# PRELIMINARY EVALUATION OF COMBUSTED FOREST FLOOR LITTERS FROM ACHALLA FOREST RESERVE AND INFLUENCE OF THEIR COMPOST ON GERMINATION POTENTIALS OF *Dacryodes Edulis* H. J. LAM

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**ABSTRACT**
*The search for non-timber forest products as functional alternative and complimentary products aimed at reducing pressure on standing forest ecosystems to abate current decline in ecological contributions to global climate and sustainable livelihood crisis remains a global task. This study evaluated the potential of different forest floor litters, types and ages as compost sources in organo-mineral and alternative products production. Six (6) different forest litters were obtained from delineated vegetation patches of Pterocarpus erinaceus, Gmelina arborea, Tectona grandis, Bambusa vulgaris, Ceiba petandra and Mangifera indica in Achalla Forest Reserve. These were analyzed for nitrogen (N), potassium (K), phosphorus (P), calcium (Ca) and magnesium (Mg) before composting for 3, 6, 9 and 12 days respectively and then combusted to produce organo-minerals for growth of Dacryodes edulis in a-6 x 4 split-plot factorial experiments. Analysis of variance was conducted for litter characteristics, calorific values, moisture and ash contents and significant means separated with Duncan multiple range test ($p > 0.05$). The results showed that Mangifera had highest mean P (0.68%) and K (1.15%) while Bamboo had the highest mean N (1.92%). Germination of D. edulis was 6>9>12>3days with Bamboo > Ceiba > Teak>Mangifera>Gmelina>Pterocarpus at 6days compost age. Mean ash content and calorific values was 12>9>6>3days compared to moisture content 6>9=3>12 composting age with the 12days compost (16.76±4.61J/kg) and Mangifera (20.73±0.59J/kg) as potential energy product. The evaluated litters therefore constitute organic products that could be amended by microbes and thermal treatments to reduce agricultural pressure of deforestation in Achalla forest reserve.*

***Key Words:*** *Forest floor litters, Organo-mineral, Compost age, Germination percentage, Ash content.*

## INTRODUCTION
The forest floor provides a dynamic platform in the ecosystem for variegated activities to generate essential energy outputs due to its interaction with the atmosphere and edaphic components at 0-5cm for a wide array of products to meet intermediate needs (Hoover and Lunt, 1952: Stephen and Patrick, 2005)). Essentially, floor litters depending on the thickness to permit air and moisture in the rhizosphere region create relative imbalance that alter underlying temperature (Groen and Savenije, 2006). Decomposition by microbial activities in this layer has been reported as critical to churning out precipitates for the modification and return of litters to the forest soil (Ochoa-Hueso *et al.*, 2019).

However, microbial activities under different thermal modifications have been observed as effective chemical pathways for bioturbation products in forest ecosystem (Lavelle, *et al*, 1997). This accounts for use of fire as a management tool in grassland and savanna ecosystems that reportedly release ash known for high quality of K, P, Ca and Mg along with a proportion of micronutrients (Bougnom *et al*., 2011). Controlled fire in land preparation as a means of combusting forest floor litters adjusted basic physicochemical soil properties that influenced tree growth characteristics due to the fertilizing capacity on both physical and chemical properties. In other climes, ash application to agricultural fields have been shown to compensate for critical nutrient deficiencies in leached and acidified soils (Saarsalmi *et al.*, 2006) while at the same time acted as anti-fungal agent against leafspot infections.

In the tropics, high soil fertility due to interactions between environmental factors and standing indigenous forest community has been observed as the attraction which has continued to endanger its sustainability by target for agricultural program (Egwunatum and Ezealisiji, 2020). This situation has accounted for loss of several hectares of protected forests in southern Nigeria because shifting cultivation has the fertile high forest as potential target for agricultural practices. Over 40% of forest reserves in Anambra State has been lost to agriculture with one-third gradually becoming degraded and encroached for residential purposes after several failures to practice inorganic agricultural due to search for fertile forest land coupled with high in availability of fertilizers(ICIR, 2022). Therefore, the propensity of agriculture to continually undermine forest reserves as a result of the soil fertility remains a serious bane to conservation and sustainable forest management.

However, standing forest patches in protected forests have been reported as notable sources of litters which can be relied upon for agricultural practices (Tjitrosemito *et al*, 2011). Whilst the forest is under strict conservation, effort at manipulating crucial parameters that aid high soil fertility status in tropical forest may provide basic rich organo-minerals for use in agricultural establishment. Organo-minerals are formed by a wide range of mechanism that involves activities of microbe on accumulated organic matter on the surface horizons of the forest floor layer in the presence of temperature, moisture and ambient soil conditions relying on the different rhizosphere qualities for individual tree ( Becker *et al*, 2015; Jones *et al*., 2004).

It is in this light that litters of different forest parchments in Achalla Forest Reserve were studied and engaged by composting and combustion for the production of ex-*situ* materials as organo-minerals for the use in agro-allied conurbations and alternative energy product as substitute for fuelwood collection with a view to saving the standing forest under conservation from deforestation and degradation by agriculture and fuelwood crisis.

## MATERIALS AND METHODS

### Description of study area

The samples were collected from Achalla Forest Reserve in Awka North Local Government Area in Anambra State. Achalla forest reserve is located on latitude 6°20'39"N and longitude 6°57´43´´E in the South East region of Nigeria. The climate of the area is a humid sub–tropical, basically within the tropical rainforest ecological zone and dominated by broad–leaved hardwood trees that form dense, layered stands. Mean annual temperature is approximately 26°C, with minimum 19°C and maximum 34°C (NiMet, 2019).

The natural vegetation is similar to that of tropical lowland rainforest but heavy anthropogenic alteration over a long period of time had replaced previous forest with secondary forest (Dania – Ogbe *et al*., 1993).

### Collection and analysis of forest floor litters

A reconnaissance survey was conducted by ground trotting to identify the various vegetation patches within the forest reserve portion not highly degraded. This was delineated into six vegetative portions of 50m x 50m plot respectively that comprised of *Gmelina arborea, Tectona grandis, Ceiba petandra, Bambusa vulgaris, Pterocarpus erinaceus* and *Mangifera indica*. Fresh forest floor litters were collected from ten quadrants (50cm x 50cm) in each plot for the six vegetations. Litters were collected from the forest floor layer (0-5cm depth) that consisted of twigs, barks, leaves and surface soil from the (L and F) layer as described by (Hoover and Lunt, 1952).

The collected forest floor litter samples were sundried at screenhouse temperature of 35-37.5°C for 24hours. Nitrogen was determined by the Microkjedahl digestion (Bremnar and Mulvaney, 1982). Then samples were dried to ashes at 120°C for 1hour before extraction with nitric-perchloric acid for determination of P, K, Ca and Mg. The P was determined by Vanado molybdate method while K, Ca and Mg by EDTA titration (Faithful, 2002).

### Preparation of forest floor litter products

The six (6) forest floor litters were composted anaerobically in black litter bags at 3 replicates per litter types for 3, 6, 9 and 12days aging period under screen house temperature. Harvested composts were then combusted semi-anaerobically for a uniform time of 240seconds at 45°C.

Emanating combusted compost litters products were allowed to cool for 24hours and analyzed for moisture content, ash content and calorific value respectively. The moisture content was analyzed by heating at 105°C for a period of 60min while the ash content was determined by heating the sample at 600°C for 4hours (ASTM, 2008).

Then 150gm each of combusted compost litters were weighed into different troughs with 75cl of sterilized water and allowed to stand for 60minutes to produce twenty-four (24) different organo-mineral slurries.

### Germination trials

Matured seeds of *Dacryodes edulis* were obtained from Eke Awka market, in Awka, and tested for viability using the floatation method. Four hundred and eighty (480) selected viable seeds were manually de-pulped before sowing in 6 germination troughs measuring 150cm x 50cm x 20cm and containing soils already inoculated with different organo-mineral slurries in uniform ratio of 1:2 at 80 seeds per organo-mineral type. Furthermore, 50gm of each ash type was applied by sprinkling 2days after sowing to support the efficacies.

Germination was then monitored at intervals of 1-5 and 5-10 weeks after sowing while germination recorded was expressed in percentage as the ratio of numbers that germinated to the total number sown per trough multiplied by 100.

## RESULTS

### Nutrient element composition of forest floor litters

The nutrient element composition of collected forest floor litters is shown in Table 1. The Bamboo litters have the highest mean N content of 1.92% and differed significantly from other litter types. The least mean N was recorded *Tectona grandis* and Pterocarpus that were not significantly different. The mean P was quite low with Ceiba and *Mangifera indica* litters showing highest means that were not significantly different. The *Gmelina arborea* litters showed the least mean P value (0.09%).

The highest mean K (1.15%) was recorded by Mangifera and was significantly different from all other types of litter. There were no significant differences in the mean K between Teak and Pterocarpus as well as between Ceiba and Gmelina. Pterocarpus recorded the highest mean Ca (1.92%) which differed significantly from other litters. there was no significant difference between mean Ca of Bamboo and Mangifera as well as between Ceiba and Teak.

Bamboo litters recorded the highest mean Mg (0.23%) that was not significantly different from Teak (0.19%). There was no significant difference in the mean Mg of Pterocarpus, Gmelina, Ceiba and *Mangifera indica*.

**Table 1: Nutrient element composition (% dry weight) of forest floor litters in Achalla Forest Reserve**

| Litter Source/ Type | Nitrogen | Phosphorus | Potassium | Calcium | Magnesium |
|---|---|---|---|---|---|
| *Pterocarpus erinaceus* | 1.58$^{c}$ | 0.25$^{c}$ | 0.28$^{c}$ | 1.92$^{a}$ | 0.03$^{b}$ |
| *Gmelina arborea* | 1.18$^{e}$ | 0.09$^{e}$ | 0.16$^{d}$ | 1.16$^{b}$ | 0.08$^{b}$ |
| *Tectona grandis* | 1.57$^{c}$ | 0.15$^{d}$ | 0.27$^{c}$ | 0.28$^{d}$ | 0.19$^{a}$ |
| *Bambusa vulgaris* | 1.92$^{a}$ | 0.63$^{b}$ | 0.47$^{b}$ | 0.58$^{c}$ | 0.23$^{a}$ |
| *Ceiba petandra* | 1.78$^{b}$ | 0.68$^{a}$ | 0.18$^{d}$ | 0.38$^{d}$ | 0.10$^{b}$ |
| *Mangifera indica* | 1.36$^{d}$ | 0.68$^{a}$ | 1.15$^{a}$ | 0.61$^{c}$ | 0.09$^{b}$ |

***Mean in the same column with the same superscript are not significantly different (p > 0.05)***

### Effect of combustion on compost forest floor litter types of Achalla forest reserve

Moisture content

Table 2 shows that the moisture content in *Tectona grandis* was significantly different (p > 0.05) from other forest floor litters types. There were no significant differences between *Pterocarpus erinaceus Ceiba Bombax, Mangifera indica, Bambusa vulgaris* and *Gmelina arborea.* The mean moisture content was *Tectona grandis* (13.99 ± 0.73%) > *Pterocapus erinaceus* (11.70 ± 0.79%) > *Ceiba petandra* (11.50 ± 0.90%) > *Mangifera indica* (9.65 ± 0.49%) > *Bambusa vulgaris (*8.80 ± 0.51%) > *Gmelina arborea* (8.45 ± 0.44%).

Ash content

There were significant differences (p > 0.05) in the ash contents of the different forest litter types at combustion (Table 2). The result of combusted litters shows that *Mangifera indica* recorded the highest ash content of 4.47±1.45%. The ash contents were *Tectona grandis* (4.30 ± 2.30%) > *Gmelina arborea* (4.24 ± 0.43%) > *Bambusa vulgaris* (3.53 ± 0.18%) > *Ceiba petandra* (3.17 ± 0.40%) > *Pterocarpus erinaceus* (2.32 ± 0.32%).

**Table 2: Effects of combustion on composted floor litters in Achalla Forest Reserve**

| Litter source/Type | Ash Content (%) | Calorific Value (J/kg) | Moisture Content (%) |
|---|---|---|---|
| *Pterocarpus erinaceus* | 2.32 ± 0.32$^{e}$ | 8.45 ± 0.40$^{f}$ | 11.70 ± 0.79$^{a}$ |
| *Gmelina arborea* | 4.24 ± 0.43$^{b}$ | 11.99 ± 0.43$^{e}$ | 8.45 ± 0.44$^{c}$ |
| *Tectona grandis* | 4.30 ± 2.30$^{b}$ | 14.78 ± 2.30$^{d}$ | 12.19 ± 0.73$^{a}$ |
| *Bambusa vulgaris* | 3.53 ± 0.18$^{bc}$ | 18.60 ± 0.85$^{c}$ | 8.80 ± 0.51$^{c}$ |
| *Ceiba petandra* | 3.17 ± 0.40$^{d}$ | 19.44 ± 0.90$^{b}$ | 11.50 ± 0.90$^{a}$ |
| *Mangifera indica* | 4.47 ± 1.45$^{a}$ | 20.73 ± 0.59$^{a}$ | 9.65 ± 0.49$^{b}$ |

***Means ±std error in the same column with same superscript are not significantly different (p > 0.05)***

Calorific value

There were significant differences (p > 0.05) in the calorific value of all the forest litters as shown in Table 2. The *Mangifera indica* recorded the highest calorific value (20.73 ± 0.59 J/kg) > *Ceiba petandra* (19.44 ± 0.90 J/kg) > *Bambusa vulgaris* (18.60 ± 0.85

J/kg) > *Tectona grandis* (14.78±2.30 J/kg) > *Gmelina arborea* (11.99±0.43 J/kg) > *Pterocarpus erinaceus/Gmelina arborea* (8.45±0.40 J/kg).

**Effect of compost age on combustion**

Moisture content

The mean moisture content of compost floor litters at 3 days age differed significantly from other ages (Table 3). There was no significant difference in the moisture contents of combusted floor litters at ages 6, 9 and 12 days. The highest moisture content of 10.12 ± 1.51 % was recorded by the 6days age forest floor litters while the others were D2 > D3 (9.60 ± 1.54 %) > D4 (8.91±0.32 %)

Ash content

There were significant differences in the ash contents of the forest floor litters at different composted ages as shown in Table 3. The highest ash content was produced by the 12days aged compost litters (4.45 ± 1.35 %) while the least of 2.95 ± 0.45 % was recorded at 3days. The 6- and 9-days aged compost produced ash contents of 3.53 ± 0.87 % and 3.77 ± 0.94 % respectively.

Calorific value

There were significant differences between the calorific values of different ages of composted forest floor litters at combustion (Table 3). The highest calorific value was produced by the 12days aged (16.76 ± 4.61 J/kg) and the least by 3days aged (14.73 ± 4.42 J/kg). The 9 and 6days aged forest floor litters recorded calorific values of 16.21 ± 4.69 J/kg and 14.95 ± 4.45 J/kg respectively that were significantly different ($p > 0.05$).

**Table 3: Effects of Compost age on Composted floor litters in Achalla Forest Reserve**

| Compost Age (Days) | Moisture Content (%) | Ash Content (%) | Calorific value (J/kg) |
|---|---|---|---|
| 3.00 | $9.92 \pm 2.62^{b}$ | $2.95 \pm 0.45^{d}$ | $14.73 \pm 4.42^{d}$ |
| 6.00 | $10.12 \pm 1.51^{a}$ | $3.53 \pm 0.87^{c}$ | $14.95 \pm 4.45^{c}$ |
| 9.00 | $9.60 \pm 1.54^{b}$ | $3.77 \pm 0.94^{b}$ | $16.21 \pm 4.69^{b}$ |
| 12.00 | $8.91 \pm 0.32^{c}$ | $4.45 \pm 1.35^{a}$ | $16.76 \pm 4.61^{a}$ |

**Means ±std error in the same column with same superscript are not significantly different ($p > 0.05$)**

**Effect of compost on Germination of *Dacryodes edulis***

The effect of various litter compost types on germination of *Dacryode edulis* is shown in Figure 1. The highest and least germination percentages during the first interval of 1-5weeks were recorded by the 6 and 12days compost litters respectively. Bamboo (BB) compost litters recorded the highest (50.5%) while the Gmelina (GM) and Pterocarpus (PE) compost litters recorded the least (10%).

The percentage germination at 5-10weeks interval showed that the 6days compost litters and Bamboo had the highest germination percentage (87.5%). Ceiba (CB), Teak (TK) and Mangifera (MG) recorded 85%, 68.75% and 42.5% respectively with the 6days. The Bamboo recorded highest germination of 71.25% while Ceiba and Teak was 60% with the 9days compost

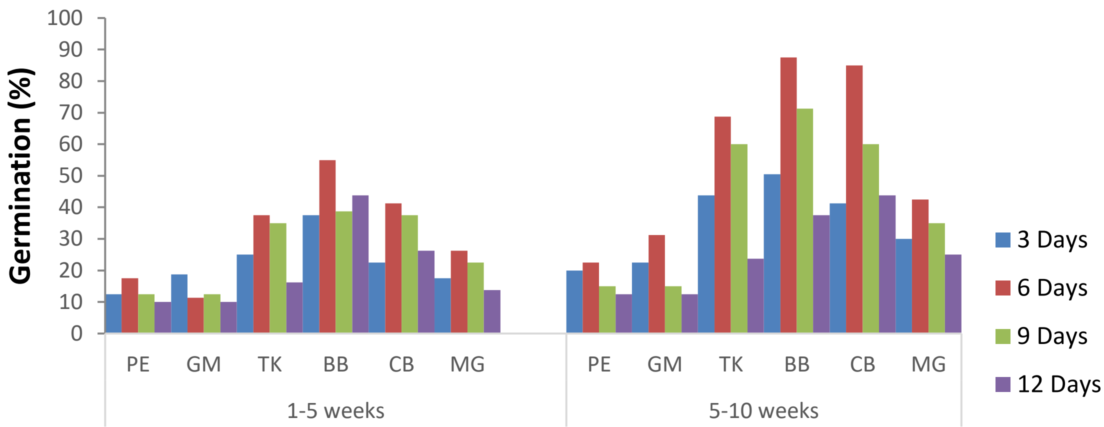


**Figure 1:Effect of Forest Floor litter Compost Types and Age on Germination of Dacryodes edulis**

**DISCUSSIONS**

The lower moisture contents of Gmelina, Bamboo and Mangifera may not be connected with growth characteristics of tree species but rather likely with the litter constituents which decreased with compost age. This may be due to the moisture use efficiency of microbes for the breakdown of vegetative matter. This finding is in line with Jonesberg (2017) that moisture availability decreases with high microbial activity as it is often employed in multiplication for enhanced services.

Ash content of combusted floor litters notably increased with age of composting. Since compost efficiency declines with age due to lower microbial population under regimented conditions, a large quantity of compost feed stocks may have contributed significantly to the ash content at combustion. Invariably, the low mean ash content could be as a result of low organic matter content and high microbial activity. Ash plays critical roles in agricultural practices and it represents critical source in adjusting soil acidity in soils. The utilization of forest fires under control in bush burning serves as latent ash source for organic agricultural practices in tropical forest to compensate for nutrient losses caused by harvesting and leaching and counter-act soil acidification (Nabatte and Nyombi, 2013). Unfortunately, the direct use of fire on soils has significant impact on resident microbial community which could reduce the potential of such forest soils to support productive agricultural activities over time. However, the fantastic germination achievement shown by the 6 and 9days compost organo-minerals implies better forest conservation, improved soil structure and capacity to retain water as well as nutrients (Atere and Olayinka, 2012). The high N and P-contents of Bamboo and Ceiba floor litters may have contributed substantially, especially during composting to the organo-mineral potential to account for the highest germination of *D.edulis*.

The calorific value of compost floor litters increased with compost age, attaining the highest mean (16.76±4.61J/kg) at 12days. Hence, longer composting age may enhance the calorific value of forest floor litters which essentially revealed and justified the need for composting before combustion. Materials with low calorific values have been reported to demonstrate poor thermal properties and may not function effectively as substitute for energy product. Consequently, the 12days compost combusted forest product and *Mangifera indica* tree species may have better potential as energy alternative products that could function as substitute of fuelwood to avert forest degradation.

**CONCLUSION**

This study indicated that investigated forest floor litter types in Achalla Forest Reserve represent veritable sources of compost and ash for use as organo-minerals products in soil enrichment. These will comparatively facilitate conservation of standing forest to enhance ecological services while still meeting the need of organic agriculture without forest degradation and deforestation in the already encroached forest reserve.

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