

# INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY: APPLIED BUSINESS AND EDUCATION RESEARCH

2026, Vol. 7, No. 3, 1078 – 1088

<http://dx.doi.org/10.11594/ijmaber.07.03.06>

## Research Article

### Silage Quality of Arrowroot (*Maranta arundinacea* L.) as Feed for Native Pigs

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#### Article history:

Submission 19 January 2026

Revised 25 February 2026

Accepted 23 March 2026

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#### ABSTRACT

High feed costs and limited availability of conventional ingredients constrain native pig production in the Philippines. This study evaluated the silage quality and nutritional composition of arrowroot plant parts ensiled with and without molasses as a potential alternative feed resource. A 2×2 factorial experiment in a completely randomized design was conducted using two plant parts (aerial parts and whole plant) and two additive levels (0 and 4% molasses), with six replicates per treatment. Arrowroot plant biomass was ensiled for 21 days under anaerobic conditions and assessed for yield, fermentation characteristics, physical quality, proximate composition, gross energy (GE), fiber contents, and mineral content. Silage yield, pH (4.87- 4.96), and Fleig scores (69.62-82.82) were not significantly affected ( $P>0.05$ ) by plant part or molasses supplementation, indicating good to very good silage quality. The addition of Molasses significantly ( $P<0.05$ ) increased the total soluble solids and improved silage odor. Dry matter content (24.09-28.84%), crude protein (5.62-7.23%), and ether extract (2.37-2.75%) were not significantly ( $P>0.05$ ) affected by treatments. Gross energy values across all treatments were not statistically differ ( $P>0.05$ ) from each other, but, molasses-treated silages obtained high GE. Neutral detergent fiber (53.17-55.19%), acid detergent fiber (31.65-34.88%), and hemicellulose (20.31- 21.52%) did not differ significantly ( $P>0.05$ ) among treatments. A significant plant part and molasses interaction ( $P<0.05$ ) was observed for phosphorus, whereas potassium, calcium, and magnesium remained unaffected. These results indicated that arrowroot plant silage has favorable fermentation quality and a consistent fibrous energy profile, supporting its potential use in native pig feeding systems.

#### How to cite:

Ibañez, Jr., R. Y., Abela, J. V., Villagonzalo, G. A. A., Cagasan, U. A., & Gacutan, Jr., M. D. (2026). Silage Quality of Arrowroot (*Maranta arundinacea* L.) as Feed for Native Pigs. *International Journal of Multidisciplinary: Applied Business and Education Research*. 7(3), 1078 – 1088. doi: 10.11594/ijmaber.07.03.08

**Keywords:** Alternative feed, Arrowroot, Fiber contents, Native pigs, Silage quality

## Introduction

High feed costs and unavailability of some feed ingredients continue to bring significant challenges Philippine to native pig production systems particularly for smallholder farmers who rely heavily on locally sourced feed materials. Native pigs (*Sus scrofa* L.) which are well-adapted to tropical environments are known for their hardiness and ability to utilize high fiber diets. However, in order to achieve the optimum growth performance, health, and meat quality requires nutritionally balanced rations that are economically feasible and environmentally sustainable (Santiago, 2020; Muth et al., 2020; Falculan, 2021). Therefore, identifying and evaluating alternative feed resources from locally available crops is essential for improving native pig productivity while reducing dependence on conventional ingredients. Arrowroot (*Maranta arundinacea* L.) is a perennial herbaceous species native to tropical Americas and well adapted to Philippine climatic conditions (Plants of the World Online, 2024). Some notable producers of arrowroot in the Philippines are Marinduque which is known for its arrowroot cookies (Embuscado, 2006) and Quezon province which serve as their primary livelihood (Pizon, 2018). The plant features broad lanceolate foliage and starch-rich underground rhizomes, and can grow under variable light conditions (Rojas-Sandoval, 2022; Oktafani et al., 2018). Arrowroot requires minimal fertilizer inputs and typically matures 8 to 12 months after transplanting and produce fresh biomass averaging 12.5 tons/ha with maximum yields reaching 31 tons/ha under favorable conditions (Brito et al., 2005; Rojas-Sandoval, 2022). Arrowroot considered as versatile high-biomass crop for diversified agricultural systems because responds well to different soil fertility levels, irrigation management, and cropping systems (Shintu et al., 2016; Sediyaama et al., 2022; Maharani et al., 2023).

Arrowroot was traditionally utilized as remedy for gastrointestinal and skin problems across food, pharmaceutical, and cosmetic industries due to its high digestibility and

hypoallergenic starch (Cooke et al., 2000; Richards, 2022). Research shows that arrowroot contains more than 85% starch on a dry weight basis with 95.7% in vivo digestibility (Faridah et al., 2014; Kumari et al., 2022). Ensiled aerial parts and processing residues of arrowroot show promising nutritional profiles with a CP of 10.8–21.1% based on its DM, fiber contents, and gross energy suitable for alternative feed applications (Erdman & Erdman, 1984; Tarique et al., 2021). Additionally, arrowroot has prebiotic properties that improve gastrointestinal health by increasing the synthesis of short-chain fatty acids and contains important minerals (Heuze & Tran, 2022; Waskita et al., 2024).

However, utilization of arrowroot as animal feedstuff is restricted by antinutritional factors (ANFs) such as tannins, phenolic compounds, alkaloids, and saponins which can negatively affect nutrient bioavailability and animal performance (Jayakumar & Suganthi, 2017; Ieamkheng et al., 2022). The ANFs content of arrowroot were reduced through ensiling because ensiling offers an effective and economically accessible processing method for reducing ANF concentrations while improving feed safety and digestibility (Coulibaly et al., 2010; Samtiya et al., 2020). This preservation technique maximizes nutrient potential, palatability, and guarantees constant production of animal feed on a yearly basis. The local breeds of pigs possess inherent biological capabilities for the efficient metabolism of fibrous as well as ensiled alternative materials as an alternative source of food other than maize and soybeans (Ngoc et al., 2021; Chisoro et al., 2023).

Notwithstanding the promising agronomic and nutritional properties of arrowroot, research on its use as livestock feed is currently insufficient and outdated, as most of these studies were carried out in the first half of the 1990s and on ruminates only (Erdman et al., 1986). In fact, there is little scientific information on the silage quality properties of the different parts of the arrowroot and its suitability as native pig feed. In an attempt to broaden the knowledge on the more judicious and less

costly use of underutilized and less extensively cultivated tropical plants such as arrowroot, this study determines the silage quality properties of arrowroot as an alternative feed material for native pigs.

## Materials and Methods

### Preparation of Silage

The parts of the arrowroot were packed into 25 kg sacks made of polypropylene and measured approximately 61 cm by 74 cm. The harvested arrowroots were processed using the forage chopper to get pieces measured between 1 to 2 cm long, as discussed by Hang et al. (2019). The chopped plants were then sun-dried to attain a moisture level between 60-70%, as discussed by Lan et al. (2021). The moisture level is the perfect moisture level required during the prior to ensiling step to prevent the loss of any nutrient via seepage of effluents.

### Ensiling Arrowroot Parts with and Without Additives

Arrowroot parts that are processed are placed in 25 kg polypropylene bags. To enhance the fermentation process, molasses was added. Some plant parts were ensiled without additives to serve as a control for comparison. For the ensiling process with additives, the mixture will consist of 4% molasses (Kaensombath & Lindberg 2013) of the total weight of the arrowroot foliage with stem, and whole parts. A vacuum machine was used during bagging to remove all air from the bags to prevent pathogen contamination during anaerobic fermentation. The bags were tightly sealed using rubber bands, weighed, labeled, and stored in a room with a temperature range of 20-30°C (Bai et al., 2022) for a duration of 21 days. Samples will be taken from each treatment to monitor pH levels and perform chemical assays.

### Research Design

The study was laid out in a 2 x 2 factorial experiment utilizing a Completely Randomized Design (CRD) comprising four (4) treatment combinations. The treatments were consisting of two factor and these are; Factor A, which includes different plant parts namely; foliage with stem, and whole plants, and Factor B,

which contains with or without molasses. These treatments were assessed both with and without additives. The additive treatment will include 4% sugarcane molasses and then incorporated into various arrowroot plant parts. Each treatment was replicated six (6) times, with samples placed in silage bags that have a capacity of 15 kg. These bags will be kept in a controlled environment, with a temperature maintained between 20-30°C for 21 days.

### Data Collection and Analysis

#### Silage Yield

The quantity of silage produced was determined at the end of the ensiling period. This involved weighing the silage from each treatment replicate to determine the yield per unit of plant material initially ensiled.

#### Color and Odor Evaluation

The Department of Agriculture's Bureau of Agriculture and Fisheries Standards (2015) physical quality parameters were used in a sensory panel evaluation to visually and olfactorily evaluate the color and odor of the silage. The color was employed as a tool for the general acceptability of silage and the quality of the fermentation process, with special emphasis on the discoloration that may result from silage deterioration and poor fermentation. The pleasant, slightly acidic smell and unwelcome smells are accepted as indicative of good lactic acid fermentation, as opposed to undesirable fermentation reactions, respectively. The odor can also influence silage quality.

#### Dry Matter (DM)

The dry matter was determined by gathering the representative sample for each treatment, weighing, and oven-drying at a low temperature of 60-70°C to attain a constant weight. In determining the dry matter, dry weight was divided by fresh weight and multiplied by 100.

$$DM (\%) = \frac{\text{Dry Weight}}{\text{Fresh Weight}} \times 100 \quad (1)$$

#### pH

pH measurement of the silage was conducted using a pH meter standardized using pH

4 and 7 buffer solutions. pH is one important aspect when it comes to silage as it gives an indication of the level of fermentation as low pH values indicate fermented silage.

*Fleig Score*

The results of the Fleig score were calculated based on the formula developed by Killic, as cited in the Ileri et al. (2020) study, where the result values ranging from 81-100 are very good, 61-80 are good, 41-60 are satisfactory, 21-40 are medium, and 0-20 are bad.

$$\text{Fleig Score} = 220 + (2 \times \text{DM Percentage}) - (40 \times \text{pH}) \quad (2)$$

*Total Soluble Solids (TSS)*

The total soluble solids content of silage was determined using a refractometer. Silage samples were sent to department of food science and technology for processing and measurement of TSS. This parameter indicated the amount of dissolved sugars and other soluble substances in the silage which can influence its nutritional value and fermentation metrics.

Statistical analysis of the data was conducted using analysis of variance in a 2 × 2 factorial arrangement under a Completely Randomized Design. The General Linear Model procedure of SAS statistical software version 9.4 was used to evaluate the effects of

treatments. Interaction and main effects were tested in group comparison using Tukey’s Honest Significant Difference (HSD) and means were declared significant when P<0.05.

**Results and Discussion**

***Silage Yield, pH, Total Soluble Solids, and Fleig Score***

The parameters of silage yield, pH, TSS, and Fleig score were presented in Table 1 and Table 2. From the table, initial and harvest weights, as well as percent change during ensiling, were not significantly different (P>0.05) among treatments, which showed minimal and consistent ensiling losses across plant parts and levels of additives. This result showed successful moisture adjustment and maintenance of anaerobic conditions during fermentation (da Silva et al., 2017). The pH levels of silage ranged from 4.872 to 4.964 and were not significantly influenced by plant part, molasses supplementation, or their interaction (P>0.05). The pH levels of silage were within the recommended range for well-preserved silage and indicated that all treatments produced satisfactory lactic acid fermentation. However, total soluble solids (TSS) were significantly higher (P<0.05) in the aerial parts supplemented with molasses, which supported the role of molasses as a readily fermentable carbohydrate source that increases soluble sugar content (Luo et al., 2021).

Table 1. Yield of arrowroot silage with and without molasses

Yield (kg)	Plant Parts	Molasses Level		Mean	p-value		
		0%	4%		A	B	AxB
<b>Initial Weight</b>	Aerial Parts	8.52 ± 0.46	8.63 ± 0.46	8.57 ± 0.33			
	Whole Plant	9.27 ± 0.46	9.78 ± 0.46	9.53 ± 0.33	0.052	0.511	0.670
	<b>Mean</b>	8.89 ± 0.33	9.20 ± 0.33				
<b>Final Weight</b>	Aerial Parts	8.36 ± 0.47	8.48 ± 0.47	8.42 ± 0.33			
	Whole Plant	9.07 ± 0.47	9.69 ± 0.47	9.38 ± 0.33	0.054	0.437	0.604
	<b>Mean</b>	8.71 ± 0.33	9.09 ± 0.33				
<b>Percent Change (%)</b>	Aerial Parts	1.92 ± 0.65	1.78 ± 0.65	1.85 ± 0.46			
	Whole Plant	2.41 ± 0.65	0.92 ± 0.65	1.66 ± 0.46	0.776	0.225	0.319
	<b>Mean</b>	2.17 ± 0.46	1.35 ± 0.46				

Means within the same row or column with different superscripts differ significantly (Tukey’s HSD, P < 0.05). Values are expressed as mean ± SEM.

Arrowroot silage obtained Fleig scores of 69.62 to 82.82 and adjectively classified as good and very good However, statistical analysis showed that Fleig scores were not

significantly different (P>0.05) across all treatments. Although aerial parts supplemented with molasses achieved a higher numerical score (82.82), the similarity in pH and DM

across all treatments reduced the sensitivity of the Fleig score as previously noted in tropical forage and root crop silages (Ileri et al., 2020). This suggests that arrowroot achieved

acceptable fermentation quality even without the supplementation of molasses due to its inherent ensilability.

Table 2. pH, total soluble solids, and Fleig score of arrowroot silage with and without molasses

Parameters	Plant Parts	Molasses Level		Mean	p-value		
		0%	4%		A	B	AxB
pH	Aerial Parts	4.91 ± 0.12	4.87 ± 0.12	4.89 ± 0.08			
	Whole Plant	4.96 ± 0.12	4.90 ± 0.12	4.93 ± 0.08	0.710	0.689	0.914
	Mean	4.94 ± 0.08	4.89 ± 0.08				
TSS (°Brix)	Aerial Parts	2.17 ± 0.04 <sup>c</sup>	2.31 ± 0.04 <sup>a</sup>	3.79 ± 0.14			
	Whole Plant	2.11 ± 0.04 <sup>c</sup>	2.23 ± 0.04 <sup>b</sup>	2.46 ± 0.14	<.0001	0.277	0.002
	Mean	3.01 ± 0.14	3.24 ± 0.14				
Fleig Score	Aerial Parts	77.01 ± 4.80	82.82 ± 4.80	79.91 ± 3.40			
	Whole Plant	69.62 ± 4.80	76.61 ± 4.80	73.12 ± 3.40	0.172	0.198	0.903
	Mean	73.32 ± 3.40	79.72 ± 3.40				
Adjectival Rating	Aerial Parts	Good	Very good				
	Whole Plant	Good	Good				

Means within the same row or column with different superscripts differ significantly (Tukey's HSD, P < 0.05). Values are expressed as mean ± SEM.

### Arrowroot Silage Quality

Table 3 shows the results of sensory analysis for arrowroot silage. The results showed consistent physical preservation across plant parts and additive levels, with color, cut size and overall quality scores showing no significant difference, P>0.05, across all treatments. According to McDonald et al. (2010), this suggests limited oxidative damage and thus effective spoilage control during ensiling. However, molasses addition significantly affected silage

odors, P<0.05, with the aerial parts ensiled with molasses receiving the highest rating (2.31). There are many reports linking a pleasant odor to increased lactic acid fermentation and decreased production of non-desirable metabolites such as butyric acid and ammonia (Liu et al., 2025). Despite this statistical difference, all treatments were adjectively classified as acceptable proving that arrowroot silage meets basic sensory quality standards regardless of plant part or additive use.

Table 3. Arrowroot silage quality with and without molasses

Parameters	Plant Parts	Molasses Level		Mean	p-value		
		0%	4%		A	B	AxB
Color	Aerial Parts	2.11 ± 2.00 <sup>a</sup>	2.23 ± 2.00 <sup>a</sup>	2.17 ± 0.04			
	Whole Plant	2.20 ± 2.00 <sup>a</sup>	2.09 ± 2.00 <sup>a</sup>	2.14 ± 0.04	0.627	0.871	0.032
	Mean	2.15 ± 0.04	2.16 ± 0.03				
Odor	Aerial Parts	2.17 ± 0.04	2.31 ± 0.04	2.24 ± 0.03			
	Whole Plant	2.11 ± 0.04	2.23 ± 0.04	2.17 ± 0.03	0.140	0.012	0.869
	Mean	2.14 ± 0.03 <sup>b</sup>	2.27 ± 0.03 <sup>a</sup>				
Cut Size	Aerial Parts	2.05 ± 0.09	2.18 ± 0.09	2.12 ± 0.06			
	Whole Plant	2.17 ± 0.09	2.21 ± 0.09	2.19 ± 0.06	0.397	0.337	0.588
	Mean	2.11 ± 0.06	2.19 ± 0.06				
Adjectival Rating	Aerial Parts	Acceptable	Acceptable				
	Whole Plant	Acceptable	Acceptable				

Means within the same row or column with different superscripts differ significantly (Tukey's HSD, P < 0.05). Values are expressed as mean ± SEM.

**Nutritional Composition of Arrowroot Silage**

The chemical assays such as gross energy, CP, EE, and fiber components of arrowroot silage were presented in Table 4. Dry matter content ranged from 24.09 to 28.84% with molasses-treated silages showing numerically higher DM particularly in the aerial parts (28.84), likely due to the addition of soluble carbohydrates that enhanced fermentation efficiency. However, no significant interaction or main effects ( $P>0.05$ ) of plant part or molasses supplementation were observed for DM, moisture content, organic matter, ash, crude protein (CP), or ether extract (EE).

Gross energy values ranged from 3300.000 to 3535.67 cal/g with numerically higher GE in molasses-treated silages, particularly in the aerial parts (3535.67 cal/g). This trend reflects the contribution of readily fermentable carbohydrates from molasses which increased energy density without significantly altering proximate composition (Irfandi et al., 2025). Although differences were not statistically significant ( $P>0.05$ ), the consistent increase in GE may be nutritionally relevant in energy-limited feeding managements.

Table 4. Nutritional composition of arrowroot silage (%) with and without molasses

Parameters	Plant Parts	Molasses Level		Mean	p-value		
		0%	4%		A	B	AxB
DM (%)	Aerial Parts	26.64 ± 1.90	28.84 ± 1.90	27.74 ± 1.34			
	Whole Plant	24.09 ± 1.90	26.37 ± 1.90	25.23 ± 1.34	0.202	0.251	0.984
	Mean	25.37 ± 1.34	27.61 ± 1.34				
MC (%)	Aerial Parts	73.36 ± 1.90	71.16 ± 1.90	72.26 ± 1.34			
	Whole Plant	75.91 ± 1.90	73.63 ± 1.90	74.77 ± 1.34	0.202	0.251	0.984
	Mean	74.634 ± 1.34	72.39 ± 1.34				
OM (%)	Aerial Parts	95.65 ± 0.44	95.72 ± 0.44	95.68 ± 0.31			
	Whole Plant	96.64 ± 0.44	96.11 ± 0.44	96.37 ± 0.31	0.127	0.606	0.504
	Mean	96.14 ± 0.31	95.91 ± 0.31				
Ash (%)	Aerial Parts	4.35 ± 0.44	4.29 ± 0.44	4.32 ± 0.31			
	Whole Plant	3.36 ± 0.44	3.89 ± 0.436	3.63 ± 0.31	0.127	0.606	0.504
	Mean	3.858 ± 0.308	4.09 ± 0.31				
GE (cal/g)	Aerial Parts	3300.00 ± 153.06	3535.67 ± 153.06	3417.83 ± 108.23			
	Whole Plant	3421.33 ± 153.06	3395.83 ± 153.06	3408.58 ± 108.23	0.952	0.500	0.404
	Mean	3360.67 ± 108.23	3465.75 ± 108.23				
CP (%)	Aerial Parts	6.58 ± 0.52	7.23 ± 0.52	6.90 ± 0.37			
	Whole Plant	5.62 ± 0.52	6.81 ± 0.52	6.21 ± 0.37	0.197	0.088	0.604
	Mean	6.10 ± 0.37	7.02 ± 0.37				
EE (%)	Aerial Parts	2.47 ± 0.12	2.37 ± 0.12	2.42 ± 0.08			
	Whole Plant	2.43 ± 0.12	2.75 ± 0.12	2.59 ± 0.08	0.168	0.369	0.094
	Mean	2.45 ± 0.08	2.56 ± 0.08				
NDF (%)	Aerial Parts	53.64 ± 1.93	53.88 ± 1.93	53.76 ± 1.36			
	Whole Plant	55.19 ± 1.93	53.17 ± 1.93	54.18 ± 1.36	0.831	0.647	0.565
	Mean	54.42 ± 1.36	53.52 ± 1.36				
ADF (%)	Aerial Parts	33.05 ± 1.41	33.33 ± 1.41	33.19 ± 0.97			
	Whole Plant	34.88 ± 1.41	31.65 ± 1.41	32.71 ± 0.97	0.731	0.154	0.106
	Mean	33.96 ± 0.97	31.94 ± 0.97				
Hemicellulose (%)	Aerial Parts	20.60 ± 1.19	20.55 ± 1.19	20.57 ± 0.99			
	Whole Plant	20.31 ± 1.19	21.52 ± 1.19	21.47 ± 0.99	0.530	0.427	0.406
	Mean	20.45 ± 0.99	21.58 ± 0.99				

Means within the same row or column with different superscripts differ significantly (Tukey's HSD,  $P < 0.05$ ). Values are expressed as mean ± SEM.

Crude protein contents ranged from 5.62 to 7.23% with aerial parts (7.23%) exhibiting numerically higher CP than whole-plant silage reflecting the greater nitrogen content of foliage. These values are consistent with previous reports describing arrowroot biomass as an energy- and fiber-rich feed containing small amount of protein (Erdman & Erdman, 1984; Heuzé & Tran, 2022). The absence of significant CP losses following ensiling suggests minimal proteolysis, likely due to adequate DM levels and rapid establishment of anaerobic conditions (Marshall et al., 1993). Ether extract (EE) content ranged from 2.37 to 2.75% with whole-plant silage showing numerically higher EE than aerial parts possibly, reflecting the contribution of rhizome-associated lipids. The ether extract was found not to be affected significantly ( $P>0.05$ ) by the molasses supplementation, which showed that the lipid fractions of the arrowroots were unaffected majorly during ensiling. The relatively lower EE values are suggestive of the fact that the contribution of the lipid fractions is minor in arrowroot silages.

The very high neutral detergent fiber (NDF) values (53.17 to 55.19%) in the analyses reflected the high concentration of structure carbohydrates in arrowroot silage. Hemicellulose ranged from 20.31 to 21.52% and acid detergent fiber (ADF) from 31.65 to 34.88%. For total fiber concentrations (NDF, ADF, and hemicellulose), there were no significance differences based on plant material and molasses supplementation ( $P>0.05$ ); molasses influenced only the supply of available carbohydrates and not cell wall composition.

#### **Mineral Composition of Arrowroot Silage**

Table 5 shows the mineral content of ensiled arrowroot as influenced by plant parts

and molasses supplementation. Phosphorus (P) levels ranged from 0.28 to 0.37%, showing a moderate level of variation based on ensiling method. Although potassium (K), calcium (Ca), and magnesium (Mg) were not significantly ( $P>0.05$ ) different due to the main factors and their interaction, the phosphorus content was significantly ( $P<0.05$ ) affected by the interaction of plant parts and molasses supplementation.

The lowest phosphorus (P) content of 0.28% was determined in whole plant silage supplemented with 4% molasses, and all other treatments were statistically similar. This trend may reflect a dilution or microbial utilization effect, whereby the supplementation of fermentable carbohydrates resulted in an increased uptake of intracellular phosphorus and microbial development. In ensiled pomegranate leaves, where the enhanced fermentation process altered mineral distribution but not the total mineral content, similar reductions in phosphorus content following molasses supplementation have been reported (Kazemi et al., 2022).

On the other hand, the absence of marked ( $P>0.05$ ) differences in K, Ca, and Mg concentrations indicates that these macrominerals remained relatively unchanged throughout the 21-day anaerobic fermentation process, which agrees with the assertion that cationic minerals have a limited role in microbial metabolism during ensiling (Erdman & Erdman, 1984; Heuzé & Tran, 2022). As stated by Dong et al. (2019), arrowroot silage can be used in the diet without increasing the danger of mineral imbalance when fed as a mixed ration because the levels of minerals are within acceptable limits for swine feed ingredients.

Table 5. Mineral content (%) of ensiled arrowroot with and without molasses

Parameters	Plant Parts	Molasses Level		Mean	p-value		
		0%	4%		A	B	AxB
P (%)	Aerial Parts	0.35 ± 0.02 <sup>a</sup>	0.37 ± 0.02 <sup>a</sup>	0.36 ± 0.01			
	Whole Plant	0.34 ± 0.02 <sup>a</sup>	0.28 ± 0.02 <sup>b</sup>	0.31 ± 0.01	0.004	0.140	0.023
	<b>Mean</b>	0.35 ± 0.01	0.32 ± 0.01				
K (%)	Aerial Parts	0.75 ± 0.10	0.94 ± 0.10	0.85 ± 0.07			
	Whole Plant	1.02 ± 0.10	1.05 ± 0.10	1.04 ± 0.07	0.061	0.252	0.438
	<b>Mean</b>	0.89 ± 0.07	1.00 ± 0.08				

Parameters	Plant Parts	Molasses Level		Mean	p-value		
		0%	4%		A	B	AxB
Ca (%)	Aerial Parts	0.57 ± 0.03	0.65 ± 0.03	0.61 ± 0.02	0.294	0.587	0.057
	Whole Plant	0.60 ± 0.03	0.55 ± 0.03	0.57 ± 0.02			
	Mean	0.58 ± 0.02	0.60 ± 0.02				
Mg (%)	Aerial Parts	0.60 ± 0.03	0.64 ± 0.03	0.62 ± 0.02	1.000	0.948	0.103
	Whole Plant	0.64 ± 0.03	0.60 ± 0.03	0.62 ± 0.02			
	Mean	0.67 ± 0.07	0.62 ± 0.07				

Means within the same row or column with different superscripts differ significantly (Tukey's HSD,  $P < 0.05$ ). Values are expressed as mean ± SEM.

## Conclusion

Arrowroot was found to have desirable ensiling properties and uniform nutritional quality regardless of plant material and molasses supplementation when ensiled as silage. Desirable pH values, Fleig scores, and physical properties indicated that ensiling aerial parts and whole plants for 21 days resulted in silages of good to very good quality. Molasses supplementation improved fermentation quality, particularly total soluble solids and odor, without any noticeable effect on dry matter, crude protein, ether extract, fiber, and most mineral fractions. The gross energy of molasses-treated silages was numerically higher, illustrating the potential of soluble carbohydrates to increase energy content without compromising nutrient quality. Arrowroot silage is primarily a fibrous energy supplement rather than a protein or lipid supplement, as indicated by its high neutral detergent fiber and moderate hemicellulose levels.

The results of this study suggested that arrowroot silage, when added to nutritionally balanced diets supplemented with sufficient sources of protein and amino acids, be used as an alternative fibrous energy feed ingredient for native pigs. While acceptable silage quality can still be attained without additives, 4% molasses supplementation may be used to enhance fermentation quality and sensory attributes, particularly when ensiling aerial parts. In order to evaluate the digestibility of nutrients, growth, carcass qualities, and economics of using arrowroot silage in local diets for pigs, it is suggested that future studies be focused on animal feeding experiments. In addition, it is recommended to conduct more research on the optimal content for inclusion, the consequent effects on animal health, and the reduction of antinutritional factors.

## Acknowledgment

The authors wish to thank the Department of Science and Technology – Accelerated Science and Technology Human Resource Development Program – Science Education Institute (DOST-ASTHRDP-SEI) for the scholarship and financial support that made this study possible.

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