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Characteristics of candlenut (*Aleurites moluccana*) and daikon radish (*Raphanus sativus* L.)

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Abstract

Background This study investigates the physicochemical properties of candlenut (*Aleurites moluccana*) and daikon radish (*Raphanus sativus* L.) to explore their potential as natural healing remedies as practised by local communities in Malaysia. Both plants have been used in traditional medicine, but there is limited research on their bioactive compounds and how their characteristics contribute to anti-inflammatory effects.

Results Colour analysis for fresh candlenut exhibited significantly higher L^* value (67.70 ± 0.11) compared to its extract (43.21 ± 0.00). This indicated that fresh candlenut had more whitish hue. Likewise, fresh daikon radish showed more whitish hue compared to its extract. Yellowish hue was more pronounced in fresh candlenut (25.46 ± 2.92) compared to its extract (0.45 ± 0.02). Hydroxyl (O–H), alkenyl (C=C), iso-dimethyl (–CH₃), and oxygen-bonded (C–O) functional groups were found in both samples using the FTIR method. Significantly higher tannin content was found in candlenut (91.77 ± 12.18 mg/L), compared to daikon radish (2.13 ± 3.00 mg/L). Similarly, alkaloid concentrations were significantly higher in candlenut (10.30 ± 0.59 mg/L) than in daikon radish (3.56 ± 0.12 mg/L). Phenolic analysis using HPLC identified gallic acid concentrations of 273.43 ± 17.23 mg/L in candlenut and 27.39 ± 20.39 mg/L in daikon radish. Daikon radish detected vanillic acid (28.43 ± 11.92 mg/L) and *p*-coumaric acid (3.04 ± 0.12 mg/L), which was not detected in candlenut.

Conclusions These results suggested that candlenut contains higher alkaloids, tannins and gallic acid compared to daikon radish. Vanillic acid and *p*-coumaric acid, however, were detected in daikon radish only. All three phenolic acids can act as an antioxidant. However, gallic acid was found in higher proportion in candlenut; hence, it has higher potential against oxidative damage condition. This research supports the traditional use of these plants in managing inflammatory conditions and highlights their potential for nutraceutical applications. It may be a useful to eliminate trigger in inflammatory with interaction with receptors. These interactions occur in NF- κ B signalling in inflammation pathway usually, and its dysregulation is an important factor for many inflammatory-related diseases such as asthma, atherosclerosis, gout, diabetes, cancer and many more.

Keywords Candlenut, Daikon radish, Thin layer chromatography (TLC), Fourier transform infrared spectroscopy (FTIR), High-performance liquid chromatography (HPLC)

1 Background

Numerous uses of plant-based resources have boosted the research exploration due to their utilisation as natural remedies, traditional medicine, and food. The study of plant-based resources has accelerated significantly in food science and technology, mainly because of the availability and safety for human consumption. Daikon radish

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Fig. 1 Candlenut (*Aleurites moluccana* L., *Longipinnatus*)



Fig. 2 Daikon radish (*Raphanus sativus* L.)

(*Raphanus sativus* L.) and candlenut (*Aleurites moluccana*), in the light of the increasing interest in natural medicines and dietary sources of health benefits worldwide. These species, essential to many cultural practices, provide interesting opportunities to learn more about their physicochemical properties and possible health advantages. Candlenut (Fig. 1), known as 'buah keras' in Malaysia and Indonesia, is a popular ingredient in South-east Asian cooking and is valued for its distinct flavour. Candlenut is used in cooking, but it is also known to have specific medicinal properties, leading scientists to investigate its composition. Candlenuts are an essential source of nutrients that may improve general health since they are high in proteins, phytochemicals, and vital fatty acids [1]. Candlenut seeds have a high oil content (30–60%) and are well-known for their antioxidant qualities, which may help reduce inflammation and oxidative stress. Daikon radish (Fig. 2), which is known for its mild flavour and crisp texture, is becoming more popular as a culinary item and for possible health benefits. This East Asian root vegetable has been linked to anti-inflammatory and anti-cancer properties. It contains vitamins, minerals, and bioactive substances, including glucosinolates [2]. Daikon

radish is a foundation in many cuisines, particularly Asian cuisine, due to its high-water content (about 93%), which promotes overall health and helps with hydration.

Bioactive substances, including tannins, alkaloids, and phenolic compounds, are essential for reducing oxidative stress and inflammation. For instance, tannins are well-known for their anti-inflammatory effects and may aid in lowering reactive oxygen species [3]. The search for natural gout remedies recently found that palmatine, an isoquinoline alkaloid, derived from *Daemonorops margaritae* (Hance) Becc and *Phellodendron amurense* Rupr. alkaloids inhibited the inflammation surge due to gouty arthritis [4]. It has been reported that polyphenols such as curcumin and resveratrol reduced uric acid levels and improved renal injury [5, 6]. Additionally, saponins extracted from *Ilex cornuta* and *Smilax riparia* leaves inhibit xanthine oxidase activity and downregulate urate transport proteins [7, 8]. Various chemical bonds and interactions, such as hydrogen bonding, van der Waals forces, electrostatic interactions, π - π stacking, and hydrophobic interactions, contribute to a crucial factor in peptide-mediated inhibition of xanthine oxidase [9].

These plant species offer a potential path for characteristics research due to their significant connections to cultural and culinary traditions [2]. As for Indian folks, radish is used to treat jaundice, gallstones, liver disease, rectal disorders, indigestion, and gastric pain [10]. Meanwhile, the Banjar indigenous community within South Kalimantan, Indonesia, used candlenut as an immunostimulant for minor burns, skin irritation, and skin disorders such as eczema and rashes [11]. Radish has also been used to treat stomach ailments, urinary infections, hepatic inflammation, cardiac disorders, and ulcers in Korean folk medicine [12]. Radish also reported to improve defecation function in a senile constipated 18-month-old mouse model (SPF-grade ICR mice) [13].

Connection can be driven by using these plants in local communities for illnesses with scientific explanations. A growing number of recent findings focus on the chemical constituents that could lead to natural additives, which are essential to our understanding of these plant-based resources. Polyphenols such as quercetin, quercitrin, kaempferol, and luteolin were identified in *Melicope ptelefolia* leaves exhibiting xanthine oxidase inhibiting properties [14]. Meanwhile, ethyl acetate inflorescence extracts of *Pogostemon benghalensis* inhibited xanthine oxidase, indicating IC_{50} was 29.1 $\mu\text{g}/\text{mL}$ compared to allopurinol ($IC_{50} = 12.7 \mu\text{g}/\text{mL}$) [15]. It was found that for *Cistus creticus* L., *Cistaceae*, *Hammada elegans* (Bunge) Botsch. (syn. of *Haloxylon salicornicum* (Moq.) Bunge ex Boiss.), *Amaranthaceae*, *Plantago ciliata* Desf., *Plantaginaceae*, and *Pituranthos scoparius* (Coss.

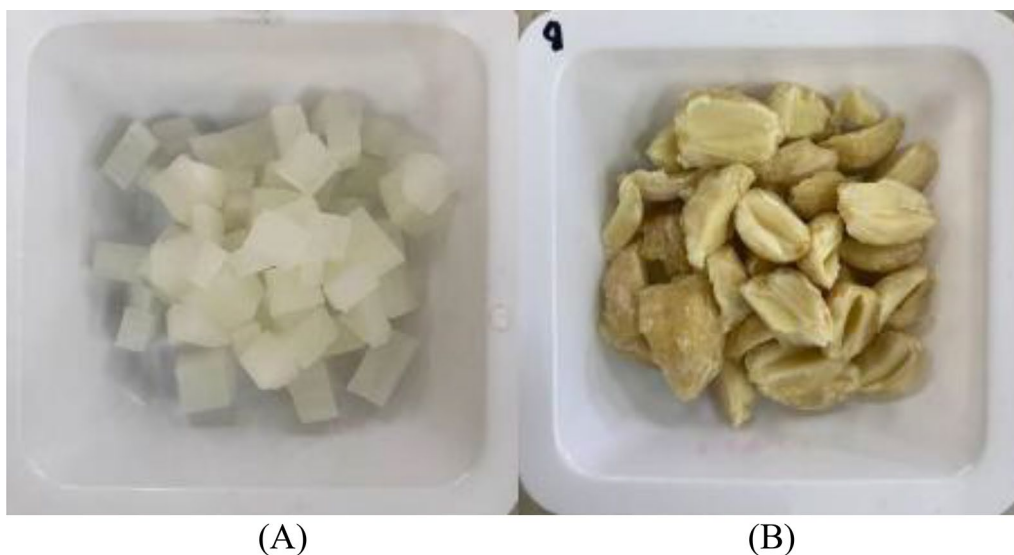


Fig. 3 Daikon radish cubes (A) and candlenut (B) prepared in cubed was boiled at 100 °C for 10 min

& Durieu) Schinz (syn. of *Deverra scoparia* Coss. & Durieu), *Apiaceae* extracts contained xanthine oxidase inhibitory properties due to 66% polyphenols and 53% attributed to flavonoids [16]. Because lack of scientific evidences is essential to bridge the knowledge gap between contemporary science and traditional herbal medicine by emphasising the value of using natural items in diets to promote health. To enhance health outcomes and knowledge of the role dietary choices play in managing disease, exploration of the potential of these medicinal plants in treating inflammatory disorders is highly necessary. In Malaysia, candlenut and daikon radish are commonly used to treat gout flares in local communities. To date, no research has been conducted on this. Additionally, scientific evidence linked to this plant has not been explored yet.

Hence, the research objective of this study is to investigate the characteristic properties of candlenut and daikon radish. Specifically, this research aims to determine the physical properties of daikon radish and candlenut, including colour analysis and functional group identification using Fourier transform infrared spectroscopy (FTIR). It also aims to assess the chemical properties of daikon radish and candlenut, focusing on bioactive compound identification through thin layer chromatography (TLC), as well as tannin, alkaloid, and phenolic analyses. Additionally, the physicochemical profiles of both plants were compared to establish their antioxidant properties and potential anti-inflammatory effects.

2 Materials and methods

2.1 Materials

The candlenut (*Aleurites moluccana*) samples were sourced from Manja Foods, located in Taman Selayang Segar, Batu Caves, Malaysia, while daikon radish (*Raphanus sativus* L.) was obtained from Cameron Highlands, Pahang. The daikon radish was washed thoroughly under running water, and the outer skin was peeled using a peeler. Both the daikon radish roots and candlenut were chopped into small cubes. To create the boiled sample, 2 kg of daikon radish roots and 50 g of candlenuts were diced into cubes and boiled in deionised water at 100 °C for 10 min, as shown in Fig. 3 [5]. Boiling for 10 min was executed as local folks commonly do it to prepare natural remedies for many ailments. Solvent extraction was then carried out using 80% methanol–water as the solvent, where the samples were immersed in 250 mL of the solvent. The extraction process was conducted overnight in a shaker incubator at 25 °C. After extraction, the samples were filtered, and the solvent was evaporated using a rotary evaporator at 45 °C to concentrate the extracts. The resulting extracts were stored in containers protected from light and heat for further analysis. An independent triplicate ($n=3$) was carried out for both samples to conduct all the studies.

2.2 Colour analysis

Colour analysis was conducted on fresh and extracted daikon radish and candlenut samples using a Chromameter CR-400/410 (Konica Minolta Optic Inc., Japan). Fresh samples were placed on the colorimeter sample holder, ensuring complete coverage of the measurement area,

and the colour parameters L^* (lightness), a^* (red-green), and b^* (yellow-blue) were recorded. A small amount of the extract was similarly placed on the colorimeter for the extracted samples, and the same colour parameters were measured. The colour results of fresh and extracted samples were compared to evaluate any changes.

2.3 Semi-purification

After extraction, the candlenut and daikon radish extracts were centrifuged at 3500 rpm for 45 min and 27 °C to remove contaminants. The supernatant of both samples from the centrifugation process was collected. The purified extracts were then stored at -20 °C until further analysis.

2.4 Bioactive compound analysis using Thin Layer Chromatography (TLC)

Bioactive compounds in the samples were analysed using thin layer chromatography (TLC) and both preparative and qualitative methods. Silica gel 60 GF254 was used as the stationary phase, and a mobile phase of n-hexane-acetate (1:4) was applied. Iodine vapour was used as a stain to visualise the spots. The retention factor (R_f) for each compound was calculated using the formula $R_f = (\text{distance travelled by the solute compound}) / (\text{distance travelled by the solvent front})$. The R_f values were compared to standard anti-inflammatory compounds to identify the bioactive components based on their distinct R_f values and visualisation patterns [6].

2.5 Functional group analysis using Fourier Transform Infrared Spectroscopy (FTIR)

Fourier transform infrared spectroscopy (FTIR) was used to identify functional groups in the extracted compounds. A small amount of the extract was applied to the FTIR sample holder. The spectra were recorded in the mid-infrared range of 4000–650 cm^{-1} using a Thermo Scientific Nicolet iS10 spectrometer with a ZnSe crystal for horizontal attenuated total reflectance (HATR). The FTIR spectra were collected with 32 scans at a resolution of 8 cm^{-1} , with the air spectrum as the background. The resulting spectra were analysed for characteristic peaks and absorption bands to identify the functional groups present in the extracts [7].

2.6 Tannin analysis

Tannin content was determined using the Folin–Ciocalteu method. Solutions of tannic acid (50, 100, 250, and 500 mg/L) created a standard curve. The sample extracts were mixed with Folin–Ciocalteu reagent, distilled water, and 7.5% sodium carbonate. The mixture was then incubated in the dark for 2 h for colour development. Subsequently, sodium carbonate was added, and the mixture was

incubated again for maximum colour development. The absorbance was measured at 765 nm using a spectrophotometer, and a standard curve was plotted based on the tannic acid standards. The tannin concentration in the candlenut and daikon radish extracts was calculated from the standard curve [8].

2.7 Alkaloid analysis

Caffeine was used as the standard for total alkaloid analysis. A 1000 ppm caffeine solution was prepared by dissolving 250 mg in 250 mL of hot distilled water. This was further diluted to create standard solutions ranging from 1 to 15 ppm. To each standard solution, 5 mL of pH 4.7 phosphate buffer and 5 mL of 10^{-4} M bromocresol green (BCG) solution were added. The mixture was shaken, and the alkaloid-BCG complex was extracted with 5 mL of chloroform. The chloroform layer was collected and adjusted to a 10 mL volume. Absorbance was measured at 415 nm using a spectrophotometer, and a calibration curve was generated by plotting absorbance against caffeine concentration. The alkaloid content in the samples was determined using this calibration curve [9].

2.8 Phenolic analysis

Phenolic compounds were analysed using high-performance liquid chromatography (HPLC) with a Thermo Scientific column (250 mm \times 4.6 mm, 5 μm). The mobile phases were 0.5% acetic acid in deionized water (Phase A) and 0.5% acetic acid in methanol (Phase B). The flow rate was set to 1.2 mL/min with a column temperature of 30 °C. A 20 μL extract sample was injected into the HPLC system, and the resulting chromatograms were recorded. A gallic acid standard (10 ppm, 20 ppm, 30 ppm, 40 ppm) was used for calibration, and the phenolic compounds in the samples were quantified by comparing peak areas and retention times. The phenolic profiles of the candlenut and daikon radish samples were then compared.

2.9 Statistical analysis

The statistical analysis was performed using one-way ANOVA with Tukey's HSD post hoc test to determine significant differences at 95% for colour analysis (L , a , b values) between the outer surface of daikon radish, extracted daikon radish, outer surface of candlenut, and extracted candlenut. For bioactive compounds, tannin, alkaloid, and phenolic analyses, independent samples T tests were conducted to identify significant differences at a 95% confidence level.

3 Results

3.1 Determination of colour, bioactive compound screening, and functional group in candlenut and daikon radish

3.1.1 Colour analysis

The colour characteristics of candlenut (*Aleurites moluccana*) and daikon radish (*Raphanus sativus* L.), both fresh and extracted, were examined for this study. Figure 4 shows the images of fresh candlenut (A), extracted candlenut (B), fresh daikon radish (C), and extracted daikon radish (D) samples. Based on the colour results (Table 1), the fresh candlenut's surface (Fig. 4a) showed a significantly higher lightness value (L^* value = 67.70) compared to the extracted candlenut with an L^* value = 43.21. Higher L^* value indicates colour towards whitish hue in fresh candlenut compared to its extract. The extracted candlenut (Fig. 4b) showed a significant decrease in yellow hue (b^* value = 0.45), compared to fresh candlenut (b^* value = 25.46). This indicated lesser yellowish hue in extracted candlenut compared to fresh candlenut. Contrarily, the surface of fresh daikon radish (Fig. 4c) showed a significantly higher lightness value (L^* value = 75.89) compared to candlenut (L^* value = 67.70). Meanwhile, daikon radish extract (Fig. 4d) showed a significant decrease in lightness (L^* value = 28.17) compared to its fresh counterpart.

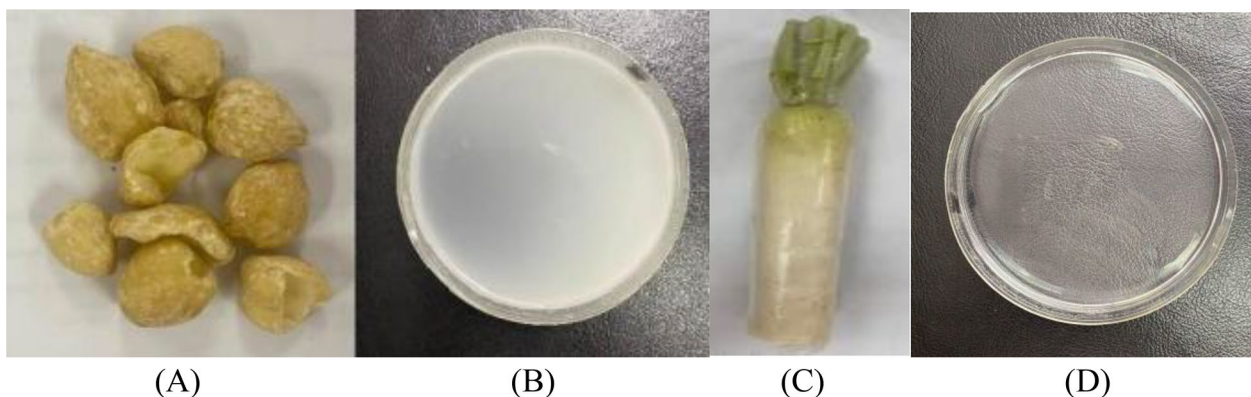


Fig. 4 Fresh candlenut (A), extracted candlenut (B), fresh daikon radish (C) and extracted daikon radish (D) samples for colour analysis. Note: A=outer surface daikon radish, B=extracted daikon radish, C=outer surface candlenut, D=extracted candlenut

Table 1 Colour analysis of fresh and extracted candlenut (*Aleurites moluccana*) and daikon radish (*Raphanus sativus* L.)

Colour properties	Fresh candlenut	Extracted candlenut	Fresh daikon radish	Extracted daikon radish
L^*	67.70 ± 0.11 ^b	43.21 ± 0.00 ^c	75.89 ± 1.74 ^a	28.17 ± 0.02 ^d
a^*	0.72 ± 0.02 ^a	-2.49 ± 0.04 ^d	-0.33 ± 0.34 ^c	0.24 ± 0.04 ^b
b^*	25.46 ± 2.92 ^a	0.45 ± 0.02 ^c	11.45 ± 1.74 ^b	0.37 ± 0.03 ^c

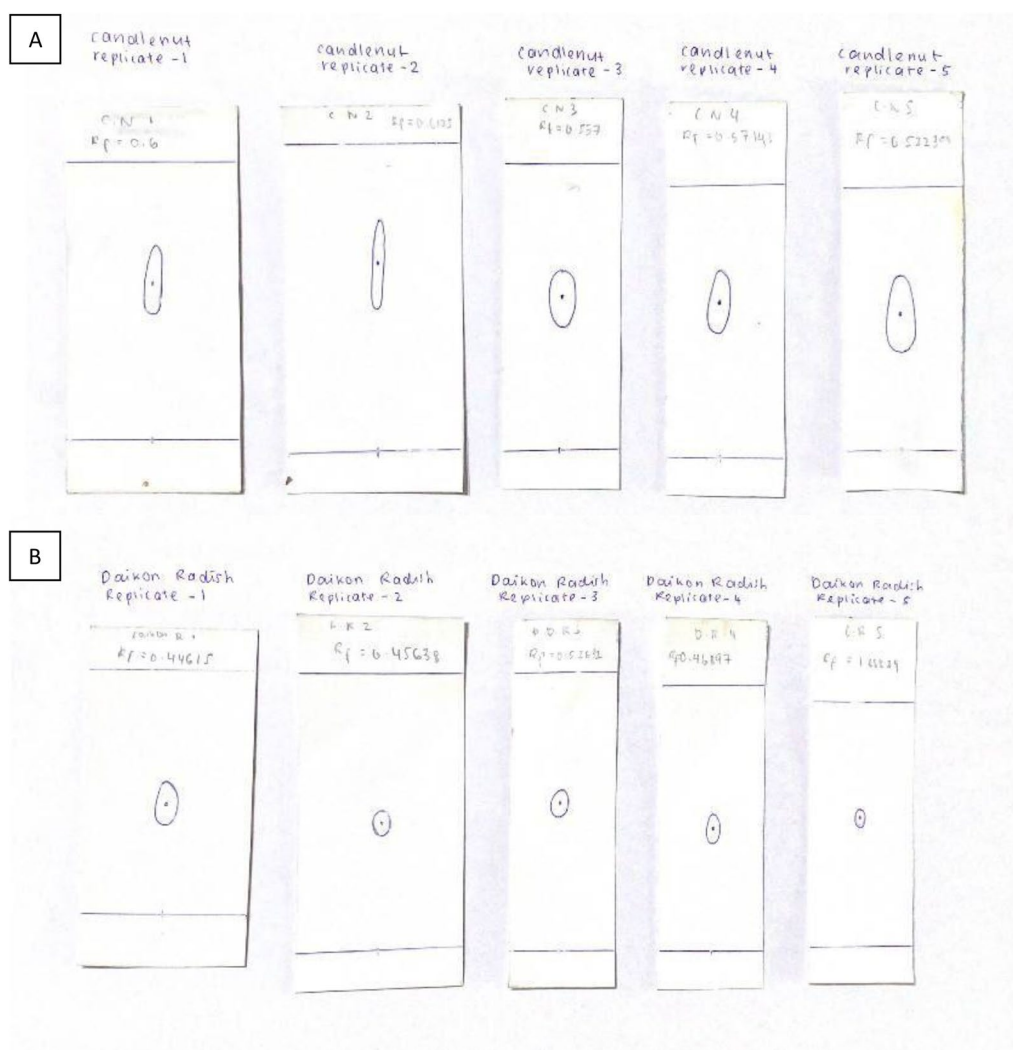
Significant differences at 95% (using Tukey's HSD post hoc test). Subscript lowercase letters indicate the mean ± SD within same row, with different letters representing significant difference ($P < 0.05$)

3.1.2 Bioactive compound screening using Thin Layer Chromatography (TLC)

Thin Layer Chromatography (TLC) was used to analyse the bioactive compounds in candlenut and daikon radish. The values of bioactive chemical spots' retention factor (Rf) were computed and visualised. The TLC plates containing bioactive compound spots for candlenut (A) and daikon radish (B) are shown in Fig. 5. The retention factor (Rf) value, as shown in Table 2, indicated that the bioactive compounds found in candlenut (0.56 ± 0.03) were significantly higher compared to daikon radish (0.49 ± 0.04). The observed variation in Rf values ($P < 0.05$) suggests differing polarity and affinity of the bioactive chemicals in the two samples for the TLC stationary phase. The higher Rf value of candlenut suggests that its bioactive compounds are less polar than those of daikon radish. The unique chemical compositions of the bioactive compounds in these plants may explain this variation in polarity.

3.1.3 Functional group analysis using Fourier Transform Infrared Spectroscopy (FTIR)

The overlay spectra of candlenut (red) and daikon radish (blue) are depicted in Fig. 6. After obtaining the FTIR spectra of both samples, an analysis was conducted to determine the prominent absorption peaks' wave numbers (cm^{-1}). Their FTIR spectra indicate candlenut and



Note: A= 5 replicate of candlenut, B= 5 replicate of daikon radish

Fig. 5 Spots of bioactive compound using TLC plate. Note: A=5 replicate of candlenut, B=5 replicate of daikon radish

Table 2 TLC analysis of candlenut (*Aleurites moluccana*) and daikon radish (*Raphanus sativus* L.)

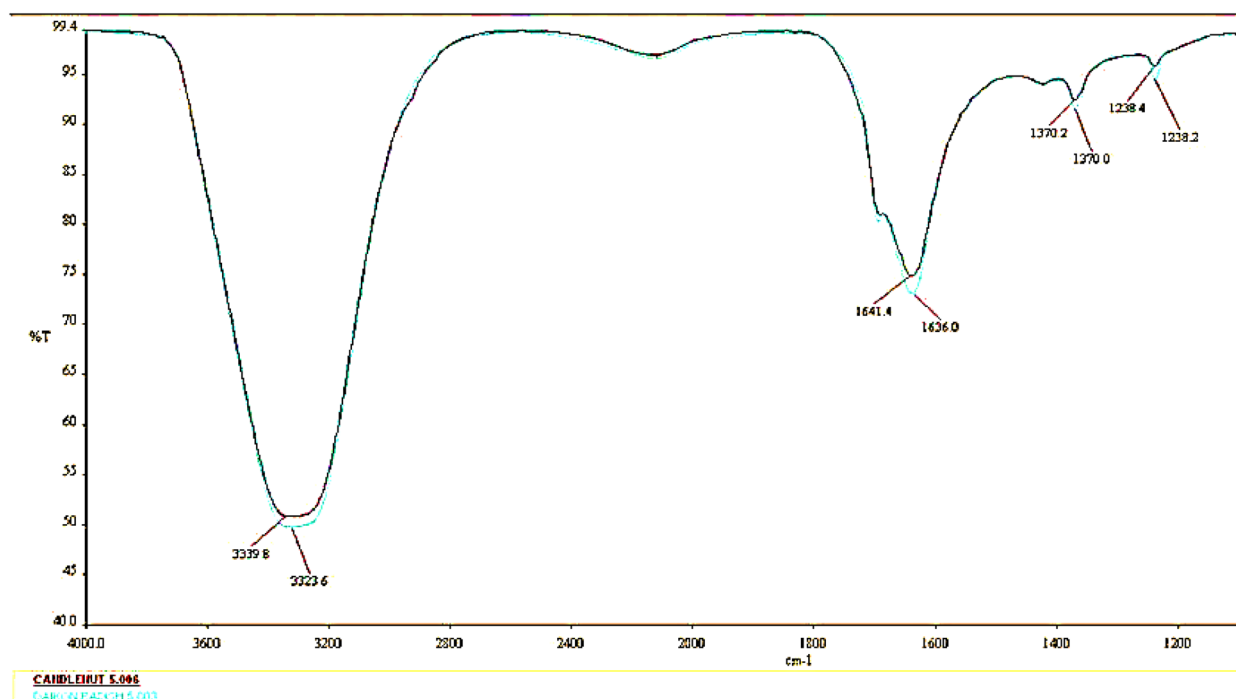
	Candlenut (<i>Aleurites Moluccana</i>)	Daikon Radish (<i>Raphanus sativus</i> L.)
Retention factor Value (Rf)	0.56 ± 0.03 ^a	0.49 ± 0.04 ^b

Significant differences at 95% (using T test). Subscript lowercase letters indicate the mean ± SD within same row, with different letters representing significant difference ($P < 0.05$)

daikon radish have many functional groups (Table 3). The presence of hydroxyl groups is indicated by the prominent absorption peak at about 3339.8 cm^{-1} in candlenut and 3323.6 cm^{-1} in daikon radish, corresponding to the

O–H stretching vibration of alcohols. The slight difference in wave numbers indicates differences in the hydrogen bonding environment of the alcohol groups.

Additionally, the C=C stretching vibrations of alkenyl groups are reflected in the absorption peaks for candlenut and daikon radish, which are located at 1641.4 and 1636.0 cm^{-1} , respectively. These peaks signify the presence of unsaturated chemicals, which are recognised for their antioxidant qualities, like phenolic compounds and fatty acids. Furthermore, the peaks at 1370.2 cm^{-1} for candlenut and 1370.0 cm^{-1} for daikon radish are associated with the stretching vibrations of iso-dimethyl ($-\text{CH}_3$) groups, indicating the presence of methylated compounds, potentially comprising significant bioactive chemicals. The C–O stretching vibrations of phenol



Note: Red= candlenut Blue= daikon radish

Fig. 6 Overlay spectra of samples. Note: Red = candlenut Blue = daikon radish

Table 3 Wave number (cm⁻¹) of dominant peak obtained from sample absorption spectra of candlenut (*Aleurites moluccana*) and daikon radish (*Raphanus sativus* L.)

Functional groups	Candlenut (<i>Aleurites Moluccana</i>) (cm ⁻¹)	Daikon Radish (<i>Raphanus sativus</i> L.) (cm ⁻¹)
Alcohol (O–H broad)	3339.8	3323.6
Alkenyl (C=C stretching)	1641.4	1636.0
Iso-Dimethyl (–CH ₃ stretching)	1370.2	1370.0
Phenols (Ar–OH stretch)	1238.4	1238.2

groups in the absorption peaks for candlenut and daikon radish are located at 1238.4 and 1238.2 cm⁻¹, respectively.

3.2 Determination of tannin, alkaloid, and phenolics in candlenut and daikon radish

3.2.1 Tannin and alkaloid analysis

Tannins are polyphenolic chemicals that can bind to proteins and other macromolecules, giving many plants their astringent flavour and potentially even some health advantages. The findings in Table 4 indicated that candlenut had a significantly higher tannin concentration of 91.77 ± 12.18 mg/L compared to daikon radish (2.13 ± 3.00 mg/L). The findings in Table 4 showed that the alkaloid contents between the two samples differed significantly. Candlenut contained significantly higher

Table 4 Concentration of tannin, alkaloid, gallic acid, vanillic and *p*-coumaric acid in candlenut (*Aleurites moluccana*) and daikon radish (*Raphanus sativus* L.)

	Candlenut (<i>Aleurites Moluccana</i>)	Daikon Radish (<i>Raphanus sativus</i> L.)
Tannin (mg/L)	91.77 ± 12.18 ^a	2.13 ± 3.00 ^b
Alkaloid (mg/L)	10.30 ± 0.59 ^a	3.56 ± 0.12 ^b
Gallic acid (mg/L)	273.43 ± 17.23 ^a	27.39 ± 20.39 ^{bA}
Vanillic acid (mg/L)	nd	28.43 ± 11.92 ^A
<i>p</i> -coumaric acid (mg/L)	nd	3.04 ± 0.12 ^B

nd = not detected. Significant differences at 95% (using T-test). Subscript lowercase letters indicate the mean ± SD within same row. Subscript uppercase letters indicate the mean ± SD within same column. Different letters representing significant difference (*P* < 0.05) and same letters representing no significant difference (*P* > 0.05)

alkaloid content (10.30 ± 0.59 mg/L) than daikon radish (3.56 ± 0.12 mg/L). The higher alkaloid content in candlenut suggests that it may serve as a richer source of bioactive compounds with potential therapeutic uses. The use of candlenuts in treating various diseases by local communities and their use in traditional medicine could be attributed to their alkaloid content.

3.2.2 Phenolic compound analysis using High-Performance Liquid Chromatography (HPLC)

HPLC was used to analyse the phenolic compounds in candlenut and daikon radish, emphasising the content of gallic acid, vanillic acid, and *p*-coumaric acid, phenolic acids with antioxidant qualities. Understanding the composition of these plant samples can offer valuable perspectives on their possible health advantages and uses in food and medicine. The accuracy of the HPLC method employed in this investigation was confirmed by the gallic acid retention times in both plant extracts, which were close to the standard gallic acid retention time (2.609 min). As shown in Table 4, the concentration of gallic acid was significantly higher in candlenut (273.43 ± 17.23 mg/L) compared to daikon radish (27.39 ± 20.39 mg/L). This difference in gallic acid content may be attributed to the phenolic composition of the two plant samples.

Meanwhile, standard vanillic acid was detected at 2.877 min. Vanillic acid was only detected in daikon radish (28.43 ± 11.92 mg/L). The retention time of standard *p*-coumaric acid was 3.136 min. Similarly, *p*-coumaric acid, contained in daikon radish (3.04 ± 0.12 mg/L), was not detected in candlenut.

4 Discussion

Colour analysis is essential when examining the physicochemical characteristics of food products like candlenut (*Aleurites moluccana*) and daikon radish (*Raphanus sativus* L.). Food appearance is one of the first qualities that consumers evaluate, hence it plays a crucial role that affects how consumers perceive and accept food products [14]. The aim was to quantify the colour variations in these samples. A fundamental criterion in discerning radish samples is the colour of the skin. The processing and extraction techniques, which may impact the pigment composition and distribution in the samples, are responsible for these colour variations [14]. In the food industry, producers need to monitor and maintain a uniform standard of product quality during the processing and storage stages by setting baseline colour values for fresh and extracted samples [15]. Besides that, food colour is frequently associated with its functional and nutritional qualities. For instance, besides enhancing colour,

pigments like anthocyanins, carotenoids, and chlorophyll offer additional health benefits as antioxidants [16].

The increased R_f value of candlenut may be related to its composition of phenolic chemicals, flavonoids, and different fatty acids [17]. In contrast, the lower R_f of daikon radish is influenced by its content of hydrophilic chemical compounds such as isothiocyanates and glucosinolates [18]. The diverse R_f values yielded in this study highlight TLC's efficacy in separating and characterising bioactive components within plant extracts. The R_f value of candlenut extract (0.56 ± 0.03) closely matched the standard R_f value of rutin (0.57) reported from literature [19], indicating the presence of this antioxidant-rich bioactive substance. Rutin is a potent xanthine oxidase (XO) enzyme inhibitor of the purine catabolism pathway, which slows down uric acid production and potentially prevents gout [20]. Similarly, the R_f value of daikon radish extract (0.49 ± 0.04) is comparable to the standard R_f value of ibuprofen (0.48) [21], indicating a similar migration pattern, requiring further investigation. Standard rutin and ibuprofen were also analysed in this research and closely matched with the findings from the literature. Ibuprofen is a well-known nonsteroidal anti-inflammatory medication (NSAID) with analgesic, anti-inflammatory, and antipyretic effects [22] that may contribute to the health benefits attributed to daikon radish. The findings from the TLC analysis reveal the diverse bioactive compound profiles of candlenut and daikon radish, highlighted by their distinct R_f values. This information sheds light on the chemical constituents of these plant samples and their potential applications across various industries for health benefits, warranting further investigation.

FTIR information can be used to determine the chemical structure of the compounds [23], suggesting the possibility of linking with human health. This information contributes to understanding the chemistry and potential bioactive substances within these plant samples and aligns with findings from previous studies [24–26]. The similar FTIR spectra of candlenut and daikon radish suggest they share functional groups, potentially indicative of similar bioactive characteristics. However, subtle differences in wave numbers point to variations in the chemical environment of these functional groups, likely stemming from variations in the specific molecules found in each plant. The presence of alkenyl, phenol, iso-dimethyl, and alcohol groups indicates that both plants contain bioactive substances that could benefit health [27]. However, further study is needed to confirm the exact activity of bioactive compounds.

Meanwhile, tannins work to prevent inflammation in several different ways. Pro-inflammatory enzymes like cyclooxygenase (COX) and lipoxygenase (LOX), which are involved in synthesising prostaglandins and

leukotrienes, respectively, can be inhibited by tannin. These substances are important inflammatory mediators. Tannins can control the activity of transcription factors such as NF- κ B, also known as nuclear factor kappa-light-chain enhancer of activated B cells, which is essential for controlling inflammatory reactions [28]. Candlenut has a higher tannin concentration because of its many polyphenolic components, giving it an astringent taste and having some health advantages. Strong antioxidant qualities found in candlenut tannins are believed to help scavenge free radicals and lessen oxidative stress. Candlenut is an essential plant for medical uses because of its antibacterial qualities, which can also stop the formation of many infections. Daikon radish had a different polyphenolic profile due to its comparatively low tannin level. The strong taste and possible health advantages of daikon radish are attributed to its high concentration of glucosinolates. Given its low tannin level, daikon radish's astringent and antioxidant qualities might be attributed to other phenolic chemicals. Considering that candlenut has a far higher tannin content than daikon radish, it can be postulated that candlenut has more anti-inflammatory properties. This may be particularly significant regarding dietary choices or developing nutraceuticals to treat inflammation-related illnesses. Understanding the alkaloid profiles of candlenut and daikon radish might offer valuable perspectives on their possible health advantages and uses in culinary and medicinal applications [29]. Numerous alkaloids are employed as pharmacological agents and for treatments [30]. Alkaloids are a naturally occurring class of nitrogen-containing chemicals found in many plants. They exhibit various pharmacological actions, including antibacterial, analgesic, and anti-inflammatory properties. The presence and concentration of alkaloids in plants can significantly impact their health benefits and potential uses.

Candlenuts have been used in traditional medicine to treat various illnesses, and their increased gallic acid level suggests that they may be a rich source of antioxidants. The notable existence of gallic acid in candlenut corresponds with its purported health advantages, such as its anti-inflammatory and anti-cancer characteristics. The results of this research emphasise the significance of candlenut as a source of phenolic chemicals, especially gallic acid, which may be used in natural healing remedies. Additionally, the results highlight the nutritional significance of daikon radish as a nutrient-dense vegetable with a high phenolic content, contributing to its health-promoting qualities [31]. Complete phenolic compounds profiling is needed to establish the bioactive characteristics for both samples.

5 Conclusion

Examining the characteristic properties of candlenut (*Aleurites moluccana*) and daikon radish (*Raphanus sativus* L.) has provided valuable insights into the chemical compounds that may have potential health benefits. The results indicated that candlenut and daikon radish contain bioactive compounds, such as phenolic compounds, tannins, and alkaloids, which may contribute to their anti-inflammatory properties, subject to further investigations. Functional group analysis using FTIR further characterised the extracts' chemical composition. TLC revealed that candlenut exhibited significantly higher retention factor ($R_f=0.56 \pm 0.03$) than daikon radish ($R_f=0.49 \pm 0.04$), indicating differences in the polarity of bioactive compounds. Tannin and alkaloid were significantly higher in candlenut compared to daikon radish.

Furthermore, a higher concentration of gallic acid was found in candlenut compared to daikon radish, highlighting its superior antioxidant potential and supporting its potential role in traditional medicine. This research aligns with global health and sustainability goals by contributing to exploring natural alternatives for managing illnesses. This study only characterises chemical constituents, limiting the link and connection to the mechanism of action in medicinal properties. Further research is recommended to investigate the anti-inflammatory properties of daikon radish and candlenut extracts through in vitro and in vivo models to validate the current findings. This would help establish a clearer link between the bioactive compounds identified and their potential benefits for many standard treatments. Additionally, efforts should be made to raise public and medical awareness about the possible health benefits of candlenut through educational materials.

Abbreviations

FTIR	Fourier Transform Infrared Spectroscopy
HPLC	High-Performance Liquid Chromatography
IC ₅₀	Half maximal inhibitory concentration
TLC	Thin Layer Chromatography
R _f	Retention factor
HATR	Horizontal Attenuated Total Reflectance
BCG	Bromocresol green
ANOVA	Analysis of variance
XO	Xanthine oxidase
NSAID	Nonsteroidal anti-inflammatory drugs
COX	Cyclooxygenase
LOX	Lipoxygenase
NF- κ B	Nuclear factor kappa-light-chain-enhancer of activated B cells

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Author contributions

This manuscript is collaboratively written with Mahirah who mainly conducted the experimental work, Raseetha who contributed in designing experiments,

analysing data, manuscript writing, and Nazimah, who provided critical insights and guidance throughout the research process, who offered valuable feedback on manuscript drafts. All authors reviewed the manuscript.

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Availability of data and materials

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Declarations

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Human and animal rights

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Competing interests

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Consent for publication

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