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Dioscorea esculenta (Lour.) Burkill: Uses and bioactivity

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Abstract

Dioscorea esculenta (Dioscoreaceae) has been long used as an alternative food ingredient and traditional medicine. This panel aims to examine the use of *D. esculenta* as a food ingredient, traditional medicine and its bioactivity. The research method uses a literature review on various research reports, books, journals obtained online at Google Scholar by using the keywords *D. esculenta*, uses, and bioactivity *D. esculenta*. The tubers of *D. esculenta* are an alternative source of alternative carbohydrates and have been traded in traditional markets, but the supply is relatively small and decreasing. The nutritional content of tuber flour is protein (7.19%), fat (1.10%) dietary fiber (10.16%) inulin (7.49%), and total starch content (71.78%). Ethnomedicinally, *D. esculenta* tubers are used as antifatigue, anti-inflammatory, anti-stress, anti-spasmodic and immune. The bioactivity of *D. esculenta* is anti-inflammatory, anti-diabetic mellitus, anti-microbial, antioxidant, anti-fertility and anti-cancer. The *D. esculenta* tubers are very potential to be developed as an alternative food ingredient because they have a good glycemic index and are able to overcome diabetes mellitus.

Keywords: Diabetes mellitus; *Dioscorea esculenta*; Alternative food; Traditional medicine

1. Introduction

Dioscorea esculenta, by local Indonesians known as *gembili* is one of the alternative food ingredients that has long been traded in traditional markets (Figure 1) [1]. This plant is easily found in tropical areas including Indonesia [2,3] especially on the outskirts of forests or neglected lands (Figure 2A). Although it has been traded for a long time, the supply is very limited and only recognized/consumed by certain groups [4] and its utilization is not widely used [5]. In contrast to the case in Africa, that *Dioscorea* sp. is the second most important crop after cassava, which is used as a source of carbohydrates. Most of the *D. esculenta* that is traded or consumed is obtained from wild plants which results in unstable supply with relatively higher selling prices compared to cassava (*Manihot esculenta*) and sweet potato (*Ipomoea batatas*).

Various studies have shown that *D. esculenta* tubers are rich in carbohydrates so they are very suitable to be used as a substitute for rice or alternative sources of carbohydrates because they have a good glycemic index value [6]. Tuber *D. esculenta* are rich in carbohydrates, which is about 22.44% [2], crude fat, crude fiber, starch and sugar [3]. Besides being used as a substitute for rice, it turns out that *D. esculenta* flour is also very potential to be used as a substitute for wheat flour because it has the swell ability of wheat and is in accordance with American wheat standards [2]. Andriani et al [5] stated that in their processing, *D. esculenta* tubers are usually steamed, but can also be developed into prebiotic food so that they function as nutraceuticals.

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Besides being rich in carbohydrates, *D. esculenta* tubers are also used as traditional medicinal ingredients. The treatment *D. esculenta* ethanol extract inhibits sperm concentration, motility and testosterone which can cause male fertility. Ethnomedicinally, *D. esculenta* tubers are used as antifatigue, anti-inflammatory, anti-stress, anti-spasmodic and immune deficiency drugs [7]. The bioactivity of *D. esculenta* tubers has secondary metabolites such as dioscorin, diosgenin, inulin and water-soluble polysaccharides that function as immunomodulators, including those that prevent metabolic diseases such as hyperglycemia [5].

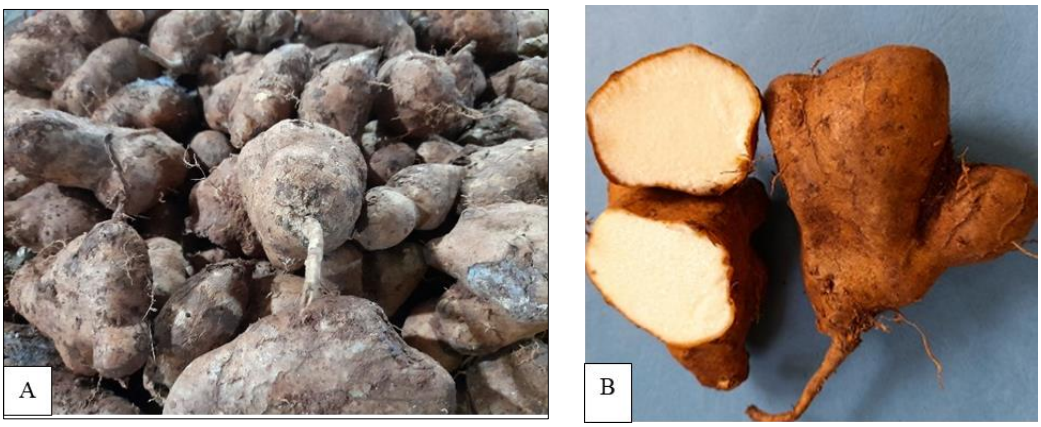

Figure 1 *Dioscorea esculenta* being traded in the traditional market. A. Pile of tubers; B. Morphology and cross section of white tuber

Deforestation is one of the threats to environmental conservation. The *D. esculenta* which is a high-value commodity but its existence is threatened with extinction due to several factors such as neglect of science, technology, research and development [8]. This study aims to comprehensively explain the use and bioactivity of *D. esculenta* so that its potential use can be developed both as food and traditional medicine and its preservation can be maintained.

2. Methods

The method used in writing this article is a literature study on various scientific articles published online at Google Scholar. Some of the keywords used are: *D. esculenta*, uses *D. esculenta*, and bioactivities *D. esculenta*. The results obtained were synthesized so as to be able to explain the botany, utilization and bioactivity of *D. esculenta* in a comprehensive manner.

3. Results and discussion

3.1. Botany of *Dioscorea esculenta*

Dioscorea L. is the largest genus in the family Dioscoreaceae and accounts for more than 95% of the species in this family. It is estimated that the genus Dioscorea has about 600 species [11], which are distributed in Southeast Asia, Africa, Central America, South America, and other tropical or subtropical regions [9]. Although there are more than 600 species of *Dioscorea*, only a few are used as food, namely D*. rotundata, D. cyaenensis, D. alata, D. dumetorum,* and *D. esculenta* [10].

Description of *D. esculenta* which has a climbing herb habitus (Figure 2A). Left twisted stem, and petiole prickly leaves, heart-shaped leaves (Figure 2B) and pubescent, spiked inflorescence with flowers having six petals and six stamens, some tubers covered with roots all over the surface, and white tuber flesh (Figure 1B) uniform [11]. Propagated by vegetative bulbi [10]. Pelser et al [12] stated that there are two varieties of *D. esculenta*, namely *D. esculenta* var. fasciculata (Roxb.) and *D. esculenta* (Lour.) Burkill var. spinous.

Dioscorea esculenta var. fasciculata has characteristic pubescent leaves on both sides; blade 74 to 105 cm long, 86 to 140 cm wide, mesophyll, leaf-length ratio 1:0.615 to 1:0.931; primary vein campylodromous, basal vein 9 to 10, one to two basal veins very often branched, primary vein size is weak, naturally curved; secondary vein brochidodromous, wide acute divergence angle, medium thickness, tortuous, branched, forming a circle of branches at an obtuse angle with secondary veins, irregularly spaced; gift intramarginal and inter secondary veins; tertiary veins branch ad medially,

reticulate random, obtuse angle with primary veins; ordinary polygonal reticulated quaternary veins; pentamery vein dichotomy; well developed areola; 1-branched to 2-or more free-end veins.

Description of *D. esculenta* (Lour.) Burkill var. spinosa i.e. Leaves pubescent on the underside; blade 50 to 91 cm long, 56 to 107 cm wide, notophilic, leaf-length ratio 1:0.832 to 1:0.956; campylodromous primary vein, basal vein 7 to 9, basal vein rarely branched, primary vein size is weak, naturally curved; secondary vein brochidodromous, moderately acute angle of divergence, moderate thickness, tortuous, branched, circular branches at obtuse angle to secondary vein, irregularly spaced; intramarginal and inter secondary veins are present; ad medial tertiary vein branching, random reticulate, obtuse angle with primary vein; ordinary polygonal reticulate of quaternary veins; pentamery vein dichotomy; well developed areola; free-end veins branch 1 to branch 2 or more [11].

Distribution is an indigenous plant of Assam, Bangladesh, Bismarck Islands, Kalimantan, Cambodia, Eastern Himalayas, Java, Lesser Sunda Islands., Malaya, Maluku, Myanmar, Nepal, New Guinea, Philippines, Sulawesi, Sumatra, Thailand, Vietnam, Western Himalayas.

Figure 2 *Gembili* (*Dioscorea esculenta*). A. Habitus; B. Leaves; C. Vegetative bulbul that appears on the node

3.2. Uses

The *D. esculenta* is an Indonesian native plant and until now can be found in various vacant lands on the islands of Java and Sumatra and has been long used as food and traditional medicine. Sweet potato tubers (*Dioscorea* spp.) are not only known as a source of carbohydrates, but also as bioactive compounds [3].

3.2.1. Foodstuffs

Plants used as food are plants that have nutritional value. In the study of ethnobotany, foodstuffs are divided into staple foods, alternative foods, fruit, vegetables and spices [13] and *D. esculenta* is classified as alternative food [1,4] reported that alternative food in Indonesia is actually very diverse, but empirically shows the exclusivity of certain foodstuffs,

especially rice. Although *D. esculenta* is rich in nutrients, its use as a food ingredient, especially as a source of carbohydrates, is still less desirable or less well known to the public [1,5].

The processing of *D. esculenta* as a food ingredient is relatively simple, namely by steaming, but various researchers have shown other alternatives for processing *D. esculenta* tubers such as yogurt [5,14], and bread making ingredients [2,15]. Andriani et al [5] reported that the addition of *D. esculenta* tubers in fermented milk has better nutritional value and has great potential as a nutraceutical for people who need a healthy diet because it contains probiotics and bioactive components. The addition of *D. esculenta* tuber flour in bread making shows that the dry matter of wheat flour has a protein content of 11.50% and protein 1.74% fat while the appropriate values for lower *D. esculenta* flour are protein 7.19% and fat 1.10% [15].

The nutritional content of *D. esculenta* tubers is strongly influenced by the processing process. The processing of *D. esculenta* tubers (boiling, steaming and roasting) affects their nutritional and anti-nutritional content [16]. The *D. esculenta* is rich in crude fat, crude fiber, starch and total sugar *D. esculenta* and is not affected by cooking, but reduces vitamin C content [3]. The phytate content was not affected, while the total oxalate content was significantly reduced by the cooking method used. Oxalate loss was greater with boiling (40–50%) than with steaming (20–25%) and roasting (12–15%) [3]. The crude protein content of tubers tends to decrease with cooking while the crude fat, crude fiber, starch and total sugar content is not affected by cooking [16]. Oxalate loss was greater by boiling (40–50%) than by steaming (20–25%) and roasting (12–15%) [16].

Alternative carbohydrate sources that are good for health are carbohydrates that have a low glycemic index value. The glycemic index of *D. esculenta* is influenced by the processing process. Boiled, steamed, and fried *D. esculenta* tubers were 68.09%, 62.11%, and 49.09%, respectively [6], much lower than rice so they are good for health. Glucomannan is a substance in the form of complex sugars and soluble fiber derived from plants, one of which is *D. esculenta*. Herlina et al [17] stated that *D. esculenta* tubers contain 2.9% glucomannan and have potential as food additives. The results showed that the addition of glucomannan *D. esculenta* flour had a significant effect on the texture, moisture content, and organoleptic of chicken sausage [18].

Proximate analysis showed that the modified *D. esculenta* flour consisted of water content (7.66%), ash content (1.42%), dietary fiber (10.16%), inulin (7.49%), and total starch content (71, 78%) [14]. Oligosaccharides are potential prebiotics and are used as an alternative dietary therapy for diabetes mellitus and *D. esculenta* in functional foods containing oligosaccharides. The oligosaccharides of *D. esculenta* contain lactulose (0.231%); inulin (2.541%) and raffinose (1.485%). The prebiotic index increased from 0.86 ± 0.20 (24 hours incubation) to 1.12 ± 0.05 (48 hours). These oligosaccharides increase probiotics and decrease pathogenic bacteria [19].

3.2.2. Bioactivity

The *D. esculenta* has long been used as a food ingredient and as a traditional medicine. For the people of Indonesia, *D. esculenta* is used as an alternative carbohydrate source and is also used in various traditional medicines. The use of ethnomedicinal as antifatigue, anti-inflammatory, anti-stress, anti-spasmodic and immune [7]. The following describes the bioactivity of *D. esculenta* as anti-inflammatory, anti-diabetic, anti-microbial, antioxidant, anti-fertility and anti-cancer.

Anti-inflammation

Inflammation or inflammation is the body's reaction to infection, so to overcome this an anti-inflammatory is formed to increase immunity. Various types of plants have long been used as anti-inflammatory including *D. esculenta*. The bioactivity of *D. esculenta* as an anti-inflammatory is thought to be related to its traditional use to treat boils, boils and abscesses externally [7]. In laboratory experiments, anti-inflammatory bioactivity was measured by measuring edema and granulomatous tissue formation in rats [20]. Shajeela et al [7] stated that *D. esculenta* contains allantoin, cell proliferation that accelerates the wound healing process. The *D. esculenta* contains saponins, diosgenin, sitosterol, stigmasterol, cardiac glycosides, fats and starch which are thought to be associated with inhibition of carrageenan-induced edema. The extract of *D. esculenta* at a dose of 100 mg/kg and 150 mg/kg, respectively, was equivalent to 150 mg/kg of acetylsalicylic acid [20].

Anti-Diabetes Mellitus

Diabetes mellitus is a metabolic disorder that causes blood glucose levels to be above normal. Various commercial drugs have been developed to treat diabetes mellitus, including metformin, but long-term use has resulted in various side effects, therefore the exploration of natural ingredients is continuously carried out, including *D. esculenta*. Tuber *D.*

esculenta tubers have bioactive compounds such as dioscorin, diosgenin, inulin and water-soluble polysaccharides that function to prevent metabolic diseases such as hyperglycemia [5]. Fermented milk enriched with *D. esculenta* showed significant results resulting in a decrease in blood sugar levels with the highest decrease of 43.59% compared to controls [5]. The increase in muscle sex steroid hormone levels induced by *D. esculenta* helps reduce insulin resistance in type 2 diabetes [21].

Anti-fertility

Antifertility compounds are compounds capable of preventing fertility by interfering with several reproductive mechanisms [22], so they can be used to prevent pregnancy or regulate the number of births. Antifertility effect of ethanolic extract of *D. esculenta* tuber was observed in male albino rats. Administration of *D. esculenta* tuber ethanol extract significantly reduced the relative weight of the testes and epididymis of male albino rats. The ethanol extract of *D. esculenta* tuber also increased serum follicle stimulating hormone (FSH) and estrogen levels but decreased serum luteinizing hormone (LH) and testosterone levels compared to controls. Giving *D. esculenta* ethanol extract inhibits sperm concentration, motility and testosterone which can cause male fertility [7]. The bioactivity of *D. esculenta* tubers as antifertility is related to the content of its secondary metabolites, namely steroidal saponin (protodioscin, dichotomin and protogracillin) [23]. The intake of *D. esculenta* combined with resistance training affects muscle hypertrophy and strength of athletes through restoring the secretion of androgen hormones [24].

Antioxidant

Free radicals are associated with various diseases such as cancer and diabetes mellitus. Compounds that are able to inhibit free radicals are called antioxidants and are widely associated with the content of phenolic compounds. The *D. esculenta* E methanol extract has antioxidant activity in vitro [25]. The total phenol content in the methanolic extract of *D. esculenta* was found to be 0.79g/100g and the flavonoid content 0.26g/100g [25].

Anti-microbial

Antimicrobial compounds are compounds that can inhibit or cause the death of microorganisms. Various pathogenic bacteria cause various infections in humans such as *Escherichia coli* and *Staphylococcus aureus*. The *D. esculenta* extract showed antibacterial activity against *Escherichia coli, Pseudomonas aeruginosa* and *Staphylococcus aureus* while no activity was shown by this extract against *Klebsiella pneumonia* and *Streptococcus pyrogens*, while the maximum inhibitory concentration (MIC) was observed at a concentration of 50 g extract against *E. coli* [26].

4. Conclusion

The tubers of *D. esculenta* are an alternative source of alternative carbohydrates and have been traded in traditional markets, but the supply is relatively small and decreasing. The nutritional content of tuber flour is protein (7.19%), fat (1.10%) dietary fiber (10.16%) inulin (7.49%), and total starch content (71.78%). Ethnomedicinally, *D. esculenta* tubers are used as antifatigue, anti-inflammatory, anti-stress, anti-spasmodic and immune. The bioactivity of *D. esculenta* is anti-inflammatory, anti-diabetic mellitus, anti-microbial, antioxidant, anti-fertility and anti-cancer.

Compliance with ethical standards

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