Physico-chemical characterization of fresh tuber of water yam (*Dioscorea alata*) germplasm

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Abstract. Information of the physical and chemical characteristics in water yam tuber (*Dioscorea alata*) is needed to complete the database of germplasm, support the breeding activities and utilization for both food and industry purposes. This study was conducted at the Food Chemistry Laboratory of Iletri to observe the physical and chemical characteristics of the water yam fresh tuber derived from 22 Iletri’s germplasm accessions. The fleshed of water yam color were varied, namely white, yellow, mixture of white and purple, white and yellow, yellow and purple. The trial was arranged using a completely randomized design with three replications. The moisture content ranged from 56.08-80.03%, dry matter 18.82-43.02%, ash 2.56-4.97% dw, starch 61.81-75.87% dw, amylose 28.40-43.15% dw, and reducing sugar 0.27-1.49% dw. The fiber content varied widely from 4.33% to 13.99% dw. The water yam also had a wide range of texture, ranging from soft to hard with a hardness level of 6.78-57.78 N. Based on the starch and fiber contents of the fresh tuber, MLGAR 0071, MLGAR 0183, MLGAR 0003 and MLGAR 0006 accessions were potential to be used as parent materials in breeding program to obtain superior varieties of water yam with high starch and fiber contents.

1. Introduction

Indonesia is a country with a very diverse biological wealth. However, this recognition has not been able to be preserved and utilized optimally [1]. Based on the morphology, yam group (*Dioscorea* spp.) has a fairly high diversity of species, one of which is water yam (*Dioscorea alata*) or some call it *uwi beras* or *ubi kelapa* [2,3]. Water yam is considered as the third most important tropical tuber crops after cassava and sweet potato [4,5,6]. Water yam are a carbohydrates sources and provides secondary metabolites for alternative food that support food diversification and food security [7,8,9], and also contains higher protein than other tubers, but has a low sugar content [10].

The fleshed of water yam are widely used as food for diabetics, because they have a low glycemic index, and can be used to treat diarrhea [2]. Glycemic index (GI) value of *D. alata* ranges from 22,4 until 24 was significantly lower than *D. rotundata Poir* (67) and *D. dementroum* (56) [11,12]. Helen *et al.* [13] proved that consumption of fleshed of water yam significantly reduced blood sugar levels and body weight compared to controls. Water yam has a high content of amylose and total dietary fiber which is very useful for consumption for people who want diet [14].

Several studies have been carried out to obtain the physico-chemical characteristics of both fresh and flour of water yam [15,16,17]. This research is expected to provide information on the physico-chemical characteristics of water yam Iletri’s collection germplasm to obtain accessions used in
breeding programs and further development for their use by farmers and industry in order to support
the government’s food diversification program.

2. Material and Methods
The experiment was conducted on the Chemical and Food Processing Laboratory, Indonesian
Legume and Tuber Crops Institute (Iletri) in June 2019. Material experiment was 22 water yam
accessions of the Iletri’s germplasm collection which were harvested from Kendalpayak
Experimental Garden, Malang, at the harvested time of 8 months. The trial was arranged using a
completely randomized design with three replications.

Observations included physico chemical characteristics. The fresh sample cut section of the base
and the tip, shelled and then shredded for moisture content analysis with the gravimetry method
according to SNI 01-2891-1992 [18]. Observations for Hunter color (L*, a*, b*) of the fleshed water
yam were used a color reader Minolta CR-200b [19]. In addition, the fresh tubers also cut into small
boxes, and then dried in an oven for 24 hours at a temperature of 55°C. The dry matter milled for
used the ash content used muffle furnace according to SNI 01-2891-1992, starch and sugar reduction
analysis with Somogyi Nelson method [20], amylase content analysis with spectrophotometry
method, and fiber content analysis with acid bases hydrolysis [20]. Analysis of texture profile
steamed fleshed tubers used texture analyzer included hardness, adhesiveness, cohesiveness,
springiness and their behaviour when chewed (chewiness).

All determinations were replicated three times, mean values and standard deviations were
reported. Analysis of variance (ANOVA) was performed by CRD’s test (p<0.05) using the MSTAT
data analysis. When the difference in ANOVA among the means of samples was significant, pair
comparison of these samples were analyzed using LSD test.

3. Result and Discussions
The fleshed of water yam color were varied, consist of white, white with purple, white with yellow,
yellow with white, and yellow with purple. The lightness fleshed of water yam (59.8-85.7), redness
(11.5-21.3), and yellowness (21.2-42.6) also varied widely (Table 1). The white fleshed tuber tends
to have a high level of lightness compared to white fleshed with a mixture of other colors or yellow
fleshed. Meanwhile, purple tuber fleshed have a lower lightness (Table 1). The fleshed of purple
tubers, or purple with a mixture of other color but the dominant purple color, have a higher level of
redness compared to white or yellow tuber fleshed. The yellow fleshed of water yam will have a
higher level of yellowness than white and purple fleshed (Table 1). In addition, the tuber fleshed
color is contributed by its biochemical contents such as minerals and bioactive compounds including
phenolic acids, anthocyanins, and total carotene [21].

3.1. Chemical characterization of water yam germplasm
The moisture content of the 22 accessions of water yam was considered moderate to high, ranging
from 56.08 to 880.3 % (Table 2), slightly lower than previous study, ranged from 65.47 to 82.46%
[17]. The moisture content determine of tubers texture. High moisture content to make the tuber
fleshed more tend and rotten easily. Meanwhile, if the moisture content was low, it was usually
followed by a high dry matter content suitable for raw materials for the flour industry [22].

The ash content of 22 water yam accessions ranged from 2.56-4.97% (Tabel 2), higher than
previous study ranged from 0.85 -1.44% dw [17], the highest in the MLGAR 0006 accession. Ash
content represents the mineral content of tubers and was highly dependent on agroecological and
genetic conditions [23]. On this study, starch content ranged from 61.81 to 75.87% dw, and it was
significantly different between accessions. The highest content was MLGAR 0183, followed by
MLGAR 0071. Water yam are quite rich in starch, accounting for 60 to 89% [24]. Starch is a
predominant determinant of water yam physical and chemical properties, hence it can be used to
predict its use [25]. Starch properties can be influence pasting and physicochemical properties
such as gelatinization, viscosity, retrogradation, solubility, swelling power and water
The amylose content in the tubers also determines the pasting properties and retrogradation behaviors. Lebot et al. [10] observed water yam varieties with good eating quality are characterized by high dry matter, starch and amylose contents. The amylose content from 22 water yam accessions in this study ranged from 28.40-43.15% dw, and highest in MLGAR 0396 accession (Table 2). The reduction sugar content was different significantly between accessions, ranged from 0.27 to 1.49 %dw. Sugar in yam confers sweetness in the cooked tuber which influences food quality [10]. The fiber content in the tubers varies widely, and tuber crops is one source of dietary fiber. In the 22 water yam accessions observed, the highest content of water yam accession was 2.43% dw (MLGAR 0006) and the lowest was 0.74% dw (MLGAR 0173).

| Accessions | Moisture content (%) | Ash content (% dw) | Starch content (% dw) | Amylose content (% dw) | Reduction sugar content (% dw) | Fiber (% dw) |
|------------|----------------------|--------------------|-----------------------|------------------------|-------------------------------|--------------|
| 1 MLGAR 0003 | 71.28±0.42 d | 4.54±0.27 bc | 71.08±0.04 fg | 31.97±0.33 kl | 1.43±0.78 ab | 2.40±0.10 a |

L*: lightness level that ranges from 0 (dark/black) to 100 (bright/white)

a*: redness level, green (-100) up to red (+100)

b*: yellowness level, blue (-100) up to yellow (+100)
3.2. Textural profile of 22 accessions of water yam germplasm

Adhesiveness value in this study was significantly different but the range was not too wide. The water yam also had a wide range of texture, ranging from soft to hard with a hardness level of 6.78-57.78 N, with the highest value on MLGAR 0130 (57.78 N) accession (Table 3). This steamed tuber with a high hardness value tends to have a hard texture.

The level of springiness also varied with the range being not too wide. The level of chewiness of steamed tubers, which was the result of the multiplication of hardness with cohesiveness and chewiness, also appears to be the highest in MLGAR 0130 accession, this showed that hardness had a dominant influence on the level of chewiness of steamed tubers. The texture profile varies between accessions, this depends on the moisture content and amylose and amylopectin content in the tubers [27].

| Accessions | Adhesiveness (mm) | Hardness (N) | Cohesiveness | Springiness (%) | Chewiness (N.mm) |
|------------|------------------|--------------|--------------|----------------|-----------------|
| MLGAR 0003 | 0.018±0.01 c     | 21.69±2.94 e | 0.065±0.03 fg| 63.9±15.32 cd | 85.68±24.92 cde|
| MLGAR 0006 | 0.199±0.05 b     | 15.78±1.55 fg| 0.135±0.02 bcd| 87.0±12.91 ab | 182.67±11.43 bed|
| MLGAR 0054 | 0.029±0.04 c     | 13.93±1.14 hi| 0.159±0.06 bcd| 75.6±6.72 ab | 164.54±54.47 bcd|
| MLGAR 0059 | 0.014±0.01 c     | 6.78±1.41 i  | 0.062±0.03 g | 90.1±17.11 a  | 39.95±28.93 c  |
| MLGAR 0071 | 0.035±0.03 c     | 10.76±0.46 jk| 0.132±0.02 bcd| 74.1±14.92 ab | 106.77±33.57 bcd|
| MLGAR 0085 | 0.184±0.18 b     | 12.93±1.57 jk| 0.236±0.10 a  | 73.6±11.46 ab | 230.93±119.21 bcd|
| MLGAR 0117 | 0.007±0.00 c     | 17.83±1.13 fg| 0.181±0.07 abc| 64.6±15.54 cd | 197.57±43.70 bcd|

Tabel 3. Texture profile of 22 accessions of water yam germplasm

**Table 3.** Texture profile of 22 accessions of water yam germplasm
4. Conclusion

The water yam had a wide range of texture, ranging from soft to hard with a hardness level of 6.78-57.78 N. Based on the starch and fiber contents of the fresh tuber, accessions are potential to be used as parent materials in breeding program to obtain superior varieties of water yam with high starch and fiber contents.

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