

**EFFECT OF DIFFERENT ACTIVATORS ON THE COMPOSTING OF
THRESHED PALM FRUIT BUNCHES**

BY

TIMOTHY OKWUDILI CHUKWUDI

B. Sc. (Hons) MICROBIOLOGY ANAMBRA STATE UNIVERSITY, ULI

**A THESIS SUBMITTED TO THE DEPARTMENT OF MICROBIOLOGY, OBAFEMI
AWOLOWO UNIVERSITY, ILE – IFE, NIGERIA, IN PARTIAL FULFILMENT OF THE
REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE IN
MICROBIOLOGY**

2011

AUTHORIZATION TO COPY

OBAFEMI AWOLOWO UNIVERSITY, ILE – IFE, NIGERIA.

HEZEKIAH OLUWASANMI LIBRARY

POSTGRADUATE THESIS

AUTHOR: TIMOTHY OKWUDILI CHUKWUDI

TITLE: Effect of Different Activators on the Composting of

Threshed Palm Fruit Bunches

DEGREE: Master of Science (M.Sc.) Microbiology

YEAR: 2011

I, **TIMOTHY OKWUDILI CHUKWUDI**, hereby authorize Hezekiah Oluwasanmi Library to copy my thesis in part or in whole in response to request from individuals and / or organizations for the purpose of private study or research.

.....

Signature

.....

Date

CERTIFICATION

This is to certify that this research work was carried out by **TIMOTHY OKWUDILI CHUKWUDI** (SCP 07/08/H/2805), in the Department of Microbiology, Obafemi Awolowo University, Ile –Ife, Nigeria.

Prof. Olu. Odeyemi

(Supervisor)

Date

Prof. G. O. Babalola

(Head, Department of Microbiology)

Date

DEDICATION

This work is dedicated with profound gratitude to my beloved brother,

Mr Marcus Chukwudi, and my cousin, Mr Williams Onyia.

OBAFEMI AWOLOWO UNIVERSITY

ACKNOWLEDGEMENTS

A work of this magnitude recognizably requires the support, advice and encouragement of a host of individuals. First and foremost, my special and sincere gratitude goes to my wonderful supervisor, Prof. Olu Odeyemi, who initiated the plan to embark on this project and thoroughly nurtured its development. Sir, I shall remain eternally grateful to you for your invaluable contributions especially your numerous words of wisdom.

I am equally indebted to Prof. G.O. Babalola for his constructive advice throughout this programme. Thank you so much.

I am also highly indebted to all Lecturers and the entire members of staff of the Department of Microbiology for impacting knowledge in me academically. I express deep appreciation.

I wish to specially extend my gratitude also to Dr. Bakare, Dr. (Mrs) Oluduro, Mr Awojobi and Mrs Awotipe for their numerous encouragements and love, may the Good Lord continue to add to your blessings. I cannot but appreciate the support of my fellow postgraduate students – Anthony Ejelonu, Adisa Oluwakemi, Nneke blessing, Oluwaniyi Tolulope, Yetunde Omidiran, Ogunkanbi Ademola, Adeniran Adeyanju, Ladesuyi Yemi, Tayo Abioye, Sola Idowu, Igbekoyi Funmi (Sociology) and others who contributed in their various capacities to ensure the success of this research work. Thank you for the numerous supports you rendered.

A very special appreciation also goes to my beloved mother, Chukwudi Janet, my brother, Mr Marcus Chukwudi and my cousin, Mr Willams Onyia, for their fervent prayers and for providing me with the necessary resources to execute this project.

I will not forgive myself if I fail to acknowledge Mr Charles Onovo who magnanimously gave me a laptop which made the typesetting of this project very easy. I always wonder how I would have coped without a laptop of my own. Thank you and may you always find favour

Above all, I am most grateful to the Almighty God, the sustainer of my breath, health and life, and for giving me the grace to make this token contribution to knowledge.

Timothy Chukwudi.

OBAFEMI AWOLOWO UNIVERSITY

TABLE OF CONTENTS

Title	Page
Title page	i
Authorization to Copy	ii
Certification	iii
Dedication	iv
Acknowledgements	v
Table of Contents	vi
List of Tables	xii
List of Figures	xiii
List of Plates	xvi
Abstract	xvii
CHAPTER ONE: INTRODUCTION	
1.1 Background information	1
1.2 Aim and objectives	3
CHAPTER TWO: LITERATURE REVIEW	
2.1 Fertilizer	4
2.2 Wastes	5

2.3 Composting	6
2.3.1 History of composting	7
2.3.2 Composting materials	8
2.3.2.1 Threshed palm fruit bunches (TPFB)	10
2.3.2.2 Animal droppings	11
2.3.2.3 <i>Gliricidia sepium</i>	12
2.3.3 Methods of composting	13
2.3.3.1 Static composting method	13
2.3.3.2 Indore method	14
2.3.3.3 Indian Bangalore method	14
2.3.3.4 Sheet method	15
2.3.3.5 Agitated/Forced aeration method	16
2.3.3.6 In-vessel (Rapid) composting method	16
2.3.3.7 Vermicomposting	17
2.3.3.8 Co-composting	19
2.3.4 Composting process	19
2.3.5 Microbiology of composting	23
2.3.6 Biochemistry of composting	27
2.3.7 Factors affecting composting	30

2.3.7.1 Nutritional balance	31
2.3.7.2 Moisture content	32
2.3.7.3 Particle size	34
2.3.7.4 Temperature	34
2.3.7.5 Aeration	36
2.3.7.6 pH	38
2.3.8 Utilization of compost	38
2.3.8.1 Soil enrichment	38
2.3.8.2 Suppression of plant diseases	40
2.3.8.3 Erosion control	41
2.3.8.4 Bioremediation	43
2.3.9 Valuation of compost quality	44
2.3.9.1 Respiratory test	45
2.3.9.2 Phytotoxicity test	46
2.3.9.3 Odour	47
2.3.9.4 Dewar self heat	48
2.3.9.5 Carbon to Nitrogen ratio	49
2.3.9.6 Agronomic analysis	49
2.3.9.7 Chemical analysis	50

CHAPTER THREE: MATERIALS AND METHODS	51
3.1 Collection of organic wastes for composting	51
3.2 Experimental treatments for composting	51
3.3 Microbiological analysis	56
3.3.1 Estimation of bacterial and fungal population	57
3.3.2 Characterization of bacterial and fungal isolates	57
3.3.3 Cultural characteristics	57
3.3.4 Microscopy	58
3.3.4.1 Gram staining for bacterial differentiation	58
3.3.4.2 Spore stain	58
3.3.5 Biochemical characteristics	59
3.4 Identification of fungal isolates	62
3.5. Physico – chemical analysis of samples	62
3.5.1 Temperature estimation	63
3.5.2 pH estimation	63
3.5.3 Moisture content	63
3.5.4 Elemental analysis	64
3.6 Stability and maturity test	64
3.6.1 Respiration bioassay:	64

3.6.2 Germination index	65
3.7 Agronomic evaluation of samples	66
3.8 Statistical analysis	67
CHAPTER FOUR: RESULTS	68
4.1 Microbiological analysis of the compost samples	68
4.1.1 Bacterial and fungal populations during the composting of the threshed palm fruit bunch alone (control)	68
4.1.2 Bacterial and fungal populations during the composting of the threshed palm fruit bunch mixed with poultry droppings (ratio 1:1).	68
4.1.3 Bacterial and fungal populations during the composting of the threshed palm fruit bunch mixed with poultry droppings (ratio 2:1).	70
4.1.4 Bacterial and fungal populations during the composting of the threshed palm fruit bunch mixed with poultry droppings and <i>Gliricidia sepium</i> (ratio 2:1:1).	73
4.1.5 Bacterial and fungal populations during the composting of the threshed palm fruit bunch mixed with cow dung (1:1).	73
4.1.6 Bacterial and fungal populations during the composting of the threshed palm fruit bunch mixed with cow dung (2:1).	75
4.1.7 Bacterial and fungal populations during the composting of the	

threshed palm fruit bunch mixed with cow dung & <i>Gliricidia sepium</i> (ratio 2:1:1).	78
4.1.8 Total coliform count of the different composting piles during the 60 days of composting of threshed palm fruit bunch.	78
4.1.9 Identification of aerobic heterotrophic bacteria and fungi isolated from different composting piles of threshed palm fruit bunch treated with different concentrations of poultry droppings, cow dung and leaves of <i>Gliricidia sepium</i>	81
4.1.10 Types of aerobic heterotrophic bacteria and fungi isolated from threshed palm fruit bunch alone.	82
4.1.11 Types of aerobic heterotrophic bacteria and fungi isolated from threshed palm fruit bunch treated with poultry droppings (1:1).	82
4.1.12 Types of aerobic heterotrophic bacteria and fungi isolated from threshed palm fruit bunch treated with poultry droppings (2:1).	83
4.1.13 Types of aerobic heterotrophic bacteria and fungi isolated from threshed palm fruit bunch treated with poultry droppings and <i>Gliricidia sepium</i> (2:1:1).	83
4.1.14 Types of aerobic heterotrophic bacteria and fungi isolated from threshed palm fruit bunch treated with cow dung (1:1).	84
4.1.15 Types of aerobic heterotrophic bacteria and fungi isolated from threshed palm fruit bunch treated with cow dung (2:1)	84

4.1.16	Types of aerobic heterotrophic bacteria and fungi isolated from threshed palm fruit bunch treated with cow dung and <i>Gliricidia sepium</i> (2:1:1).	85	
4.2	Temperature Changes within the Piles of Threshed Palm Fruit Bunch Mixed with Different Concentrations of Poultry Droppings, Cow Dung and <i>Gliricidia sepium</i>	85	
4.3	Changes in pH during the 60 days composting of threshed palm fruit bunch treated with different concentrations of poultry droppings, cow dung and <i>Gliricidia sepium</i> .	93	
4.4	Characteristic changes of nutrient contents of the various experimental compost piles	95	
4.5	Respiration and germination index test of the matured composts	112	
4.6	The physical appearances of the different treatments	113	4.7
	Effects of composted threshed palm fruit bunch on maize plant height, fresh and dry weight	115	
	CHAPTER FIVE: DISCUSSION	120	
	Conclusion and recommendation	132	
	References	135	
	Appendices	154	

LIST OF TABLES

Table		Page
1:	The respiration and the germination index of the matured threshed palm fruit bunch composts	114
2:	Mean plant height (cm) of maize fertilized with the different threshed palm fruit bunch composts	117
3:	Mean fresh and dry weights of maize fertilized with the matured different composted threshed palm fruit bunch	118

LIST OF FIGURES

Figures	Page
1: Generalized representation of the composting process	20
4.1a Percentage increase of total heterotrophic bacterial and fungal populations of threshed palm fruit bunch mixed with poultry droppings (1:1).	69
4.1b: Percentage increase of total heterotrophic bacterial and fungal populations of threshed palm fruit bunch mixed with poultry droppings (2:1)	71
4.1c: Percentage increase of total heterotrophic bacterial and fungal populations of threshed palm fruit bunch mixed with poultry droppings and <i>Gliricidia sepium</i> (2:1:1).	72
4.1d: Percentage increase of total heterotrophic bacterial and fungal populations of threshed palm fruit bunch mixed with cow dung (1:1)	74
4.1e: Percentage increase of total heterotrophic bacterial and fungal populations of threshed palm fruit bunch mixed with cow dung (2:1)	76
4.1f: Percentage increase of total heterotrophic bacterial and fungal populations of threshed palm fruit bunch mixed with cow dung & <i>Gliricidia sepium</i> (2:1:1)	77

4.1g: Percentage increase of Coliform populations in the compost piles of threshed palm fruit bunch mixed with different concentrations of poultry droppings, cow dung and <i>Gliricidia sepium</i> .	80
4.2a: Temperature changes of threshed palm fruit bunch treated with poultry droppings (1:1) following 60 days of composing	86
4.2b: Temperature changes of threshed palm fruit bunch treated with poultry droppings (2:1) following 60 days of composing	87
4.2c: Temperature changes of threshed palm fruit bunch treated with poultry droppings & <i>Gliricidia sepium</i> (2:1:1) following 60 days of composing	89
4.2d: Temperature changes of threshed palm fruit bunch treated with cow dung (1:1) following 60 days of composing	90
4.2e: Temperature changes of threshed palm fruit bunch treated with cow dung (2:1) following 60 days of composing	91
4.2f: Temperature changes of threshed palm fruit bunch treated with cow dung & <i>Gliricidia sepium</i> (2:1:1) following 60 days of composing	92
4.3: Weekly pH variation of the different treatment set ups of threshed palm fruit bunch following 60 days composting	94
4.4a: Changes in the carbon concentration of the different composting piles of threshed palm fruit bunch after 60 days of composting.	96

4.4b: Changes in the nitrogen concentration of the different composting piles of threshed palm fruit bunch after 60 days of composting period	97
4.4c: Changes in the phosphorus concentration of the different composting piles of threshed palm fruit bunch after 60 days of composting	99
4.4d: Changes in the potassium concentration of the different composting piles of threshed palm fruit bunch after 60 days of composting	100
4.4e: Changes in the calcium concentration of the different composting piles of threshed palm fruit bunch after 60 days of composting	102
4.4f: Changes in the magnesium concentration of the different composting piles of threshed palm fruit bunch after 60 days of composting.	103
4.4g: Changes in the zinc concentration of the different composting piles of threshed palm fruit bunch after 60 days of composting	105
4.4h: Changes in the chromium concentration of the different composting piles of threshed palm fruit bunch after 60 days of composting	107
4.4i: Changes in the copper (Cu) concentration of the different composting piles of threshed palm fruit bunch after 60 days of composting	108
4.4j: Changes in the manganese (Mn) concentration of the different composting piles of threshed palm fruit bunch after 60 days of composting	109
4.4k: Changes in the iron concentration of the different composting piles of	

OBAFEMI AWOLOWO UNIVERSITY

LISTS OF PLATES

Plates

- | | | |
|----|--|-----|
| 1: | Picture of harvested fresh oil palm bunch | 52 |
| 2: | Threshed palm fruit bunch (TPFB) called spadix
(fibrous by-product of palm oil processing) used for the study | 53 |
| 3: | Picture of shredded threshed palm fruit bunch (TPFB) used for
the study | 54 |
| 4: | Pictures of <i>Gliricidia sepium</i> (Jacq.) used for the study | 55 |
| 5: | The physical appearances of the different treatments of
threshed palm fruit bunch before and after 60 days composting | 115 |

ABSTRACT

This study was undertaken to investigate the composting characteristics of threshed palm fruit bunch with different concentrations of poultry droppings, cow dung and *Gliricidia sepium* (Jacq.) as activators with the aim of generating quality soil conditioner.

Seven treatment piles of threshed palm fruit bunch comprising of threshed palm fruit bunch mixed with poultry dropping (1:1) (TPFB-P1), threshed palm fruit bunch mixed with poultry droppings (2:1) (TPFB-P2), threshed palm fruit bunch mixed with poultry dropping and *Gliricidia sepium* (2:1:1) (TPFB-PG), threshed palm fruit bunch mixed with cow dung (1:1) (TPFB-C1), threshed palm fruit bunch mixed with cow dung (2:1) (TPFB-C2), threshed palm fruit bunch mixed with cow dung and *Gliricidia sepium* (2:1:1) (TPFB-CG), and threshed palm fruit bunch alone (TPFB-CON), were set up for this study. During composting, several parameters including total bacteria and fungi count, the physicochemical properties [pH, temperature and elemental (N, P, K, Mg, Mn, Cu)], maturity and phytotoxicity index of each composting pile were measured using standard procedures.

The bacterial populations of the treatment piles were between 5×10^4 cfu/g and 2×10^8 cfu/g while the fungi populations were between 5×10^3 cfu/g and 9×10^6 cfu/g. There was diversity in occurrence of microbial populations of the various piles. TPFB-P1 attained the highest bacteria counts (2×10^8 cfu/g) jointly followed by TPFB-C1, TPFB-PG and TPFB-CG with bacterial counts of 1×10^8 cfu/g. TPFB-C1 attained the highest fungi count of 9×10^6 cfu/g. The control pile attained the least bacterial (2×10^7 cfu/g) and fungal counts (5×10^5 cfu/g). The temperature regime of all the composting piles ranged between 27 °C and 43 °C. TPFB-PG attained the highest temperature (43 °C). Maximum temperatures of 41 °C, 39 °C, 38 °C, 37 °C, 35 °C and 35 °C were attained by TPFB-CG, TPFB-P1, TPFB-C1, TPFB-P2, TPFB-C2 and TPFB-CON respectively. All the treatment piles showed an alkaline pH range

of 7.62 and 8.26 after composting. There was significance decrease of C/N ratio at the end of composting in all the composting piles with the lowest C/N ratio of 11.1 being observed in TPFB-P1 followed by TPFB-PG with C/N ratio of 13.6, while the highest C/N ratio of 28.9 was observed in TPFB-CON. TPFB-C1, TPFB-CG, TPFB-P2 and TPFB-C2 had C/N ratios of 13.8, 14.5, 14.6 and 19.8 respectively. The cured composts contained considerable varying amounts of elemental nutrients and very low levels of heavy metals. The phytotoxic evaluation of the various composts measured as germination index (GI) showed that all the composting piles have GI value greater than 60% which was indicative of their being none phytotoxic and suitable as soil conditioners. Except for TPFB-CON with CO₂ evolution of 39.6, the respiration test of the composts had CO₂ evolution that ranged between 17.4 and 32.1. All the generated composts significantly increased the growth of maize plant agronomically.

In conclusion, this study established that threshed palm fruit bunches could be converted into a very good organic fertilizer especially by composting them with the right proportions of poultry droppings, cow dung and *Gliricidia sepium*.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Instead of imitating nature's complex stability, industrial farmers use force, attempting to bend the naturally simplified ecosystem to their will. As a result, most agricultural districts are losing soil at a non-sustainable rate and produce food of lowered nutritional content, resulting in decreasing health of all life forms which depend on the products of farms. The high cost of synthetic fertilizers has greatly contributed to the recent global problems of food shortage most especially in the developing countries where most farmers could not afford the exorbitant prices of chemical fertilizers (Odeyemi, 1998). New technologies that can enhance the economic viability of farming systems with little or no use of chemical fertilizers and pesticides are urgently needed and composts seem to be an important consideration to farmers especially in less developed countries.

Composting has been described as a viable means of transforming various organic wastes into products that can be used safely and beneficially as biofertilizers and soil conditioners (Odeyemi, 2011). Thus, composting offers several benefits such as enhancement of soil fertility and soil health which increase agricultural productivity, improve soil biodiversity and reduce ecological risks all of which provide a better environment. According to Atkinson *et al.*, (1997), composting can be used to stabilize many solid wastes and is, therefore, expected to increase substantially in many countries.

Composting may be applied to many waste products to release nutrients and render them safe to use (Jones and Martin, 2003). The end product of composting (compost) can be considered a soil conditioner that contributes to soil fertility, structure, porosity, organic matter, water-holding capacity, cation exchange capacity, and disease suppression, provided it is properly prepared (Sesay *et al.*, 1997; Zucconi *et al.*, 1981).

Recycling of organic wastes for agricultural purposes through appropriate biological treatments can produce valuable organic matter which can be of great interest to the farmers. Parr *et al.*, (1986) noted that when agricultural and municipal organic wastes are properly managed through composting, the end product (compost) has the capability of improving soil productivity which can lead to about 60 % food production increase worldwide. In fact, the end product of composting process has been shown to be the remarkably resistant and complex organic substance called humus (Keener *et al.*, 2000), which is largely responsible for the brown colour of the majority of soils in temperate regions

In Nigeria, the potentials for compost have been recognised long ago, but its exploitation has remained at rudimentary level, abandoned to peasant poor farmers and most of the potential biodegradable/compostable wastes are rather thrown away instead of converting them into valuable

products (compost). Much of our wastes including food residues, municipal leaves, farm yard materials, agricultural wastes, human and livestock manure, form good materials for composting and consist of organic materials, all of which should be returned to the soil from which they originated.

One of the agricultural wastes commonly generated in Nigeria is the oil palm bunch refuse. Nigeria, as the third largest oil palm producing country after Malaysia and Indonesia, generates large amounts of wastes (threshed palm fruit bunches (TPFB), fibres/nuts, palm oil mill effluent (POME), trunk/fronds) during palm oil processing. Of all the aforementioned wastes, TPFB, the ligno-cellulose fibrous medium left after bunch stripping (removal of palm fruits), remains the most abundant of all these wastes (Baharuddin *et al.*, 2009). While few of these wastes are used for heating, large amount are heaped in the open, where they not only constitute an eye sore but serve as a breeding ground for many dangerous insects, reptiles and rodents.

According to Saletes *et al.*; (2004), a mill with a capacity of 60 tonnes fresh fruit bunches (FFB) per hour will thus produce almost 83, 000 tonnes of TPFB per year. Thus, in many oil palm plantations, producers have access to a plentiful supply of this waste material that can be converted into a valuable soil conditioner. In fact, the oil palm waste, which has been estimated from this industry at about seven million metric tonnes annually, is yet to be harnessed for the production of organic manures and agricultural development generally.

There is, therefore, a need to develop effective composting system to produce high quality soil conditioners from this waste product in order to ensure that the agronomic value of TPFB is put to the optimum and profitable use.

1.2 Aim and objectives

The aim of this work was to investigate the decomposition characteristics of oil palm bunch using poultry droppings, cow dung and *Gliricidia sepium* as activators. The specific objectives of this research, therefore, are to:

- (a) determine the best concentration of activator among cow dung, poultry droppings and *Gliricidia sepium* for effective composting of threshed palm bunches;
- (b) Isolate and identify the bacteria and fungi associated with the composting;
- (c) determine the physico-chemical parameters, phytotoxicity and maturity of the end products of the composting mixes; and
- (d) carry out the agronomic evaluation of the matured compost in the greenhouse.

OBAFEMI AWOLowo UNIVERSITY