BIODIVERSITAS
Volume 24, Number 10, October 2023
Pages: 5634-5642

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d241045

The identification of potato genotype diversity based on morpho-agronomy and nutritional traits in the highland areas of Papua, Indonesia

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Manuscript received: 17 August 2023. Revision accepted: 26 September 2023.

Abstract. *Prabawardani S, Yogi DJ, Mawikere NL, Gari NM, Noya AI, Taberima S, Djuuna IA, Luhulima FDN. 2023. The identification of potato genotype diversity based on morpho-agronomy and nutritional traits in the highland areas of Papua, Indonesia. Biodiversitas 24: 5634-5642.* Potatoes (*Solanum tuberosum* L.) are a potential food crop in terms of economic value and food security, and, therefore, its development must be considered. The missionaries introduced several potato genotypes from 1959 to the 1960s in Papua; however, this area has not been widely studied. This research aimed to identify the agro-morphological characteristics and analyze the tuber nutritional traits of potato genotypes. The research was conducted in Mimin Village, Oksop Sub-district, Pegunungan Bintang District of Papua Province, Hungku Village, Anggi Sub-district, Pegunungan Arfak District of West Papua Province. The research in both locations was designed using a descriptive method, and the samples were collected based on the random sampling technique. There were 2 potato genotypes found in Mimin (KM-O and KP-O) and 5 in Hungku (KM-A, KH-A, KP-A, KB-A, and KT-A) with quite diverse traits, particularly in tuber components. With several prominent morphological characters, potato genotypes from Hungku (KM-A, KBH-A, KT-A) produced the highest yields (0.8 kg/plant). Based on the agro-morphological and nutritional characteristics, it shows the formation of two main clusters with a dissimilarity index of Squared Euclidean Distance ranging from 6.112 to 46,643. Cluster one consisted of genotypes KM-O, KP-O, KM-A, and KH-A, and cluster two consisted of KP-A, KBH-A, and KT-A genotypes, and the dissimilarity mainly lies in the yield and nutrient characters. Based on the nutrient analysis, the highest dry matter content was found in KH-A. The highest starch content was in KP-O and KBH-A, and the highest reducing sugar was in KM-A. The potato genotype with the lowest reducing sugar content was KP-A. Each potato genotype shows various agro-morphological and nutritional characteristics that can be used as a basis material for plant breeding.

Keywords: Agro-morphology, nutrition, Papua, potato, *Solanum tuberosum*

INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the priority food crops for its development because of its economic value (Zaheer and Akhtar 2014; Indrasti et al. 2021) and potential food security crop (Devaux et al. 2014; Wang et al. 2023), and income generation. According to Setiawan and Inayati (2020), potatoes have a good opportunity and profitability from a business perspective and agro-industry, although it is less competitive globally (Saptana et al. 2022). The demand for potatoes in Indonesia is quite high (Rahayu and Sukardi 2018) and continues to increase while the supply is still lacking. Hence, the government imports potatoes (Rahayu and Sukardi 2018). Potato consumption in Indonesia is predicted to reach 1.15 million metric tons in 2026. The country's demand has experienced growth of 0.3% year-on-year since 2017. In 2021, Indonesia is the 34th largest potato consumer. Meanwhile, potato production in Indonesia is targeted to reach 1.44 million metric tons in 2026 (Linker 2023). This shows that potato is a very potential plant in agribusiness.

Potatoes usage varied from staple food consumption, food industry (Zaheer and Akhtar 2014; Wang et al. 2023), feed, and plant propagation material (Gonzales et al. 2016). Potatoes contain not only large amounts of starch but vitamins, especially vitamins C and B, and minerals such as K and Fe, phenolic compounds that have an important role in health, almost free of soluble sugar (Haddad et al. 2016; Van Dingenen et al. 2019).

The history of potato cultivation in Papua, especially in the Pegunungan Bintang District, is relatively unique, in line with the uniqueness of the diverse culture of the Papuan people. According to the Ngalum Community in the Pegunungan Bintang District, potato plants were first introduced by missionaries at the end of 1959. After that, potatoes began to develop in the Ngalum Community and its surroundings. Similarly, in Anggi, Pegunungan Arfak District potato is also an introduced crop brought by missionaries in the 1959s and introduced by CIP (International Potato Center) in the 1980s.

In its development, the area of potato plants in Indonesia tends to increase. In 1969, the national potato area was 14,770 ha; in 1981 it was 30,278 ha; in 1991 it was 39,620 ha; in 2018 it increased to 68,683 ha (Direktorat Jenderal Hortikultura 2019). In 2011, the national potato production was 955,488 tons, increasing to 1,219,558 tons in 2015 (Direktorat Jenderal Hortikultura 2019), and reached 1,503,998 tons in 2022 (BPS 2022). Although the area and national potato production continue to increase, productivity remains low. Considering the increased world population, the need to improve potato productivity has to be addressed.

The harvested area and potato production in Papua Province, including the Pegunungan Bintang District, declined. It was 70 ha with a production of 201 tons in 2014, decreasing to 45 ha with 42 tons in 2016, and 14 ha in 2018 with 27 tons, and no potato production data was reported in 2022. Potato production is also reported to be declining in West Papua. In 2016, potato production in this area was 598.90 tons, decreasing to 113.80 tons in 2018 (BPS Papua Barat 2019), and further declining to 29.00 tons in 2022 (BPS 2023). The decline in potato productivity is mainly due to low-quality seeds that come from their harvest and are used continuously as seeds. Low productivity is also caused by other factors, namely disease attacks, especially stem rot and tuber rot, and inappropriate potato cultivation techniques.

Potato has potential as an alternative staple food crop in anticipating droughts that periodically occur in the central highlands of Papua due to El Niño. This is because potato has a short harvest time of 3-4 months, while sweet potato, as a local staple food, has a longer time (8 months) to be harvested. In its development, the potato genotypes have not yet been recorded in Oksibil, and only a few studies have been carried out in Anggi; therefore, it is important to identify potato genotypes still present in these areas. Potato genetic resources and their potential must be known, considering that genetic diversity is important as a source of genes for potato breeding and crop improvement. Determining the diversity of potatoes can be identified by evaluating morphological and agronomic characters as the first step in describing plant genotypes. The objective of this study was to identify the diversity of potato genotypes based on agro-morphological characters and their nutrients in Mimin Village, Oksibil, Papua, and Hungku Village, Anggi, West Papua.

MATERIALS AND METHODS

Study area

The research was conducted in Mimin Village (4°43' 17.7456" S, 140°24' 44.13708"E) of Oksop Sub-district, Pegunungan Bintang District, Papua Pegunungan Province, and Hungku Village (1°19'26.44536"S, 133°53' 59.53128"E) of Anggi Sub-district, Pegunungan Arfak District, West Papua Province, Indonesia, from November 2020 to February 2021. The two villages were selected according to the information from the local communities and the local leaders that both villages are in potato-producing areas. The study sites were chosen according to the suggestion by the Extension of Agricultural Board and information from the local communities. in both districts. A map of the study areas is presented in Figure 1.

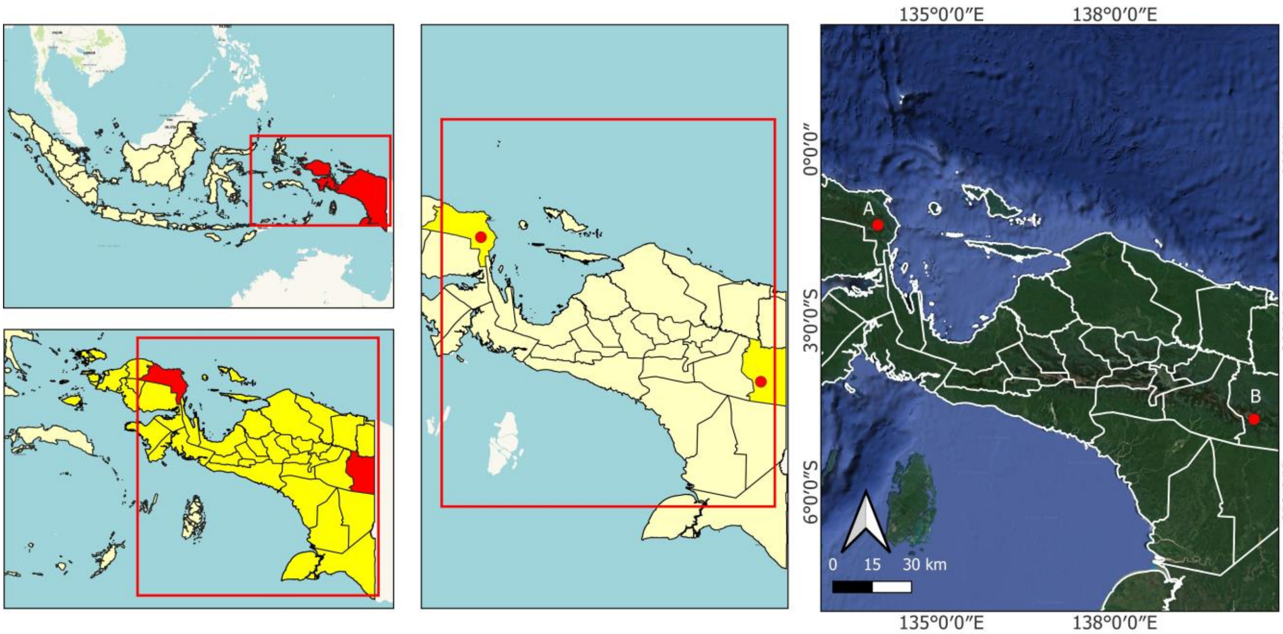

Figure 1. Map of the study areas in Papua, Indonesia. A. Mimin Village of Pegunungan Bintang District, Papua Pegunungan Province. B. Hungku Village of Pegunungan Arfak District, West Papua Province

Research method

This study used a descriptive method with direct observation techniques in the field. The observed variables included morphological, agronomic characters, and nutritional tuber content. An interview with farmers was conducted semi-structural (10% of respondents per village), including the traditional elders and figures who know the history of potato cultivation and various potato genotypes. For tuber nutrient analysis, dried potato samples were analyzed in the Laboratory of Chemistry and Food Technology, Research Institute of Nuts and Tubers, Malang, Indonesia. Observations on the chemical composition of fresh potato tubers include (i) Water content, using gravimetric method, (ii) Dry matter content, using gravimetric method, according to SNI 01-2891-1992 (National Standardization Agency 1992), the samples were taken from the middle of the tuber, cut into small pieces, 100 g dried in an oven at 55-60ºC for 24 hours and weighed, (iii) starch (acid hydrolysis followed by the Nelson-Somogy method), and (iv) reducing sugar (Nelson-Somogy method).

Research procedure

The implementation of the research included determining the location by conducting an initial survey to determine the location of the garden and the genotype of potatoes cultivated by the community, characterizing the morphology of leaves and stems when the plant is 2 months after planting, and characterizing the morphology of tubers at harvest. There were 3 plant samples for each genotype, which were taken randomly. The samples taken are then characterized by their morphology and agronomy. The morphological characteristics studied refer to the the descriptors by the International Board for Plant Genetic Resource (IBPGR), including vine, leaf, and root crops.

Data analysis

Agro-morphological observations referred to the descriptors by the International Board for Plant Genetic Resources (IBPGR). Collected data of plant morphology, tuber yields, and the level of nutrition content of all genotypes was used as numerical data and was analyzed to observe the level of character dissimilarity among genotypes. Cluster analysis was carried out using the NTSYS program ver. 2.0.

RESULTS AND DISCUSSION

Mimin Village, Oksop Sub-district, Pegunungan Bintang District, Papua Province

Mimin Village is one of the villages in Oksop District, Pegunungan Bintang District, Papua Province, dominated by the Ngalum Tribe. This village is located in the highlands (400-1,452 m above sea level). Among several villages in the Oksop Sub-district, the community in Mimin Village is the one that cultivates potato plants. The identification results in Mimin Village indicated that there are currently 2 potato genotypes, namely Red and White Potatoes (Table 1). People call the name potato based on the tuber skin color. According to the local community, there were more than 2 previous potato genotypes, but several other ones were diminished and difficult to find. These two existing genotypes that are maintained are the most favored by the local community because of their delicious and fluffier tastes. The decrease in several potato genotypes was due to disease attacks and could not stand the extreme weather conditions, such as a long dry period of El-Nìno.

Hungku Village, Anggi Sub-dstrict, Pegunungan Arfak District, West Papua Province

Hungku Village belongs to the Anggi Sub-district, Pegunungan Arfak District, West Papua Province. This village is located at an altitude of 2,955 m above sea level. The yield of potatoes in this area is mostly sold, while a small portion is consumed and used for seeds. The Arfak community relies mostly on sweet potatoes as a staple food. Based on this study, there are 5 potato genotypes, namely *kentang merah* (red potatoes), *kentang hitam* (black potatoes), *kentang putih* (white potatoes), *kentang bintik hitam* (black spotted potatoes), and *kentang telur* (egg potatoes). Likewise, in the Oksop Distrik, the people in the Anggi named the potato genotype based on the tuber skin color (Table 1). Compared to the data presented by Mawikere and Prabawardani (2017), there were 21 potato cultivars found in 15 villages of Hink Sub-district, the Pegunungan Arfak District. Based on personal communication with the old farmers' community in Oksop and Anggi, previously, they had about 6 and more than 10 potato cultivars, respectively. It shows the declining number of potato cultivars in both areas due to several factors. Therefore, a deep study of the current status and its diversity must be prioritized.

Table 1. Potato genotypes collected from Mimin and Hungku Villages of Papua Island, Indonesia

Sub-district/District/Province	Village	Genotype	Code
Oksop/Oksibil/Papua	Mimin	*Kentang merah* (red potato)	KM-O
		Kentang putih (white potato)	KP-O
Anggi/Arfak Mountain/West Papua	Hungku	*Kentang merah* (red potato)	KM-A
		Kentang hitam (black potato)	KH-A
		Kentang putih (white potato)	KP-A
		Kentang bintik hitam (black spot potato)	KB-H
		Kentang telur	5. KT-A

Morphological characters

Growth habit

Two genotypes of potatoes in Mimin Village have a slightly upright (semi-erect) growing habit and green stems, but the cross-sectional shape of the stems is different, namely square in KM-O and round in KP-O. Similarly, the 5 genotypes of potatoes in Hungku village have the same characteristics as the two genotypes of potatoes from Mimin Village, namely semi-erect growth habit, except for the KH-A genotype with an erect growth habit. Meanwhile, the cross-section of the potato genotype from Hungku shows a square shape characteristic in KM-A, KH-A, KB-A genotypes and a round shape in KP-A and KT-A genotypes (Table 2).

Color and stem cross section

Plant stems function as a pathway for nutrients and water from the soil to the leaves and to distribute photosynthetic products from the leaves to other plant parts (Elo et al. 2009; Aliche et al. 2020). The stem color of all genotypes from both locations was green (Table 2). The stem color of a potato varies; it can also be reddish-green or purplish-green. The cross-sectional tuber in all potato genotypes in the two regions were square and round. The potato stems are rectangular or pentagonal, depending on the variety, and the stems are ribbed, hollow, and not woody (Warnita et al. 2019). Variation in morphological characteristics results from the interaction between genotypic and environmental factors. Therefore, genetic variability is of primary interest to the plant breeder.

Color and leaf structure

The leaf color of all potato genotypes from Mimin and Hungku Villages was green, and the leaf structure was moderate (Table 2). Green leaf color indicates leaf chlorophyll content. High chlorophyll content in leaves will increase photosynthetic activity if other factors are met. The color of plant leaves is mainly related to the type, content, and distribution of pigments in the leaves (Chu et al. 2013). Leaf color that remains green in any environmental conditions indicates that the leaves carry out their photosynthetic activities well. Leaf color is mainly determined by the pigment present in the cells of the leaf and depends on the dominant pigment. Pigments are classified into chlorophyll, carotenoids, flavonoids, and betalains (Sudhakar et al. 2016); the leaves are green if chlorophyll pigment is higher than other pigments.

Leaf structure, namely leaf shape, thickness, stomata distribution, leaf color, number, and distribution of palisade cell layers, is related to various aspects of its physiology. Leaf mass-based traits are important for the whole-plant resource economic (Poorter et al. 2014); however, area-based photosynthetic trait is more appropriate for addressing whether the evolution of thicker or denser leaves impedes CO_2 and carbon diffusion (McElrone 2013). Leaf structure will determine the distribution of light and CO_2 in the leaf, affecting CO_2 uptake in photosynthesis per unit of leaf biomass. The closed leaf structure shows a dense leaf density, while the open leaf structure shows a loose-leaf structure.

Trichomes

Trichomes, which appear on the potato shoots of all genotypes in both locations, were classified as moderate, except the KH-A genotype from Hungku shows a slightly high Trichome (Table 2). Trichomes play a crucial role in the plant to avoid excessive evaporation. There is an indication that many glandular trichomes are related to pest resistance. According to Tsunaki and Morimoto (2020), a secondary metabolite isolated from the trichomes of *Smallanthus sonchifolius* (Poepp. & Endl.) H.Rob. showed strong insecticidal activity against caterpillars. Therefore, trichomes can function as a plant resistance factor. This means trichomes on leaves help plants resist insects or pests, so they can be used to reduce pesticides. Trichomes are also known to modulate leaf properties, especially radiation absorption, having a broader role in plant-environment interactions (Bickford 2016). In addition to being a light reflector, the dense or dense canopy of the trichomes modulates leaf heat balance and light interception and consequently affects gas exchange properties. Abundant trichomes generally increase the reflectance of visible light and infrared radiation. Trichomes are reflective and protective, reducing photoinhibition and UV-B-related damage to leaf photochemistry (Karabourniotis et al. 2020). The KH-A genotype has many trichomes, so this genotype provides more advantages in preventing plant pest organisms. It can be cultivated in extreme (high) temperatures and light conditions.

Shape, color, and tuber skin type

Each genotype of potato has a different tuber shape (Table 3, Figures 2 and 3). KM-O has a compressed shape (elongated dense tends to be rectangular), while KP-O genotype has a round shape (Table 3). Potato genotypes collected from Hungku showed more variations in tuber shape (Figure 3). KM-A is elliptical (long round), KH-A is compressed (solid), KP-A is oblong (oval), KB-H is round oval, and KT-A is round. Besides yields and nutrition, tuber shape is an important characteristic needed by the food processing industry (Custers 2015).

Depth, number, and distribution of potato buds

On the surface of tubers, buds will release shoots in time; these are potential buds or potato plants that can become new individuals. The buds on the tuber surface can be deep, medium, and shallow. The shoot depth among potato genotypes varied. Potato genotypes from Mimin Village showed a deep shoot depth in KM-O genotype and a medium depth in KP-O genotype. Genotypes KM-A and KH-A from Hungku showed a medium shoot depth, whereas KP-A is classified as a medium depth. KB-H and KT-A genotypes have shallow deep (Table 3).

Table 2. Growth habit, stem and leaf characters of potato genotypes

Village/district	Potato genotype	Growth habit	Stem color	Stem cross section	Leaf color	Leaf structure	Trichomes
Mimin	KM-O	Semierect	Green	Rectangle	Green	Close	Moderate
	KP-O	Semierect	Green	Round	Green	Open	Moderate
Hungku	KM-A	Semierect	Green	Rectangle	Green	Close	Moderate
	KH-A	Erect	Green	Rectangle	Green	Open	Slightly high
	KP-A	Semierect	Green	Round	Green	Close	Moderate
	KB-H	Semierectt	Green	Rectangle	Green	Close	Moderate
	KT-A	Semierect	Green	Round	Green	Close	Moderate

Table 3. The morphological characters of tubers

Village	Potato genotype	Tuber shape	Tuber skin color	Tuber skin type	Budding eye depth	Number of eyes per bulb	Bud distribution
Mimin	KM-O	Compressed	Pink	Rough (flaky)	Deep	Medium	Apical
	KP-O	Round	Cream	Partially netted	Medium	Medium	Apical
Hungku	KM-A	Elliptic	Pink	Rough (flaky)	Deep	Medium	Apical
	KH-A	Compressed	Dark purple	Rough (flaky)	Medium	Medium	Spread
	KP-A	Oblong	Cream whiteness	Partially netted	Medium	Medium	Apical
	KB-H	Round to oval	Yellow	Smooth-totally netted	Shallow	Less	Spread
	KT-A	Round	Brown	Smooth	Shallow	Less	Spread

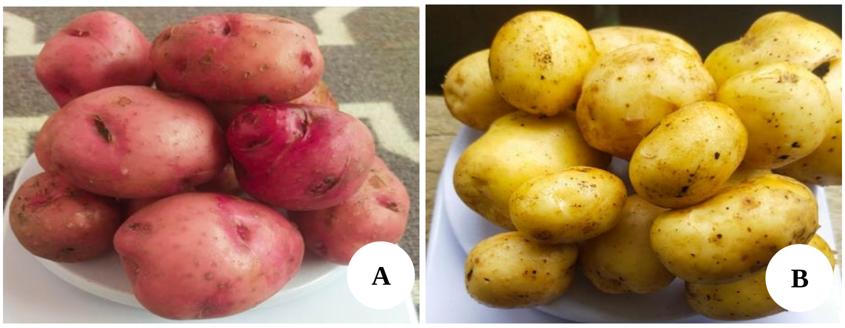

Figure 2. Tuber shape of potato genotypes collected from Mimin. A. KM-O. B. KP-O

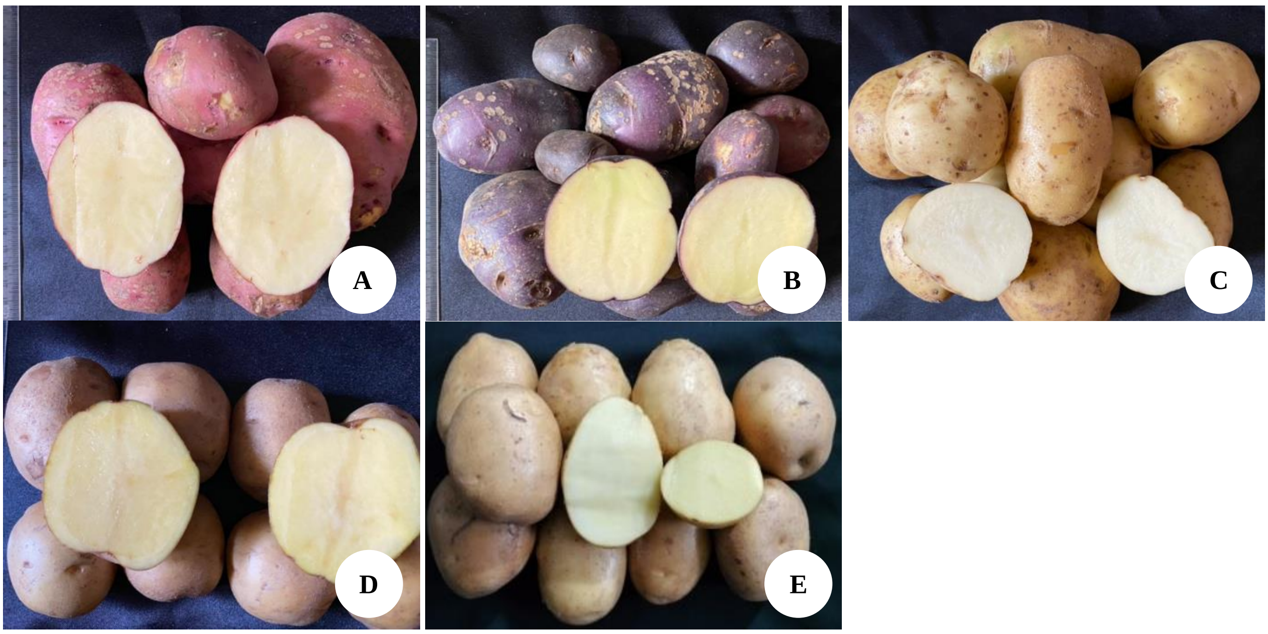

Figure 3. Tuber shape of five potato genotypes collected from Hungku. A. KM-A. B. KH-A. C. KP-A. D. KB-A. E. KT-A

The distribution of shoots on tubers of two potato genotypes from Mimin Village (KM-O and KP-O) was predominantly apical. The spread of shoots with a predominantly apical character was found in potato genotypes from H (KM-A and KP-A), while evenly distributed characters were found in KH-A, KB-H, and KT-A. Bud number in potatoes varies, depending on plant genotype, age, nutritional status, and environmental conditions (Bunphan and Anderson 2019). Potato tubers stored for seed purposes will sprout at the shelf life or dormancy period of approximately 2 weeks to 3 months after storage. Good potato seeds are ready to be planted when the shoots are approximately 2 cm in size, and the number of shoots reaches 5 shoots per tuber. Therefore, the criteria and characteristics of shoots are important factors in morphological identification. Consumers and the food industry prefer shallow shoots because they make peeling the tuber skin easier and maintain the tuber shape.

Tuber flesh color and secondary flesh color distribution

The potato genotype from Mimin Village showed a creamy whitish flesh color with a secondary color of narrow vascular ring tuber found in the KM-O genotype and yellowish cream in the KP-O genotype with a scatter plot secondary color distribution of tuber flesh. The potato genotype from Hungku, KM-A, had a yellowish cream tuber color with a narrow vascular ring tuber color distribution, while the KH-A genotype had a creamy yellow tuber flesh color with a vascular ring and medulla secondary color distribution, while tuber flesh of KT-A is dark yellow (Table 4). The flesh color of KP-A is light yellow whitish with a secondary color distribution of scatter spot (scattered), and genotype KT-A is dark yellow with a secondary color distribution of scatter area (spread in certain parts). The color of the tubers can indicate the presence of antioxidant compounds. The potato varieties with blue flesh color are powerful antioxidants and, hence, have the potential as the richest antioxidant sources in the human diet (Jarienė et al. 2013). Similarly, according to Franková et al. (2022), higher total antioxidant activity was found in the purple tuber variety than in the orange and the white flesh variety. Sweet potato flesh and skin vary in color, from yellow, cream, red, and pink to dark purple. This color is an indication of the presence of carotenoid and anthocyanin pigments. The different compositions and intensities of the two compounds resulted in the distribution of secondary colors in potato skins and tubers.

Agronomic characters

Tuber number, length, diameter, and yield

The average tuber number of potato genotypes from Mimin village was 8/plant produced by KM-O genotype and 9/plant produced by KP-O genotype (Table 5). While potato genotype from Hungku (KP-A) produced the highest tuber number (9/plant), followed by the KT-A (8/plant). The potato genotype with the lowest tuber number was KB-A (5/plant).

The tuber length of the potato genotype from Mimin village ranged from 7-8 cm with a diameter of 6-7 cm, while the tuber length of the potato genotype from Hungku ranged from 7.3 cm to 9.3 cm, and the longest tuber (9.3 cm). The largest tuber diameter (8.7 cm) was produced by KB-H genotype. The lowest tuber weight was produced by potato genotypes from Mimin (0.4-0.5 kg/plant). On the other hand, potato genotypes (KM-A, KB-H, and KT-A) from Hungku produced an average of 0.8 kg/plant, which is relatively similar to what was produced by Haddad et al. (2016) in their experiment using the doze of 380 kg KNO_3.

Nutrition analysis

Nutrient content is an indication of tuber internal quality. Many properties determine internal quality, but the most important is dry matter content, starch, sugar, and tuber flesh discoloration (Naumann et al. 2020). The result of the nutritional analysis of potato tuber (moisture content, dry matter content, starch content, and reducing sugar) is presented in Table 6.

Table 4. The morphological characteristics of potato tuber flesh

Village	Potato genotype	Tuber flesh color	Tuber flesh secondary color distribution
Mimin	KM-O	White cream	Narrow vascular ring
	KP-O	Yellowish cream	Scatter spot
Hungku	KM-A	Yellowish cream	Narrow vascular ring
	KH-A	Creamy yellow	Vascular ring and medulla
	KP-A	Whitish light yellow	Scatter spot
	KB-H	White cream	Vascular ring and medulla
	KT-A	Dark yellow	Scatter areas

Table 5. Characteristics of potato tuber yield

Village	Potato genotype	Tuber number per plant	Tuber length (cm)	Tuber diameter (cm)	Tuber weight per plant (kg)
Mimin	KM-O	8.00	8.00	7.00	0.40
	KP-O	9.00	7.00	6.00	0.50
Hungku	KM-A	7.00	9.00	8.30	0.80
	KH-A	6.00	7.30	8.30	0.70
	KP-A	9.00	7.30	8.30	0.60
	KB-H	5.00	9.30	8.70	0.80
	KT-A	8.00	7.70	7.30	0.80
SD		1.51	0.89	0.97	0.16

Table 6. Moisture content, dry matter, starch, and reducing sugar of potato tubers

Potato Genotype	Water content % (bb)	Dry matter (%) (bb)	Starch* % (bb)	Reducing Sugar** % (bb)
KM-O	64.15	35.85	64.89	0.86
KP-O	67.21	32.79	75.51	0.35
KM-A	61.45	38.55	65.97	0.95
KH-A	59.50	40.5	62.35	0.78
KP-A	73.43	26.57	50.68	0.21
KB-H	65.32	34.68	75.04	0.49
KT-A	65.67	34.33	59.99	0.67

Note: *: Acid hydrolysis; **: Nelson-Somogy method; bb: wet base

Moisture content is one of the material's physical properties, indicating the amount of water contained in the material. Results of the analysis showed that the highest moisture content was found in KP-A genotype (73.43%); on the other hand, this genotype produced the lowest dry matter content (26.57%), followed by the KP-O (67.21%) and dry matter content of 32.79%. At the same time, the lowest water content was found in KH-A genotype (59.50%), with the highest dry matter content of 40.5% and KM-A of 61.45%, with a dry matter content of 38.55%. Water content of other genotypes (KBH-A and KT-A) was 65.32% and 65.67%, respectively, with dry matter content of 34.68% and 34.33% (Table 5). Dry matter and starch content are important for food industries. In the potato chip food industry, high dry matter increases yield and crispness and reduces oil absorption in fried products (Johnson et al. 2010; Dewayani et al. 2020). Mimin Village (KP-O) and Hungku (KB-H) genotypes produced the highest starch content, 75.51%, and 75.04%, respectively. Potato genotypes with the lowest starch were KP-A from Hungku, accounting for 50.68%, and KT-A 59.99%. The other genotypes were KM-O from Mimin village at 64.89%, KM-A, and KH-A from Hungku at 65.97% and 62.35%, respectively. The highest reducing sugar content was produced by KM-A (0.95%), followed by KM-O (0.86%). The lowest reducing sugar content was produced by KP-A (0.21%), KP-O (0.35%), and KB-H (0.49%). In addition, potato tubers are an industry source of high-quality starch (Tong et al. 2023). In the food industry, high starch content and low reducing sugar are highly required for the chips, french fries, and mashed potato industries. But for vegetable potatoes, taste preferences, texture, and tuber structure depend on people's tastes. According to Leonel et al. (2017), the chemical composition of potato tubers is influenced by variety, soil type, cultivation method, harvesting method, level of maturity, and storage conditions. The environment and genotype influence the nutrient composition and content (Ismail et al. 2015). According to (Kaur and Aggarwal 2014; Ismail et al. 2015), different cultivars may produce different water, dry matter, and starch content.

Cluster analysis

The cluster analysis was carried out to determine patterns of genetic diversity, classify genotypes, and determine the genetic distance between plant genotypes (Afshari et al. 2017). The similarity analysis uses agro-morphological and nutritional characteristics to determine the distance between the seven genotypes of potato plants from the Mimin and Hungku Villages.

The dendrogram was built based on 22 characters consisting of agro-morphological and nutritional characters (Figure 4). It shows the formation of 2 main groups, namely group I, which consists of 1 KH-A genotype, and group II consists of KP-A genotype, KP-O, KT-A, KB-H, KM-A, and KM-O with a similarity coefficient of 0.30. Group II is divided into two sub-groups (group II A consisting of genotypes KP-A and KP-O with a similarity coefficient value of 0.64 and group II B consisting of genotypes KT-A, KBH-A, KM-A, and KM. -O, with a similarity value of 0.36). Group II B then formed 2 groups (IIB1 and IIB2 with a similarity value 0.40). The similarity index of KH-A compared to other potato genotypes was the lowest (0.30). These results indicate that the KH-A genotype has a distant phenetic relationship with the other six potato genotypes. Morphological, agronomic, and nutritional properties can be used to describe the similarity of genotypes. Genotypes with a high degree of similarity have many characteristics in common between one genotype and other genotypes (Balkaya et al. 2009). The KH-A genotype has several characteristics that are different from other genotypes, namely the characteristic of growth habits, hair or feathers on the shoots, leaf arrangement, tuber shape, tuber skin color, tuber skin type, tuber flesh color, distribution pattern of secondary tuber color, depth buds, distribution of buds, number of tubers per plant, tuber length, potato weight, moisture content, dry matter content, reducing sugar content. The KM-O genotype had a close similarity to KM-A at 78%, followed by the KP-O and KP-A genotypes at 64%. The genotypes of KM-O and KM-A have many similarities, especially in the reddish tuber skin and various other characteristics, so the local people in the Mimin and Hungku areas call it red potato. Several other characteristics that distinguish the two genotypes are tuber shape (KM-O is elliptical and KM-A is compressed), tuber flesh color (KM-O is white cream, KM-A is yellowish beige), potato weight per plant (genotype KM-O 0.4 kg/plant and KM-A 0.8 kg/plant). Likewise, the KP-O and KP-A genotypes have a similarity level of 64%. It is estimated that the genotypes with a high degree of similarity are the same genotypes brought by foreign missionaries in the 1959-1960s, but some characters are recorded differently, for example, yield differences. The yield difference between the Mimin and Hungku potato genotypes was due to the differences in the physical and chemical soil properties and potato cultivation techniques. Hungku farmers are more intensive in maximizing potato yield using better cultivation techniques than Mimin farmers. Hence, potatoes play a crucial role in Hungku farmer's income. It is also supported by a better market, road, and transportation infrastructure, which are much better than in Mimin. Therefore, potato yield cultivated in Mimin is mostly used for farmer's family needs.

Matrix similarity was presented in order to indicate the compactness value in groups resulting from the clustering process (Table 7).

Table 7. Matrix of similarity of morphological and nutritional characters between potato genotypes from Mimin and Hungku

Potato genotype	KM-O	KP-O	KM-AK	KH-A	KP-A	KB-H	KT-A
KM-O	1.00						
KP-O	0.36	1.00					
KM-AK	0.73	0.36	1.00				
KH-A	0.41	0.27	0.32	1.00			
KP-A	0.36	0.64	0.41	0.27	1.00		
KB-H	0.36	0.32	0.41	0.32	0.32	1.00	
KT-A	0.45	0.41	0.41	0.18	0.32	0.50	1.00

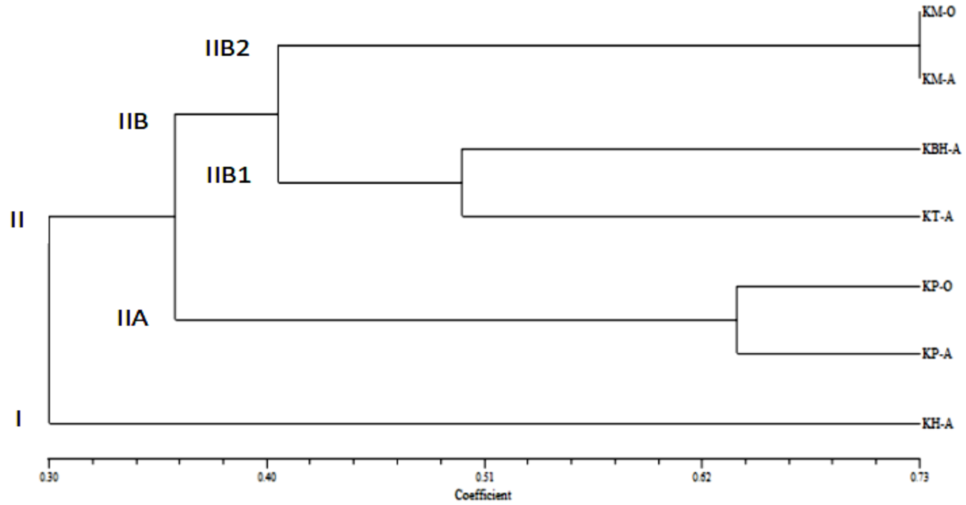

Figure 4. Dendogram of similar morphological and nutritional characters of potato genotypes from Mimin and Hungku

In conclusion, there are 2 potato genotypes found in Mimin Village, Oksop Sub-district, Papua Province and 5 in Hungku Villages, Anggi Sub-district, West Papua Province, with diverse morphological characters, especially in the tuber. Each character has good potential as a gene source for potato plant breeding programs. Based on the cluster analysis, it shows the formation of two main clusters with a dissimilarity index of Squared Euclidean Distance ranging from 6.112 to 46,643. Cluster one (I) consisted of KM-O, KP-O, KM-A, and KH-A genotypes, and cluster two (II) consisted of genotypes KP-A, KBH-A, and KT-A. The dissimilarity between clusters 1 and 2 is largely due to differences in several tuber and nutritional characteristics. Several genotypes show prominent morphological characteristics related to the need for starch industry, seed propagation, and plant physiological aspects (light reflectance, pest resistance). Potato genotypes of KM-A, KB-H, and KT-A produced the highest yields. KP-A genotype produced the highest dry matter content, KP-O and KB-H genotypes produced the highest starch content, while KM-A genotype produced the highest reducing sugar.

ACKNOWLEDGEMENTS

The authors thank the farmers' community in Mimin and Hungku Villages for their great help during the research. Thank you also to the local tribe leaders of both Districts and to Mr. Marnangon Tambunan for facilitating the instruments in the Agroclimatology Laboratory of the Agriculture Faculty, Universitas Papua. Thank you to Mr. Samsul Fatoni and Mr. Indra F. Luhulima for field collection and sample preparation.

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