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Effectiveness of a Mixture of Clam Shell Flour, Fly Ash & Bottom Ash (FABA) in Honey Gourd Planting Media

Junita M. Butarbutar[1], Drajat Suseno[1], Nabilah Dzakiroh[1], Rizal Bahtiar[2] & Zulfikar Damaralam Sahid[3]

Article Info
**Correspondence Author*
[1] PT PLN Indonesia Power UBP Banten 3 Lontar.
[2] Department of Economics, Faculty of Economics and Management, Bogor Agricultural University (IPB)
[3] Department of Agronomy and Horticulture, Faculty of Agriculture, Bogor Agricultural University (IPB)

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Correspondence E-Mail:
junita.butarbutar@plnindonesiapower.co.id

Abstract
Shellfish, Fly Ash & Bottom Ash (FABA) is waste produced by Steam Power Plants (PLTU) and is often seen as a useless material. Shellfish shell waste which is then processed into flour is produced from the filtration process or during extracting sea water supplies. These clam shells were carried by the suction current of the Circulation Water Pump (CWP), then were collected in a holding tank. On the other hand, FABA is a waste product of the coal combustion process in the form of flying and precipitated materials. The location of Steam-electric power station is in coastal areas where this activity is carried out at Lontar Steam-electric power station. The presence of the Lontar Steam-electric power station in the coastal area generates green mussel shell waste. Both types of waste can be detrimental to the environment if not used. One use of waste is in the agricultural sector as a substitute for planting media. The Lontar community prefers butternut squash (*Cucurbita moschata*) plants as the main commodity for cultivation. The results revealed that mixing shellfish flour waste and FABA could be utilized as a substitute for growing media in honey gourd cultivation. Additionally, this new method provides economic, social, and environmental benefits with a total benefit value amounting to Rp115,580,000 per year.

Keywords: Bottom Ash; Clam Shel; Eficiency; Fly Ash; Potting Mix

Introduction

PT PLN Indonesia Power UBP Banten 3 Lontar is one of the steam powers generating units owned by PT PLN (Persero) an Indonesian government-owned corporation which has a monopoly on electric power distribution in Indonesia and generates the majority of the country's electrical power, UBP Banten 3 Lontar utilized a Circulation Water Pump (CWP) pump as a means of taking sea water supply. This process generates a buildup of shells on the CWP pump which may disrupt the electricity production process. This process generates a buildup of shells on the CWP pump which may disrupt the electricity production process. Apart from that, coal is also utilized as the main fuel. It is estimated that domestic coal demand utilized for electricity generation purposes shall reach to 97 million tons in 2018 and shall continue to increase to 162 million tons in 2027. In the process of burning coal, Fly Ash & Bottom Ash (FABA) waste is produced every day and shall affect the temporary storage area for FABA waste for a certain period of time. This would generate environmental problems such as air and water pollution and a decline of the quality of the surrounding environment, thus efforts must be carried out to control and optimally utilize shellfish and FABA waste.

Clam shells contain calcium carbonate ($CaCO_3$). Clamshells also contain other minerals beneficial to plants, such as: Na, P, Mg as macro nutrients and Fe, Cu, Ni, B, Zn, Si as micro nutrients. Calcium carbonate ($CaCO_3$) contained in clam shells can function as an alternative fertilizer to neutralize soil acidity on marginal land. The heavy metal content in FABA comprised: Pb, Mn, Cu, Cd, and As (Verma *et al.* 2016; Okoye *et al.* 2016; Sari et al. 2021; Ondrasek *et al.* 2021). The characteristics of FABA are that it has fine particles, contains Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg) and Iron (Fe) which are essential for plants, but also contains dangerous heavy metals. Alkaline chemical characteristics generally contain Ca concentrations that vary between 3–10%, also varying P and K concentrations (Bhattacharya and Kim 2016; Utami 2018; Andarini et al. 2018). Materials containing Ca, such as dolomite ($MgCa(CO_3)_2$), are usually utilized to maintain pH stability during the compost making process (Moelyaningrum et al. 2018). It is hoped that these Ca content characteristics could be utilized in composting, without environmental pollution by heavy metal content.

Sustainable agriculture has become a vital issue in modern times, where innovation is required to increase agricultural productivity without damaging the environment. One approach taken is the use of industrial waste as a planting medium in agriculture. Butternut squash (*Cucurbita moschata*) is a horticultural crop commodity from the *Cucurbitaceae* family. Butternut squash has various beneficial compounds including vitamin A, vitamin C, vitamin E, and minerals which help increase the body's immunity and antioxidant compounds to fight free radicals. The orange color of honey pumpkin indicates high levels of β-carotene compounds which can function to reduce the risk of cancer (Ariyanti and

Suminar 2021). Kurniati *et al.* (2018) stated that butternut squash has a relatively high selling price compared to other types of pumpkins in general. This fruit has the potential to be cultivated to increase farmers' income. National production of butternut squash is generally still relatively low when compared to domestic needs. The Central Statistics Agency (2020) recorded butternut squash production in Indonesia from 2017 to 2019 at 566,845, 454,001 and 407,963 tons. Meanwhile, the consumption level in 2019 was 1,822 kg/capita/year (Ministry of Agriculture 2020). In general, this production shortage is due to the intensification of cultivation technology which is not yet optimal (Yuwono and Basri 2021). Cultivating butternut squash plants in less than optimal environments is a solution to increase productivity. Supported by the utilization and processing of shellfish waste and FABA as alternative planting media.

In efforts to optimize clam shells and FABA waste at PT PLN Indonesia Power UBP Lontar, waste utilization and processing is needed to overcome and prevent environmental damage. Efforts that could be made to overcome this problem require innovation in processing waste into soil ameliorant materials and alternative planting media mixtures. One plant that has the potential to be developed is the butternut squash plant. However, the composition and formulation of planting media and soil ameliorant materials from clam shell waste are still not available. Therefore, research was conducted by utilizing and processing green mussel shell waste as an ameliorant material and an alternative planting medium for butternut squash.

Method

Innovation Goals

The target of the innovation program is the use of clam shell waste and FABA as a substitute for planting media, namely for the agricultural sector and is beneficial for economic, social and environmental aspects. For Lontar UBP, the use of waste as a substitute for planting media is one step in supporting the realization of a sustainable environment. Utilizing shellfish and FABA waste as a substitute for honey pumpkin planting media is also a form of waste management with circular economic principles developed by Lontar UBP in collaboration with the IPB University. The substitute for waste shells and FABA that farmers get for free from UBP Lontar through the Corporate Social Responsibility (CSR) program, provides savings in purchasing planting media compared to what they usually do, thus providing economic benefits that are directly felt by farmers. In addition, the use of clam shells and FABA as a substitute for planting media is also able to reduce environmental pollution as their use could be optimized.

Innovation Utilized

This program of utilizing clam shell waste and FABA as a substitute for planting media is an innovation that has only recently been implemented among farmers and Lontar UBP. The planting medium being utilized for cultivating butternut squash is generated by mixing conventional planting media with shellfish waste and FABA in certain proportions. Clam shells and FABA, which initially only existed as waste and were piled up at the Lontar UBP Temporary Disposal Site (TPS), may now be utilized by mixing the planting media. The substitution of clam shells and FABA in the planting medium for butternut squash cultivation utilizes a method that is quite simple, making it easier for all groups to practice independently.

Methods for Implementing Innovation

Innovation commences by conducting soil analysis on: Fly Ash (FA), Bottom Ash (BA), Clam Shells (CK), Lontar UBP Area Land (TA), and Women Farming Group Land (TKWT). Laboratory scale soil analysis comprises: soil pH, soil organic C, N, P, K, Ca, Mg, Na, and soil texture. The outcome of the analysis determines the comparison in mixing planting media. The innovation utilized in this activity is the mixing ratio of the planting media.

The method of implementing innovation is conducted to overcome this problem, namely by making the right planting medium (M) to balance the content of these three components through the use of: Manure : Red Clay : *Cocopeat* : Husk charcoal with a ratio of 3: 3 : 2 : 1. Then, add alternative formulations for compounding new planting media, including: M + CK (2:1), M + FA + BA (4:1:1), M + FA + BA + CK (3:1:1:1), and only M. Compounding the planting media formulation is carried out by manually mixing the ingredients until evenly distributed, then placing the ingredients in a prepared planter bag. The planting media that have been put into the planter bag is left for one to two days to allow organic reactions to occur while waiting for the seedbed to grow.

Location, Materials, and Tools for Activities

Soil analysis was carried out at the Soil Laboratory, Faculty of Agriculture, IPB University. Demo-plot scale planting activities were conducted on the land of the Agria Lestari Women's Farming Group (KWT) in Klebet Village, Kemiri District, Tangerang Regency and the land of the Lontar Village Creative Team (TKL) in Lontar Village, Kemiri District, Tangerang Regency. Activities were carried out in June-August 2023. The materials utilized in this activity include butternut squash planting media at KWT and TKL locations, butternut squash seeds, Movento 50EC insecticide, *Curacorn*, AB Mix fertilizer specifically for pumpkins, basic fertilizer, bamboo stakes, fly-ash, bottom-ash, shellfish, cocopeat, husk charcoal, manure, planting medium. The tools utilized in this activity include: 60L planter bag, shovel, hoe, sack, and other tools that support butternut squash planting.

Data Collection and Analysis

The data gathering began by conducting a survey and taking samples of soil, FABA, shells at the Agria Lestari Women's Farming Group (KWT) in Klebet Village, Kemiri District, Tangerang Regency and the land of the Lontar Village Creative Team (TKL) in Lontar Village, Kemiri District, Regency Tangerang. For the laboratory scale analysis. The outcome of laboratory analysis was utilized as a reference for conducting comparisons of butternut squash planting media mixtures. The composition of butternut squash planting media was made and the growth of honey pumpkin was evaluated on a demo-plot scale. The plant observations carried out were growth characteristics (increase in plant height and number of leaves) and planting media characteristics (pH and soil temperature). The data analysis was carried out by utilizing qualitative descriptive analysis.

Discussion

The outcome of the analysis (Table 1) indicated that the soil conditions of the KWT and TKL soils had an optimum pH for the growth of butternut squash plants (pH 7.76 and 7.83). However, should the existing soil be mixed with animal waste, coir, husk charcoal, and others, it would generate the condition of the planting medium to become acidic, around a pH of 4.5. The low pH generated by the planting media requires the addition of planting material that has a high pH in order for the pH of the planting media mixture could be neutralized or become alkaline. Based on laboratory results, it was revealed that the pH produced by Bottom Ash and Shellfish showed almost the same pH (pH 9.30 and 9.01). The highest pH was generated by Fly Ash (pH 11.55). The addition of FABA and green mussel shells has the effect that the planting medium which is originally acidic could change to alkaline so that the pH of the planting medium mixed with FABA and/or mussel shells became around 7.70 to 8.06 according to pH requirements in butternut squash. However, the organic C content in FA, BA and CK was confirmed to be almost non-existent (0.07 – 1.00). This caused the need for good soil organic matter intake for plant growth. Additionally, the content of the elements N, P, and K of these three components are very low. Both components have a high sand texture (BA and CK) of 74.67% and 88.41%. The high texture of sand could support the plant roots to absorb nutrients much easier. However, this would require available soil organic matters so that it could be absorbed by plants.

Several points that could be conveyed regarding the outcome of this soil analysis are:

1. The pH of the three components was classified as very high (pH 9 - 11) so an acidic planting media mixture is needed to lower the pH, such as: *cocopeat* and husk charcoal;

2. The organic C content of the soil was almost non-existent; thus, the addition of planting media or organic material could be obtained from drum fertilizer;
3. The N content in the soil was also very low and could be supported by fertilizing with Urea or NPK 16-16-16;
4. The soil texture had almost no clay (dust and sand), therefore red soil/clay is needed so that the fertilizer application does not lose when watered.

Table 1. Results of Soil Analysis on Shellfish Waste, FABA and Planting Media

No. Lab	No. Lapang	IKM-ITSL-22	IKM-ITSL-24	IKM-ITSL-25	Olsen	IKM-ITSL-05					KB	IKM-ITSL-11		
		pH 1:5	Walkley & Black	Kjeldahl		*N* NH_4OAc pH 7.0						Tekstur (Metode Pipet)		
		H_2O	C-org	N-Total	P*	Ca	Mg	K	Na	KTK		Pasir	Debu	Liat
			..(%)..	..(%)..	...(ppm)...	..........(cmol$^{(+)}$/kg)..........					..(%)..	........(%)........		
FH 1105	BA 1	9.30	0.14	0.10	12.0	7.72	1.62	0.06	0.12	3.93	100.00	74.67	15.92	9.41
FH 1106	CK 1	9.01	1.00	0.30	120.2	35.03	1.68	0.23	3.60	3.86	100.00	88.41	3.84	7.76
FH 1107	FA 1	11.55	0.07	0.05	157.3	44.94	4.35	0.09	1.63	0.73	100.00	35.24	55.03	9.72
FH 1108	TG 1	7.76	5.87	0.57	357.4	48.70	3.15	5.62	3.20	19.28	100.00	58.76	5.77	35.47
FH 1109	TW 1	7.83	5.76	0.59	286.0	42.40	11.00	3.65	2.89	40.22	100.00	54.20	8.31	37.49

Source: IPB Laboratory Results

Planting butternut squash began by preparing the planting medium. The planting media being utilized were 4 mixing formulas. Media making is carried out by preparing media raw materials including: husk charcoal, *cocopeat*, red soil, shells, fly ash and bottom ash. Moreover, the need for 2 seedbed trays is also prepared for the KWT planting location. The making of planting media and sowing at the KWT planting location was conducted on July 20, 2023. Each media utilized for the KWT location was 10 planter bags per media combination (F1, F2, F3, and F4). After mixing the media and placing it in a planter bag, the media was incubated by leaving it and watering it regularly and daily for 10 days. The seedbed was also watered regularly every afternoon and its growth was closely observed. Growth conditions in the nursery are shown in Table 2 and Figures 1-3. The seedbed was watered by utilizing AB Mix platinum fruit fertilizer from the 9th day after sowing. Watering fertilizer with a dose of 1000 ppm by dissolving 5 mL of stock A and stock B solutions in 1 L of water. Each plant or planter bag was watered with 250 mL.

Table 2. Germination of Butternut squash Plants at the KWT Planting Site

Day	The number of seeds grown	The number of seeds sown	Percentage of Growth (%)
4	0	50	0
8	11	50	22
12	42	50	84
13	Transplanting at the KWT planting location (*Transplanting*)		

Source: IPB Laboratory Results

Figure 1. Honey Pumpkin Seeding Day 4

Figure 2. Honey Pumpkin Seeding Day 8

Figure 3. Honey Pumpkin Seeding Day 12
Source: Company Documentation, 2024

Transplanting activities were carried out on the 13th day where the media in the planter bag was ready to be utilized and the butternut squash plants had sufficient roots and leaves to be transplanted (5 leaves). Transplanting activities were carried out in the afternoon, where in the morning water was poured onto the planting medium (Figure 4). Three days before transplanting, the media was treated with *Curacorn* 250_{EC} insecticide with a dose of 2 mL L^{-1} water (Figure 5).

Figure 4. Transplanting Honey Pumpkin into 4 Formula Planting Media

Figure 5. Application of *Curacorn* to the Planting Medium Prior to Transplanting
Source: Company Documentation, 2024

After transferring the plants to the planting medium, watering was carried out immediately to avoid the plants from getting stressed when transplanted. The care carried out during planting was watering and fertilizing utilizing AB Mix Platinum Fruit. Fertilization was carried out twice a week with the same dose and application method. Plant care comprises of preventing pest attacks by spraying insecticide containing the active ingredient Abamectin at a dose of 2 mL dissolved in 1 L of water. For 40 plants, 1 liter of dissolved insecticide is required. Spraying was done evenly by spraying from the bottom to the top of the plant. This was carried out so that pest attacks such as thrips, whitefly, earthworms could be avoided.

Figure 6. Watering, Measuring Temperature and pH of Planting Media
Source: Company Documentation, 2024

The outcome of measuring the temperature and pH of the planting medium indicated that the composition of the planting medium was compatible for the growth of butternut squash, shown in Table 2. The measurement results indicated that the soil pH produced in all combinations of planting media ranges from 4.5 - 6.5. The third and fourth media formulations showed an upper soil pH of 4.5, which was too low for pumpkin plants, so water was sprinkled to help dissolve the acid that occurred due to the reaction of the media with clam shells. Previous laboratory results showed that the pH of clam shells and FABA was classified as very alkaline (9.01-11.55). The formulation successfully aided to lower the pH so that plant nutrients could be properly absorbed by the roots.

Table 3. Temperature and pH of Butternut squash Planting Media in KWT Agria Lestari

Planting media	Media pH		Media temperature	
Formula 1 (M)	Top	6	Top	30^0C
	Bottom	6.5	Bottom	32^0C
Formula 2 (M+FABA)	Top	6.5	Top	31^0C
	Bottom	6.5	Bottom	33^0C
Formula 3 (M+CK)	Top	4.5	Top	33^0C
	Bottom	6	Bottom	33^0C
Formula 4 (M+FABA+CK)	Top	4.5	Top	33^0C
	Bottom	6.5	Bottom	33^0C

Source: Company Documentation, 2024

Observations were made twice a week by counting the number of butternut squash leaves, plant height and plant stem diameter. The results showed that the plants in the planter bag of the second planting media formulation (Media + FABA) reacted well to butternut squash stem growth. The butternut squash stems in the second planting media formulation showed that they were stronger and had thicker stem diameters. Meanwhile, the plants in the 3rd planting media formulation showed a good response to the growth of butternut squash leaves, but when the plants were 1 month old the growth response was reduced. The growing butternut squash leaves look more numerous, wider and uniform on all planter bags. Meanwhile, plants on formula 1 planting media showed non-uniformity of growth. The 4th planting media formulation showed that the honey pumpkin plants are better than the other formulas, have a large number of leaves and a sturdy tree trunk. This revealed that the simultaneous substitution of shellfish and FABA in the planting medium was better for butternut squash plants (according to formula 4). Field conditions in the four formulas were shown in Figure 7.

Figure 7. Condition of Butternut squash in Four Planting Media Formulations
Source: Company Documentation, 2024

Based on the growth characteristics of butternut squash plants in the four planting media mixture formulas, it was revealed that the response of butternut squash plants to F2 was observed in the stem diameter of the plants being thicker and sturdier compared to the other three formulations. While the response of honey pumpkin plants to F3 was observed in wider leaf sizes, however, when the plant was 1 month old, the plant's response was reduced. Meanwhile, the plant response to F4 (M+FABA+CK) showed much better growth compared to other formulas due to the growing media formula mixed with clam shells and FABA which suited the needs of butternut squash plants. It was found that the stem diameter was thicker and stronger compared to planting media alone, while the leaves were wider when compared to planting formula 3 and planting formula 1.

A. Environmental Impact of Utilizing Clam Shell Waste and FABA as Planting Media

Through the butternut squash cultivation program run by the Agria Lestari Farming Women's Group and the Lontar Village Creative Team in the Kemiri District area, Tangerang Regency, 1,200 butternut squash trees/year are planted using shells and FABA as follows:

Table 4. Need for Clam Shells and FABA for Planting Media

No	Material	KWT Agria Lestari	Lontar Village Creative Team	Total	Unit
1	Clam Shells	75.3	52.71	128.01	Kg
2	FABA	225.9	158.13	384.03	Kg

Source: Company Documentation, 2024

Through the use of clam shell waste and FABA as a planting medium, it was able to reduce the load on the Lontar UBP TPS by 128.01 kg of clam shell stockpiles and 384.03 kg of FABA stockpiles which were used as a substitute for planting media. In addition, planting 1,200 honey pumpkin trees is equivalent to CO^2 absorption of 1,260 kg CO^2eq/year. Therefore, cultivating butternut squash by utilizing shell waste and FABA as a substitute for planting media provides good environmental impact.

B. Efficiency of Utilizing Clam Shell Waste and FABA

The use of clam shell waste and FABA as a substitute for butternut squash planting media provides direct economic benefits for farmers, namely efficiency for purchasing planting media. In cultivating butternut squash, farmers required 35 kg of planting media/polybag at a cost of IDR 33,280/polybag. In accordance with the land area owned by KWT Agria Lestari, the group could plant 1,200 polybags/year with a cost of purchasing planting media of IDR 39,936,000/year. Meanwhile, should you use planting media with the substitution of clam shell and FABA, it could be seen through the following calculations:

Table 5. Cost of Planting Media with a Mixture of Clam Shells and FABA

No	Material	Number of Comparisons	Mixture Comparison	Unit	Requirement of 100 Polybags
1	Laterite	3	16.67%	Liter	1000
2	Manure	3	16.67%	Liter	1000
3	Burnt Husk	2	11.11%	Liter	660
4	*Cocopeat*	1	5.56%	Liter	330
5	*Fly Ash*	2	11.11%	Liter	1000
6	*Bottom Ash*	1	5.56%	Liter	1000

7	Clam Shells	6	33.33%	Liter	1000
		18			

Quantity Per Polybag 60 Liters

Cost Requirements					
No	**Description**	**Unit of**	**Measurement**	**Unit Price**	**Total**
1	*Pollybag*	8	Kg	Rp25,000	Rp200,000
2	Manure	25	Bag	Rp25,000	Rp625,000
3	Red Clay	1	Lot	Rp280,000	Rp280,000
4	Burnt Husk	16.5	Bag	Rp15,000	Rp247,500
5	F1 Honey Pumpkin Seeds	1	Pack	Rp123,000	Rp123,000
6	*Cocopeat*	8	Bag	Rp40,000	Rp330,000
		Grand Total			**Rp1,805,500**

Source: Company Documentation, 2024

By substituting clam shells and FABA in butternut squash planting media, it resulted in savings on purchasing planting media of IDR 16,055/polybag and for planting 1,200 polybags/year it only costed 19,266,000, thus providing savings on purchasing planting media of IDR 20,670,000/ year for 2 farmer groups.

C. Social Benefits of Utilizing Clam Shell Waste and FABA

In addition to providing economic benefits, the program for utilizing clam shells waste and FABA as a substitute for planting media also provides social benefits. The social benefits obtained:

- Creation of new jobs: Agria Lestari Women's Farmers Group (KWT), Lontar Village Creative Team (TKL), and Manggala Putri Group (KMP).
- Establishment of a butternut squash processing business: butternut squash sticks, butternut squash milk, butternut squash jam, butternut squash tray cake, and butternut squash pudding.
- The formation of butternut squash tourist education has become a means of learning and research for the general public.

To discover the value of social benefits, we shall approach the income and turnover value of the business. The social benefit values shall be as follows:

Table 6. Social Benefit Values

Social Benefit	Economic Value	Details
Sales of KWT Agria Lestari fruits	Rp10,000,000	Per year
Lontar Village Creative Team Fruit sales	Rp6,000,000	Per year
Sales of processed KWT Agria Lestari	Rp36,408,000	Per year
Sales of Manggala Putri Group products	Rp42,520,000	Per year
TOTAL	**Rp94,910,000**	**Per year**

Source: Company Documentation, 2024

The value of the social benefits obtained was IDR 94,910,000 per year. Therefore, the overall benefit of the Lontar UBP CSR program through the activity of making planting media with the substitution of clam shells and FABA, both from economic and social aspects, is IDR 115,580,000 per year.

Conclusion

The main conclusion from this activity is that FABA waste and clam shells could be utilized as a substitute for planting media for butternut squash plants, especially in raising soil pH. The F2 and F4 planting media formulas have a better effect on the yield of honey pumpkin plants. Moreover, the making of planting media with a mixture of FABA and clam shells provided benefits for economic, environmental, and social aspects with a total value of IDR 115,580,000 per year. The presence of Lontar UBP 's CSR program in community empowerment provides many benefits for the welfare of the community surrounding the company, especially through this program new groups were formed with diversified activities, the Tim Kreatif Lontar village with agricultural activities cultivating butternut squash, melons, chilies and vegetables. The Manggala Putri group of Patra Manggala village with agricultural and fishery product processing activities that are able to provide increased income.

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