



UNIVERSITI PUTRA MALAYSIA

**THE EFFECT OF ZEOLITE AND PALM KERNEL CAKE (PKC)
ON FECAL AMMONIA PRODUCTION AND
HOUSE FLY POPULATION**

WIHANDOYO

FPV 2000 2

**THE EFFECT OF ZEOLITE AND PALM KERNEL CAKE (PKC)
ON FECAL AMMONIA PRODUCTION AND
HOUSE FLY POPULATION**

By

WIHANDOYO

**Thesis Submitted in Fulfilment of the Requirements for the
Degree of Doctor of Philosophy in the
Faculty of Veterinary Medicine
Universiti Putra Malaysia**

November 2000



DEDICATION

For my beloved:

Sri Banun
Catri Pratidina
Restra Pindyawara

I was reminded of my school:

SD Pati Wetan, SMP Negeri I Pati, SMA Negeri Pati,
Fapet Sekip Unit II, Fapet Karangmalang, Pasca Sarjana UGM,
Animal Science and Veterinary Medicine UPM



Abstract of the thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for Degree of Doctor of Philosophy

**THE EFFECT OF ZEOLITE AND PALM KERNEL CAKE (PKC)
ON FECAL AMMONIA PRODUCTION AND
HOUSE FLY POPULATION**

By

WIHANDOYO

November 2000

Chairman: Associate Profesor Kassim Hamid, Ph.D.

Faculty: Veterinary Medicine

Four experiments were conducted to evaluate the effect of zeolite and Palm Kernel Cake (PKC) on ammonia production and house fly *Musca domestica* L population.

In the first experiment, three periods of manure removal (every 30, 20 and 10 days or MR3, MR2 and MR1) with two cage densities (single and double birds or CD1 and CD2) were carried out. The low cage density and frequent manure removal decreased significantly ($P < 0.01$) the ammonia (NH_3) production by the feces and fly larvae population in the manure, but had no effect on layer performance.

In the second experiment, three levels of zeolite (0, 6 and 12% ZD) in the diet and three levels of zeolite spread directly on the manure (0, 6 and 12% ZS of total daily feed intake) were tested. Incorporation of high levels of zeolite in the diets and zeolite spread on the manure decreased significantly ($P < 0.01$) the fly larvae population, NH_3 production, water, pH, CP, Ca and P contents of manure.



Incorporation of high levels of zeolite in the diets affected the FCR, HDA and shell thickness, but did not influence chemical content of both egg albumen and yolk. Dietary zeolite also had no significant affect on tibial length, weight, Ca and P content.

In the third experiment, three levels of zeolite (0, 6 and 12%) and four levels of PKC (0, 12, 24 and 36%) were incorporated in the layer diets. Incorporation of high levels of PKC and zeolite decreased significantly ($P<0.01$) the fly larvae population, NH_3 production, fecal water content, and Ca, P and CP of the feces. Incorporation of high levels of PKC and zeolite significantly ($P<0.01$) increased FI, FCR HU, eggshell weight and thickness but decreased HDA. Crude protein and Ca of egg albumen and yolk contents increased in accordance with increasing levels of zeolite and PKC in the diets. The increasing levels of zeolite improved Ca but decreased the P content of egg shell, while the levels of PKC decreased shell Ca and P. Incorporation of high levels of PKC and zeolite in the layer diets increased the tibia and femur length but decreased tibial Ca and P contents. Increasing levels of PKC and zeolite in the layer diets increased Ca, P and cholesterol contents of blood plasma.

In the fourth experiment, three levels of zeolite (0, 1 and 2%) and three levels of PKC (0, 15 and 30%) were incorporated in the broiler diets. Incorporation of high levels of PKC and zeolite in the broiler diets reduced broiler performance (FI, body weight, carcass percentage and FCR). Increasing levels of zeolite significantly ($P<0.05$) decreased the cholesterol, Ca and P contents of blood plasma, Incorporation of high levels of PKC and zeolite were able to reduce NH_3 , number of fly larvae and water content of manure. Palm kernel cake and zeolite could be used as a poultry

feedstuff or a feed additive and zeolite was able to assist in reducing the ammonia production and house fly larvae population in the poultry feces.

Abstrak tesis yang dikemukakan kepada Senate Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Doktor Falsafah.

**PENGARUH PENGGUNAAN ZEOLITE DAN ISIRONG KELAPA SAWIT
(PKC) TERHADAP PENGELUARAN AMMONIA DAN POPULASI
LARVA LALAT RUMAH DI DALAM NAJIS AYAM**

Oleh

WIHANDOYO

November 2000

Pengerusi: Profesor Madya Kassim Hamid, Ph.D.

Fakulti: Perubatan Veterinar.

Tiga penyelidikan telah dijalankan keatas ayam penelur dan satu penyelidikan keatas ayam pedaging untuk menilai kesesuaian penggunaan isirong kelapa sawit (PKC) sebagai bahan makanan dan zeolite sebagai bahan tambahan untuk pengawalan pencemaran kimia dan biologi (pengeluaran ammonia dan pembiakan larva lalat rumah *Musca domestica* L) didalam najis ayam.

Di dalam penyelidikan pertama, tiga jadual pembuangan najis ayam, iaitu setiap 30, 20 dan 10 hari sekali (MR3, MR 2 dan MR1) dan dua kepadatan sangkar ayam penelur iaitu satu dan dua ekor setiap sangkar (CD1 dan CD2) telah dijalankan. Kepadatan rendah ayam dalam sangkar dan kekerapan pembuangan najis memberi kesan yang bererti ($P < 0.01$) dalam mengurangkan NH_3 dan larva lalat di dalam najis, tetapi tidak berkesan keatas pengeluaran ayam penelur (FC, HDA, FCR dan berat telur).

Pada kajian ke dua, telah di cuba tiga paras zeolite di dalam makanan (0, 6 dan 12%

ZD) dan tiga paras zeolite ditabur keatas najis (0, 6 dan 12% daripada jumlah makanan yang dimakan) telah dijalankan. Gabungan paras zeolite didalam makanan dan penaburan keatas najis mengurangkan dengan bererti ($P < 0.01$) keatas populasi larva lalat, NH_3 , kandungan air, pH, CP, Ca and P daripada najis. Gabungan paras zeolite yang tinggi didalam makanan menjejaskan FCR, HDA dan ketebalan kulit telur tanpa menjejaskan kandungan kimia di dalam putih dan kuning telur, juga keatas panjang, berat serta kandungan Ca dan P daripada tulang tibia.

Dalam kajian ketiga, tiga paras zeolite (0, 6 dan 12%) dan empat paras PKC (0, 12, 24 dan 36%) dicampurkan dalam makanan ayam penelur. Gabungan paras PKC dan zeolite didalam makanan mengurangkan dengan bererti ($P < 0.01$) keatas populasi ulat lalat, NH_3 , kandungan air, pH, CP, Ca and P daripada najis. Gabungan paras PKC dan zeolite didalam makanan meningkatkan dengan bererti ($P < 0.01$) keatas FI, FCR, HU, berat dan ketebalan kulit telur, tetapi mengurangkan HDA. Kandungan CP dan Ca didalam putih dan kuning telur meningkat mengikut peningkatan paras zeolite dan PKC didalam makanan. Paras zeolite memperbaiki kandungan Ca dan mengurangkan P daripada kulit telur, sedang paras PKC mengurangkan kandungan Ca dan P daripada kulit telur. Gabungan paras zeolite dan PKC didalam makanan memperbaiki panjang tulang tibia dan femur tetapi mengurangkan kandungan Ca dan P. Peningkatan paras PKC dan zeolite meningkatkan plasma Ca, P dan kolesterol.

Dalam kajian keempat, telah dicuba tiga paras zeolite (0, 1 dan 2%) dan tiga paras PKC (0, 15 dan 30%) didalam makanan ayam pedaging. Gabungan paras PKC dan

zeolite didalam makanan ayam pedaging telah mengurangkan dengan bererti ($P < 0.01$) prestasi ayam pedaging (FI, berat badan, % karkas dan FCR). Peningkatan paras zeolite didalam makanan telah mengurangkan dengan bererti ($P < 0.05$) keatas plasma kolesterol, Ca dan P, tetapi berlawanan dengan PKC. Gabungan paras PKC dan zeolite telah berjaya mengurangkan NH_3 , larva lalat dan kandungan air najis. Isirong kelapa sawit dan zeolite sebagai bahan makanan ayam atau sebagai bahan tambahan, dan zeolite juga mampu mengawal pengeluaran ammonia dan populasi larva lalat rumah didalam najis ayam.

ACKNOWLEDGEMENTS

The author wishes to express his profound and sincere appreciation to Associate Prof. Dr. Kassim Hamid, chairman of the supervisory committee and providing graduate assistantship from the Intensification of Research Priority Areas (IRPA) Program (Project No. 01-02-04-0226), also to Associate Prof. Dr. Abdul Razak Alimon and Dr. Ismail Idris, members of the supervisory committee, for their advises, guidance, support, encouragement and patience throughout the author's period of graduate studies and in the preparation of the thesis.

Deep appreciation is also due to the Dean, Faculty of Animal Science, GMU, to the Rector of Gadjah Mada University, Yogyakarta, Indonesia for allowing the author to pursue the study program smoothly, and also to the Dean, and of the staffs Faculty of Veterinary Medicine, Universiti Putra Malaysia for their valuable help in the pursuance of this degree in Malaysia.

I would like to express my appreciation to Mrs Aishah, Ms Rohana, Ms Rohani, Mr H Rahman, Mr Adnan, Mr Jayawiren and Mr Nathan, staffs of the Commercial Poultry Unit. Sincere appreciation and gratefulness are also extended to the the staffs of the Physiology Laboratory, Faculty of Veterinary Medicine and Department of Animal Science Laboratories for the facilities and technical support. Many thanks are in particular to Mr. Kufli Che Nor, Mr. Johari Ripin, Mrs. Zainab, Mrs Rosmawati and Mr Islahuddin, and also thanks to my post graduate friend Dr. Izzeldin Babiker Ismail from Sudan for his help in the conduct of the experiment.

Special thanks are due to my mother-in-law Sumirah and my brothers'



family Drs Yosef Riwukaho, Drs Agus, Drs Suharto, Drs Ono Baroto (alm) and Rusdi Hasan BA, for their moral, financial support and encouragement. Also the author shall always be indebted to his parents Soedjana (alm) and Sriyatoen, brothers and sisters.

Finally, the author is indebted to his lovely wife Sri Banun, daughter Castri Pratidina and son, Restra Pidyawara, for their patience, support and understanding.

TABLE OF CONTENTS

DEDICATION	ii	
ABSTRACT	iii	
ABSTRAK	vi	
ACKNOWLEDGEMENTS	ix	
APPROVAL SHEETS	xi	
DECLARATION FORM	xiii	
LIST OF TABLES	xvii	
LIST OF FIGURES.....	xx	
LIST OF ABBREVIATIONS	xxi	
 CHAPTER		
I	INTRODUCTION	1
	Objectives	5
II	LITERATURE REVIEW	6
	Poultry Farm Pollution	6
	Cage Density	9
	Chemical Pollutants	13
	Ammonia	13
	Effect of Ammonia on Poultry Production	16
	Biological Pollutants	19
	House Fly (<i>Musca domestica</i> L)	19
	House Fly on Poultry Farm	22
	Zeolite	23
	Zeolite as Feed Additive	26
	Zeolite to Control Manure Pollutant.....	29
	Palm Kernel Cake	31
	Utilization of PKC on Poultry Feeding	34
III	GENERAL MATERIALS AND METHODS	38
	Location of Experiment	38
	Experimental Animals	38
	Feeding Trial	39
	Egg Production and Quality	39
	Poultry Manure	41
	Femur and Tibia ..	42
	Analytical Method	42
	Moisture and Dry Matter of Manure.....	43
	Crude Fiber of Manure.....	43
	Crude Protein	44
	Calcium	45
	Phosphorous	46
	Fat of Yolk and Albumen.....	48



	Plasma Cholesterol	49
	Plasma Calcium.....	50
	Plasma Phosphorous	51
	Statistical Analysis	52
IV	EXPERIMENT I.....	54
	THE EFFECT OF CAGE DENSITIES OF MANURE REMOVAL FREQUENCIES AND ON AMMONIA PRODUCTION AND HOUSE FLY LARVAE POPU- LATION ON THE MANURE	
	Introduction	54
	Materials and Methods	56
	Animal and Treatments	56
	Data Collection	57
	Measuring Parameters	58
	Statistical Analysis	58
	Results	59
	Discussion	63
	Conclusion	65
V	EXPERIMENT II.....	67
	THE EFFECT OF ZEOLITE IN THE LAYER DIETS AND SPREADING ON TO MANURE ON AMMONIA PRODUCTION AND HOUSE FLY LARVAE POPU- LATION	
	Introduction	67
	Materials and Methods	70
	Animal and Treatments.....	70
	Diets	71
	Data Collection	72
	Measuring Parameters	73
	Statistical Analysis	73
	Results	74
	Discussion	79
	Conclusion	90
V	EXPERIMENT III.....	91
	THE EFFECT OF ZEOLITE AND PALM KERNEL CAKE (PKC) IN THE LAYER DIETS ON PRODUC- TION PERFORMANCE, MANURE AMMONIA AND HOUSE FLY LARVAE POPULATION	
	Introduction	91
	Materials and Methods	94



	Animal and Treatments	94
	Diets	95
	Data Collection	97
	Measuring Parameters	97
	Statistical Analysis	98
	Results	99
	Fecal Parameters.....	99
	Egg Production Performance	102
	Physical Characteristic of the Egg	103
	Chemical Parameters of the Egg	104
	Egg Albumen	104
	Egg Yolk	106
	Egg shell	108
	Tibia and Femur.....	110
	Blood Plasma Mineral	112
	Discussion	114
	Conclusion	131
VII	EXPERIMENT IV.....	133
	THE EFFECT OF ZEOLITE AND PALM KERNEL CAKE IN THE BROILER DIETS ON PERFOR MANCE AND MANURE CHARACTERISTICS	
	Introduction	133
	Materials and Methods	135
	Animal and Treatments	135
	Diets	135
	Data Collection	136
	Measuring Parameters	136
	Statistical Analysis	137
	Results	139
	Discussion	144
	Conclusion	149
VIII	GENERAL DISCUSSION	151
IX	CONCLUSION	168
	BIBLIOGRAPHY.....	170
	APPENDICES..	188
	BIODATA OF THE AUTHOR.....	193

LIST OF TABLES

Table	Page
1 Exposure Limit for Gasses and Dust in Livestock Houses	18
2 Chemical Compositions and Physical Performance of Zeolite	24
3 Typical Properties of Clinoptilolite and Zeolite A	25
4 Typical Analyses of Clinoptilolite and Zeolite A	25
5 Chemical Composition of Palm Kernel Cake	33
6 Treatments Lay-out of Cage Densities (CD) and Manure Removal (MR) Frequencies	57
7 The Effect of Cage Densities on Manure Production and Manure Removal Frequencies on Ammonia and Larvae Population.....	59
8 Average Dynamic Population of Adult Fly During First Experiment ..	60
9 The Effect of Cage Densities and Manure Removal Frequencies on Manure Condition	61
10 The Effect of Cage Densities and Manure Removal Frequencies on Layer Performance.....	62
11 Treatments Lay-out of Zeolite Levels in the Diets (ZD)) and Spreading (ZS) on to Manure	71
12 Composition and Calculated Analyses of Layer Diets of Second Experiment.....	72
13 The Effect of Zeolite Levels in the Diet and Spreading on to Feces on Ammonia and Fly Larvae in the Feces	74
14 Average Dynamic Population of Adult Flies.....	75
15 The Interaction Between Zeolite Levels in the Diets (ZD) and Spreading on to Feces (ZS) on Ammonia and Fly Larvae in the Feces	75
16 The Effect of Zeolite Levels in the Diets and Spreading on to Feces on Chemical Content of the Feces	76
17 The Interaction Between Zeolite Levels in the Diets (ZD) and Spreading on to Feces (ZS) on Chemical Content of the Feces	77
18 The Effect of Zeolite Levels in the Diet on Layer Performance	77
19 The Effect of Zeolite Levels in the Diet on Physical Egg Characteristic, Calcium and Phosphorous of Shell	78



20	The Effect of Zeolite Levels in the Diet on Chemical Composition of Egg Yolk	78
21	The Effect of Zeolite Levels in the Diet on Chemical Composition of Egg Albumen	79
22	The Effect of Zeolite Levels in the Diet on Physical Performance Calcium and Phosphorous Content Tibia	79
23	Treatment Lay-out of Zeolite (Z) and PKC Levels in the Layer Diets...	95
24	Composition and Calculated Analyses of the Layer Diets.....	96
25	The Effect of Zeolite and PKC Levels in the Layer Diets on Fecal Parameters	99
26	Average Dynamic Population of Adult Fly in this Experiment	100
27	The Effect of Zeolite and PKC Levels in the Layer Diets on Fecal Chemical Content	101
28	The Interaction Effect Between Zeolite and PKC Levels in the Layer Diets on Fecal Chemical Content	102
29	The Effect of Zeolite and PKC Levels in the Layer Diets on Production Performance	103
30	The Effect of Zeolite and PKC Levels in the Layer Diets on Egg Characteristic.....	104
31	The Effects of Different Levels of Zeolite and PKC in the Layer Diets on Chemical Content of Egg Albumen	105
32	The Interaction Effects Between Zeolite and PKC Levels in the Layer Diets on Chemical Content of Egg Albumen	106
33	The Effects of Different Levels of Zeolite and PKC in the Layer Diets on Chemical Content of Egg Yolk	107
34	The Interaction Effects Between Levels of Zeolite and PKC in the Layer Diets on Chemical Content of Egg Yolk	107
35	The Effect of Increasing Levels of Zeolite and PKC in the Layer Diets on Calcium and Phosphorous Content of Egg Shell	108
36	The Interaction Effects Between Levels of Zeolite and PKC in the Layer Diets on Calcium and Phosphorous Content of the Egg Shell	109
37	The Effect of Levels of Zeolite and PKC in the Layer Diets on Physical Performance (Length and Weight) of Tibia and Femur	110

38	The Effect of Zeolite and PKC Levels in the Layer Diets on Calcium and Phosphorous Content of Tibia and Femur	111
39	The Interaction Effects Between Levels of Zeolite and PKC in the Layer Diets on Calcium and Phosphorous Content of Tibia and Femur	112
40	The Effect of Zeolite and PKC Levels in the Layer Diets on Ca, P and Cholesterol of Blood Plasma	112
41	The Interaction Effects Between Different Levels of Zeolite and PKC in the Layer Diets on Blood Plasma Calcium Phosphorous Cholesterol	113
42	Treatment Lay-out of Zeolite and PKC Levels Broiler Diets	135
43	Composition and Calculated Analyses of the Broiler Diets	138
44	The Effect of Zeolite and PKC Levels in the Broiler Diets on Production Performance at 42 days	139
45	The Interaction Effects Between Zeolite and PKC Levels in the Broiler Diets on Production Performance at 42 days	140
46	The Effect of Levels of Zeolite and PKC in the Broiler Diets on Length and Weight of Tibia and Femur	141
47	The Effect of Levels Zeolite and PKC in the Broiler Diets on Plasma Blood Cholesterol, Calcium and Phosphorous	141
48	The Effect of Zeolite and PKC Levels in the Broiler Diets on Feces Condition	142
49	The Interaction Effects Between Zeolite and PKC Levels in the Broiler Diets on Fecal Condition	143
50	Weekly Dynamic Population of Adult Fly During Fourth Experiment ...	144

LIST OF FIGURES

Figure		Page
1.	Origin of the gases in animal house air.	13
2.	Aerobic decomposition of uric acid (simplified).....	14



LIST OF ABBREVIATION

ADF	Average Daily Feed intake
ADG	Average Daily Gain
AF	Aflatoxin
am	Ante meridian
ANOVA	Analysis of variance
AOAC	Association of Official Analysis of Chemistry
BW	Body Weight
°C	Celcius
Ca	Calcium
CD	Cage Density
CE	Cholesterol Esterase
CEC	Cation Exchange Capacity
CF	Crude fiber
ChOD	Cholesterol Oxidase
cm	Centimeter
CP	Crude Protein
DCP	Dicalcium Phosphate
FCR	Feed Conversion Ratio
FC	Feed Consumption
FI	Feed Intake
g	Gram
g/d/h	Gram/day/hen
HDA	Hen Day Average
HU	Haugh Unit
kg	Kilogram
l	Liter
M	Molar
meq/g	Milli-equivalents per gram
ml	Milliliter



mm	Millimeter
mmol/l	Millimolar per liter
NH ₃	Ammonia
nm	Nano meter
PKC	Palm Kernel Cake
PKM	Palm Kernel Meal
pm	Post meridian
ppm	Part per million
SAS	Statistic Analysis System
SSA	Synthetic Sodium Aluminoisilicate
SZ	Synthetic Zeolite
SZA	Sodium Zeolite A
TF	Tibia Femur
ZA	Zeolite A
μl	Micro liter

CHAPTER I

INTRODUCTION

The poultry industry in the Asia Pacific Region has achieved rapid growth of 10% per annum, producing 35% of the world's poultry meat and accounting for 40% of the egg consumption (Raghavan, 1997). Intensive poultry production in the next century will have to cope with the fact that as the world population continues to grow, land will become scarce and environmental cleanliness will become increasingly important. The development and form of the poultry industry reflect its objectives of providing eggs and poultry meat for human consumption. However, the poultry industry also has implications for the environment and for poultry welfare which may influence future changes (Appleby *et al.*, 1992).

The development of modern, intensive layer production has required efficient usage of land area, and battery cages have become the choice for raising higher stocking densities of layers, because the size of the cage is an economic factor and will affect layer performance. The concentration of birds at higher stocking density, will create considerable problems of manure disposal and spread of diseases between farms (Strauch, 1987). In modern layer production systems, poultry are housed in high densities with, especially in high-rise cage-layer houses or narrow caged-layer houses, consequently, accumulations of large amounts of manure beneath the cages resulting in physical, chemical and biological pollution (dust, odor and house flies *Musca domestica*, L. breeding). This could lead to public nuisance and protest if not handled judiciously.

Other environmental issues related to the poultry industry are dust, ammonia, odors and pathogen (Rinehart, 1996). Studies, particularly in the US, have indicated that the powdery dust typically found in poultry consists of particles of feathers, feed, manure and dust. Analysis of the dust in the exhaust air from poultry houses in the US shows it to contain about 60% crude protein, 11% ash, 9% fat, 3% cellulose, and 17% other carbohydrates (Gowan, 1972).

Odor, especially ammonia (NH_3), is one of the chemical pollutants from the poultry industry, resulting from microorganism activities in which uric acid and undigested protein are degraded. Montenegro (1996) stated that poultry produce manure containing uric acid, which is microbially converted to urea first before urea degradation and ammonia emission take place. Urea degradation, mainly taking place inside the animal houses, is catalyzed by the enzyme urease which is produced by microorganisms that are present in the feces. This means that these microorganisms will also be present on the floor in poultry houses (Ketelaars and Rap, 1994). The ammonia emission process is strongly influenced by the chemical and physical conditions of surfaces where there is contact with air (Elzing *et al.*, 1992).

House flies (*Musca domestica* L) have become a constant problem of biological pollution on intensive poultry farms. Lysyk and Axtell (1986) reported that there were three species of house flies common in poultry production systems that is *Musca domestica* L, *Fannia canicularis* L and *Ophyra spp* (*Ophyra aenescens* and *Ophyra leucostoma* which are difficult to distinguish). Presence of flies can occur because manure is an excellent medium for fly breeding. Moon and Meyer (1985) stated that house flies frequently deposit their eggs in batches with