3-6 Potential food waste management system for agriculture in Guam

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ABSTRACT

For Year 2 (2011-2012) of the project, two activities were performed; (a) to observe food waste management systems in Japan, and (b) to conduct a study on making compost using available natural resources and food waste in Guam. The Japan tour was very successfully since after returning to Guam, a pilot study on waste oil collection was conducted by tour participants to put into action to educate the island community. The pilot project was also linked with a commercial waste management company to support our program. A compost study is ongoing to gather more data on how to manage the system. The black soldier fly (*Hermetia illucens*) was recently found in the food waste composting box.

KEYWORDS

Compost, Recycling

INTRODUCTION

Guam's agriculture is characterized by a small multiple-crop production system with importation of almost all fertilizers, pesticides and animal feeds. In addition, Guam is nearly 100% dependent on imported oils for their power needs including energy used in agriculture. In 2008, the U.S. territory set a goal to have *renewable* sources provide 5 % of net electricity sales by 2015 and 25 % of net electricity sales by 2035 (http://www.guampowerauthority.com/gpa). For sustainable island agriculture, food waste management takes an important role in reduction of imported fertilizers, animal feeds and fuels. The collaborative education and research project between University of Guam and

Okayama University was initiated in 2010 to study the potential use of food waste in agricultural activities in Guam (Marutani and Kishida, 2011)

During Year 1 (2010-2011) the project conducted a survey to find out the status of food waste utilization by hog farmers in Guam and how food waste providers such as hotels and restaurants disposed their wet garbage. The project also initiated an internship program for Okayama University students to participate in the food waste survey and to engage in agricultural activities in Guam. Marutani and Kishida visited several food waste management facilities including organic farms in Japan in two occasions for further development of a collaborative research and outreach program (Marutani and Kishida, 2011). The first visit also included two representatives from Guam, Mr. Joe San Agustin, a farmer and Ms. Margaret J. (Peggy) Denney of Denney Environmental & Educational Consulting Services, and the director of on-profit recycling organization in Guam.

For Year 2 (2011-2012), the project had two goals. The first goal was to carry out an educational tour in Japan by decision maker(s) of food recycling group or organization to initiate a food waste management system in Guam. The second goal was to conduct a pilot study on composting using available natural resources and food waste in Guam. This paper reports on Year 2 activities of the project.

PROCEDURE

1. Visit food waste management facilities in Japan.

Three participants from Guam were Mayor Melissa Savares of Dededo municipal, Elvie Tyler of University of Guam Center of Island Sustainability and Mari Marutani (PI). Additionally Mr. Ebisco Hocog of Rota, a neighboring island of Guam in Northern Mariana, joined the tour. From Japan, Dr. Yoshitaka Kimura (Co-PI) and Mr. You, a graduate student of Okayama University joined the tour. The purpose of this trip during October 10 – 14, 2011 was to observe facilities and practices that could be applied in Guam, and on return to Guam, participants would initiate a food-waste recycling program. The places visited for this period had been selected based on the observation of Year 1 tour that facilities, practices and concepts would be adopted in Guam. Places visited in Year 2 were:

a. Tanabe Meat Inc. (Nikuno Tanabe), Joetsu, Niigata
b. Todaya Hotel, Toba, Mie
c. Toba City Recycling Park, Toba, Mie
d. Daiei Kogyo Inc. Mie
e. Dowa Biodiesel, Okayama
f. Tobu Clean and Recycle Center, Okayama

The food waste processing practices and concepts observed at each site was highlighted. As an assessment of the trip, activities by participants after return to Guam were also recorded.

2. A pilot study making compost and animal feeds using natural resources and food waste in Guam.

2-1. Analysis of potential composing materials in Guam.

Composting materials were collected at University of Guam Triton Farm and University of Guam campus. Materials were dried, ground and vacuum packed and sent to Okayama University for analysis of carbon, nitrogen and C/N ratio. Materials included:

a. Tangan-tangan, *Leucaena leucocephala* (Lam.) de Wit. Leaves
b. Plumeria, *Plumeria obtusa* L. Leaves
c. Ironwood, *Casuarina equisetifolia* L. Needles
d. Coconut, *Cocos nucifera* L. Leaves
e. Horseradish tree, *Moringa oleifera* Lam. Seeds/pods
f. Jatropha, *Jatropha curcas* L. Exocarp
g. Da'ok, *Calophyllum inophyllum* L. Shells, leaves & exocarp
h. Sunnhemp, *Crotalaria juncea* L. Seedpods, leaves & flowers
i. Spent grains after brewing beer Grains

2-2. Construction of composts in Guam.

A canopy (6 m×12m) was construction at University of Guam Triton Farm for rain protection. Three small compost piles were made under canopy on the ground. Ingredients of the composts were as followed:

Compost A: Wood chips (*Leucaena leucocephala*) 6 parts (90gal; 405L)
Chicken manure (partially composted) 4 parts (60gal; 270L)
Soil (Guam cobbly clay soil, pH=7.5) 1 part (15gal; 67.5L)
Needles of *Casuarina equisetifolia* 1 part (15gal; 67.5L)
[Water --Added to make about 60% moist 10 gal. (45L)]

Compost B: Wood chips (*Leucaena leucocephala*) 6 parts (90gal; 405L)
Chicken manure (partially composted) 2 parts (30gal; 135L)
Soil (Guam cobbly clay soil, pH=7.5) 1 part (15gal; 67.5L)
Broad leaves (non-specific) 1 part (15gal; 67.5L)
[Water --Add to make about 60% moist 5 gal. (22.5L)]

Compost C: Wood chips (*Leucaena leucocephala*) 10 parts (150gal; 675L)
Chicken manure (partially composted) 2 parts (15gal; 135L)
Leaves (non-specific) 1 part (15gal; 67.5L)

Spent grains from beer making 1 part (15gal; 67.5L)

[Moisture content of grains was more than 90 %]

The temperature of the composts were monitored during the first ten days to examine if composting process began and continued by a thermometer (Thermo Recorder, T AND D Inc., Nagano, Japan). Larger volume compost was made from the result of a preliminary study to monitor.

2-3. Kitchen food waste to make compost.

The base materials in the 1st composting stage of modified Hashimoto system (Mr. Rikio Hashimoto, per. comm.) was made by mixing spent grains after making beer (5gal, 22.5L), finely ground coconut stem 3 blocks (543g/block), rice bran (irinuka) 3 packages (500g/package), soil form Triton Farm (0.5gal, 2.2L), and fallen leaves (1gal, 4.5L). The base composting materials were placed in a 75L box filled 40% with the base composting materials. Periodically, kitchen food waste were thrown in the box and mixed with base materials. Currently the composing process is being observed.

2-4. Animal feeds from spent grains from beer brewing by-product.

Spent grains were placed and press hard to remove air in a container to induce an anaerobic fermentation. Sugar was added to promote microbial activities. After a month, the product was used to feed chicken at Triton farm as supplemental feed.

RESULTS AND DISCUSSION

1. The highlights of the 5-day trip in Japan.

a. Tanabe Meat Inc. (Nikuno Tanabe), Joetsu, Niigata (Oct. 12, 2011)

The system at Tanebe Meat Inc. started with production of own pig feeds using food waste collected from supermarkets, bakeries, Japanese cookies (arare and senbei manufactures), schools, Japanese self-defense facilities and other cooperative food waste suppliers in Niigata. The rapid fermentation/pasteurization equipment was used to process food waste to make pig feeds. There were about 350 pigs at the farm and meats were processed to be served at their own restaurant and to make value-added products such as sausages. At the farm, pig manure was composted to make organic fertilizers or soil amendments for sale (Fig. 1).

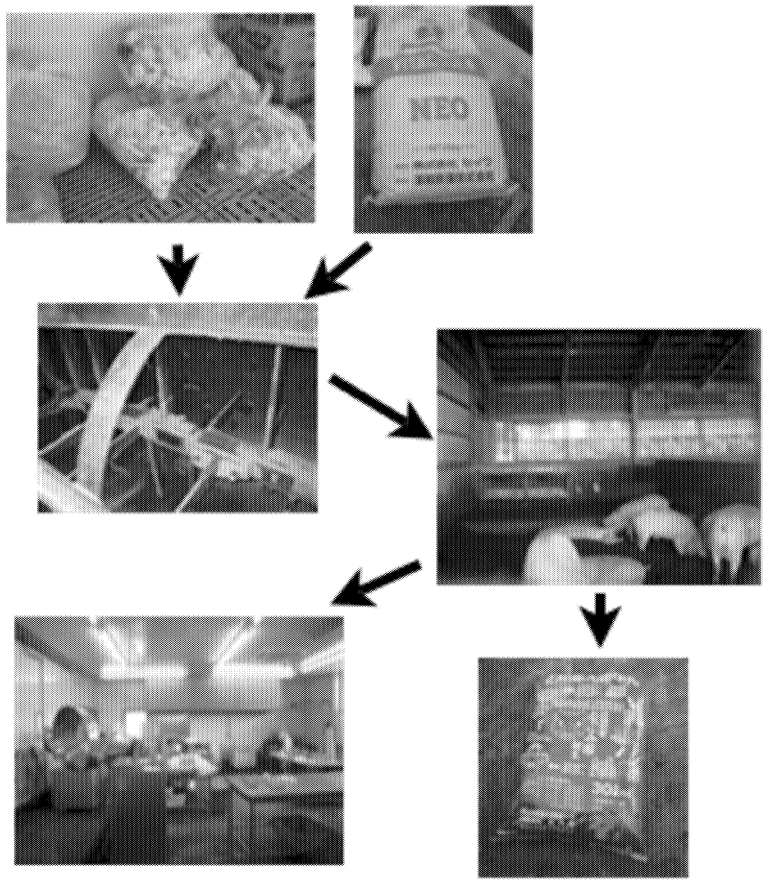

Fig. 1. Food waste and EM (effective microorganisms) are mixed in an equipment for crashing, drying, pasteurizing, fermenting to make pig feeds. Meat is processed to serve at the company's own restaurant and making value-added products such as sausage. Manure is converted to compost and sold as a fertilizer.

b. Todaya Hotel, Toba, Mie

Tourism is the No. 2 industry in Guam. There are many hotels in Guam that could use the similar food waste management and recycling method, which Todaya Hotel is in active practice. The hotel collected all food waste from its own kitchens daily and several portable equipments are used for pasteurization/crushing/fermentation/drying to make organic fertilizers for farmers and feedstock for aquaculture and farm animals (Fig. 2). In addition, used cooking oil was converted to biodiesel to run a shuttle bus (Fig. 3).

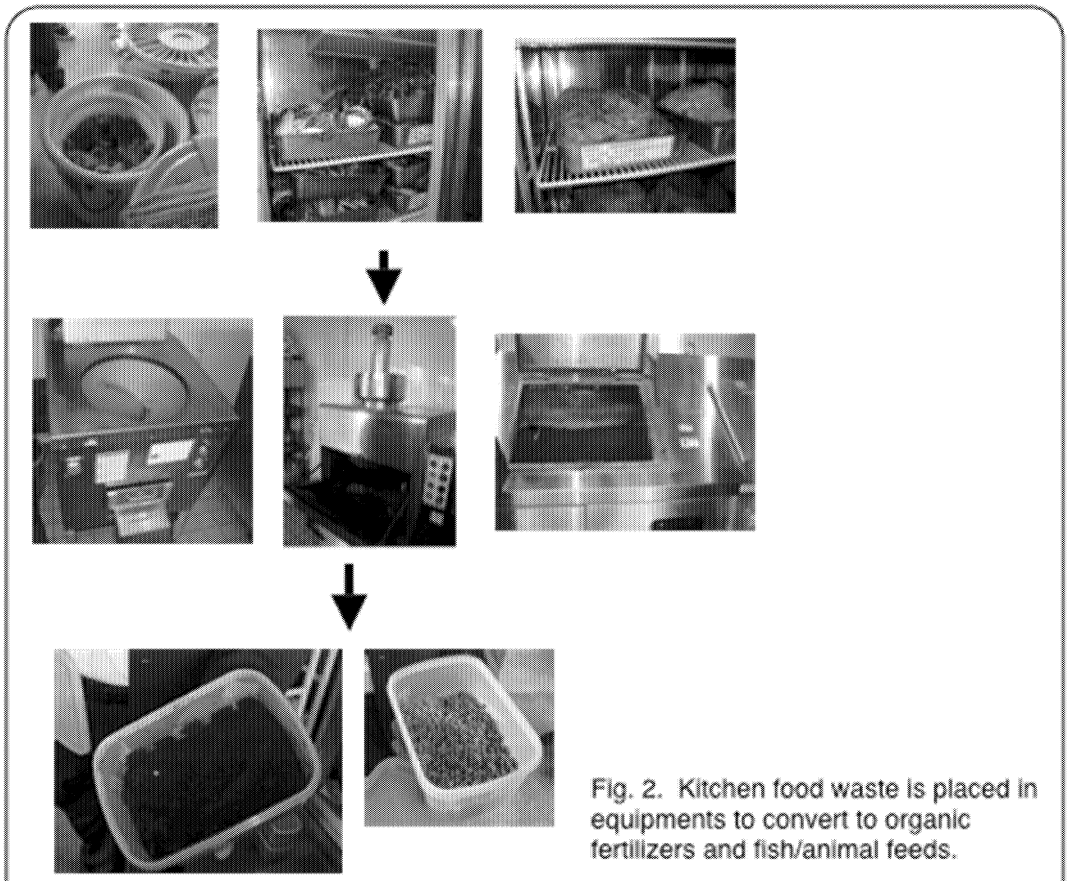

Fig. 2. Kitchen food waste is placed in equipments to convert to organic fertilizers and fish/animal feeds.

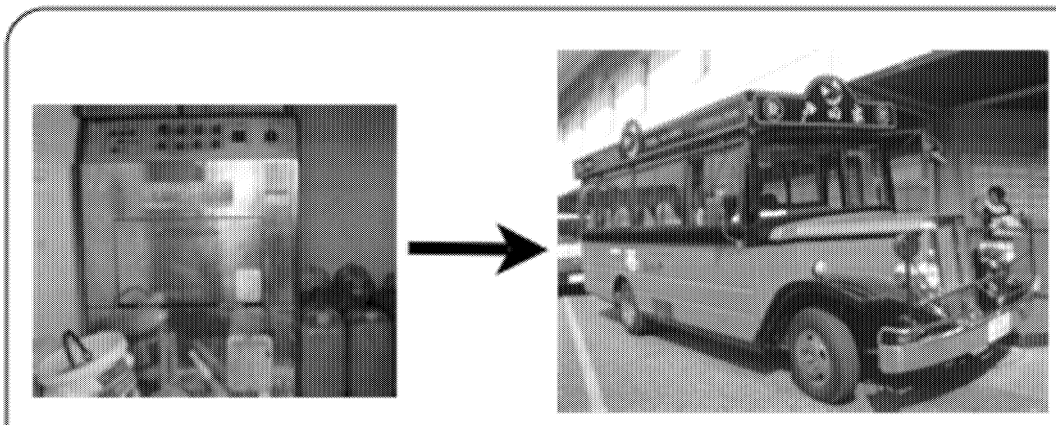

Fig. 3. Waste cooking oil is processed to make biodiesel to run a shuttle bus.

c. Toba City Recycling Park, Toba, Mie

Toba City Recycling Park is operated by the government and a non-profit organization to demonstrate recycling activities. The drive-through collection of recyclable materials was found to be convenient for the program's participating residents (Fig. 4).

Fig. 4. Drive-through waste collection area at Toba City Recycling Park

Food waste from individual household was collected using the Hashimoto method that each household was provided by a box with base composting materials. Each family added their food waste to the box, which was called the 1st stage of composting. When the box became full, they brought it to the Toba City Recycling Park to process the second stage of composing to mature the compost for distribution back to participated households with another batch of composting base materials (Fig. 5).

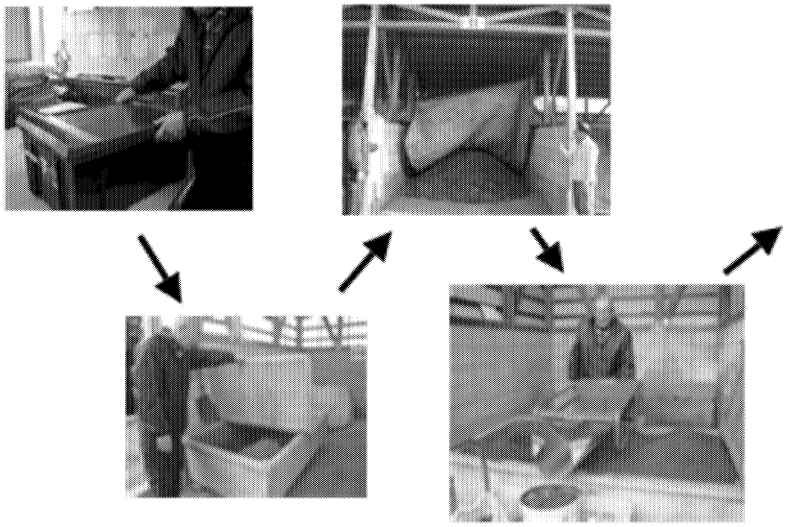

Fig. 5. Food waste is collected in a box with compost base at each household and processed at Recycling Park to make a final product for distribution to participants of the program.

d. Daiei Kogyo Inc. Mie

Daiei Kogyo Inc. presented a large scale of food waste management that a village or a district in Guam could use their operation practice (Fig. 6).

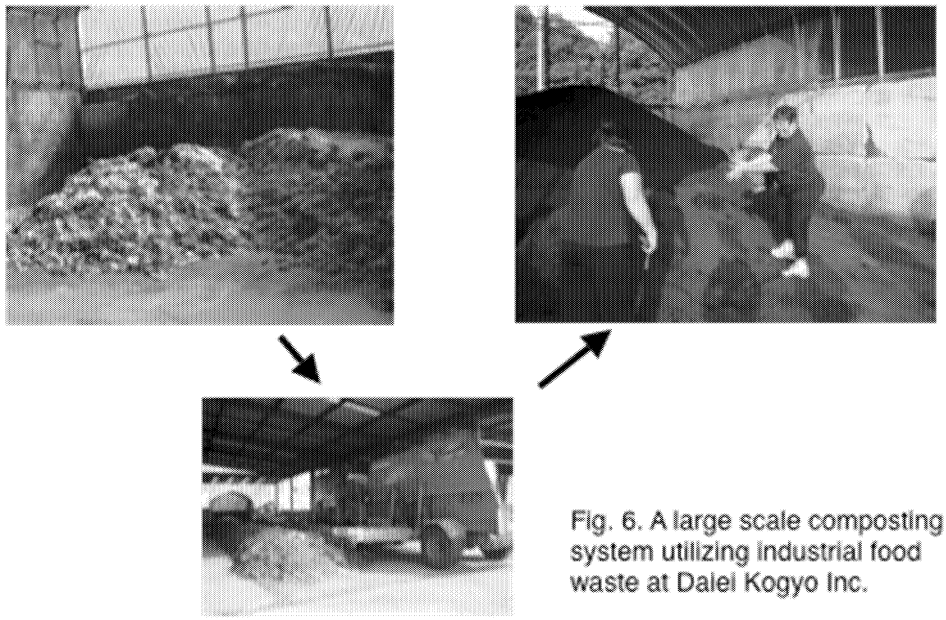

Fig. 6. A large scale composting system utilizing industrial food waste at Daiei Kogyo Inc.

e. Dowa Biodiesel, Okayama

Used vegetable oil is one of bio-fuel materials available in Guam. Dowa Biodiesel showed the production process and equipments to convert waste cooking oils to diesel oils in Okayama city (Fig. 7).

Fig, 7. Mayor Saveres, Ms. Tyler and Dr. Kimura are observing the facility at Dowa Biodiesel, Okayama.

f. Tobu Clean & Recycle Center, Okayama

Tobu Clean & Recycle Center was a very large-scale recycling center dealing with various materials for Okayama city. Different styles and ideas of the 1st stage composing as a small household food waste management system were presented by representatives from a recycling and waste management group (Fig. 8).

Fig. 8. Different styles of composters

In summary, the tour was very informative and successful to learn different types of food waste management systems in Japan. Some systems and ideas could easily be implemented in Guam. Several meetings among participants of this tour were held after returning to Guam. As a result Mayor Saveres and Ms. Tyler conducted a pilot study on collection of waste oils from residents of Dededo, Guam with a cooperating waste management company on February 4, 2012 (only in the morning). There were 126 people participated to bring 234.25 gal (887L) of waste cooking oils. Newspaper announcement was the most effective way to send out the announcement of the event and 45% of people were the first time participant to this type of recycling program.

2. A pilot study making compost and animal feeds using natural resources and food waste in Guam.

2-1. Analysis of potential composing materials in Guam.

The amount of carbon, nitrogen and C/N ratio of composing materials are presented in Table 1. Three common farm plants in Guam, *C. juncea*, *L. leucocephala* and *M. oleifera* contained higher nitrogen contents while other plants had more carbon. Leaves of nitrogen fixing legumes, *C. juncea* and *L. leucocephala*, had 3.59% and 2.31% of nitrogen, respectively. Spent grains, a by-product of

brewing beer, had 43.7% carbon and 2.26 % nitrogen. Lignified tissues of hard shells of *C. inophyllum* have the least nitrogen content of 0.1% and giving the highest C/N ratio. Fallen ironwood needles are very common in some farms since the plant is used as windbreak tree in Guam. Needles can be used as composting materials with high amount of carbon.

Table 1. The carbon and nitrogen contents and C/N ratio of composting materials. (all values are average of two readings except sunnhemp seed pods with one reading)

Plant	Tissue	C%	N%	C/N
Tangan-tangan, *Leucaena leucocephala*	Leaves	44.6	2.31	19
Plumeria, *Plumeria obtusa*	Leaves	44.5	0.64	70
Ironwood, *Casuarina equisetifolia*	Needles	49.3	0.94	52
Coconut, *Cocos nucifera*	Leaves	49.0	0.44	115
Horseradish tree, *Moringa oleifera*	Seeds+pods	45.4	1.16	39
Jatropha, *Jatropha curcas*	Exocarp	39.2	0.63	63
Da'ok, *Calophyllum inophyllum*	Shells	46.8	0.10	515
Da'ok, *Calophyllum inophyllum*	Leaves	48.8	0.61	80
Da'ok, *Calophyllum inophyllum*	Exocarp	46.7	0.91	52
Sunnhemp, *Crotalaria juncea*	Seed pods	44.6	1.95	23
Sunnhemp, *Crotalaria juncea*	Leaves & fls	41.1	3.59	12
Spent grains after brewing beer	Grains	43.7	2.26	19

2-2. Compost trials

Temperatures of three small compost piles were determined for 10 days to select one potential one to be made a larger scale. Table 2 shows the results of temperature changes.

Table 2. Temperatures (°C) of three composts recorded from Day 1 to Day 10.

	Compost A	Compost B	Compost C
Day 1	31	30	45
Day 2	40	33	57
Day 3	42	35	64 (after mixing)
Day 4	39	38	44
Day 5	40	48 (+rice bran)	58
Day 6	58 (+rice bran)	50	58
Day 7	55	39	59
Day 8	46	38	64
Day 9	40	41 (after mixing)	65
Day 10	47 (after mixing)	42	59

From the result of having steady temperature in Compost C (Table 2), a larger volume of compost was made using ingredients as follows:

Wood chips (*Leucaena leucocephala*)	60 parts (900gal; 4,050L)
Chicken manure (partially composted)	12 parts (180gal; 810L)
Fallen leaves	6 parts (90gal; 405L)
Spent Grains from beer	6 parts (90gal; 405L)

Periodical mixing, adding water and monitoring of temperature of compost have been continued. Currently the temperature of compost is maintained at about 55°C.

2-3. Kitchen food waste to make compost.

Periodical addition of kitchen food waste has been continued. Black soldier fly (*Hermetia illucens*) in family Stratiomyidae was found in composting boxes. Since the larvae are common detritivores, the composing process would accelerate by the presence of the insect (Fig. 9).

Fig. 9. Preparation of compost base materials (above) and addition of food waste to be composted in boxes (below).

2-4. Animal feeds from spent grains from beer brewing by-product

After a month of anaerobic fermentation, the product was fed to farm chicken as supplemental feed at Triton Farm. Analysis of the product was not done. This is a simple process and it is worth studying how to develop the system to reduce importation of animal feeds.

CONCLUSIONS AND PERSPECTIVES

The first part of the project was successfully completed. Right after the tour, a pilot study was conducted by Mayor Saveres and Ms. Tyler to promote recycling of waste oils and linked with a commercial waste management company to support our program. Similar projects will be conducted in near future and implementations of food waste management practices observed in Japan are expected.

The second part of the project, the compost study, was initiated and would be continued to gather more data on how to manage the system. Finding black soldier fly (*Hermetia illucens*) in food waste composting box would possibly lead to other research projects and modifications to composting systems in Guam.

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