

**ENVIRONMENT FRIENDLY DISPOSAL OF
POULTRY DROPPINGS BY ANAEROBIC
FERMENTATION AND RECYCLING AS
FEED INGREDIENT**

By

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THESIS SUBMITTED TO THE
ANDHRA PRADESH AGRICULTURAL UNIVERSITY
IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE OF
MASTER OF VETERINARY SCIENCE
IN THE FACULTY OF VETERINARY SCIENCE

DEPARTMENT OF POULTRY SCIENCE
COLLEGE OF VETERINARY SCIENCE
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NOVEMBER, 1996

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I, K.Madhu kumar, hereby declare that the thesis entitled **ENVIRONMENT FRIENDLY DISPOSAL OF POULTRY DROPPINGS BY ANAEROBIC FERMENTATION AND RECYCLING AS FEED INGREDIENT TO BROILERS** submitted to the Andhra Pradesh Agricultural Univeristy for the degree of MVSc is a result of the original research work done by me. I also declare that the thesis or part thereof has not been published earlier elsewhere in any manner.

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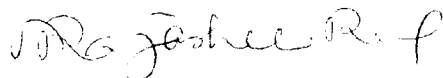

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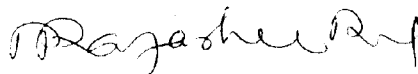
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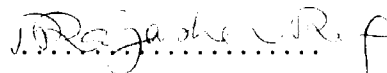
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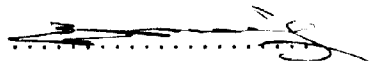
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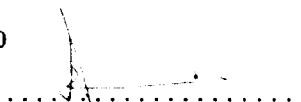
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ABBREVIATIONS

AME	Apparent metabolizable energy
b	bird
BW	body weight
Ca	Calcium
cft	cubic feet
cm	centimeter
d	day (s)
DM	dry matter
DPBS	dried poultry biogas slurry
DPM	dried poultry manure
DMRT	Duncan's multiple range test
FCR	feed conversion ratio
g	gram
GE	gross energy
ICU	International chick unit
IU	International unit
K	potassium
kcal	kilo calories
kg	kilogram
KVIC	Khadi village industries commission
m	metre
m ³	cubic meter
mcg	microgram (s)
ME	metabolizable energy
mg	milligram
mm	millimeter
NFE	nitrogen-free-extract
N	Nitrogen
P	Phosphorus
PD	Poultry droppings
SEM	standard error of mean
WL	White Leghorn
Wk	week
Wt	weight

ACKNOWLEDGEMENTS

I express my gratitude to the chairman of my advisory committee, Dr. A.Rajasheker Reddy, MVSc., Ph.D (Poultry Science), Assistant Professor, All India Coordinated Research Project on Poultry Breeding, Rajendranagar, Hyderabad for his guidance in conducting the research work and presentation of this thesis.

I am grateful to my Advisory Committee members Dr.Eshwaraiah, MVSc.,Ph.D.(Poultry Science) Associate Professor, Department of Poultry Science and Dr. A.Seshagiri Rao, MVSc., Ph.D (Microbiology), Department of Microbiology, College of Veterinary Science, Rajendranagar, Hyderabad for their guidance and help in carrying out research work.

I am highly indebted to Dr. V.Ravindra Reddy MVSc., Ph.D Professor and University Head, Department of Poultry Science, for providing research facilities and valuable suggestions.

I express my sincere thanks to Dr. K.C.Mohankumar, Ph.D, Associate Professor and then coordinator, Regional Biogas Training and Development Centre, APAU, Hyderabad for providing the biogas plant facilities.

I also express my thanks to Dr. A.Sreeramamurthy, Ph.D. Senior Scientist AICRP On Poultry Breeding for providing computer and laboratory facilities and to the Director, Project Directorate on Poultry (ICAR) for providing the laboratory facilities to carryout the ME estimation.

Thanks are also due to Dr. V.Ramasubba Reddy, Ph.D.(Poultry Science) Associate Professor, Department of Poultry Science and Dr.V.Ravindra Reddy, Farm Manager, AICRP on Poultry Breeding for their help in this study.

I acknowledge that a research paper from this thesis work has been presented (oral) and published in the World Poultry Congress 1996 held at New Delhi, India (WPC proceedings Vol II).

I wish to place on record my heartfelt regard to Dr.Ramarao, Dr.Nageswararao for their help which made my work to go smooth.

I express my love and affectionate gratitude to my parents Mr.Venkataramaiah and Vanajakshi, brother Narendranath and my cousins Radha and Sandhya, brother-in-laws Dr.Chandrababu and Sambasivarao and relatives.

My pleasant association with Srinivasa Prasad, Roopkumar, Seshiah, Y.P, Pradeep, Sreedhar, Sudhakar Rao, Dharmendra, Venu, Makkena, Rajasheker, Narendra, Swamy, Kishore, Chinni, Raviprakash Reddy, Murthy, Ravindra Reddy and George is memorable.

I wish to extend my thanks to all technical and non-technical staff of Dept.of Poultry Sci and AICRP Poultry Breeding for their timely help.

(K.Madhu kumar)

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Title of the thesis **ENVIRONMENT FRIENDLY DISPOSAL OF POULTRY
DROPPINGS BY ANAEROBIC FERMENTATION AND
RECYCLING AS FEED INGREDIENT TO BROILERS**
Degree to which
it is submitted: **Master of Science**
Faculty **Veterinary Science**
Department **Poultry Science**
Major advisor **Dr. A.Rajasheker Reddy**
University **Andhra Pradesh Agricultural University**
Year **1996**

ABSTRACT

Disposal of poultry droppings (PD) through anaerobic fermentation leading to biogas production, and the nutritive value and utilization of the resultant biogas slurry was studied in broilers. Economics of the biogas production and recycling of biogas slurry as a feed ingredient to broilers was examined

Floating drum (KVIC-Khadi village and industries commission) and fixed dome (Deenabandhu) model of biogas plants, each of 2 m³ capacity was used to generate biogas from poultry droppings. Poultry droppings about 35 kg were collected from cage housed cocks fed on layer mash, and a mixture of poultry droppings and water (1:2 w/v) was prepared daily to feed the biogas plants

The fermented effluent from biogas plants i.e., biogas slurry was sun dried. The dried poultry biogas slurry (DPBS) meal was analysed for proximate composition, calcium, phosphorus, aflatoxin and phytin phosphorus. Dry matter metabolizability,

apparent metabolizable energy(AME) was estimated *in vivo* in DPBS meal, PD and maize.

DPBS meal, was included in broiler diets at 100 and 200 g/kg replacing a mixture of groundnut extraction + saw-dust + dicalcium phosphate + calcite powder constituted to contain the same amount of protein, calcium and phosphorus as in DPBS meal. The performance of broilers (24 groups, 7 chicks/group) was studied on diets containing 0, 100 and 200 g/kg DPBS meal for 1-39 d age. The performance criterion was growth, feed intake, feed conversion ratio (FCR) and carcass yield.

PD yielded biogas in both the biogas plants. Floating drum model of plant yielded lower quantity of biogas and the slurry was more watery resulting in higher viscous digester contents than fixed dome model. Biogas slurry was free from offensive odour, insect breeding and fly menace.

DPBS meal contained 383 kcal AME, 125 g crude protein, 18.9 g ether extract, 219.6 g crude fibre, 475.3 g ash, 210 g acid insoluble ash, 66.8 g calcium and 23.1 g phosphorus per kg. The entire phosphorus content was non-phytin

DPBS meal was free from *Salmonella* sps, *E.coli* pathogens.

Body weight gain of broilers fed on reference, 100 and 200 g/kg DPBS meal were 1125, 1099 and 1057 g respectively. Only on 200 g/kg level of DPBS meal, growth depression was significant ($p > 0.05$) compared to reference. Feed intake was higher and FCR was poorer on DPBS meal diets than on reference diet.

The DPBS meal can be safely used upto 100 g/kg in broiler diets without depression in growth. The cost of broiler production on DPBS meal was similar to broilers reared on reference diet. Economic study revealed that PD can be processed to generate biogas and DPBS meal, and recycled to broilers thus making an environmental friendly disposal.

INTRODUCTION

CHAPTER 1

INTRODUCTION

Poultry industry is growing rapidly in our country. Poultry excreta is contributing to about 1 million tonnes per annum. Poultry excreta is available in the form of deep litter manure from floor reared birds and poultry droppings from cage reared birds.

Fresh poultry droppings contain about 70 % moisture and favour insect/fly breeding in the premises of poultry house. Also moisture accumulation in the poultry house leads to ammonia generation detrimental to health of the birds.

Poultry droppings is known to cause fly menace, obnoxious odour particularly during high humid weather conditions. Its disposal as manure for crops and fish ponds is known to create environmental problems such as increased soil nitrogen and phosphorus levels favouring acceleration of eutrophication process leading to drastic changes in plant and animal ecosystem.

There are reports that poultry droppings via anaerobic fermentation, yield biogas, biogas slurry of nutritional importance to animal feeding, improve sanitation, and reduces environmental pollution.

Poultry droppings are rich in calcium and phosphorus and also contain unidentified growth factors such as B-complex vitamins. Dried poultry excreta has been used in poultry diets to minimise the cost of feed. It is known that droppings contain undesirable micro organisms which may endanger the health of the birds and consumers safety.

This study is aimed on the influence of anaerobic fermentation in the process of recycling poultry droppings through biogas technology.

Objectives:

- To study the influence of anaerobic fermentation on poultry droppings to minimize environmental problems.
- To study the suitability of anaerobic fermented byproduct as a feed ingredient to broilers
- To evaluate economics involved in disposal of poultry droppings for biogas production and recycling to broilers.

REVIEW OF LITERATURE

CHAPTER 2

REVIEW OF LITERATURE

Poultry industry is growing rapidly in our country. There are about 89 million commercial layers and 275 million commercial broilers. India ranks sixth position in the world's egg production, producing 24,800 million eggs per annum. Andhra Pradesh ranks first, contributing to 6420 million eggs per annum (Indian Poultry Industry Year Book, 1994).

2.1 Poultry manure and its disposal

Poultry manure is available in the form of deep litter manure from floor reared birds and poultry droppings from cage reared birds. An adult laying hen voids 0.048 kg dry matter per day (Langar, 1994). Based on this, it is estimated that the present commercial layer stock of 89 millions can generate 1.6 million tonnes of poultry manure. Among this, cage droppings alone can contribute to nearly 1 million tonnes per annum. Poultry manure is disposed mainly as fertilizer to crops and to a lesser extent to fish ponds.

2.2 Poultry manure - a threat to environment

Fresh poultry droppings contain high moisture (60-70 %), pose fly menace, favours insect/fly breeding and often liberates ammonia in the poultry house detrimental to health of the bird. Poultry droppings generates obnoxious odour, and creates environmental pollution to humans as well.

Poultry droppings contain nitrogen (1.22 -1.63 %), phosphorus (0.89 - 2.04 %) and potassium (1.34 - 1.7 %)(Bishnoi and Bajwa, 1994), of which nitrogen and phosphorus are the main soil pollutants when poultry droppings are applied to crops as fertilizer. It also enriches the surface water with these pollutants and accelerates eutrophication (environment that favours plant life over animal life due to organic matter decomposition reducing dissolved oxygen levels in water) leading to imbalance in ecosystem (Roland *et al.*, 1993).

Poultry droppings (PD) can cause spread of diseases to human and animals particularly *Salmonella* sps, *E.coli* pathogens etc. (Aili *et al.*, 1990). PD when applied to fish ponds can cause increased mortality of fish particularly fingerlings due to organic matter decomposition which lowers the dissolved oxygen in water (Jiayu and Zhengfang, 1990).

2.3 Chemical composition and nutritive value of Poultry droppings

Composition of poultry droppings varies with the age, body weight, breed of birds, quality of feed given and the system of collection, processing and storage. Chemical composition and nutritive value of poultry droppings is shown in Table 1 and 2.

2.4 Biogas production

2.4.1 Mechanism of biogas production

Biogas production occurs in many natural ecosystems such as organic sediments of aquatic systems, marshes and soil, in the rumen and large intestine especially in herbivorous animals. It involves a complex mixture of anaerobic bacteria which convert up to 90 % of the combustible energy of the degradable organic matter to methane and carbondioxide (Fig. 1).

Figure 1: Anaerobic fermentation of organic solids

	<u>Stage -I</u> <u>(hydrolysis)</u>	<u>Stage-II</u> <u>(acidogenesis)</u>	<u>Stage -III</u> <u>(methane</u> <u>formation)</u>
Fats	Fat decomposing organisms		
Cellulose	Cellulose decomposing organisms	Acid bacteria	Methanogenic bacteria Methane + Carbondioxide
Proteins	Protein decomposing organisms		

Table 1 Chemical composition of poultry excreta from different sources (% on DM basis) (Langar ~~et al.~~, 1994)

	Broiler waste		Layer waste	
	Litter	Cage droppings	Litter	Cage droppings
Crude protein	28.1(24-31)	21.6 (20-23)	17.4(15-19)	24.8 (23-28)
True protein	15.8(15-17)	10.8 (10-12)	-	11.3
Crude fibre	20.4(16-24)	20.2 (17-28)	23.2(20-26)	19.2 (12-28)
Ether extract	3.3	1.44(1.21-1.66)	0.73	1.45(0.9-2.0)
NFE	29.5	33.9 (30-37)	38.0	33.8 (28-38)
Total ash	15.0	26.4 (21-29)	29.0(28-29)	23.7 (21-28)
ME (kcal/kg)	-	950-1350	-	-
Calcium	2.30	1.65	-	8.80
Phosphorus	1.70	1.45	-	2.50
Magnesium	0.48	0.66	-	0.67
Sodium	0.54	0.40	-	0.94
Potassium	2.04	1.40	-	2.33
Iron(ppm)	1414	3480	-	0.20
Copper(ppm)	267	20.5	-	150
Manganese(ppm)	286	245	-	406
Zinc(ppm)	275	47.5	-	463

Table 2. Amino acid composition of *dried poultry manure (g/kg)
(McNab et al.,1974)

<u>Amino acid</u>	<u>g/kg</u>	<u>Amino acid</u>	<u>g/kg</u>
Asparatic acid	9.7	Threonine	6.3
Serine	6.2	Glutamic acid	16.6
Glycine	6.6	Alanine	8.2
Valline	4.9	Methionine	1.2
Cystine	1.8	Leucine	7.0
<i>iso</i> -Leucine	3.8	Phenylalanine	3.9
Tyrosine	3.4	Histidine	3.0
Lysine	5.4	Arginine	6.1

*contained 54.9 g nitrogen, 112.1 g true protein, 88.4 g uric acid, 0.6 g urea per kg

2.4.2 Composition and properties of biogas

Biogas contains 55 - 65 % methane, 35 - 45 % carbondioxide, traces of hydrogen, hydrogen sulphide and ammonia (Majundar, 1982). Biogas is non poisonous. It has a calorific value of 4700 - 6000 kcal/m³, specific gravity of 0.86 (Bhattacharyya, ^{et al} 1993).

2.4.3 Factors affecting anaerobic fermentation

Anaerobic fermentation is governed by some parameters. These parameters as given by the Tata Energy Research Institute, 1985 are tabulated below

Parameter	Optimum anaerobic conditions for anaerobic fermentation
• Temperature	35 - 40°C
• pH	6.8 - 8.5; slurry acts as buffer
• C/N ratio	25 - 30
• Solid content	8 - 11 %
• Water content	90 % in input material Too high water - low gas production Too little water - acetic acid accumulation and interferes fermentation
• Toxic substances	High concentration of ammonia, antibiotics, pesticides, heavy metals like copper and zinc etc.,
• Relative time	80-90 % of biogas production is obtained within 3-4 wk period
• Organic loading rate	Dependent on digester volume

2.4.4 Advantages of anaerobic digestion

(National Academy of Sciences, 1977).

- Produces methane, and can be stored at room temperature
- Slurry has fertilizer value, used as soil conditioner
- Reduces organic content by 30-50 %
- Pathogens are destroyed or greatly reduced in number
- Rodents and flies are not attracted to the end product of the process
- Provides better sanitation for disposal of wastes
- Helps conserve local energy resources such as wood, electricity.

2.4.5 Biogas generating substrates

Most of the organic materials are potential inputs for biogas production. The commonly used materials are wastes like animal and human manure, agricultural wastes and crop residues, aquatic plants, industrial and municipal solid wastes etc.,

Among the animal excreta, cattle dung is commonly used. The constitution and biodegradability of the animal manure varies from animal to animal and the biogas yield from few substrates is mentioned below (Bhattacharyya *et al.*, 1993).

Substrate	Gas yield (m³) per kg of fresh manure
Cattle dung	0.04
Chicken manure	0.06
Pig manure	0.07
Horse manure	0.07

2.4.6 Biogas plants

Biogas plant is the physical installation where biogas is generated by anaerobic digestion of organic matter. Floating drum (KVIC) model, Deenabandhu model (Fig.2) are more popular and are given below (Tata Energy Research Institute, 1985).

Floating drum model: This plant is designed by the Khadi and village industries commission, India, popularly known as KVIC model based on a model originally designed by J.J Patel in 1951.

Floating drum model plant is a composite unit of digester and gas holder. The digester is an underground masonry tank. The gas holder is a balancing tank for receiving the gas produced in the digester. The gas holder also acts as a cover of the digester. The drum rises as the gas is collected in it. The inlet and outlet pipes are two slanting cement pipes reaching the bottom of the digester well on either side and have their opening on the surface in the inlet and outlet tanks. The mixing tank mixes the feed stock materials and water. A galvanised iron pipe is used to lead the gas to the point of use. This model generally runs on a continuous basis.

Fixed dome model (Deenabandhu): Fixed dome model of gas plant was designed by the UP state Planning Research Institute, Gobar gas Research station, Ajitmal, India in 1977.

The fixed dome model is a continuous fed one with an underground cylindrical digester and a hemispherical closed dome. The gas outlet is through a small piece of GI pipe fitted at the top of the dome. The heights of the opening of the inlet and outlet pipes from the floor of the digester are the same. An opening is provided in the outer wall of the outlet chamber for discharging the sludge.

2.4.7 Materials for construction of biogas plants

Materials required for construction of floating drum and fixed dome model of biogas plants are presented in Table 3.

2.5 Poultry droppings - recycling in feed

Limited feed and fodder resources in India have necessitated the development of alternate non-conventional feed resources, primarily agro-industrial byproduct wastes in livestock feed. One such waste is poultry litter or cage droppings which can be recycled as an ingredient in animal feed.

Poultry droppings (PD) has been used as a feed ingredient mainly for nitrogen, calcium and phosphorus content. In India, the current value of PD as a soil fertilizer is not more than Rs 1500 per lorry load about 10 tonnes. Considering the prevalent cost of poultry feed at Rs. 7000 per tonne, the value of processed PD as a feed ingredient would be more than its prevalent cost as fertilizer.

Poultry droppings is rich in nitrogen, organic matter and minerals (McNab *et al.*, 1974, Blair, 1974). Limitations for recycling PD in poultry rations are high ash, uric acid, crude fibre and low metabolizability content (Blair, 1974) and the presence of pathogenic organisms (Ichhponani and Lodhi, 1976).

Table 3. Materials for construction of floating drum and fixed dome model biogas plants

<u>Material</u>	<u>Quantity</u>
<u>Floating drum model biogas plant (2 m³)</u>	
Digester:	
1 Bricks	2060 Nos
2 Sand	1.75 m ³
3 Stone chips 0.5 - 0.75" size	0.60 m ³
4 Cement	11 bags
5 A.C pipes, 100 mm internal dia	3-4 RM
CG Frame:	
1 Angle iron	10.90 m (35x35x5 mm)
2 M.S pipe	1.95 m (40 mm dia)
3 Square plates	2 Nos (250x250x6 mm)
4 14 mm dia and 32 mm long bolts with nuts	16 Nos
Gas holder:	
1 Angle iron	16.8 m (35x35x5 mm)
2 M.S pipe	1.15 m (50 mm dia)
3 Flange plates	2 Nos (250 mm dia and 6 mm thick)
4 Flats (40x6 mm)	4.2 m
5 Gas outlet flange (25 mm dia)	1 No
6 GI bend (25 mm dia)	1 No
7 M.S sheet, 2.5 mm (12 gauge)	2.25 Nos (2.5 m x 1.0 m)
<u>Fixed dome model biogas plant (2 m³)</u>	
1 Bricks	1000 Nos
2 Cement	14 bags
3 Stone chips	40 cft (Approx 1.14 m ³)
4 Sand	40 cft (Approx 1.11 m ³)
5 Coarse sand	40 cft (Approx 1.14 m ³)
6 GI pipe of 0.5 dia with sockets	7" (17.78 cm)
7 A.C pipe 6 dia	6' (Approx 1.8 meters)
8 Iron bars (6 mm dia) for outlet tank cover	7 kg
9 Paint	1 L

McNab *et al.*, (1974) studied the use of commercial dried poultry manure (DPM) in layer diets. DPM nutritive value was examined using colostomised hens. Metabolizable energy content of DPM was 833 kcal/kg. The true digestibility of nutrients of DPM were 64.2 % for true protein, 69.5 % for fat, 91.2 % for uric acid, 25.5 % for total organic matter and 23.1 % for carbohydrates. Author concluded that the DPM contained nutrients of value to the laying hen and that it could be incorporated into poultry diets in which energy is of secondary importance and where use could be made of the calcium and phosphorous contents. The apparent digestibility of calcium and phosphorus ranged from 7.1 - 45.3 % and 7.5 - 46.2 % in layers.

Virk and Langar (1988) reported that caged poultry droppings serve as a source of minerals in broiler ration. For each 5 kg of PD added in a ration 0.5 kg mineral supplement was reduced.

Apart from aesthetics, a major constraint for recycling poultry droppings as feed is the apprehension of animal and human health risks likely to be caused due to the presence of pathogenic microorganisms, mycotoxins, pesticide residue, drugs or heavy metals.

Few reports are available that pathogenic microorganisms are present in poultry litter. Poultry litter was reported to contain *Clostridium perfringens*, *C1 chauvoei*, *C1 novel*; *Coliform* sps, *Salmonella* sps, *corynebacterium* sps (Alexander *et al.*, 1968; Toro and Mudgal, 1983).

The health risk attributed to pathogenic microorganisms isolated from the waste (*Coliform* sps; *E.coli*; *Klebsella* sps; *Listeria* sps and *Salmonella* sps) does not pose any problem if the waste is processed before feeding. Heat processing by direct dehydration, steam pelleting, deep stacking or ensiling at pH 4.5 are some of the methods which destroy these pathogens from poultry waste (Langar, 1994)

Information on the effect of processing of poultry droppings through biogas plant is scarce.

Toro and Mudgal (1983) subjected PD to dry heat, autoclaving. Dry heating at 135°C for 10 hours and 150°C for 4 hours were effective in completely sterilizing the litter. Autoclaving was not effective in eliminating all the microorganisms. *Clostridium* sp were destroyed at 135°C and above. Dry heat treatment resulted in loss of amino acids particularly lysine, methionine, histidine, threonine and cystine. The cost of processing of litter ranged from Rs.0.38 - 0.57 per kg for dry heat treatment.

Ahuja *et al.* (1983) studied the solid state fermentation technique by *Aspergillus niger* and *Rhizopus oriza* for the biodegradation of crude fibre and uric acid in the PD into protein rich mass to be incorporated in the poultry diets.

Roland *et al.* (1993) studied the recycling of PD by way of subjecting to lagoon formation in which the sediment recovered from a cement lined settling basin or secondary lagoon to which layer waste was initially discharged. Suspended material from the secondary lagoon was discharged to a large primary lagoon. Sediments were allowed to accumulate in secondary lagoon for 3 months before they are removed. The sediment was reported to contain 30 % Calcium, 0.86 % Phosphorus and 0.35 % magnesium. Use of lagoon sediment in layers resulted in better bioavailability of calcium and phosphorus leading to significant savings.

Teotia and Miller (1974) reported the use of fresh poultry manure for growing house fly (*Musca domestica*) pupae for making protein rich substance. The pupae meal grown on poultry manure contained 614 g protein and 2528 kcal ME per kg . The residual manure after separation of pupae meal from digester contained only 61.4 g protein and 600 kcal ME per kg on dry matter basis.

Not much work has been done to make poultry litter pollution free and recycle in an effective way. Experiments on disposal of Poultry droppings conducted at Andhra Pradesh Agricultural University revealed that PD can replace conventional cow dung for generating biogas (Rajasheker and Mohankumar, 1994).

Experiments have been conducted in China on utilization of Poultry droppings for biogas production through anaerobic fermentation. The spent slurry from this process did not contain pathogenic organisms and was efficiently used in fish rearing (Jiayu and Zhengfang, 1990). No work has been reported on the utilization of biogas slurry to poultry

MATERIALS AND METHODS

CHAPTER 3

MATERIALS AND METHODS

3.1 Disposal of poultry droppings by anaerobic fermentation through biogas plants

Influence of anaerobic fermentation on poultry droppings to minimize the environmental problems were studied by utilizing conventional biogas plants available at Regional biogas training and development centre, Andhra Pradesh Agricultural University campus, Hyderabad.

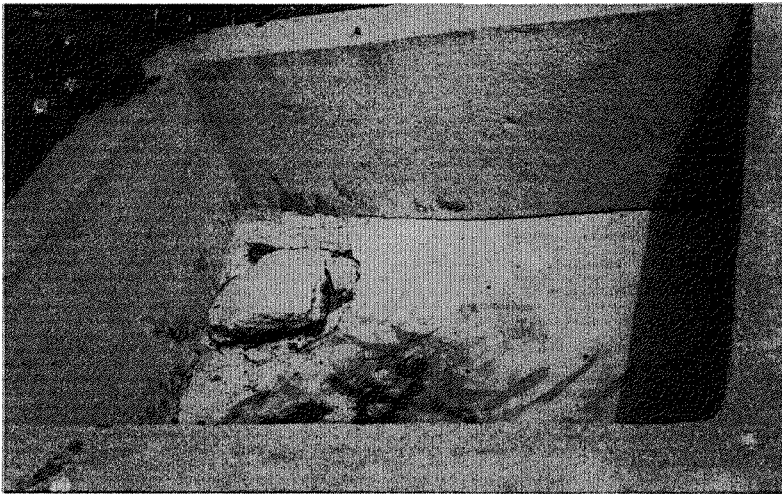
3.1.1 Biogas plants

Floating drum (KVIC) and fixed dome (Deenabandhu) model biogas plants (Fig.2) each of 2 m³ capacity were utilized for studying the suitability of caged birds poultry droppings for the production of biogas.

Fresh poultry droppings about 35 kg were collected daily from caged birds (WL cocks) fed on layer mash at All India coordinated Research Project on Poultry breeding centre, Rajendranagar, Hyderabad and placed in mixing tank of each of the biogas plant. A mixture of poultry droppings and water (1:2 w/v)



FLOATING DRUM (KVIC) MODEL



FIXED DOME (DEENABANDHU) MODEL

FIG. 2. BIOGAS PLANTS

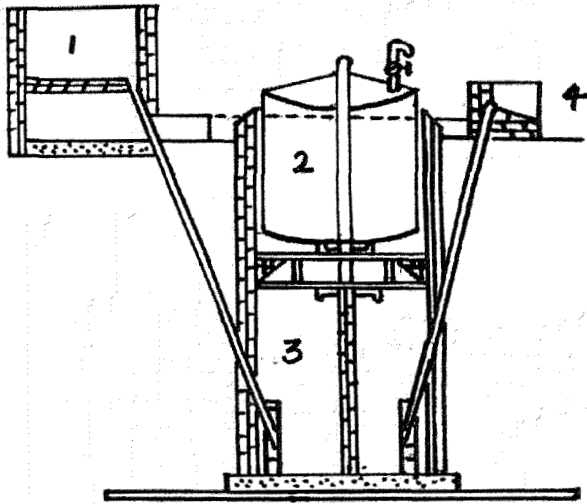
was prepared daily and allowed to settle for 15 minutes. Feathers and extraneous matter were removed from the mixture before feeding to the biogas plants (Fig. 3). The cattle dung, earlier used as regular feed material for these two plants was gradually replaced with poultry droppings in about 50 days for establishing poultry droppings based biogas plants.

3.1.2 Biogas plant slurry

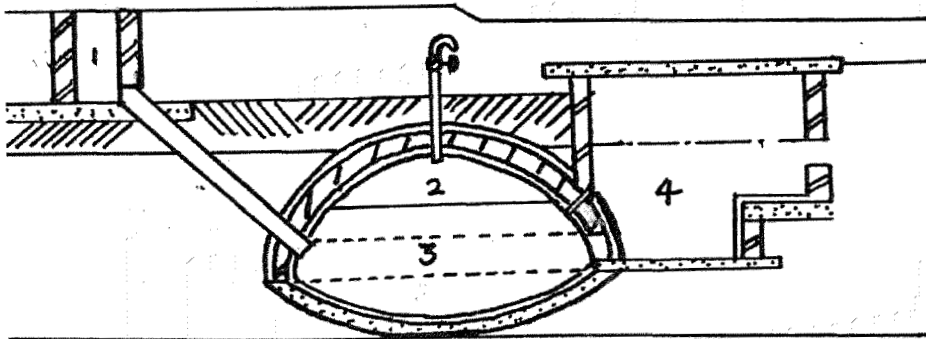
The slurry from both the biogas plants was collected combinedly in an open pit (about 3' x 4') and dried under natural conditions. The partially dried material was scooped out from the pit and allowed to sun dry. The dried poultry biogas slurry (DPBS) meal (Fig.4) was stored in gunny bags for further experimental use.

3.2 Suitability of anaerobic fermented byproduct as a feed ingredient to broilers

The dried poultry biogas slurry (DPBS) meal collected from both the biogas plants was examined for suitability as feed ingredient through *in vitro* and *in vivo* studies



FLOATING DRUM MODEL (KVIC)



FIXED DOME MODEL (DEENA BANDHU)

ing tank, 2. Gas storage, 3. Digester, 4. Outlet tank.

Fig.3. DESIGN OF BIOGAS PLANTS.

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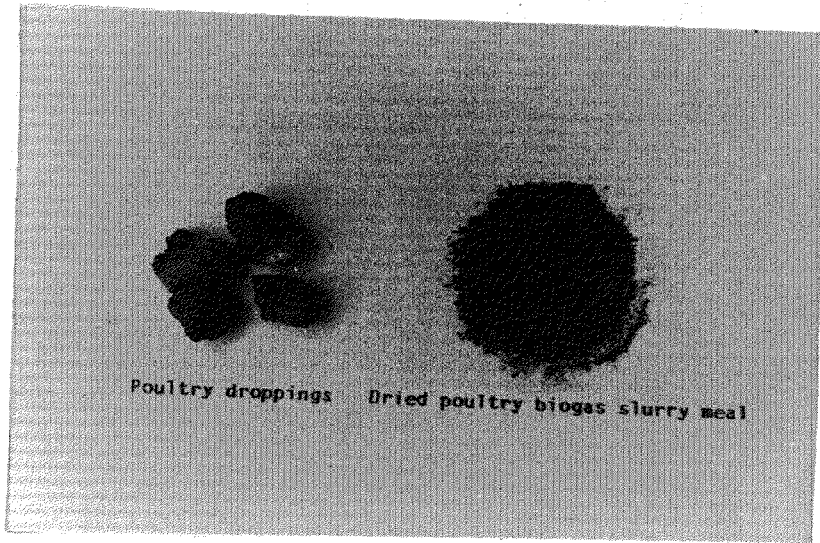


FIG.4. POULTRY DROPPINGS &
DRIED POULTRY BIOGAS SLURRY(DPBS) MEAL

3.2.1 Chemical analysis and nutritive value of dried poultry biogas slurry meal

The dried poultry biogas slurry (DPBS) meal and poultry droppings (PD) were sampled from the main collections and analysed in triplicate for proximate composition, calcium, phosphorus (AOAC, 1990), aflatoxins (Pons *et al.*, 1966) and phytin phosphorus (Haug and Lantzsich, 1983).

Metabolizable energy was estimated in DPBS meal, PD and yellow maize by modified European reference method (Bourdillon *et al.*, 1990) using WL cocks (5 replications per test ingredient). The assay period for estimation of ME of each diet (Table 4) comprised of 3 different phases. In the first phase, the birds were on *ad libitum* feed for 3 days to measure the exact quantity of feed consumed per day by each cockerel. In the second phase the birds were fed 80 % *ad libitum* for 2 days and proportionate quantity for 7 hours for acclimatization. The acclimatization period was followed by the fasting period of 17 hours (4.00 PM to 9.00 AM). In the third phase, the diet under test was fed at 80 % *ad libitum* for 3 days and 7 hours on the fourth day, followed by a fast for 17 hours (4.00 PM to 9.00 AM). The details of experimental schedule are depicted in figure 5.

Table 4 Ingredient composition (%) of diets fed to WL cockerels for dry matter metabolizability and apparent metabolizable energy measurement

Ingredient	Maize (g/kg)	Dried poultry biogas slurry meal (g/kg)	Poultry droppings (g/kg)
Maize	955	594	594
Dried poultry biogas slurry meal	-	400	-
Poultry droppings	-	-	400
Dicalcium phosphate	18.6	-	-
Calcite powder	20.4	-	-
Common salt	4	4	4
*Trace mineral mixture	1.5	1.5	1.5
**Vitamin mixture	0.5	0.5	0.5

*Trace mineral mixture provided (mg/kg diet): Manganese, 79; Iron, 38; Zinc, 57; Copper, 4; Iodine, 0.99; Selenium, 0.08

**Vitamin mixture provided (mg/kg diet): retinol acetate, 4.23; riboflavin, 6; cholecalciferol, 0.045; cyanacobalamin, 0.02; dl- α tocopheryl acetate, 20; thiamine hydrochloride, 1; menadione sodium bisulphite, 0.5; biotin, 0.15; calcium pantothenate, 15; pyridoxine hydrochloride, 3; niacin, 40 and folic acid, 0.5.

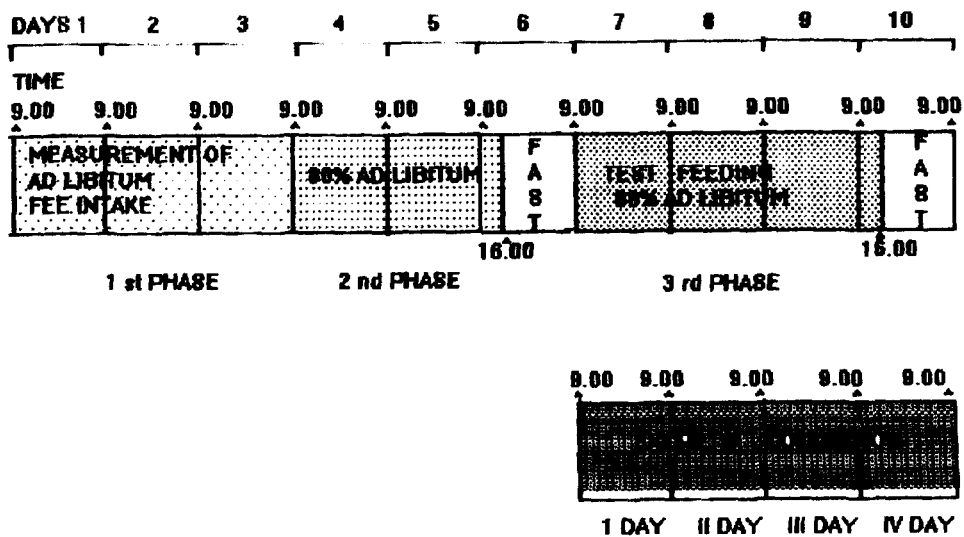


FIG. 5. SCHEMATIC PRESENTATION OF THE MODIFIED EUROPEAN REFERENCE PROCEDURE FOR DETERMINATION OF APPARENT METABOLIZABLE ENERGY (AME) IN COCKERELS

Excreta collection:

The excreta free from feathers was collected quantitatively on respective subsequent days of feeding. The excreta was dried in hot air oven at a temperature of 80° C for 20 hours (Farrell, 1978). The dried excreta was equilibrated with atmospheric moisture, weighed and stored in clean air tight plastic containers for further analysis.

Dry matter, GE of feed and excreta were determined in duplicate. The GE was estimated using adiabatic oxygen bomb calorimeter.

Calculations:

$$\text{Dry matter metabolizability(\%)} = \left[\frac{\text{DM intake (g)} - \text{DM excreta (g)}}{\text{DM intake (g)}} \right] \times 100$$

The classical apparent metabolizable (AME) energy values of diets were obtained by the equation of Hill and Anderson (1958) as suggested in European reference method.

$$\text{Apparent metabolizable energy(AME) per g dietary DM} = E_{\text{diet}} - E_{\text{excreta}}$$

Where $E_{\text{diet}} = \text{GE per g dietary DM}$

$E_{\text{excreta}} = \text{GE in excreta per g DM}$

AME values for test ingredients (maize, DPBS meal, PD) were calculated based on the proportion of individual ingredients in their respective diets.

$$\text{AME of Maize} = \text{AME of maize diet} / 0.955$$

$$\text{AME of DPBS meal} = [\text{AME of DPBS meal diet} - (0.594 \times \text{AME of maize})] / 0.4$$

$$\text{AME of PD} = [\text{AME of PD diet} - (0.594 \times \text{AME of maize})] / 0.4$$

3.2.2 Utilization of dried poultry biogas slurry(DPBS) meal in broiler diets

Dried poultry biogas slurry meal was included in broiler diets at varying levels to study the feasibility of recycling poultry droppings as feed ingredient to broilers

Diets: Groundnut extraction, having a protein content of 446 g/kg on a dry matter basis was included in the reference diet at 56 g/kg. DPBS meal with protein content of 125 g/kg on DM basis was incorporated in broiler diets at 0, 100 and 200 g/kg to replace 0 %, 50% and 100 % protein of groundnut meal of reference diet. Calcium and phosphorus levels were made equal in all the diets by inclusion of appropriate levels of dicalcium phosphate and calcite powder (Table 5). Each diet was fed to 8 groups (7 chicks/group) of broiler males from 1 - 39 d age.

Table 5 Composition of diets varying in the proportions of dried poultry biogas slurry meal fed to broiler males (1-39 d age)

Ingredient	Dried poultry biogas slurry meal (g/kg)		
	0(Reference)	100	200
Diet premix ¹	800	800	800
Groundnut meal extraction	56.0	28.0	-
Dicalcium phosphate	25.0	12.5	-
Calcite powder	22.2	11.1	-
Dried poultry biogas slurry meal	-	100	200
Saw-dust	96.8	48.4	-
<u>Nutrient composition (dry basis)</u>			
Crude protein (g/kg)	212.60	212.43	212.39
Crude fibre (g/kg)	99.39	85.4	76.6
Metabolizable energy (kcal/kg)	2580	2545	2510
Calcium (g/kg)	16.89	16.85	16.79
Available phosphorus (g/kg) ²	5.50	5.67	5.82
Lysine (g/kg) ²	10.98	10.54	10.10
Methionine (g/kg) ²	5.84	5.67	5.50

¹Diet premix (g/800g) contained: Yellow maize, 489.5; soybean meal, 300; l-lysine, 0.7; dl-methionine, 2.3; salt, 4; coxistac, 1; choline chloride, 1; vitamin B12 premix (100 ppm), 0.2; vitamin E (50%), 0.02; trace mineral mixture*, 1 and vitamin mixture**, 0.28.

*Trace mineral mixture provided (mg/kg diet): Manganese, 79; Iron, 38; Zinc, 57; Copper, 4; Iodine, 0.99; Selenium, 0.08.

**Vitamin mixture provided (mg/kg diet): retinol acetate, 4.23; riboflavin, 6; cholecalciferol, 0.045; cyanacobalamin, 0.02; dl- α tocopheryl acetate, 20; thiamine hydrochloride, 1; menadione sodium bisulphite, 0.5; biotin, 0.15; calcium pantothenate, 15; pyridoxine hydrochloride, 3; niacine, 40 and folic acid, 0.5.

²Calculated values.

Bird management:

Broilers were reared on wire floor battery brooders. Feed and water were provided *ad libitum*. Broilers were vaccinated against Marek's disease, Newcastle disease and Infectious bursal disease on one, seven and fourteen days age respectively.

Parameters recorded:

During the experiment, weekly body weights on individual birds and group feed intake were recorded. At 39 d age two broilers per group were killed and the dressing yields were recorded. Lengths of duodenum, jejunum plus ileum and caecum were recorded and expressed on m/kg body weight and weights of gizzard and liver were also recorded and expressed on g/kg body weight.

3.3 Microbiological assay

Microbiological assay was conducted on both poultry droppings and dried poultry biogas slurry meal for the presence of pathogenic microorganisms such as *Salmonella* sps and *E.coli*.

3.3.1 Qualitative test for the presence of *Salmonella* sps

Test material about 10 g was soaked in a sterile normal saline, while mixing thoroughly and allowed to settle for 15 minutes at room temperature. Sample was inoculated in tetrathionate broth at 10% level. Incubated at 37°C for 24 hours and subcultured on MacConkey agar, brilliant green agar and Salmonella-Shigella agar. Non-lactate fermented colonies were picked up to examine its morphology by Gram stain and other biochemical properties (Cruickshank *et al.*, 1974).

3.3.2 Qualitative test for the presence of *E. coli*

Test material about 10 g was soaked in a sterile normal saline while mixing thoroughly and allowed to settle for about 10 minutes at room temperature. Sample was inoculated on MacConkey agar. Pink colonies were picked from MacConkey agar and subcultured on EMB agar. Presence of colonies with blackish metallic sheen on EMB agar was considered as characteristic of *E. coli*.

3.4 Economics in disposal of poultry droppings for biogas, and recycling as feed ingredient to broilers.

3.4.1 Input and output costs in disposal of poultry droppings through biogas plant

Input and out put costs involving the integrated approach of disposal of poultry droppings was estimated. The following norms were used for working out the economics:

- Capacity of the Biogas plants/d 2 m³
- Capital cost (construction cost) Rs. 8000
- Rate of interest 18 %
- Life of the Unit 10 years
- Working days 365 days
- Poultry droppings required
for plant/annum 12775 kg
(fresh PD about 35 kg/day for 365 days)
- Contingency for handling PD per annum Rs.1800
- Biogas production per kg fresh PD/d 0.06 m³
- Monetary value of biogas, 767 m³ Rs.1900
(Sufficient for 4-6 family members
cooking needs per year)
- Monetary value of fermented byproduct
dried poultry biogas slurry meal Rs.2.00/kg

3.4.2 Estimation of cost of production of broiler fed on diets containing dried poultry biogas slurry (DPBS) meal

Economics were calculated at the end of broiler feeding experiment, 1-39 d age.

Cost of production of broilers on diets containing DPBS meal was calculated based on the feed cost and FCR and compared to that of reference diet containing no DPBS meal.

Feed cost per kg was calculated based on the local market prices of feed ingredients. The cost of DPBS meal was kept at minimum of Rs 2.00/kg based on its value of calcium and phosphorus contents.

3.5 Statistical analysis

The experimental results were subjected to analysis of variance, and the differences between the treatment means were compared with DMRT (Duncan, 1955). Regression analysis was done. Regression equations were fitted to the data and also given in the tables and graphs where significant effects were detected (Snedecor and Cochran, 1967).

RESULTS

CHAPTER 4

RESULTS

Investigations were carried out to dispose poultry droppings, in an environmental friendly manner through anaerobic fermentation for the production of biogas, recycling the residue as a feed ingredient to broilers and also economics involved in such an integration. Results obtained on these aspects are presented in this chapter.

4.1 Biogas production

Poultry droppings as regular input material to floating drum and fixed dome model biogas plants of 2 m³ capacity yielded biogas after a period of 40 days.

During the first 30 days period, intolerable odour was noticed at each time of discharge of spent slurry. After 40 days period, no obnoxious odour and no fly menace/insect breeding was observed in the discharged biogas slurry from the biogas plants. The concentration of the solids in the digester tank ranged from 8 - 11 %.

Problems of biogas production:

In only floating drum model of biogas plant, the biogas production receded slowly in about 60 days. More discharge of water was observed from the digester tank, leading to more viscous digester contents. Scum formation in the digester tank was seen extending up to the neck of the mixer tank of the biogas plant.

The problem of poor biogas production was overcome by the fixed dome model biogas plant, in which the exertion of downward thrust of gas on the digester fluid lead to expulsion of slurry through outlet. The operation being a continuous process, there was little or no increase of per cent of suspended solids in the digester tank of fixed dome model plant.

4.2 Chemical composition and nutritive value of dried poultry biogas slurry meal

Dried poultry biogas slurry meal was powdery, light in weight and black in colour. The chemical composition and nutritive value of DPBS meal and PD was given in Table 6.

Table 6. Chemical composition and nutritive value of dried poultry biogas slurry meal and poultry droppings (on DM basis)

	Dried poultry biogas slurry meal	Poultry droppings
Dry matter (g/kg)	916	935
Crude protein (g/kg)	125	257
Ether extract (g/kg)	18.9	25.0
Crude fibre (g/kg)	219.6	152
Ash (g/kg)	475.3	254
Nitrogen-free-extract (g/kg)	161.2	312
Calcium (g/kg)	66.8	67.2
Phosphorus (g/kg)	23.1	25.3
Metabolizable energy (kcal/kg)	383	1661

The DPBS meal contained 916 g dry matter, 125 g crude protein, 18.9 g ether extract, 219.6 g crude fibre, 475.3 g ash, 161.2 g nitrogen-free-extract, 66.8 g calcium, and 23.1 g phosphorus while PD contained 935 g dry matter, 257 g crude protein, 25 g ether extract, 152 g crude fibre, 254 g ash, 312 g nitrogen-free-extract, 67.2 g calcium and 25.3 g phosphorus per kg meal. DPBS meal contained 210 g acid insoluble ash per kg meal.

Dietary dry matter intake and output, ratio of dry matter output to intake and percent dry matter metabolizability values of DPBS meal, PD and maize are presented in Table 7. Dry matter metabolizability of DPBS meal, PD and maize were 62.8 %, 75.7 % and 84.2 % respectively.

Apparent metabolizable energy content of DPBS meal, PD and maize were 383 kcal, 1661 kcal and 3826 kcal per kg respectively (Table 8)

4.3 Performance of broilers on dried poultry biogas slurry(DPBS)meal

Performance of broiler males on varying levels of DPBS meal is presented in Table 9.

Inclusion of DPBS meal at the expense of groundnut extraction has significantly ($p < 0.05$) lowered the body weight gain of broilers only at 200 g/kg level. However, at 100 g/kg

Table 7. Dietary drymatter intake and output, ratio of dry matter output to intake and per cent dry matter metabolizability of maize, dried poultry biogas slurry meal and poultry droppings

R	Ad Lib	Feed	DM	DM	DM	Ratio of	DM
e	feed	allowance		intake	output	DM	metaboli
p	intake/	at 80%			in	output	zability
l	l day	ad lib			excreta	to DM	
i	(g)	(g)	(%)	(g)	(g)	intake	(%)
Maize							
• 86	275.2		91.05	241.7	37.706	0.156	84.4
• 102	326.4			281.4	47.460	0.169	83.1
• 102	326.4			280.9	42.867	0.153	84.7
• 90	288.0			258.0	41.276	0.160	84.0
• 106	339.2			273.7	42.243	0.154	84.6
\bar{X} 97.2	311.0			267.1	42.310	0.158	84.2
Dried poultry biogas slurry meal							
• 112	358.4		92.23	325.4	126.725	0.389	61.1
• 80	256.0			237.0	89.676	0.378	62.2
• 94	300.8			259.8	95.133	0.366	63.4
• 90	288.0			237.0	82.584	0.348	65.2
• 86	275.2			257.4	97.352	0.378	62.2
\bar{X} 92.4	295.7			263.3	98.294	0.372	62.8
Poultry droppings							
• 70	224.0		91.29	195.0	43.494	0.223	77.7
• 98	313.6			263.6	67.546	0.256	74.4
• 96	307.2			269.2	63.064	0.234	76.6
• 70	224.0			208.0	52.862	0.254	74.6
• 104	332.8			309.8	76.619	0.247	75.3
\bar{X} 87.6	280.3			249.1	60.717	0.243	75.7

Table 8. Apparent metabolizable energy (AME) values of maize, dried poultry biogas slurry meal and poultry droppings (on DMbasis)

Rep	GE in diet (E-diet) (kcal/g)	GE in excreta (kcal/g)	DM output in excreta (g)	GE output in excreta (kcal)	DM intake (g)	GE in excreta /g DM intake (E excreta) (kcal)	AME of diet (E diet-E excreta) (kcal/g)	AME of ingredient (kcal/g)
Maize								
•	4.171	3.383	37.706	127.559	241.7	0.527	3.644	3.815
•		2.930	47.460	139.056	281.4	0.494	3.677	3.850
•		3.368	42.867	144.375	280.9	0.514	3.657	3.829
•		3.267	41.276	134.847	258.0	0.522	3.649	3.821
•		3.433	42.241	145.019	273.7	0.529	3.642	3.813
\bar{X}		3.276	42.310	138.171	267.1	0.517	3.654	3.826
Dried poultry biogas slurry meal								
•	3.388	2.489	126.725	315.149	325.4	0.969	2.420	0.368
•		2.558	89.676	229.392	237.0	0.968	2.420	0.368
•		2.640	95.133	251.152	259.8	0.987	2.420	0.368
•		2.736	82.584	225.950	237.0	0.953	2.435	0.406
•		2.521	97.352	245.426	257.4	0.953	2.435	0.406
\bar{X}		2.589	98.294	253.414	263.3	0.962	2.426	0.383
Poultry droppings								
•	3.707	3.504	43.494	152.404	195.0	0.782	2.926	1.633
•		3.173	67.546	214.324	263.6	0.813	2.894	1.553
•		3.226	63.064	203.443	269.2	0.756	2.951	1.696
•		2.982	52.862	157.632	208.0	0.758	2.949	1.691
•		3.002	76.619	230.009	309.8	0.742	2.965	1.731
\bar{X}		3.177	60.717	191.562	249.1	0.770	2.937	1.661

Table 9. Performance of broiler males (1-39 d age) on dried poultry biogas slurry meal

Dried poultry biogas slurry meal (g/kg)	Body weight gain (g/bird)	Feed intake (g/bird)	Feed efficiency (feed/gain)	Dressed yield (%)
0	1125 ^a	2013 ^c	1.790 ^b	64.6 ^a
100	1099 ^a	2119 ^a	1.930 ^a	65.7 ^a
200	1057 ^b	2066 ^b	1.954 ^a	64.7 ^a
SEM	10.6	13.3	0.0183	0.63
Analysis of variance				
df				
level	2	2	2	2
error	21	21	21	45
MSS				
level	9330.125	22419.042	0.063	6.325
error	842.369	1405.089	0.0026921	6.357
DMRT	30.18	38.98	0.0539	1.795
Regression analysis				
Regression	1127- 0.3388x	2040+0.2644 x	1.809+0.00082 x	
Standard errors				
Intercept	28.5957	53.5817	0.0583	
Slope	0.0715	0.4590	0.000145	
R value	0.5051	0.1504	0.5902	
p value	0.0001	0.06111	0.000001	
residual df	22	22	22	

SEM= standard error of mean
Means with different superscripts in the column differ significantly (p<0.05).

inclusion level, body weight gain was statistically comparable to the reference group (1099 g vs 1125 g)

Body weight gain was ($p = 0.0001$) linearly related with the dietary DPBS meal ($1127 - 0.3388x$ where x is the level of DPBS meal g/kg). Regression curve fit on body weight gain is presented graphically (Fig. 6)

Feed intake of broilers increased (2013 vs 2119 and 2066 g) and consequently, the feed efficiency decreased (1.790 vs 1.930 and 1.954) with the increased concentration of dietary DPBS meal. The feed intake ($p = 0.06111$) and feed efficiency ($p = 0.000001$) were linearly related with dietary DPBS meal (Table 9). Regression curve fits on feed intake and feed efficiency are presented graphically (Fig. 7 and 8). DPBS meal feeding to broilers did not influence the dressed yields.

Influence of DPBS meal on intestinal segments and visceral organs of broiler males (1-39 d age) is presented in Table 10.

DPBS meal inclusion in broiler diets did not influence the lengths of duodenum and jejunum plus ileum of broilers. Caecum length was significantly ($p < 0.05$) lowered in broilers on 100 g/kg level of DPBS meal. Gizzard and liver weights were not influenced by the level of DPBS meal.

FIG. 8. BODY WEIGHT GAIN OF BROILERS ON DRIED POULTRY
BIOGAS SLURRY (DPBS) MEAL

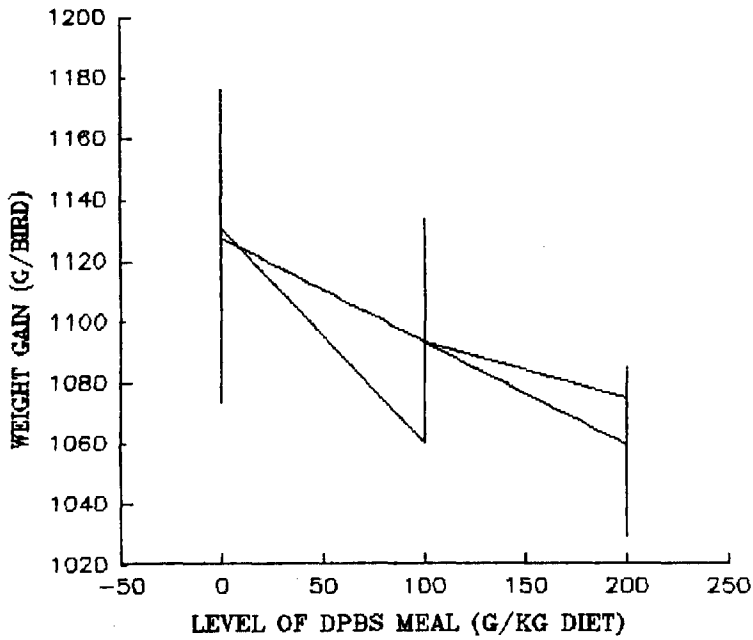


FIG. 7. FEED INTAKE OF BROILERS ON DRIED POULTRY BIOGAS SLURRY (DPBS) MEAL

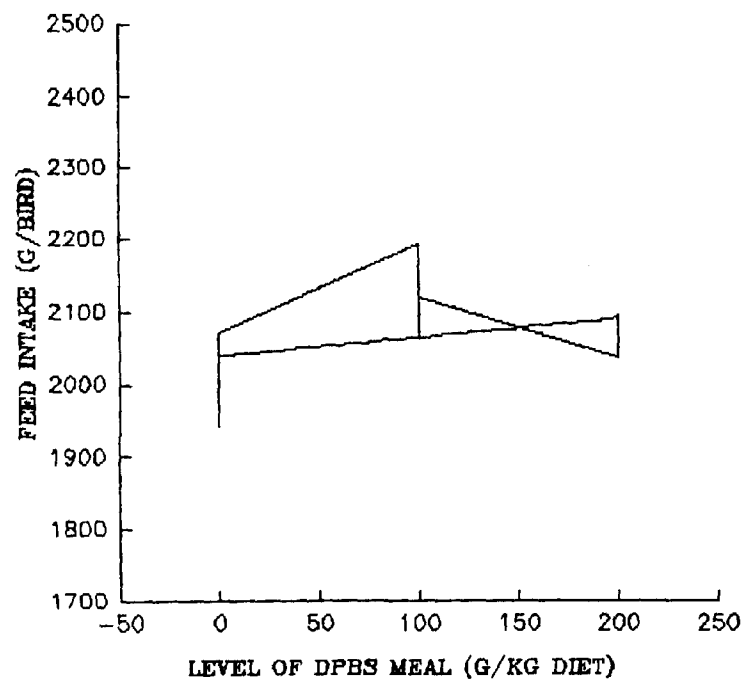


FIG.8. FEED EFFICIENCY (FEED/GAIN) OF BROILERS ON DRIED
POULTRY BIOGAS SLURRY (DPBS) MEAL

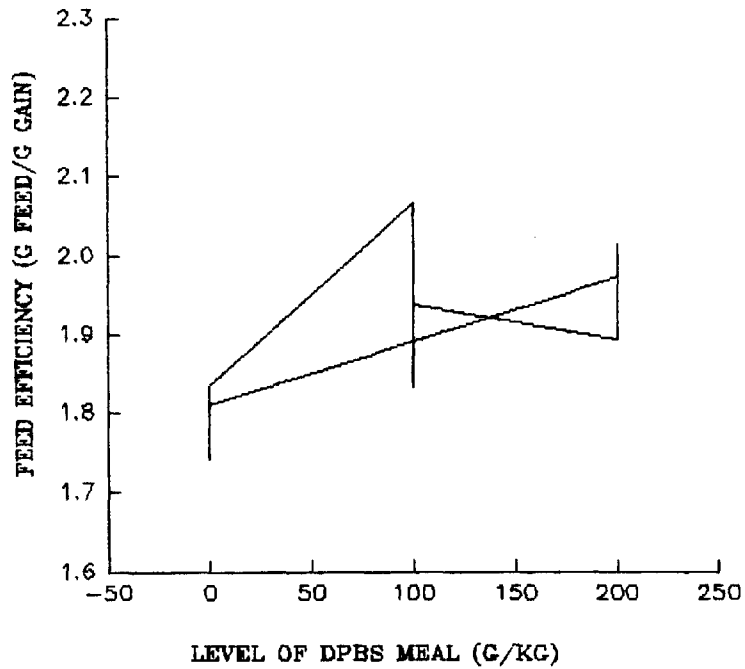


Table 10. Influence of dried poultry biogas slurry (DPBS) meal on lengths of intestinal segments and visceral organ weights of broilers (1-39 d age)

DPBS meal (g/kg)	Duodenum length (m/kg body wt)	Small intestine length (m/kg body wt)	Caecum length (m/kg body wt)	Gizzard weight (g/kg body wt)	Liver weight (g/kg body wt)
0	0.243 ^a	1.119 ^a	0.160 ^a	2.964 ^a	2.802 ^a
100	0.250 ^a	1.058 ^a	0.142 ^b	2.954 ^a	2.658 ^a
200	0.241 ^a	1.096 ^a	0.156 ^a	3.005 ^a	2.714 ^a
SEM	0.0068	0.0306	.0017	0.08624	0.0576
Analysis of variance					
df					
level	2	2	2	2	2
error	45	45	45	45	45
MSS					
level	0.0006775	0.015	0.0015454	0.012	0.085
error	0.0007314	0.015	0.000468	0.119	0.053
DMRT	0.019	0.087	0.004	0.246	0.164

SEM = standard error of mean
Means with different superscripts in a column differ significantly (p < 0.05).

4.4 Microbiological assay

Dried poultry biogas slurry meal was found negative for both *Salmonella* sps and *E.coli*, while poultry droppings contained *E.Coli*.

4.5 Economics in disposal of poultry droppings and recycling as feed ingredient to broilers

Results on cost of economics in disposal of poultry droppings through biogas production, recycling as feed ingredient to broilers and cost of production of broilers on diets containing dried poultry biogas slurry meal are presented in 4.5.1 and 4.5.2 sections.

4.5.1 Input and output cost and cost benefit analysis of poultry droppings disposal through biogas plant

Input and output cost and cost benefit analysis in disposing the poultry droppings via biogas generation calculated per annum are as follows.

Input cost:

Non recurring:

Biogas plant installation	Rs.8000
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Recurring:

Interest on non recurring cost (18 %/year)	Rs.1440
Depreciation cost	Rs.800
Quantity of PD, 12775 kg /year	
Contingency for handling droppings	Rs 1800
Total recurring cost	Rs.4040

Output cost:

Monetary value of biogas, 767 m ³	Rs.1800
Monetary value of DPBS meal, 3833 kg (30 % of 12775 kg PD) at Rs.2.00/kg	Rs.7665
Total output cost	Rs.9465

Net income: Rs. = 9465 - 4040 = 5425

Capital pay back period = 8000 / 5425 = 1.4 i.e capital investment can be cleared in about one and half year.

**4.5.2 Cost of production of broilers on dried poultry
biogas slurry(DPBS) meal diets**

<u>Parameter</u>	Diets containing DPBS meal (g/kg)		
	0(Reference)	100	200
Feed cost/kg (Rs)	8.66	8.25	7.96
FCR (Feed /gain)	1.790	1.930	1.954
Feed. Cost per kg live broiler (Rs)	15.50	15.90	15.55

DISCUSSION

CHAPTER 5

DISCUSSION

5.1 Biogas production

Poultry droppings (PD) generated biogas, in 2 m³ capacity of floating drum model and Deenabandhu model biogas plants. Yield of biogas from PD was reported at 0.06 m³ / kg (wet basis) as against 0.04 m³/kg cattle dung (Bhattacharyya *et al.*, 1993). This indicates the PD can become a potential feed material for biogas generation in place of cattle dung which is becoming scarce commodity due to increased industrialization of agriculture. The concentration of solids ranged from 8 - 11 %, this confirmed the mixing practice of one part of poultry droppings with two parts of water for obtaining optimum biogas. Rajashekher and Mohankumar (1994) reported 9 % solids in the digester contents during *in vitro* trials using poultry droppings.

In only floating drum model, a gradual recession of biogas was seen. This can be attributed to the problem of quick separation of suspended solids due to high mineral content of poultry droppings particularly calcium (66.8 mg/kg) and phosphorus (23.1 mg/kg). Rajashekher and Mohankumar (1994) observed the problem of quick separation of suspended solids, only in the poultry biogas slurry as compared to the cow dung in an *in vitro* trials involving batch fermentation cultures with glass jars.

The separation of aqueous phase from suspended solids resulted in expulsion of large quantity of water from digester at each time of feeding of PD. The low water content was reported to interfere on the biogas production due to accumulation of acetic acid (Tata Energy Research Institute, 1985).

The problem of quick separation, more discharge of water from the digester tank was overcome by the fixed dome model of biogas plant, in which the exertion of downward thrust of gas on the digester fluid lead to expulsion of slurry through outlet. The operation being a continuous process, there was little or no increase of per cent of suspended solids in the digester tank of fixed dome model plant.

5.2 Chemical composition and nutritive value of dried poultry biogas slurry (DPBS) meal:

Dried poultry biogas slurry (DPBS) meal resulted in low protein (125g vs 257 g) and low energy (383 kcal vs 1661 kcal/kg) as compared to Poultry droppings (PD). The low levels could be the result of the biodegradability of the organic matter of PD by anaerobic fermentation for the production of methane, which is the main component of biogas. Teotia and Miller (1974) have reported 469 g/kg crude protein, 2200 kcal ME/kg and 176.2 g/kg crude protein, 600 kcal ME/kg in poultry manure before and after digestion by fly pupae.

The ash content of DPBS meal increased (475 vs 254 mg/kg) to about 87 % due to biodegradation of the organic matter. DPBS meal contained high acid insoluble ash (210 g/kg). Biogas manure was reported to contain high silicon content. The elemental analysis of slurry by x ray indicated 66 % silicon, 8.3 % phosphorus, 3.1 % sulphur, 7.6 % potassium, 11.7 % calcium and 3.7 % iron (Bhattacharyya *et al.*, 1993).

Dry matter metabolizability of DPBS meal was lower by 17% as compared to PD.

The higher content of crude fibre in DPBS meal (219 vs 152 g/kg) was inconclusive. The calcium and phosphorus contents were similar in both DPBS meal and PD. However, the phosphorus content in DPBS meal was completely non-phytin phosphorus.

5.3 Performance of broilers on dried poultry biogas slurry (DPBS) meal diets

Dried poultry biogas slurry (DPBS) meal , 100 g/kg level in starter diets can be safe to broilers with out depression in growth. However, high level of feeding (200 g/kg) resulted in poor growth. Due to low nutrient density of the meal, the feed intake was higher consequently poor feed conversion ratio occurred in broilers. Broiler carcass yields, length of duodenum and jejunum plus ileum, weight of gizzard and liver were unaffected by the level of DPBS meal.

The DPBS meal at 100 g/kg level feeding to broilers dispensed 50% of dicalcium phosphate (25 g/kg) of the diet.

DPBS meal was negative for *Salmonella* sps, *E.coli* and aflatoxins and the meal was innocuous to broilers.

5.4 Economics in disposal of poultry droppings and recycling as feed ingredient to broilers

In case of biotechnology the benefits are of two types

1. Direct benefits 2. Indirect benefits.

Direct benefits:

Direct benefits from this study are biogas production and anaerobic fermented byproduct i.e., DPBS meal. Biogas production, 767 m³/annum can be obtained from 12775 kg PD by application of anaerobic fermentation technique through biogas plants. The biogas monetary value estimated at Rs. 140 per tonne of PD. DPBS meal, 300 kg with a monetary value of Rs. 600 can be obtained per tonne of PD.

Indirect benefits:

It is noted from this study that the environmental problems can be minimised.

Saving of forest through curtailing the use of fire wood and thus ecosystem.

SUMMARY AND CONCLUSIONS

CHAPTER 6

SUMMARY AND CONCLUSIONS

Poultry droppings (PD) particularly cage droppings is known to cause fly menace and objectionable odour in and around the poultry premises. Its disposal as manure for crops and fish ponds is responsible for environmental pollution. Advantages of anaerobic fermentation process of PD through biogas technology needs to be explored in terms of biogas production, rendering better sanitary and environmental conditions in the process of PD disposal. The modalities of biogas production and recycling of biogas slurry as feed ingredient to poultry was examined in this study.

Floating drum (KVIC) and fixed dome (Deenabandhu model) model biogas plants each of 2 m³ capacity were utilized for studying the suitability of PD for the production of biogas. Fresh PD about 35 kg collected from cage housed birds (cocks) fed on layer mash, and a mixture of PD and water (1:2 w/v) was prepared daily to feed the biogas plants. The biogas production, fly menace, objectionable odour during the experiment was monitored. Biogas slurry was collected in an open pit and dried (dried poultry biogas slurry meal) under natural conditions.

Dried poultry biogas slurry (DPBS) meal was analysed for proximate composition, calcium, phosphorus, aflatoxin and phytin

phosphorus. Dry matter metabolizability and metabolizable energy was estimated *in vivo* in DPBS meal, PD and maize.

DPBS meal having 125 g/kg protein was incorporated in broiler diets at 0, 100 and 200 g/kg to replace 0, 50, 100% protein of groundnut extraction (446 g/kg) of reference diet. Calcium and phosphorus levels were made equal in all the diets. Each of the diet was fed to 8 groups (7 chicks/group) of broiler males from 1-39 d of age to study the performance of broilers.

Poultry droppings, as a regular feed material yielded biogas in both floating drum and fixed dome model biogas plants. Discharged biogas slurry from biogas plant was free from obnoxious odour, fly menace / insect breeding. In only floating drum model of biogas plant problem of low biogas production occurred due to the discharge of more water from the digester resulting in more viscous digester contents. The problem can be attributed to the quick separation of digester contents due to higher content of minerals particularly calcium and phosphorus than cattle dung.

The problem of quick separation and more discharge of water from the digester tank was overcome by the design of fixed dome model biogas plant.

DPBS meal obtained from the biogas slurry contained 383 kcal ME, 125 g crude protein, 18.9 g ether extract, 219.6 g crude fibre, 475.3 g ash, 210 g acid insoluble ash, 66.8 g calcium and 23.1 g phosphorus per kg. The lower content of protein (125 vs

257 g/kg)and ME (383 vs 1661 kcal/kg) in DPBS meal as against poultry droppings could be due to the result of the biodegradation of the organic matter of poultry droppings by anaerobic microbes for the production of methane which is a major component of biogas.

Phosphorus content of DPBS meal was completely non-phytin.

Salmonella sps, *E.coli*, aflatoxins were not found in DPBS meal.

On inclusion of DPBS meal in broiler starter diets at 100 g/kg level, growth was statistically similar to the reference group. While at 200 g/kg level DPBS meal depressed the broiler growth. Broiler carcass yield, length of duodenum and jejunum plus ileum, weight of gizzard and liver were unaffected by feeding DPBS meal diets.

Direct benefits from the economic study on environmental friendly disposal of poultry droppings were biogas production, and DPBS meal. This study revealed that biogas production and DPBS meal were worth of about Rs. 140 and RS. 600 respectively from each tonne of Poultry droppings when processed through biogas technology. Cost of production of broilers on DPBS meal was comparable to the reference group.

CONCLUSIONS

- Poultry droppings and water mixed at 1:2 (w/v) as a regular feed material to biogas plants yielded biogas.
- Low gas production was observed only in floating drum model of plant as a result of loss of more water (slurry) from the digester due to the quick separation of solids from the liquid phase in the digester tank.
- Fly menace / insect breeding, obnoxious odour were practically free in discharged biogas slurry of the biogas plant.
- The anaerobic fermented material i.e., dried poultry biogas slurry (DPBS) meal discharged from the biogas plant contained 383 kcal ME, 125 g crude protein, 18.9 g ether extract, 219.6 g crude fibre, 475.3 g ash, 66.8 g calcium and 23.1 g phosphorus per kg on dry matter basis. Phosphorus content of DPBS meal was completely of non-phytin.
- DPBS meal did not contain *Salmonella* sps and *E.coli*.
- DPBS meal upto 100 g/kg level can be safely included in broiler starter diets with out depression in growth.
- Feed intake was higher and FCR was poor on DPBS meal than on reference diet.
- Economics revealed that PD can be processed to generate biogas and recycle poultry droppings thus making environmental friendly.

LITERATURE CITED

LITERATURE CITED

- Ahuja A K, Sethi R P, Makkar G S and Langar P N 1983
Bioconversion of poultry droppings through fermentation.
Indian Journal of Animal Science 53: 445-447.
- Alli Y, Kejun Y, Yaixin Z and Guoyuan F 1990 Study and design on
a high performance biogas project treating chicken manure.
China Biogas 8: 30-33. Cited in Biogas Forum (editor, Bremen
Overseas Research and Development Association, Federal
Republic of Germany) 2: 14-19.
- Alexander D C, Garriere J A and McKay K A 1968 Biological
studies of poultry litter fed to livestock. Canadian
Veterinary Journal 9: 127
- AOAC 1990 Official Methods of Analysis. Association of Official
Analytical Chemists, Ottawa, Canada.
- Bhattacharyya B C, Hanuman H S, Banerjee R, Bhattacharyya P and
Singh R P 1993 Practical Hand Book for Biogas Managers -
Regional Centre for Biogas Development, Indian Institute of
Technology, Kharagpur, India.
- Bishnoi S R and Bajwa M S 1994 Poultry manure for more crops.
Indian Poultry Industry Year Book, 10th edition Published
by SP Gupta, New Delhi, 110015.
- Blair R 1974 Evaluation of dehydrated poultry waste as a feed
ingredient for poultry. Federation, Proceedings of the
Federation of the Society of Experimental Biology 33:1934-36.
- Bourdillon A, Carre B, Conna L, Duperray J, Juyghebaert G,
Leclercq B, Lessire M, McNab J and Wiseman J 1990 European
reference method for the In Vivo determination of
metabolizable energy with adult cockerels: Reproducibility,
effect of food intake and comparison with individual
laboratory methods. British Poultry Science 31: 557-565.
- Cruickshank R, Duguid J P, Marmion B P and Swain R H A 1974
Medical Microbiology. A guide to Laboratory diagnosis and
control of infection 12th edition, Published by Longman group
Ltd.
- Duncan D B 1955 Multiple range and multiple F tests. Biometrics
11: 1 - 42.

- Farrell D J 1978 Rapid determination of ME of foods using cockerels. *British Poultry Science* 19: 303-308.
- Hill F W and Anderson D L 1958 Comparison of ME and PE determination with growing chicks. *Journal of Nutrition* 64: 587-603.
- Ichhponani J S and Lodhi G N 1976 Recycling animal waste as feed. A review. *Indian Journal of Animal Science* 46: 234
- Haug W and Lantzsch H J 1983 Sensitive method for the rapid determination of phytate in cereals and cereal products. *Journal Science Food and Agriculture* 34: 1423 -1426.
- Indian Poultry Industry Year Book 1994 Poultry development in India- Indian Poultry Industry Year Book, 10th edition, Published by SP Gupta, New Delhi, 110 015.
- Jiayu Min and Zhengfang Li 1990 A comparative study on the efficiencies of fingerling raising with slurry from biogas digester chicken manure and mixed baits. *China Biogas* 8: 36 - 38. Cited in Biogas Forum (editor, Bremen Overseas Research and Development Association, Federal Republic of Germany) 2: 20- 25.
- Langar P N 1994 Recycling poultry waste in feed. Indian Poultry Industry Year Book 10th edn published by SP Gupta, New Delhi, 110 015.
- Majundar A 1982 Biogas Handbook. Tata Energy Research Institute documentation centre, Bombay, p 82.
- McNab J M, Shannon D W F and Blair R 1974 The nutritive value of a sample of dried poultry manure for the laying hen. *British Poultry Science* 15: 159 - 161.
- National Academy of Sciences 1977 Methane generation from human, animal and agricultural wastes, Washington, USA, pp 3-125.
- Pons U A, Cococullu A F, Lee L S, Robertson J A, Franz A O and Goldblatt L A 1966 Determination of aflatoxins in agricultural products. Use of aqueous acetone for extraction. *Journal of Association of Official Agricultural Chemists* 49: 554 - 562.

- Rajasheker A R and Mohankumar K C 1994 Studies on utilization of poultry litter for the production of biogas. Unpublished data, All India Coordinated Research Project on Poultry Breeding, Andhra Pradesh Agricultural University, Hyderabad, India.
- Roland D A, Gordon R W and Rao S K 1993 Phosphorus solubilization and its affect on the environment with examples of common misformulation problems associated with calcium and phosphorus. Multistate Poultry Meeting (May 25-27, 1993) held at Auburn University, Alabama, USA: 25-27.
- Snedecor G W and Cochran W G 1967 Statistical Methods, 6th edn, IBH Publishing Company, Calcutta, India.
- Tata Energy Research Institute, 1985 Biogas technology an information package, Tata Energy documentation and Information centre, pp 5- 46.
- Teotia J S and Miller B F 1974 Nutritive content of house fly pupae and manure residue. British Poultry Science 15: 177 - 182.
- Toro V A and Mudgal V D 1983 Utilization of Poultry litter as animal feed. 1. Effect of processing method on bacteriological quality and nutritive value. Indian Journal of Animal Science 53: 470- 476.
- Virk R S and Langar P N 1988 Caged poultry droppings as a source of minerals in broiler ration. Indian Journal of Animal Science 58: 382 - 387.

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