EFFICACY OF CERTAIN LITTER MATERIALS ON BROILER PERFORMANCE

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THESIS

Submitted in partial fulfilment of the requirement for the degree of

Master of Veterinary Science

Faculty of Veterinary and Animal Sciences
Kerala Agricultural University

Department of Poultry Science
COLLEGE OF VETERINARY AND ANIMAL SCIENCES
MANNUTHY, THRISSUR
KERALA, INDIA

1999

DECLARATION

I hereby declare that the thesis entitled "**EFFICACY OF CERTAIN LITTER MATERIALS ON BROILER PERFORMANCE**" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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ACKNOWLEDGEMENTS

I sincerely express my whole-hearted gratitude to Dr. Amritha Viswanath, Associate Professor, Department of Poultry Science, College of Veterinary and Animal Sciences, for her expert advice, valuable suggestions, meticulous guidance and constant encouragement during the period of study. I am much obliged to her for the help and support offered to me as the Chairperson of the Advisory Committee.

I am highly grateful to Dr. G. Reghunathan Nair, Director, Centre for Advanced Studies in Poultry Science, for his valuable suggestions and advice offered to me as member of the Advisory Committee.

I am grateful to the members of Advisory Committee, Dr. K. Narayanankutty, Associate Professor, Department of Poultry Science and Dr. P.C. Saseendran, Associate Professor, Department of Livestock Production Management for their creative suggestions and whole-hearted help during this study.

I express my sincere thanks to Dr. A.K.K. Unni, Former Director, Centre for Advanced Studies in Poultry Science, for his valuable help and co-operation.

My sincere thanks to Dr. A. Jalaludeen, Senior Scientist, AICRP, Mannuthy, Dr. P.A. Peethambaran, Associate Professor, Centre for Advanced Studies in Poultry Science, Dr. Leo Joseph, Associate Professor, University Poultry Farm and Dr. V.K. Elizabeth, Assistant Professor (SG), Department of Poultry Science for their help and co-operation.

I am very grateful to all other staff members of the Department of Poultry Science, All India Co-ordinated Research Project on Poultry and University Poultry Farm for their friendly co-operation and accommodation shown to me.

I am thankful to Dr. S. Sulochana, Dean i/c, College of Veterinary and Animal Sciences, for providing facilities needed for the research work.

I extend my sincere thanks to the help offered by Smt. U. Narayanikutty, Professor i/c, Department of Statistics, Smt. K.P. Santha Bhai, Programmer and Mr. K.V. Prasadan, Technical Assistant, Department of Statistics for their help in computerised data processing and analysing the data.

I express my thanks to staff members of Department of Nutrition and Department of Preventive Medicine for their help.

My sincere thanks to Dr. N.N. Potty, Professor, Department of Agronomy, College of Horticulture, Dr. P.K. Sushama, Associate Professor, Department of Soil Science and Agricultural Chemistry for helping me to conduct the litter analysis.

I am thankful to the help offered by Mr. M. Vimal, Post Graduate student, College of Forestry, Mr. K.M. Sunil and Ms. Divya Unnikrishnan, Post Graduate students, College of Horticulture during the experiment.

I am thankful to Ms. V. Mini, Mrs. Zeena Ravi and Mr. Dileep, Research Associates in the Department of Animal Nutrition for the valuable assistance.

I wish to extend my thanks to my Departmental colleagues, Dr. P. Vidyadharan, Dr. S.P., Muthukumar, Dr. K. Sangilimadan, Dr. P. Kanagaraju, Dr. E. Sreedharan, Dr. M. Murugan, Dr. K.V. Shibu, Dr. Jomy John,

Dr. K.S. Jayashree, and Dr. D. Sukumar for their precious help and constant encouragement.

I express my indebtedness to my friends and fellow post graduate scholars Dr. Biju Chacko, Dr. P. Vinu David, Dr. Reghu Ravindran, Dr. P.T. Dinesh, Dr. V.K. Vinod, Dr. V.N. Vasudevan, Dr. K.C. Jayan, Dr. G. Sunil and Dr. V. Dildeep for their help, encouragement and concern, shown throughout the experiment.

I am short of words to acknowledge the help rendered by my undergraduate friends Mr. Dosen, Mr. Jitheshkumar, Mr. Abhijith Thampan, Mr. Bini Raj, Mr. K.P. Anwar, Mr. Dijesh Unnikrishnan, Mr. R. Sudhi, Mr. Avish J. Kuzhimattathil, Mr. Kishore Kumar, Mr. Harikrishnan, and a few more who helped me to record the experimental observations.

No space or words can express my deep sense of gratitude to my beloved father, mother, sisters and their families who always stood as a source of encouragement and affection to me.

I am thankful to Mr. O.K. Ravindran, Peagles, Mannuthy and Mr. George, Platen Printers for their unflagging patience and care in the preparation of this manuscript.

I am grateful to Kerala Agricultural University for providing financial assistance in the form of KAU junior fellowship.

Last but not the least, to every one who gave me a helping hand whose name I missed to mention, I express my gratitude and above all, I bow my head before God Almighty for the blessings showered on me.

SINI THOMAS

Dedicated to my Appa, Amma and Guide

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Introduction

INTRODUCTION

Broiler industry has emerged itself as an important agribusiness and as a potential means of generating self employment in India. Over the past two decades, production of broilers has grown faster than that of any other major food item. The growing demand for animal products due to westernization of the food habits has been the main driving force behind the fast development of the broiler industry.

The broiler population which was only four million in 1971 rose to 190 million in 1990 and was projected to 400 million in 1996 (Anon., 1994). Despite the impressive achievement of broiler industry in India, a wide gap exists between the current poultry meat availability and the minimum needs of the country. In India, per capita availability of poultry meat is only 566 g in 1994 (Anon., 1994). The National Institute of Nutrition recommends per capita consumption of 10.8 kg meat per annum. Taking into consideration of meat from all sources, the per capita availability accounts to a meagre 1.5 kg/year in India. With the limited scope for increasing meat from other sources, poultry meat offers vast scope for filling the gap. In Kerala the broiler population is estimated to be 9 million (Anon., 1994).

Management plays a pivotal role in the successful operation of poultry enterprises. With the introduction of deep litter system in poultry farming, the entire concept of poultry keeping has taken a new turn. Deep litter system is the most popular system of broiler raising. Wood shavings is the common poultry litter used in Kerala. At present in Kerala, there is high demand for wood shavings due to increase in the number of broiler farms and decrease in the availability of wood shavings. There is also demand for wood shavings in the hard board manufacturing industries and as fuel.

The major constraint in the rapid development of broiler industry is the high cost of production. In order to improve the margin of profit, cost of inputs has to be reduced. In this context, reduction in the cost of litter material is also one of the means to reduce the cost of production.

Due to the high cost and scarcity of litter materials, during the past few years, many farmers are reusing old litter. There are inherent risks attached to this practice including the chances for the spread of disease and high level of ammonia production in poultry house. Hence, reusing of old litter is not a scientific solution to the problem of litter shortage and high cost.

Considerable research has been conducted to evaluate alternate sources of litter materials and a number of potential materials have been investigated. Easily available agricultural and industrial by-product wastes such as straw, peanut hulls, tree leaves, processed paper and composted municipal garbage have been studied (Andrews and Mc Pherson, 1963; Ruszler and Carson, 1968; Chaloupka *et al.*, 1974; Chaloupha *et al.*, 1980 and Narahari and Venukopalan, 1996). To be effective, the litter materials must be highly absorbent, dust free, not consumed by the bird, easily available and in expensive.

With the introduction of mechanical defibering units, large quantities of coir pith are available and disposal of which is a problem especially in wet land areas. In India, about 6.6 lakh tonnes of coir pith is produced every year (Baskar and Saravanan, 1998). They also reported that coir pith has a good porosity (75 per cent) and water holding capacity (500 per cent). If coir pith is useful as a litter material it can minimise the problem of disposal and also can increase its utility as a good manure. India recorded a total production of 82.12 million tonnes of rice during the period 1997-'98 (Anon, 1999). The by-products of rice industry, rice husk which is discarded during milling of rice and paddy chaff discarded during cleaning of paddy can be used as litter materials. Similarly saw dust which is a waste of wood

industry when used as a litter material can be converted into an effective fertilizer. Hence, the present study is planned to find out the suitability and efficiency of saw dust, rice husk, coir pith and paddy chaff as litter materials in place of wood shavings and its fertilizer value under the hot-humid climate of Kerala.

Review of Literature

REVIEW OF LITERATURE

Comprehensive review of research findings available in the literature on the efficacy of different litter materials on the performance of broilers have been gathered and presented in this chapter.

Meteorological profile of Mannuthy

Data pertaining to the meteorological profile of Mannuthy (Latitude 10°32" N; Longitude 76°16" E; Altitude 22.25 m above MSL) for five years were summarised by Somanathan (1980). He reported the highest mean maximum temperature of 32.35°C during May and lowest during July (28.15°C). The lowest mean minimum temperature recorded was 23.28°C during July and highest as 25.27°C during May. The daily average per cent relative humidity varied between 75.68 during May to 86.52 during July. Climatograph of this locality fell within the hot and humid climate.

Thiagarajan (1989) reported mean maximum temperature of 29.36 to 37.79°C and mean minimum temperature of 22.33 to 25.93°C from April to July in 1988 and relative humidity of 55 to 87 per cent during the same period.

Amritha Viswanath (1992) reported mean maximum temperature of 32.29 to 38.33°C and mean minimum temperature of 22.14 to 27.86°C from February to May in 1991. The

relative humidity ranged from 49.5 to 87.0 per cent during the same period.

Impact of meteorological parameters on the performance of broilers

Adams *et al.* (1962) reported that high environmental temperature (29°C), reduced growth rate and feed consumption in chicks than those reared at low temperature (21°C).

Milligan and Winn (1964) studied the effect of temperatures of 46, 53, 60, 70, 80, 95 and 100°F and relative humidities ranging from 30 to 90 per cent on broiler performance. They reported that 60-80°F as optimum constant temperature for such criteria as body weight gain, feed conversion, pigmentation and feathering. They observed that broilers were extremely sensitive to constant high relative humidity at constant temperature of 90-100°F. Body weight gain, feed conversion, feathering and pigmentation were adversely affected at high temperature and high humidity.

McDowell (1972) reported that in warm humid areas where air temperature is 21.0°C or above, livestock production is affected when the relative humidity is 60 per cent and above.

Nesheim *et al.* (1979) reported that symptoms of heat stress started at 26.6°C leading to reduced production performance. At 28.4 to 37.8°C there was reduction in feed

intake and subsequent increase in water intake leading to damp litter and subsequent higher humidity in the house, enhancing the adverse effects of higher temperature.

Reece and Lott (1983) found that growth rate of commercial broilers decreased as environmental temperature increased. The growth rate at 26.7°C was 6 per cent less at 35 days and 10 per cent less at 55 days of age than at 15.6°C. At 49 days of age, the birds grown at 15.6°C required 16 per cent more feed than at 26.7°C.

Al-Fataftah (1987) studied the effect of high temperature on broiler performance in Jordan. He reported that exposure of broilers at high temperature (exceeding 29.0°C) significantly decreased feed intake, feed efficiency and body weight gain.

Osman *et al.* (1989) conducted two experiments to study the effect of environmental temperature on growth and carcass quality of broilers. They found that higher temperatures (30 to 32°C) reduced body weight gain and feed efficiency.

Body weight

Golan *et al.* (1969) compared pine bark particles and pine shavings as litter materials for broilers and reported that the broilers reared on pine bark litter was one-fourth pound heavier than broilers on pine shavings.

Muller (1972) found that the growth of broilers was influenced by different litter materials. Twenty four bedding materials including hay, wood shavings, oat husks, straw, wheat chaff and coniferous saw dust were used for the study.

Oliveira *et al.* (1974) reported that litter type did not significantly affect growth rate upto ten weeks of age for broilers grown on six different litters including sand, wood shavings and rice hull.

Carter *et al.* (1979) in their study, using four litter materials could not find any significant difference for eight week body weight in broilers. They reared broilers on four types of litter materials namely green wood chip litter from standing pine, hardwood trees and a 50/50 pine hardwood mixture.

Chaloupka *et al.* (1980) reported that broilers reared on shredded newspaper and processed newspaper (less than 1.27 cm diameter) were significantly heavier than those reared on processed newspaper (less than 2.54 cm diameter) and hardwood saw dust at 28 days of age. At 49 days of age broilers reared on processed newspaper (less than 1.27 cm diameter) were significantly heavier than broilers reared on processed newspaper (less than 2.54 cm diameter) as well as on hardwood saw dust.

Jones and Hagler (1982) studied the performance of broilers reared on new and reused hardwood saw dust and reported that there was no significant difference in body weight between the two groups.

Malone *et al.* (1982) found that broilers reared on recycled paper had improved body weight compared with those birds grown on wood shavings. They compared the suitability of different litter materials namely hardwood saw dust (control), shredded newspaper, processed newspaper and processed cardboard and found that body weights at 28 and 49 days of age were significantly influenced by the different treatments. Broilers reared on shredded newspaper weighed more than those on hardwood saw dust and the broilers on processed card board weighed lowest.

Malone and Chaloupka (1983) studied the influence of litter type and size on broiler performance and found that litter type significantly influenced their performance. They compared three particle sized processed newspaper with particle sizes 1.27 to 2.54 cm (L-PN), 0.64 to 1.27 (M-PN) and less than 0.64 cm diameter (S-PN) to hardwood saw dust and found that broilers reared on S-PN and M-PN had numerically higher body weights than those on saw dust. Body weights with L-PN were similar to those with saw dust.

Malone *et al.* (1983) reported that litter type significantly influenced bird performance. They found that broilers reared on composted municipal garbage litter had significantly higher body weight than those on wood shavings.

Soft wood chipping fines, a by-product of paper manufacturing industry was compared with that of pine shavings as litter materials for broilers and reported that there was no difference at 49 day body weight (Parsons and Baker, 1985).

Sundaresan (1984) studied the influence of season, stocking density and litter material on broiler performance by rearing broilers for eight weeks on paddy husk, wood shavings and groundnut shell as litters. He reported that influence of broiler productive parameters by litter materials were not quite evident. It was also stated that the body weight of birds reared on different litter materials was not significant.

Al-Zubaidy *et al.* (1986) evaluated wood shavings, rice hulls, chopped papyrus, an equal mixture of wood shavings and rice hulls and an equal mixture of wood shavings and chopped papyrus as litter materials for broiler chicken upto eight weeks of age. They found that there was no significant difference among litter types for body weight throughout the experimental period.

Kassed and Coleman (1989) reared broilers on dehydrated poultry waste and wood shavings as litter materials. They found no significant effect on body weight by the litter difference.

Malone *et al.* (1990) compared kenaf core and fresh pine saw dust, reused kenaf core and reused pine saw dust as litter material and concluded that litter age and type had no significant effect on body weight.

Brake *et al.* (1992) evaluated the chemical and physical properties of hardwood bark and pine shavings as a broiler litter material and found that litter type did not influence the body weight gain of broilers.

Body weight was not influenced by the type of litter materials as reported by Lien *et al.* (1992), when conducted studies on the suitability of recycled paper chips and pine shavings for broilers.

Sand, fine wood shavings, half wood shavings and half peat moss were compared as litter materials for broilers by Shanawany (1992) and found no significant difference between the groups in eight week body weight. The body weight at eight weeks of age averaged 1944, 2051, 2104 and 2192 g respectively for the four groups.

Burke *et al.* (1993) raised broilers on four different litter materials viz., wood shavings mixed with shredded newspaper, wood shavings layered over paper and paper layered over wood shavings and reported that litter materials had no effect on body weight.

Chavan *et al.* (1993) reared broilers on chopped dry grass, rice husk, sawdust and sea sand as litter materials and found that there was significant difference in body weight between treatments. Broilers reared on sea sand as litter material had lower body weight.

Mizubuti *et al.* (1994) reared Arbor Acres and Hubbard broilers on rice hull and grass litter at a density of 10, 12 and 24 birds/m^2. The body weight at 45 days averaged 2.10 kg and 2.22 kg respectively and there was no significant difference between the two litter treatments.

Kalita *et al.* (1995) obtained a higher body weight for broilers reared on used rice husk litter (1350 g) than those on fresh rice husk litter (1259 g) at eight weeks of age.

An experiment was conducted in broilers to evaluate the performance of broilers reared on pelleted newspaper, and pine saw dust as litter material by Malone and Gedamu (1995). The study revealed that the type of litter had no significant difference in body weight at 46th day of age.

Narahari and Venukopalan (1996) carried out studies in broilers using litter materials viz., paddy husk (control) and all dried and fallen leaves of casuarina claudode, neem, rain tree and subabul upto six weeks of age and found no significant difference among the various litter materials in comparison to control in body weight.

Influence of litter materials on broiler performance was reported by Mallikarjunappa (1996). He conducted two experiments using peanut shell, paddy husk, wheat straw and saw dust as litter materials for broilers upto six weeks of age. Results of his study showed that broilers performed equally well on different litter materials with respect to six week body weight.

Angelo *et al.* (1997) studied the effect of quality and quantity of litter material on broiler performance by rearing broilers on wood shavings, rice husk, brachiaria hay, Napier grass hay and Coast Cross hay. They reported that the eighth week body weight for broilers as 2705, 2736, 2659, 2664 and 2640 g respectively for each treatment and there was no significant difference between treatments.

Wills *et al.* (1997) reported that litter material had no significant influence on live weight attained by broilers after evaluating leaves as litter material.

Body weight gain

Siddiqui *et al.* (1976) studied the effect of using various litter materials, viz., paddy husk, groundnut hulls, sugarcane pulp, sawdust and straw on the performance of broilers. They reported that there was no significant differences in body weight gain due to different littermaterials, however broilers reared on saw dust had shown numerically higher body weight.

Ranade and Rajmane (1990) compared rice husk (control) with wood shavings, paper cuttings, chopped hay and fine sand as litter materials for starter chick raising and found no significant difference among the various litter materials in comparison to control in the case of total gain in weight in starter chicks at eight weeks of age.

Brake *et al.* (1992) evaluated the chemical and physical properties of hardwood bark and pine shavings used as broiler litter material and found that litter type did not influence the body weight gain.

Wyatt and Goodman (1992) used wood shavings and refined gypsum as broiler litter and found that body weight gain was significantly lower for chicks reared on refined gypsum compared with that of the other litter materials at 21 days of

age, but at 41 days of age there was no difference between the litter treatments.

Haque and Chowdhury (1994) studied the use of rice husk litter at different depths of 20, 30, 40 and 50 mm for broiler chicks during summer and concluded that the depth of the litter did not significantly affect the live weight gain.

Martinez and Gernat (1995) utilized chopped computer and bond paper as litter materials to study the growth performance of broilers. They used 100 per cent chopped computer paper and bond paper, a mixture of 75 per cent chopped computer paper and 25 per cent wood shavings, 50 per cent chopped computer paper and 50 per cent wood shavings and 100 per cent wood shavings as control. Results of the study revealed that litter materials had no effect on body weight gain in broilers.

Anisuzzaman and Chowdhury (1996) reared broilers upto 56 days of age on four types of litter materials, viz., sawdust, paddy straw, sand and rice husk and found that the birds reared on rice husk had higher weight gain than that of other treatments.

Shakila and Naidu (1998) carried out an experiment to find the suitability of groundnut hulls, paddy husk, sawdust and chopped straw as litter materials for broilers and

reported that the body weight gain of broilers reared on sawdust was significantly lower than that of birds reared on chopped straw, rice husk and groundnut hulls.

Feed intake

Azahan (1982) reported no significant difference in feed intake for broilers reared on used and fresh wood shavings as litter materials.

Sundaresan (1984) studied the influence of season, stocking density and litter material on broiler performance by rearing on paddy husk, wood shavings and groundnut shell. He reported that influence of broiler productive parameters by litter materials were not quite evident. He also stated that the feed intake of broilers reared on different litter materials was not found significant.

Ranade and Rajmane (1990) reported no significant difference among treatment groups in feed consumption for starter chicks reared on litter materials like wood shavings, paper cuttings, chopped hay, fine sand and rice husk.

Lien *et al.* (1992) found that there was no influence on feed consumption in broilers on different litter treatments, viz., recycled paper chips and pine shavings litter.

Burke *et al.* (1993) after evaluating the performance of broilers on four different litter materials claimed that there was significant difference in feed consumption. The broilers were reared for 46 days. The litter materials used were wood shavings, wood shavings mixed with shredded newspaper, wood shavings layered over paper and paper layered over wood shavings. Feed consumption during 39-46 days was found significantly higher for broilers reared on wood shavings and wood shavings mixed with shredded newspaper.

Chavan *et al.* (1993) studied the use of different litter materials, viz., chopped dry grass, rice husk, sawdust and sea sand and reported that there was significant low feed consumption in broilers reared on sea sand as litter material.

Haque and Chowdhury (1994) studied the use of rice husk litter at different depths for broiler raising and found that the depth of the litter did not significantly influence feed consumption.

Significant difference $P<0.01$) in feed consumption was reported by Mizubuti *et al.* (1994) in broilers reared on different litters. He reported feed intake of 4.22 kg and 4.49 kg for broilers grown on rice hull and purpureum litters upto 45th day of age.

Martinez and Gernat (1995) studied the effect of chopped computer and bond paper mixed with wood shavings at different proportion as litter material and wood shavings as control on broiler performance and found that there was no effect on feed consumption.

Anisuzzaman and Chowdhury (1996) compared saw dust, paddy straw, sand and rice husk as broiler litter materials and reported higher feed consumption for broilers reared on rice husk.

Mallikarjunappa (1996) carried out studies in broilers reared on peanut shell, paddy husk, wheat straw and saw dust litters and reported that mean feed intake values for a six week period averaged 3750.4, 3732.73, 3937.19 and 3831.64 g respectively. Statistical analysis of this data revealed no significant difference in feed consumption upto six week period.

Narahari and Venukopalan (1996) carried out studies on broilers using litter materials viz., paddy husk (control) and all dried and fallen leaves of casuarina claudode, neem, rain tree and subabul upto six weeks of age and reported that litter treatment did not differ for feed consumption.

Feed efficiency

Oliveira *et al.* (1974) compared six types of litter materials including sand, wood shavings and rice hulls and concluded that litter type did not significantly influence feed efficiency in broilers.

Siddiqui *et al.* (1976) studied the effect of using various litter materials, viz., paddy husk, groundnut hulls, sugarcane pulp, sawdust and straw on the performance of broilers and reported that feed efficiency was comparable on the different litter materials.

Significant difference in feed intake for broilers reared in different litter materials was reported by Kaniok and Rozycka (1978). Broilers were reared on straw; saw dust;straw and peatmoss (2:1); straw and sawdust (2:1) and straw, saw dust and peatmoss mixture (1:1:1) litter for a period of eight weeks. Results of their study revealed that the least feed efficiency was in the group reared on straw and peat moss litter. Feed efficiency for the broilers reared on straw and peatmoss litter was 2.33 and for the other groups it ranged from 2.37 to 2.45 during the experimental period.

Carter *et al.* (1979) compared air-dried timber shavings with green wood chip from standing pine, hardwood tree shavings and a mixture of hardwood and pine hardwood mixture

as litter materials and found that the feed efficiency did not differ significantly between broilers reared on the four types of litter.

Chaloupka *et al.* (1980) studied the performance of broilers grown on shredded newspaper, processed newspaper and hardwood saw dust. The study revealed that different litter materials did not influence feed efficiency.

Jones and Hagler (1982) studied the performance of broilers reared on new and reused hardwood saw dust and found that there was no significant difference in feed efficiency.

Malone *et al.* (1982) reported an improved feed conversion in broilers reared on shredded newspaper litter at 28 days of age and no difference was noticed at 49 days of age. They studied the suitability of three types of recycled paper produces for use as broiler litter materials with that of hardwood saw dust as the control.

Malone and Chaloupka (1983) revealed no significant effect on feed efficiency when three particle sizes of processed newspaper were compared to saw dust as broiler litter materials.

Malone *et al.* (1983) reported an improved feed efficiency in broilers reared on composted municipal garbage than that on wood shavings as litter materials.

Sundaresan (1984) reported that the feed efficiency of broilers reared upto eight weeks on different litter materials, viz., paddy husk, wood shavings and groundnut shell was not significant.

Soft wood chipping fines, a by-product of the paper manufacturing industry, was evaluated for its efficacy, as poultry litter material by Parsons and Baker (1985). It was found that there was no difference in feed efficiency at 49 days of age between broilers grown on soft wood chipping fines and on pine shavings.

Papyrus was evaluated as a litter material for broilers by Al-Zubaidy *et al.* (1986) in comparison with wood shavings and rice hulls and found no significant difference among litter types on the feed efficiency throughout the experiment.

Kassed and Coleman (1989) studied the effects of using dried poultry waste and wood shavings as broiler litter and found that the type of litter had no significant effect on feed efficiency.

Malone *et al.* (1990) reported that litter age (fresh and reused) and litter type (kenaf and saw dust) had no significant influence on feed conversion in broilers.

Quinones *et al.* (1990) used zeolite, sugar mill ashes and rice hulls as litter materials for broilers and found that the

feed gain ratio averaged 2.23, 2.25 and 2.47 respectively. They could not find any significant difference between treatments.

Ranade and Rajmane (1990) in their study using different litter materials could not find any significant difference in feed efficiency in starter chicks. They reared chicks on litter materials like wood shavings, paper cuttings, chopped hay and fine sand.

Brake *et al.* (1992) found that feed conversion was not influenced by litter type when hardwood bark and pine shavings were used as litter materials for broilers.

Lien *et al.* (1992) stated that feed conversion was not influenced by litter materials for broilers reared after rearing birds on recycled paper chips and pine shavings.

Wyatt and Goodman (1992) conducted a study to evaluate the utilization of refined gypsum (recycled sheetrock) as a litter material with that of wood shavings in broilers and concluded that litter materials had no significant influence on feed conversion.

Brake *et al.* (1993) evaluated whole chopped kenaf and kenaf core as broiler litter material and found that feed conversion was not influenced by the type of litter.

Kalita *et al.* (1995) reported better feed efficiency in broilers reared on fresh rice husk than those on used rice husk as litter material. They reported a feed efficiency of 2.40 and 2.61 respectively for broilers reared on fresh and used rice husk litter.

Malone and Gedamu (1995) stated that type of litter had no significant effect on feed conversion efficiency in broilers reared on pine saw dust and fresh low density paper and fresh low density paper with an adhesive as litter material.

The influence of chopped computer and bond paper mixed with wood shavings as a litter material on broiler performance was studied by Martinez and Gernat (1995) and they reported that litter material had no significant effect on feed efficiency.

Anisuzzman and Chowdhury (1996) reported that broilers reared on rice husk litter showed best feed conversion efficiency compared to those on saw dust, paddy straw and sand as litter materials.

Narahari and Venukopalan (1996) carried out studies in broilers using litter materials, viz., paddy husk (control) and all dried and fallen leaves of casuarina claudode, neem, rain tree and subabul upto six weeks of age and reported that

litter treatments did not differ for feed conversion efficiency.

Angelo *et al.* (1997) obtained feed conversion ratio of 1.92, 1.91, 1.91, 1.90 and 1.93 for broilers reared on litter materials, viz., wood shavings, rice husks, brachiaria hay, Napier grass hay and Coast Cross hay respectively. They reported that the feed conversion efficiency of broilers grown on different litter materials was not significant.

Willis *et al.* (1997) after evaluating leaves as litter material reported that litter had no significant influence on feed conversion.

Shakila and Naidu (1998) carried out an experiment to find the suitability of groundnut hull, paddy husk, saw dust and chopped straw as litter materials and reported that the respective feed efficiencies as 2.58, 2.52, 2.44 and 2.55, these being comparable.

Processing yields and losses

Siddiqui *et al.* (1976) studied the effect of using various litter materials, viz., paddy husk, groundnut hulls, sugarcane pulp, sawdust and straw on the performance of broilers and reported that there were no significant differences in the percentage carcass yields due to litter treatments.

Malone *et al.* (1983) reported that type of litter did not influence processing yields and losses when broilers were reared on composted municipal garbage and wood shavings as litter materials.

Sundaresan (1984) studied the influence of season, stocking density and litter materials on broiler performance by rearing broilers on paddy husk, wood shavings and ground nut shell litters and stated that ready-to-cook and giblet yields were unaffected by litter materials.

Kassed and Coleman (1989) compared the effects of dried poultry waste and wood shavings as broiler litter and found that there was no significant effect on carcass quality.

Rejikumar (1991) reported, ready-to-cook yield of 72.76 per cent, total loss of 27.24 per cent, blood loss of 3.42 per cent and feather loss of 3.06 per cent for broilers reared upto eight weeks.

Brake *et al.* (1992) found that carcass grade was not effected by litter type when broilers were reared on hardwood bark and pine shavings.

Lien *et al.* (1992). studied the influence of litter materials on carcass yield and reported that the carcass yield was not influenced by the litter materials. They reared

broilers using recycled paper chips and pine shavings [redacted] as litter materials.

Shanawany (1992) evaluated the performance of broilers reared on different litter materials, viz., sand, fine wood shavings, half wood shavings and half peat moss. He reported that there was no significant difference between the groups in dressing percentage, but carcass quality score increased with increasing litter water-holding capacity.

Narahari and Venukopalan (1996) carried out studies in broilers using litter materials, viz., paddy husk (control) and all dried and fallen leaves of casuarina claudode, neem, rain tree and subabul upto six weeks of age and reported that litter treatments did not differ for eviscerated, giblet and ready-to-cook yields for broilers.

Willis *et al.* (1997) after evaluating leaves as litter material for broilers reported that litter had no significant influence on dressed carcass weight and carcass yield percentage.

Weight of litter

Availability of literature regarding this parameter is scanty.

Sreenivasaiah (1998) reported that on an average, 240 broilers produce one tonne of fresh droppings.

North (1984) found that the broiler dropping produced will be approximately 1.4 g/g of feed consumed.

Broiler chicken of body weight 1.8 kg [redacted] produced 1.227 kg manure by nine weeks of age (Ensminger, 1992).

Moisture content of the litter

Andrews and McPherson (1963) reported that litter moisture increased significantly from initial value, after eight weeks of rearing. He reared broilers on litter materials, viz., straw, straw plus rice hulls, rice hulls, cane bagasse, wood shavings, ground flax and clay and recorded per cent moisture content as 40.9, 35.2, 34.1, 32.4, 30.6, 27.2 and 22.8 respectively at eighth week and concluded that litter materials did not affect bird performance.

Ruszler and Carson (1968) compared cane pomace and peanut shells as broiler litter and found that different sources and kinds of litter have different moisture holding capacity. They reported that litter with smaller particle size absorbed less moisture than larger particle litter.

Golan *et al.* (1969) compared pine bark particles (one inch long) and pine shavings as litter materials for broilers and reported that moisture content of pine bark and pine shavings were the same at the end of the experiment (24.57 and 24.51 per cent respectively).

Kaniok and Rozycka (1978) conducted experiments using straw, saw dust, and a mixture of straw and saw dust as litter materials for broilers and found that the moisture content of the litter after eight weeks increased from 5 to 6 per cent to 22 to 23 per cent.

Carter *et al.* (1979) reared broilers using green wood chip and hardwood shavings as litter materials and reported that although the initial moisture of wood chip litter was high, the moisture content was similar in all the treatment groups after the eighth weeks.

Litter moisture increased over the course of the experiment from 15.97 to 20.06 per cent in fresh litter and 15.95 to 20.11 per cent in reused litter was the result of study conducted by Jones and Hagler (1982) in broilers. They used hardwood sawdust to a thickness of three centimetres and reused litter top dressed with hardwood sawdust as treatments.

Adeleye and Kitts (1983) found that moisture content of wood shaving litter increased with age of bird.

Huff *et al.* (1984) reported that litter moisture content increased significantly from initial values after rearing broilers for eight weeks.

Sundaresan (1984) studied the influence of season, stocking density and litter material on the performance of broilers reared on paddy husk, wood shavings and groundnut shell and reported that the moisture content of litter was found to be unaffected by the type of litter material.

Al-Zubaidy *et al.* (1986) evaluated dried papyrus as broiler litter in comparison with wood shavings and rice hulls and reported that the moisture content of the litter materials were not significantly different at the end of the experiment. The moisture content ranged from 27.3 per cent in wood shavings to 30.0 per cent in chopped papyrus.

Malone *et al.* (1990) evaluated kenaf core for broiler litter by comparing fresh kenaf core particles to fresh pine saw dust and reused kenaf with reused saw dust and observed that in both fresh and reused kenaf core had 21 and 10 per cent higher litter moisture respectively.

Ranade and Rajmane (1990) compared wood shavings, paper cuttings, chopped hay and fine sand with rice husk as litter materials and found that the average moisture content of wood

shavings, paper cuttings and chopped hay was significantly higher than that of rice husk control.

Brake *et al.* (1992) evaluated physical and chemical properties of hardwood bark and pine shavings and reported that fresh pine shavings had less moisture and more moisture absorbing capacity than fresh hardwood bark. However no consistent difference was found in moisture content for the different litter types during the experiment. They also reported moisture content of 44.01 and 40.29 percentages respectively for pine shavings and hardwood bark.

Lien *et al.* (1992) compared recycled paper chips with waste newspaper and pine shavings as broiler litter and found that litter moisture was higher in recycled paper chips during the third week of age but did not differ between treatments during the entire experimental period.

Martinez and Gernat (1995) reported that there was no difference in moisture content of litter materials used, viz., shavings, chopped computer and bond papers for broilers.

Ammonia nitrogen content of the litter

Ranade and Rajmane (1990) compared wood shavings, paper cuttings, chopped hay and fine sand as litter materials to that of rice husk by rearing starter chicks for eight weeks. They found that initial ammonia nitrogen content of the

different materials before use as 0.028, 0.070, 0.098, 0.067 and 0.035 per cent respectively. These values reached to 0.840, 0.510, 0.780, 0.510 and 0.420 per cent respectively at the end of the experiment.

Hoy and Kuhnel (1995) measured harmful gases in broiler houses by using multiple gas monitoring equipment and stated that when litter material was disturbed during the emptying of a house, ammonia reached 100 ppm, and persisted at 20 ppm or more. It was also found that in deep litter systems a high ammonia concentration (15.80 ppm) built up within the first week and 25.20 ppm in the fifth week.

Skewes and Harmon (1995) determined ammonia levels in broiler houses as 20 to 25 ppm.

Elwinger and Svensson (1996) studied the ammonia emission from broiler houses and found that the ammonia emission was about 19 per cent of total nitrogen input during a six week growing period. There was no difference in ammonia emission between straw and wood shavings litter.

Cornen *et al.* (1996) reared broilers using wood shavings as litter material and found that the litter materials contained 6 to 9 g of ammonia nitrogen per kilogram wet weight at the end of the study.

Nitrogen, phosphorus and potassium content of litter materials

Andrews and McPherson (1963) reared broilers on litter materials like straw, straw plus rice hulls, rice hulls, cane bagasee, wood shavings, ground flax and clay and reported that litter nitrogen level ranged from 4.5 to 3.5 per cent after the eight week grow-out period.

Temple Smith (1979) reported 2.20, 1.40 and 0.70 percentages of nitrogen, phosphorus and potassium respectively in broiler litter.

Analysis of broiler litter samples collected from 106 farms in Alabama, USA showed that the nutrient content varies widely (Stephenson *et al.*, 1990). They reported an average content of nitrogen as four per cent (24.90 per cent crude protein) but ranged from 2.30 per cent (14.40 per cent crude protein) to 6.00 per cent (37.50 per cent crude protein). Phosphorus averaged 1.56 per cent and potassium 2.32 per cent of dry matter. The average N:P:K ratio of poultry manure was 3:3:2. Ash content was extremely variable ranging from 8.90 to 64.30 per cent and averaging 24.70 per cent.

Brake *et al.* (1992) could not find any consistent difference in nitrogen content of hardwood bark and pine shavings litter during the growing periods in broilers. They

reported a nitrogen content of 2.24 to 3.14 per cent respectively at eight weeks of age.

Babu *et al.* (1993) studied the nitrogen, phosphorus and potassium contents of broiler litter at eight weeks of age of different stocking density and litter thickness. They reported that percentage nitrogen, phosphorus and potassium content of litter as 2.24, 0.82 and 0.55 respectively in broilers reared at a floor space of 930cm^2 with a litter thickness of 7.50 cm. They also observed that the nitrogen, phosphorus and potassium content of the litter were comparatively higher in treatments with less floor space and litter thickness.

Nicholson *et al.* (1996) in their study using 12 poultry litter samples found that broiler litter had a higher dry matter content (>60 per cent) than layer litter (>35 per cent). They also found that N, P, K, Mg and S content was not affected by type of litter. It was also observed that the N:P:K ratios were 6:2:3 for broiler litter and that the ammonia nitrogen plus uric acid nitrogen of the poultry litter ranged from 30-50 per cent of the total nitrogen. They reported non-significant difference in manurial value of different litter materials at the end of the experiment.

Mondini *et al.* (1996) reported nitrogen content of dried manure of broilers as 55.1 mg/g. They reported a lower value

of 19.2 mg/g in composted poultry manure than that in dried poultry manure.

Shakila and Naidu (1998) carried out an experiment to find the suitability of groundnut hull, paddy husk, saw dust and chopped straw as litter materials for broilers and reported that per cent nitrogen contents of chopped straw (1.94) and saw dust (1.48) were the highest and the lowest respectively ($P<0.05$). The per cent nitrogen content of groundnut hull and paddy husk was 1.60 and 1.72 respectively. However, they reported that the per cent phosphorus content of different litter materials were comparable and that being 0.71, 0.84, 0.65 and 0.92 respectively for groundnut hull, paddy husk, saw dust and chopped straw.

Litter pH

Jones and Hagler (1982) studied the pH of new and reused litter for growing broilers and found that the litter pH values increased over the course of the experiment. They reported the pH values as 6.96 initially and 7.90 at the end of the experiment for new litter and 7.74 initially and 8.15 at the end of the experiment for used litter.

Huff *et al.* (1984) reared broilers for eight weeks and reported that litter pH rose throughout the experimental period to approximately 8.

Sundaresan (1984) reported that there was no significant difference in pH of different litter materials like paddy husk, wood shavings and ground nut shell after rearing of broilers for eight weeks.

Broiler litter, layer litter and layer excreta were evaluated for pH by Egana *et al.* (1986) and results of their study showed that the pH were 8.5, 7.9 and 7.3 respectively.

Brake *et al.* (1992) compared hardwood bark and pine shavings as broiler litter materials and found that the pH of pine shavings and hardwood bark was not different during the growing period.

Various physical and chemical properties of a mixture of pine shavings and sawdust, kenaf core and whole chopped kenaf were determined in two successive broiler trials. Litter pH increased throughout the first trial and reached a maximum value at 8.75 (Brake *et al.*, 1993).

Shakila and Naidu (1998) carried out an experiment to find the suitability of groundnut hull, paddy husk, saw dust and chopped straw as litter materials for broilers and reported that litter pH values of different litter materials was comparable and that being 7.09 ± 0.89, 7.18 ± 0.90, 7.35 ± 0.63 and 7.16 ± 0.75 respectively.

Proximate composition of litter materials

Muller (1972) conducted experiments to study the nutritive value of deep litter used in poultry farms such as hay, straw, rape straw, crude and fine flex by-products, coniferous shavings, wheat bran, barley straw, dried sugar beet pulp, dried fural waste, maize cobs and straw, cocoa peelings, oat husks and straw, wheat straw, pea straw, a mixture of wheat straw and peat, peat coniferous needles, coniferous saw dust, foliaceous shavings, and a mixture of wheat straw, peat and coniferous saw dust and found that there were differences among deep litter with regard to crude protein, crude fibre, ash, calcium, phosphorus and the vitamins.

Nutrient composition and *in vitro* digestibility of litter materials were determined for raw and composted soft wood and hardwood bark and soft wood planer shavings and observed no significant difference in the nutrient content and digestibility between different types of litter materials used (Labosky *et al.*, 1977).

Analysis of proximate composition of litter materials from deep litter system of rearing broilers by Ryssen *et al.* (1977) revealed that it contains 24.70 per cent crude protein, 16.10 per cent true protein, 13.70 per cent ash and 1.92 mg/kg copper respectively.

Kaniok and Rozycka (1978) assessed the proximate composition of broiler litters, viz., straw, saw dust, straw and peat moss mixture, straw and saw dust mixture and straw-sawdust-peat moss mixture and found that dry matter of litter materials after eight weeks decreased from 94-95 per cent to 67-78 per cent; crude protein increased from 1-3 per cent to 20-25 per cent of dry matter. They also reported that crude fibre content of sawdust decreased from 56 to 36 per cent and that of straw from 42 to 23 per cent.

Jones and Hagler (1982) in their study using fresh and reused hardwood sawdust as litter materials for broilers upto six weeks of age reported that the ash value increased from 15.43 per cent to 17.26 per cent in fresh litter. Their study also revealed that litter ash content decreased from 14.68 per cent to 13.33 per cent in reused litter.

Adeleye and Kitts (1983) analysed the chemical composition of wood shavings used as broiler litter and found that some chemical constituents such as crude protein, ash and uric acid nitrogen increased as age advanced.

McClure and Fontenot (1987) reported that per cent crude protein averaged 26.3 and 31.8 in litter materials used for raising turkey and broilers respectively.

Egana *et al.* (1989) reported that poultry litter contained 75 per cent dry matter, 23.5 per cent crude protein and 21.8 per cent ash.

Ali *et al.* (1995) reported proximate composition of dried poultry manure as 24.5 per cent crude protein, 1.2 per cent ether extract, 10.2 per cent crude fibre, 31.1 per cent nitrogen free extract and 33.0 per cent total ash.

Bagley *et al.* (1996) found that the ash, protein and nutrient content of broiler litter increased with age.

Livability

Oliveira *et al.* (1974) reported that litter type did not influence mortality in broilers. They used six types of litter materials including wood shavings and rice hull.

Carter *et al.* (1979) reported non significant effect in mortality for broilers reared on litter materials like green wood chip litter from standing pine, hardwood trees and an equal mixture of pine and hardwood.

Chaloupka *et al.* (1980) reared broilers on shredded newspaper and hardwood saw dust and found that the mortality was not influenced significantly at 28 as well as 49 days of age.

Malone *et al.* (1982) studied the suitability of recycled paper products as broiler litter by comparing with hardwood saw dust and observed no significant influence on mortality.

Sundaresan (1984) studied the influence of season, stocking density and litter material on broiler performance by rearing broilers on paddy husk wood shavings and groundnut shell and found that the per cent mortality was unaffected by litter material.

Parsons and Baker (1985) compared soft wood chipping fines and pine shavings as broiler litter. He reported higher mortality in broilers reared on softwood chipping fines than those on pine shavings.

Al-Zubaidy *et al.* (1986) reared broilers on wood shavings, rice hulls, chopped papyrus, an equal mixture of wood shavings and rice hull and an equal mixture of wood shavings and chopped papyrus and concluded that mortality was not affected by the type of litter materials.

Kassed and Coleman (1989) found that type of litter had no significant effect on mortality when broilers were reared on dehydrated poultry waste and wood shavings as litter materials.

Andrews *et al.* (1990) found out that percentage mortality was least in broilers reared on rice hull litter floor than those on other three types of raised floors.

Malone *et al.* (1990) evaluated the performance of broilers reared on different litter materials like fresh pine, saw dust and kenaf plant core and reported that litter type had no significant effect on mortality.

Quinones *et al.* (1990) reared broilers on zeolite, sugar mill ashes and rice hulls as litter materials. They reported that the livability percentages was not affected by different litter materials.

Ranade and Rajmane (1990) found no significant difference in mortality among starter chicks reared on wood shavings, paper cuttings, chopped hay, fine sand and rice husk as litter material.

Lien *et al.* (1992) studied the suitability of recycled paper chips and pine shavings as litter material for rearing broilers and found that mortality was not influenced by litter materials.

Wyatt and Goodman (1992) evaluated recycled sheetrock and fir wood shavings as litter materials for broilers and found that litter material had no significant influence on mortality.

Burke *et al.* (1993) found that livability in broilers was not effected by different litter material. They reared broilers on different litter materials, viz., wood shavings, wood shavings mixed with shredded newspaper, shavings layered over paper and paper layered over shavings.

Mizubuti *et al.* (1994) compared the performance of broilers on rice husk litter and purpureum grass litter and stated that litter type had no significant effect on viability.

Malone and Gedamu (1995) reported no significant difference in mortality for broilers reared in fresh pine saw dust and pelleted newspaper as litter materials.

Martinez and Gernat (1995) studied the effect of chopped computer and bond paper mixed with wood shavings as litter materials on broiler performance and stated that livability was not influenced by litter materials.

Anizuzzaman and Chowdhury (1996) reared broilers on four types of litter, viz., saw dust, paddy straw, sand and rice husk and found that livability was not significantly affected by different litter materials.

Narahari and Venukopalan (1996) carried out studies in broilers using litter materials, viz., paddy husk (control) and all dried and fallen leaves of casuarina claudode, neem,

rain tree and subabul upto six weeks of age reported that litter material did not significantly effect mortality of broilers.

Angelo *et al.* (1997) reared broilers on different litter materials, viz., wood shavings, rice husks, brachiaria hay, Napier grass and Coast Cross hay and reported the mortality as 5.10, 4.90, 4.10, 3.31 and 3.59 per cent respectively. They found that there was no significant difference between the different litter materials in mortality.

Wills *et al.* (1997) reported that broiler mortality was not influenced by litter materials after evaluating leaves as litter material.

Shakila and Naidu (1998) carried out an experiment to find the suitability of groundnut hulls, paddy husk, saw dust and chopped straw as litter materials for broilers and reported mortality percentage of 6.66, 4.44, 8.88 and 6.66 respectively, and these being comparable.

Cost benefit analysis

Sundaresan (1984) studied the influence of season, stocking density and litter material on broiler performance by rearing broilers on paddy husk, wood shavings and ground nut shell. He stated that the cost and returns for purebred broilers reared on three litters, two stocking densities under

four seasons showed the profit per bird as 0.39, 0.12, 0.49, 0.19 and 0.43 and 0.56 Re. respectively for the high and low density groups of paddy husk, wood shavings and groundnut shell litters whereas with commercial broilers the profit per bird was 3.98, 5.97; 5.15, 5.59 and 4.80 and 5.57 Rs. respectively for the summer and south west monsoon season.

Poyraz *et al.* (1990) reared broilers on wood shavings, rice hull and shredded paper litters for five consecutive forty nine-day production period and reported that the production indices were highest for broilers reared on rice hull litter.

Chavan *et al.* (1993) reared broilers on saw dust, rice husk, sea sand and chopped dry grass to explore the possibility of utilization of these materials as poultry litter and reported that the average cost of rearing each broiler for eight weeks of age on saw dust, rice husk, sea sand and chopped dry grass deep litters were 27.08, 26.40, 24.49 and 26.62 Rs. respectively. However, the average cost per kilogram live weight gain was the highest for broilers raised on sea sand (Rs.17.81) followed by saw dust (Rs.17.59), chopped dry grass, (Rs.17.39) and rice husk (Rs.16.61), and these differences were found to be non significant.

Narahari and Venukopalan (1996) carried out studies in broilers using litter materials, viz., paddy husk (control)

and all dried and fallen leaves of casuarina claudode, neem, rain tree and subabul upto six weeks of age and reported that litter materials did not differ for cost of production per bird.

Materials and Methods

MATERIALS AND METHODS

An experiment was designed and carried out at the Department of Poultry Science, College of Veterinary and Animal Sciences, Mannuthy to evaluate the efficacy of different litter materials on the performance of broilers. The study was carried out during the period from January to March 1998.

Two hundred and ten, one-day old straight - run broiler chicks (Cobb) were procured from a commercial hatchery for the study. The chicks were wing banded, weighed individually and allotted randomly to the different treatment groups and replicates as detailed below:

Treatment groups	Type of litter materials used	No. of replicates	No. of birds per replicate
T_1	Wood shavings	3	14
T_2	Saw dust	3	14
T_3	Rice husk	3	14
T_4	Coir pith	3	14
T_5	Paddy chaff	3	14

The allotment of chicks to the different treatment groups and replicates was made in such a way that the weight of the

chicks within a group as well as between groups were reasonably similar. The chicks were reared under deep litter system of rearing. In the first treatment group, wood shavings was used as litter material which formed the control group (T_1). In the other treatment groups, sawdust (T_2), rice husk (T_3), coir pith (T_4) and paddy chaff (T_5) were used as litter materials. Each treatment group consisted of three replicates of 14 birds each.

The experimental shed was cleaned and disinfected three days before the commencement of the experiment. The litter materials used were weighed and spread to a thickness of 8 cm in each pen. For each chick a floor space of 925 sq cm was allotted. In each pen litter was stirred once a week. From each pen, five litter samples were collected, one each from four corners and one from the middle of the pen, at the end of each week for further studies.

The chicks were brooded for a period of three weeks of age. Thereafter light was provided to enhance feed intake during night hours. The chicks were reared under standard managemental condition upto eight weeks of age. They were protected against Ranikhet Disease and Infectious Bursal disease.

Chicks were provided with broiler starter ration till six weeks of age and afterwards finisher ration till the end of eight weeks of age. Both the rations were formulated as per

BIS (1992) specification of nutrients for broiler chicken. The ingredient composition of diets is presented in Table 1. The proximate analysis of the ration was carried out according to the procedure described in AOAC (1990). The chemical composition of diets is presented in Table 2.

The production performance of the birds was recorded for a period of eight weeks. The following observations were recorded during the experimental period.

1. Meteorological parameters

Daily recording of temperature and humidity inside the house was done to assess the influence of the microenvironment on the litter condition. The dry bulb and wet bulb thermometer readings were taken at 8 AM and 2 PM daily. The maximum and minimum temperatures were recorded on all days. From these data, period-wise maximum and minimum temperatures and per cent relative humidity were arrived at.

2. Body weight

The body weight of individual birds was recorded at fortnightly intervals from day-old to study the pattern of body weight gain for broilers reared on different litter materials.

3. Feed intake

Quantity of feed issued to each replicate and balance feed on the last day of each week were recorded. From this data, the average feed intake per bird per week was calculated for each treatment group.

4. Feed efficiency

Feed conversion efficiency was calculated at fortnightly intervals based on the data on kilogrammes of feed consumed per kilogramme of body weight.

5. Processing yields and losses

At the end of the eighth week three birds from each replicate were taken at random to study the processing yields and losses. The birds were fasted for 12 hours and killed by modified Kosher's method.

The jugular vein was severed just below the ear and bled for two minutes. The birds were weighed after bleeding to find out the weight of blood. Thereafter they were scalded and defeathered by using mechanical feather plucker. The pin feathers were removed using pinning knife. Singeing was done to remove hair like structures. Head and shanks were removed. Then the evisceration was done. The gizzard was sliced and the inner lining and contents were removed. Gall bladder was removed carefully from the liver. The weight of giblets, ie.

the weight of liver, heart and gizzard was recorded. The eviscerated weight was then recorded and ready-to-cook weight was calculated by adding eviscerated weight and weight of giblets.

6. Weight of the litter

Total weight of the litter materials in each replicate was recorded using a platform balance at the beginning and end of the experiment.

7. Moisture content of the litter

Moisture content of litter materials in each replicate at the beginning of the experiment and at weekly intervals was estimated by drying the samples to a constant weight in a hot air oven.

8. Ammonia-nitrogen content in the litter

Ammonia-nitrogen of litter materials was estimated at fortnightly intervals using MicroKjeldahl method as per AOAC (1990).

9. Estimation of nitrogen, phosphorus and potassium content of the litter

Nitrogen content was estimated using MicroKjeldahl method as outlined by Jackson (1958).

Phosphorus content was estimated by Vanedomolbydo-phosphoric yellow colour method as per the method suggested by Jackson (1958).

Potassium content of the litter was estimated by Flame Photometry as per the method suggested by Jackson (1958).

10. pH of the litter

The pH of the litter material was recorded at weekly intervals with the help of digital pH meter.

11. Proximate composition of the litter

Proximate composition of litter materials used in each replicate at the beginning, sixth week and at the end of the experiment was carried out as per method outlined in AOAC (1990).

12. Livability

The mortality of birds in the different treatment groups was recorded during the experimental period and the livability was worked out. Post mortem examination was carried out to determine the causes of death.

13. Cost-benefit analysis

Costs for rearing of broilers in each treatment were calculated based on body weight attained and recurring expenditure at sixth week and eighth week.

14. Statistical analysis

The data collected on various parameters were statistically analysed as per the method of Snedecor and Cochran (1985).

Table 1. Percentage ingredient composition of broiler rations

Sl. No.	Ingredients	Starter	Finisher
1.	Yellow maize	44.00	53.00
2.	Groundnut cake (expeller)	32.00	26.00
3.	Gingelly oil cake	3.00	-
4.	Unsalted dried fish	9.00	8.00
5.	Rice polish	10.00	11.00
6.	Common salt	0.25	0.25
7.	Mineral mixture[1]	1.75	1.75
	Total	100.00	100.00
	Added per 100 kg of feed		
8.	Vitamin mixture (g)[2]	10	10
9.	Lysine hydrochloride (g)	200	100
10.	Choline chloride (g)	100	100
11.	Coccidiostat (g)[3]	50	50
12.	Methionine (g)	150	150

1. Mineral mixture composition

   Calcium 32%, phosphorus 6%, magnesium 1000 ppm, cobalt 60 ppm, zinc 2600 ppm, iron 0.1%, iodine 100 ppm, copper 100 ppm, manganese 2700 ppm.

2. Vitamin mixture (INDOMIX) composition

   Each gram contains: vitamin A 82,500 IU, vitamin B_2 50 mg, vitamin D_2 12,000 IU and vitamin K 10 mg.

3. Coccidiostat (SUPER DOT) composition

   Each gram contains: Dinitrotoluamide 250 mg and Ethopabate 16 mg

Table 2. Percentage proximate composition of nutrients in broiler rations (on dry matter basis)

Sl. No.	Ingredients	Starter	Finisher
1.	Moisture	9.48	9.43
2.	Crude protein	23.38	20.26
3.	Ether extract	6.32	6.53
4.	Crude fibre	4.52	4.43
5.	Nitrogen free extract	54.32	57.21
6.	Total ash	11.46	11.57
7.	Acid insoluble ash	2.11	2.14
8.	Calcium	1.43	1.36
9.	Phosphorus	0.76	0.69
Calculated value			
	Metabolisable energy (kcal/kg)	2810	2915

Results

RESULTS

An experiment was conducted to evaluate the efficacy of different litter materials for rearing broilers for a period of eight weeks. The results obtained in the study are presented in this chapter.

Meteorological parameters

The data pertaining to microclimate inside the experimental house regarding the mean maximum and minimum temperature (°C) and per cent relative humidity during the experimental period from January to March 98 are presented in Table 3 and graphically represented in Figure 1 and 2 respectively. During the experimental period the maximum temperature ranged from 36.86 to 38.86°C with an overall mean of 37.81°C and minimum temperature from 22.29 to 24.29°C with an overall mean of 23.23°C. The per cent relative humidity in the morning varied from 71.00 to 82.14 with an overall mean of 77.41, while in the afternoon it ranged from 35.57 to 55.29 with an overall mean of 45.97.

Body weight

Individual body weight of broiler chicks was recorded at day old and subsequently at fortnightly intervals and the data are presented in Table 4 and graphically represented in Fig.3.

Table 3. Mean weekly meteorological parameters recorded in the experimental house (January to March, 1998).

Period (weeks)	Temperature (°C)		Relative humidity (%)	
	Maximum	Minimum	8 a.m.	2 p.m.
1	37.00	22.29	78.71	50.29
2	37.86	23.43	76.29	48.43
3	38.57	22.71	78.29	47.57
4	37.86	23.00	71.00	40.00
5	37.29	22.86	78.43	52.00
6	36.86	23.86	77.43	55.29
7	38.86	24.29	77.00	35.57
8	38.14	23.43	82.14	38.57
Overall mean	37.81	23.23	77.41	45.97

Fig.1 MEAN MAXIMUM & MINIMUM TEMPERATURE(°C)
IN THE EXPERIMENTAL HOUSE

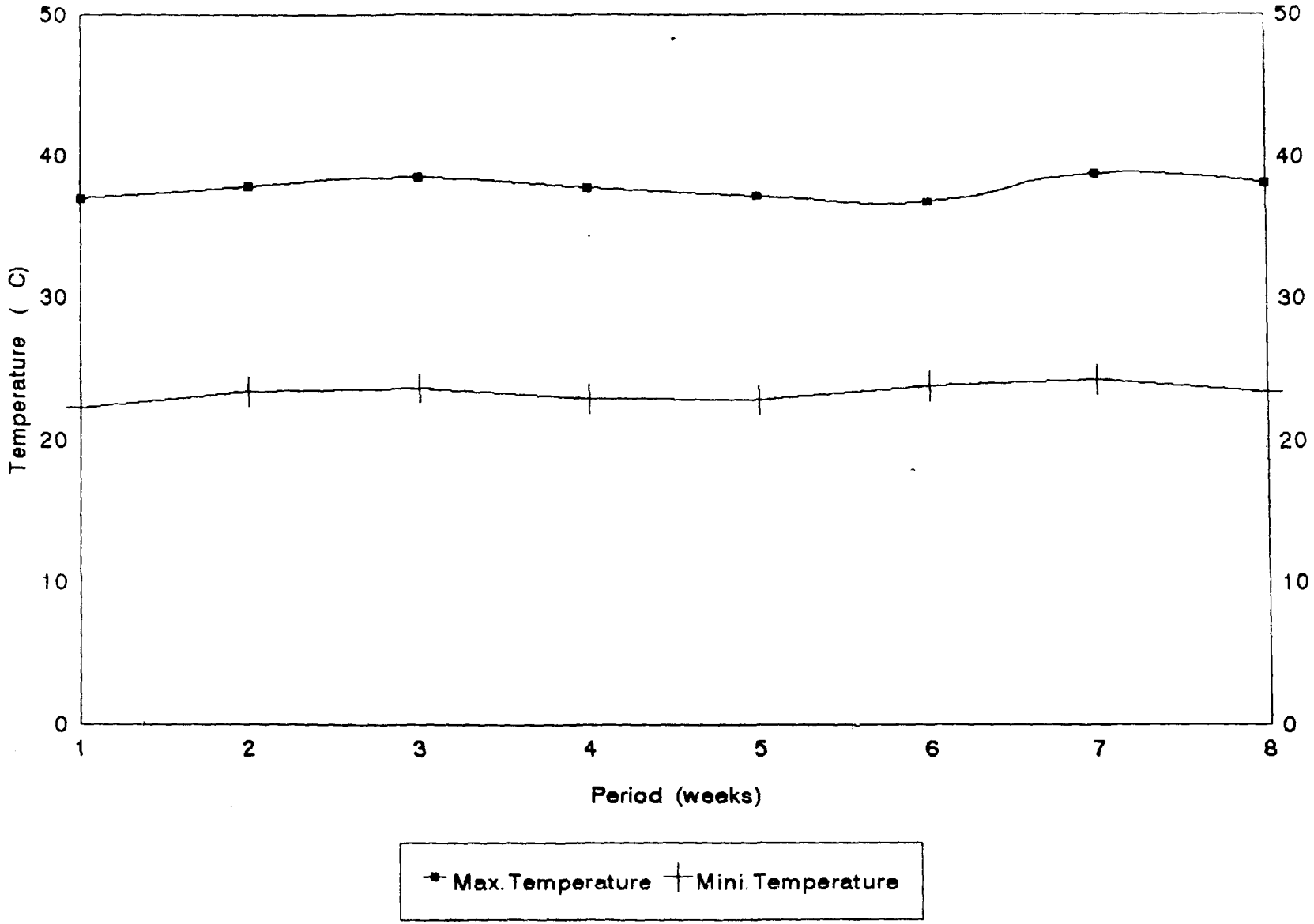
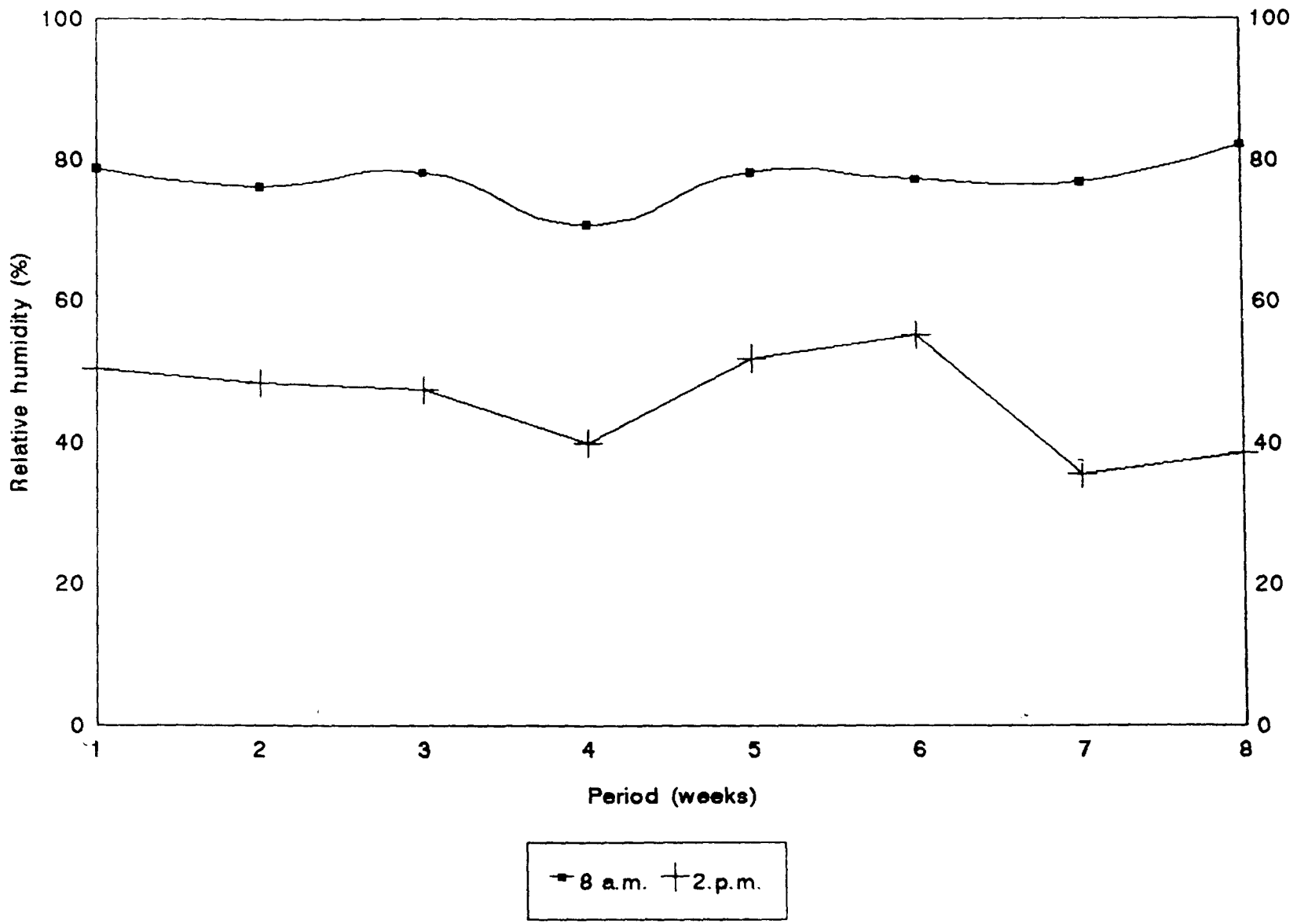


Fig.2 MEAN RELATIVE HUMIDITY (%)
IN THE EXPERIMENTAL HOUSE



The mean day-old body weights of broiler chicks for different treatments viz., T_1, T_2, T_3, T_4 and T_5 were 43.67, 42.73, 42.90, 44.20 and 43.57 g respectively with an overall mean of 43.44 g. Statistical analysis of the data does not reveal any significant difference.

Data on mean body weights recorded at second week of age for treatments T_1, T_2, T_3, T_4 and T_5 were 271.33, 263.83, 264.97, 269.10 and 258.43 g with an overall mean 262.52 g and there was statistically no difference among different treatments.

At fourth week of age the mean body weights recorded for treatments T_1, T_2, T_3, T_4 and T_5 were 697.77, 685.47, 681.87, 725.60 and 679.13 g respectively with an overall mean of 693.96 g. Statistical analysis of the data on body weight did not reveal any significant difference, eventhough highest body weight of 725.60 g was recorded in birds reared in group wherein coir pith was used as litter material.

The mean body weights recorded at sixth week of age for treatments T_1, T_2, T_3, T_4 and T_5 were 1384.82, 1430.70, 1371.67, 1421.50 and 1406.43 g respectively with an overall mean of 1403.02 g. The highest body weight of 1430.70 g was recorded in treatment 2 having saw dust as litter material and statistical analysis of the data did not reveal any significant difference.

The mean body weight at eighth week of age were 1954.87, 2051.10, 2013.33, 2016.56 and 2013.83 g respectively for

Table 4. Mean fortnightly body weight (g) of experimental birds as influenced by litter treatments

Treatments	Age in weeks				
	0	2	4	6	8
T_1	43.67	271.33	697.77	1384.82	1954.87
T_2	42.73	263.83	685.47	1430.70	2051.10
T_3	42.90	264.97	681.87	1371.67	2013.33
T_4	44.20	269.10	725.60	1421.50	2016.56
T_5	43.57	258.43	679.13	1406.43	2013.83
Overall mean±SE (NS)	43.44 ±0.475	265.52 ±4.070	693.96 ±18.078	1403.02 ±25.982	2009.93 ±38.298

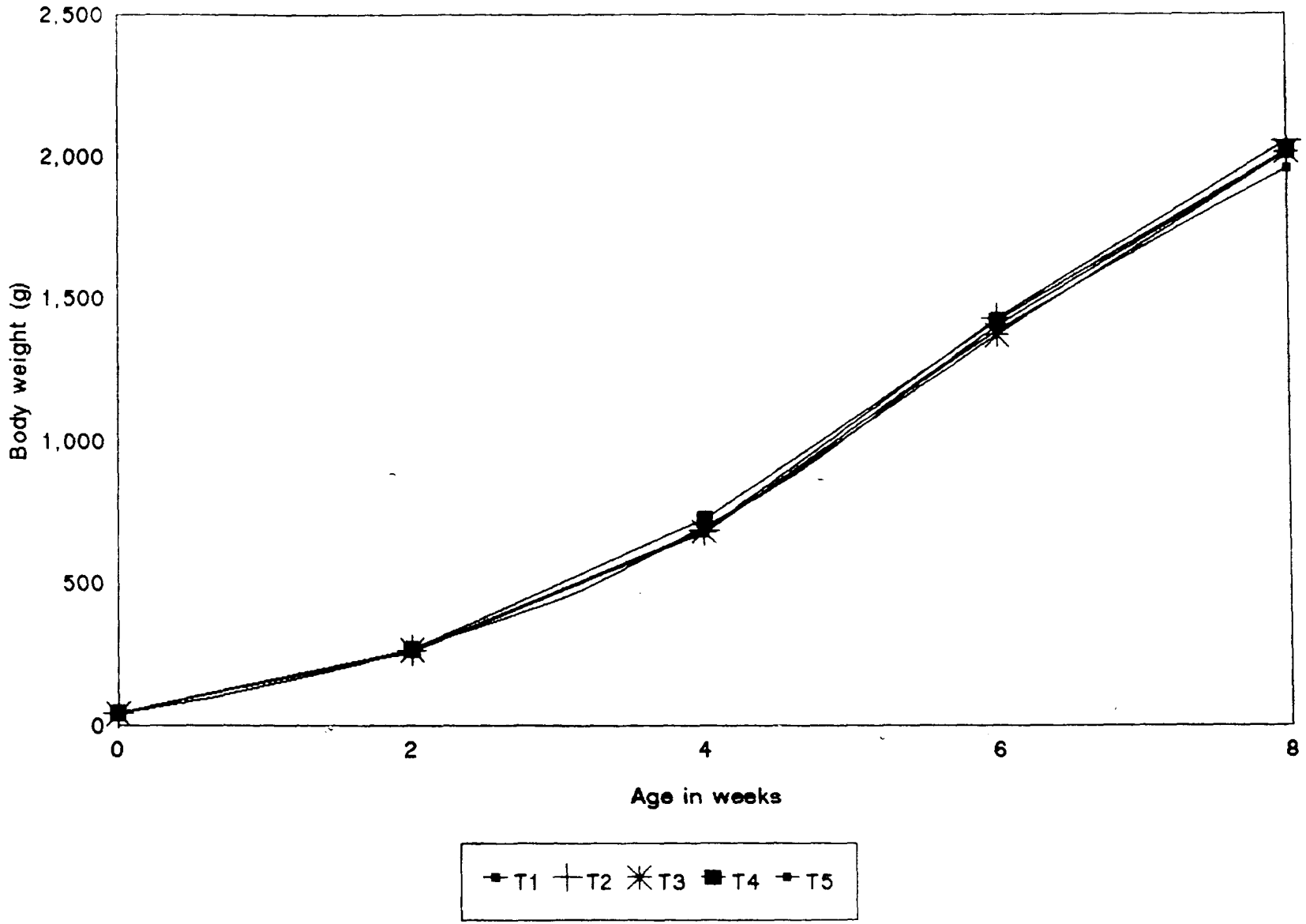
NS - Non-significant

Table 5. Analysis of variance for body weight (g) of experimental birds as influenced by litter treatments

Period (weeks)	Source	df	SS	MSS	F
0	Treatment	4	4.297	1.074	1.267 NS
	Error	10	8.481	0.848	
2	Treatment	4	299.952	74.987	1.445 NS
	Error	10	519.113	51.911	
4	Treatment	4	4361.392	1090.347	0.969 NS
	Error	10	11255.593	1125.558	
6	Treatment	4	7301.221	1825.305	0.693 NS
	Error	10	26354.903	2635.491	
8	Treatment	4	14393.024	2598.255	0.658 NS
	Error	10	54694.061	5469.405	

NS - Non-significant

Fig.3 MEAN FORTNIGHTLY BODY WEIGHT (g) OF EXPERIMENTAL BIRDS AS INFLUENCED BY LITTER MATERIALS



treatments T_1, T_2, T_3, T_4 and T_5 with an overall mean of 2009.93 g. Highest body weight of 2051.10 g was recorded in broilers reared on sawdust as litter material (T_2) and statistical analysis of data did not reveal any significant difference.

Body weight gain

The mean fortnightly body weight gain of broiler chicks reared under different litter treatments from 0-8 weeks of age is presented in Table 6 and graphically represented in Fig.4. Statistical analysis of the data on body weight gain at fortnightly interval is presented in Table 7.

The mean fortnightly body weight gain among the different treatment groups viz., T_1, T_2, T_3, T_4 and T_5 were 227.67, 221.10, 222.07, 224.90 and 214.80 g respectively with an overall mean of 222.10 g during the second week of age. Statistical analysis of the data indicated that different litter treatments did not influence body weight gain.

At fourth week of age, the body weight gain recorded for the treatments T_1, T_2, T_3, T_4 and T_5 were 426.43, 421.63, 416.90, 446.50 and 420.70 g respectively with an overall mean of 426.43 g. Statistical analysis of the data indicated that different litter treatments did not influence body weight gain.

At sixth week of age, maximum body weight gain was recorded in all the treatment groups. Among the different treatment groups, maximum body weight gain, eventhough statistically not

Table 6. Mean fortnightly body weight gain (g) of experimental birds as influenced by litter treatments

Treatments	Period in weeks			
	0-2	3-4	5-6	7-8
T_1	227.67	426.43	687.05	570.05
T_2	221.10	421.63	745.23	620.40
T_3	222.07	416.90	689.80	641.67
T_4	224.90	446.50	695.63	595.05
T_5	214.80	420.70	727.30	607.40
Overall mean±SE (NS)	222.10 ±4.065	426.43 ±16.199	709.00 ±32.284	606.91 ±36.713

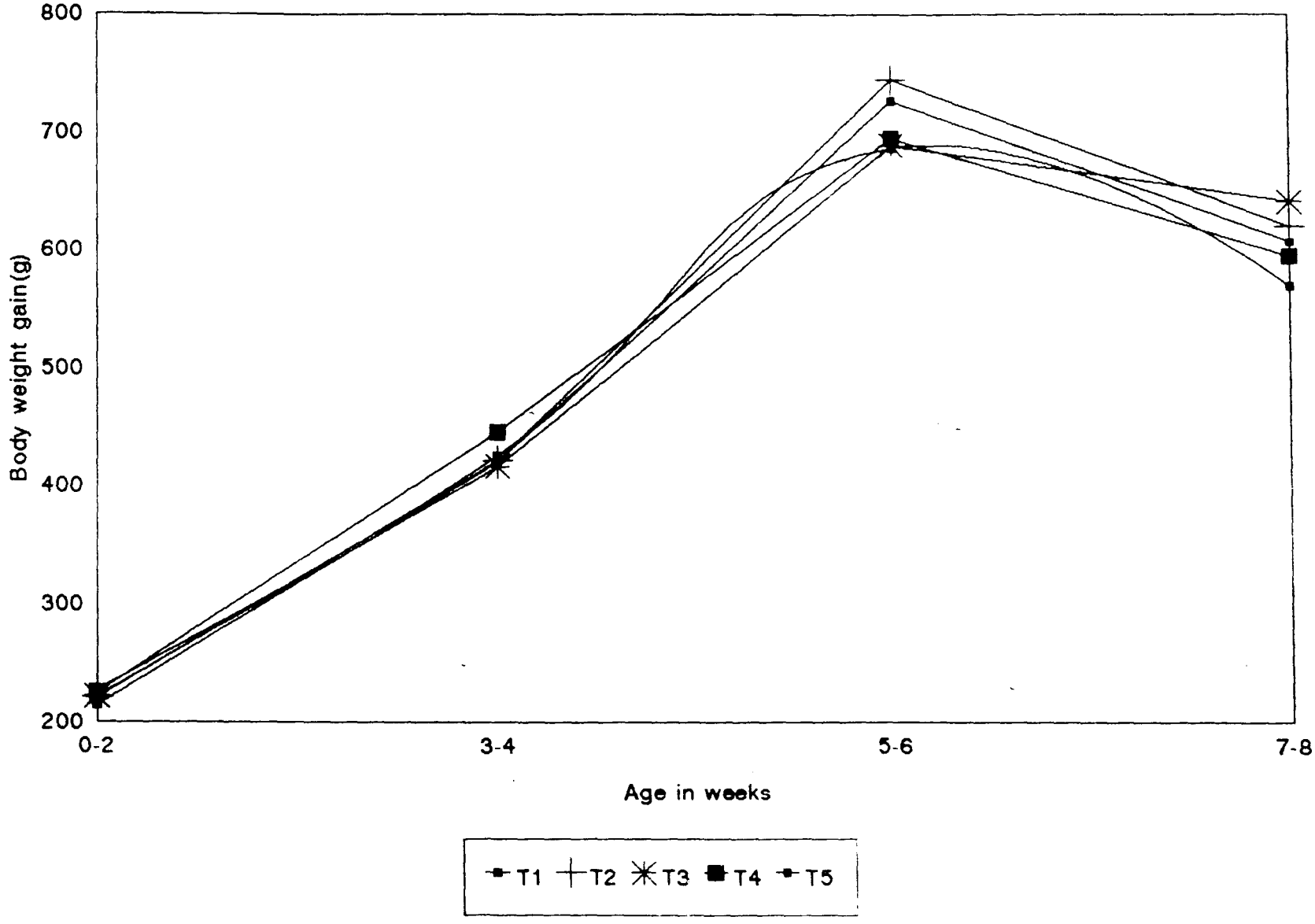
NS - Non-significant

Table 7. Analysis of variance for mean fortnightly body weight gain (g)

Period (weeks)	Source	df	SS	MSS	F
0-2	Treatment	4	279.356	69.839	1.370 NS
	Error	10	509.653	50.965	
3-4	Treatment	4	1648.40	412.10	0.361 NS
	Error	10	11424.311	1142.431	
5-6	Treatment	4	8030.561	2007.64	0.545 NS
	Error	10	36843.318	3684.332	
7-8	Treatment	4	8668.218	2167.055	0.307 NS
	Error	10	70480.127	7048.013	

NS - Non-significant

Fig.4 MEAN FORTNIGHTLY BODY WEIGHT GAIN (g) OF EXPERIMENTAL BIRDS AS INFLUENCED BY LITTER MATERIALS



significant, was recorded in broilers reared on sawdust litter (T_2). Body weight gain recorded at sixth week of age was 687.05, 745.23, 689.80, 695.63 and 727.30 g for T_1, T_2, T_3, T_4 and T_5 respectively with an overall mean of 709.00 g.

At eight weeks of age, body weight gain showed a decreasing trend. Body weight gain recorded was 570.05, 620.40, 641.67, 595.05 and 607.40 g respectively for treatments T_1, T_2, T_3, T_4 and T_5 with an overall mean of 606.91 g. Statistical analysis of the data showed that variations in body weight gain due to different litter treatments were not statistically significant.

Feed intake

The mean weekly feed intake per bird during the experimental period among different treatment groups are given in Table 8 and graphically represented in Fig.5. Statistical analysis of the data is presented in Table 9.

The mean weekly feed intake per bird among the five treatment groups, viz., T_1, T_2, T_3, T_4 and T_5 were 112.35, 119.93, 139.16, 127.57 and 114.74 g respectively with an overall mean of 122.75 g for the first week. During the second week of age the mean weekly feed intake per bird was 219.75, 241.19, 257.85, 257.07 and 228.86 g respectively for treatments T_1 to T_5 with an overall mean of 240.94 g. The mean weekly feed intake per bird during the third week was 334.57, 297.94, 310.30, 334.03 and 326.50 g respectively for treatments T_1 to T_5 with an overall mean

Table 8. Mean weekly feed intake (g) per bird as influenced by litter materials

Treatments	Age in weeks								
	1	2	3	4	5	6	7	8	Total
	a	c	a	a	a	a	a	a	a
T	112.35	219.75	334.57	469.37	697.73	825.14	837.59	940.03	4436.45
	a	abc	a	a	a	a	a	a	a
T_2	119.93	241.19	297.94	429.45	750.80	893.10	902.50	1004.13	4639.03
	a	a	a	a	a	a	a	a	a
T_3	139.16	257.85	310.30	431.97	683.44	802.30	920.13	1052.33	4598.31
	a	ab	a	a	a	a	a	a	a
T_4	127.57	257.07	334.03	470.14	679.31	798.41	887.90	994.97	4549.79
	a	bc	a	a	a	a	a	a	a
T	114.74	228.86	326.50	466.63	726.37	869.12	916.03	1013.99	4674.23
Overall mean±SE	122.75 ±5.408	240.94 ±8.112	320.66 ±18.590	453.51 ±24.596	707.53 ±34.37	837.61 ±41.256	892.83 ±54.672	1001.09 ±59.182	4579.56 ±106.79
LSD	-	28.58	-	-	-	-	-	-	-

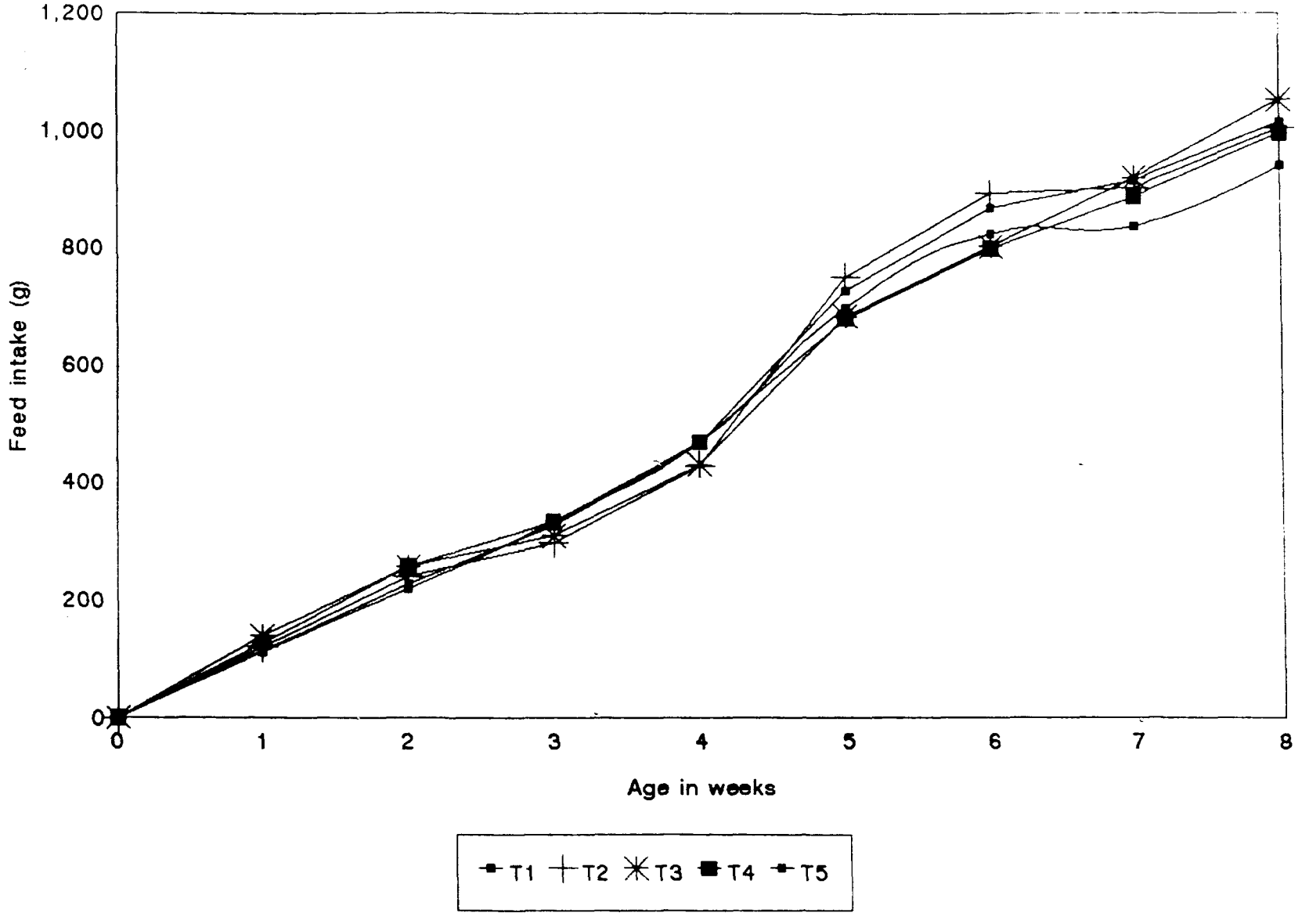
Means bearing the same superscript within the same column do not differ significantly ($P<0.05$)

Table 9. Analysis of variance for mean weekly feed intake per bird

Period (weeks)	Source	df	SS	MSS	F
1	Treatment	4	1499.165	374.791	3.1 NS
	Error	10	1208.968	120.897	
2	Treatment	4	3423.561	855.89	3.481*
	Error	10	2458.87	245.887	
3	Treatment	4	3089.975	722.494	0.505 NS
	Error	10	15305.658	1530.566	
4	Treatment	4	5231.082	1307.771	0.563 NS
	Error	10	23209.674	2320.967	
5	Treatment	4	11099.914	2774.98	0.706 NS
	Error	10	39305.164	3930.516	
6	Treatment	4	21036.956	5259.239	0.927 NS
	Error	10	56714.215	5671.42	
7	Treatment	4	13360.525	3340.131	0.217 NS
	Error	10	153638.313	15363.831	
8	Treatment	4	19700.885	4925.221	0.294 NS
	Error	10	167754.95	16775.495	
Total	Treatment	4	102654.55	25663.637	0.598 NS
	Error	10	429009.213	42900.921	

NS - Non-significant
* Significant at 5% level

Fig.5 MEAN WEEKLY FEED INTAKE PER BIRD (g)
AS INFLUENCED BY LITTER MATERIALS



of 320.66 g. The mean weekly feed intake per bird for treatments T_1 to T_5 were 469.37, 429.45, 431.97, 470.14 and 466.63 g respectively for the fourth week with an overall mean of 453.51 g. At fifth week of age the mean weekly feed intake per bird was 697.73, 750.80, 683.44, 679.31 and 726.37 g respectively for treatments T_1, T_2, T_3, T_4 and T_5 with an overall mean of 707.53 g. During sixth week of age the mean weekly feed intake per bird for the treatments T_1 to T_5 were 825.14, 893.10, 802.30, 798.41 and 869.12 g respectively with an overall mean of 837.61 g. At seventh week of age the mean weekly feed intake per bird was 837.59, 902.50, 920.13, 887.90 and 916.03 g respectively for treatments T_1 to T_5 with an overall mean of 892.83 g. The mean weekly feed intake per bird was 940.03, 1004.13, 1052.33, 944.97 and 1013.99 g respectively for treatments T_1 to T_5 with an overall mean of 1001.09 g for eighth week. The cumulative feed intake was 4436.45, 4639.03, 4598.31, 4549.79 and 4674.23 g respectively for treatments T_1, T_2, T_3, T_4 and T_5 with an overall mean of 4579.56 g.

The analysis of variance of the data on feed intake (Table 9) showed that the weekly feed intake did not significantly differ between the different treatment groups throughout the experimental period except for the second week ($P<0.05$).

Feed efficiency

The mean feed efficiency of broilers reared under different litter materials recorded fortnightly is presented in Table 10 and is graphically represented in Fig.6. Statistical analysis of the data on feed efficiency is presented in Table 11.

The feed efficiency during first fortnight was 1.223, 1.370, 1.500, 1.436 and 1.330 respectively for treatments T_1 to T_5 with an overall mean of 1.371. Statistical analysis of data on feed efficiency during first fortnight (0-2 weeks of age) showed better feed efficiency in control group (T_1) eventhough it is statistically similar to T_3, T_4 and T_5. Broilers reared on rice husk litter had significantly ($P<0.01$) lower feed efficiency during second week, eventhough it is statistically similar to T_2 and T_4.

During second fortnight (3-4 weeks of age) the feed efficiency recorded for the treatments T_1, T_2, T_3, T_4 and T_5 were 1.880, 1.727, 1.780, 1.763 and 1.883 respectively with an overall means of 1.806. Statistical analysis of the data did not reveal any significant difference between the treatments. During third fortnight (5-6 weeks of age) the feed efficiency recorded for T_1, T_2, T_3, T_4 and T_5 were 2.213, 2.210, 2.157, 2.213 and 2.210 respectively with an overall mean of 2.200.

Data on feed efficiency at seven to eight weeks of age for broilers reared under different litter treatments were 3.117,

Table 10. Fortnightly feed efficiency (kg feed/kg body weight) of broilers as influenced by litter materials

Treatments	Period in weeks				
	0-2	3-4	5-6	7-8	Cumulative mean
T_1	a 1.223	a 1.880	a 2.213	a 3.117	a 2.263
T_2	b 1.370	a 1.727	a 2.210	a 3.073	a 2.263
T_3	ab 1.500	a 1.780	a 2.157	a 3.080	a 2.283
T_4	ab 1.436	a 1.763	a 2.213	a 3.167	a 2.253
T_5	a 1.330	a 1.883	a 2.210	a 3.183	a 2.317
Overall mean±SE	1.371 ±0.0496	1.806 ±0.058	2.200 ±0.062	3.124 ±0.041	2.275 ±0.019
LSD	0.1409	-	-	-	-

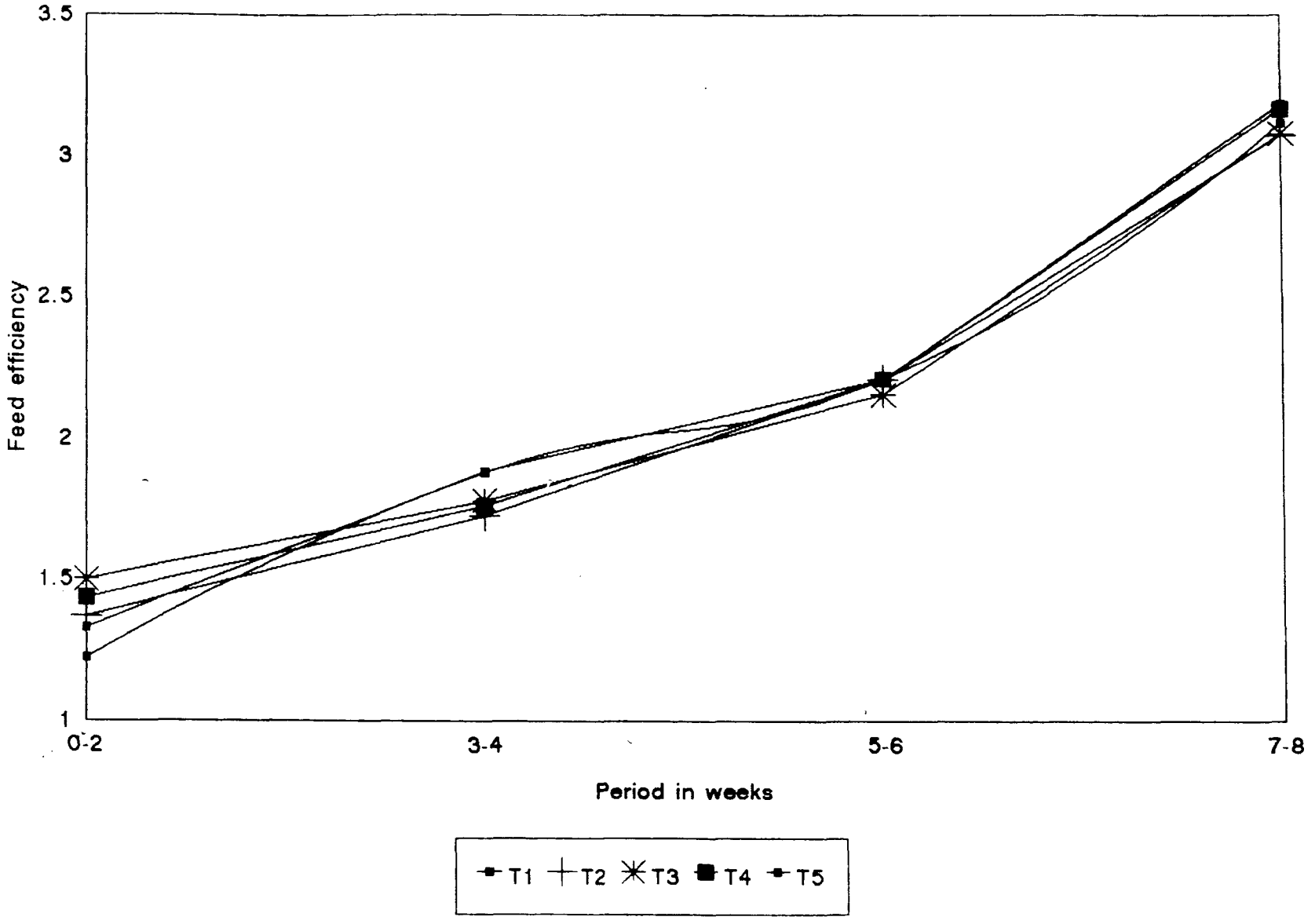
Means bearing the same superscript within the same column do not differ significantly ($P<0.01$)

Table 11. Analysis of variance for feed efficiency

Period (weeks)	Source	df	SS	MSS	F
0-2	Treatment	4	0.131	0.033	5.934 **
	Error	10	0.055	0.006	
3-4	Treatment	4	0.061	0.015	1.293 NS
	Error	10	0.117	0.012	
5-6	Treatment	4	0.019	0.005	0.362 NS
	Error	10	0.129	0.013	
7-8	Treatment	4	0.03	0.007	1.166 NS
	Error	10	0.064	0.006	
Cumulat-ive mean	Treatment	4	0.008	0.002	1.713 NS
	Error	10	0.011	0.001	

NS - Non-significant
** Significant at 1% level

Fig.6 FORTNIGHTLY FEED EFFICIENCY (kg feed / kg body weight) OF BROILERS AS INFLUENCED BY LITTER MATERIALS



3.073, 3.080, 3.167 and 3.183 respectively for treatments T_1 to T_5 with an overall mean 3.124. Statistical analysis of data did not reveal any significant difference between treatments for fourth fortnightly feed efficiency. The cumulative mean feed efficiency for treatments T_1 to T_5 were recorded as 2.263, 2.263, 2.283, 2.253 and 2.317 respectively with an overall mean of 2.275. Statistical analysis of the data on cumulative feed efficiency did not reveal any significant difference for this parameter.

Processing yields and losses

The processing yields and losses recorded in broilers slaughtered at eighth week of age is presented in Table 12 and graphically represented in Fig.7. The statistical analysis of the data (Table 13) revealed that yields and losses due to processing of broilers were not influenced by different litter materials.

The mean per cent blood loss for the treatments T_1 to T_5 were 3.52, 3.91, 3.92, 3.39 and 3.09 respectively and the overall mean per cent blood loss was 3.56.

The mean per cent feather loss for the different treatments T_1 to T_5 were 4.21, 3.28, 3.81, 4.50 and 4.87 respectively with an overall mean of 4.13.

Table 12. Mean processing yields and losses of broilers as influenced by litter materials at eight weeks of age

Treat-ments	Starved body weight (g)	Blood loss (%)	Feather loss (%)	Total loss (%)	Eviscerted yield (%)	Giblet yield (%)	Ready-to cook yield (%)
T_1	2000.03	3.52	4.21	24.41	70.05	5.53	75.59
T_2	2051.12	3.91	3.28	24.78	69.43	5.79	75.17
T_3	1988.87	3.92	3.81	24.11	70.05	5.83	75.89
T_4	1964.47	3.39	4.50	23.19	70.38	5.94	76.32
T_5	2023.33	3.09	4.87	24.34	70.10	5.50	75.63
Overall mean±SE (NS)	2005.56 ±38.764	3.56 ±0.234	4.13 ±0.127	24.17 ±0.252	70.00 ±0.252	5.71 ±0.021	75.72 ±0.018

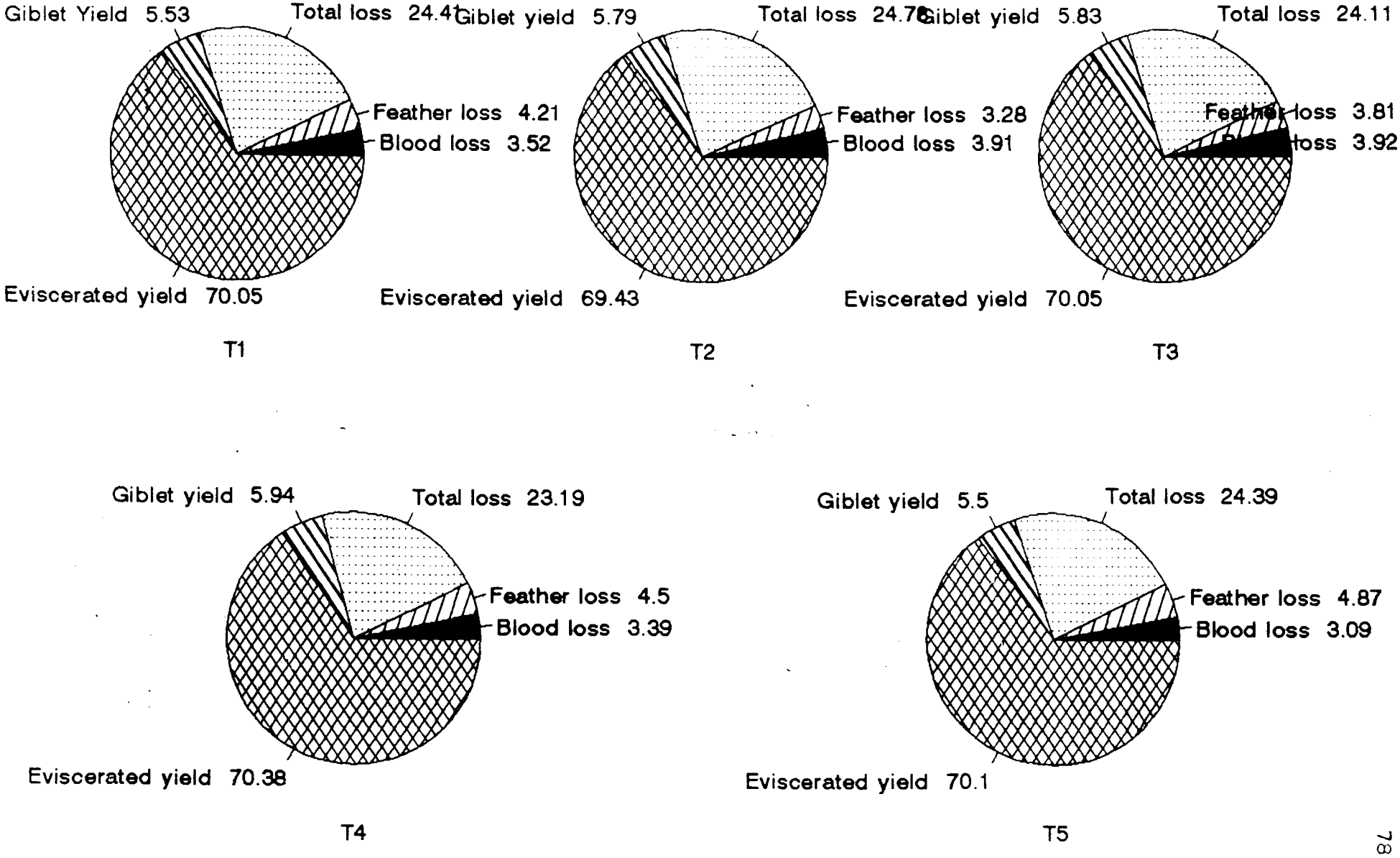
NS - Not significant

Table 13. Analysis of variance for mean processing yields and losses of broilers at eight weeks of age

Yields and losses	Source	df	SS	MSS	F
Starved body weight (g)	Treatment	4	13162.98	3290.745	0.611 NS
	Error	10	53860.204	5386.02	
Blood loss (%)	Treatment	4	0.100	0.025	0.503 NS
	Error	10	0.499	0.05	
Feather loss (%)	Treatment	4	0.311	0.078	1.418 NS
	Error	10	0.549	0.055	
Total loss (%)	Treatment	4	1.463	0.366	0.945 NS
	Error	10	3.87	0.387	
Eviscerated yield (%)	Treatment	4	1.463	0.366	0.945 NS
	Error	10	0.87	0.387	
Giblet yield (%)	Treatment	4	0.019	0.005	2.665 NS
	Error	10	0.018	0.002	
Ready-to-cook yield (%)	Treatment	4	0.007	0.002	1.114 NS
	Error	10	0.016	0.002	

NS - Non-significant

Fig.7 MEAN PROCESSING YIELDS AND LOSSES (%) OF BROILERS AS INFLUENCED BY LITTER MATERIALS AT EIGHT WEEKS OF AGE



The total losses during processing for the treatment groups T_1 to T_5 averaged 24.41, 24.78, 24.11, 23.19 and 24.34 per cent respectively and the overall mean being 24.17.

The mean per cent eviscerated yield at eight weeks of age for broilers reared on treatments T_1 to T_5 were 70.05, 69.43, 70.05, 70.38 and 70.10 respectively with an overall mean of 70.00.

The mean per cent giblet yield at eighth week for broilers on treatments T_1 to T_5 were 5.53, 5.79, 5.83. 5.94 and 5.50 respectively with an overall mean of 5.71.

The mean per cent ready-to-cook yield for broilers at eight weeks of age were 75.59, 75.17, 75.89, 76.32 and 75.63 for treatments T_1 to T_5 respectively and the overall mean per cent ready-to-cook yield was 75.72.

Mean weight (kg) of the litter at the beginning and end of the experiment

The mean weight of the litter materials at the beginning and end of the experiment are presented in Table 14 and graphically represented in Fig.8.

The mean weight of the different treatment groups, viz., T_1, T_2, T_3, T_4 and T_5 were 14.00, 30.00, 16.67, 8.75 and 33.50 kg respectively at the beginning of the experiment with an overall mean of 20.58 kg. At eighth week, the mean weight of the used

Table 14. Mean weight (kg) of the litter materials at the beginning and end of the experiment

Treatments	Weight of the litter at the beginning	Weight of the litter at the end
T_1	14.00 d	58.40 c
T_2	30.00 b	75.71 b
T_3	16.67 c	60.27 c
T_4	8.75 e	52.65 d
T_5	33.50 a	80.20 a
Overall mean±SE	20.58 ±0.290	65.44 ±1.186
LSD	0.9609	3.586

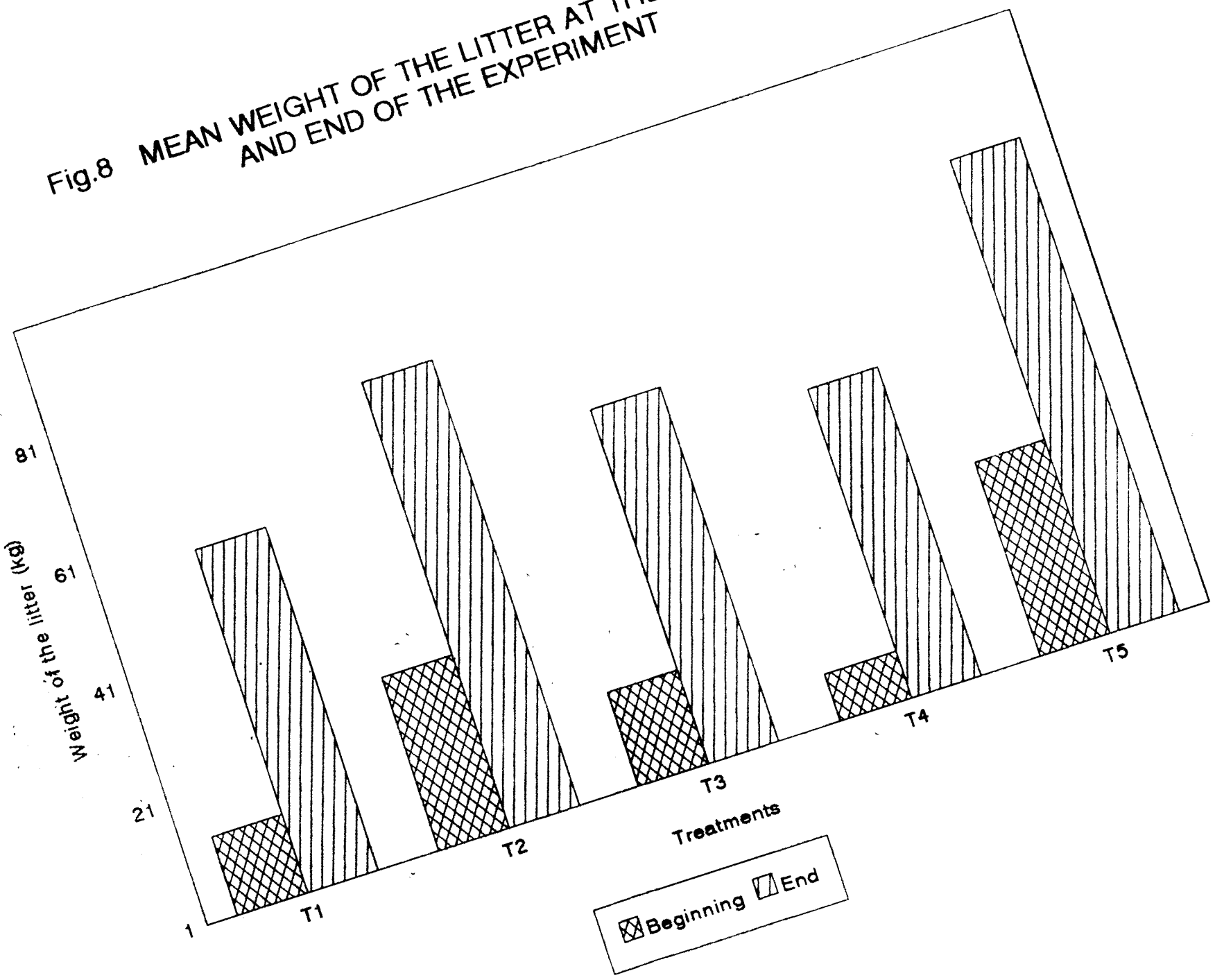
Means bearing the same superscript within the same column do not differ significantly ($P<0.01$)

Table 15. Analysis of variance for mean weight of the litter materials (kg) at the beginning and end of the experiment

Period	Source	df	SS	MSS	F
Beginning	Treatment	4	1689.513	422.378	108.698 **
	Error	10	38.858	3.886	
End	Treatment	4	1362.667	340.667	1220.299 **
	Error	10	2.792	0.279	

** Significant at 1% level

Fig.8 MEAN WEIGHT OF THE LITTER AT THE BEGINNING AND END OF THE EXPERIMENT



litter were 58.40, 75.71, 60.27, 52.65 and 80.20 kg respectively for treatments T_1 to T_5 with an overall mean of 65.44 kg.

The analysis of variance (Table 15) for the fresh litter at the beginning of the experiment revealed a highly significant difference ($P<0.01$) between litter materials. Treatment group which used paddy chaff as litter material had significantly higher weight and group which used coir pith aslitter material had significantly lower weight. The statistical analysis for the mean weight of the litter at the end of the experiment also showed significant difference ($P<0.01$) among the different treatment groups.

Litter moisture content

The mean per cent moisture content of five different litter materials was recorded at the beginning of the experiment and at weekly intervals and is presented in Table 16 and graphically represented in Fig.9. Statistical analysis of the data on weekly moisture content of the different litter materials is presented in Table 17.

The initial mean per cent moisture content of litter materials, viz., wood shavings, sawdust, rice husk, coir pith and paddy chaff were 8.93, 8.83, 6.11, 12.44 and 7.33 respectively with an overall mean of 8.72 per cent. Statistical analysis of the data revealed significant difference ($P<0.01$) between different treatments. The initial moisture content of wood

shavings (T_1) and saw dust (T_2) was found similar. Rice husk litter (T_3) had significantly ($P<0.01$) lower moisture content (6.11 per cent) than that of other groups. Paddy chaff (T_5) also had lower initial moisture content (9.33 per cent) and is significantly ($P<0.01$) different from other groups. The initial moisture content of coconut pith (T_4) was significantly ($P<0.01$) higher (12.44 per cent) than that of other groups.

At the end of first week the same trend in moisture content was noticed in all the treatment groups. The per cent moisture content for the treatments T_1 to T_5 were 9.67, 9.77, 6.87, 13.23 and 8.15 per cent respectively with an overall mean 9.53 per cent and coir pith (T_4) contained significantly ($P<0.01$) higher moisture content than that of other groups.

At the end of second week the mean per cent moisture content for the different treatment groups, viz., T_1 to T_5 were 10.69, 10.60, 7.35, 14.55 and 8.62 respectively with an overall mean 10.36 per cent. Statistical analysis of the data on per cent moisture content revealed significant difference ($P<0.01$) between treatments. Mean per cent moisture content was higher for the treatment group (T_4) having coir pith as litter material.

During third week of the experiment the mean per cent moisture content for all the treatments showed an increasing trend. The per cent moisture content for the treatment which used coir pith as litter material had significantly ($P<0.01$) higher moisture content and T_3 (rice husk) had significantly

Table 16. Mean weekly per cent moisture content in the litter material

Treatments	Period in weeks								
	0	1	2	3	4	5	6	7	8
T_1	b 8.93	b 9.67	b 10.69	b 12.41	b 15.23	b 21.42	b 25.77	b 29.33	b 34.66
T_2	b 8.83	b 9.77	b 10.60	b 11.56	b 13.96	c 15.94	d 20.23	c 25.20	c 26.79
T_3	d 6.11	d 6.87	d 7.35	c 8.50	c 10.07	c 16.37	c 22.67	bc 26.82	c 29.03
T_4	a 12.44	a 13.23	a 14.55	a 16.30	a 26.33	a 31.45	a 37.32	a 47.03	a 54.43
T_5	c 7.33	c 8.15	c 8.62	c 9.02	c 11.33	c 17.34	bc 24.30	bc 27.87	b 32.21
Overall mean±SE	8.72 ±0.041	9.53 ±0.036	10.36 ±0.045	11.55 ±0.036	15.38 ±0.043	20.50 ±0.559	26.05 ±0.488	31.25 ±0.712	35.42 ±0.841
LSD	0.129	0.1151	0.1522	0.1409	0.3452	1.92	1.677	2.456	2.781

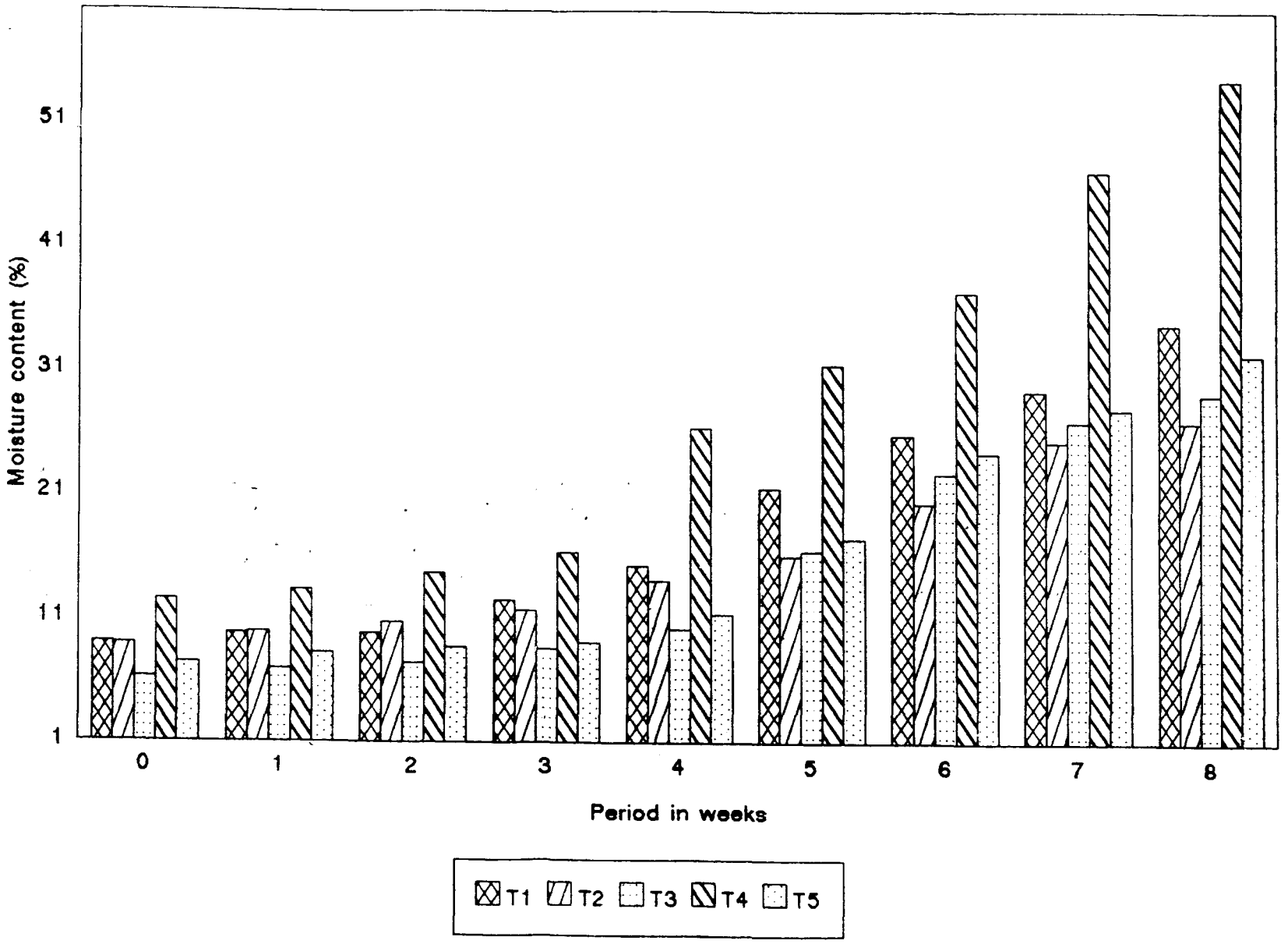
Means bearing the same superscript within the same column do not differ significantly ($P<0.01$)

Table 17. Analysis of variance for mean weekly moisture content of the litter materials

Period (weeks)	Source	df	SS	MSS	F
0	Treatment	4	1.847	0.462	95.814 **
	Error	10	0.048	0.005	
1	Treatment	4	1.735	0.434	109.345 **
	Error	10	0.04	0.004	
2	Treatment	4	2.084	0.521	78.785 **
	Error	10	0.066	0.007	
3	Treatment	4	2.432	0.608	108.917 **
	Error	10	0.056	0.006	
4	Treatment	4	6.99	1.747	48.848 **
	Error	10	0.358	0.036	
5	Treatment	4	235.242	58.810	52.790 **
	Error	10	11.14	1.14	
6	Treatment	4	211.978	52.995	62.352 **
	Error	10	8.199		0.85
7	Treatment	4	632.039	90.51	49.639 **
	Error	10	18.234	1.823	
8	Treatment	4	1462.461	365.615	156.432 **
	Error	10	23.372	2.337	

** Significant at 1% level

Fig.9 MEAN WEEKLY PER CENT MOISTURE CONTENT IN THE LITTER MATERIALS



($P<0.01$) lower moisture content than that of other treatment groups. The moisture content for the treatments T_1 to T_5 were 12.41, 11.56, 8.50, 16.30 and 9.02 per cent respectively with an overall mean of 11.55 per cent.

During fourth week also the moisture content of all the litter materials showed an increasing trend. The moisture content for the treatments T_1 to T_5 were 15.23, 13.96, 10.07, 26.33 and 11.33 per cent respectively with an overall mean of 15.38 per cent. The treatment group which used coir pith as litter material had significantly ($P<0.01$) higher moisture content. The groups in which rice husk was the litter material (T_3) had lower moisture content (10.07 per cent) and are statistically similar to T_5 (paddy chaff). However there was no significant difference between first and second treatment groups in moisture content at fourth week.

Estimation of moisture content of the litter materials at the end of fifth week revealed significant ($P<0.01$) difference between treatments and there was a trend of increase in moisture content in all the treatment groups. Treatment group which used coir pith as litter material (T_4) had significantly ($P<0.01$) higher moisture percentage (31.45) than that of other groups. Control group (T_1) which used wood shavings as litter material had moisture content of 21.42 per cent. The moisture content of T_2, T_3 and T_5 were 15.94, 16.37 and 17.34 per cent respectively and were not statistically significant.

At the end of sixth week the per cent moisture content for the treatments T_1 to T_5 were 25.77,20.23, 22.67, 37.32 and 24.30 respectively with an overall mean of 26.05 per cent. Statistical analysis of the data revealed significant difference ($P<0.01$) between treatments. The treatment group which used coir pith as litter material (T_4) had significantly ($P<0.01$) higher moisture content (37.32 per cent) than that of other groups. The treatment group which used sawdust (T_2) as litter material had significantly ($P<0.01$) lower per cent moisture content (20.23). The control group which used wood shavings (T_1) as litter material had moisture content of 25.77 per cent and was similar to treatment group which used paddy chaff (T_5) as litter material (24.30 per cent). Treatment which used rice husk (T_3) as litter material had moisture content of 22.67 per cent and was similar to T_5.

Estimation of moisture content of the litter material at the end of seventh week revealed significant difference ($P<0.01$) between different treatment groups. The treatment which used coir pith as litter material (T_4) had significantly ($P<0.01$) higher moisture content (47.03 per cent) than those in other groups. The moisture content of treatments, T_1, T_2, T_3 and T_5 were 29.33, 25.20, 26.82 and 27.87 per cent respectively.The moisture content of T_1, T_3 and T_5 were not different statistically. The group which used saw dust as litter material (T_2) had significantly ($P<0.01$) lower moisture content (25.20 per cent) than that of control group (29.33 per cent).

At the end of eighth week the same trend was similar to that of seventh week for the parameter. The treatment group which used coir pith as litter material (T_4) had significantly higher moisture content (54.43 per cent) than other groups. Control group (T_1) had recorded moisture content of 34.66 per cent and is significantly different from other groups except the one which used paddy chaff as litter material (T_5). The moisture content of T_2 and T_3 were 26.79 and 29.03 per cent and was statistically similar.

Ammonia-nitrogen content in litter

The mean per cent ammonia-nitrogen content of fresh as well as that of used litter at fortnightly intervals upto eight weeks of age are presented in Table 18 and is graphically represented in figure 10.

Statistical analysis of the data (Table 19) on mean per cent ammonia-nitrogen revealed highly significant difference ($P<0.01$) between different treatment groups throughout the experimental period.

The ammonia-nitrogen content of fresh litter for the treatment groups, viz., T_1, T_2, T_3, T_4 and T_5 were 0.0131, 0.0077, 0.0244, 0.0318 and 0.0105 per cent respectively with an overall mean of 0.0175 per cent. Treatment groups having sawdust (T_2) as litter material had significantly ($P<0.01$) lower ammonia-nitrogen content (0.0077 per cent) and was statistically similar to that

Table 18. Mean per cent ammonia-nitrogen content (fortnightly) as influenced by litter materials

Treatments	Period in weeks				
	0	2	4	6	8
T_1	b 0.0131	c 0.0268	d 0.0475	d 0.1657	d 0.2477
T_2	c 0.0077	c 0.0263	bc 0.0851	c 0.2186	d 0.2726
T_3	a 0.0244	a 0.0537	a 0.1496	a 0.4562	a 0.6338
T_4	a 0.0318	b 0.0372	ab 0.1184	b 0.3587	c 0.3718
T_5	bc 0.0105	ab 0.0463	c 0.0765	b 0.3483	b 0.4744
Overall mean±SE	0.0175 ±0.0092	0.0380 ±0.0092	0.0950 ±0.0252	0.3095 ±0.3095	0.4000 ±0.0162
LSD	0.02573	0.02573	0.05753	0.05733	0.05753

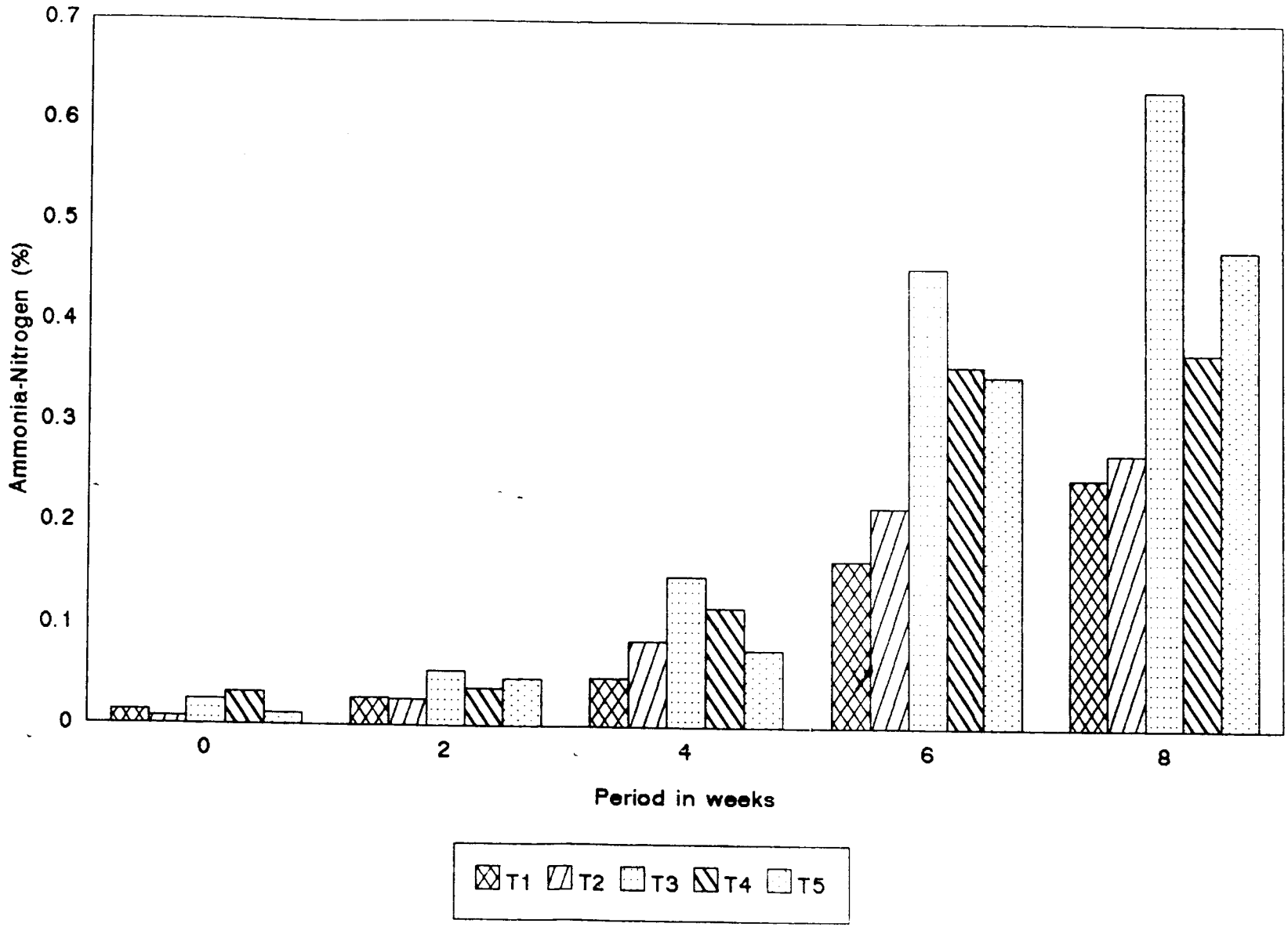
Means bearing the same superscript within the same column do not differ significantly ($P<0.01$)

Table 19. Analysis of variance for mean per cent ammonia-nitrogen content (fortnightly) of litter materials

Period (weeks)	Source	df	SS	MSS	F
0	Treatment	4	0.017	0.004	16.914 **
	Error	10	0.002	0.0002	
2	Treatment	4	0.011	0.003	12.666 **
	Error	10	0.002	0.0002	
4	Treatment	4	0.049	0.012	8.562 **
	Error	10	0.014	0.001	
6	Treatment	4	0.142	0.035	23.725 **
	Error	10	0.015	0.001	
8	Treatment	4	0.181	0.045	62.944 **
	Error	10	0.007	0.001	

** Significant at 1% level

Fig.10 MEAN PER CENT AMMONIA-NITROGEN CONTENT (FORTNIGHTLY) AS INFLUENCED BY LITTER MATERIALS



of T_5 (paddy chaff). Eventhough ammonia-nitrogen content was numerically higher in T_4 it did not reveal statistical difference with that of T_3.

The ammonia-nitrogen content of different litter treatments, viz., T_1, T_2, T_3, T_4 and T_5 were 0.0268, 0.0263, 0.0537, 0.0372 and 0.0463 per cent respectively with an overall mean of 0.0380 per cent at the end of the first fortnight. The ammonia-nitrogen content of sawdust litter (T_2) was significantly ($P<0.01$) lower (0.0263 per cent) and was found to be statistically similar to that of wood shavings litter (0.0268 per cent). The ammonia-nitrogen content of T_3 (rice husk) was 0.0537 per cent which was significantly ($P<0.01$) high revealing no statistical difference from that of T_5 (0.0463 per cent).

During the second fortnight, ammonia-nitrogen content for treatments T_1 to T_5 were 0.0475, 0.0851, 0.1496, 0.1184 and 0.0765 per cent respectively with an overall mean of 0.0950 per cent. Statistical analysis of the data revealed significantly ($P<0.01$) higher litter ammonia-nitrogen content in rice husk (0.1496 per cent) which was statistically similar to that of coir pith litter (0.1184 per cent). The control group (wood shavings) recorded significantly ($P<0.01$) low ammonia-nitrogen content.

During the third fortnight, the litter ammonia-nitrogen content of treatments, viz., T_1, T_2, T_3, T_4 and T_5 were 0.1657, 0.2186, 0.4562, 0.3587 and 0.3483 per cent respectively with an overall mean of 0.3095 per cent. When these data were

statistically analysed, the rice husk litter showed significantly ($P<0.01$) high value (0.4562 per cent).Wood shavings (control) showed significantly ($P<0.01$) low mean per cent litter ammonia-nitrogen content (0.1657 per cent).

The mean per cent ammonia-nitrogen content during the fourth fortnightly interval were 0.2477, 0.2726, 0.6338, 0.3718 and 0.4744 respectively for treatments T_1 to T_5 with an overall mean of 0.4000 per cent. Rice husk litter (T_3) recorded significantly ($P<0.01$) high ammonia-nitrogen content than other treatments. Coir pith litter (T_4) recorded significantly ($P<0.01$) high (0.3718 per cent) ammonia nitrogen content than that of wood shavings and sawdust. Mean per cent ammonia-nitrogen content of litter materials collected from T_5 recorded significantly ($P<0.01$) high value than that of T_4.

Nitrogen, phosphorus and potassium content

Data on mean per cent nitrogen, phosphorus and potassium content in the beginning, sixth week and eighth week of the experiment as influenced by different litter materials, viz., wood shavings (T_1), saw dust (T_2), rice husk (T_3), coir pith (T_4) and paddy chaff (T_5) are charted out in Table 20 and graphically represented in Fig.11.

The initial mean per cent nitrogen content of the litter treatments T_1 to T_5 were 0.651, 0.576, 0.645, 0.427 and 1.669 respectively with an overall mean of 0.793 per cent. Statistical

Table 20. Mean per cent nitrogen, phosphorus and potassium content of the litter materials

Treatments	Nitrogen			Phosphorus			Potassium		
	Initial	6th wk	8th wk	Initial	6th wk	8th wk	Initial	6th wk	8th wk
T_1	b 0.651	ab 3.781	b 4.395	a 0.203	b 0.572	d 0.747	b 0.257	a 0.766	b 0.893
T_2	b 0.576	bc 3.498	bc 4.112	a 0.105	a 0.882	b 1.229	bc 0.204	c 0.623	c 0.755
T_3	b 0.645	bc 3.333	b 4.251	a 0.213	b 0.679	c 0.986	c 0.182	bc 0.653	c 0.757
T_4	c 0.427	c 3.073	c 3.797	a 0.075	a 0.967	c 1.056	c 0.196	ab 0.721	b 0.880
T_5	a 1.669	a 4.245	a 5.157	a 0.391	a 0.987	a 1.497	a 0.383	a 0.817	a 1.263
Overall mean±SE	0.793 ±0.0196	3.586 ±0.0428	4.342 ±0.0336	0.197 ±0.0474	0.817 ±0.0301	1.103 ±0.0207	0.244 ±0.0161	0.716 ±0.0162	0.909 ±0.0196
LSD	0.0575	0.1409	0.0814	-	0.09965	0.0814	0.0575	0.0575	0.0575

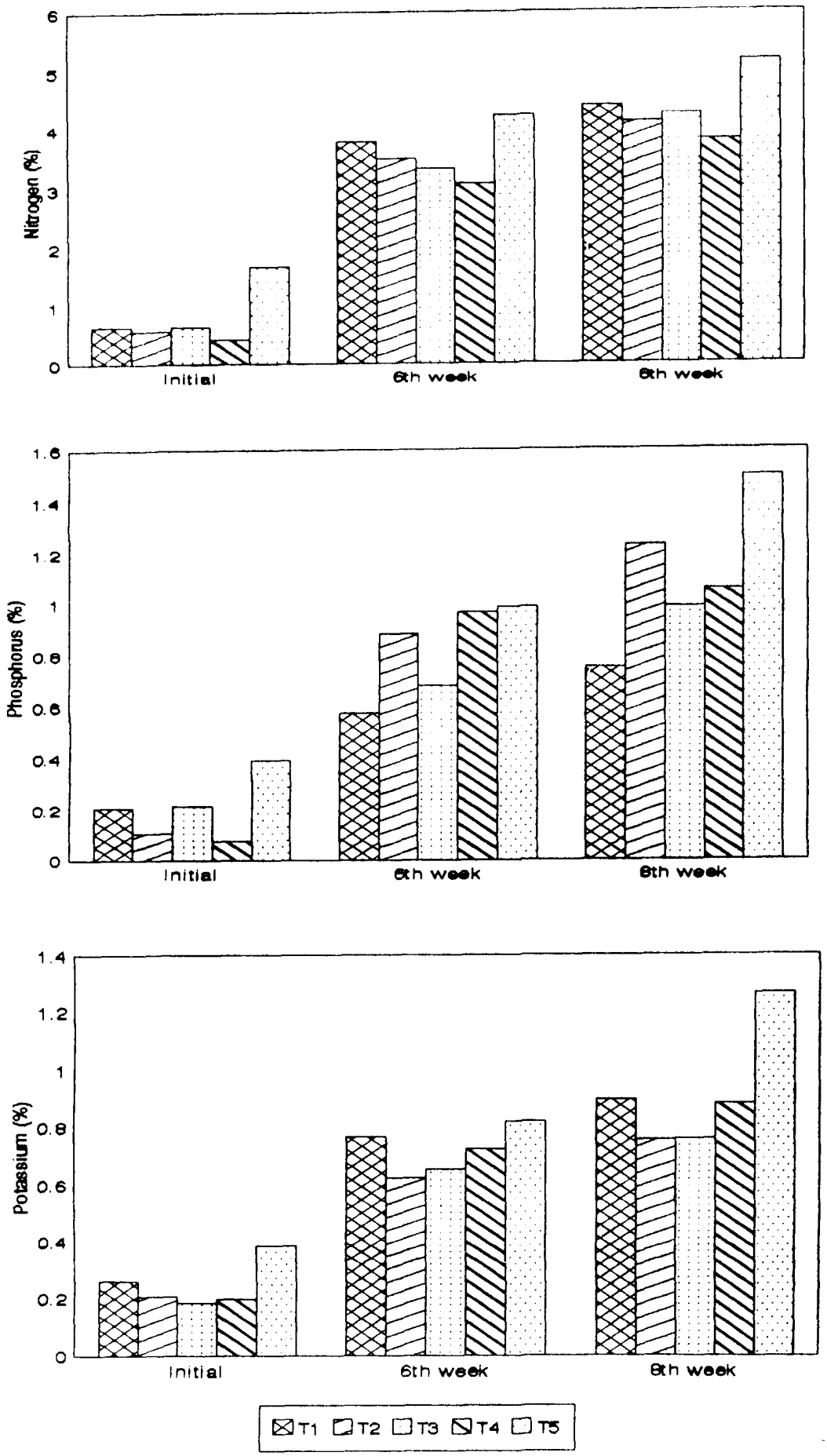
Means bearing the same superscript within the same column do not differ significantly ($P<0.01$)

Table 21. Analysis of variance for mean per cent nitrogen, phosphorus and potassium content of the litter materials

Content	Period	Source	df	SS	MSS	F
	Initial	Treatment	4	0.736	0.184	134.609 **
		Error	10	0.014	0.001	
Nitrogen	6th wk	Treatment	4	0.165	0.041	6.857 **
		Error	10	0.060	0.006	
	8th wk	Treatment	4	0.171	0.043	22.136 **
		Error	10	0.019	0.002	
	Initial	Treatment	4	0.235	0.059	3.181 NS
		Error	10	0.185	0.018	
Phosphorus	6th wk	Treatment	4	0.130	0.032	9.525 **
		Error	10	0.034	0.003	
	8th wk	Treatment	4	0.214	0.054	9.525 **
		Error	10	0.016	0.002	
	Initial	Treatment	4	0.074	0.018	20.057 **
		Error	10	0.009	0.001	
Potassium	6th wk	Treatment	4	0.026	0.007	6.857 **
		Error	10	0.01	0.001	
	8th wk	Treatment	4	0.13	0.033	21.825 **
		Error	10	0.015	0.001	

NS - Non-significant
** Significant at 1% level

Fig.11 MEAN PER CENT NITROGEN, PHOSPHORUS AND POTASSIUM CONTENT OF THE LITTER MATERIALS



analysis (Table 21) of the data revealed significant difference ($P<0.01$) between the different treatment groups. Litter nitrogen content of paddy chaff (T_5) had significantly ($P<0.01$) higher value (1.669 per cent) among the group. Nitrogen content of treatments T_1, T_2 and T_3 were statistically similar. Among the groups, nitrogen content of fresh coir pith (0.427 per cent) was significantly lower ($P<0.01$) than the others.

At sixth week the nitrogen content of treatment group T_1, T_2, T_3, T_4 and T_5 were 3.781, 3.498, 3.333, 3.073 and 4.245 per cent respectively with an overall mean of 3.586 per cent. Statistical analysis of the data revealed significant difference ($P<0.01$) between the different treatment groups. The treatment group having paddy chaff as the litter material (T_5) had high nitrogen content (4.245 per cent) and it differed significantly ($P<0.01$) from T_2, T_3 and T_4. The litter treatments T_1, T_2 and T_3 were statistically similar. The lowest nitrogen content was recorded in T_4 (3.073 per cent) and it was statistically similar to that of T_2 and T_3.

By the end of eighth week the mean per cent nitrogen content of litter treatments, viz., T_1, T_2, T_3, T_4 and T_5 were 4.395, 4.112, 4.251, 3.797 and 5.157 respectively with an overall mean of 4.342 per cent. During the eighth week also statistical analysis of the data revealed highly significant difference ($P<0.01$) between the different litter treatments. The highest nitrogen content of 5.157 per cent was recorded in T_5 and the lowest in coir pith litter (3.797 per cent).

At the beginning of the experiment the mean per cent phosphorus content of the five treatment groups T_1 to T_5 averaged 0.203, 0.105, 0.213, 0.075 and 0.391 respectively with an overall mean of 0.197 per cent. Statistical analysis of the data showed no significant difference between the treatment groups.

The sixth week mean per cent phosphorus content of the different litter treatments, viz., T_1, T_2, T_3, T_4 and T_5 were 0.572, 0.882, 0.679, 0.967 and 0.987 respectively with an overall mean of 0.817 per cent. Statistical analysis of the data revealed highly significant difference ($P<0.01$) between the different treatment groups. The sixth week phosphorus content of sawdust, coir pith and paddy chaff litters were statistically similar and higher than that of T_1 and T_3.

The eighth week phosphorus content of the different treatments were 0.747, 1.229, 0.986, 1.056 and 1.497 per cent respectively with an overall mean of 1.103 per cent for treatments T_1 to T_5. There was highly significant difference ($P<0.01$) between the different treatments, on statistical analysis. The mean per cent phosphorus content of paddy chaff litter was significantly higher ($P<0.01$) value than that of others. Wood shavings litter showed significantly ($P<0.01$) lower value for per cent phosphorus content (0.747).

The per cent potassium content of different treatment groups, viz., T_1, T_2, T_3, T_4 and T_5 were 0.257, 0.204, 0.182, 0.196 and 0.383 respectively with an overall mean of 0.244 per cent on

fresh basis. When the data on potassium content on fresh basis was analysed statistically a highly significant difference ($P<0.01$) was obtained between the different treatment groups. The paddy chaff litter showed significantly ($P<0.01$) higher potassium content (0.383 per cent) on fresh basis than the others. Sawdust, rice husk and coir pith litters showed statistically similar potassium content on fresh basis.

The sixth week potassium content of the different treatment groups, viz., T_1, T_2, T_3, T_4 and T_5 were 0.766, 0.623, 0.653, 0.721 and 0.817 per cent respectively with an overall value of 0.716 per cent. Statistical analysis of the data showed a highly significant difference ($P<0.01$) between the different treatment groups. Eventhough paddy chaff (T_5) recorded significantly ($P<0.01$) high value (0.817 per cent) for potassium content among the groups, it was statistically similar to T_4 and T_1. There was no significant difference between T_2 and T_3 treatment groups for mean per cent potassium content at sixth week.

Analysis of data on eighth week mean per cent potassium content of different litter treatments were 0.893, 0.755, 0.757, 0.880 and 1.263 respectively for treatments T_1 to T_5 with an overall mean of 0.909 per cent. Statistical analysis of the data on potassium content at eighth week also revealed a highly significant ($P<0.01$) difference between the different treatment groups. Paddy chaff litter showed a significantly ($P<0.01$) higher value (1.263 per cent) than the others. Saw dust litter

recored significantly ($P<0.01$) low potassium content and did not differ significantly from T_3.

pH of the litter materials

The mean pH of five litter treatments at weekly intervals is presented in Table 22 and graphically represented in Fig.12.

Statistical analysis of the data (Table 23) revealed highly significant difference between the different treatment groups throughout the experimental periods.

The mean pH of treatments T_1 to T_5 were 6.04, 6.18, 6.70, 6.19 and 6.87 respectively with an overall mean of 6.40 on fresh basis. The paddy chaff litter (T_5) recorded significantly ($P<0.01$) high pH content (6.87) and wood shavings significantly low (6.04).

At the end of the first week, mean pH content of the different treatments, viz., T_1, T_2, T_3, T_4 and T_5 were 6.55, 6.21, 6.77, 6.29 and 7.08 respectively with an overall mean of 6.58. Paddy chaff recorded high pH content (7.08) and saw dust litter recorded significant ($P<0.01$) low pH content (6.21) but was statistically similar to that of coir pith litter.

At the end of second week, pH content averaged as 6.76, 6.30, 7.01, 6.37 and 7.37 for the treatments T_1 to T_5 respectively with an overall mean of 6.72. As that of the earlier periods, here also paddy chaff litter showed significantly ($P<0.01$) high

Table 22. Mean weekly pH of the litter as influenced by different litter materials

Treatments	Period in weeks								
	0	1	2	3	4	5	6	7	8
T_1	d 6.04	c 6.55	c 6.76	b 6.96	bc 7.11	c 7.23	a 8.30	ab 8.48	b 8.88
T_2	c 6.18	d 6.21	d 6.30	c 6.47	cd 6.87	c 7.22	d 7.45	c 7.95	c 7.99
T_3	b 6.70	b 6.77	b 7.01	b 7.14	ab 7.35	ab 7.76	bc 8.03	b 8.36	b 8.89
T_4	c 6.19	d 6.29	d 6.37	c 6.52	d 6.62	bc 7.45	a 7.83	ab 8.43	b 8.76
T_5	a 6.87	a 7.08	a 7.37	a 7.40	a 7.55	a 7.87	ab 8.25	a 8.64	a 9.34
Overall mean±SE	6.40 ±0.0396	6.58 ±0.0378	6.72 ±0.0360	6.90 ±0.0600	7.10 ±0.0750	7.50 ±0.0960	7.97 ±0.0704	8.37 ±0.0774	8.77 ±0.0520
LSD	0.1286	0.1409	0.1286	0.2074	0.2441	0.3305	0.2301	0.2441	0.252

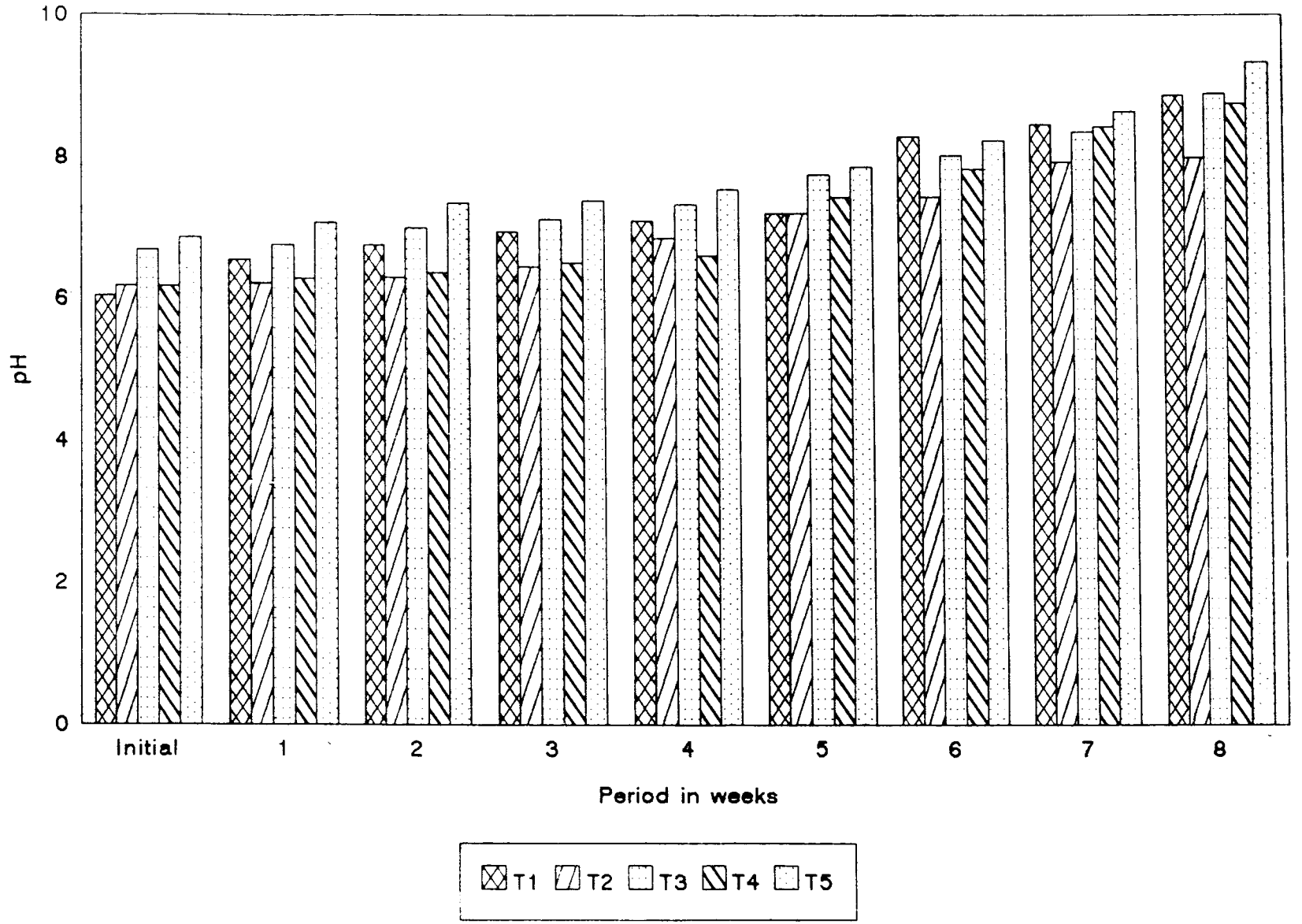
Means bearing the same superscript within the same column do not differ significantly ($P<0.01$)

Table 23. Analysis of variance for mean weekly pH of the litter materials

Period	Source	df	SS	MSS	F
0	Treatment	4	1.589	0.397	74.22 **
	Error	10	0.054	0.005	
1	Treatment	4	1.527	0.382	62.842 **
	Error	10	0.061	0.006	
2	Treatment	4	1.727	0.432	89.839 **
	Error	10	0.048	0.005	
3	Treatment	4	1.914	0.479	36.943 **
	Error	10	0.130	0.013	
4	Treatment	4	1.631	0.408	23.278 **
	Error	10	0.175	0.018	
5	Treatment	4	1.082	0.271	8.162 **
	Error	10	0.332	0.033	
6	Treatment	4	1.438	0.360	22.342 **
	Error	10	0.161	0.016	
7	Treatment	4	0.799	0.20	11.058 **
	Error	10	0.181	0.018	
8	Treatment	4	2.891	0.723	76.607 **
	Error	10	0.094	0.009	

** Significant at 1% level

Fig.12 MEAN WEEKLY pH AS INFLUENCED BY DIFFERENT LITTER MATERIALS



pH content (7.37) and the saw dust litter recorded significantly ($P<0.01$) low value and was statistically similar to that of coir pith litter.

At the end of third week, the litter pH recorded for the treatments, viz., T_1, T_2, T_3, T_4 and T_5 were 6.96, 6.47, 7.14, 6.52 and 7.40 respectively with an overall mean of 6.90. Here also, paddy chaff litter recorded significantly ($P<0.01$) high pH value (7.40). The saw dust litter recorded a low pH but was statistically similar to coir pith.

By fourth week the mean litter pH content were 7.11, 6.87, 7.35, 6.62 and 7.55 respectively for treatments T_1 to T_5 with an overall mean of 7.10. Paddy chaff litter (T_5) showed significantly ($P<0.01$) high pH which was statistically similar to that of rice husk litter. Coir pith litter recorded significantly ($P<0.01$) low pH during fourth week (6.62) and did not statistically differ from that of saw dust litter.

By the end of fifth week, litter pH of treatments T_1 to T_5 averaged 7.23, 7.22, 7.76, 7.45 and 7.87 respectively. Significantly high ($P<0.01$) pH was recorded in paddy chaff (7.87) and low in saw dust litter (7.22).

The sixth week litter pH for treatments, viz., T_1, T_2, T_3, T_4 and T_5 were 8.30, 7.45, 8.03, 7.83 and 8.25 respectively with an overall mean of 7.97. At sixth week wood shavings recorded

significantly (P<0.01) high pH value (8.30) and was statistically similar to that of coir pith and paddy chaff litters.

At seventh week the mean pH of litter treatments T_1 to T_5 were 8.48, 7.95, 8.36, 8.43 and 8.64 respectively with an overall mean of 8.37. During seventh week, paddy chaff litter recorded significantly (P<0.01) high litter pH (8.64) and was statistically similar to that of wood shavings and coir pith. Saw dust litter showed significantly (P<0.01) low litter pH (7.95) at seventh week.

By eighth week the litter pH content of different treatment groups, viz., T_1, T_2, T_3, T_4 and T_5 averaged 8.88, 7.99, 8.89, 8.76 and 9.34 respectively with an overall mean of 8.77. Paddy chaff recorded significantly (P<0.01) high litter pH (9.34) and the saw dust the lower (7.99).

Proximate composition of the litter materials

The mean per cent proximate composition of the five litter materials at the beginning, sixth week and eighth week of the experiment are presented in Tables 24, 25 and 26 and graphically represented in Fig.13, 14, 15 and 16.

Dry matter: The per cent dry matter content of the different litter treatments, viz., T_1, T_2, T_3, T_4 and T_5 on fresh basis were 91.11, 91.19, 93.95, 87.62 and 92.40 respectively with an overall mean of 91.25 per cent. Statistical analysis of the data (Table 27) showed a highly significant difference (P<0.01) between the

different treatments. The dry matter content of rice husk showed a significantly ($P<0.01$) higher value (93.95 per cent) than the other treatments whereas that of coir pith showed a significantly ($P<0.01$) lower value (87.62 per cent).

By the end of sixth week the per cent dry matter content averaged 74.26, 79.79, 77.34, 62.71 and 75.72 respectively for litter treatments T_1 to T_5 respectively with an overall mean of 73.96 per cent. A highly significant difference ($P<0.01$) was seen between the litter treatments, on statistical analysis. The saw dust litter treatment (T_2) recorded a significantly ($P<0.01$) high and coir pith litter the least dry matter content.

At the end of the eighth week the dry matter content were 65.35, 73.22, 71.02, 45.62 and 67.80 per cent respectively for treatment groups, viz., T_1, T_2, T_3, T_4 and T_5 respectively with an overall mean of 64.60 per cent. Statistical analysis of the data revealed significant difference ($P<0.01$) between the different treatment groups. The saw dust litter recorded significantly ($P<0.01$) high dry matter content (73.22 per cent) and it did not statistically differ from that of T_3. Among the group, coir pith litter showed significantly ($P<0.01$) lower dry matter conent (45.62 per cent) among the groups.

Crude protein: Crude protein content of litter treatments, viz., T_1 to T_5 on fresh basis were 4.09, 3.66, 4.07, 2.71 and 10.45 per cent respectively with an overall mean of 4.99 per cent. On statistical analysis, significant difference ($P<0.01$) was obtained

Table 24. Per cent proximate composition of the litter materials at the beginning of the experiment

Treatments	Dry matter	Crude protein	Ether extract	Crude fibre	Nitrogen free extract	Total ash
T_1	c 91.11	b 4.09	b 0.03	a 57.05	e 22.03	a 16.79
T_2	c 91.19	b 3.66	b 0.06	b 50.02	d 29.77	a 16.67
T_3	a 93.95	b 4.07	a 1.34	d 26.07	b 52.01	a 16.35
T_4	d 87.62	c 2.71	a 1.56	e 21.37	a 67.67	b 6.83
T_5	b 92.40	a 10.45	a 1.77	c 32.47	c 41.83	a 13.60
Overall mean±SE	91.25 ±0.0115	4.99 ±0.0452	0.95 ±0.056	37.39 ±0.807	42.66 ±0.918	14.05 ±0.278
LSD	0.05733	0.1627	0.1908	2.687	3.027	0.478

Means bearing the same superscript within the same column do not differ significantly ($P<0.01$)

Table 25. Per cent proximate composition of the litter materials at sixth week of age

Treat-ments	Dry matter	Crude protein	Ether extract	Crude fibre	Nitrogen free extract	Total ash
T_1	c 74.26	ab 23.66	bc 1.33	a 26.44	c 20.18	a 28.59
T_2	a 79.79	bc 21.87	c 0.96	a 28.45	c 22.12	a 26.73
T_3	b 77.34	bc 20.86	ab 1.73	b 17.66	b 33.96	a 25.90
T_4	d 62.71	c 19.28	ab 1.93	c 12.36	a 49.69	c 16.97
T_5	bc 75.72	a 26.57	a 2.07	b 18.29	b 31.94	b 21.31
Overall mean±SE	73.96 ±0.495	22.44 ±0.108	1.60 ±0.114	20.64 ±0.121	31.57 ±1.033	23.90 ±0.112
LSD	1.697	0.3546	0.2636	0.4108	4.098	0.377

Means bearing the same superscript within the same column do not differ significantly ($P<0.01$)

Table 26. Per cent proximate composition of the litter materials at eighth week of age

Treatments	Dry matter	Crude protein	Ether extract	Crude fibre	Nitrogen free extract	Total ash
T_1	b 65.35	b 27.49	a 1.89	a 23.06	d 13.33	a 34.86
T_2	a 73.22	bc 25.72	a 1.49	a 20.68	c 19.70	a 32.54
T_3	a 71.02	b 26.64	a 2.22	b 12.37	b 29.15	ab 29.81
T_4	c 45.62	c 23.79	a 2.57	c 8.61	a 47.12	c 18.15
T_5	b 67.80	a 32.25	a 2.39	b 14.25	b 25.43	b 25.78
Overall mean±SE	64.60 0.520	27.17 0.059	2.11 0.175	15.79 0.1237	26.94 1.029	28.22 0.839
LSD	1.717	0.1993	-	0.4343	3.485	2.964

Means bearing the same superscript within the same column do not differ significantly ($P<0.01$)

Table 27. Analysis of variance for per cent proximate composition of litter materials

Proximate principle	Period	Source	df	SS	MSS	F
	Initial	Treatment	4	0.171	0.045	89.130 **
		Error	10	0.005	0.001	
Dry matter	6th wk	Treatment	4	211.786	52.947	61.085 **
		Error	10	8.668	0.867	
	8th wk	Treatment	4	507.788	126.947	142.426 **
		Error	10	8.913	0.891	
	Initial	Treatment	4	4.527	1.132	135.103 **
		Error	10	0.084	0.008	
Crude protein	6th wk	Treatment	4	1.024	0.256	6.812 **
		Error	10	0.376	0.038	
	8th wk	Treatment	4	1.057	0.264	22.058 **
		Error	10	0.120	0.012	
	Initial	Treatment	4	3.86	0.965	88.460 **
		Error	10	0.109	0.011	
Ether extract	6th wk	Treatment	4	0.424	0.106	4.982 **
		Error	10	0.213	0.021	
	8th wk	Treatment	4	0.273	0.068	2.878 NS
		Error	10	0.237	0.024	
	Initial	Treatment	4	1041.720	260.43	119.346 **
		Error	10	21.822	2.182	
Crude fibre	6th wk	Treatment	4	6.655	1.664	32.786 **
		Error	10	0.507	0.051	
	8th wk	Treatment	4	0.964	1.741	30.293 **
		Error	10	0.575	0.051	
	Initial	Treatment	4	1398.85	349.712	126.325 **
		Error	10	27.684	2.768	
Nitrogen free extract	6th wk	Treatment	4	630.82	157.705	31.084 **
		Error	10	50.735	5.073	
	8th wk	Treatment	4	812.065	203.016	55.311 **
		Error	10	36.704	3.67	
	Initial	Treatment	4	5.034	1.259	14.163 **
		Error	10	0.889	0.089	
Total ash	6th wk	Treatment	4	2.976	0.744	17.425 **
		Error	10	0.427	0.043	
	8th wk	Treatment	4	219.532	54.883	20.673 **
		Error	10	26.548	2.655	

NS - Non-significant ** Significant at 1% level

Fig.13 PROXIMATE COMPOSITION OF THE LITTER
- CRUDE PROTEIN CONTENT (%)

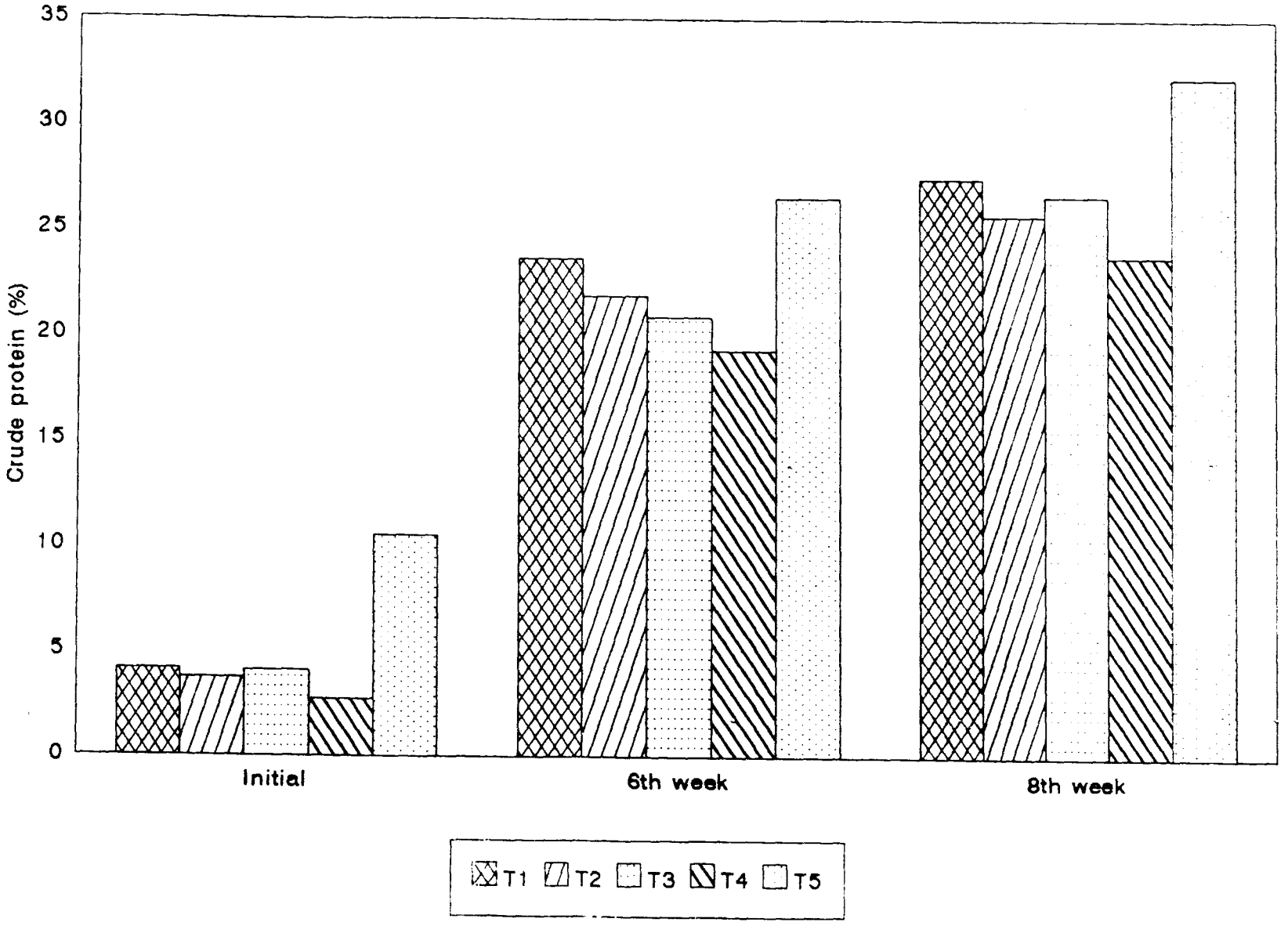


Fig.14 PROXIMATE COMPOSITION OF THE LITTER
- ETHER EXTRACT CONTENT (%)

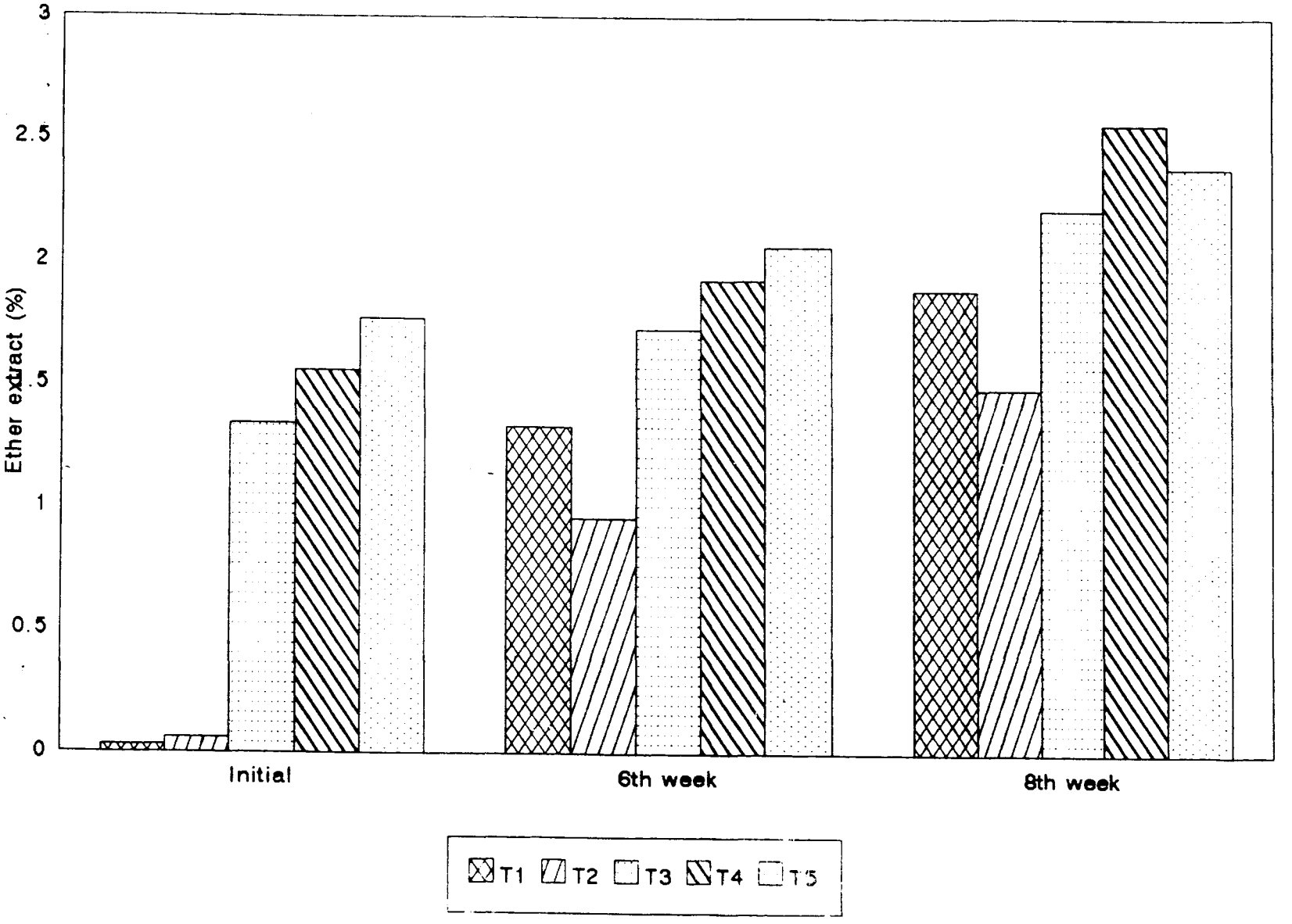


Fig.15 PROXIMATE COMPOSITION OF THE LITTER
- CRUDE FIBRE CONTENT (%)

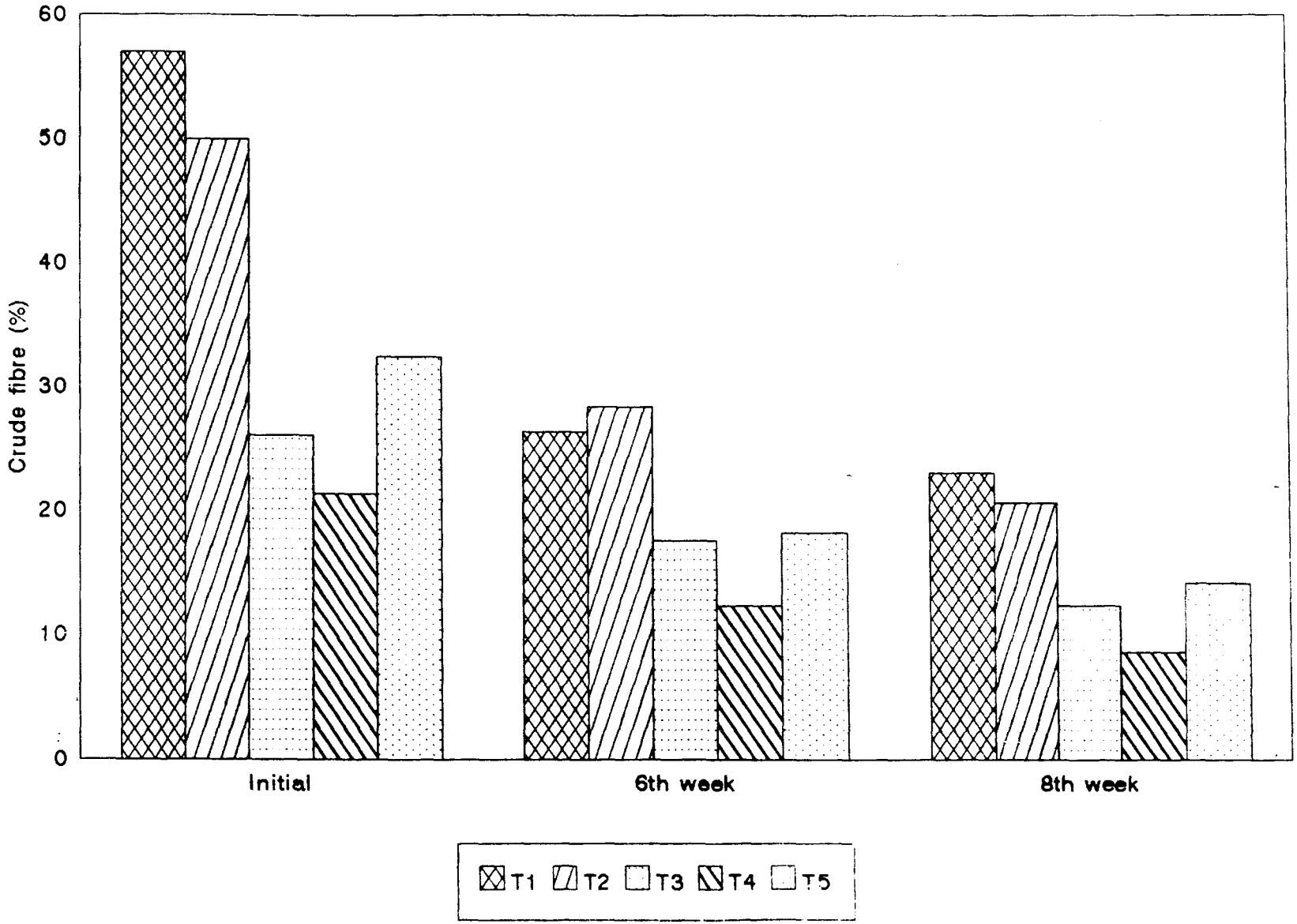
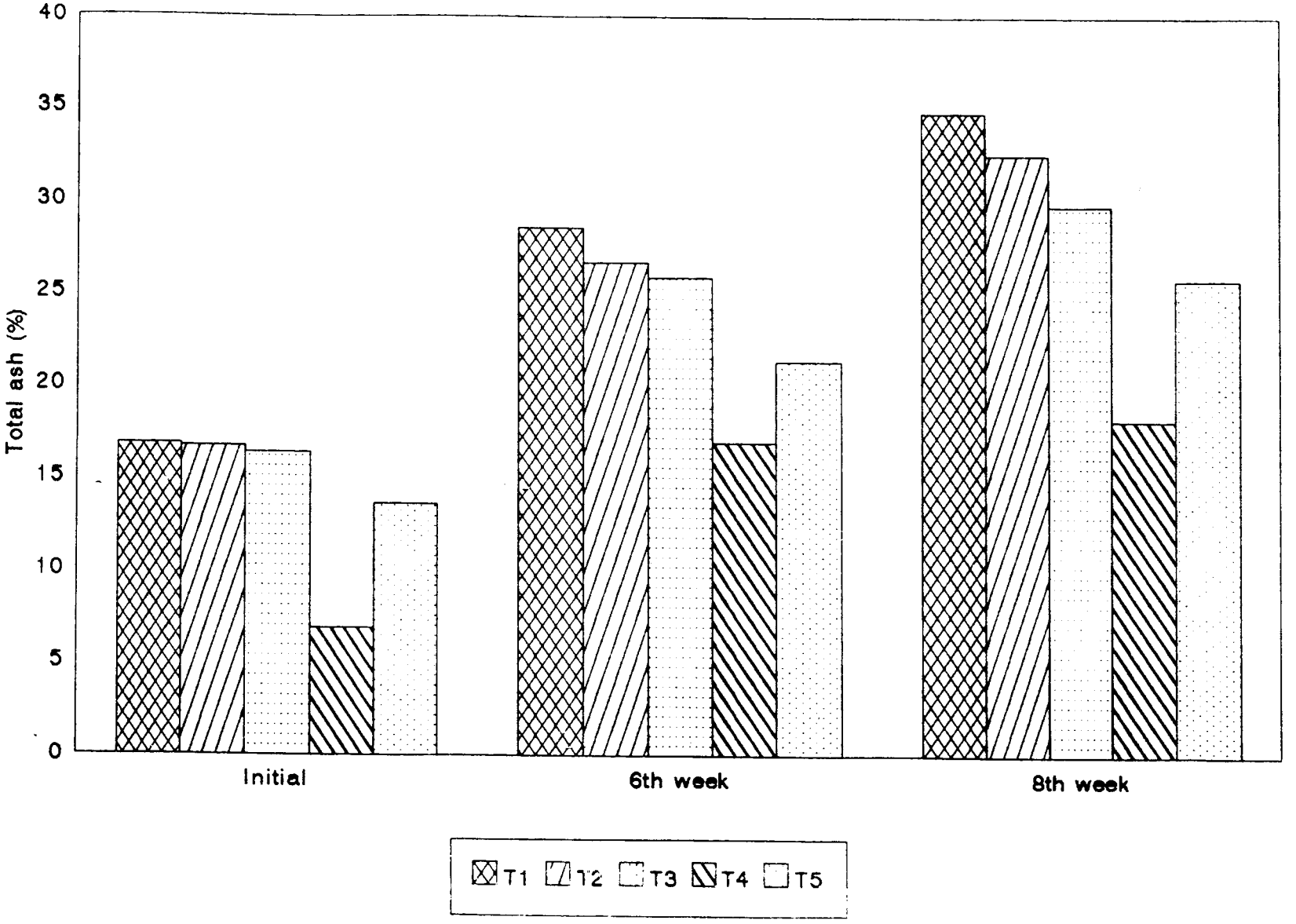


Fig.16 PROXIMATE COMPOSITION OF THE LITTER
- TOTAL ASH CONTENT (%)



between the different treatment groups. Among these the paddy chaff litter (T_5) showed a significantly ($P<0.01$) high crude protein content (10.45 per cent) on fresh basis. The per cent crude protein content of fresh wood shavings, saw dust and rice husk were statistically similar. The coir pith litter showed significantly ($P<0.01$) low crude protein content (2.71 per cent).

At the end of sixth week, crude protein content of the different litter materials were 23.66, 21.87, 20.86, 19.28 and 26.57 per cent respectively for treatments T_1 to T_5 with an overall mean of 22.44 per cent. On statistical analysis there was significant ($P<0.01$) difference between the litter treatments. The paddy chaff litter (T_5) showed significantly higher ($P<0.01$) crude protein content (26.57 per cent) at sixth week but was statistically similar to wood shavings litter. Wood shavings, saw dust and rice husk litters were statistically similar in crude protein content at sixth week. Among the group, the coir pith litter recorded significantly low ($P<0.01$) crude protein content (19.28 per cent) but was statistically similar to that of T_2 and T_3.

At eighth week, per cent crude protein content of different treatment groups, viz., T_1, T_2, T_3, T_4 and T_5 were 27.49, 25.72, 26.64, 23.79 and 32.25 respectively with an overall mean of 27.17 per cent. Statistical analysis of the data recorded a highly significant difference ($P<0.01$) between the different treatment groups. Among the different litter materials, the paddy chaff (T_5) recorded significantly ($P<0.01$) high crude protein content

(32.25 per cent). The crude protein content of wood shavings, saw dust and rice husk were statistically similar. The crude protein content of coir pith litter was significantly ($P<0.01$) low during eighth week also and was statistically similar to T_2.

Ether extract: The mean per cent ether extract content of the different treatment groups, viz., T_1, T_2, T_3, T_4 and T_5 were 0.03, 0.06, 1.34, 1.56 and 1.77 respectively on fresh basis with an overall mean of 0.95 per cent. On statistical analysis, significant difference ($P<0.01$) was obtained between treatments. It was seen that the ether extract content of T_1 and T_2 were significantly low than that of T_3, T_4 and T_5.

At sixth week, mean per cent ether extract content of the different litter treatments, viz., T_1, T_2, T_3, T_4 and T_5 were 1.33, 0.96, 1.73, 1.93 and 2.07 respectively with an overall mean of 1.60 per cent. There was significant difference ($P<0.01$) between the different treatment groups, when the data on sixth week ether extract content was statistically analysed. Among the treatment groups, T_5 recorded significantly ($P<0.01$) high ether extract content and was statistically similar to T_3 and T_4. Treatment group T_2 (saw dust) recorded significantly low ether extract content and was similar to T_1.

At eighth week, per cent ether extract content of different treatment groups, viz., T_1, T_2, T_3, T_4 and T_5 were 1.89, 1.49, 2.22, 2.57 and 2.39 respectively with an overall mean of 2.11 per cent. Statistical analysis of the data revealed no significant

difference between treatments for the eighth week per cent ether extract content.

Crude fibre: The per cent crude fibre content on fresh basis for treatments T_1, T_2, T_3, T_4 and T_5 averaged 57.03, 50.02, 26.07, 21.37 and 32.47 per cent respectively with an overall mean of 37.39 per cent. Statistical analysis of the data revealed highly significant difference ($P<0.01$) between the different litter treatments. Among the group, coir pith litter showed significantly ($P<0.01$) low crude fibre content (21.37 per cent) on fresh basis. Significantly ($P<0.01$) higher percentage crude fibre content (57.05 per cent) was recorded in T_1 (wood shavings).

At sixth week, per cent crude fibre content of different treatment groups, viz., T_1, T_2, T_3, T_4 and T_5 were 26.44, 28.45, 17.66, 12.36 and 18.29 respectively with an overall mean of 20.64 per cent. A highly significant difference ($P<0.01$) was observed between the different litter treatments for sixth week per cent crude fibre content when the data were subjected to statistical analysis. During the period of study, crude fibre content showed a decreasing trend. Coir pith litter showed significantly ($P<0.01$) lower crude fibre content (12.36 per cent) than the others whereas saw dust litter recorded a high value and was statistically similar to that of T_1 (wood shavings).

By eighth week the crude fibre content of the litter treatment groups T_1 to T_5 averaged as 23.06, 20.68, 12.37, 8.61

and 14.25 per cent respectively with an overall mean of 15.79 per cent. Statistical analysis of data showed significant difference ($P<0.01$) between the different treatment groups. Coir pith litter showed significantly ($P<0.01$) lower crude fibre content (8.61 per cent) whereas wood shaving recorded a high value (23.06 per cent) eventhough it was statistically similar to T_2 (saw dust).

Nitrogen free extract: The nitrogen free extract (NFE) of the different litter treatments on fresh basis were 22.03, 29.77, 52.01, 67.67 and 41.83 per cent respectively with an overall mean of 42.66 per cent for treatments T_1 to T_5. There was significant difference ($P<0.01$) between the different litter treatments for the per cent NFE content on fresh basis. Wood shavings litter showed significantly ($P<0.01$) lower NFE content (22.03 per cent) and coir pith litter recorded significantly ($P<0.01$) high NFE content (67.67 per cent).

By sixth week of age the NFE content of different litter treatment, viz., T_1, T_2, T_3, T_4 and T_5 were 20.18, 22.12, 33.96, 49.69 and 31.94 per cent respectively with an overall mean of 31.57 per cent. There was significant difference ($P<0.01$) between the litter treatments. Wood shavings recoreded significantly ($P<0.01$) low NFE content (20.18 per cent) but was statistically similar to that of T_2 (saw dust). By sixth week the coir pith litter recorded significantly ($P<0.01$) high NFE content (49.69 per cent).

At the end of eighth week, NFE content of the different litter materials were 13.33, 19.70, 29.15, 47.12 and 25.43 per cent respectively for treatments T_1 to T_5 with an overall mean of 26.94 per cent. The statistical analysis of data for eighth week NFE content of the different litter treatments showed highly significant difference ($P<0.01$) between them. The eighth week NFE content of wood shavings was significantly ($P<0.01$) lower (13.33 per cent) and that of coir pith was significantly high (47.12 per cent).

Total ash: The total ash content on fresh basis for the different groups, viz., T_1, T_2, T_3, T_4 and T_5 averaged 16.79, 16.67, 16.35, 6.83 and 13.60 per cent respectively with on overall mean of 14.05 per cent. Statistical analysis of the data revealed significant difference ($P<0.01$) between the different litter treatments. The total ash content of T_4 (coir pith) was significantly low (6.83 per cent) whereas that of T_1, T_2, T_3 and T_5 were statistically similar eventhough that of wood shavings (16.79 per cent) being numerically high.

On analysis of litter material for total ash content at sixth week, for treatment groups, viz., T_1 to T_5 averaged 28.59, 26.73, 25.90, 16.97 and 21.31 per cent respectively with an overall mean of 23.90 per cent. Coir pith litter recorded significantly ($P<0.01$) low total ash content (16.97 per cent) whereas T_1, T_2 and T_3 did not differ significantly.

By eighth week the total per cent ash content of different litter treatments; viz., T_1, T_2, T_3, T_4 and T_5 were 34.86, 32.54, 29.81, 18.15 and 25.78 respectively with an overall mean of 28.22 per cent. Coir pith recorded significantly ($P<0.01$) low total ash content (18.15 per cent). Litter treatments T_1, T_2 and T_3 did not differ significantly between them and T_3 was statistically similar to T_5.

Livability

The weekly mortality in number for broilers reared on five litter materials, viz., T_1, T_2, T_3, T_4 and T_5 is presented in Table 28.

There was no mortality for the broilers during the first and second weeks of age. During third week there were one mortality each for the wood shavings and paddy chaff litter. Fourth week mortality were 1, 2, 3 and 3 for wood shavings, saw dust, rice husk and coir pith and no mortality was recorded for paddy chaff. During the fifth week there was no mortality among broilers in coir pith but one bird died each for litter treatments T_1, T_2, T_3 and T_5 respectively. During sixth week there was one mortality each for wood shavings, saw dust and paddy chaff. During seventh week, there were mortality of 16, 16, 19, 16 and 16 respectively for the litter treatments T_1, T_2, T_3, T_4 and T_5. The eighth week mortality figures were 2, 3, 3 and2 for the litter treatments T_1, T_2, T_4 and T_5 respectively. The total mortality figures for the

Table 28. Mortality (number) in broilers under different litter materials

Treatments	Period in weeks								
	1	2	3	4	5	6	7	8	Total
T_1	-	-	1 a	1 bc	1 a	1 a	16 a	2 a	22 a
T_2	-	-	-	2 ab	1 a	1	16 a	3 a	23 a
T_3	-	-	-	3 a	1 a	-	19 a	-	23 a
T_4	-	-	-	3 a	-	-	16 a	3 a	22 a
T_5	-	-	1 a	-	1 a	1 a	16 a	2 a	21 a
Overall mean±SE	-	-	0.4 0.134	1.8 0.134	1 0.268	0.4 0.134	16.6 0.425	2 0.432	22.2 0.692
LSD	-	-	-	0.6635	-	-	-	-	-

Means bearing the same superscript within the same column do not differ significantly ($P<0.05$)

Table 29. Analysis of variance for mortality (number) in broilers under different litter materials

Period (weeks)	Source	df	SS	MSS	F
1	Treatment	4	-	-	-
	Error	10			
2	Treatment	4	-	-	-
	Error	10			
3	Treatment	4	0.4	0.1	0.75 NS
	Error	10	1.33	0.133	
4	Treatment	4	2.267	0.567	4.25 *
	Error	10	1.333	0.133	
5	Treatment	4	0.667	0.167	0.625 NS
	Error	10	2.667	0.267	
6	Treatment	4	0.40	0.10	0.75 NS
	Error	10	1.333	0.133	
7	Treatment	4	2.4	0.60	0.45 NS
	Error	10	13.33	1.333	
8	Treatment	4	2.0	0.5	0.682 NS
	Error	10	7.33	0.733	
Total	Treatment	4	0.933	0.233	0.35 NS
	Error	10	6.667	0.667	

NS - Non-significant
* Significant at 5% level

litter treatments, viz., T_1, T_2, T_3, T_4 and T_5 were 22, 23, 23, 22 and 21 numbers respectively.

Statistical analysis of the data (Table 29) recorded no significant difference between the different treatments throughout the experimental period except at fourth week ($P<0.05$).

Cost-benefit analysis

The cost-benefit particulars at sixth week and eighth week for broilers reared on different litter materials, viz., wood shavings (T_1), saw dust (T_2), rice husk (T_3), coir pith (T_4) and paddy chaff (T_5) to evaluate their suitability as alternate litter materials are presented in Table 30 and 31 respectively. The average cost of production and the total returns from a bird at sixth week and eighth week was calculated to assess the cost-benefit. The cost of production includes the chick, feed, litter and miscellaneous costs. Feed cost was calculated to be Rs.9.20 per kilogramme. Litter cost was 1.00 and 0.78 rupee for one kilogramme each of wood shavings and saw dust respectively and the other litters being free of cost. The miscellaneous expenditure includes vaccination and medication, which averaged three rupees per bird. In each treatment there were forty two birds and broiler chick cost was fourteen rupees.

The birds were sold at the rate of thirty eight rupees per kilogramme live body weight. Poultry manure also accounted for

Table 30. Cost benefit analysis per bird for the different treatment groups at the end of the sixth week

Sl. No.	Particulars	Treatments				
		T_1	T_2	T_3	T_4	T_5
1.	Live body weight at sixth week of age (g)	1384.82	1430.70	1371.67	1421.50	1406.43
2.	Total feed consumption upto sixth week of age (g)	2658.83	2732.40	2625.85	2666.92	2744.21
3.	Feed cost (Rs.) per kilogramme feed*	9.20	9.20	9.20	9.20	9.20
4.	Total feed cost (Rs.)	24.45	25.14	24.16	24.54	25.25
5.	Chick cost (Rs.)	14.50	14.50	14.50	14.50	14.50
6.	Miscellaneous cost (Rs.)+	3.00	3.00	3.00	3.00	3.00
7.	Cost of litter material (Re)#	1.00	0.78	-	-	-
8.	Total cost of production upto six weeks of age (Rs.)	42.98	43.42	41.66	42.04	42.75
9.	Returns from sale of broilers (Rs.)$	52.62	54.34	52.12	54.02	53.44
10.	Returns from sale of manure (Re)f	0.70	0.90	0.72	0.63	0.95
11.	Total returns (Rs.)	53.52	55.24	52.84	54.65	54.39
12.	Profit per bird (Rs.)	10.54	11.82	11.18	12.61	11.64
13.	Net profit per kilogramme body weight (Rs.)	7.61	8.26	8.15	8.87	8.28

* Average of starter (Rs.9.47) and finisher (Rs.8.93) rations

\+ Rupees three per bird was accounted as miscellaneous cost for vaccination, medication etc.

\# Litter materials for treatments T_3, T_4 and T_5 were available free of cost

$ @ Rs.38/- per kilogramme live body weight

f @ Re0.50/- per kilogramme poultry manure

Table 31. Cost benefit analysis per bird for the different treatment groups at the end of the eighth week

Sl. No.	Particulars	Treatments				
		T_1	T_2	T_3	T_4	T_5
1.	Live body weight at sixth week of age (g)	1954.87	2051.00	2013.33	2016.56	2013.83
2.	Total feed consumption for eight weeks (g)	4436.45	4639.03	4598.31	4549.79	4674.23
3.	Feed cost (Rs.) per kilogramme feed*	9.20	9.20	9.20	9.20	9.20
4.	Total feed cost (Rs.)	40.46	42.91	42.48	42.07	43.21
5.	Chick cost (Rs.)	14.50	14.50	14.50	14.50	14.50
6.	Miscellaneous cost (Rs.)+	3.00	3.00	3.00	3.00	3.00
7.	Cost of litter material (Re)#	1.00	0.78	-	-	-
8.	Total cost of production for eight weeks (Rs.)	58.96	61.19	59.98	59.57	60.71
9.	Returns from sale of broilers (Rs.)$	74.29	77.94	76.51	76.63	76.49
10.	Returns from sale of manure (Re)f	0.70	0.90	0.72	0.63	0.95
11.	Total returns (Rs.)	74.99	78.84	77.23	77.26	77.44
12.	Profit per bird (Rs.)	16.03	17.65	17.25	17.69	16.73
13.	Net profit per kilogramme body weight (Rs.)	8.20	8.61	8.57	8.77	8.31

* Average of starter (Rs.9.47) and finisher (Rs.8.93) rations

\+ Rupees three per bird was accounted as miscellaneous cost for vaccination, medication etc.

\# Litter materials for treatments T_3, T_4 and T_5 were available free of cost

$ @ Rs.38/- per kilogramme live body weight

f @ Re0.50/- per kilogramme poultry manure

the total returns and that being 0.70, 0.90, 0.72, 0.63 and 0.95 rupee per bird respectively from treatments T_1, T_2, T_3, T_4 and T_5.

The net profit per kilogramme body weight at sixth weeks of age was 7.61, 8.26, 8.15, 8.87 and 8.28 rupees respectively for birds reared on wood shavings, saw dust, rice husk, coir pith and paddy chaff litters. The values at eighth week of age were 8.20, 8.61, 8.57, 8.77 and 8.31 rupees respectively for treatments T_1 to T_5.

Discussion

DISCUSSION

The results obtained from the study to evaluate the efficacy of different litter materials on the performance of broilers and other related parameters are discussed in this chapter.

Meteorological parameters

The data pertaining to microclimate inside the experimental house are presented in Table 3. During the course of the experiment (January to March, 1998) the mean maximum temperature ranged from 36.86 to 38.86°C with an average of 37.81°C. The mean minimum temperature recorded ranged from 22.29 to 24.29°C with an average of 23.23°C. The mean relative humidity recorded ranged from 71.00 to 82.14 per cent in the morning and 35.57 to 55.29 per cent in the evening during the experimental period. The mean maximum and minimum temperature as well as the mean relative humidity in the morning and evening recorded during the course of the experiment is similar in trend to that reported by Thiagarajan (1989) and Amritha Viswanath (1992). The data obtained in this study therefore indicated that the maximum as well as minimum temperature were well within the stress level as reported by McDowell (1972) and Reece and Lott (1983).

Body weight

Mean body weight of broiler chicks reared on different litter materials recorded at fortnightly intervals did not show any statistically significant difference between treatments (Table 4). The results of the study indicated that, different litter materials did not influence body weight of broilers upto eight weeks of age. The present findings agree with the findings of Oliveira *et al.* (1974); Carter *et al.* (1979); Jones and Hagler (1982); Kassid and Coleman (1989); Burke *et al.* (1993); and Malone and Gedamu (1995); Mallikarjunappa (1996) and Angelo *et al.* (1997). Contrary to the present findings, Muller (1972) and Mizubuti *et al.* (1994) reported that litter materials significantly influenced body weight of broilers. Positive growth response in broilers reared on different litter materials was also reported by Malone *et al.* (1983). Based on the present study it could be concluded that broilers perform equally well when reared on litter materials like wood shavings, saw dust, rice husk, coir pith and paddy chaff.

Body weight gain

Data on mean body weight gain (Table 6) revealed that the gain in body weight was statistically similar for birds reared on five different litter materials. Similar findings were reported by Haque and Chowdhury (1994) and Martinez and Gernat

(1995). But Wyatt and Goodman (1992) and Anisuzzaman and Chowdhury (1996) reported significant difference in body weight gain for broilers reared on different litter materials. Overall mean body weight gain recorded during first, second, third and fourth fortnightly intervals were 222.10, 426.43, 709.00 and 606.91 g respectively. Maximum body weight gain was recorded during five to six weeks of age and there was decrease in body weight gain during seven to eight weeks of age. Maximum gain in body weight during fifth to sixth weeks of age in broilers was reported by Amritha Viswanath (1992). Thus the study revealed that saw dust, rice husk, coir pith and paddy chaff can be used as litter materials for broilers in the place of wood shavings without affecting body weight gain.

Feed intake

Weekly feed consumption (g/bird/week) of broilers reared on different litter materials (Table 8) revealed that feed intake was statistically similar in all treatments except during second week of age. During second week of age, broilers reared on wood shavings (T_1) recorded significantly ($P<0.05$) low feed intake than T_3 and T_4 but was statistically similar to T_2 and T_5. Birds reared on saw dust litter (T_2) recorded feed consumption of 241.19 g and was statistically comparable to T_3, T_4 and T_5 during second week of age. Feed consumption recorded at sixth week and cumulative feed

consumption at eighth week of age did not reveal any significant difference between treatments indicating that different litter materials did not have any effect on feed consumption. Similar findings were reported by Sundaresan (1984), Lien *et al.* (1992), Martinez and Gernat (1995) and Mallikarjunappa (1996). Azahan (1982) and Haque and Chowdhury (1994) also reported non significant difference in feed consumption for broilers reared on different litter materials. Contrary to the above findings Burke *et al.* (1993), Mizubuti *et al.* (1994) and Anisuzzaman and Chowdhury (1996) could notice influence on feed consumption in broilers by different litter materials.

An overall view of weekly feed consumption data revealed that feed intake of broilers reared on different litter treatments were within normal limits indicating that different litter materials, viz., sawdust, rice husk, coir pith and paddy chaff can be used for broilers in place of wood shavings. The gradual increase in feed consumption from first week to eighth week of age is a normal phenomenon due to increase in body weight as age advances.

Feed efficiency

The feed efficiency calculated (based on kilogrammes of feed consumed per kilogramme body weight) at fortnightly

intervals for the five different litter treatments is presented in Table 10. Statistical analysis of fortnightly data on feed efficiency revealed non-significant difference between treatments except that for the first fortnight. During the first fortnight, birds reared on wood shavings (T_1) and paddy chaff (T_5) had significantly higher feed efficiency but is statistically similar to that of T_3 and T_4. Birds reared on rice husk litter (T_2) had significantly ($P<0.01$) lower feed efficiency but is statistically similar to T_3, T_4 and T_5. The difference in feed efficiency during first fortnight may be due to significant ($P<0.01$) difference in feed consumption recorded during this period. Malone *et al.* (1982) also reported significant difference in feed efficiency at 28 days of age and no difference at 49 days of age. The cumulative mean feed efficiency recorded at the end of the eighth week was 2.263, 2.263, 2.283, 2.253 and 2.317 respectively for treatments T_1 to T_5. Statistical analysis of the data (Table 11) did not reveal any significant difference between treatments indicating that birds perform equally well in all litter materials used for the study. The present study corroborates with the findings of Oliveira *et al.* (1974), Jones and Hagler (1982), Parsons and Baker (1985), Lien *et al.* (1992), Martinez and Gernat (1995) and Angelo *et al.* (1997). But Anisuzzaman and Chowdhury (1996) reported that different litter materials influenced feed efficiency in his study using saw dust, paddy straw, sand and rice husk.

Processing yields and losses

Data on processing yields and losses presented in Table 12 revealed that parameters tested were not influenced by the different litter materials used. The present findings agree with the findings of Malone *et al.* (1983), Sundaresan (1984), Kassed and Coleman (1989), Lien *et al.* (1992) and Shanawany (1992). The blood loss ranged from 3.09 to 3.92 with an overall mean of 3.56 and feather loss ranged from 3.28 to 4.87 with an overall mean of 4.13 per cent. The total loss ranged from 23.19 to 24.78 with an overall mean of 24.17 and eviscerated yield ranged from 69.43 to 70.38 with an overall mean of 70.00 per cent. The giblet yield ranged from 5.50 to 5.94 with an overall mean of 5.71 and ready-to-cook yield ranged from 75.17 to 76.32 with an overall mean of 75.72 per cent.

Rejikumar (1991) reported, ready-to-cook yield of 72.76, total loss of 27.24, blood loss of 3.42 and feather loss of 3.06 per cent in broilers at eighth week of age. Amritha Viswanath (1992) reported blood loss as 3.98, feather loss as 4.76, total loss as 23.45, eviscerated yield as 71.66, giblet yield as 4.89 and ready-to-cook yield as 76.55 per cent. The present findings corroborates with that of the above studies. The present study revealed that litter materials, viz., wood

shavings, saw dust, rice husk, coir pith and paddy chaff did not influence processing yields and losses of broilers.

Weight of the litter

Mean weight of the litter materials at the beginning and end of the experiment presented in Table 14 revealed significant difference ($P<0.01$) between treatments. Treatment which used paddy chaff (T_5) as litter material recorded more weight followed by T_2, T_3, T_1 and T_4 in a descending order. After eighth week of age also the same trend continued except that for T_1 and T_3 which were statistically similar. The low weight of the litter at the end of the eighth week in T_4 is due to initial low weight of the coir pith used for the study. The difference in weight of the litter material depends on the type of material used. North (1984) reported that the broiler dropping produced will be approximately 1.4 g/g of feed consumed.

Moisture content in the litter

Moisture content of fresh litter materials as well as those recorded at weekly intervals, presented in Table 16 revealed significant ($P<0.01$) difference between treatments. Coir pith (T_4) litter had significantly ($P<0.01$) high moisture content on fresh basis and rice husk (T_3) the lowest. The mean moisture content recorded on fresh litter materials

ranged from 6.11 to 12.44 per cent. Sundaresan (1984) also reported significant difference in initial moisture content of litter materials. Moisture content of litter materials increased gradually from first to eighth week of age in all treatment groups. Andrews and McPherson (1963) and Huff *et al.* (1984) reported that litter moisture increased significantly from initial value. The present findings corroborate with the findings of above workers. The increase in moisture content from initial value is due to increased excreta deposited and increased respiration of growing broilers.

At the end of eighth week of age there was significant ($P<0.01$) difference between treatments in moisture content. Highest per cent moisture content of 54.43 was recorded in T_4 and lowest moisture content of 26.79 was recorded in T_2. Treatment which used woodshavings as litter material (control) did not differ significantly from T_5 (paddy chaff). Treatment which used saw dust as litter material (T_2) is statistically similar to T_3 (rice husk). Kaniok and Rozycka (1978) reported that initial moisture content (per cent) of litter materials like straw; saw dust; straw and peat moss (2:1); straw and saw dust (2:1) and straw, saw dust and peat moss (1:1:1) increased from 5 to 6 and reached 22 to 34 at the end of eight weeks of age. Andrews and McPherson (1963) reported that moisture content of litter after eight weeks of rearing broilers as

34.10 per cent in rice hull and 30.60 per cent in wood shavings. Present observations agree with the findings of above authors. In the present study it could be seen that moisture absorbing capacity of wood shavings was similar to paddy chaff (T_5). After the eighth week period the moisture content of saw dust (T_2) was statistically similar to that of rice husk (T_3). Coir pith had significantly ($P<0.01$) higher moisture content than other litter materials. Adequate absorption of moisture is a characteristic for an ideal litter material. Thus from the results of the study it could be seen that litter materials used had required water absorbing capacity.

Significant higher moisture content of 54.43 per cent for coir pith at the end of eighth week was due to high initial moisture content. The same trend continued throughout the experimental period. Over and above this, small particle size of coir pith caused an increase in the incidence of litter caking which also contributed to decreased evaporation of water from beneath. Baskar and Saravanan (1998) reported that the water holding capacity of coir pith as five hundred per cent. But this factor did not affect the body weight gain and feed efficiency of broiler. Thus it indicates that wood shavings, saw dust, rice husk, paddy chaff and coir pith can be used as potential sources of litter material.

Ammonia nitrogen content

Mean per cent ammonia-nitrogen content recorded at fortnightly interval (Table 18) revealed significant difference throughout the experiment. The ammonia-nitrogen content of T_1 to T_5 ranged from 0.0077 to 0.0318 per cent in fresh litter materials. Highest ammonia-nitrogen level of 0.0318 per cent was recorded for coir pith but it did not differ significantly from rice husk litter. Lowest value for ammonia-nitrogen was reported for saw dust litter but it was statistically similar to paddy chaff (T_3). Ranade and Rajmane (1990) reported significant difference in ammonia-nitrogen content in different litter materials, viz., wood shavings, paper cuttings, chopped hay, fine sand and rice husk. The present findings agree with their findings. At the end of eighth week the ammonia-nitrogen content ranged from 0.2477 to 0.6338 per cent. There was significant ($P<0.01$) difference between treatments at the end of eighth week also. Rice husk litter (T_5) recorded significantly high ammonia-nitrogen content of 0.6338 per cent followed by paddy chaff and coir pith. Wood shavings (T_1) and saw dust (T_2) recorded significantly lower ammonia-nitrogen content. The significant difference in ammonia-nitrogen content in different litter materials may be due to difference in microbial activity in the litter material. Significant difference in ammonia-nitrogen percentage was reported by Andrews and

McPherson (1963) and Ranade and Rajmane (1990). Cornen *et al.* (1996) reported an ammonia-nitrogen percentage of 0.6 to 0.9 in wood shavings litter at the end of eighth week in broilers. The present findings agree with the findings of above authors.However, the difference in ammonia-nitrogen levels did not have any deleterious effect on production performance of broilers.

Nitrogen, phosphorus and potassium content

Data on mean per cent nitrogen, phosphorus and potassium contents of litter materials analysed at the beginning, sixth week and eighth week presented in Table 20 revealed significant difference ($P<0.01$) between litter treatments. Paddy chaff (T_5) litter had higher nitrogen content and coir pith (T_4) had lower value. Nitrogen content of the litter materials increased as the age advanced. Nitrogen content ranged from 0.427 to 1.669 per cent on fresh litter materials. At sixth week of age it increased to 3.073 to 4.245 per cent. At the end of eighth week of age, nitrogen content increased as 3.797 per cent to 5.157 per cent. Brake *et al.* (1992) reported a nitrogen content of 2.24 to 3.14 per cent in broiler litter at eight weeks of age. The present findings corroborates with the above.

Phosphorus content (per cent) of fresh litter materials did not reveal any significant difference (Table 20). The per cent phosphorus content increased as age advanced in all the treatments. There was significant difference ($P<0.01$) in phosphorus content at sixth week of age as well as at eighth week of age. The per cent phosphorus content at eighth week of age ranged from 0.747 to 1.497 per cent. This findings agree with that of Stephenson *et al.* (1990) and Babu *et al.* (1993).

The data on per cent potassium content of the litter material at the beginning, sixth week and eighth week revealed significant difference ($P<0.01$) between treatments. The potassium content of litter materials increased with advancement of age. It was observed that nitrogen, phosphorus and potassium content of paddy chaff were comparatively higher than the other litter materials. The reason for higher manurial value in paddy chaff is due to the effect of fertilizers used for the cultivation of paddy.

Results of the present study tend to indicate that type of litter influence the nitrogen, phosphorus and potassium content. Contrary to the present findings, Brake *et al.* (1992) and Nicholson *et al.* (1996) reported no significant differences in manurial value of different litter materials.

Litter pH

Data on mean pH of litter recorded at the beginning of the experiment and on weekly intervals revealed significant difference ($P<0.01$) between treatments (Table 22) throughout the experimental period. The initial pH was significantly lower for T_1 and higher for T_5. The litter pH showed an increasing trend throughout the experimental period. This agree with the findings of Jones and Hagler (1982) and Brake *et al.* (1992). Initially the pH was acidic with a mean value of 6.40 and turned alkaline from third week onwards. At eighth week of age the mean pH recorded was 8.77. Treatment which used paddy chaff as litter material (T_5) recorded higher pH throughout the experiment. This increase in pH may be due to liberation of ammoniacal compounds by microbial activity.

Proximate composition

The mean per cent proximate composition of fresh litter materials (Table 24) revealed significant difference ($P<0.01$) in crude protein, ether extract, crude fibre and total ash contents.

Crude protein: On fresh basis the crude protein content of paddy chaff litter (T_5) was significantly high and the least was for coir pith (T_4), whereas crude protein content of T_1, T_2 and T_3 were statistically similar. High crude protein

content (10.45 per cent) of paddy chaff may be due to the presence of rice inside it. During sixth week of age also significant difference in crude protein content between litter materials occurred (Table 25). The crude protein content ranged from 19.28 to 26.57 per cent during this period. Highest crude protein content was recorded in T_5. This may be due to initial high crude protein content of paddy chaff over and above the presence of crude protein in poultry manure. However T_5 is statistically similar to T_1. During sixth week of age, T_1 was statistically similar to T_2 and T_3. Saw dust litter (T_2) did not differ significantly from T_3 and T_4. Irrespective of the litter material, crude protein content increased from its initial value. During eighth week also the same trend continued. Highest crude protein content was recorded in paddy chaff litter. Crude protein content of T_1 did not differ significantly from T_2 and T_3. During eighth week of age, crude protein content of saw dust litter was statistically similar to T_4. Irrespective of litter material, crude protein content increased as the age advanced. This finding fall in line with the reports of Bagley *et al.* (1996). Significant difference in crude protein content of different litter materials was also reported by Muller (1972), Ryssen *et al.* (1977) and Kaniok and Rozycka (1978). Contrary to the present findings, Labosky *et al.* (1977) stated that different litter materials did not differ significantly in nutrient content.

Ether extract: Mean per cent ether extract content of fresh litter materials (Table 24) and at sixth week (Table 25) revealed significant difference between treatments. The ether extract content ranged from 0.03 to 1.77 per cent in fresh litter materials. During sixth week it ranged from 0.96 to 2.07 per cent. The ether extract content recorded during eighth week of age did not reveal any significant difference (Table 26) between treatments. The ether extract content at eighth week of age ranged from 1.49 to 2.57 per cent. The results of the present study agree with that of Ali *et al.* (1995).

Crude fibre: Mean per cent crude fibre content of fresh litter materials revealed significant difference between treatments (Table 24). Wood shavings and saw dust recorded high crude fibre content and coir pith the least crude fibre content. During sixth week (Table 25) and eighth week (Table 26) also there was significant difference in crude fibre content between different treatments. Results of the study revealed that irrespective of litter materials, crude fibre decreased as the age advanced. This is due to microbial degradation of litter materials. These findings agree with the findings of Kaniok and Rozycka (1978).

Total ash: At the beginning of the experiment, per cent total ash content recorded significant difference between litter materials. Coir pith litter (T_4) recorded significantly low

total ash content than the other litter materials. The same trend continued during sixth and eighth week. Irrespective of the litter material, total ash increased as the age advanced. This finding is in agreement with the findings of Bagley *et al.* (1996).

Livability

Data on the mortality pattern of broilers reared under different litter treatments are presented in Table 28. During the first two weeks of the experiment there was no mortality. During the third week, only one bird each died in T_1 and T_5. During the fourth week of age, mortality was there in all the treatments except T_5. Statistical analysis of the data revealed significant difference between treatments. Among the treatment groups the birds reared on wood shavings (T_1) had significantly low mortality than T_2, T_3 and T_4. During the fifth, sixth, seventh and eighth week of age statistical analysis of the data on per cent mortality did not record any significant difference between treatments. Similar findings were reported by Oliveira *et al.* (1974), Kassed and Coleman (1989), Malone *et al.* (1990), Quinones *et al.* (1990), Lien *et al.* (1992), Burke *et al.* (1993) and Angelo *et al.* (1997). The main cause of death in the present work during seventh week was due to outbreak of Infectious Bursal Disease even after taking preventive vaccination. The high atmospheric temperature (38°C) during seventh week and eighth week of age

coupled with high humidity (71 to 82 per cent) during the period might have caused stress which precipitated the outbreak of Infectious Bursal Disease.

Cost-benefit analysis

Feed cost, chick cost, litter cost and other miscellaneous cost were taken into account for cost benefit analysis. The total cost of production upto sixth week of age (Table 30) revealed lowest for T_3 (Rs.41.66) and highest for T_2 (Rs.43.42). Net profit per bird in rupees calculated at the end of the sixth week was 10.54, 11.82, 11.18, 12.61 and 11.64 respectively for treatments T_1 to T_5. Net profit per kilogramme body weight was lowest for T_1 (control) and highest for T_4 (coir pith). Cost-benefit analysis of the birds carried out at the end of the eighth week also revealed a higher profit for treatment groups than control. Profit per bird (Rs.) recorded for treatments T_1 to T_5 was 16.03, 17.65, 17.25, 17.69 and 16.73 respectively. Net profit per kilogramme body weight (Rs.) at eighth week of age was 8.20, 8.61, 8.57, 8.77 and 8.31 respectively for treatments T_1 to T_5. The lowest profit in T_1 (control) is due to the numerical difference in body weight attained. The cost benefit analysis presents a fact that saw dust, rice husk, coir pith and paddy chaff can be used as litter materials in place of wood shavings.

Summary

SUMMARY

An experiment was designed and carried out at the Department of Poultry Science, College of Veterinary and Animal Sciences, Mannuthy to evaluate the efficacy of different litter materials on the performance of broilers under hot-humid conditions prevailing in Kerala.

Two hundred and ten, one-day old straight run commercial broiler chicks (Cobb) were procured for the study. The chicks were wing banded, weighed individually and allotted randomly to the five different treatment groups. Each treatment group consisted of three replicates of fourteen birds each. In the first treatment group, wood shavings was used as litter material and formed the control group (T_1). In other treatment groups, saw dust (T_2), rice husk (T_3), coir pith (T_4) and paddy chaff (T_5) were used as litter materials.

Standard routine managemental practices were followed throughout the experimental period. Feed and water were provided *ad libitum*. Chicks were provided with broiler starter ration upto six weeks of age and broiler finisher ration upto eight weeks of age. Both the rations were formulated as per BIS (1992) specifications of nutrients for broiler chicken.

The production performance of the birds were recorded for a period of eight weeks. The following observations were recorded during the experimental period and the efficacy of different litter materials on the performance of broilers for the following parameters were evaluated.

1. Fortnightly body weight
2. Fortnightly body weight gain
3. Weekly feed intake
4. Fortnightly feed efficiency
5. Processing yields and losses at the end of eight weeks of age
6. Weight of the litter at the beginning and end of the experiment.
7. Weekly moisture content of the litter
8. Fortnightly ammonia-nitrogen content of the litter
9. Nitrogen, phosphorus and potassium content of the litter at the beginning, sixth week and at the end of the eighth week.
10. Weekly pH of the litter

11. Proximate composition of the litter at the beginning, sixth week and at the end of eighth week

12. Livability

13. Cost-benefit analysis by the sixth and at the end of the eighth week

14. Meteorological parameters

The results obtained during the course of the study are summarised in Table 32. Based on the results of this study following observations were made.

1. Statistical analysis of the data on mean body weight of broiler chicks reared on different litter materials recorded at fortnightly intervals did not reveal any significant difference between treatments. The mean body weight for different treatment groups ranged from 1371.67 g to 1430.70 g at sixth week and 1954.87 g to 2051.10 g at eight weeks of age.

2. Data on fortnightly body weight gain revealed that this parameter was not influenced by the different litter treatments upto eight weeks of age. The highest body weight gain was recorded during five to six weeks of age and thereafter a reduction was noticed.

3. Analysis of the data on weekly feed consumption (g/bird/week) indicated that litter treatments did not influence feed consumption throughout the experimental period except during second week ($P<0.05$).

4. Statistical analysis of fortnightly data on feed efficiency recorded non-significant difference between treatmentsexcept during the first fortnight. The cumulative mean feed efficiency recorded at the end of the eighth week was 2.263, 2.263, 2.283, 2.253 and 2.317 respectively for treatments T_1 to T_5.

5. Data on processing yields and losses viz., blood loss, feather loss, total loss, eviscerated yield, giblet yield and ready-to-cook yield did not reveal any significant difference between litter treatments.

6. The weight of the litter at the beginning and the end of the experiment showed significant difference ($P<0.01$) between the different litter treatments. Paddy chaff litter (T_5) showed significantly higher weight (80.20 kg) and coir pith (T_4) the lower weight (52.65 kg) at the end of the experiment.

7. Weekly estimation of moisture content of litter materials revealed significant difference ($P<0.01$) among the

different treatment groups. Coir pith litter (T_4) showed significantly high value and sawdust (T_2) the least.

8. Estimation of per cent ammonia-nitrogen content of fresh litter materials for treatments T_1 to T_5 ranged from 0.0077 to 0.0318. Rice husk litter (T_3) had high ammonia-nitrogen content. Fortnightly ammonia-nitrogen content showed significant difference ($P<0.01$) between the different treatment groups throughout the experimental period. Saw dust litter (T_2) showed significantly low ammonia-nitrogen content. At the end of eighth week, wood shavings (T_1) recorded lower ammonia-nitrogen content (0.2477 per cent) while rice husk the higher (0.6338 per cent).

9. Data on mean per cent nitrogen, phosphorus and potassium content of the litter at the beginning, at the end of sixth week and eighth week revealed significant ($P<0.01$) difference between the different treatment groups except for the initial phosphorus content which was statistically similar among different treatment groups. Paddy chaff litter (T_5) had higher and coir pith litter (T_4) had lower nitrogen content at the beginning, sixth week and eight weeks of age. The per cent phosphorus content at eighth week of age ranged from 0.747 to 1.497. The mean per cent potassium content of litter materials increased with advancement of age.

10. Data on weekly pH of the litter showed significant difference ($P<0.01$) between the different treatment groups throughout the experimental period. Initially the pH was acidic with a mean value of 6.40 and turned alkaline from third week onwards.

11. Proximate composition of the litter at the beginning, sixth and eighth weeks for dry matter, crude protein, ether extract, crude fibre, nitrogen free extract and total ash showed significant difference ($P<0.01$) between the different litter treatments except for eighth week ether extract contents.

12. Weekly per cent mortality was not influenced by different litter treatments except during fourth week of age ($P<0.05$). During fourth week of age birds reared on wood shavings (control) had significantly low mortality than other treatment groups.

13. Cost-benefit analysis revealed that net profit per bird was least in wood shavings litter (T_1) and more in coir pith litter (T_4) during sixth and eighth weeks of age.

14. The mean maximum temperature during the experimental period inside the experimental shed ranged from 36.86to 38.86°C and the mean minimum temperature ranged from 22.29 to 24.29°C. The relative humidity ranged from

71.00 to 82.14 per cent in the morning and 35.57 to 55.29 per cent in the evening.

From the overall results of the study, it was concluded that commercial broilers can be grown under deep litter system of rearing using saw dust, rice husk, coir pith and paddy chaff as litter materials in place of wood shavings. Eventhough, the different litter materials differed in the litter quality parameters, the production performance of broilers was not affected by the difference in litter materials. Since the study is carried out only during a part of the year, further studies are recommended in other seasons to arrive at a final conclusion.

Table 32. Efficacy of different litter materials on the performance of broilers

Sl. No.	Particulars	Treatments				
		T_1	T_2	T_3	T_4	T_5
1.	Live body weight (g)	1954.87	2051.10	2013.33	2016.56	2013.83
2.	Body weight gain (g)	1911.20	2008.37	1970.43	1972.36	1970.26
3.	Total feed consumed (g)	4436.45	4639.03	4598.31	4549.79	4674.23
4.	Feed efficiency	2.263	2.263	2.283	2.253	2.317
5.	Ready-to-cook yield (%)	75.59	75.17	75.89	76.32	75.63
6.	Mean weight of litter(kg)	58.40	75.17	60.27	52.65	80.20
7.	Weekly moisture content(%)	34.66	26.79	29.03	54.43	32.21
8.	Ammonia-nitrogen content (%)	0.2477	0.2726	0.6338	0.3718	0.4744
9.	NPK content (%)					
	a. Nitrogen	4.395	4.112	4.251	3.797	5.157
	b. Phosphorus	0.747	1.229	0.986	1.056	1.497
	c. Potassium	0.893	0.755	0.757	0.880	1.263
10.	Weekly pH of the litter	8.88	7.99	8.89	8.76	9.34
11.	Proximate composition (%) of the litter materials					
	a. Dry matter	65.35	73.22	71.02	45.62	67.80
	b. Crude protein	27.49	25.72	26.64	23.79	32.25
	c. Ether extract	1.89	1.49	2.22	2.57	2.39
	d. Crude fibre	23.06	20.68	12.37	8.61	14.25
	e. Nitrogen free-extract	13.33	19.70	29.15	47.12	25.43
	f. Total ash	34.86	32.54	29.81	18.15	25.78
12.	Mortality (No.)	22	23	23	23	22
13.	Cost benefit analysis					
	a. Net profit per kilogramme body weight at sixth week (Rs.)	7.61	8.26	8.15	8.87	8.28
	b. Net profit per kilogramme body weight at eighth week (Rs.)	8.20	8.61	8.57	8.77	8.31

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EFFICACY OF CERTAIN LITTER MATERIALS ON BROILER PERFORMANCE

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ABSTRACT OF A THESIS

Submitted in partial fulfilment of the
requirement for the degree of

Master of Veterinary Science

Faculty of Veterinary and Animal Sciences
Kerala Agricultural University

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MANNUTHY, THRISSUR
KERALA, INDIA

1999

ABSTRACT

An experiment was designed and conducted at the Department of Poultry Science, College of Veterinary and Animal Sciences, Mannuthy to evaluate the efficacy of different litter materials on the performance of broilers under hot-humid conditions of Kerala. Two hundred and ten, one-day old straight-run commerical broiler chicks were reared for a period of eight weeks. The birds were allotted into five different litter treatment groups, viz., wood shavings (T_1) which formed the control group, saw dust (T_2), rice husk (T_3), coir pith (T_4) and paddy chaff (T_5), each comprising of three replicates with fourteen birds each. Standard broiler starter and finisher rations were formulated as per BIS (1992) specifications for the broilers. The chicks were reared under standard managemental conditions upto eight weeks of age.

Results of the study revealed that body weight and body weight gain were not influenced by different litter treatments throughout the experimental period. Eventhough feed consumption and feed efficiency were influenced by litter materials during the initial periods, there was no impact for the rest of the experimental period. Processing yields and losses were not affected by different litter treatments. Litter quality parameters like weight of the litter at the beginning and end of the experiment, weekly moisture content,

fortnightly ammonia-nitrogen content, nitrogen-phosphorus-potassium content, litter pH and proximate composition of the litter at the beginning, at sixth week and eighth week were significantly different ($P<0.01$) between different treatment groups. It was observed that eventhough there was significant difference ($P<0.05$) between treatment groups for mortality by fourth week of age, no significant difference was obtained for all other periods. Cost-benefit analysis revealed that net profit per bird by sixth week and eighth week of age was more for litter materials, viz., saw dust, rice husk, coir pith and paddy chaff than wood shavings.

Based on the above findings, it can be concluded that different litter materials, viz., saw dust, rice husk, coir pith and paddy chaff are equally good for broiler raising as wood shavings during the month of January through March in Kerala.