

Quality of sugar palm sap (*Arenga pinnata*) from various production centers in West Sumatra, Indonesia

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Abstract. Anggraini T, Anwar A, Hervani D, Suhendra D, Wisnubroto MP, Noflindawati, Nasution IM. 2025. Quality of sugar palm sap (*Arenga pinnata*) from various production centers in West Sumatra, Indonesia. *Biodiversitas* 26: 859-860. *Arenga pinnata* is a palm tree that produces palm sap, which contains high sugar content and offers a sweet taste and bioactive components that function as antioxidants. These *A. pinnata* trees grow in West Sumatra, where sugar palm fruit and palm sap sugar are the main horticultural products. In this study, we investigated the quality of palm sap (*A. pinnata*) from various sap-producing regions thrive in West Sumatra, Indonesia, focusing on their color, total sugar contents, antioxidant activities, total phenolic contents, and Fourier Transform Infra-Red (FTIR) measurements. We compared palm sap sugar from the West Pasaman, Agam, Tanah Datar, Limapuluh Kota, South Solok, and Dharmasraya regions in West Sumatra. The color of palm sugar sap is vibrant yellow-red. The total sugar content ranges from 7-15.73%. The antioxidant activity of palm sap varies based on its concentration, with its total polyphenol content ranging from 46.32-499.32 mg GAE/g, highlighting the potential health benefits of palm sap. We also used the FTIR analysis to identify functional groups in the samples. This finding showed that the quality of palm sap found in West Sumatra varies in terms of quality. Based on its antioxidant content, MNJ A has the highest antioxidant activity, and TLM A has the highest total polyphenols. These results show that total polyphenols are not the only ones that contribute to the antioxidant activity of palm sap.

Keywords: Antioxidant, *Arenga pinnata*, palm sap, quality, total polyphenol

INTRODUCTION

Palm sap sugar is an alternative sweetener produced from nectar or sap tapped from the flowers of several species of palm trees, such as sugar palm (*Arenga pinnata* (Wurmb) Merr.), palmyra palm (*Borassus flabellifer* L.), nipa palm (*Nypa fruticans* Wurmb), and coconut palm (*Cocos nucifera* L.), which have the potential to be incorporated into food products as substitutes for sucrose. This sugar, which is commonly used in many traditional foods in the Southeast and South Asian regions, has been claimed to exhibit health benefits because of its low glycemic index (35-42), high antioxidants, and rich in vitamin and mineral contents (Betikua et al. 2023), making it a beneficial addition to the human diet.

Palm sap is a liquid with high sugar content and is obtained from palm plants, including *A. pinnata*. In addition to its potential as a palm fruit producer, *A. pinnata* is a sap-producing plant. *A. pinnata* sap is used as a natural sweetener and is traditionally processed into brown sugar. Palm sap is a sweet liquid obtained from the bunches of coconut and sugar palm trees (*A. pinnata*). It has a unique flavor profile, often described as rich and caramel-like, owing to its high glucose content. Owing to its unique taste

and high glucose content, the community often uses this sap to process traditional sugars (Wiboonsirikul 2024).

Ideally, the sap's pH must be between 6 and 7.5, with a Brix value of more than 17%. However, this sap is readily damaged; therefore, it must be processed immediately after tapping. This step is of utmost importance as it prevents damage or loss of sugar, as indicated by the decrease in pH because of fermentation. Consistent sap quality over time is essential to ensure consistent results. Controlling the production process and regular monitoring can help maintain sap quality (Hanis et al. 2024).

Palm sap is rich in natural sugars, minerals, and other nutrients and is a fascinating natural health product. It is often considered a healthy drink that can benefit human health by preventing chronic diseases, including heart disease and cancer (Sarkar et al. 2023). Palm juice tapped from the flowers of palm plants consists of 80% water and 10-15% total sugar in addition to amino acids, vitamins, and minerals (Palachum et al. 2023). Sucrose is the most abundant sugar in palm sap, followed by smaller amounts of glucose, fructose, inositol, and raffinose. The nutritional content of palm sap varies depending on several factors, such as plant type, geographic region, tapping method, and the maturity of the palm (Sarkar et al. 2023; Yermia et al. 2024).

In addition, the quality of palm sap is impacted by environmental factors, such as climate, soil conditions, and agricultural practices. For example, sugar palm plants planted in areas with high rainfall and fertile soil tend to produce high-quality sap (Ampofo et al. 2024). Palm sap has numerous important health benefits. The citric acid present in palm sap functions as an antioxidant that is highly effective in fighting free radicals. In addition, palm sap is rich in carbohydrates, fats, and proteins, making it an excellent source of energy. This aspect of palm sap can make you feel energized and invigorated (Ansar et al. 2021). It also has natural laxative properties and can be used to treat cancer, cardiovascular illnesses, or other degenerative ailments caused by oxidative damage (Arshad et al. 2022). Palm sap quality varies depending on the geographic origin, such as moisture content, pH, total sugar, and kind of sugar (glucose ranged from 0.49-86.90 g/100 mL, sucrose ranged from 0.26-1.61 g/100 mL and fructose ranged from 5.30-27.00 g/100 mL, the K content 65.28-86.52 mg (Sarkar et al. 2023; Wiboonsirikul 2024).

Several areas in West Sumatra are used as *A. pinnata* production centers. The cultivation area and climatic conditions impact the characteristics and composition of palm sap. Sugar palms contain antioxidants as their functional components. The quality of the sap drastically impacts the quality of the produced brown sugar and sugar products. In West Sumatra, several areas, including West Pasaman, Agam, Tanah Datar, Limapuluh Kota, South Solok, and Dharmasraya, are considered palm sap-producing centers because of natural factors and the palm sap-producing skills of people from these regions.

Based on the description above, further research is needed to determine the quality of palm sap obtained from several palm sap-producing areas in West Sumatra. Therefore, this study aimed to analyze the quality of *A. pinnata* palm sap from various production centers in West Sumatra.

MATERIALS AND METHODS

Raw materials, reagents, and instruments

The main ingredient used in this study was palm sap obtained from the West Pasaman, Agam, Tanah Datar, Limapuluh Kota, South Solok, and Dharmasraya areas in West Sumatra, Indonesia. The materials used in the analysis were distilled water, a buffer solution of pH 7, DPPH (1,1-diphenyl-2-picrylhydrazyl) merk, Folin-Ciocalteu reagent, 95% ethanol, methanol, and Na₂CO₃. The tools used in this research were cool boxes (Marvel Coolers), digital automatic temperature compensation refractometers, test tubes, micropipettes, 10 mL measuring cups, 100 mL measuring cups, scales, Erlenmeyer flasks, Fourier Transform Infra-Red (FTIR) (Shimadzu Co., Ltd., Kyoto, Japan), Spectrophotometer UV VIS Shimadzu 1800 (Kyoto, Japan), a Colorimeter Colorflex EZ (Reston, Virginia USA).

The palm sap area for the research

The samples were 15 samples from 6 regions of the center of *A. pinnata* in West Sumatra. Where the variables

letters A, B, and C indicate the location of the trees used for sampling palm sap. Reason considered, these areas are palm sap-producing centers due to natural factors as well community skills in producing palm sap from these various regions, so it is considered a center for palm sap production in West Sumatra, as per the results of previous research: Limapuluh Kota (AKAB A and AKAB B, TB A, TB B, and TB C), Dharmasraya (DMS A, DMS B), Agam (MNJ A), South Solok (SSL A, SSL B, SSL C), Tanah Datar (SUA and SUB), West Pasaman (TLMA and TLMB). The samples were collected in August 2024; there were no preservatives used in the sample. The sample was first frozen and brought at a cool temperature from the field into the lab on the same day and fridge in deep freeze (-80°C) before use for analyses.

Experimental design

The research uses explorative research with 15 samples. The data was calculated as the average and \pm standard deviation.

Analysis of sugar palm sap

Color measurement

Color analysis of the palm sap samples was performed by measuring their L*, a*, and b* values using a colorimeter (HunterLab). The L* value corresponds to the brightness level from 0 to 100, which indicates the reflected light that produces black, gray, and white colors. The greater the L value, the greater the brightness value. The a* value indicates the degree of red to green coloration, and the b* value indicates the degree of blue to yellow coloration. Moreover, chroma shows the color intensity, and °Hue shows the proportion of color in the material.

Total sugar content

The total sugar content in palm sap was analyzed using the refractor-photometric method because it is extremely effective for samples with high sugar concentrations, making it suitable for this purpose. First, the refractor-photometric prism was cleaned with lens paper or tissue. Subsequently, a drop of a palm sap sample was dropped onto the surface of the prism using a dropper pipette and carefully covered. The measured total sugar contents were expressed in Brix units, indicating the total sugar content in a solution.

Antioxidant activity and inhibitory concentration (IC₅₀) value (Perveen et al. 2024)

Next, to measure the total antioxidant content, 1 mL of a palm sap sample was taken into a test tube and mixed with 10 mL of methanol. After vortexing and soaking this solution mix in an ultrasonic bath for 15 min, 1 mL of the mix was added to 9 mL of fresh methanol. Once the sample became clear, 2 mL of this sample was mixed with 1 mL of 0.2 mM DPPH solution, prepared by dissolving 0.0154 mg of DPPH powder in 100 mL of methanol. A blank solution (control) was prepared without adding the sample to the DPPH solution. Spectrophotometry was performed at 517 nm.

Each sample was tested for absorbance at five concentrations: 20, 40, 60, 80, and 100 ppm. Moreover, the

absorbance of each blank solution (DPPH without sample) was also measured. The mean absorbance was obtained by averaging the absorbance values for the five different concentrations of the samples and also for the blanks. The antioxidant activity (%) of each palm sap sample was then calculated using the following formula:

$$\text{Antioxidant activity (\%)} = \frac{\text{abs control} - \text{abs sample}}{\text{abs control}} \times 100\%$$

Analysis of total phenolic content (Van Tai et al. 2024)

Then, to measure the total polyphenol content, 1 mL of a palm sap sample was taken into a test tube containing 2 mL of distilled water, 1 mL of Folin ciocalteu reagent (50%), and 1 mL of Na₂CO₃ (7.5%). This mix was stirred homogeneously using a vortex and then allowed to react in the dark for 60 min after being wrapped in aluminum foil. Next, absorbance was measured at 725 nm to determine the total polyphenol content, which was expressed in the units of mg of gallic acid equivalents per gram of sample (mg GAE/g).

FTIR analyses

Each palm sap sample was mixed with KBr at a ratio of 1 mL: 9 mg. After mixing KBr pellets with the samples, they were subjected to the FTIR analysis. All FTIR spectra were obtained in the 4,000-400 cm⁻¹ region, with a spectral resolution of 4 cm for metabolite profiling.

RESULTS AND DISCUSSION

Color of the palm sap samples

The palm sap samples' color was tested using the HunterLab Colorflex EZ colorimeter, which measures three color parameters: L* (lightness), a* (redness), and b* (yellowness). The colors of the palm sap samples are listed in Table 1. All palm sap samples exhibited a yellow-red color with different degrees of lightness. This difference

was because of the presence of phenolic and sugar compounds and the content of total soluble solids in each sample. The presence of phenolic affected the color sensory evaluation of the samples (Hebbar et al. 2018).

Based on the results presented in Table 1, the L* value of the palm sap samples ranged between 7.83 and 22.63, with the lowest value found in the SSL C sample and the highest in the TB A sample at 22.63. The a* (redness) value ranges from -0.05 to -0.25 and describes the color spectrum from green to red. Based on the results presented in Table 1, the b* value of the palm sap samples ranged from -0.22 to -4.23. The °Hue value was 75.21-88.72, which described the color spectrum of the palm sap samples as yellow-red. The lowest value was found in the MNJ A sample and the highest in the TB B sample, implying that the average °Hue value in the MNJ A sample was 75.21 and that in the TB B sample was 88.72, with all samples exhibiting a yellow-red color range. Even though the numbers are different, they produce the same °Hue, namely yellow red. The difference in numbers doesn't really contribute to the color because the numbers aren't that different. Previous studies have reported that *A. pinnata* has an L* value of 44.5-54.8, a* value of 1.2-1.6, and a b* value of 6.5-9.8 (Ansar et al. 2021). The results showed that all of the samples have similar colors based on the °Hue value.

Chemical analysis of sugar palm nira obtained from sugar palm trees

Total sugar content

The total sugar content in palm sap was measured using a handheld refractometer after rinsing it with distilled water and then wiping it with a soft cloth. Palm juice was dropped onto the prism of the refractometer, which was then directed towards a light source and then viewed at the scale printed on the instrument. The total sugar content was expressed in °Brix units (°Brix). The total amount of palm sugar in the palm sap samples is shown in Figure 1.

Table 1. Color analysis of palm sap

Sample	L*± sd	a*± sd	b*± sd	°Hue± sd	Color
AKAB A	15.91 ± 1.08	-0.08 ± 0.02	-1.33 ± 0.03	86.70 ± 0.69	Yellow red
AKAB B	17.04 ± 1.52	-0.14 ± 0.03	-2.31 ± 0.10	86.59 ± 0.90	Yellow red
DMS A	15.40 ± 0.70	-0.08 ± 0.06	-2.07 ± 0.41	87.77 ± 1.32	Yellow red
DMS B	18.09 ± 0.48	-0.11 ± 0.02	-2.21 ± 0.20	87.06 ± 0.39	Yellow red
MNJ A	11.70 ± 1.41	-0.05 ± 0.04	-0.22 ± 0.11	75.21 ± 11.44	Yellow red
SSL A	17.09 ± 3.66	-0.10 ± 0.04	-1.16 ± 0.45	84.91 ± 0.25	Yellow red
SSL B	15.86 ± 2.10	-0.21 ± 0.17	-1.07 ± 0.21	78.25 ± 11.18	Yellow red
SSL C	7.83 ± 0.58	-0.05 ± 0.03	-0.96 ± 0.19	86.80 ± 1.91	Yellow red
SU A	19.48 ± 0.96	-0.19 ± 0.05	-3.17 ± 0.53	86.67 ± 0.37	Yellow red
SU B	19.45 ± 0.81	-0.16 ± 0.02	-3.30 ± 0.77	87.10 ± 1.18	Yellow red
TB A	22.63 ± 1.18	-0.14 ± 0.06	-4.23 ± 0.69	87.98 ± 1.23	Yellow red
TB B	18.66 ± 1.13	-0.07 ± 0.02	-2.96 ± 0.54	88.72 ± 0.07	Yellow red
TB C	20.15 ± 2.55	-0.21 ± 0.04	-2.09 ± 0.19	84.19 ± 0.68	Yellow red
TLM A	20.88 ± 1.16	-0.25 ± 0.02	-2.75 ± 0.37	84.78 ± 0.32	Yellow red
TLM B	18.19 ± 0.98	-0.11 ± 0.03	-2.90 ± 0.27	87.78 ± 0.41	Yellow red

Note: sd: Standard deviation

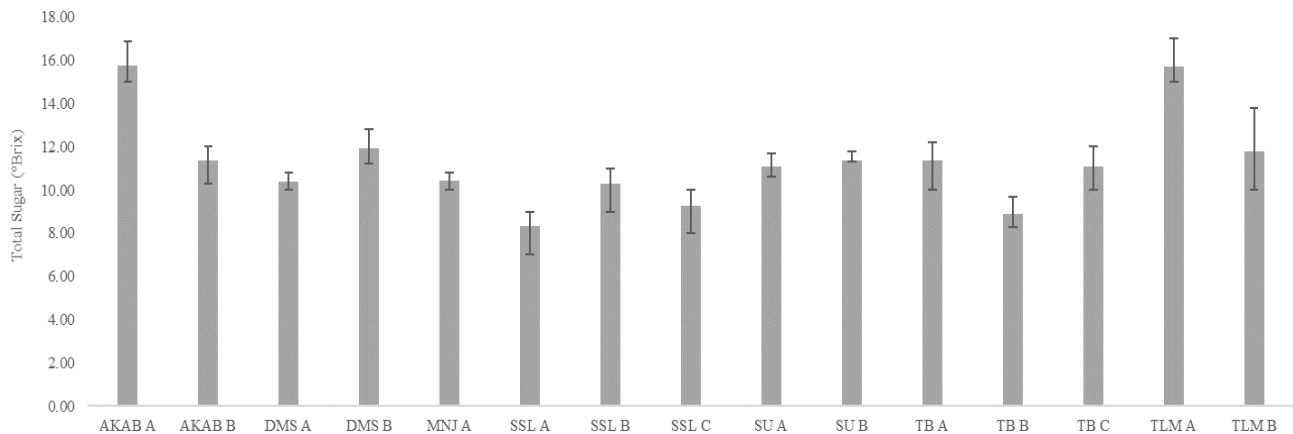


Figure 1. Total sugar content

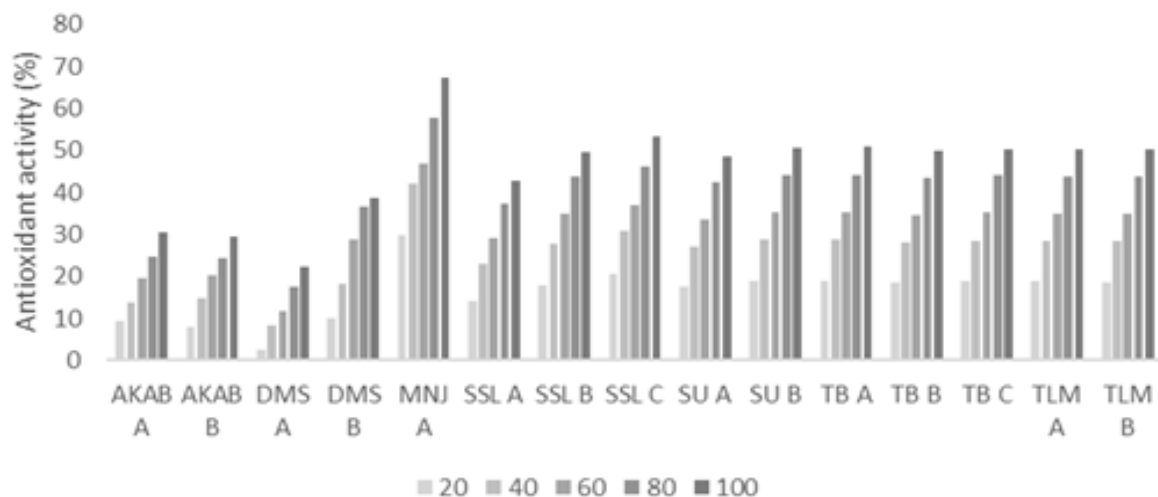


Figure 2. Antioxidant activity (%). Concentration: 20, 40, 60, 80 and 100 ppm

Palm sap has a low glycemic index, with glucose content in the range of 0.49-86.90 g/100 mL, fructose content in the range of 0.26-1.61, and sucrose content in the range of 5.30-27.00 g/100 mL (Sarkar et al. 2023). The variation observed in the total sugar content in this study could be because of variations in genetic factors, soil nutrition, climate, or other factors. According to a previous study, the sugar content in *A. pinnata* is 10% (Tomomatsu et al. 1996). Palm sap sugar and other products derived from different parts of a palm tree can be used to make value-added products, such as chocolate, cola, toddy wine, candy, and palm vinegar; however, their primary products are brown sugar or syrup. According to an earlier study, the total sugar content of palm sap is 9-18.6 g/100 mL (Sarkar et al. 2023).

The AKAB A, DMS B, TLM A and TLM B sap samples contained sugar levels approaching or exceeding 12. The inclusion of different varieties of palm sap in the analysis may have caused a low sugar content in the obtained palm sap samples. If freshly tapped palm sap is not processed immediately, it undergoes fermentation. Total sugar is the main factor affecting the quality of sugar palm sap. Even if the samples were sourced from the same

region, their total sucrose content was different, indicating an impact of various climatic or environmental factors in determining the total sucrose content. Plant oil is a major factor that impacts primary and secondary metabolites in plants. This research underscores the need for further investigation to determine whether the palm oil content of palm trees affects the sugar content of palm sap. This issue has a significant potential for future discoveries.

Antioxidant activity

Antioxidants are essential compounds that play a role in maintaining body health by counteracting free radicals produced in the body (Pelealu et al. 2019). The results of the antioxidant activity of palm sap can be seen in Figure 2. Antioxidant activity results were obtained from several sample concentrations, namely 20 ppm, 40 ppm, 60 ppm, 80 ppm, and 100 ppm. At a sample concentration of 20 ppm, the antioxidant activity found in each sample ranged from 2.66 to 37.26%. Based on the data, it was found that the higher the concentration, the antioxidant activity values for all samples also increased. The lowest antioxidant activity with a sample concentration of 20 ppm was in the DMS A sample, and the highest was in the TLM A sample.

At a sample concentration of 40 ppm, the antioxidant activity found in each sample ranged from 8.24 to 44.87%. The lowest antioxidant activity with a sample concentration of 40 ppm was in the DMS A sample, and the highest was in the TLM A sample. At a sample concentration of 60 ppm, the antioxidant activity found in each sample ranged from 11.66 to 47.02%. The lowest antioxidant activity with a sample concentration of 60 ppm was in the DMS A sample, and the highest was in the TLM A sample. Meanwhile, at a sample concentration of 80 ppm, the antioxidant activity found in each sample was 17.49-57.67%. The lowest antioxidant activity with a sample concentration of 80 ppm was in the DMS A sample, and the highest was in the MNJ A sample. At a sample concentration of 100 ppm, the antioxidant activity found in each sample was 22.43-67.43%. The lowest antioxidant activity with a sample concentration of 80 ppm was in the DMS A sample, and the highest was in the MNJ A sample; bioactive compounds occurring in plants a strong antioxidants that naturally occur as secondary metabolites and could decrease some diseases. Naturally, an antioxidant found in plants has a potent and strong antioxidant ability that could prevent many diseases (Siddique 2025). Polyphenols, as the secondary metabolites in plants, greatly contribute to the antioxidant ability, protect the cell wall, and inhibit lipid peroxidation (Chen et al. 2023; Che et al. 2024). The difference in the antioxidant capacity in palm sap could be because of the difference in the climate of each region and even climate change (Limantol et al. 2022).

The results of this study provide valuable insights into the antioxidant activity of palm sap samples. The lowest antioxidant activity was found in the DMS A samples at 20, 40, 60, 80, and 100 ppm concentrations. The highest antioxidant activity was found in the TLM A samples at 20, 40, and 60 ppm concentrations and in the MNJ A samples at 80 and 100 ppm concentrations. The low antioxidant activity of the palm sap samples can be attributed to the storage time of the samples. The content of free radicals in palm sap increases during storage; therefore, the ability of antioxidants to eliminate these increased concentrations of free radicals decreases. The polyphenolic compounds present in palm trees, including in sugar palm sap, include flavonoids (quercetin, kaempferol, and luteolin), phenolics (coumaric acid and ferulic acid), polyphenols (epicatechin), and steroids (stigmasterol, campesterol, and spirostane), further contribute to the understanding of the antioxidant activity in palm sap samples (Sartinah et al. 2022).

IC₅₀ values of antioxidants present in palm sap samples

The IC₅₀ value indicates the ability of an antioxidant to reduce as much as 50% of free radicals. The lower the IC₅₀ value, the stronger the antioxidant activity. The IC₅₀ values of the palm sap samples from the different regions are shown in Figure 3. This research does not display all the IC₅₀ values that have been studied, but the researchers only want to represent the palm-sap production center area in West Sumatra. The vitamins contained in the palm sap samples included vitamins B and C, and the amount of vitamin C was approximately 13.25 mg/100 mL, which contributed to the pH of palm sap samples. The effects of

several factors, such as climate, cultivar, and the agronomic management of the palm plant, may have caused the differences in the pH values of the different palm sap samples. The compositional attributes of palm sugar vary based on the palm species, growth region, and climatic conditions (Sarkar et al. 2023). The major organic acid in *A. pinnata* was malic acid, followed by succinic, lactic, pyroglutamic, citric, tartaric, and fumaric acids. The quality and chemistry of palm sap samples depend on several factors, such as extraction techniques, weather conditions, and preservation methods. Our results are in agreement with the results of another study, which reported the presence of vitamins C (ascorbic acid), B1 (thiamine), B2 (riboflavin), B3 (niacin), B5 (pantothenic acid), and B6 (pyridoxine) in palm sap (Hai et al. 2024). The presence of organic acid could improve the flavor of the product and enhance the specific aroma (Chen et al. 2024). The presence of vitamins also contributes to the antioxidant ability and to reducing oxidative stress (Mo et al. 2024).

Total phenolic content

The total polyphenol content in the palm sap samples was analyzed using Folin-Ciocalteu method. The results of the total polyphenol content analysis of the palm sap samples are shown in Figure 4. Figure 4 revealed the total polyphenol content in the palm sap samples ranged from 46.32-571.11 mg GAE/g. Palm sap contains phenolic compounds, which have one or more hydroxyl groups attached to their aromatic rings. The lowest total polyphenol content was found in the DMS A sample and the highest in the TLM A sample. Polyphenols are a diverse and extensively studied class of secondary metabolites characterized by the presence of multiple phenolic hydroxyl groups attached to their aromatic rings. They are mainly classified into flavonoids, phenolic acids, stilbenes, lignans, and other phenolic compounds (Huang et al. 2025). Polyphenols, as antioxidant properties, could prevent lipid oxidation and reduce the cholesterol and level of triglycerides (Lee-Martínez et al. 2024). Obesity is correlated with a high amount of sugar. Palm sap, as the sugar producer, could also increase the potential for obesity due to the presence of phenolics in it.

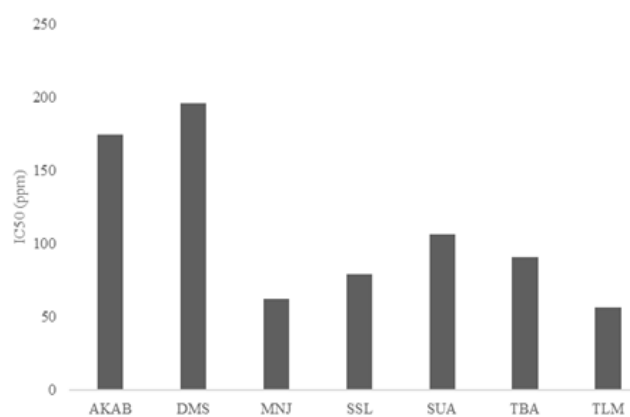


Figure 3. IC₅₀ value of palm sap

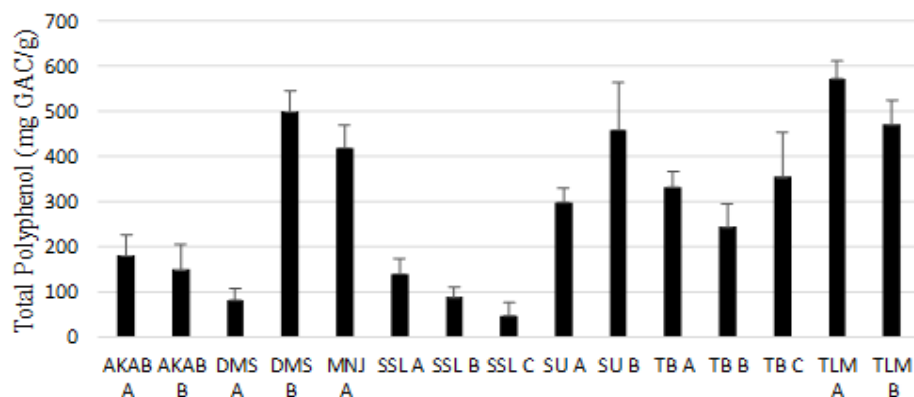


Figure 4. Total polyphenols

Phenolic compounds, with their unique aromatic ring and hydroxylated phenol structure, are the most abundant antioxidants in fruits and plants. This unique structure imparts redox properties to the phenolic compounds, making them beneficial for human health without causing harmful side effects. These compounds are also present in palm sap, and their content increases when heated due to the release of bound polyphenols after exposure to heat (Sarkar et al. 2023). The phenolic content and antioxidant activity of plant extracts are closely related. Free radical scavenging mechanisms, a process by which phenolic compounds neutralize harmful free radicals in the body, play a crucial role in the antioxidant potential of palm sugars. The predominant acid present in the analyzed palm varieties was *p*-hydroxybenzoic acid. Additionally, ferulic acid and small amounts of *p*-coumaric acid were present. Gallic, vanillic, syringic, and catechuic acids are other phenolic compounds that are benzoic acid derivatives and were found in the analyzed palm varieties. Table 1 shows that the TLM and MNJ samples have high polyphenol contents. In addition, the results of the antioxidant activity analysis strengthened these results, indicating that the total polyphenol content contributes significantly to the antioxidant content in palm sap. The difference in the total polyphenols of each sample indicates that the composition of the palm sap is affected by many factors, such as its species, region of growth, and climatic conditions (Sarkar et al. 2023). Other research also suggested that soil conditions influence the polyphenol content (Oney-Montalvo et al. 2020).

Total polyphenols are the most significant contributors to the antioxidant activity in the samples. High polyphenol content will also increase the antioxidant activity of the samples. Based on the data, the IC₅₀ showed the ability of antioxidants to reduce radicals (DPPH), where the lowest values indicate that the sample has the strongest antioxidant activity. At the same time, the highest value on antioxidant activity showed the strongest antioxidant in the sample.

Other compositions also have another contribution to antioxidant activity, and vitamin C is one of them since palm sap also contains vitamin C (Hilda and Syarifuddin 2019).

Fourier Transform Infra-Red (FTIR)

FTIR spectroscopic analysis is an analytical method used to characterize a sample and determine its organic components, chemical bonds, and functional groups based on its infrared absorption (Victor 2015). The FTIR analysis of the palm sap samples was performed to identify the differences in functional groups in palm sap based on the location of the palm sap samples. The FTIR spectra of each sample are shown in Figure 5. This figure shows that the palm sap samples obtained from the various locations showed no differences between the samples, as can be seen from the functional groups. Each sample exhibited a peak spectrum at wave numbers 3,267.65-3,338.59 cm⁻¹ with strong and broad absorption, indicating a hydroxyl group (-OH) in palm sap components (Manurung et al. 2016). The wavelength of 3,338.59 cm⁻¹ showed the O-H stretching (Hassan et al. 2025). The absorption peaks that appear in an FTIR spectrum indicate changes caused by the degradation of complex compounds, which are accompanied by changes in a material's chemical and physical properties.

The FTIR spectrum showed changes in wavelength at wave numbers 2,811.99-2,883.98 cm⁻¹. The absorption at 2,900-2,800 cm⁻¹ indicated the presence of C-H bonds and aldehyde compounds in the palm sap samples (Barta et al. 2025). In the spectrum, an absorption peak was found in the wave number range 997.32-1,788.28 cm⁻¹. The absorption peaks in this wavenumber range indicated the presence of C-O double bonds (C=O), C-O, and C-H, indicating the presence of aldehydes, ketones, carboxylic acids, esters, amides, amihydrides, hydrochloric acid, alcohols, and alkenes in the palm sap samples (Barta et al. 2025).

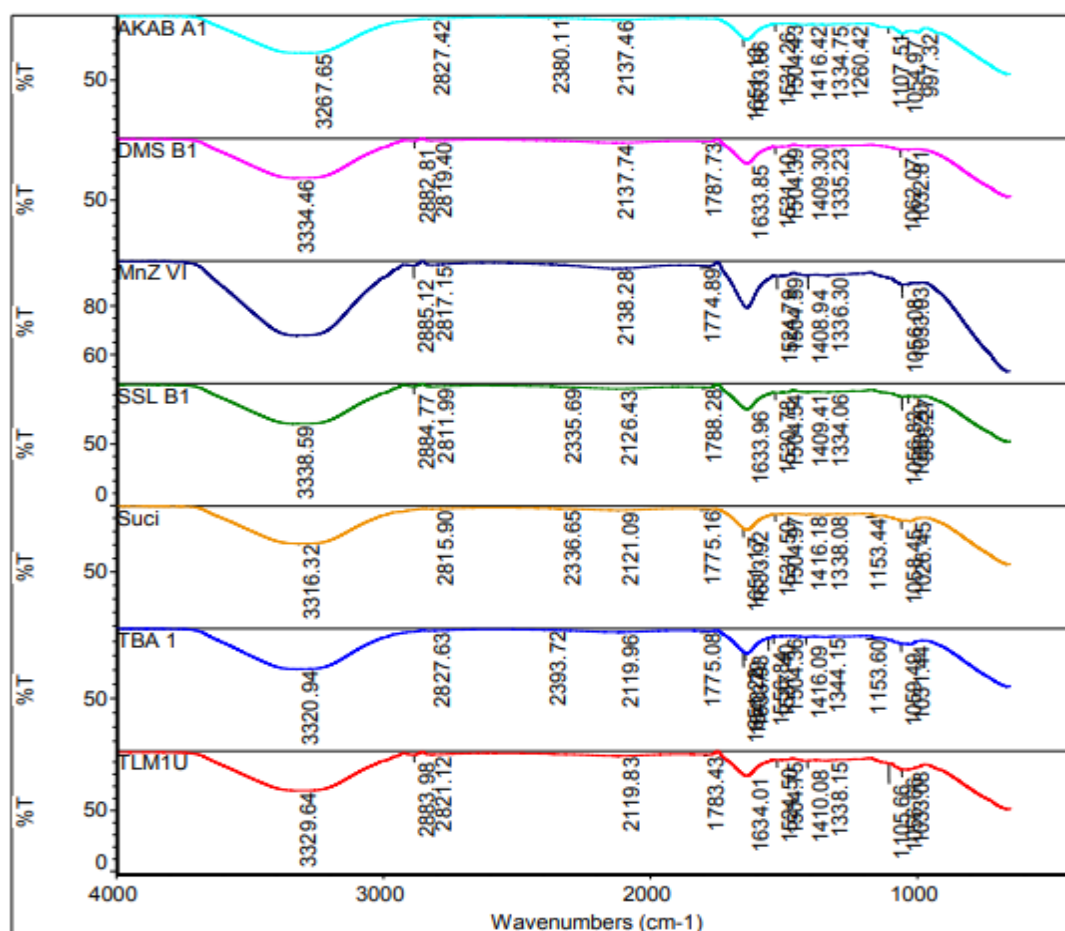


Figure 5. FTIR spectrum of palm sap from various locations

In conclusion, the color of the analyzed palm sap samples varied, with the color range of all samples being yellow-red, with Hue values of 75.21-88.72. The highest antioxidant activity was found in the MNJ sap samples, with values of 67.43% (at a concentration of 100 ppm), and the concentration of antioxidants in the palm sap samples increased as the sample concentration increased. The total polyphenol content in the palm sap samples also varied, with the lowest value in SSL C sample at 46.32 mg GAE/g and the highest in the TLM A sample at 571.11 mg GAE/g. The FTIR spectra showed the complexity of the chemical composition of the palm sap samples from various locations, characterized by the presence of functional groups, such as -OH, C=O, C-O, and C-H, showcasing the rich variety of organic compounds present in the sap, such as aldehydes, ketones, carboxylic acids, esters, amides, amihydrides, hydrochloric acid, alcohols, and alkenes. Based on the results of the present study, each location has its advantages, both in terms of the highest pH value and total sugar content obtained in the SSL and AKAB samples, respectively, the highest antioxidant activity obtained in the TLM and MNJ samples, and the highest total phenolic contents found in the DMS and TLM palm sap samples.

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