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Flavonoid and Alkaloid Content of Red Onion Skin Extract (*Allium cepa* L.)

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Abstract: Red onion skin (*Allium cepa* L.) is often discarded as waste, despite being rich in flavonoids and alkaloids, which possess antioxidant, anti-inflammatory, antimicrobial, and anticancer properties. This study aims to determine the flavonoid and alkaloid content of red onion skin extract using reflux and Soxhlet extraction methods with 96% ethanol as the solvent. The extraction was performed using reflux and Soxhlet techniques, followed by UV-Vis spectrophotometry to quantify flavonoid and alkaloid content. A quercetin standard curve was used to determine flavonoid levels, while a caffeine standard curve was applied for alkaloid content analysis. The Soxhlet method yielded a higher flavonoid content (108.21 mg/g or 10.82%) compared to the reflux method (105.55 mg/g or 10.55%). In contrast, the reflux method resulted in a higher alkaloid content (169.56 mg/g or 16.95%) than Soxhlet extraction (167.0 mg/g or 16.70%). These differences are attributed to the continuous solvent circulation in Soxhlet extraction, which enhances flavonoid solubility, while the lower temperature in the reflux method prevents alkaloid degradation. The findings suggest that Soxhlet extraction is more effective for flavonoid extraction, whereas reflux extraction is better for alkaloid extraction. Given their significant bioactive properties, red onion skin extracts have potential applications in the pharmaceutical, nutraceutical, and food industries. Future research should focus on optimizing extraction techniques and conducting toxicological and pharmacological studies to explore the therapeutic potential of red onion skin extract.

Keywords: Red onion skin; flavonoids; alkaloids; Soxhlet extraction; UV-Vis spectrophotometry.

Introduction

Red onion (*Allium cepa* L.) is one of the most widely cultivated and consumed agricultural commodities globally due to its distinctive flavor and nutritional benefits (Liguori *et al.*, 2017). Besides its culinary use, red onion skin is often considered waste, despite containing bioactive compounds such as flavonoids and alkaloids, which have various pharmacological activities, including antioxidant, anti-inflammatory, antimicrobial, and anticancer properties. Utilizing red onion skin as a natural source of bioactive compounds can add value to both the medical and industrial fields (Lu *et al.*, 2011). Flavonoids are a group of polyphenolic compounds known for their strong antioxidant activity. Studies have shown that red onion skin is rich in flavonoids, particularly quercetin and its derivatives, which play a role in neutralizing free radicals and reducing oxidative stress. For instance, research by Jabbari et al. (2021) optimized the extraction of quercetin from red onion skin waste using a combination of microwave and ultrasonic methods, achieving a quercetin recovery rate of 10.32%. Additionally, a study by Maryuni et al. (2021) identified 14 flavonoid compounds in red onion skin extract using LC-ESI-QTOF-MS/MS, confirming the abundance of flavonoids in red onion skin.

Alkaloids, nitrogen-containing organic compounds, have also been found in red onion skin and are known to possess various biological activities, including antimicrobial and anticancer effects. Although research on the alkaloid content in red onion skin remains limited, the presence of these compounds enhances its therapeutic potential.

Despite containing beneficial bioactive compounds, red onion skin is often underutilized and discarded as agricultural waste. Utilizing red onion skin as a natural antioxidant source not only helps reduce waste but also provides a sustainable alternative to synthetic antioxidants in the food and pharmaceutical industries (Slimestad *et al.,* 2017). Fahaj et al. (2024) reported that red onion skin extract exhibits potent antioxidant activity with an IC_{50} value of 29.9 ppm, highlighting its potential as a natural antioxidant source. Furthermore, compounds such as spiraeoside, extracted from red onion skin, have demonstrated anticancer activity by inducing apoptosis in HeLa cells and exhibiting significant enzyme inhibition effects (Sun *et al.*, 2017; Kim *et al.*, 2021). This suggests that red onion skin is not only beneficial as an antioxidant but also holds promise in the development of therapeutic agents for cancer treatment.

The utilization of red onion skin as a source of bioactive compounds also aligns with waste reduction efforts and the development of value-added products in the agricultural and pharmaceutical industries (Rangkadilok *et al.,* 2015). By optimizing extraction techniques and characterizing the bioactive compounds in red onion skin, as demonstrated by Jabbari et al. (2021), the potential applications of red onion skin can be expanded to various commercial fields, including food, cosmetics, and healthcare. This study aims to analyze the flavonoid and alkaloid content of red onion skin extract to determine its potential pharmacological applications. By investigating the concentration and composition of these compounds, the research seeks to highlight the importance of onion skin as a valuable natural resource. The findings of this study may provide a foundation for further research and potential commercial applications in medicine, food preservation, and cosmetic formulations.

Tools and Materials

Location and Time of Research

This research was conducted in November 2024. Red onion (*Allium cepa* L.) peel samples were obtained from Sigi Regency, Central Sulawesi.

Tools and Materials

The tools used in this research include a reflux apparatus, Soxhlet apparatus, UV-Vis spectrophotometer, beakers, 250 mL Erlenmeyer flask, 50 mL graduated cylinder, filter paper, spatula, stirring rod, dropper pipette, analytical balance, condenser, clamp stand, tubing, iron tripod, and spirit lamp/Bunsen burner.

The materials used in this research include red onion peel simplicia, solvents, 96% ethanol, distilled water, Na_2CO_3, $AlCl_3$, quercetin, caffeine, citric acid, glacial acetic acid, sodium phosphate, hydrochloric acid, chloroform, Liebermann-Burchard reagent, Mayer's reagent, Dragendorff's reagent, Bouchardat's reagent, NaOH, and 2N HCl.

Procedures

The first step is the preparation of red onion peel, which involves air-drying and grinding it into a fine powder. The extraction process is then carried out using reflux and Soxhlet methods with 96% ethanol as the solvent. After extraction, the solution undergoes an evaporation process to obtain a concentrated extract, followed by phytochemical screening. Finally, the flavonoid and alkaloid content in both extracts, obtained from different extraction methods, is determined using UV-Vis spectrophotometry.

Results and Discussion

This study employed phytochemical screening and the determination of flavonoid and alkaloid content using UV-Vis spectrophotometry on ethanol extracts of red onion skin (*Allium cepa* L.). The extraction results of red onion skin (*Allium cepa* L.) using reflux and Soxhlet methods with 96% ethanol as the solvent are presented in Table 1. The results of the phytochemical screening of red onion skin extract using the reflux and soxhlet methods can be seen in Table 2.

Table 1. The result of red onion skin extract

Code	Sample weight (g)	Thick extract weight (g)	Yield (%)
AC.1	550	45.53	7.59
AC.2	550	46.75	8.47

Explanation:
A: Red onion skin extracted using ethanol solvent with the reflux method.
B: Red onion skin extracted using ethanol solvent with the Soxhlet method.

The standard curve of quercetin was prepared using varying concentrations of 1, 3, 5, 7, and 9 ppm, measured at a maximum wavelength of 435 nm. The linear regression equation was obtained based on the absorbance data and the concentration of the quercetin standard solution. The resulting linear regression equation is Y = 0.0046x + 0.0232, with a correlation coefficient (r) of 0.9975. The sample absorbance was then inserted into this linear regression equation. The results of flavonoid content determination using 96% ethanol solvent on red onion skin with UV-Vis spectrophotometry can be seen in Table 3.

Table 2. The result of the phytochemical screening of red onion skin extract

Method	Compounds phytochemicals	Observation results	Test results
Reflux	Flavonoid	Yellow precipitate	(+)
	Alkanoid	Brown precipitate	(+)
	Tannin	Bluish black	(+)
	Saponin	Foamy/Bubbles	(+)
Soxhlet	Flavonoid	Yellow precipitate	(+)
	Alkanoid	Brown precipitate	(+)
	Tannin	Bluish black	(+)
	Saponin	Foamy/Bubbles	(+)

Description: (+) Positive (Contains the tested compound), (-) Negative

Table 3. Result of the determination of flavonoid content in red onion skin

Methods	Replication	Absorbance	Total flavonoid content (mg/g)	Average (mg/g)	Flavonoid content (%)
Reflux	1	0.0787	107.33	107.34	10.73
	2	0.0784	107.45		
	3	0.0783	107.24		
Soxhlet	1	0.0892	108.12	108.89	10.88
	2	0.0815	108.86		
	3	0.0815	109/69		

The standard curve of quercetin was prepared using varying concentrations of 1, 3, 5, 7, and 9 ppm, measured at a maximum wavelength of 273 nm. The linear regression equation was obtained based on the absorbance data and the concentration of the caffeine standard solution. The resulting linear regression equation is Y = 0.0219x + 0.0028, with a correlation coefficient (r) of 0.9974. The sample absorbance was then inserted into this linear regression equation. The results of alkaloid content determination in 96% ethanol extract of red onion skin, using UV-Vis spectrophotometry, can be seen in Table 4.

Table 4. The result of the determination of alkaloid content in red onion skin

Methods	Replication	Absorbance	Total flavonoid content (mg/g)	Average (mg/g)	Flavonoid content (%)
Reflux	1	0.4575	169.0	169.56	16.95
	2	0.4574	169.8		
	3	0.4577	169.9		
Soxhlet	1	0.4582	168.8	167.0	16.70
	2	0.4679	164.0		
	3	0.4583	168.2		

The results of this test showed that the total alkaloid content in the ethanol extract of red onion skin, using the reflux and Soxhlet methods, was 157.5 mg/g (15.75%) and 159.3 mg/g (15.93%) of the extract, respectively.

Discussion

This study compares the flavonoid and alkaloid content in red onion skin (*Allium cepa* L.) extract using two extraction methods: reflux and Soxhlet extraction, with 96% ethanol as the solvent. The results indicate that both methods effectively extract bioactive compounds; however, there are variations in the flavonoid and alkaloid yields depending on the extraction technique. The extraction method significantly influences the yield of bioactive compounds. As presented in the results, the Soxhlet extraction method produced a higher flavonoid content than the reflux method. The average flavonoid content obtained via Soxhlet extraction was 108.21 mg/g (10.82%), whereas the reflux method yielded 105.55 mg/g (10.55%). These findings suggest that Soxhlet extraction is more efficient for extracting flavonoids from red onion skin. This difference can be attributed to the working principle of each method. Soxhlet extraction allows for continuous solvent circulation through the sample, enhancing solubility and diffusion of active compounds (Azwanida, 2015). In contrast, reflux extraction is less efficient because the solvent does not continuously recirculate after the initial extraction.

In addition to flavonoids, this study also measured the alkaloid content in red onion skin extract. The results indicate that the reflux method produced a slightly higher alkaloid content (169.56 mg/g or 16.95%) compared to Soxhlet extraction (167.0 mg/g or 16.70%). Although the difference is minimal, this suggests that the reflux method is more effective for alkaloid extraction.This can be explained by the thermal stability of alkaloids. Alkaloids are generally more stable at lower to moderate temperatures (Dai & Mumper, 2010; Rodríguez *et al.*, 2016; Yoo *et al.*, 2020). Since reflux extraction operates at a lower temperature compared to Soxhlet extraction, it may prevent alkaloid degradation, resulting in a higher alkaloid content in the final extract.

Red onion skin is often regarded as waste; however, this study confirms that it is rich in bioactive compounds with potential pharmaceutical and food industry applications. Flavonoids, particularly quercetin, are well known for their antioxidant, anti-inflammatory, and anticancer activities (Boots et al., 2008; Benítez *et al.*, 2021). Therefore, red onion skin extract could be developed as a natural ingredient for herbal medicine, dietary supplements, and functional food products. Furthermore, the high alkaloid content in the extract suggests its potential use as an antimicrobial and anticancer agent. Previous studies have demonstrated that alkaloids from various plant sources exhibit cytotoxic effects against cancer cells (Kam et al., 2016). As a result, red onion skin could be explored as a natural candidate for therapeutic applications.

Based on these findings, Soxhlet extraction is more suitable for flavonoid extraction, while reflux extraction is more effective for alkaloid extraction. The choice of extraction method should align with the primary research objective or industrial application.Future research should focus on optimizing extraction conditions by integrating advanced techniques, such as ultrasound-assisted extraction or enzyme-based extraction, to maximize the yield of flavonoids and alkaloids. Additionally, toxicological and biological studies are necessary to evaluate the efficacy of red onion skin extract for various clinical and industrial applications.

Conclusion

This study confirms that red onion skin (*Allium cepa* L.) is a rich source of flavonoids and alkaloids, with Soxhlet extraction being more effective for flavonoid extraction and reflux extraction yielding higher alkaloid content. These bioactive compounds have antioxidant, anti-inflammatory, and antimicrobial properties, making red onion skin extract a promising candidate for pharmaceutical and functional food applications. Further research is needed to optimize extraction methods and evaluate its therapeutic potential.

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