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Curcumin Content in *Curcuma Longa* L From Various Area in Indonesia, It's Alfa Glucosidase Inhibitory Activity and Nanoparticle Formulation

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ABSTRACT: Type 2 diabetes mellitus (T2DM) is characterized by impaired insulin secretion, in which pancreatic beta cells do not produce sufficient insulin, leading to glucose accumulation in the blood or the development of insulin resistance. Damaged insulin receptors prevent insulin from stimulating glucose uptake into cells. Previous studies have shown that turmeric (*Curcuma longa* L.) contains phenolic compounds known as curcuminoids, consisting of approximately 77% curcumin, 17% demethoxycurcumin, and 3% bisdemethoxycurcumin. However, curcumin has low bioavailability due to limited absorption and rapid elimination from the body. Recently, new trends have emerged in the management of type 2 diabetes mellitus (T2DM), with nanotechnology gaining considerable attention due to its potential benefits. This study aimed to develop a turmeric extract formulation to enhance its bioavailability. Methanolic turmeric extracts from Medan, Sumba, and Papua were tested for their *in vitro* α-glucosidase inhibitory activity, with the Medan extract showing the highest activity (IC50 = 33.17 ppm). The Sumba extract was selected for nanoencapsulation due to its high curcumin content (30.28%). Chitosan–turmeric extract nanoparticles were formulated using ionic gelation and nanoemulsion methods. Characterization using a Particle Size Analyzer (PSA) revealed nanoscale particle sizes for both formulations (ionic gelation: 876.0 ± 24.0 nm; nanoemulsion: 279.2 ± 3.5 nm). However, zeta potential analysis indicated low physical stability (ionic gelation: –3.8 ± 0.1 mV; nanoemulsion: –17.5 ± 1.0 mV). This study concludes that the Medan turmeric extract exhibited the highest α-glucosidase inhibitory potential, and nanoscale formulations using the Sumba extract were successfully developed, though further optimization is required to improve their stability. Evaluation of the α-glucosidase inhibitory activity of the nanocurcumin formulations is necessary to confirm their enhanced effectiveness.

KEYWORDS: Nanocurcumin, *Curcuma longa*, α-glukosidase, Nanopartikel, PSA, Zeta Potensial

I. INTRODUCTION

Diabetes mellitus, a chronic metabolic disorder characterized by hyperglycemia due to deficient insulin secretion, insulin resistance, or both, is a global health problem with increasing prevalence. The management of Type 2 Diabetes Mellitus (T2DM), which accounts for the majority of diabetes cases, often involves therapeutic strategies aimed at controlling postprandial blood glucose levels. One important target in postprandial glucose regulation is the inhibition of the alpha-glucosidase enzyme in the small intestine. This enzyme is responsible for breaking down complex carbohydrates into readily absorbable glucose; therefore, its inhibition can slow glucose absorption and reduce post-meal blood sugar spikes.

Curcumin, a natural polyphenolic compound extracted from turmeric (*Curcuma longa* L.), has long been known for its various pharmacological activities, including antioxidant, anti-inflammatory, and anti-diabetic effects. Several *in vitro* and *in vivo* studies have demonstrated the potential of curcumin in inhibiting alpha-glucosidase enzyme activity. The inhibitory mechanism is believed to involve the interaction of curcumin with the enzyme's active site, thereby reducing its ability to bind and hydrolyze carbohydrate substrates. However, the therapeutic use of curcumin is often limited by its low water solubility, poor bioavailability, and rapid metabolism in the body.

To overcome these limitations, various formulation strategies have been developed to enhance the solubility and bioavailability of curcumin. One promising approach is nanoencapsulation, which involves packaging curcumin into nanoparticles. Nanotechnology-based formulations such as nanosuspensions, nanoemulsions, and liposomes have been proven to improve curcumin dissolution, protect it from degradation, and enhance its absorption within biological systems. Nanocurcumin, as a form of nanoencapsulated curcumin, has the potential to provide superior α-glucosidase inhibitory effects compared to conventional

curcumin. Turmeric samples were obtained from three regions in Indonesia: Medan, Sumba, and Papua. This study aimed to evaluate and compare the curcumin content in the crude and methanolic extracts of turmeric from these regions, assess their *in vitro* α-glucosidase inhibitory activity, and develop an optimal turmeric extract nanoparticle formulation. The physicochemical characterization of nanocurcumin included particle size analysis using a Particle Size Analyzer (PSA) and surface charge analysis via zeta potential measurement. These analyses are essential for understanding the stability and potential interactions of turmeric extract nanoparticles. Accordingly, this research is expected to provide deeper insights into the potential of turmeric nanoparticles as a natural compound-based therapeutic candidate for the treatment of type 2 diabetes mellitus.

II. METHOD

Preparation of Turmeric Powder and Methanolic Extract:

Fresh turmeric was washed, dried, and ground into powder. The turmeric powder was then macerated with 98% methanol for 24 hours to obtain a thick methanolic extract through filtration and evaporation using a rotary evaporator. The quality of the powder and extract was evaluated based on the standards of the Herbal Pharmacopeia, including parameters such as organoleptic properties, microscopic characteristics, chromatographic profiles, loss on drying, total ash, acid-insoluble ash, water-soluble extractives, ethanol-soluble extractives, essential oil content, and curcumin content.

Formulation of Chitosan–Turmeric Extract Nanoparticles:

Chitosan nanoparticles containing turmeric extract were formulated using the ionic gelation method. A 1% chitosan solution was prepared in glacial acetic acid. The methanolic turmeric extract was formulated into nanopartikel according to Sandhiutami et al. The mixture was stirred continuously for two days, followed by dropwise addition of 0.3% NaTPP solution under constant stirring until nanoparticles were formed. The suspension was then stabilized by further stirring for 15 minutes.

Nanoparticle Characterization:

The resulting nanoparticle system was characterized to determine particle size, size distribution, and surface charge.

- Particle Size and Distribution: The particle diameter and polydispersity index (PDI) of the nanoparticles were measured using a Malvern™ Particle Size Analyzer (PSA) with triplicate measurements.
- Zeta Potential: The surface charge (zeta potential) of the nanoparticles was analyzed using a Zetasizer Nano Malvern™ to predict the physicochemical stability of the nanoparticles.

α-Glucosidase Enzyme Inhibition Assay (In Vitro):

The inhibitory activity of turmeric extract nanoparticles against α-glucosidase enzyme was evaluated *in vitro*. Both the turmeric extract and its nanoparticle formulations were tested at various concentrations. The α-glucosidase enzyme solution was incubated with the substrate p-NPG and the test samples. After incubation, the reaction was stopped by adding Na_2CO_3, and the absorbance of the reaction product (p-nitrophenol) was measured at a wavelength of 410 nm using a spectrophotometer. The percentage of inhibition and IC_{50} values (the concentration required to inhibit 50% of the enzyme activity) were calculated to compare the inhibitory effectiveness between the turmeric extract and the nanocurcumin formulations.

III. RESULT

A. *α-Glucosidase Inhibition Assay*

The α-glucosidase enzyme inhibitory activity of methanolic turmeric extracts from Medan, Sumba, and Papua was measured to determine their antihyperglycemic potential. The IC_{50} values, which indicate the concentration of extract required to inhibit 50% of the enzyme activity, are presented in Table 1.

Table 1. α-Glucosidase Inhibitory Activity of Methanolic Turmeric Extracts from Various Regions

Various Regions	IC50 (ppm)
Medan	33.17
Sumba	487.48
Papua	272.77

B. *Curcumin Content in Crude and Methanolic Turmeric Extracts*

The curcumin content was measured using the High-Performance Liquid Chromatography (HPLC) method in both crude turmeric and methanolic extracts from the three regions. The results are presented in Table 2.

Table 2. Curcumin Content in Crude and Methanolic Turmeric Extracts

Various Regions	Curcumin Content of simplicia Curcumin	Curcumin Content in Crude
Medan	3.41	13.11
Sumba	14.93	30.28
Papua	3.17	16.27

C. *Chitosan–Turmeric Extract Nanoparticle Formulation*

Nanoparticle formulations using turmeric extract from Sumba were successfully developed: ionic gelation formulation and nanoemulsion formulation. Particle size and zeta potential of the ionic gelation and nanoemulsion nanoparticle formulations were measured using PSA and a Zeta Potential Analyzer. The measurement results are presented in Table 3.

Table 3. Results of PSA and Zeta Potential Tests of Sumba Turmeric Extract Nanoparticle Formulations

Formula	Test	Average
Ionic Gelation	Particle Size Analyzer	876.0 ± 24.0
	Zeta Potential	-3.8 ± 0.1

IV. DISCISSION

Study aims to explore the potential of turmeric extracts from various regions in indonesia as inhibitors of the α-glucosidase enzyme and to develop a nanoparticle formulation of sumba turmeric extract to enhance this inhibitory activity. the research findings provide important insights into the variation in active compound content and pharmacological potential of turmeric from different sources, as well as the challenges in nanoparticle formulation for enzyme inhibition applications.

A. Variation in α-Glucosidase Inhibitory Activity and Curcumin Content in Turmeric Extracts from Various Regions

The α-glucosidase inhibition test results showed significant variation in the activity of methanol extracts of turmeric from Medan, Sumba, and Papua. The extract from Medan was significantly more effective in inhibiting the α-glucosidase enzyme (IC50 33.17 ppm) compared to extracts from Sumba (487.48 ppm) and Papua (272.77 ppm). Previous studies reported that the saponin content in the crude drug and turmeric extract from Medan was higher compared to those from Sumba and Papua. Saponin compounds act by inhibiting the α-glucosidase enzyme, which is present in the intestine and functions to convert carbohydrates into glucose. α-Glucosidase enzyme inhibitors block glucose absorption in the small intestine, thereby functioning as antihyperglycemic agents. Saponins also affect the composition of cell membranes, which can inhibit molecular absorption and cause disruption in the glucose transporter system, resulting in reduced glucose absorption. Curcumin content analysis using HPLC revealed that the crude drug and turmeric extract from Sumba have the highest curcumin content (14.93% and 30.28%, respectively), meeting the requirements of the Indonesian Herbal Pharmacopoeia. Although curcumin is known to have anti-diabetic activity and may contribute to α-glucosidase inhibition, these results indicate that high curcumin content does not always directly correlate with the strongest α-glucosidase inhibitory activity. The Medan extract, despite having lower curcumin content, showed significantly higher inhibitory activity. This suggests the possible presence of other compounds in the Medan extract, such as saponins detected in previous phytochemical tests (as mentioned in the results), which significantly contribute to α-glucosidase inhibitory activity. In previous research, saponins are known to inhibit this enzyme and interfere with glucose absorption in the intestine. The selection of Sumba turmeric extract for nanoparticle formulation was based on its high curcumin content and compliance with the Indonesian Herbal Pharmacopoeia quality standards, with the expectation that nanoencapsulation could improve the bioavailability and effectiveness of curcumin as an α-glucosidase inhibitor.

B. Chitosan-Turmeric Extract Nanoparticle Formulation

This study successfully developed two types of nanoparticle formulations of Sumba turmeric extract. The ionic gelation method utilizes electrostatic interactions between positively charged chitosan and the polyanion TPP to form nanoparticles. Meanwhile, the nanoemulsion formulation aims to improve the solubility and dispersion of turmeric extract in different media. The use of various surfactants and co-surfactants (Tween 80, glycerin, lecithin, cremophor, PEG, and VCO) in the formulations is intended to stabilize the nanoparticle system.

C. Characterization of Nanoparticles Using PSA and Zeta Potential

The characterization results using PSA showed that the Ionic Gelation formulation method successfully produced particles in the nanoscale range (10–1000 nm). Zeta potential analysis provides information regarding the colloidal stability of the

nanoparticle system. The zeta potential values for ionic gelation -3.8 mV, fall below the ±30 mV threshold generally considered adequate for stability. Low zeta potential values indicate that particles in the dispersion tend to aggregate due to dominant attractive forces over electrostatic repulsion. Stability of the nanoparticle formulation remains a major challenge in this study and requires further optimization of composition and formulation methods.

CONCLUSIONS

The study successfully identified variations in the α-glucosidase enzyme inhibitory potential of methanol turmeric extracts from various areas in Indonesia, with the Medan extract showing the highest inhibitory activity (IC50 33.17 ppm). The highest curcumin content was found in the crude drug and turmeric extract from Sumba, which met the Indonesian Herbal Pharmacopoeia quality standards and served as the basis for selecting the extract for nanoparticle formulation. Nanoparticle formulations of Sumba turmeric extract, namely ionic gelation, were successfully developed with particle sizes in the nanometer range. The ionic gelation formula (approximately 876.0 nm). However, zeta potential analysis revealed that both formulations exhibited low physical stability (-3.8 mV), indicating a tendency for particle aggregation. Recent advancements and numerous studies have highlighted the potential of chitosan, particularly the versatility of its modified derivatives in enhancing therapeutic efficacy. Consequently, the development of nanoparticle formulations using the ionic gelation method is expected to offer a promising solution for effective drug delivery in the treatment of type 2 diabetes mellitus, especially in Indonesia.

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