Chemical Composition Of Dioscorea Alata L. And Dioscorea Esculenta (Lour.) Burk. Cultivars From Wakatobi Islands, Indonesia

Indrawati, Sahta Ginting, La Ode Safuan, Jamili

Abstract: Kaledupa and Tomia islands are groups of islands incorporated in the Wakatobi Islands region. Research on the identification of tuber morphology was successfully identified consisting ten cultivars of Dioscorea alata L. and two cultivars of Dioscorea esculenta (Lour.) Burk. Each cultivar has a local name, such as D. alata cultivars from Kaledupa are called ifi tofu, ifi longko, kano ambo, ifi loiya, kano nsolo, ifi safora, ifi madu, and kano mohute; while D. alata cultivars from Tomia are named kano fungo, kano isitangisi, opa lelu, and opa honiki. The results of the chemical components analyses showed that all tubers have the potency as an alternative for food ingredient. However, the content of each component varies greatly depend on geographical conditions. Carbohydrate levels in D. alata and D. esculenta are higher than other tuber species ranging from 20.4 to 47.9%. Therefore, these ten cultivars have been used as the source of carbohydrate for a long time in the Wakatobi community.

Index Term : Kaledupa, Tomia, Dioscorea alata, Dioscorea esculenta, Carbohydrate.

1. INTRODUCTION

The Wakatobi archipelago is one of the ecosystems of Indonesia's small islands in the Wallace Line forming in a combination of four islands namely Wanci, Kaledupa, Tomia, and Binongko. Geographically, Wakatobi Islands are regions of rocks or corals so that crops are difficult to develop. Tubers are commonly type of plant in this area which is easily cultivated by the local community to meet the needs of carbohydrates. The number of Dioscorea species in the world is estimated to be 600 species. In Indonesia, there are 7 species, namely Dioscorea alata, Dioscorea pentaphylla, Dioscorea hispida, Dioscorea esculenta, Dioscorea oppositta, Discorea bulbifera, and Dioscorea rotundata [1]. The abundant tuber potential in the islands can be purposed to develop a food sustainable region with dozens of tuber cultivars from the genus Dioscorea. Dioscorea has long been known and utilized in human life [2]. Two prominent forms of Dioscorea are usually consumed for food and medicine [3]. Its large size, high carbohydrate and mineral contents make it widely used as a staple food in Africa [4]. Dioscorea is a source of energy containing important minerals for health, such as calcium (Ca), phosphorous (P), iron (Fe) and some essential amino acids [5]. Meanwhile, saponin and sapogenin compounds are used as precursors for cortisone and steroidal hormones [6]. Dioscorea chemical composition, especially on the content of carbohydrates, proteins, fats, ash, and fiber varies greatly depend on the geographical conditions [7]. Research on the aspects of Dioscorea metabolites has been extensively steroid allantoin and saponin compounds [8]. The steroid saponins have cytotoxic activity, lowering blood pressure, anti-inflammatory, and antifungal properties [9]. Similarly, allantoin has a very strong antihypertensive activity. Both of these compounds have the potency as new therapeutic agents [10]. Dioscorea also has the secondary metabolite component which is very diverse in various regions; thus, some studies are continuing to uncover various pharmacological potentials and their development as a very promising functional food source [8]. Based on the above descriptions, Dioscorea has the potential to be used as a source of nutrition and functional food, mainly for Tomia and Kaledupa communities. The aim of this paper is to report the chemical composition of 12 cultivars of Dioscorea species that have been identified in Wakatobi islands.

- *Indrawati, Department of Biology, Faculty of Mathematics and Natural Science, Halu Oleo University, indrawatiansar67@gmail.com*
- *Sahta Ginting, Department of Soil Science, Faculty of Agriculture, Halu Oleo University, sahta_ginting55@yahoo.co.id*
- *La Ode Safuan, Department of Agrotechnology, Faculty of Agriculture, Halu Oleo University, safuan65@yahoo.co.id*
- *Jamili, Department of Biology, Faculty of Mathematics and Natural Science, Halu Oleo University, jamili66@yahoo.com*

2. MATERIALS AND METHODS

2.1. Materials

Tubers used in this study were cultivated in the Kaledupa and Tomia Islands. There were eight cultivars of D. alata from Kaledupa namely as ifi tofu, ifi longko, kano ambo, ifi loiya, kano nsolo, ifi safora, ifi madu, and kano mohute; while two D. alata and two D. esculenta cultivars from Tomia Islands were also used identifying as kano fungo, kano isitangisi, opa lelu, and opa honiki. The chemical analysis materials used in this study were: CH_3COOPb (p.a. Merck), $Na_2C_2O_4$ (p.a. Merck); C_2H_5OH (p.a. Merck); HCl (p.a. Merck); K_2SO_4 (p.a. Merck), HgO (p.a. Merck), H_2SO_4 (p.a. Merck); KOH (p.a. Merck), and Phenolptlain. All other chemical reagents were used as analytical grade.

2.2. Sampling

This research has been conducted by applying an exploratory survey to obtain data of plant identity and tuber chemical compositions. Data on plant species and cultivars were achieved through local community interviews and direct observations using the prepared guidelines of Dioscorea alata and Dioscorea esculenta. Tuber sampling technique was completed by taking matured tubers as the leaves turned to yellow. The matured tubers were dug out using crowbars then the they were packed in plastic bags and labeled to local

names. The research sites were in Tomia and Kaledupa islands, Wakatobi Regency, Southeast Sulawesi Province.

2.3. Determination of Chemical Components of D. alata and D. esculenta

Moisture, Crude Protein, Sugar, total Lipid, Ash and Crude Fibre were carried out by using AOAC standard methods [11]. All determinations were made in triplicate.

3. RESULTS AND DISCUSSION

3.1. Identification of Tuber Cultivar In Kaledupa and Tomia Islands

The tubers on the research were identified as D. alata and D. esculenta species mostly in Kaledupa and Tomia islands. There were found 12 tuber cultivars dividing into 10 cultivars of D. alata L. and two cultivars of D. esculenta (Lour.) Burk. The survey results showed that various D. alata L and D. esculenta were grown and distributed in several areas of Kaledupa and Tomia islands. Tubers which were grown in these two islands exhibited various morphological shapes, textures, inner skin color, and tuber flesh. According to the morphological observations, tuber in Kaledupa Island was dominated by cultivars of D. alata L counting eight tubers collections. Meanwhile, in Tomia Island, there were found four tubers collections consisting of two D. alata and two D. esculenta. Tuber collections that were identified by morphological characteristics are listed in Table 1. It has been reported that Dioscorea is a vine with the shape of leaves resembling a heart and its original habitat in the forest [4].

Table 1. *Local Species of D. alata and D. esculenta from Wakatobi Islands Indonesia*

Island	Species	Tuber Morphology			
	Dioscorea alata	Shape	Inner Skin Color	Texture	Flesh color
Kaledupa	Ifi tofu	Oval-oblong	Purple	Grained	White-purple
	Ifi longko	Oval-oblong, slightly branched	Light brown	Grained	Orange
	Kano ambo	Oval-oblong, slightly branched	Purple	Grained	White-purple
	Ifi loiya	Finger-shaped	Purple	Grained	Cream
	Kano nsolo	Oval-oblong, slightly branched	Dark purple	Smooth	White-purple
	Ifi safora	Oval	Purple	Very grained	Cream-light purple
	Ifi madu	Oval-oblong	Light brown	Smooth	Cream
	Kano mohute	Oval-oblong	Light brown	Smooth	White
Tomia	Kano fungo	Irregular-highly branched	Purple	Grained	Purple
	Kano isitangisi	Cylindrical	Brown	Grained	White
	Dioscorea esculenta				
	Opa lelu	Oval	Light brown	Smooth	White
	Opa honiki	Round-Branched	Light brown	Smooth	White

The diversity of tubers in Wakatobi was very high, especially species of D. alata and D esculenta. Based on the survey results at the four islands, there were 26 tubers collections. In this reported paper only the tubers collections from Kaledupa and Tomia islands were collected and identified. Dioscorea has long been known by the people of Indonesia. This plant has many members with various characteristics. In nature, there are various species and varieties of Dioscorea with properties are extremely different or very similar to each other. There are approximately 750 species discovered from five genera of Dioscorea [12]. It is estimated that there are 600 species of Dioscorea, of which 50 species have been cultivated [13]. In Indonesia, people recognized Dioscorea as a group of uwi (uwi, gembili, gembolo) and gadung [4]. The popular name of Dioscorea in English is yam. However, the same name is also used to refer to the species that have different classifications, such as potato yam used for D. bulbifera and D. esculenta. Thus, the classification of Dioscorea becomes blurred. Therefore, identification of more detailed classification is important. Dioscorea has long been known and utilized in human life [2]. The use of plants and forms of utilization vary, with two prominent forms are as food and medicine [1]; [8]; [14]. Studies of Dioscorea for drugs and foods have been reported by a number of scientists in Japan, China, Korea, India, Indonesia, Africa, France, and the United Kingdom. The results of the studies showed the large potential of Dioscorea for human life [4].

3.2. Moisture, Crude Fiber, and Ash Contents of D. alata and D. esculenta

Dioscorea is a tuber plant that used as a source of food and medicine. As a food source, Dioscorea is composed of various chemical components. Each Dioscorea cultivar has a diverse chemical composition, including the moisture, ash, and crude fiber contents as shown in Table 2.

Table 2*. Moisture, Ash and Crude Fibre Content of D. alata and D. esculenta*

Island	Species	Local Name	Moisture (%)	Ash (%)	Crude Fibre (%)
Kaledupa	D. alata	Ifi tofu	69.48	0.69	2.71
		Ifi longko	64.60	1.33	4.55
		Kano ambo	68.30	1.62	3.14

		Ifi loiya	47.50	1.79	3.00
		Kano nsolo	66.44	0.52	2.72
		Ifi safora	65.05	0.95	4.71
		Ifi madu	69.55	0.65	4.58
		Kano mohute	76.12	1.26	3.56
Tomia	D. esculenta	Kano fungo	73.90	1.41	5.92
		Kano isitangisi	55.39	1.53	4.18
		Opa lelu	56.92	ND	ND
		Opa honiki	57.77	ND	1.60

*Not Detected (ND)

Table 2 showed that moisture, ash and crude fiber contents in D. alata and D. esculenta vary greatly. The moisture content of 12 cultivars ranged from 47.5% (ifi loiya) to 76.12% (kano mohute); the ash content were from 0.52% (kano nsolo) to 1.79% (ifi loiya); and the crude fiber were from 1.60% (opa honiki) to 5.92% (kano fungo). The high fiber content of Dioscorea affects the glycemic index and has a positive effect on colon health [15-16]. The variation of the chemical content is influenced by the geographical conditions of an area. Furthermore, the time of harvest, genetic factor, and storage preserving also affect the chemical composition of Dioscorea tubers. There is indication that the tuber physiology reaction is still to continue even in the post-harvest condition. One report showed that the moisture, ash, and fiber contents of Dioscorea could reach 71.8%; 1%, and 0.5%, respectively [17]. Meanwhile, [18] reported that the moisture contents of D. alata, D. cayenensis, D. rotundata, and D. esculenta are greater than 60-80%. This discrepancy can be caused by humidity or rainfall effects in the area. [1] investigated ten species of Dioscorea from East Java and found that moisture would ranged from 71.89 to 85.07% and ash contents were from 0.59 to 1.83%, respectively. Dioscorea is also a source of energy and can contribute to important minerals for health, such as calcium (Ca), phosphorus (P), and iron (Fe) [18]. Minerals which commonly found in Dioscorea are calcium (Ca), Fe, and zinc (Zn) [19] and some essential minerals (Zn, Co, Cr, Fe) [20]. However, there are found a small number of toxic minerals such as arsenic (As) and bromine (Br). Data showed that improper processing of Dioscorea will cause negative effects such as poisoning. So that, every society has an unique method to overcome this toxic effect. The toxic component can also be derived from the alkaloid compound and Dioscorea protein [8].

3.3. Glucose and Carbohydrate Contents of D. alata and D. esculenta

Dioscorea has long been used primarily as a source of carbohydrate for people who living in the continents of Asia, Africa, and South America [21]). Nigeria is known the highest producer country with 67% of global products. Total global production in 2008 was around 51 million metric tons and 95% was planted in Africa [10]. Dioscorea can produce 200 calories every day for 60 million people in humid tropics [22]. Therefore, Dioscorea cannot be separated as a source of carbohydrate, including for people living in Wakatobi islands. Thus, it is essential to analyze glucose or carbohydrate content in the various Dioscorea collections. Table 3 showed the total sugar and carbohydrate content of D. alata and D. esculenta collected from the Kaledupa and Tomia islands. All collections are generally sources of carbohydrates which have been consumed by the people who living in both islands. In addition, Manihot utilisima and Manihot esculenta crants are also cultivated in this area; thus, the Wakatobi community does not depend on rice as the source of carbohydrate. The carbohydrate content of the 12 collections has been analyzed to average about 30% which was in the range of 20.40 – 47.87%. Data showed that Dioscorea from Kaledupa and Tomia islands has the higher carbohydrate contents when compared to Dioscorea reported by [23] which was only around 15 – 25%. Other study reported that D. alata and D. esculenta may reach 22 – 31% and 17 – 25%, respectively [24].

***Table 3**. Content of Glucose and Carbohydrate of D. alata and D. esculenta*

Island	Species	Local Name	Glucose (%)	Carbohydrate (%)
Kaledupa	D. alata	Ifi tofu	0.26	27.09
		Ifi longko	0.31	31.35
		Kano ambo	0.07	26.89
		Ifi loiya	0.16	47.87
		Kano nsolo	0.51	30.63
		Ifi safora	0.42	31.26
		Ifi madu	0.4	27.37
		Kano mohute	0.22	20.40
Tomia		Kano fungo	0.54	21.87

	Kano isitangisi	0.26	40.80
D. esculenta	Opa lelu	ND	ND
	Opa honiki	0.35	ND

*Not Detected (ND)

High fiber contents of Dioscorea could reduce glycemic index. Eventhough D. alata has a low glycemic index it is potential to be an alternative food supplement for wheat or rice which is safe for diabetics and autists [25]. D. alata tubers with white flesh can be developed as a source of alternative carbohydrate while colored tubers are easily oxidized to produce flour or browned products [26].

3.4. Protein and Lipid Contents of D. alata and D. esculenta

Chemical composition of Dioscorea is very important to be analyzed for the purpose of the tubers potential as a food source. Chemical composition is also referred to as primary metabolites, which can act as precursors for various secondary metabolite products. Protein and lipids are primary metabolite products as supplement in the nutritional components of the food source. Therefore, this study analyzed the total protein and total lipid content as they are shown in Table 4.

Table 4. *Content of Protein and Lipid of D. alata and D. esculenta*

Island	Species	Local Name	Protein (%)	Lipid (%)
Kaledupa	D. alata	Ifi tofu	2.13	0.60
		Ifi longko	2.21	0.51
		Kano ambo	2.93	0.27
		Ifi loiya	2.26	0.58
		Kano nsolo	1.81	0.60
		Ifi safora	2.02	0.72
		Ifi madu	1.84	0.60
		Kano mohute	1.81	0.41
Tomia	D. alata	Kano fungo	2.08	0.74
		Kano isitangisi	1.92	0.38
	D. esculenta	Opa lelu	ND	1.07
		Opa honiki	ND	ND

*Not Detected (ND)

Total protein content of 12 collections ranged from 1.81 – 2.93% while the fat content ranged from 0.27 – 1.07%. Protein and fat contents in all Dioscorea sources throughout the world high compared to the results of our study. However, some researchers report the Dioscorea protein content in the range of 1 – 2.5% [23]; 1.2 – 1.8% [28]; D. alata 1.2 – 3.1% and D. esculenta 1.2 – 1.9% [24] and 2.87 % [29]. Moreover, the total fat content of Dioscorea is very diverse but is in the small range of 0.1 – 2.5 [30-32]. Dioscorea has the low contents of protein and lipid. The protein and fat contents of Dioscorea should be further analyzed to find out the contents of amino acids and fatty acids. Current research developments has focused on dioscorin, a water-soluble protein, containing 80-85% dioscorin [33-34]. Dioscorin is an enzyme protein that has carbonic anhydrase (CA) and trypsin inhibitors such as dehydro ascorbate reductase (DHAR) and monodehydro ascorbate reductase (MDHAR) [35-36]. These enzymes play a key role in various chemical reactions in the tubers, including protection against stress from environmental factors. Knowledge and understanding of the types of enzyme activity are essential for understanding the biochemical and physiological changes of Dioscorea tubers during storage. Therefore, it is expected that the biochemical and biotechnological studies of these enzymes would help to design the treatments to break the chain of food [37-38] have different values due to many factors involved in the biosynthesis of both components. D. alata purpurea contains 9.34% protein and 0.28% lipid [27]. This protein content is very

4. CONCLUSION

Dioscorea alata L. and Dioscorea esculenta (Lour.) Burk. are twisted tuber plants. These tubers are very potential to be developed on Kaledupa and Tomia islands as the food source of carbohydrates. The huge number of species cultivars and the high carbohydrate content clearly indicate that Dioscorea in the Wakatobi Islands could be designed as the center of tubers agricultural areas for food source and diversification.

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