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Characterization and Genetic Diversity of Golden Berries *(Physalis* spp.*)* Based on Morphological Characters

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ABSTRACT

Golden berries is a plant that has medicinal functions, fresh fruit and has high economic value. Golden berries plant breeding is carried out to improve the quality of the plant. This research aims to analyze the genetic diversity of Golden berries to produce new varieties. This research was conducted at the Lampung State Polytechnic Greenhouse from April to September 2023. This research used qualitative methods and the variables observed included variables in the vegetative and generative phases. The results showed that the five genotypes studied showed quite high diversity, namely at a copenhetic distance of 0.8. The golden 1 and golden 2 and red genotypes belong to *Physalis peruviana* while the two local genotypes are *Physalis angulata*. High diversity has great potential for crossbreeding so that it can produce heterosis traits. Heterosis is the characteristic of offspring being able to exceed the characteristics of their two parents. Based on this research, the genotypes observed are good for use as parents in plant breeding.

INTRODUCTION

Golden berries (*Physalis* spp.*)* is a plant that is distributed in various countries with tropical and subtropical climates. Golden berries is rich in chemical compounds that are useful for body health because they contain antioxidants, flavonoids, alkaloids, saponins, steroids and tripernoids (Nuranda *et al.*, 2016). These substances are known to function as natural abatements, anticancer, diabetes, antioxidant and antibacterial (Ratri and Darini, 2016; Nuranda *et al.*, 2016; Silalahi, 2018; Singh *at al.,* 2019).

This fruit, which is sweet and fresh and has many health benefits, has been widely developed in Brazil, Colombia, India, Mexico and the Mediterranean, both as a fruit plant and as a medicinal plant (Steal *et al.,* 2018). Golden berries is classified as an exotic germplasm in Indonesia, which has not been widely cultivated. These plants generally still grow wild and are limited in terms of quality. In recent years, Golden berries has begun to be exploited for commercial use (USDA, 2021), and is even sold in several supermarkets in Indonesia both as fresh fruit and as industrial raw material because it has high

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economic value. This great potential should be supported by the quantity and quality of golden berries plants agronomically.

Efforts to increase quantity and quality can be done through plant breeding activities. Plant breeding activities can be carried out effectively by collecting and identifying potential genetic sources for the development of Golden berries plants. Several researchers in Indonesia have identified and characterized Golden berries . Hadiyanti *et al.* (2018) have carried out an analysis of genetic diversity in Golden berries genotypes in the Mount Kelud area. Wahyunita *et al.,* 2021 have carried out on physiological characteristics and yields of golden berries. Based on research by Pharamita and Zazaroh (2022); Rukmi and Waluyo (2019), there is significant diversity in qualitative and quantitative morphological characters. such as plant height, flowering age, fruiting age, leaf length and width, fruit weight and number of fruit per plant, and Golden berries fruit diameter. Analysis of genetic diversity in Golden berries has even been carried out at the molecular level in Colombia using microsatellites and SNPs markers (Garzón-Martínez *et al*. 2015; Delgado-Bastidas *et al.*, 2019).

High genetic diversity is expected to be obtained in the genotypes studied which aim to develop Golden berries plants through plant breeding activities. It is possible to carry out Golden berries crossing activities even with interspecific crossings. Arruum and Waluyo (2021) reported that in self-pollination the compatibility level reached 100% and in interspecific cross-pollination several species were compatible and partially compatible. Crossing plants from parents with high diversity can produce superior offspring. The aim of this research is to analyze the genetic diversity of golden berries plants studied in an effort to expand genetics.

MATERIALS AND METHOD

This research was carried out in May - September 2023 in the Plant Laboratory Greenhouse 3 of Lampung State Polytechnic, Bandar Lampung. The materials that will be used in this research are polybags, Golden berries seeds, furpresentn, NPK fertilizer, manure. The tools used include: pot trays, hoses, labels, roll meters, scales, blenders, jerry cans, sprayers, photo backdrops and stationery.

This research was structured in a completely randomized design consisting of 1 factor, namely 5 genotypes of golden berries plants. Each treatment was repeated three times to obtain 15 experimental units. The research includes plant preparation, sowing seeds, planting media preparation, planting, plant maintenance, and harvesting.

The variables observed included: anthocyanin in the hypocotyl, growth habit, length of the first internode, length of the internode, anthocyanin in the internode. Anthocyanin intensity in segments, pubescence in segments, leaf shape, leaf length, leaf width, leaf margins, leaf color, intensity of leaf greenness, condition of leaf stalks, length of leaf stalks, condition of flower stalks, length of flower stalks, flower diameter, number of anthers , stalk thickness near the fruit, fruit size, fruit length, fruit diameter, length/diameter ratio, fruit vertical cross-sectional shape, fruit cross-sectional shape, fruit base cavity depth, fruit tip shape, main color (at harvest), main color intensity (at harvest), main color of fruit (at physiological maturity), intensity of main color of fruit (at physiological maturity), flesh color, number of protruding loci, strength of petals, cover of petals, pubescence of petals, angle on petals, anthocyanins on petals, intensity of anthocyanins on the calyx, fruit hardness, number of seeds, seed color, seed size, flowering time, ripe fruit harvest time, physiological ripening time, fruit shelf life.

The data is displayed descriptively and then compared with the literature. Vegetative and generative data. Vegetative and generative character data were arranged in the form of nominal, ordinal, internal and ratio data using Microsoft Excel 2016. Data were analyzed using the Gower (1971) and UPGMA (Unweighted Paired Group Method with Arithmetic Mean) methods. This analysis was visualized in the form of a phylogenetic tree and PCoA using PBSTAT-CL 2.1

RESULT AND DISCUSSION

Genetic diversity is an initial guideline in plant breeding activities. Selection activities carried out on various characters require greater variety or variation. In the research that has been carried out, vegetative characters were observed, namely the hypocotyl, stem, segments, leaves, flowers, fruit and seeds.

Genotypes golden 1 and golden 2 do not contain anthocyanin in the hypocotyl, while genotypes red, local 1 and local 2 do not have anthocyanin in the hypocotyl. The golden 1 and golden 2 and red genotypes have medium first internode length and high internode length, while local 1 and local 2 genotypes have medium first internode length and low internode length (Table 1).

The golden 1 and golden 2 genotypes have weak anthocyanin intensity in the segments, while in red, local 1 and local 2, the anthocyanin intensity in the segments is moderate. All genotypes have pubescence on the segments. The golden 1 and golden 2 and red genotypes have an upright growth habit and a broad elliptic leaf shape, while the local 1 and local 2 genotypes have a prostate growth habit and a narrow elliptic leaf shape.

The golden 1 and golden 2 and red genotypes have long, wide leaves and are green. The green intensity of the leaves is weak to medium and the leaf stalks are medium to long. Local 1 and local 2 genotypes have medium leaf length, narrow leaves, sharp leaf margins and a purplish green color. Strong green intensity of leaves and short leaf stalks.

The genotypes planted are a collection of genotypes from different regions, so they show different performance. As in the research of Hadiyanti *et al*. (2018) which shows that there are two species of *Physalis* found on the slopes of Mount Kelud, East Java, namely *P. minima* L. and *Physalis angulata* L. This shows that in one area, there are different genetics between plants. Local genotypes tend to have smaller plant performance and narrower leaf shapes than those from outside the region.

The differences that arise, especially in qualitative traits, are most likely genetic influences, while quantitative characters need to be reviewed whether they originate from genetics or environmental factors. Quantitative characters are regulated by many genes (polygenic) and are influenced by environmental factors other than genetic factors (Syukur *et al*., 2012). The results showed that the five genotypes studied showed quite high diversity. It is hoped that high

Table 1. Characters of golden berries in the vegetative phase

Variable	Golden 1	Golden 2	Red	Local 1	Local 2
hypocotyl anthocyanins	absent	absent	present	present	Present
growing habits	upright	upright	upright	prostrate	semi upright
length of first segment	medium	medium	medium	low	Low
segment length	length	length	length	low	Low
internode anthocyanins	present	absent	present	present	Present
internode anthocyanin intensity	weak	weak	medium	medium	Medium
pubescence on segments	present	present	present	present	Present
leaf shape	broad elliptic	broad elliptic	broad elliptic	narrow elliptic	narrow elliptic
leaf length	length	length	length	medium	Medium
leaf width	width	width	width	narrow	Narrow
leaf edge border	medium	medium	medium	pointed	Pointed
leaf color	green	green	green	Purplish green	Purplish green
intensity of green leaves	weak	weak	medium	strong	strong
petiole condition	intermediet	intermediet	intermediet	intermediet	intermediet
leaf stalk length	medium	medium	length	shorts	Shorts

diversity will increase the choice of characters to determine the direction of plant breeding and improve plant quality.

In the generative phase characters (Table 2), observations were made on flowers, fruit and seeds. The five genotypes studied had diversity in flower stalks, flower diameter, base color of flower corolla, but there was no diversity in the number of anthers.

Fruit size, length and diameter range from small to medium. In terms of fruit cross-sectional shape and cavity depth, there was no variation in either cross-section or vertical section. All genotypes are circular, meaning

Table 2. Characters of golden berries in the generative phase

Variable	Golden 1	Golden 2	Red	Local 1	Local 2
condition of flower stalks	Intermediet	intermediet	Drooping	errect	Errect
Flower stalk length	Medium	length	Medium	shorts	Shorts
flower diameter	Medium	Medium	Medium	small	Small
base color of flower crown	yellow	yellow	yellow	white	White
number of anthers	5	5	5	5	5
thickness of the stalk near the fruit	Medium	Medium	Medium	thin	Thin
fruit size	Medium	Medium	Small	small	Medium
fruit length	Medium	Medium	Medium	length	Medium
fruit diameter	Medium	Medium	Small	small	Medium
fruit length/diameter ratio	Small	Small	Small	small	Small
vertical cross-sectional shape of the fruit	Circular	Circular	Circular	circular	Circular
cross-sectional shape of the fruit	Circular	Circular	Circular	circular	Circular
depth of the cavity at the base of the fruit	very shallow	very shallow	very shallow	very shallow	very shallow
shape of the tip of the fruit	Rounded	Rounded	Rounded	pointed	Rounded
main color (at harvest)	Yellow	Orange	Orange	White	Green
main color intensity (at harvest)	bright	Medium	Medium	Medium	Medium
main color of fruit (at physiological maturity)	Yellow	Yellow	Yellow	Green	Green
main color of fruit Intensity (at physiological maturity)	weak	weak	weak	strong	Strong
fruit flesh color	Yellow	Yellow	Yellow	greenish yellow	greenish yellow
number of prominent loci	2	2	2	4	4
petal power	medium	medium	medium	medium	Medium
petal cover	fully enclosed	fully enclosed	fully enclosed	slightly open	fully enclosed
pubescence of petals	Present	Present	Present	absent	absent
Ribbing on petals	Present	Present	Present	present	Present
anthocyanins in petals	Absent	absent	absent	Present	Present
anthocyanin intensity in petals	Very weak	Very weak	Very weak	medium	Weak
fruit firmness	Medium	Medium	Medium	firm	Medium
number of seeds	Banyak	medium	medium	lots	lots
Seed color	Yellow	Yellow	Yellow	Brownish yellow	Brownish yellow
seed size	medium	medium	medium	small	Small
flowering time	medium	medium	medium	shorts	shorts
physiological ripening time	medium	medium	medium	shorts	shorts
time to harvest ripe fruit	medium	medium	medium	shorts	shorts
fruit shelf life	medium	medium	medium	Long	Long

the surface of the fruit tends to be flat. Quite clear diversity can be seen in the color of the fruit, the color of the fruit flesh, and the fruit petals as well as the anthocyanins in the fruit. The golden 1, golden 2 and red genotypes have yellow to orange fruit color, while the local 1 and local 2 genotypes have a greenish white color with anthocyanins (Figure 1).

In seed organs, the characters that have diversity are seed color, seed size and number of seeds. The golden 1, golden 2 and red genotypes on average have yellow seeds of medium size and a moderate number of seeds, but the local genotype has brownish yellow seeds, small and numerous. Flowering time, flowering time and fruiting time also look different. The local 1 and local 2 genotypes are more mature than the golden 1, golden 2 and red genotypes. On the other hand, the shelf life of fruit in local 1 and local 2 is longer than in the golden 1, golden 2 and red genotypes. These quite contrasting characters have enormous potential for improving the quality of Golden berries plants.

Based on cluster analysis, the golden 1, golden 2 and red genotypes are in the same cluster, while the local 1 and local 2 genotypes are in another cluster (Figure 2). In the dendogram you can see the grouping into 2 large groups which have a fairly high copenhetic distance, namely 0.8. According to Suwardike *et al.* (2019) with similarity coefficients of 13% and 38% respectively, or dissimilarity of 62% to 87% in mango plants, shows that they have been able to differentiate samples at the species level. This means that at

Figure 1. Golden berries fruit character

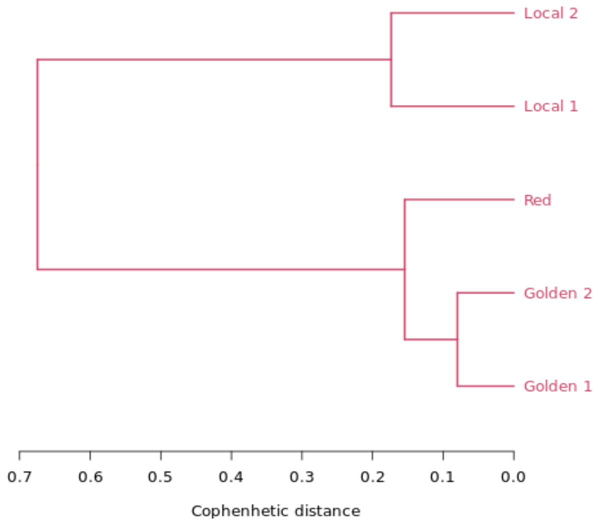

Figure 2. Dendogram of five Golden Berries genotypes based on vegetative and generative characters

a distance of 80% the dissimilarity has exceeded the threshold. This distance indicates high genetic dissimilarity. This is supported by PcoA analysis (Figure 3.) which shows that the golden 1, golden 2, and red genotypes with local 1 and golden 2 genotypes are in opposite quadrants. So it can be concluded that these two clusters have a long genetic distance. The greater the genetic distance shown, the more diverse the population studied.

Based on the characters observed in the five genotypes both in the vegetative and generative phases. Genotypes golden 1, golden 2 and red have an upright growth habit, and the stem, leaf, flower and fruit characteristics

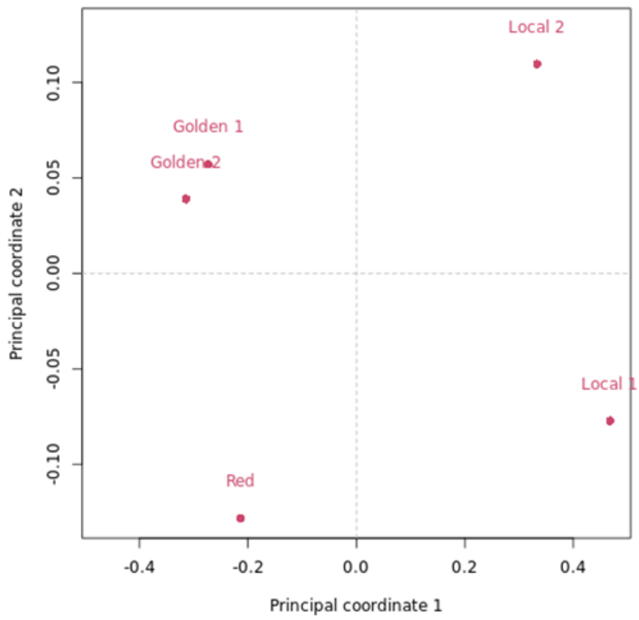

Figure 3. Results of Principal Coordinate Analysis (PCoA) on vegetative and generative characters

are categorized into *Physalis peruviana.* This refers to the research results of Rodrigues *et al*. (2021) who conducted research on fruit characterization of *Physalis peruviana*, while the local genotype has characters similar to *Physalis angulata,* in accordance with the characters observed by Nadhifah *et al*. (2016) regarding the phenetic relationships of Golden berries (*Physalis angulata* L.) in the former Surakarta residency area. *Physalis peruviana, Physalis pubences* and *Physalis angulata* are the most suitable species to be used as raw materials for the jelly industry.

High diversity has great potential for crossbreeding so that it can produce heterosis traits. Heterosis is the characteristic of offspring being able to exceed the characteristics of their two parents (superior). Crossing is done to improve better plant quality. So that the needs of Golden berries in the growing period can be met by getting varieties that have superior quality

CONCLUSION

The genetic diversity observed in Golden berries was high. High diversity provides greater opportunities for selection of desired characters. The greater the genetic distance between the parents being crossed, the greater it will also produce the heterosis trait which is the ideotype of the breeding activities carried out.

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