

## PHYTOCHEMICAL EXPLORATION OF TURMERIC AND ETHNOPHARMACY IN BENGKALA VILLAGE FOR DIABETES PREVENTION AS A SUPPLEMENT TO PHARMACOGNOSY INSTRUCTION AT VOCATIONAL HIGH SCHOOLS

Putri Layani Gea<sup>1\*</sup>, I Nyoman Tika<sup>2</sup>, Siti Maryam<sup>3</sup>

<sup>1,2,3</sup>Kimia, Universitas Pendidikan Ganesha, Singaraja, Indonesia

E-mail: putrilgea@gmail.com

\* Corresponding Author

### ABSTRACT

Pharmacognosy instruction at vocational high schools specializing in pharmacy generally still focuses on theoretical concepts and does not yet sufficiently link the material to the practical use of medicinal plants in the students' local communities. This study aims to describe the ethnopharmaceutical practices of turmeric (*Curcuma longa* L.) processing in Bengkala Village, examine the phytochemical composition of turmeric based on a literature review, and integrate these findings as a supplement to pharmacognosy instruction grounded in local knowledge. The study employed a descriptive qualitative approach with data collection techniques including observation, interviews, documentation, literature review, and descriptive organoleptic testing of turmeric-based herbal drinks. The results showed that the community in Bengkala Village processes turmeric into traditional herbal drinks through the steps of washing, grinding, boiling, and straining. The results of the organoleptic test showed that turmeric loloh has a brownish-yellow color (64.1%), a characteristic turmeric aroma (69.2%), a predominantly moderately bitter taste (40.5%), a thin texture (60.0%), and an aftertaste (42.4%) that was still acceptable to the panelists. A literature review indicates that turmeric rhizomes contain secondary metabolites such as curcuminoids, flavonoids, essential oils, and tannins, which have the potential for antioxidant and anti-inflammatory activity and may support blood glucose control. These ethnopharmaceutical findings and phytochemical studies were subsequently integrated into pharmacognosy course materials covering.

**Keywords:** *Curcuma longa* L., diabetes mellitus, ethnopharmacy, phytochemistry, pharmacognosy learning

### INTRODUCTION

Diabetes mellitus is a health problem that continues to rise both globally and nationally. This disease is a chronic metabolic disorder characterized by elevated blood glucose levels (hyperglycemia) resulting from impaired insulin secretion, impaired insulin action, or a combination of both (Widagdo, dkk, 2024). A 2023 report from the World Health Organization (WHO) shows that the number of people with diabetes worldwide continues to rise and is estimated to have reached approximately 422 million (Sari, dkk, 2024).

According to the 2021 International Diabetes Federation (IDF) Atlas, approximately 10.5% of the global adult population aged 20–79 lives with diabetes, and nearly half of that number remains undiagnosed. This figure is projected to continue rising, reaching approximately 783 million cases by 2045—equivalent to one in eight adults worldwide—representing an increase of about 46%. In Indonesia alone, the number of people with

diabetes places the country among the top five in the world, with approximately 19.5 million cases in 2021 and an estimated increase to 28.6 million cases by 2045 (Mediakom, 2024). Most of these cases—more than 90%—are type 2 diabetes mellitus, which is influenced by various factors such as socioeconomic status, demographics, the environment, and genetics (Sun et al., 2023).

This disease not only affects patients' health but also imposes a significant economic burden because it requires long-term treatment and can potentially lead to various microvascular complications such as nephropathy, neuropathy, and retinopathy (Hardjalukita, 2024). Modern treatments such as insulin and oral hypoglycemic agents have indeed been proven effective in controlling blood glucose levels, but long-term use is often associated with certain side effects, the potential for dependence, and relatively high treatment costs (Halomoan, 2022). In addition, some patients also experience burnout from undergoing long-term treatment, which can affect their adherence to their medication regimen (Fandinata & Darmawan, 2020).

These circumstances have led some people to consider using alternative treatments to complement conventional medical therapy, one of which is through the use of traditional medicinal plants that have long been used in community healing practices (Yosia, dkk, 2021). Medicinal plants are part of local medical knowledge that has been passed down from generation to generation and are used in various forms of traditional remedies. However, the level of utilization of medicinal plants in the community remains relatively low. Rizki, dkk, (2021) reported that the use of traditional medicinal plants for therapeutic purposes is only about 24.6%. This low utilization rate is influenced by various factors, including the public's limited knowledge of the benefits of medicinal plants, a lack of skills in preparing herbal remedies on their own, and limited access to raw materials. Nevertheless, traditional herbal medicines still have advantages because they are relatively safer, easily obtainable, and have been widely used in traditional medical practices (Karita et al., 2022; Nursanti, dkk, 2023).

One area that still preserves the practice of traditional medicine based on medicinal plants is Bengkala Village, located in Kubutambahan Subdistrict, Buleleng Regency, Bali. The community in this village still practices ethnopharmacy—the use of traditional herbal remedies based on local wisdom through the traditional Balinese healing system known as *usada*. The existence of these traditional healing practices is also supported by government regulations that recognize and protect traditional medicine as part of the nation's cultural heritage (Dewi, 2023).

In the Balinese *Usada* tradition, various natural substances are used as medicinal ingredients and are categorized based on their source, such as plants (*taru pramana*), animals (*sato pramana*), water (*toya pramana*), and energy or non-physical elements (*bayu pramana*) (Suatama, 2021). One well-known traditional remedy in Bengkala Village is *loloh*, a herbal drink made from various medicinal plants. One type of *loloh* widely consumed by the local community is a turmeric-based herbal drink known as *Sari Kunyit Bengkala*. This remedy, derived from turmeric rhizomes (*Curcuma longa* L.), is traditionally believed to

offer various benefits, such as helping to maintain the body's immune system, supporting digestive health, and possessing antioxidant and anti-inflammatory properties.

In addition to being used as a traditional medicinal ingredient, turmeric is also widely cultivated by the residents of Bengkala Village as a biopharmaceutical plant with economic value. This plant is processed in various forms, including as a fresh ingredient, dried crude drug, and traditional herbal beverage. Turmeric production in this region indicates that there is significant potential in local resources for further development (Arifin, dkk, 2022).

Although turmeric has been used as a traditional remedy by local communities for generations, scientific studies specifically documenting the ethnopharmaceutical practices of the people of Bengkala Village remain limited, particularly those related to its use in diabetes prevention. In fact, this local knowledge has great potential to be developed as a contextual learning resource in pharmacy education, particularly in pharmacognosy courses at vocational high schools specializing in pharmacy. The integration of traditional knowledge and scientific research can not only enrich the curriculum but also play a role in preserving local wisdom and opening up opportunities for the sustainable use of local resources.

However, to date, there has been little research that systematically examines the relationship between traditional turmeric processing practices and scientific studies on the phytochemical content of turmeric rhizomes, as well as their potential as a learning resource in the field of pharmacognosy. As a result, the local knowledge that has developed within the community has not yet been scientifically documented and has not been optimally utilized in the learning process at vocational high schools specializing in pharmacy.

Given this background, there is a need for research that integrates the community's ethnopharmaceutical practices with scientific studies on the phytochemical composition of turmeric (*Curcuma longa* L.). The results of this study are expected to be developed into relevant, context-based teaching materials to support pharmacognosy education at vocational high schools specializing in pharmacy. Therefore, this study aims to: (1) describe the ethnopharmaceutical practices of turmeric processing in Bengkala Village, (2) examine the phytochemical composition of turmeric (*Curcuma longa* L.) based on a literature review and describe the organoleptic characteristics of turmeric-based herbal drinks through organoleptic testing, and (3) integrate the results of this exploration as a supplement to pharmacognosy instruction at vocational high schools specializing in pharmacy.

## **METHODS**

This study employed a descriptive qualitative approach. Primary data were collected through observation and interviews with turmeric loloh artisans in Bengkala Village, while secondary data were obtained through a literature review. Data collection was conducted through observation of the processing, semi-structured interviews, documentation, and a review of the literature on the phytochemical content of turmeric. In addition, an organoleptic test of turmeric loloh was conducted using 30 participants to assess color,

aroma, taste, and texture. The data were analyzed descriptively through data reduction, data presentation, and concluding.

## RESULTS AND DISCUSSION

### Result

Based on the results of observations and interviews, the preparation of turmeric drink begins by thoroughly washing fresh turmeric rhizomes, then grinding and straining them to extract the turmeric juice. The turmeric juice is then boiled with water, and in some cases, sugar and acid are added to enhance the flavor. Once the boiling process is complete and the drink has cooled, the turmeric drink is stored in an appropriate container. Interview results also indicate that turmeric drink has long been used by the community as a herbal beverage to maintain health, aid digestion, and serve as a complementary drink for people with diabetes mellitus. This use is part of the traditional knowledge passed down through generations in Balinese traditional medicine (*usada*).

The literature identification for this study was conducted using the Systematic Literature Review (SLR) method in accordance with the PRISMA 2020 guidelines. Articles obtained from various databases were selected through the identification, screening, and eligibility assessment stages based on predetermined criteria. The selection results showed that 14 articles met the criteria for further analysis.

Table 1: Results of the Article Review

No.	Autor (Year)	Main Compound	Key Findings	Mechanism
1.	Mokgalaboni et al. (2024)	Curcumin	Reduced FBG by -11.48 mg/dL and HbA1c by -0.54% in T2DM	AMPK activation; NF-κB inhibition; anti-inflammatory and antioxidant effects
2.	Baniasadi et al. (2025)	Curcumin	Improving insulin sensitivity and anthropometric indices in prediabetes and T2DM	Modulation of glucose metabolism; increased insulin sensitivity; antioxidant effects
3.	Reisa et al. (2023)	Nano-curcumin	FBG decreased by -22.3 mg/dL; HbA1c decreased by -0.8%; CRP decreased	AMPK activation; NF-κB inhibition; anti-inflammatory
4.	Chun et al. (2026)	Curcumin + piperine	Reduces FBG by -18.7 mg/dL; bioavailability ↑ 2000%	Increased bioavailability; increased GLUT-4; piperine synergy
5.	Yaikwawon et al. (2024)	Curcumin	12-Month RCT: Improved Glycemic Control in T2DM	Improved insulin sensitivity; long-term effects

No.	Autor (Year)	Main Compound	Key Findings	Mechanism
6.	Wu et al., (2024)	Curcuminoids, omics	Phytochemistry & omics: identification of bioactive properties	Multi-target: antidiabetic, anti-inflammatory, antioxidant
7.	Tian et al., (2025)	Turmeron, zingiberene (terpenoid)	Identifies active metabolites; reduces LDL by 25%	Modulation of lipid and glucose metabolism; regulation of metabolites
8.	Mardianis dkk. (2017)	Curcumin, quercetin (flavonoids)	72% $\alpha$ -glucosidase inhibition; high antioxidant activity	$\alpha$ -glucosidase inhibition; inhibition of carbohydrate digestion
9.	Roney et al. (2025)	Turmeric Powder (Curcuminoids, flavonoids)	Inhibisi $\alpha$ -amylase & $\alpha$ -glucosidase 68% & 72% in vitro	Inhibition of carbohydrate-digesting enzymes
10.	Dinanti Kesuma (2022)	Curcumex (kurkuminoids)	RCT on T2DM: improvement in metabolic parameters	Increased insulin sensitivity; anti-inflammatory
11.	Stefano et al. (2022)	Curcumin	GLUT-4 $\uparrow$ 2,8x; glucose uptake $\uparrow$ 45%	GLUT-4 translocation; AMPK activation
12.	Zohreh et al. (2019)	Turmeric powder (kurkuminoids)	RCT on hyperlipidemic T2DM: improvement in lipid profile	Hypocholesterolemic; lipid modulation
13.	Batani et al. (2022)	Curcumin Nanomicelles	CRP levels decrease in T2DM	Anti-inflammatory; inhibition of NF- $\kappa$ B
14.	Xiaolu Li, (2021)	Curcumin	ROS $\downarrow$ ; iNOS activity $\downarrow$ 40%	Antioxidants; ROS scavengers

In general, the antidiabetic mechanisms identified in various studies include activation of the AMP-activated protein kinase (AMPK) pathway, increased translocation of Glucose Transporter Type 4 (GLUT-4), increased insulin sensitivity, inhibition of the inflammatory factor Nuclear Factor kappa B (NF- $\kappa$ B), antioxidant activity through the scavenging of reactive oxygen species (ROS), and inhibition of the carbohydrate-digesting enzymes  $\alpha$ -amylase and  $\alpha$ -glucosidase. These mechanisms contribute to a reduction in blood glucose levels, improvement in insulin resistance, protection of pancreatic  $\beta$ -cells, and prevention of complications associated with type 2 diabetes mellitus.

To supplement the research data, a descriptive organoleptic test was conducted to determine the sensory characteristics of turmeric paste prepared by the residents of Bengkala Village. The test involved 30 untrained adult panelists from the local community. The panelists' evaluations of each sensory parameter are presented in the organoleptic test results diagram.



Figure 1. Diagram of Organoleptic Test Results for Color Parameters

Based on Figure 1, the majority of panelists (64.1%) rated the color of the turmeric extract as brownish-yellow. A total of 20.5% of panelists rated it bright yellow, and 15.4% yellowish brown. No panelists rated the color as cloudy or in any other category.

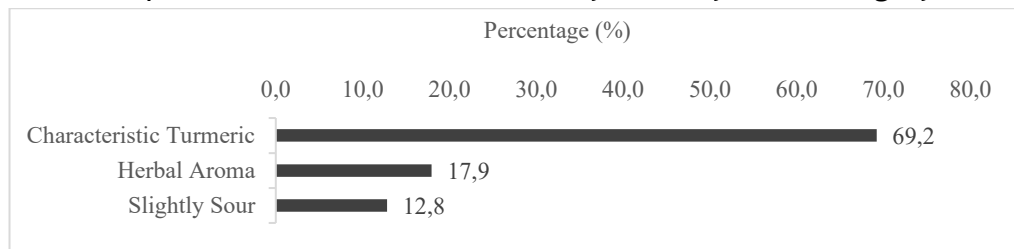


Figure 2. Diagram of Organoleptic Test Results for Aroma Parameters

Based on Figure 2, the majority of panelists rated the aroma of turmeric decoction as falling into the “distinctive turmeric” category, accounting for 69.2% (27 panelists). Furthermore, 17.9% of the panelists (7 people) rated the aroma of turmeric juice as herbal, while 12.8% of the panelists (5 people) noted a slight sour aroma. No panelists rated the aroma as odorless or assigned it to any other category.

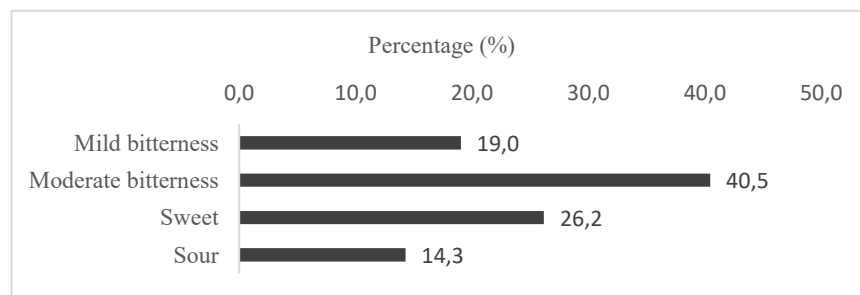


Figure 3. Diagram of Organoleptic Test Results for Taste Parameters

Based on Figure 3, the flavor category most frequently selected by the panelists was “moderately bitter,” at 40.5% (17 panelists). Next, 26.2% of the panelists (11 people) rated the turmeric paste as having a sweet taste, 19.0% of the panelists (8 people) detected a mild bitterness, and 14.3% of the panelists (6 people) noted a sour taste. No panelists provided ratings for any other categories.

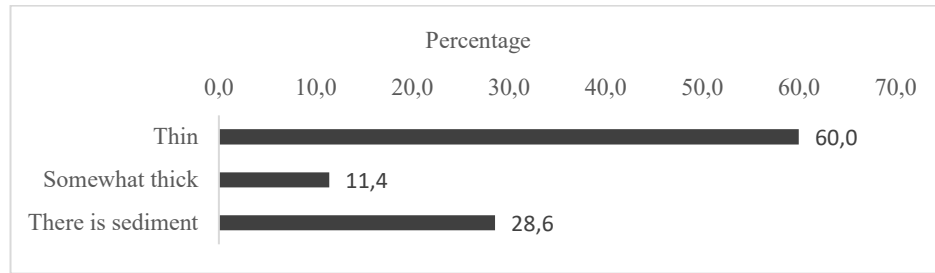


Figure 4. Diagram of Organoleptic Test Results for Texture/Consistency Parameters

Based on Figure 4, most panelists rated the texture of the turmeric drink as “thin,” accounting for 60.0% (21 panelists). Furthermore, 28.6% of the panelists (10 people) reported the presence of sediment, while 11.4% of the panelists (4 people) rated the texture of the turmeric drink as somewhat thick. No panelists rated the texture as thick or in any other category.

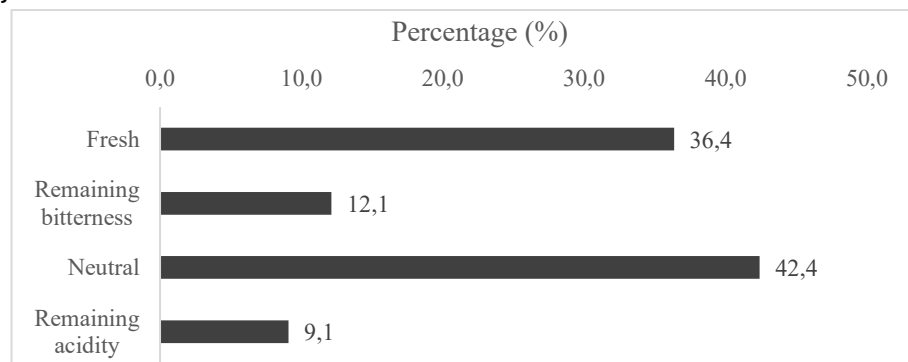


Figure 5: Diagram of Organoleptic Test Results for the Aftertaste Parameter

Based on Figure 5, most panelists rated the aftertaste of the turmeric drink as neutral, accounting for 42.4% (14 panelists). Furthermore, 36.4% of the panelists (12 people) experienced a refreshing sensation after consuming the turmeric drink. Some of the other panelists reported a lingering bitter taste (12.1%, or 4 people) and a lingering sour taste (9.1%, or 3 people). No panelists rated the drink in any other category.

## Discussion

### 1. Ethnopharmaceutical Practices Involving Turmeric in Bengkala Village

The processing of turmeric tea found in Bengkala Village indicates that ethnopharmaceutical practices are still upheld by the local community. The production stages—which include washing, grinding, straining, and boiling—are simple processes aimed at obtaining turmeric extract ready for consumption as a herbal drink. The addition of sugar and acid in some processing practices indicates an adjustment to the flavor without compromising its primary purpose as a traditional beverage. The research findings also indicate that the use of turmeric drink is not only related to cultural aspects but also to efforts to maintain public health. Turmeric drink is believed to help maintain physical health, aid digestion, and is used as a complementary beverage for people with diabetes

mellitus. This belief aligns with the concept of traditional Balinese medicine (*usada*), which utilizes local natural resources as part of preventive and health-promoting efforts.

Knowledge regarding the use of turmeric as a herbal remedy has been passed down from generation to generation, and its continued existence reflects local wisdom that remains well-preserved. These findings indicate that the ethnopharmaceutical practices of the Bengkala Village community not only play a role in preserving traditional health culture but also have the potential to serve as a source of information for scientific research on the use of turmeric as a herbal remedy to support health.

## **2. A Phytochemical Study of Turmeric and Its Antidiabetic Potential**

The results of a systematic literature review indicate that *Curcuma longa* L. contains various phytochemical compounds that may support antidiabetic activity, particularly curcuminoids, flavonoids, phenolic compounds, terpenoids, and essential oil components. Based on 14 articles that met the inclusion criteria, curcumin is the compound most frequently reported to contribute to antihyperglycemic activity through various biological mechanisms. The antidiabetic mechanisms identified in various studies include activation of AMP-activated protein kinase (AMPK), increased translocation of Glucose Transporter Type 4 (GLUT-4), increased insulin sensitivity, inhibition of Nuclear Factor kappa B (NF- $\kappa$ B), antioxidant activity through the scavenging of Reactive Oxygen Species (ROS), and inhibition of the enzymes  $\alpha$ -amylase and  $\alpha$ -glucosidase. These mechanisms contribute to lowering blood glucose levels, improving insulin resistance, protecting pancreatic  $\beta$ -cells, and reducing the risk of complications from type 2 diabetes mellitus.

These findings support the traditional use of turmeric tea by the residents of Bengkala Village as a complementary herbal beverage to maintain health and assist people with diabetes mellitus. Although this practice stems from traditional knowledge passed down through generations, a review of the literature reveals a scientific basis for the pharmacological potential of turmeric in controlling blood glucose levels.

## **3. Organoleptic Test of Turmeric Paste**

The results of the organoleptic test show that the turmeric paste produced by the residents of Bengkala Village has distinctive sensory characteristics. The product's color falls predominantly into the brownish-yellow category; it has a characteristic turmeric aroma, a moderately bitter taste, a relatively thin texture, and a generally neutral aftertaste. These characteristics reflect the use of turmeric rhizomes as the main ingredient, as well as the traditional processing methods employed by the community.

The predominance of a brownish-yellow color is believed to be related to the presence of curcuminoids, which are the primary pigments in turmeric. The distinctive aroma of turmeric detected by most panelists indicates that the volatile components of the essential oil remain detectable even after boiling. Meanwhile, the moderate bitterness most frequently selected by the panelists likely stems from turmeric's bioactive compounds, while the sweet and sour flavors also detected are associated with the addition of supporting ingredients during the *loloh* preparation process. The relatively thin texture suggests that the processing was carried out using water-based extraction. The

presence of a small amount of sediment reported by some panelists likely stems from fine particles of turmeric rhizome that were not completely filtered out. Additionally, most panelists rated the aftertaste of the turmeric loloh as neutral to refreshing after consumption. Overall, the organoleptic test results show that turmeric loloh possesses sensory characteristics consistent with those of traditional herbal beverages and is well-received by the panelists.

#### 4. Integration of Findings into the Concept of Pharmacognosy

The results of this study indicate that the ethnopharmaceutical practices of the Bengkulu Village community, the phytochemical composition of turmeric, and the organoleptic characteristics of turmeric decoction are relevant to the pharmacognosy curriculum at vocational high schools specializing in pharmacy. Findings regarding the use of turmeric rhizomes as a traditional medicinal ingredient can be used to introduce the concept of plant-based crude drugs, while the process of making turmeric decoction can serve as an example of applying a simple extraction method using water as a solvent (decoction). Additionally, the results of the phytochemical analysis, which indicate the presence of curcuminoids, flavonoids, and essential oils, can be used to explain the concept of secondary metabolites in medicinal plants and their biological activities.

The organoleptic characteristics of turmeric paste—including color, aroma, taste, texture, and aftertaste—can also serve as examples of simple quality testing methods for natural materials and herbal products. Integrating these research findings provides a more contextual learning experience, as students can connect pharmacognosy concepts with the practical use of medicinal plants in their communities. The implementation of this local wisdom-based learning aligns with the learning outcomes for Pharmacognosy at vocational high schools specializing in pharmacy, which emphasize an understanding of crude drugs, secondary metabolites, herbal preparations, and the processing of natural materials. A mapping of the research results to the Pharmacognosy curriculum is presented in Table 2 below:

Table 2. Integration of Research Findings into Pharmacognosy Curriculum Materials at Vocational High Schools for Pharmacy

Research Findings	The Concept of Pharmacognosy	Forms of Learning Activities
The use of fresh turmeric rhizomes	Identification of herbal crude drugs	Morphological observations and characteristics of turmeric rhizomes
Boiling turmeric paste	Simple extraction using the decoction method	Laboratory Experiment on the Preparation of Turmeric Rhizome Water Extract
Curcuminoids, flavonoids, and essential oils	Secondary metabolites of medicinal plants	Discussion of Compound Classes and Biological Activities

Research Findings	The Concept of Pharmacognosy	Forms of Learning Activities
Organoleptic characteristics of turmeric paste	Organoleptic testing of natural ingredients and herbal products	Laboratory exercise on observing color, aroma, taste, and texture
The Use of Turmeric as a Traditional Remedy	Ethnopharmacy	A case study on the use of medicinal plants based on local traditional knowledge

## CONCLUSION

The ethnopharmaceutical practices of the Bengkala Village community in utilizing turmeric rhizomes (*Curcuma longa* L.) are carried out through the traditional processing of turmeric decoction, which involves washing, grinding, straining, and boiling. These practices represent a form of local knowledge that has been passed down from generation to generation and is still preserved by the community to this day.

A literature review indicates that turmeric rhizomes contain secondary metabolites such as curcuminoids, flavonoids, essential oils, and tannins, which may possess antioxidant and anti-inflammatory properties and support blood glucose control. Organoleptic test results show that turmeric decoction has a brownish-yellow color, a characteristic turmeric aroma, a moderately bitter taste, a thin texture, and a generally neutral aftertaste.

The research findings can be integrated into pharmacognosy instruction at vocational high schools specializing in pharmacy through topics such as plant-based crude drugs, secondary metabolites of medicinal plants, ethnopharmacy, organoleptic testing, and simple extraction methods. This integration has the potential to support a more contextual approach to pharmacognosy instruction that is grounded in local knowledge.

## REFERENCES

- Arifin, M., Ahmad, Y. R., Hartato, M., Utami, D. H., & Paramitasari, A. (2022). Pemberdayaan masyarakat bisu tuli: Studi kasus program KEM Bengkala PT Pertamina DPPU Ngurah Rai. *Indonesian Journal For Social Responsibility*, 4(2), 115–129. <https://doi.org/10.36782/ljsr.V4i02.138>
- Baniasadi, M. M., Arzhang, P., Setayesh, A., Moradi, M., & Nasli-Esfahani, E. (2025). The effect of turmeric/curcumin supplementation on anthropometric indices in subjects with prediabetes and type 2 diabetes mellitus: A GRADE-assessed systematic review and dose-response meta-analysis of randomized controlled trials. *Nutrition & Diabetes*, 15(1), 34. <https://doi.org/10.1038/s41387-025-00386-7>.
- Bateni, Z., Behrouz, V., Rahimi, H. R., Hedayati, M., Afsharian, S., & Gholami, S. (2022). Effects of nano-curcumin supplementation on oxidative stress, systemic inflammation, adiponectin, and NF-kb in patients with metabolic syndrome: A randomized, double-blind clinical trial. *Journal of Herbal Medicine*, 32, 100531. <https://doi.org/10.1016/j.hermed.2021.100531>
- Dewi, A. A. I. B. P. (2023). Etnokimia tanaman obat tradisional Bali untuk penyakit hipertensi

- sebagai suplemen materi pembelajaran farmakognosi di SMK Farmasi.
- Dinanti, F. K. (2022). *Pengaruh kombinasi metformin dan ekstrak kunyit terhadap kadar HDL, TNF- $\alpha$ , dan interleukin-6* [Master's thesis, Universitas Islam Sultan Agung Semarang]. Repository Unissula. <https://repository.unissula.ac.id/25210/>
- Fandinata, S. S., & Darmawan, R. (2020). Pengaruh kepatuhan minum obat oral antidiabetik terhadap kadar gula darah pada pasien diabetes melitus tipe II. *Jurnal Bidang Ilmu Kesehatan*, 10(1), 23–31. <https://doi.org/10.52643/jbik.v10i1.825>
- Halomoan Michael Sintong. (2022). Efek Samping Dan Interaksi Obat Insulin Regular. *Alomedika*. <https://General.Alomedika.Com/Obat/Anti-Diabetes-Parenteral/Insulin-Regular/Interaksi-Dan-Efek-Samping>
- Mardianis, Y., Anwar, C., & Haryadi, W. (2017). Sintesis analog kurkumin monoketon berbahan dasar sinamaldehida dan uji aktivitasnya sebagai inhibitor enzim  $\alpha$ -glukosidase. *Jurnal Farmasi*, 6(2), 123–132.
- Mokgalaboni, K., Mashaba, R. G., & Phoswa, W. N. (2024). Curcumin attenuates hyperglycemia and inflammation in type 2 diabetes mellitus: Quantitative analysis of randomized controlled trial. *Nutrients*, 16(23), 4177. <https://doi.org/10.3390/nu16234177>
- Pan, C., Wang, S., Yang, Y., Hu, J., & Pan, Y. (2026). Curcumin-piperine supplementation modulates inflammation, oxidative stress, and cardiometabolic risk: A systematic review of randomized controlled trials. *Frontiers in Nutrition*, 13, 1814168. <https://doi.org/10.3389/fnut.2026.1814168>
- Reisa, D. C. M. V., Alvarenga, L., Cardozo, L. F. M. F., Baptista, B. G., Fanton, S., Paiva, B. R., ... & Mafra, D. (2023). Can curcumin supplementation break the vicious cycle of inflammation, oxidative stress, and uremia in patients undergoing peritoneal dialysis? *Clinical Nutrition ESPEN*, 58, 293–301. <https://doi.org/10.1016/j.clnesp.2023.11.015>
- Rizki Amelia AP, A., Lindawati, & Afrianty Gobel, F. (2021). Perilaku Pemanfaatan Tanaman Obat Tradisional di Masa Pandemi Covid-19 pada ASN di Dinas Kesehatan Provinsi Sulawesi Utara. *Jurnal Ilmiah Kesehatan Diagnosis*, 16, 11.
- Sari, P. L., Abbas, A., & Jayanti, K. D. (2024). Faktor yang Berhubungan dengan Kejadian Diabetes Mellitus Pada Wanita di Desa Jajar Kabupaten Kediri Factors Associated with the Incidence of Diabetes Mellitus in Women in Jajar Village , Kediri Regency. *Jurnal Riset Pengembangan Dan Pelayanan Kesehatan*, 3(2), 8–22.
- Stefano, E., Muscella, A., Benedetti, M., Castro, F. De, & , Francesco Paolo Fanizzi, S. M. (2022). Antitumor and antimigration effects of a new Pt compound on neuroblastoma cells. *Sciencedirect*. <https://doi.org/https://doi.org/10.1016/j.bcp.2022.115124>
- Suatama, I. B. (2021). *Usada Bali Modern*. AGLitera Publishing – Yogyakarta, 212. <https://doi.org/10.31142/ijahm/v10i6.04>
- Sun, H., Saeedi, P., Karuranga, S., Pinkepank, M., Ogurtsova, K., Duncan, B. B., ... Magliano, D. j. (2023). Erratum untuk “IDF Diabetes Atlas: Estimasi prevalensi diabetes global,

- regional, dan tingkat negara untuk tahun 2021 dan proyeksi untuk tahun 2045.”  
*Penelitian Diabetes Dan Praktik Klinis.*  
<https://www.sciencedirect.com/science/article/pii/S0168822723007088>
- Tian, W. W., Liu, L., Chen, P., Yu, D. M., Li, Q. M., Hua, H., & Zhao, J. N. (2025). *Curcuma Longa* ( turmeric ): from traditional applications to modern plant medicine research hotspots. *Chinese Medicine*. <https://doi.org/10.1186/s13020-025-01115-z>
- Widagdo, W., Mumpuni, & Tambun, Y. M. (2024). *Diabetes Mellitus Dan Remaja* :
- Wu, X., Wu, J., Dai, T., Wang, Q., Cai, S., Wei, X., ... Jiang, Z. (2024). b -elemene promotes miR-127-3p maturation , induces NSCLCs autophagy , and enhances macrophage M1 polarization through exosomal communication. *Journal of Pharmaceutical Analysis*, 14(9), 100961. <https://doi.org/10.1016/j.jpha.2024.03.002>
- Xiaolu Li, Nicholas J. Day, Song Feng, Matthew J. Gaffrey, Tai-Du Lin, Vanessa L. Paurus, Matthew E. Monroe, Ronald J. Moore, Bin Yang, Ming Xian, dan W.-J. Q. (2021). Mass spectrometry-based direct detection of multiple types of protein thiol modifications in pancreatic beta cells under endoplasmic reticulum stress. *Sciencedirect*. <https://doi.org/https://doi.org/10.1016/j.redox.2021.102111>
- Yaikwawong, M., Jansarikit, L., Jirawatnotai, S., & Chuengsamarn, S. (2024). Curcumin extract improves beta cell functions in obese patients with type 2 diabetes: A randomized controlled trial. *Nutrition Journal*, 23(1), 119. <https://doi.org/10.1186/s12937-024-01022-3>
- Yosia Mikhael, BMedSci, PGCert, D. (2021). Semua Hal tentang Pengobatan Alternatif yang Perlu Anda Tahu. *Hellosehat*. <https://hellosehat.com/herbal-alternatif/alternatif/pengobatan-alternatif/>
- Zohreh Bateni, Vahideh Behrouz, Hamid Reza Rahimi, Mehdi Hedayati, Shila Afsharian, dan G. S. (2022). Effects of nano-curcumin supplementation on oxidative stress, systemic inflammation, adiponectin, and NF-κB in patients with metabolic syndrome: A randomized, double-blind clinical trial. *ScienceDirect*. <https://doi.org/10.1016/j.hermed.2021.100531>