give *C. indica* cultivation in the yard.

In conclusion, *Canna indica* can grow in yards with low soil fertility without watering and fertilization. Under environmental conditions such as temperature of 34.3°C, humidity of 59%, and light intensity of 20086 lux, the dry weight of tubers reached 112.64 g per clump. The produced tubers contain 84.36% water content, 12.78% carbohydrates, 1.11% crude fiber, 0.15% fat, 1.01% protein, alkaloids, saponins, flavonoids, and triterpenoids. The antioxidant content in tubers is relatively low. Therefore, *C. indica*, which can be grown in yard areas, can be used as an alternative food. The innovation for cultivating *C. indica* in the yard is fertilization equipped with microelements, planting locations in areas that are not directly exposed to sunlight, and intensive watering, especially in the dry season. This is done to increase growth, nutrient, and antioxidant contents.

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REFERENCES

Andrés Juan C, Pérez de Lastra JM, Plou Gasca FJ, Pérez-Lebeña E. 2021. Molecular sciences the chemistry of Reactive Oxygen Species (ROS) revisited: Outlining their role in biological macromolecules (DNA, lipids and proteins) and induced pathologies. Intl J Mol Sci 22: 4642. DOI: 10.3390/ijms.

Attademo AM, Sanchez-Hernandez JC, Lajmanovich RC, Repetti MR, Peltzer PM. 2021. Enzyme activities as indicators of soil quality: Response to intensive soybean and rice crops. Water Air Soil Pollut 232: 1-12. DOI: 10.1007/s11270-021-05211-2.

Ayusman S, Duraivadivel P, Gowtham HG, Sharma S, Hariprasad P. 2020. Bioactive constituents, vitamin analysis, antioxidant capacity and α-glucosidase inhibition of *Canna indica* L. rhizome extracts. Food Biosci 35: 100544. DOI: 10.1016/j.fbio.2020.100544.

Cai C, Ma J, Han C, Jin Y, Zhao G, He X. 2019. Extraction and antioxidant activity of total triterpenoids in the mycelium of a medicinal fungus, *Sanghuangporus sanghuang*. Sci Rep 9 (1): 7418. DOI: 10.1038/s41598-019-43886-0.

Capowiez Y, Sammartino S, Keller T, Bottinelli N. 2021. Decreased burrowing activity of endogeic earthworms and effects on water infiltration in response to an increase in soil bulk density. Pedobiologia 85: 150728. DOI: 10.1016/j.pedobi.2021.150728.

Chen Z-J, Tian Y-H, Zhang Y, Song B-R, Li H-C, Chen Z-H. 2016. Effects of root organic exudates on rhizosphere microbes and nutrient removal in the constructed wetlands. Ecol Eng 92: 243-250. DOI: 10.1016/j.ecoleng.2016.04.001.

Chiang C, Bånkestad D, Hoch G. 2020. Reaching natural growth: Light quality effects on plant performance in indoor growth facilities. Plants 9 (10): 1-19. DOI: 10.3390/plants9101273.

De Las Mercedes Ciciarelli M. 2012. Life cycle in natural populations of *Canna indica* L. from Argentina. In Phenology and Climate Change. IntechOpen. DOI: 10.5772/34338.

Diantina S, Sanjaya R, Atmini KD, Suhendar A, Koswanudin D. 2022. Tuber starch content of edible canna (*Canna indica* L.) from different geographical origins. In AIP Conf Proc 2462 (1): 020027. DOI: 10.1063/5.0075922.

Ding Y, Yang S. 2022. Surviving and thriving: How plants perceive and respond to temperature stress. Dev Cell 57 (8): 947-958. DOI: 10.1016/j.devcel.2022.03.010.

Dissanayake DHG, Maredia KM. 2021. Home Gardens for Improved Food Security and Livelihoods. www.routledge.com/books/.

Effendi Y, Pambudi A, Sasaerila Y, Wijihastuti RS. 2019. Metagenomic analysis of diversity and composition of soil bacteria under intercropping system *Hevea brasiliensis* and *Canna indica*. IOP Conf Ser: Earth Environ Sci 391 (1): 012023. DOI: 10.1088/1755-1315/391/1/012023.

Ganganelli I, Galatro A, Grozeff GG, Bartoli CG, Senn ME. 2024. 3 - Reactive oxygen species (ROS): Chemistry and role in plant physiology. In: Ziogas V, Corpas FJ (eds.). Oxygen, Nitrogen and Sulfur Species in Post-Harvest Physiology of Horticultural Crops. Academic Press. DOI: 10.1016/B978-0-323-91798-8.00007-2.

Guerriero G, Berni R, Muñoz-Sanchez JA, Apone F, Abdel-Salam EM, Qahtan AA, Alatar AA, Cantini C, Cai G, Hausman JF, Siddiqui KS. 2018. Production of plant secondary metabolites: Examples, tips and suggestions for biotechnologists. Genes 9 (6): 309. DOI: 10.3390/genes9060309.

Homayoonzadeh M, Torabi E, Talebi K, Allahyari H, Nozari J. 2022. Micronutrient fertilization amplified the antioxidant capacity in tomato plants with improved growth and yield. Biol Life Sci Forum 11 (1): 62. DOI: 10.3390/iecps2021-12008.

Huang W, Wang Y, Tian W, Cui X, Tu P, Li J, Shi S, Liu X. 2022. Biosynthesis investigations of terpenoid, alkaloid, and flavonoid antimicrobial agents derived from medicinal plants. Antibiotics (Basel, Switzerland) 11 (10): 1380. DOI: 10.3390/antibiotics11101380.

Hussain A, Bashir H, Zafar SA, Rehman RS, Khalid MN, Awais M, SADIQ M, Amjad I. 2023. The importance of Soil Organic Matter (SOM) on soil productivity and plant growth. Biol Agric Sci Res J 2023 (1): 11-11. DOI: 10.54112/basrj.v2023i1.11.

Ifandari M, Widyarini S, Nugroho LH, Pratiwi R. 2018. Cytotoxicity and antioxidative effects of ethanolic extract green and red cultivar *ganyong* rhizome (*Canna indica* Linn) against colon cancer cell line WiDr. In International Conference on Applied Science and Engineering (ICASE 2018) (pp. 10-13). Atlantis Press. DOI: 10.2991/icase-18.2018.3.

Jiao XQ, Zhang HY, Ma WQ, Wang C, Li XL, Zhang FS. 2019. Science and technology backyard: A novel approach to empower smallholder farmers for sustainable intensification of agriculture in China. J Integr Agric 18 (8): 1657-1666. DOI: 10.1016/S2095-3119(19)62592-X.

Kanase V, Vishwakarma S. 2018. Treatment of various diseases by *Canna indica* l.-a promising herb. In Asian J Pharm Clin Res 11 (12): 51-56. DOI: 10.22159/ajpcr.2018.v11i12.28219.

Korpelainen H. 2023. The role of home gardens in promoting biodiversity and food security. Plants 12 (13): 2473. DOI: 10.3390/plants12132473.

Kravchuk V, Ivaniuta M, Bratishko V, Humeniuk Y, Kurka V. 2023. On-stream soil density measuring. INMATEH-Agric Eng 69 (1): p665. DOI: 10.35633/inmateh-69-64.

Kumbhar ST, Patil SP, Une HD. 2018. Phytochemical analysis of Canna indica L. roots and rhizomes extract. Biochem Biophys Rep 16: 50-55. DOI: 10.1016/j.bbrep.2018.09.002.

Küpers JJ, Oskam L, Pierik R. 2020. Photoreceptors regulate plant developmental plasticity through auxin. Plants (Basel, Switzerland) 9 (8): 940. DOI: 10.3390/plants9080940.

Lenaerts B, Collard BCY, Demont M. 2019. Review: Improving global food security through accelerated plant breeding. Plant Sci 287: 110207. DOI: 10.1016/j.plantsci.2019.110207.

Lim JG, Park HM, Yoon KS. 2019. Analysis of saponin composition and comparison of the antioxidant activity of various parts of the quinoa plant (*Chenopodium quinoa* Willd.). Food Sci Nutr 8 (1): 694-702. DOI: 10.1002/fsn3.1358.

Liu Z, Ren Z, Zhang J, Chuang CC, Kandaswamy E, Zhou T, Zuo L. 2018. Role of ROS and nutritional antioxidants in human diseases. Front Physiol 9: 477. DOI:10.3389/fphys.2018.00477.

Luziatelli G, Alandia G, Rodríguez JP, Manrique I, Jacobsen S-E, Sørensen M. 2023. Chapter 7 - Ethnobotany of Andean root crops: tradition and innovation—Arracacha (*Arracacia xanthorrhiza* Bancr.), Yacón (*Smallanthus sonchifolius* (Poepp.) H. Rob.), Mauka (*Mirabilis expansa* (Ruíz & Pav.) Standl.), Ahipa (*Pachyrhizus ahipa* Parodi), Maca (*Lepidium meyenii* Walp.), Achira (*Canna indica* L.). In: Pascoli Cereda M, François Vilpoux O (eds.). Varieties and Landraces: Cultural Practices and Traditional Uses. Academic Press. DOI: 10.1016/B978-0-323-90057-7.00013-9.

Macáková K, Afonso R, Saso L, MLaděnka P. 2019. The influence of alkaloids on oxidative stress and related signaling pathways. Free Radic Biol Med 134: 429-444. DOI: 10.1016/j.freeradbiomed.2019.01.026.

Mahesh KN, Wickramaratne MN, Wickramaratne DB. 2014. Evaluation of antioxidant activity of five medicinal plants in Sri Lanka. Pharmacognosy J 6 (3): 49-54. DOI:10.5530/pj.2014.3.8.

Mao H, Zhao W, Yang X, Sheng L, Zhu S. 2023. Recruitment and metabolomics between *Canna indica* and rhizosphere bacteria under Cr stress. Front Microbiol 14: 1187982. DOI: 10.3389/fmicb.2023.1187982.

Molyneux P. 2004. The use of stable free radical Diphenylpicrylhydrazyl (DPPH) for estimating antioxidant activity. Songklanakarin J Sci Technol 26: 211-219.

Nel T, Bruneel Y, Smolders E. 2023. Comparison of five methods to determine the cation exchange capacity of soil. J Plant Nutr Soil Sci 186 (3): 311-320. DOI: 10.1002/jpln.202200378.

Noriko N, Wijihastuti RS, Primasari A, Perdana AT, Sasaerila HY. 2023. *Canna indica* L and *Spirulina platensis* for Food Security. Jurnal Penelitian Pendidikan IPA 9: 10-21. DOI: 10.29303/jppipa.v9iSpecialIssue.5888.

Okonwu K, Ariaga CA. 2016. Nutritional evaluation of various parts of *Canna indica* L. Annu Res Rev Biol 11 (4): 1-5. DOI: 10.9734/ARRB/2016/31029.

Pang Z, Chen J, Wang T, Gao C, Li Z, Guo L, Xu J, Cheng Y. 2021. Linking plant secondary metabolites and plant microbiomes: A Review. Front Plant Sci 12: 621276. DOI: 10.3389/fpls.2021.621276.

Pusat Penelitian Tanah (PPT). 1983. Analisis Kimia Tanah, Tanaman Air dan Pupuk. Departemen Pertanian Bogor, Bogor. [Indonesian]

Qian J, Liu J, Wang P, Wang C, Li K, Shen M. 2017. Riparian soil physicochemical properties and correlation with soil organic carbon of an inflowing river of Taihu Lake. IOP Conf Ser: Earth Environ Sci 59 (1): 012053. DOI: 10.1088/1755-1315/59/1/012053.

Salazar D, Arancibia M, Ocaña I, Rodríguez-Maecker R, Bedón M, López-Caballero ME, Montero MP. 2021. Characterization and technological potential of underutilized ancestral andean crop flours from ecuador. Agronomy 11 (9): 1693. DOI: 10.3390/agronomy11091693.

Santacruz-Ruvalcaba F, Castañeda-Nava JJ, Torres Morán JP, Sánchez JJ, De la Cruz L. 2020. Light-intensity and leaf-area are important factors development tubers of yam. Russ J Plant Physiol 67: 201-206. DOI: 10.1134/S1021443720010185.

Sari N, Purnomo, Daryono BS, Suryadiantina, Setyowati M. 2016. Variation and intraspecies classification of edible canna (*Canna indica* L.) based on morphological characters. AIP Conf Proc 1744 (1): 020041. DOI: 10.1063/1.4953515.

Sarje SK, Ingole K, Angad S, Priya B, Ghiware NB. 2019. A pharmacognostic and pharmacological review on *Canna indica* Linn. Intl J Res Pharm Chem 9 (3): 61-77. DOI: 10.33289/ijrpc.9.3.2019.929.

Sasaerila YH, Sakinah S, Noriko N, Wijihastuti RS. 2021. Effects of light environments on leaf traits and phenotypic plasticity of *Canna indica*. Biosaintifika: J Biol Biol Educ 13 (2): 169-177. DOI: 10.15294/biosaintifika.v13i2.30175.

Sasaerila YH, Tajuddin T. 2019. Study on the survival and adaptation of *Canna indica* L. to different light environments and herbivore attacks study on the survival and adaptation of *Canna indica* L. to different light environments and herbivore attacks. Intl J Adv Sci Eng Technol 7 (4): 9-14.

Sasaerila HY, Effendi Y, Wijihastuti RS, Pambudi A, Nicola F De. 2024. Studies on the short- and long-term effects of rubber-canna agroforestry through soil analysis and a metagenomic approach. Biosaintifika: J Biol Biol Educ 15 (1): 73-88. DOI: 10.15294/biosaintifika.v15i1.3514.

Sirin S, Nigdelioglu Dolanbay S, Aslim B. 2023. Role of plant derived alkaloids as antioxidant agents for neurodegenerative diseases. Health Sci Rev 6: 100071. DOI:10.1016/j.hsr.2022.100071.

Sultana N, Akhi SS, Hassan Md.A, Rahman MO. 2019. Morphological and anatomical investigation among six variants of *Canna indica* L. Bangladesh J Plant Taxon 26 (2): 219-230. DOI: 10.3329/bjpt.v26i2.44582.

Swain A. 2023. Bioactive compounds and biological activities of indian shot (*Canna indica* L.). In: Murthy HN, Paek KY, Park SY (eds.). Bioactive Compounds in the Storage Organs of Plants. Reference Series in Phytochemistry. Springer, Cham. DOI: 10.1007/978-3-031-29006-0_24-1.

Szymańska R, Ślesak I, Orzechowska A, Kruk J. 2017. Physiological and biochemical responses to high light and temperature stress in plants. Environ Exp Bot 139: 165-177. DOI: 10.1016/j.envexpbot.2017.05.002.

Wang M, He D, Shen F, Huang J, Zhang R, Liu W, Zhu M, Zhou L, Wang L, Zhou Q. 2019. Effects of soil compaction on plant growth, nutrient absorption, and root respiration in soybean seedlings. Environ Sci Pollut Res 26: 22835-22845 DOI: 10.1007/s11356-019-05606-z.

Wardani YK, Kristiani EB, Sucahyo S. 2020. Korelasi antara aktivitas antioksidan dengan kandungan senyawa fenolik dan lokasi tumbuh tanaman *Celosia argentea* Linn. Bioma: Berkala Ilmiah Biologi 22 (2): 136-142. [Indonesian]

Yustiningsih M. 2019. Intensitas cahaya dan efisiensi fotosintesis pada tanaman naungan dan tanaman terpapar cahaya langsung. Bio-Edu: Jurnal Pendidikan Biologi 4 (2): 44-49. DOI: 10.32938/jbe.v4i2.385. [Indonesian]

Zhou W, Han G, Liu M, Li X. 2019. Effects of soil pH and texture on soil carbon and nitrogen in soil profiles under different land uses in Mun River Basin, Northeast Thailand. PeerJ 7: e7880. DOI: 10.7717/peerj.7880.