Potential of Three Taro (*Colocasia esculenta* L.) Cultivars as Animal Feed

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ABSTRACT The growth and yield of taro (*Colocasia esculenta* L.) plants are influenced by the planting material. The use of planting material derived from corms is expected to improve the quality and quantity of taro growth and yield. This research aimed to find the best type of planting material and cultivars for taro growth and the potential of taro plants as animal feed. The experiment was carried out in Jember, East Java (elevation ±89 m asl). The experiment used the randomized completed block design method with two treatment factors, the type of planting material (B) as the first factor (B1: taro corms, B2: taro tiller, B3: taro stolon) and the use of taro cultivars (V) as the second factor (V1: green taro, V2: ketan taro, V3: Sukabumi taro). The treatment was repeated four times. The results showed that there was an interaction between the use of taro planting material and taro cultivar that could influence the tuber weight per plant. The types of planting material had a significant effect on the number of tillers, leaf area, corm weight and diameter, and the planting of several taro cultivars significantly affected all observed variables. The treatment that gave the best results was planting material from taro tuber (B1) and Sukabumi cultivar (V3) with a tuber weight yield of 362.58 g (±14.5 tons/ha). Meanwhile, the Sukabumi cultivar (V3) had the best potential as animal feed. Overall, the stems and leaves of taro had a protein content of 1.19–2.02%, while the corms had 2.82–4.09%.

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1. INTRODUCTION

Taro is a food crop that can grow in tropical regions like in Indonesia. Foodstuffs from taro corms are very good as a staple food substitute for rice between 20–43 when compared with rice which can reach 97 (Arif et al. 2013). A low glycemic index is very good consumption for diabetics because it can slow the increase of sugar blood, so it is good for health. Innovation processing of taro corms increase the value of products and have a high economic value (Lucy and Ifedayo 2012). The optimum productivity of taro can reach more than 30 tons per hectare (Rahmawati et al. 2012). The productivity of green taro in year 1996 in Hawaii had reached of 37 tons/ha and in Nigeria 21.9 tons/hectare (Ubalua et al. 2016). The productivity of green taro in Indonesia only reached 9.52 tons/hectare in 2011 (Onwueme 1999). One of the reasons for this is the selection and use of poor planting materials/seeds.

The use of good seeds is one example of the efforts to increase plant productivity (Djukri 2003). Seedlings for taro cultivation can be obtained from a variety of planting materials ranging from seeds, tissue culture, tillers, stolons, and corms (Wulansari et al. 2013). Planting material from corms is taken from the main corm that has been cut and there are buds in each part. Taro planting with seeds from corms reportedly resulted in higher weight per corm and yield per hectare than taro from seedlings of Sukabumi taro Istiqomah et al. (2010). It was noted that the highest average corm weight per plant was found in the type of plant-

ing material from corms rather than planting material from tillers (Tsedalu et al. 2014). Planting materials derived from saplings are generally more often used by farmers in Indonesia. Tillers for planting material are taken from the main plant that already has small shoots and corms (Moore and Lawrence 2003). In addition to corms and tillers, some farmers also use planting material derived from stolons. The use of stolons as planting material is less common than corms and tillers. Stolons selected for planting material are taken from around the main plant and usually have small shoots (Wang 1983).

There are various taro cultivars that grow in Indonesia. Some of them that are cultivated are green taro, ketan taro, and Sukabumi taro. green taro variety is the most widely distributed variety in Indonesia. The plant size is relatively small with an almost entirely green color, has long stolons and medium-sized corms (Andarini and Risliawati 2018). Ketan taro is generally grown in highlands with sufficient water availability. Ketan taro is relatively small with dark brown leaf stalks and medium-sized corms (International Plant Genetic Resources Institute 1999). The Sukabumi taro cultivar comes from Sukabumi. The corms can reach a length of 12–18 cm with a minimum weight of 100 grams and a maximum of 930 grams with a larger plant size (Setyowati et al. 2016). Taro corms other than as food crops, also produce agricultural waste such as of stems and leaves which unuseful (Khairuna 2018). The waste of taro plant potential to be used as animal feed. The aim of this research was to find the best type of planting material and cultivars

on the nature of growth of taro and the potential of taro plants as animal feed.

2. MATERIALS AND METHODS

2.1 Plant materials

This experiment was conducted in the village of Antirogo, Sumbersari District, Jember Regency, East Java with an altitude of ± 89 m asl from April–October 2018. Prepared taro seedling from corms by splitting the corms into thin sections with a size of 75 grams each and each slice has at least one bud. Drying the corm slices becomes dry inside. Sowing corms in soil media. Seedlings from tillers that separated from the parent corm and already have small corms. Sowing the tillers and keep them until the leaves begin to growth. Seedlings from stolons by cutting the part that connects the shoots to the main plant and then sowing in soil media until 2–3 leaves are formed.

Prepare the land by plowing the soil until it is loose and cleaning it from plant residues or grass. Make beds and planting holes with an area of each bed of 100 cm x 50 cm on an area of 6 m x 4.5 m. Add compost to the planting hole. The spacing used is 50 cm x 50 cm. Planting taro seeds by inserting the seeds into the planting hole perpendicularly, then covering them with soil. Maintaining taro plants that have been transplanted by replanting on dead plants 15 DAP, weeding once a month, fertilizing when plants are 3 months old, reducing tillers 150 DAP, irrigation, and pest control.

2.2 Observation

The proximate test of nutrient quality including crude protein, ash content, water content, carbohydrate and crude fat of tubers, stems, and leaves of taro when the plants were harvested at the age of 6 months was conducted in Jember State Polytechnic Bioscience Laboratory. Crude protein content analysis by Kjeldahl method, moisture content using the oven method in temperature 105 $^{\circ}$ C for an hour, ash content using the tannur methods at temperature 650 $^{\circ}$ C. Crude fat content using the gravimetric method, and carbohydrates using the spectrophotometry method. The plant productivity variables are plant height, petiole length, number of stolons, number of leaves, leaf area, corms weight and corm diameter.

2.3 Data analysis

The experiment used a randomized completed block design method with two treatment factors. The first factor was the type of planting material (B), B1: corms; B2: tillers; B3: stolon. The second factors are taro cultivar (V), V1: green taro; B2: ketan taro; B3: Sukabumi taro. The treatment was repeated 4 times. Data were processed by analysis of variance (ANOVA) using SPSS Software ver. 24, followed by Tukey's range test.

3. RESULTS AND DISCUSSION

The treatment in the form of a combination of the use of various planting materials for the three cultivars of taro was carried out to increase the growth and production of taro plants and to determine the growth response and yield of three cultivars of taro plants (*Colocasia esculenta* L.). Growth and production of taro can be seen and observed from several observation variables including plant height, petiole length, number of leaves, leaf area, corm

weight, and corm diameter. The following is a summary of the F-count values of the observation parameters from the treatment of various planting materials and three cultivars of taro, which can be seen in Table 1.

Based on the results of the analysis of the chemical composition of taro tubers, stems, and leaves in Table 2, the highest total protein content in corms was shown by the Sukabumi taro (V3), which was 4.09% as well as the total protein content in taro stems and leaves which was 2.02%. The value of comb crude protein in each taro cultivar is different but it can be used as feed protein (Wang 1983). The Sukabumi taro stems and leaves has a higher crude protein content than the other two cultivars, it almost equivalents to the amount of crude protein in corn stalks which is 2.49% (Irawan et al. 2012) and higher than the protein content in corn cobs which is only 1.92% (Gustiani and Permadi 2015). The highest fat content in the corms of the three taro cultivars was found in the green taro (V1), which was 6.993%, while the highest fat content in the taro stems and leaves was shown by the V3 variety, which was 2.99%. The fat in taro tubers is also quite low (Hermita et al. 2017), therefore, taro corms can be used as a low-fat diet food for the prevention of heart-related diseases such as high blood pressure, heart attack, and arteriosclerosis (Lucy and Ifedayo 2012). The fat content of taro stems and leaves is lower compared with corms (Wang 1983). Taro can be used as feed for *Osporonemus gouramy* and did not interfere with its growth (Elfida and Yuspita 2018). Up to 21% of corm taro flour can be used to reduce feed costs (Umar et al. 2005).

The highest corm carbohydrate analysis was found in the Sukabumi taro (V3), which was 20.60%, higher than the carbohydrate content of potatoes, which was 19.1% (Ministry of Health of Indonesia 1989). Taro corm can be used as a staple food rich of carbohydrate source for people of all ages (Wang 1983), while the highest carbohydrate in taro stems and leaves is in the green taro (V1), which is 4.75%. Carbohydrate content is inversely proportional to water content (Hermita et al. 2017). The highest ash content of the corms of the three taro cultivars was shown by the green taro variety (V1) which was 2.08% as well as the highest ash content in the stems and leaves found in the V1 variety at 1.73%. contained in corn leaves is 8.78%. High ash content indicates that a material contains more inorganic materials than fiber (Lucy and Ifedayo 2012). Ash content below 4% is included in the low level (Adane et al. 2013). The highest water content in corms was shown by the ketan taro (V2) which was 75.923% as well as the stem and

TABLE 1. Summary of F-count values of ANOVA from several observation variables.

Observation variable	F-count value of ANOVA		
	Planting material (B)	Taro cultivar (V)	Interaction of B x V
Plant height	3.19 ^{ns}	3.96 [*]	0.79 ^{ns}
Petiole length	2.78 ^{ns}	3.93 [*]	2.24 ^{ns}
Stolon/tiller number	4.26 [*]	4.85 [*]	1.12 ^{ns}
Leaf number	0.48 ^{ns}	4.98 [*]	1.16 ^{ns}
Leaf area	4.06 [*]	5.53 [*]	2.67 ^{ns}
Corm weight	23.29 ^{**}	60.09 ^{**}	3.99 [*]
Corm diameter	14.81 ^{**}	35.3 ^{**}	1.31 ^{ns}

** : Significantly different at = 99%, * : significantly different at = 95%, ^{ns} : not significantly different.

TABLE 2. Data analysis results of the chemical composition of combs, stems, and leaves of the taro plant.

Analysis	Tuber (%)			Stems and Leaves (%)		
	Green (V1)	Ketan (V2)	Sukabumi (V3)	Green (V1)	Ketan (V2)	Sukabumi (V3)
Crude Protein	3.75	2.82	4.09	1.77	1.19	2.02
Crude Fat	6.99	4.99	5.98	1.99	2.50	2.99
Carbohydrates	13.58	15.25	20.60	4.75	3.37	3.41
Ash Content	2.08	2.01	1.35	1.73	1.69	1.56
Water Content	71.10	75.92	67.72	89.72	90.69	89.46

leaf moisture content of V2 of 90.69%. The carbohydrate content is inversely proportional to the water content, the higher the carbohydrate content, the lower the water content (Hermita et al. 2017). Water is an important component in foodstuffs because water can affect the appearance, texture, taste of food (Wang 1983).

3.1 Corm weight (grams)

There was an interaction between the two treatments, namely the type of planting material and taro cultivars on the weight of taro corms per plant (Table 3). The best results in the treatment of planting material derived from tubers (B1) were shown by treatment V3 (362.58) which was significantly different from treatment V1 (262.92) while V1 was not significantly different from treatment V2 (179.79). The best results in the treatment of planting material from tillers (B2) were found in treatment V3 (309.95) which was significantly different from V1 (203.73) and V2 (193.35).

The best results on planting material from stolons (B3) were found in treatment V3 (238.88), which was significantly different from V1 (162.13), while V1 was not significantly different from V2 (161.57). The best overall yield was found in the Sukabumi taro (V3) with corm planting material. The type of planting material has a significant effect on the average corm weight per taro plant. The highest average corm weight per plant was found in the type of planting material from corms rather than that from tillers (Tsedalu et al. 2014). This is because planting material from corms grows faster than planting material from tillers and stolons. The growing tillers and stolons will get their energy source from the parent plant. If the tillers/stolons already have the leaves, they will get energy from the leaves through photosynthesis (Eze et al. 2018), so if the tillers grow faster and have produced their energy source, the main plant will use the energy source it produces for corm enlargement. Along with the increase in the number of tillers/stolons, there is a decrease in the size and weight of tubers per plant (Tsedalu et al. 2014), this was because competition for resources for plant growth would increase so that some tillers were removed, leaving only 1–2 of them.

TABLE 3. Interaction of types of planting material with taro cultivars on corm weight per plant (g).

Planting material (B)	Green (V1)	Ketan (V2)	Sukabumi (V3)
Corms (B1)	262.92 ^a	179.79 ^{ab}	362.58 ^a
Tillers (B2)	203.73 ^b	193.35 ^a	309.95 ^b
Stolon (B3)	162.13 ^c	161.57 ^b	238.88 ^c

Note: numbers followed by different letters show a significant difference according to Tukey's range test with $\alpha = 5\%$.

The best yield on the green taro variety (V1) was found in planting material B2 (203.73) which was significantly different from B1 (262.92) and B3 (162.13). The best results on the ketan taro variety (V2) were found in the treatment of planting material B1 (179.79) which was significantly different from B2 (193.35) and B3 (161.57). The best results on the Sukabumi (V3) taro variety were found in treatment B1 (362.58) which was significantly different from treatments B2 (309.95) and B3 (238.88). Taro cultivars cause differences in the physical characteristics of tubers shape, tuber weight, and size of taro tubers. There are significant differences in tubers and physical characters of different cultivars of taro (Singh et al. 2013). The Sukabumi taro (V3) taro has a greater physical character than the green taro and ketan taro, causing the yield of Sukabumi taro corms to be higher. Based on the description above, the use of planting material from corms (B1) on the Sukabumi taro (B1V3) was able to give the best yield of 362.58 grams.

The taro cultivar factor has a significant effect on plant height, petiole length, number of tillers/stolons, number of leaves, leaf area and corm diameter of the taro plant (Table 4). The growth of the Sukabumi taro (V3) showed the highest morphology (73.67 cm) compared with the other two cultivars of taro (V1 and V2). Plant height growth is influenced by genetic factors. Genetic influence is the influence of heredity possessed by each variety (Haryati and Karsidi 2015). The research conducted gave the results that it did not affect the treatment of the use of different types of planting material. The height of each plant is determined by the cultivar due to a genetic character or identity according to its genetic composition, so that is one of the factors that determine the growth of plant body parts (Levitt 1980). The results of the study of plant height showed significant differences because each cultivar had its own genetic inheritance (Permanasari and Kastono 2012).

The largest petiole was shown by the Sukabumi taro (V3) of 60.33 cm followed by the Green variety (V1) of 55.17

TABLE 4. The effect of taro cultivars on plant height, petiole length, number of tillers/stolons, number of leaves, leaf area, and corm diameter of the taro plant.

Observation variable	Green taro	Ketan taro	Sukabumi taro
Plant height (cm)	69.88 ^{ab}	65.13 ^b	73.67 ^a
Petiole length (cm)	55.17 ^{ab}	53.63 ^b	60.33 ^a
Tiller/stolon number	3.17 ^a	2.00 ^b	2.17 ^{ab}
Leaf number (blade)	5.50 ^a	4.58 ^b	4.50 ^b
Leaf area (cm ²)	1263.60 ^{ab}	1186.72 ^b	1380.31 ^a
Corm diameter	7.31 ^b	6.36 ^c	8.07 ^a

Note numbers followed by different letters show a significant difference according to Tukey's range test with $\alpha = 5\%$.

TABLE 5. The effect of material planting on number of tillers/stolons, leaf area, and corm diameter.

Observation variable	Green taro	Ketan taro	Sukabumi taro
Tiller/stolon number	3.08 ^a	2.33 ^{ab}	1.92 ^b
Leaf area (cm ²)	1361.31 ^a	1275.15 ^{ab}	1194.18 ^b
Corm diameter	7.82 ^a	7.11 ^b	6.81 ^c

Note: numbers followed by different letters show a significant difference according to Tukey's range test with $\alpha = 5\%$.

cm while the lowest was the ketan cultivar (V2) of 53.63 cm. Petiole length also plays an important role in measuring plant height. The results obtained in the study showed that the use of various planting materials was also not significantly different from the length of the petiole. This is because the length of the petiole related to plant height can also be influenced by the taro cultivar itself, and plant height is influenced by plant genotype (Herman et al. 2016). Cultivar is one of the important factors in supporting the yield and growth of plants. The growth of plant height in the same cultivar did not show a significant difference when compared with the shorter cultivar (Sadik et al. 2018).

The treatment of cultivars can also have a significantly different effect on production of the number of tillers/stolons. The cultivar that produces the most tillers/stolons is V1 with an average of 3.17 and followed by V3 of 2.17 and the smallest number of tillers by V2 as much as 2.00. The number of tillers/stolons produced by taro is closely related to genetic and environmental factors, in other words, the number of tillers is controlled by genes and the growing environment because plants require optimal growing environmental conditions to be able to express their genetic potential (Syarif et al. 2017).

Treatment of the different taro cultivars also showed an impact on the number of leaves of the taro plants, with V1 having the highest number of leaves (5.50) compared with V2 and V3. Cultivars affect the growth of leaf number, plant height, stem diameter, and yield components (Levitt 1980). The number of leaves on taro plants was significantly influenced by genotype during the assessment period in several taro cultivars in Nigeria. There is a positive and significant correlation between leaf area and the number of taro leaves, which indicates that the gene is closely related in controlling both parameters (Eze et al. 2018).

Treatment of different cultivars of taro also showed an effect on the area of taro leaves. V3 had the highest leaf area (1,380.31 cm²) compared with treatments V1 and V2 (Table 4). Taro cultivation of several varieties in Hawaii gave significantly different results which included wet weight, number of tillers and leaf area (Ahmed et al. 2017). Leaf area is related to the canopy because if the growth of the leaf area is reduced, the resulting canopy is also small (Hoque and Sultana 2012). This is influenced by internal factors such as genetics (cultivated varieties) and external factors that affect physiological processes in plants (Trimanto et al. 1970). The Sukabumi taro (V3) has a larger leaf area than the other two cultivars because each leaf blade also has a larger size. The highest corm diameter was found in V3 (8.07 cm) compared with V1 (7.31 cm) and V2 (6.36 cm). The response to diameter increases in each taro variety is different because the genetic, resulting in variations in the speed of division, cell multiplication, and to increase the size or diameter of the corms (Permanasari and Kastono 2012).

As shown in Table 5, the treatment of the type of planting material gave a significantly different effect on the number of tillers/stolons of taro. It is known that the average tiller/stolon of taro was shown by planting material from corms (B1) of 3.08 while the lowest was found in planting material from stolon which were 1.92. Observations on the number of tillers/stolons from tuber planting material tend to produce more tillers when compared with other treatments (Istiqomah et al. 2010). This is because more buds can grow on corms that have been split. Planting material from corms (B1) has more buds in each hemisphere while from tillers (B2) and stolons (B3) has only one main growing point until side shoots grow on corms that have grown. In addition to the number of buds, tillers from each type of planting material are also affected by the energy source used for plant growth. Tillers derived from corms have more reserve energy sources (carbohydrates) to be used for the development of new shoots in plants (Sutoro and Hadiatmi 2016).

The highest leaf area was found in corm treatment (B1) which was 1,361.31 cm². Plant population density has a very significant effect on the number of shoots and leaf area (Wilson 1987). The type of planting material derived from corms gave the highest value and had a significant effect on the number of leaves, weight, size of corms, and leaf area per plant (Tsedalu et al. 2014). The leaf area of corm planting material is larger because the tillers/stolons grow faster so that they can produce energy separately and the main plant can use the energy it produces for leaf growth and tuber enlargement (Syarif et al. 2017). Planting material from stolons has the lowest leaf area because it is susceptible to damage, stress so that growth slows down and many leaves wither. Stolons that have been transplanted still have corms that enough to support growth from food reserves compared with corm and tillers planting material that already have large enough corms at the time of seeding. Small corm size when transplanting will affect taro yield and low adaptation rate (Uyeda et al. 2011).

The treatment B1 is significantly different at $\alpha = 99\%$, from B2 and B3. The treatment of planting material which has the largest diameter is B1 which is 7.82 cm while the smallest is found in stolon planting material (B3) which is 6.81 cm. The use of various planting materials is closely related to the number of tillers, number of leaves, and leaf area so that it affects the size and weight of corm (Tsedalu et al. 2014). Planting material affects the number of tillers produced by taro plants and has a significant effect on corm diameter. This is because, the competition between plants for resources, especially for corm enlargement, will be higher when the more tillers grow (Sadik et al. 2018). Therefore, too many tillers were thinned, leaving only 1-2 tillers. Planting material from corms has a larger diameter because tillers/stolons grow faster and can produce their own energy for growth so that the main plant can use the energy for corm enlargement (Eze et al. 2018).

4. CONCLUSIONS

Based on the research that has been done, it can be concluded that there is an interaction effect between types of planting material and cultivars of taro on corm weight per taro plant. The highest treatment combination was planting material from corms and the Sukabumi taro cultivar (B1V3) with an average tuber weight per plant of 362.58 g (± 14.5 tons/ha. The taro variety that has the potential for

animal feed is the Sukabumi taro cultivar (V3) because the stems and leaves of this taro have crude protein content 2.021% and 4.09% in corms (1.92%).

AUTHORS' CONTRIBUTIONS

HBS and OZ conceived and designed the experiments. OZ and RY performed the experiments and analyzed the data. HBS contributed materials and analysis tools. LP drafted the manuscript. All authors read and approved the final version of the manuscript.

COMPETING INTERESTS

The authors declare no competing interest.

REFERENCES

- Adane T, Shimelis A, Negussie R, Tilahun B, Haki G. 2013. Effect of processing method on the proximate composition, mineral content and antinutritional factors of taro (*Colocasia esculenta*, L.) grown in Ethiopia. *Afr J Food, Agric, Nutr Dev*. 13(2):7383–7398. <https://www.ajol.info/index.php/ajfand/article/view/87463/77154>.
- Ahmed B, Sultana M, Chowdhury M, Akhter S, Alam M. 2017. Growth and yield performance of potato varieties under different planting dates. *Bangladesh Agron J*. 20(1):25–29. doi:10.3329/baj.v20i1.34878.
- Andarini YN, Risliawati A. 2018. Variabilitas karakter morfologi plasma nutfah talas (*Colocasia esculenta*) lokal Pulau Jawa [Morphological character variability of Javanese local taro (*Colocasia esculenta*) germplasm]. *Buletin Plasma Nutfah*. 24(1):63–76.
- Arif AB, Budiyo A, Hoerudin. 2013. Nilai indeks glikemik produk pangan dan faktor-faktor yang mempengaruhinya [Glycemic index of foods and its affecting factors]. *J Litbang Pert*. 32(2):91–99.
- Djukri. 2003. Efek fisiologis naungan buatan pada tanaman talas (*Colocasia Esculenta* (L.) Schott) [Physiological effects of artificial shade on taro (*Colocasia Esculenta* (L.) Schott) plants]. *Jurnal Pendidikan Matematika dan Sains*. 8(2):114–120.
- Elfida, Yuspita Y. 2018. Pengaruh pemberian pakan daun talas terhadap pertumbuhan ikan gurami (*Osphronemus gouramy*) di desa Sungai Liput kabupaten Aceh Tamiang [Effect of feeding taro leaves on the growth of gourami (*Osphronemus gouramy*) in Sungai Liput village, Aceh Tamiang district]. *Jurnal Joempa*. 4(2):68–74.
- Eze CE, Nwofia GE, Onyeka TJ, Nwaogu A. 2018. Growth and tuber yield performance of taro landraces in the face of taro leaf blight (*Phytophthora colocasiae* Racib.) outbreak. *Niger J Agric, Food, Environ*. 13(February):102–114.
- Gustiani E, Permadi K. 2015. Kajian pengaruh pemberian pakan lengkap berbahan baku fermentasi tongkol jagung terhadap produktivitas ternak sapi po di Kabupaten Majalengka [Study of the effect of providing complete feed made from fermented corn cobs on the productivity of cattle in Majalengka Regency]. *Jurnal Pertenakan Indonesia* (Indones J Anim Sci). 17(1):12. doi:10.25077/jpi.17.1.12-18.2015.
- Haryati Y, Karsidi DAN. 2015. Kajian beberapa varietas unggul jagung hibrida dalam mendukung peningkatan produktivitas jagung [A study of several high yielding hybrid maize varieties in support of increasing maize productivity]. *Agrotrop: J Agric Sci*. 4(2):188–194.
- Herman, Roslim DI, Fitriani IY. 2016. Respon genotipe ubi kayu (*Manohot esculenta* Crantz) terhadap dosis pupuk kandang kotoran sapi Raluk Kuantan [Cassava (*Manohot esculenta* Crantz) genotypes response to the dose of cow fertilizer Taluk Kuantan. *Dinamika Pertanian*. XXXII(2):135–142.
- Hermata N, Ningsih EP, Fatmawaty AA. 2017. Analisis proksimat dan asam oksalat pada pelepah daun talas beneng liar di kawasan Gunung karang, Banten [Analysis of proximate and oxalic acid on leaf midrib of wild beneng taro in Gunung Karang area, Banten]. *Jurnal Agrosains dan Teknologi*. 2(2):95–104.
- Hoque MA, Sultana MS. 2012. Disease free seed potato production through seed plot technique at farmers' level in Bangladesh. *J Plant Prot Sci*. 4(2):51–56.
- International Plant Genetic Resources Institute. 1999. Descriptors for taro (*Colocasia esculenta*). Rome: International Plant Genetic Resources Institute.
- Irawan P, Sutrisno I, Utama C. 2012. Komponen proksimat pada kombinasi jerami padi dan jerami jagung yang difermentasi dengan berbagai aras isi rumen kerbau [Proximate components in the combination of fermented rice straw and corn straw with various levels of buffalo rumen content]. *Anim Agric J*. 1(2):17–30. <https://ejournal3.undip.ac.id/index.php/aaj/article/view/870>.
- Istiqomah N, Arifin Z, Krismawati A. 2010. Kajian pembibitan varietas lokal ungu dan lokal hijau terhadap pertumbuhan dan produksi talas Malang [Study of local purple and green local varieties on growth and production of taro in Malang]. *Prosiding Seminar Hasil Penelitian Tanaman Aneka Kacang dan Umbi*. p. 639–645.
- Khairuna. 2018. Pemanfaatan batang genjer (*Limncharis flava*) dan kertas dengan menggunakan NaOH dan CaO [Utilization of genjer stems (*Limncharis flava*) and paper using NaOH and CaO]. *KLOROFIL: Jurnal Ilmu Biologi dan Terapan*. 1(2):56–63. doi:10.30821/kfl.jibt.v1i2.1596.
- Levitt T. 1980. Responses of plants to environmental stresses. Vol. 2. Water, radiation, salt, and other stresses. Orlando: Academic Press.
- Lucy OF, Ifedayo OA. 2012. Guinea Corn (*Sorghum vulgare*) Leaf, a potential source of nutrients and phytochemicals. *Food Public Health*. 2012(6):228–230. doi:10.5923/j.fph.20120206.07.
- Ministry of Health of Indonesia. 1989. Komposisi bahan makanan [Composition of food ingredients]. Jakarta: Bhartara.
- Moore LM, Lawrence JH. 2003. Plant guide - taro. Washington, DC: United States Department of Agriculture-Natural Resources Conservation Service.
- Onwueme I. 1999. Taro cultivation in Asia. Bangkok: Food and Agriculture Organization of the United Nations Regional Office for Asia and the Pacific.
- Permanasari I, Kastono D. 2012. Pertumbuhan tumpang sari jagung dan kedelai pada perbedaan waktu tanam dan pemangkasan jagung [Intercropping growth of corn and soybeans at different time of planting and pruning corn]. *Jurnal Agroteknologi*. 3(1):13–20. doi:10.24014/j.a.v3i1.90.
- Rahmawati W, Kusumawati YA, Aryanti N. 2012. Alternatif sumber pati industri di Indonesia [Alternative sources of industrial starch in Indonesia]. *Jurnal Teknologi Kimia dan Industri*. 1(1):347–351.
- Sadik E, Hussien M, Tewodros A. 2018. Effects of seed tu-

- ber size on growth and yield performance of potato (*Solanum tuberosum* L.) varieties under field conditions. *Afr J Agric Res*. 13(39):2077–2086. doi:10.5897/ajar2018.13405.
- Setyowati M, Hanarida I, Sutoro N. 2016. Karakteristik umbi plasma nutfah tanaman talas (*Colocasia esculenta*) [Characteristics of taro germplasm tubers (*Colocasia esculenta*)]. *Buletin Plasma Nutfah*. 13(2):49. doi:10.21082/blpn.v13n2.2007.p49-55.
- Singh P, Dube A, Kumar LK. 2013. Physico-chemical properties of six varieties of taro (*Colocasia esculenta* L. Schott) flour. *Asian J Exp Chem*. 8(1-2):7–11.
- Sutoro N, Hadiatmi N. 2016. Perbanyak bibit stek umbi dan uji adaptabilitas plasma nutfah garut (*Marantha arundinaceae* L.) [Propagation of tuber cuttings seedlings and germplasm adaptability test of arrowroot (*Marantha arundinaceae* L.)]. *Buletin Plasma Nutfah*. 17(1):1–11. doi:10.21082/blpn.v17n1.2011.p1-11.
- Syarif Z, Akhir N, Satria B. 2017. Identification of plant morphology of taro as a potential source of carbohydrates. *Int J Adv Sci, Eng Inf Technol*. 7(2):573–579. doi:10.18517/ijaseit.7.2.1323.
- Trimanto T, Sajidan S, Sugiyarto S. 1970. Characterisation of taro (*Colocasia esculenta*) based on morphological and isozymic patterns markers. *Nusantara Biosci*. 3(1). doi:10.13057/nusbiosci/n030102.
- Tsedalu M, Tesfaye B, Goa Y. 2014. Effect of type of planting material and population density on corm yield and yield components of taro (*Colocasia esculenta* L.). *J Biol, Agric Healthcare*. 4(17):124–138.
- Ubalua AO, Ewa F, Okeagu OD. 2016. Potentials and challenges of sustainable taro (*Colocasia esculenta*) production in Nigeria. *J Appl Biol Biotechnol*. 4(1):53–59. doi:10.7324/jabb.2016.40110.
- Umar S, Mirwandhono E, Tobing ILT. 2005. Pemanfaatan tepung umbi talas (*Colocasia esculenta* L.) dan solid dekanter dalam ransum terhadap karkas itik peking umur 12 minggu [Utilization of black radish (*Colocasia esculenta* L.) flour and solid dekanter flour in feed on the carcass of 12 weeks old pekin's duck]. *Agribisnis Peternakan*. 1(3):111–116.
- Uyeda J, Radovich T, Sugano J, Fares A, Paull R. 2011. Effect of irrigation regime on yield and quality of three varieties of taro (*Colocasia esculenta*). *Food Provide*. 1(1):1–8.
- Wang JK. 1983. A review of *Colocasia esculenta* and its potential. Honolulu: University of Hawaii.
- Wilson JW. 1987. Taro planting material. Suva: Institute for Research, Extension and Training in Agriculture.
- Wulansari A, Martin AF, Rantau DE, Ermayanti TM. 2013. Perbanyak beberapa aksesori talas (*Colocasia esculenta* L.) diploid secara kultur jaringan dan konservasinya mendukung diversifikasi pangan [Propagation of several accessions of diploid taro (*Colocasia esculenta* L.) by tissue culture and its conservation supports food diversification]. *Prosiding Seminar Nasional Riset Pangan, Obat-obatan dan Lingkungan Untuk Kesehatan*.