NUTRITIVE EVALUATION OF PRAWN WASTE-PADDY STRAW SILAGE IN CATTLE

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled **"Nutritive Evaluation of Prawn Waste-Paddy Straw Silage in Cattle"** 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 similiar title of any other University or Society.

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Certified that this thesis entitled **"Nutritive Evaluation of Prawn Waste - Paddy Straw Silage in Cattle"** is a record of research work done independently by **Dr. Jose James** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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Dedicated to
my loving parents

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Introduction

INTRODUCTION

Livestock rearing in India is almost exclusively a rural occupation with a complementary relationship to agricultural sector. Livestock being the largest productive asset in rural India, next to land and irrigation, contributes significantly to the national economy. Lack of adequate feed and virtual absence of processing and marketing infrastructure are the major problems facing this sector. Acute shortage of quality feeds and fodders is the major constraint in the development of economic livestock farming in India. Moreover, only four per cent of the total cultivable land in the whole country is under fodder production. The scope for further increase in the area under fodder crop is restricted due to small size of holdings and competing demands for increasing the production of food grains and cash crops from the limited cultivated area. As per the estimates available (Mudgal, 1988) the annual requirements in million tonnes are estimated to be 25.4 for concentrates, 353.0 for dry fodder and 308.1 for green fodder. The gap between the availability and requirements of concentrates and green fodder is very wide. It is estimated that feed and fodder availability fall short by

44 per cent for concentrates and 38 per cent for green fodder which in terms of digestible crude protein and total digestible nutrients comes to 35 per cent and 37 per cent respectively (Mudgal, 1988).

Chronic shortage of feeds and fodder has in general lowered the productive capacity and fertility of Indian livestock. Hence, larger numbers of them have to be maintained and this in turn causes an overall deficiency of feeds and fodder. This focusses on an imperative need to reduce the number of unproductive stock and to augment feed resources. But the resource base of feeds and fodder seems shrinking day by day. Changes in the cropping pattern and a linear increase in human population demanding for more and more land use for food production, rather than animal feed and fodder production, have had definite discernible impact on the cattle holding complex. This being the scenario, increasing the size of cross-bred stock will exert further pressure on the available animal feed supply.

It is therefore, the challenging need of the day to explore all the domestic feed resource potential and to sort out effective ways and means to expand it further in terms of quantity and quality so as to improve the nutritional standards of Indian livestock. Crop residues and other cellulosic materials are presently the staple livestock feeds in India of which rice straw forms the bulk. But they cannot meet even the maintenance requirements of ruminants owing to their low nitrogen content, poor digestibility and presence of other incriminating factors. As such, concentrates and /or green fodder have to be fed along with straw to obtain better animal performance. But the availability of concentrate supplements is inadequate and they are expensive too. It is therefore necessary to improve the existing feed resource situation by adding non-conventional feed ingredients to the animal feed reservoir.

Properly processed animal wastes are wholesome in appearance, taste and smell. They are almost higher in crude protein and contain substantial amounts of minerals, vitamins and some unidentified nutritive factors. Despite all these, they are often wasted or create disposal problems. Replacing conventional feeds by such organic wastes of little or no commercial value, inevitably leads to a significant reduction in the cost of production of milk, meat and other animal products. Extensive studies on the identification and utilisation of various agro-industrial byproducts and animal wastes in the ration of livestock have been done in India (Punj, 1988; Gupta, 1988). Under the All India Co-ordinated Research Project on Agricultural Byproducts at the college of Veterinary and Animal Sciences, Mannuthy, elaborate studies were carried out for screening and assessing the nutritive values of various agricultural byproducts and industrial waste materials which are available in adequate quantities in Kerala (A I C R P Report, 1988). Different methods and technologies have been adopted to improve the nutritive value of such animal wastes before being incorporated in animal rations. Of the various methods of processing, ensiling is the least cost one, wherein most of the energy and nutrients of the original material ensiled is preserved. Satisfactory methods of ensiling animal wastes such as excreta of pigs, cattle and poultry (Caswell et al., 1977; Jakhmola et al., 1988) and slaughter house wastes such as rumen contents and blood(Rao and Fontenot, 1987) have been reported.

Aquatic animal wastes, if they are properly processed, can supply good quality protein at a lower cost. Advent of newer technologies have improved sea food processing industry, but also resulted in wastage ranging from 50 to 90 per cent. Handling of these wastes poses problems of disposal due to their high moisture content, quick deterioration, offensive odour and pollution hazards. Earlier methods like throwing wastes back into the sea, land filling, use as fertilizer or drying into meal for livestock feed, ran into problems of pollution and economic loss. Research on alternative methods of disposal led to the studies on their use as livestock feed.

Various byproducts of aquatic animal origin, processed by different methods, like fish silage, crab meal and krill meal are found to be satisfactory feed supplements for different species of animals. Ensiling of aquatic animal wastes with crop residues like straw and other additives produce a desirable product for feeding animals. Prawn waste is one such byproduct of aquatic origin that can be used as a source of animal feed. Studies conducted under the All India Co-ordinated Research Project on Agricultural Byproducts, Mannuthy revealed that prawn waste can be successfully ensiled with additives like rice bran or paddy straw to produce a satisfactory silage (AICRP Report, 1991).

With a coastal line of 600 km and about 4000 ha of land available for rearing of prawns, Kerala stands first among the Indian states in the production of sea foods. With the increase of annual prawn processing, the availability of prawn waste is increasing. The annual availability of prawn waste in Kerala is estimated to be 93,000 tonnes (Fisheries Statistics, 1991), which at present is mostly being wasted or used as manure in coastal areas.

Though prawn waste is found to be a potential source of nutrients like protein and minerals(Morrison., 1984; Jarquin et al., 1972; AICRP Report, 1991) and can be converted to a satisfactory silage with proper additives, little has been done to comprehensively evaluate its suitability of being used as a livestock feed. It is in this context, the present study has been designed to evaluate the fermentation characteristics of good quality prawn waste-paddy straw silage and to assess its nutritive value in cattle.

Review of Literature

REVIEW OF LITERATURE

The seafood processing industry uses many types of fish including shell fish, and thereby produces a sizable quantity of wastes and by-products. Research on the nutritive evaluation and utilisation of these aquatic animal wastes as livestock feed is limited. While, in India, such aquatic animal wastes have rarely been tried in animal feeds, many such by-products have been used as sources of animal protein in the rations of livestock in other countries.

2.1 Shrimp meal:

Shrimp meal also called "Shrimp bran" consists of the dried waste of the shrimp industry, including the head, appendages and shell.

2.1.1 Chemical composition:

Morrison (1948) reported that shrimp meal contained 89.7 per cent dry matter consisting of 46.7 per cent crude protein, 2.8 per cent fat, 11.1 per cent fibre, 1.3 per cent nitrogen free extract and 27.8 per cent ash and providing a digestible crude protein content of 37.8 per cent, total digestible nutrient content of 43.5 per cent and a nutritive ratio of 0.2.

Jarquin et al. (1972) reported that two shrimp by-product meals prepared separately from heads and from bodies plus tails of a mixture of four species (Penaeus stylirostris, Penaeus vannameir, Penaeus californiensis and Penaeus brevirostris) had the following percentage chemical composition: water- 12.1, 12.4; fat- 2.4, 1.4; protein- 37.4, 47.5; ash- 29.2. 34.3; lysine- 1.98, 3.4; methionine-0.77, 1.56 and calcium- 5254, 2437; phosphorus- 1302, 1078 and iron- 90.8, 29.4 mg per 100g respectively.

Meyers et al. (1973) observed that shrimp heads made up 40 to 44 per cent of the whole raw shrimp and found to contain 47 to 55 per cent protein with a good amino acid balance. They also noticed variability in the proximate composition of different processed shrimp meals, due to difference in condition and species involved and also different processing and recovery techniques used.

Madhavan and Nair (1975) reported the proximate composition of shrimp waste and squilla (Oratosquilla nepa). On dry matter basis, the percentage composition of prawn waste and squilla were: protein- 39.76 and 44.71, ash- 31.13 and 35.42, fat -5.05 and 2.68 and chitin- 23.08 and 14.71 respectively.

Menachery et al. (1978) reported that prawn waste on dry matter basis contained 32.1 per cent crude protein, 5.6 per cent ether extract, 6.0 per cent crude fibre, 15.4 per cent nitrogen free extract, 40.9 per cent total ash, 17.4 per cent acid insoluble ash, 9.30 per cent calcium, 1.3 per cent phosphorus and 3.7 per cent sodium chloride.

Landau (1985) found that larger shrimp provided higher percentages of protein, total lipid and energy than smaller shrimp, while the smaller organism had more fatty acid (20:5) and glycogen.

Rua et al. (1985) reported that a meal consisting of a 1.00: 1.15 dry mixture of shark filleting by-product and shrimp by-product, had a crude protein content of 55.66 per cent, a calcium: phosphorus ratio of 5.76 and an essential amino acid pattern similar to that of fish meat or shark meat.

Studies on the chemical composition of shrimp shell (AICRP Report, 1988) indicated that, on dry matter basis, the material contained 30.2 per cent crude protein, 6.0 per cent crude fibre, 5.3 per cent ether extract, 40.2 per cent total ash, 18.3 per cent nitrogen free extract, 17.5 per cent acid insoluble ash, 9.1 per cent calcium and 1.2 per cent phosphorus. Chemical analyses of prawn waste samples (AICRP Report, 1991) collected from different processing centres revealed that fresh prawn waste on an average contained 18.2 per cent dry matter consisting of

41.8 per cent crude protein, 29 per cent total ash, 11.65 per cent calcium and 1.92 per cent phosphorus. Syammohan (1991) also reported almost similar results with 34.6 per cent protein, 41.8 per cent ash, 2.3 per cent fat, 8.2 per cent nitrogen free extract, 4.8 per cent acid insoluble ash, 13.52 per cent calcium and 1.21 per cent phosphorus.

2.1.2 Feeding value:

Bray et al. (1932) found that shrimp meal was superior to tankage as a supplement to maize or to maize and rice polishings, regardless of whether these supplements were used alone or in combination with cotton seed meal and other protein feeds in growing and finishing swine diets.

Perez (1932) obtained satisfactory results when shrimp meal was used as a protein supplement at 5 per cent level in the ration of pigs. Angel (1935) reported that on the basis of rate of gain and feed consumed per unit of gain, the ration with 10 per cent of shrimp gave the best results out of the four levels of 5, 10, 15 and 20 parts of shrimp, in the same basal ration of growing pigs.

Fronda et al. (1938) stated that in order to obtain the same level of egg production, shrimp meal had to be fed at a higher level than fish meal.

Connor (1963) observed a prompt rise in the serum cholesterol levels of mature rats fed a special chow containing shrimp meal, and that their aortic cholesterol contents were as much as 60 times than normal. Lovell (1968) found that shrimp waste was as good as amino acid fortified soya as the sole source of protein for rats. Jarquin et al. (1972) reported that shrimp by-product meals produced a somewhat slower growth rate when compared with fish meal at equal protein levels, in the diet of growing chicken. They also noticed that supplementation of shrimp meal with lysine improved weight gains, but the addition of methionine produced no further response.

Chawan et al. (1974) reported that shrimp meal could serve as a complementary pigment source in broiler diets, when part of the maize in the diet was replaced by wheat.

Patton and Chandler (1975) evaluated the in vivo digestibility of chitinous materials in the rumen of fistulated steers and found that the average rumen solubility of shrimp meal was 17.4 per cent.

Menachery et al. (1978) reported a lower gain in weight of broiler chicks when shrimp shell powder replaced dry fish powder at 5 or 10 per cent levels, during the first eight weeks. However, after six weeks, the weights of chicken given 5 per cent shrimp shell powder were similar to those of the control birds.

Watkins et al.(1982), based on their studies, concluded that crustacean waste products could be satisfactory protein supplements for mink, provided the protein and energy concentration of the diet were maintained at sufficient levels and dietary calcium does not become excessive.

Ilian et al. (1985) reported that shrimp by-catch meal, ground and heated to 55 ^{o}C, 70 ^{o}C and 90 ^{o}C for 24 hours each and incorporated at a level of 5 per cent in the diet of broiler chicken, significantly increased their performance. Though the meal had greater amounts of calcium and phosphorus, it was inferior to menhaden fish meal in sulphur containing amino acids and crude protein contents.

Rua et al. (1985) found that when a meal of 1.00:1.15 dry mixture of shark filleting by-product and shrimp by-product was included in the diets of weanling rats at 3, 6, 9, or 12 per cent levels, it had a protein efficiency ratio of 1.60, protein value of 2.49 and an apparent digestibility of 88.8 per cent. However, when growing chicken were given diets similar to those given to rats for six weeks, no difference in feed efficiency was noticed between diets, though diets with 3 and 6 per cent levels of the meal were considered better, nutritionally and economically.

The biological efficiency and economics of inclusion of shrimp shell powder in rations of growing pigs, replacing fish meal were assessed (AICRP Report, 1988) and it was observed that inclusion of shrimp shell in pig rations replacing fish meal at 50 and 100 per cent levels resulted in lowering of feed consumption, weight gain and feed efficiency. Inclusion of shrimp shell at both the levels had no adverse effects on the carcass characteristics, though complete replacement reduced the eye muscle area. But Syammohan (1991) observed that, replacement of animal protein source at 50 per cent level with dried prawn waste in the ration of growing and finishing pigs increased the digestibility of dry matter and nitrogen free extract, whereas 100 per cent replacement with prawn waste decreased the digestibility of crude protein. Partial or complete replacement of unsalted dried fish with prawn waste adversely affected the carcass characteristics. He observed no significant differences in growth rate, gain in body measurements, average age at slaughter and carcass characteristics of pigs fed diets at the two levels of replacement.

2.2 Crab meal:

Crab meat for human consumption forms only 15 per cent of the total harvested, and the remainder consisting of the shell, viscera and some meat parts forms the crab processing waste, which is dried and ground to form the crab meal.

2.2.1 Chemical composition:

Lubitz _et al_. (1945) estimated the chemical composition of crab meal and found to contain 32.7 per cent crude protein, 12.9 per cent crude fibre which was mainly chitin, 41.6 per cent ash, 16.4 per cent calcium and 1.64 per cent phosphorus. It was also found that crab meal was a good source of manganese and iron and contained 2.9 µg riboflavin per gram, and the chitin which contained 7.4 per cent nitrogen was valueless as a protein supplement. They recommended that crab meal should not contain more than 3 per cent of sodium chloride. Varela and Pujol (1956) found that meal made from crushed whole crabs had 24.46 per cent dry matter comprising of 44.20 per cent crude protein, 7.03 per cent ether extract and 36.36 per cent ash. The ash fraction contained 53g carbonate and calcium- 163, phosphorus- 266, iron- 103 and potassium- 76mg per 100g. Lovell _et al_. (1968) reported that the ash fraction of crab meal was made up of over 50 per cent calcium. They stated that the fibre content of crustacean waste meals is a reliable estimate of the amount of chitin present and the nitrogen content of chitin is 6.9 per cent which accounts for 19 to 20 per cent of the total nitrogen in crustacean waste meals.

Patton _et al_. (1975) determined the trace element concentrations in crab meal by neutron activation analysis, and found that the microelement concentrations in crab meal were bromine 300 ppm, copper 60 ppm and iodine 26 ppm. Moreover, crab meal contained macroelements like calcium 22 per cent, sodium 1.1 per cent, chlorine 1.45 per cent, potassium 0.55 per cent and magnesium 1.45 per cent. Husby (1980) found that king crab meal had 36 to 48 per cent ash and 17.6 to 17.9 per cent fibre, which was mainly chitin. Samuels _et al_. (1982) reported the percentage chemical composition of crab waste to be: dry matter 40.18 with soluble carbohydrates 3.74, protein 44.14, acid detergent fibre 0.18, ash 34.48, calcium 14.16, phosphorus 1.76 and magnesium 0.11.

Mercy (1990) reported that crab waste on dry matter basis contained 43.64 per cent crude protein with 33.31 per cent true protein and 1.55 per cent non-protein nitrogen, 37.97 per cent total ash, 12.15 mg per cent trimethylamine, 0.010 mg per cent indole and it had an _in vitro_ dry matter digestibility of 64.40 per cent Ramachandran (1990) estimated the per cent chemical composition of crab waste to be dry matter 36.29 consisting of crude protein 42.25, acid detergent fibre 19.21, chitin 10.72 and total ash 41.40. Viswanathan (1990) reported that crab waste contained 29.49 per cent dry matter with 42.84 per cent crude protein, 14.66 per cent neutral detergent fibre, 13.55 per cent chitin, 46.11 per cent ash and 0.24 per cent water soluble carbohydrates.

Analysis of crab waste meal by Velez et al. (1991) indicated an average composition of 93.9 per cent dry matter comprising of 36.4 per cent crude protein, 13.3 per cent acid detergent fibre, 46.2 per cent ash, 13.0 per cent calcium, 0.78 per cent magnesium and 1.57 per cent phosphorus. The nonchitin crude protein in crab waste meal was calculated to be 30.7 per cent .

2.2.2 Feeding value:

Parkhurst et al. (1944a,b) reported that crab meal prepared by steam drying cannery waste of the blue crab (Callinectes sapidus), proved to be a satisfactory protein concentrate for chicks and broilers as far as growth, feathering and efficiency of feed utilisation were concerned, provided the absolute and relative amounts of calcium and phosphorus were adjusted and some other protein sources were included in the ration. They observed no difference in egg production, efficiency of feed utilisation, fertility, hatchability, egg weight, yolk colour, albumin quality or texture when rations containing crab meal or fish meal on an equal protein basis and with mineral contents equalised, were fed to laying pullets. But, when the breeding stock received rations containing crab meal supplemented with dried, skimmed milk or fermentation solubles, better hatchability and vigour were observed in the chicks, indicating that crab meal contained certain factors of special value for hatchability.

Varela and Pujol (1956) obtained an apparent digestibility of 84 per cent for dry matter, 79 per cent for crude protein and 84 per cent for ether extract with diets containing crab meal in young rats, but they found that the protein in crab meal was of low biological value.

Potter and Shelton (1973) reported beneficial effects on body weight gains by the addition of crab meal to the diets of young turkeys.

Patton and Chandler (1975) reported a rumen degradation rate of 35.9 per cent for dry matter and 50.2 per cent for crude protein with crab meal diets, in fistulated steers. In subsequent trials(Patton et al., 1975), no declines were found for average daily gain, feed intake or feed efficiency due to the addition of upto 20 per cent of crab meal to the diet of Holstein calves, though nitrogen retention was reduced by similar levels of inclusion. The above authors also reported a digestibility of 66 per cent for chitin from crab meal with variability levels ranging from 26 to 87 per cent. Besides, it was observed that when crab meal was added to a protein deficient diet (7.2 per cent crude protein), average daily gain and feed intake were higher for the supplemented ration.

Ortega and Church (1979) evaluated the feeding value of crab meal for cattle and found that nitrogen from crab meal was not used to any great degree by rumen micro organisms. Husby (1980) stated that king crab meal could effectively replace soybean meal upto 50 per cent in the diets of growing pigs with 40 to 125 pound body weight, without causing significant difference in average daily gain and feed efficiency.

Brundage et al. (1984) observed reduced dry matter intake and milk yield when cows were introduced to concentrates containing 7.5, 22.5 or 30 per cent tanner crab meal, without any significant effect on milk flavour. It was also found that those cows fed on 7.5 and 22.5 per cent crab meal levels in concentrates recovered much of the initial deficit, but those on 30 per cent crab meal did not establish a consistent pattern of intake and lost weight.

Laflamme (1988) reported that inclusion of crab meal at 35 per cent levels in a barley concentrate ration resulted in reduced feed intake and growth in calves, but most of this negative effect was eliminated after a period of adaptation.

Sticker _et al_. (1989), on the basis of studies on ruminal degradation and subsequent absorption of menhaden fish meal and blue crab meal in cannulated sheep and cattle, reported that crab meal protein had similar ruminal escape potential to the menhaden fish meals.

Velez _et al_. (1991) in an _in situ_ trial observed that crab waste meal had higher dry matter and crude protein disappearances from the rumen of growing dairy heifers than craw fish waste meal, and that the crude protein of crustacean waste meals were only about half as degradable as the protein in soybean meal. They opined that the inferiority of crustaecan waste meals were due to less ruminal degradation resulting in decreased microbial protein synthesis, relative unavailability at the intestinal level of ruminally undegraded dietary crude protein or a possible mineral imbalance and concluded that this lower protein degradation of crustacean waste meals in the rumen reflected a lower digestibility and not utility as an 'escape protein' source.

2.3 Krill meal:

Luberda and Iwanska (1981) found that krill meal included at a level of 1.2 to 1.6 per cent in the ration of growing and finishing swine did not influence the physico-chemical features of depot fats. However, they found that higher proportions of krill meal, from 2.4 to 4.8 per cent in the diets caused a decrease of the fat and dry matter contents and an increase of the polyunsaturated fatty acids in the lard and outer layer of back fat. Krokhina and Antonov (1982) observed that when pigs were reared and finished on feed mixtures containing fish meal or krill meal, no lowering of feed intake were seen. Instead, krill meal helped to achieve very high average daily body weight gains. Based on their findings, they stated that in feed mixtures for growing pigs, in which fish meal is the single animal protein source, krill meal could replace upto 50 per cent of the fish meal protein. Luberda et al. (1983) reported that krill meal can be incorporated as a partial or complete replacement of animal protein in the ration of pigs, without any significant difference in average daily weight gain, dressing percentage and carcass length.

2.4 Ensiling of aquatic animal wastes:

Ensiling is considered a potentially effective method of preservation of aquatic animal wastes. This low-cost fermentation process will also help to alleviate waste disposal and water pollution problems, as well as providing a method of recovering some of the most valuable nutrients in the wastes.

2.4.1 Fish silage:

Fish silage is a product formed when whole fish or parts of fish are treated with an acid, usually either formic or a mineral acid. Ensilage offers a means by which most types of fish or fish offals can be used efficiently by conversion into a highly nutritious liquid food to be included in animal rations.

2.4.1.1 Chemical composition:

The chemical composition of fish silage is dependant on the species and the relative fractions of fish tissue used.

Tatterson and Windsor (1974) reported that silage made from white fish offal on dry matter basis contained 71.1 per cent crude protein, 2.4 per cent oil and 19.9 per cent ash. Whittemore and Taylor (1976) reported that silage made from herring offal had 48.3 per cent crude protein, 28.2 per cent oil and 12.5 per cent ash, on dry matter basis. Disney _et al_. (1978) analysed the silage made from the by-products of tuna processing and found that it contained on dry matter basis 69.9 per cent crude protein, 12.2 per cent oil and 10.5 per cent ash.

Siriwardane (1979) produced a good quality silage with silver belly fish and ground maize, which had a crude protein content of 26 per cent. Johnsen and Ekern (1982) found that silage made from viscera of fish and preserved with formic and propionic acids had a low content of dry matter which consisted of 75 per cent crude protein of which only 15 per cent was true protein. Batterham _et al_. (1983) reported that fish silage prepared either from fish or from prawn offal contained a similar nutrient level of 23.9 per cent dry matter consisting of 68.6 per cent crude protein, 10 per cent ether extract, 16.3 per cent ash and a concentration of 1.05 mg per kg of total mercury.

Abazinge _et al_. (1984) prepared a silage by mixing fish waste with rye straw in a 1:1 ratio and adding 5 per cent molasses and reported its chemical composition as 59.22 per cent crude protein, 66.18 per cent neutral detergent fibre, 44.47 per cent acid detergent fibre, 35.89 per cent cellulose, 8.65 per cent lignin and 6.59 per cent ash.

Haard *et al*. (1985) observed that addition of 0.25 to 0.39 per cent of formaldehyde to fish silage after liquefaction was complete, served to prevent continued protein hydrolysis and oxidative rancidity of the oil. Ward *et al*. (1985) found that fish waste could be ensiled with formic and propionic acids to produce a silage containing 76.55 per cent moisture, 14.00 per cent crude protein and 4.56 per cent ash. Cordova and Bello (1986) prepared a silage from different species taken as by-catch during shrimp fishing, which after drying contained 8.4 per cent moisture, 63.2 per cent protein, 5.0 per cent ether extract and 19.2 per cent ash.

Hassan and Heath (1986) evaluated the biological fermentation of whole fish, viscera and heads using *Lactobacillus plantarum* and found that the minimum lactose necessary for a successful fermentation was 5 per cent They also observed that fermentation temperatures of 25 ^{o}C and 35 ^{o}C and an inoculum size of 10^{3} organisms per gram of fish produced successful fermentations. Moreover, pre-heating the fish before fermentation, decreased the amount of soluble nitrogenous substances. Myer *et al*. (1990) prepared a silage from scallop (*Aeiquipeiten gibbus*) by mixing minced fresh viscera with 3.5 per cent formic acid. The above product on dry matter basis contained 85 per cent crude protein, 2.5 per cent crude fat, 6.7 per cent ash, 1.8 per cent calcium, 0.7 per cent phosphorus, 5.8 per cent lysine and 7.5 mg per kg cadmium.

2.4.1.2 Feeding value:

James (1966) reported that different varieties of fish when ensiled with 10 per cent molasses and a pure culture of Lactobacillus plantarum, formed a slurry product of high nutritive value which can be used as an ingredient in poultry and cattle rations.

Hillyer et al. (1976) found that in experiments where all diets were balanced to contain the same level of essential amino acids, fish silage diets provided better feed conversion efficiency than soybean diets for growing pigs. Nair et al. (1976) reported that the dried fish component of the layer ration(10 per cent) can be effectively replaced by fish silage.

Whittemore and Taylor (1976) reported that the silage made from de-oiled herring offal had a nitrogen digestibility of 91 per cent and a digestible energy value of 17.9 MJ per kg dry matter. Disney et al. (1978) compared isoenergetic diets with fish meal, a mixture of fish meal and soybean meal or fish silage as the protein supplement for growing pigs and found that animals given fish silage diets had superior growth performance.

Siriwardane (1979) found that the silage made from silver belly fish and ground maize when used in combination with soy bean meal, can completely replace high quality fish meal in broiler diets. Kompiang et al. (1980) conducted feeding trials and found that microbial fish silage was a satisfactory replacement for fish meal at levels upto eight per cent of the diet of young chicken, but at higher levels (29 per cent) growth was significantly depressed in comparison with the fish meal controls.

Feeding trials conducted by Poulter et al. (1980) gave satisfactory results when fish silage was used in broiler or layer rations upto 20 per cent, compared to other protein sources like fish meal or meat meal. Rangkuti et al. (1980) reported that fish silage had almost similar nutritive value as that of fish meal when supplemented at 6 per cent level in the diet of pigs. Rattagool et al. (1980) obtained satisfactory growth responses in chicken, fed acid and microbial silages produced from fresh, average or spoiled fish. Winter et al. (1980) reported that fish silage can be used as a protein source for young calves.

Based on the studies with fish silage, Tibbets et al. (1981) reported that efficiency of feed conversion by weanling and finishing pigs fed fish silage was related to the balance of essential amino acids in the silage and that the feed conversion efficiency with fish silage diets were better than with soybean meal diets except when the amino acid balance of the fish silage was poorer than that of the substituted soybean meal. It was also found that ensiled fish waste could be incorporated in the rations of these animals upto 9 per cent without any significant difference in average daily gain, feed conversion ratios and carcass characteristics, when compared to a diet containing corn-soybean meal. Ganegoda et al. (1982) observed a significantly lower feed intake, weight gain and feed conversion efficiency in broiler chicken fed fish silage diets than with fish meal diets.

Johnsen and Ekern (1982) observed that addition of fish viscera silage to the diet of sheep increased the digestibility of organic matter, protein and ether extract, but addition of formaldehyde to this silage increased the digestibility of crude fibre also. However, a drastic reduction in feed intake was noticed when the rumen of sheep was not previously adjusted to a diet with fish silage prior to supplementation. Johnsen (1982) observed a lowered feed intake, milk yield and milk fat content when dairy cows were given fish silage. But it increased the free fatty acid content of milk as against a diet with soybean meal and had no adverse effect on the taste of milk.

Machin et al. (1982) reported that fattening pigs fed fish silage had significantly greater daily weight gain than those fed on a control diet containing fish meal. Tatterson (1982) reported that fish silages of low oil content can be used to replace conventional non-cereal proteins such as fish meal or soybean meal in the diet of pigs and produce good quality carcass, free of taint. Batterham et al. (1983) observed that addition of fish silage as partial or complete replacement of soybean meal in wheat based diets of growing pigs, improved the growth rate and feed conversion ratio during the 20 to 45 kg growth phase, without any adverse effect on carcass quality.

Lindgren and Pleje (1983) observed that silage fermentation of minced fish and fish offal after mixing with cereals pre-fermented with *Pediococcus acidilactici* and *Lactobacillus plantarum*, initiated a rapid fall in pH to less than 4.5 within 30 h and the competing gram negative fermenters and fish pathogens such as *Vibrio anguillarum* and *Aeromonas salmonicida* were eliminated. Abazinge et al. (1984) found that addition of fish waste-straw silage to the diet of finishing steers did not adversely affect feed intake, rate of gain and carcass characteristics. However, higher levels of addition resulted in reduced feed intake without affecting the rate of gain or flavour characteristics of meat. Anglesea and Jackson (1985) observed that a thiaminase activity persisted during spoilage and immediately after ensiling of whole sprats(Sprattus sprattus L.) which was reduced significantly by extended storage at ambient temperature. Studies on the effect of mixing such thiaminolytic silage with a dry binder meal into a moist pellet indicated that thiaminase containing silage may be used to produce a safe moist feed for fish, provided an adequate supplement of thiamine is included in the binder meal.

Fish silage was evaluated as a protein supplement for wheat straw diets by Chirase et al. (1985) and they found that fish silage and wheat straw mixed and ensiled together, fermented well as indicated by lactic acid production. The above authors also reported that feeding of fish silage diets produced similar nitrogen retention in sheep when compared to straw ensiled with ammonium hydroxide alone.

Haard et al. (1985) reported that fish silage can be readily mixed with hay at a ratio of 1.5: 1.0 to form a product referred to as haylage. Voluntary intake was higher when wethers were fed haylage prepared from de-oiled, formaldehyde treated fish silage than when fed haylage prepared from untreated silage.

Ward et al. (1985) found that the silage produced by ensiling fish waste with formic and propionic acids effectively replaced some of the soybean meal in the diet of starter pigs. Cordova and Bello (1986) observed no significant difference in weight gain or feed intake per unit gain between chicken fed silage made from shrimp by-catch and those given fish meal.

Hussain and Offer (1987) reported that treatment of acid preserved fish waste with 5 ml formalin per kg had the potential for improvement of its protein value for ruminants and gives a product which can be easily handled for incorporation into diets. Offer and Hussain (1987) also reported that fish silage should be restricted to approximately four per cent of the diet on dry matter basis, as higher levels reduce intake and live weight gain. They also demonstrated that inclusion of fish silage in the diets did not affect digestibility of either organic matter or gross energy. Green et al. (1988) observed that growing pigs when fed on diets supplemented with fish silage grew faster than those given no silage, owing to an improved feed conversion ratio.

Surdzhiiska et al. (1988) prepared a product 'Ribotricin K' from fish cannery waste, having a protein content of 24 to 25 per cent, 0.6 per cent calcium, 1.4

per cent phosphorus and metabolisable energy 3465 kcal per kg. They found that it could be incorporated at 3 or 4 per cent levels replacing fish meal in the diets for broiler chicken. Myer et al. (1990) reported that supplementation of scallop viscera silage in the diets of growing and finishing swine had no detrimental effects on average daily gain, feed intake or feed to gain ratio. Apparent digestibilities of dry matter, nitrogen and energy of the grower and finisher diets were not affected by the supplementation. Reyes et al. (1991) reported that ensiling of the waste after addition of molasses and fruit wastes, significantly increased the liquefaction of silage by a process independant of bacterial lactic acid production.

2.4.2 Crab waste silage:

Satisfactory ensiling of crab waste with straw and other crop residues have been reported by many workers.

2.4.2.1 Chemical composition:

Abazinge et al. (1986 a) found that the crude protein content of crab waste-straw silage averaged between 12 and 13 per cent on dry matter basis. Abazinge et al. (1986 b) prepared silages by mixing crab waste and wheat straw (1:1 wet basis) and by using three different additives viz. 16 per cent acetic acid, 20 per cent molasses and 20 per cent molasses plus 0.1 per cent inoculant containing a blend of Streptococcus faecium and Lactobacillus plantarum. The percentage chemical composition of the above three silages were reported to be: dry matter- 56.60, 58.41 and 57.58 with crude protein- 12.13, 13.44 and 13.53; neutral detergent fibre- 55.84, 59.30 and 60.30; acid detergent fibre- 40.57, 44.66 and 45.53; cellulose- 28.92, 32.78 and 33.55; hemicellulose- 15.27, 14.64 and 14.77; lignin- 9.36, 10.56 and 11.54; ash- 21.02, 16.94 and 16.75 respectively.

Mercy (1990) prepared a silage by mixing crab waste, wheat straw and molasses, providing a dry matter level of 53.29 per cent. She reported the chemical composition of the silage on dry matter basis as 12.92 per cent crude protein, 12.22 per cent total ash, 58.77 per cent neutral detergent fibre, 34.94 per cent acid detergent fibre and 6.37 per cent lignin. It was also observed that treatment with sodium hydroxide prior to ensiling increased the dry matter and total ash content but decreased the crude protein, neutral detergent fibre and acid detergent fibre contents of the silage significantly. Ramachandran (1990) studied the relative effects of addition of urea or sodium hydroxide to crab waste-wheat bran (1:1 wet basis) mixtures during ensiling, and found that crude protein was significantly increased by urea treatment, whereas sodium hydroxide treatment significantly increased only the total ash content of silage. There was a linear increase in the acid detergent fibre and cellulose contents with increasing level of molasses.

Viswanathan (1990) ensiled crab waste and corn forage in three different proportions of 30:70, 40:60 and 50:50 and found that the percentage crude protein contents of crab waste silages were 15.08, 18.03 and 20.83 respectively without any significant difference in dry matter content between the three.

Crab waste and wheat straw were ensiled in different proportions of 60:40 and 40:60 by Samuels et al. (1991). The percentage chemical composition of the two silages on dry matter basis were: crude protein-17.3 and 13.1; ether extract- 0.32 and 0.27; ash- 17.5 and 11.1; calcium-6.33 and 3.31; phosphorus- 0.31 and 0.23; magnesium- 0.42 and 0.27; sodium- 0.64 and 0.47; potassium- 0.13 and 0.12; neutral detergent fibre- 49.8 and 67.2; acid detergent fibre- 35.1 and 46.5; cellulose- 26.0 and 34.1; hemicellulose- 14.7 and 20.7 and permanganate lignin- 7.9 and 11.3 respectively.

2.4.2.2 Fermentation characteristics:

Samuels et al. (1982) ensiled waste from fish and from crab processing using either maize stover, ground nut hulls or wilted Johnson grass with or without additives. All such silages had desirable aroma and substantial levels of acetic acid, but butyric acid level was higher in silages containing crab waste. Lower pH and higher lactic acid contents were observed in fish waste silage than in crab waste silage. Ensiling decreased or completely eliminated coliforms and caecal coliforms. Abazinge et al. (1984) found that crab waste when ensiled with wheat straw showed a rise in post ensiled pH with negligible amounts of lactic acid. Trimethylamine levels showed a threefold increase after ensiling.

Studies on the ensiling characteristics(Abazinge et al., 1986 a) of crab waste and wheat straw treated with various additives showed that addition of 20 per cent molasses to crab waste-straw mixtures prior to ensiling resulted in silages with substantial amounts of lactic acid and low levels of trimethylamine. A lower pH and higher lactic acid contents were noticed in ensiled mixtures with added molasses and inoculant of lactic acid bacteria, compared to molasses alone. Abazinge et al. (1986 c) used various additives for preservation of crab waste prior to ensiling and found that silage produced from molasses preserved crab waste with wheat straw, fermented better as indicated by a lower pH, greater disappearance of water soluble carbohydrates and higher levels of lactic acid.

Ayangbile et al. (1987 b) in their studies to determine the effect of chemicals on preservation and fermentation characteristics of crab waste-straw mixtures indicated that preserving crab waste with either 0.2 per cent sodium hypochlorite or 0.4 per cent hydrogen peroxide prior to ensiling prevented deterioration upto seven days and the waste treated with either preservative fermented well as indicated by decrease in pH and water soluble carbohydrates and rise in lactic acid contents. Desirable fermentation was also observed for crab waste preserved with a mixture of 1.5 per cent propionic /formic acid (1:1) for 14 days. Mercy (1990) in an attempt to evolve a suitable method for preserving crab waste found that 0.4 per cent sodium hypochlorite was more suitable than other chemicals. A significant improvement in dry matter digestibility was noticed by sodium hydroxide treatment of crab waste-straw silage, but it significantly increased the pH and reduced the lactic acid contents to nil.

Ramachandran (1990) reported that crab waste can be preserved by mixing with wheat bran (1:1 wet basis) and ensiling with molasses (10 or 20 per cent), with or without urea (5 per cent) or sodium hydroxide (4 per cent) to produce a satisfactory silage. But, sodium hydroxide treatment resulted in significantly higher pH, lower lactic acid and acetic acid concentrations and higher levels of water soluble carbohydrates in the post ensiled biomass indicating restricted bacterial fermentation. All silages had very little butyric acid contents and addition of molasses increased lactic acid levels and reduced the pH. He also stated that nutrient enhancement was possible by sodium hydroxide, as indicated by the increase in in vitro dry matter digestibility of sodium hydroxide treated crab waste-wheat bran silage.

Viswanathan (1990) produced silage by ensiling crab waste with corn forage in different proportions of 0:100; 30:70; 40:60 and 50:50 (wet basis) and found that among the crab waste silages, 30;70 combination fermented better as evidenced by significantly lower pH and trimethylamine contents, greater disappearance of water soluble carbohydrates and higher concentrations of acetic acid, lactic acid and total volatile fatty acids. Samuels et al. (1992) reported that fish wastes ensiled better when mixed with low quality roughages, compared to crab waste. Satisfactory silage was produced with crab waste only with the addition of a large quantity of acetic acid to initially lower the pH.

2.4.2.3 Feeding value:

Abazinge et al. (1986 b) conducted metabolism and palatability trials in sheep to evaluate crab waste and wheat straw mixtures ensiled with different additives and found a higher dry matter and crude protein digestibility for molasses treated silages. Crab waste was satisfactorily ensiled with wheat straw (1:1 wet basis) and 16 per cent molasses by Ayangbile et al. (1987a). Studies on the effects of inclusion of :.15 and 30 per cent levels of this silage in the finishing diets of steers indicated that 30 per cent level resulted in higher average daily gain, feed efficiency and carcass weight.

Studies on the digestibility and nutrient utilisation of crab waste-straw silage fed to sheep (Ayangbile et al., 1987 c) indicated that apparent digestibilities of dry matter, organic matter, crude protein, energy, neutral detergent fibre and acid detergent fibre were lower with the silage diets than for the control. But, a higher nitrogen retention was observed in animals fed with crab waste-straw silage compared to those fed control diet. Samuels et al. (1991) compared fish waste and crab waste by mixing each of them with straw in different proportions and ensiling. Apparent digestibilities of dry matter and crude protein were higher for diet containing silage with a higher proportion of fish waste. Based on the findings, they concluded that seafood processing wastes are potentially valuable to ensile with crop residues for use as a ruminant feed stuff.

2.4.3 Prawn waste silage:

Very limited studies have been carried out on ensiling and subsequent nutrient evaluation of prawn waste as an animal feed.

2.4.3.1 Chemical composition:

Satisfactory silage was obtained when fresh prawn waste and rice bran were ensiled (1:1 wet basis) after adding 10 or 20 per cent tapioca flour or 10 or 20 per cent coconut cake (AICRP Report, 1991). Silage prepared with 10 per cent tapioca flour as additive was found to provide crude protein- 16.67 per cent, neutral detergent fibre- 33.21 per cent, acid detergent fibre-24.87 per cent, cellulose- 12.5 per cent, lignin- 8.49 per cent and total ash- 15.04 per cent.

It was also observed that satisfactory silage can be prepared by ensiling fresh prawn waste with paddy straw (1:1 wet basis) and tapioca flour at 10 or 20 per cent levels as additives (AICRP Report, 1991). The percentage chemical composition on dry matter basis of prawn waste-paddy straw silage with 10 per cent tapioca flour was shown to be : crude protein- 15.91, total ash-16.51, neutral detergent fibre- 55.16, acid detergent fibre-

39.27, cellulose- 28.10 and lignin- 5.38.

2.4.3.2 Fermentation characteristics:

When prawn waste was ensiled with rice bran, with or without additives like tapioca flour or coconut cake in in different concentrations, there was significant reduction in post ensiled pH and increase in lactic acid levels in the mixtures ensiled with additives. Trimethylamine level was highest in the silage without additives, and it was concluded that prawn waste can be converted to a satisfactory silage by mixing with rice bran (1:1 wet basis) and with the addition of tapioca flour or coconut cake (10 or 20 per cent) as additive (AICRP Report, 1991).

Studies on the ensiling of fresh prawn waste and paddy straw with or without additives like tapioca flour or coconut cake in different proportions (AICRP Report, 1991) revealed a reduction in post ensiled pH and increase in lactic acid levels in those ensiled with tapioca flour as additive. It was concluded that fresh prawn waste can be ensiled satisfactorily with paddy straw (1:1 wet basis) and with the inclusion of 10 or 20 per cent tapioca flour as additive.

In a study to find out the optimum period of ensiling of prawn waste with rice bran, it was observed that though there was linear decrease in pH and increase in lactic acid content over periods of time, seven days ensiling was found to be sufficient to produce satisfactory silage, with 21 days period considered optimum. Microbiological evaluation of this prawn waste-rice bran silage indicated that the ensiled material was free from pathogenic bacteria (AICRP Report, 1991).

2.4.3.3 **Feeding value:**

Raa et al. (1983) suggested a method of producing a semi-moist silage from prawn waste by addition of acids, which can be used as an additive at 5 per cent level in moist feeds for fishes.

Studies on the palatability and digestibility of prawn waste-rice bran silage in cattle (AICRP Report, 1991) showed that the material was palatable and the digestibility coefficients of dry matter, crude protein, ether extract, crude fibre and nitrogen free extract were found to be 61.66$\pm$ 5.62; 80.55$\pm$ 3.62; 91.41$\pm$ 2.80; 77.78$\pm$ 4.30 and 36.83$\pm$ 7.61 respectively. The digestible crude protein and total digestible nutrient contents of prawn waste-rice bran silage were shown to be 13.85 and 71.0 per cent respectively.

Evaluation of the nutritive value of prawn waste-rice polish silage in growing calves (AICRP Report, 1992) by replacing 50 per cent of the total protein requirement from silage indicated that, prawn waste-rice polish silage is well relished by animals though it took a few days for the animals to get adapted to the new feed. Results of the growth studies further indicated that prawn waste-rice polish silage is a potential alternate feed source for cattle, worth studying in detail.

Materials and Methods

MATERIALS AND METHODS

The studies carried out during the course of present investigation are described under the following heads.

i) Preparation of prawn waste silage by mixing with paddy straw, using tapioca flour as additive.

ii) Evaluation of the chemical composition and fermentation characteristics of prawn waste-paddy straw silage over different periods of ensiling viz. 21 days and 50 days.

iii) Determination of the digestibility coefficients of the nutrients of grass hay, paddy straw and prawn waste-paddy straw silage in cattle.

3.1 Silage preparation:

Prawn waste was procured from prawn peeling sheds at Kodungalloor, a coastal area located south west of Thrissur. The material was packed in gunny bags and transported to the site of ensiling without time delay to minimize aerobic fermentation and putrefaction. Paddy straw was chopped to pieces of about one inch length, using a grass chopper, few days prior to ensiling. The chopped paddy straw was mixed with prawn waste in equal proportions (1:1 wet basis). Mixing was done in lots of 100 kg each. The ingredient composition of the pre-ensiled mixture is given in Table 1.

Table 1. Percentage ingredient composition of the pre-ensiled mixture.

Ingredients	Percentage
Prawn waste	37
Paddy straw (chopped)	37
Tapioca flour	10
Water	16

Chopped paddy straw was spread in thick layers over clean, dry, cemented floor. Prawn waste and tapioca flour were layered over it. The different ingredients were thoroughly mixed using a shovel so as to ensure uniform mixing. Water in required amounts was sprinkled over the mixture, to adjust the dry matter to 50 per cent and again mixed thoroughly.

Ensiling was done in concrete tanks of dimensions 3.3 x 1.2 x 0.9 m, the inner surface of which were plastered with cement and corners rounded off. The ingredients after proper mixing were transferred to the silos, layered and packed tightly at each stage by trampling. Samples of this mixture were taken in double lined polythene bags and kept in the freezer for analysis. The whole lot of mixture in the silo's were packed tightly by continuous trampling. The material was covered with double layer of polythene sheets, and sealed air tight by plastering with mud to about 5cm thickness over it. The silage was allowed to ferment for a period of 50 days.

Simultaneously, the same proportion of ingredients were mixed and ensiled similarly in six smaller concrete tubs, to study the silage characteristics on twenty first day of ensiling.

3.2 Digestibility trials:

3.2.1 Animals:

Six, adult, dry, non pregnant cows of uniform age, breed and body weight, belonging to the University Livestock Farm, Mannuthy, formed the experimental animals for the study. All the animals were kept in individual pens, under identical conditions of management, during the entire course of the experiment.

3.2.2 Experimental diets:

Grass hay was fed as basal ration during the feeding trials. The following diets were fed to the animals during three feeding trials as per standards (ICAR, 1985).

Trial (1)- Basal ration consisting of hay alone, for a period of 28 days.

Trial (2)- Basal ration plus paddy straw for a period of 28 days.

Trial (3)- Basal ration plus prawn waste- paddy straw silage for a period of 28 days.

Clean drinking water was provided _ad libitum_ at all times. Common salt and mineral mixture (MILKMIN*) were given at the rate of 25g each per day per animal, during the experimental period.

Table 2. Percentage chemical composition of basal ration (grass hay) on dry matter basis.

Component	Percentage
Dry matter	87.66
Crude protein	8.11
Ether extract	3.30
Crude fibre	29.83
Total ash	4.12
Nitrogen free extract	54.64
Neutral detergent fibre	78.60
Acid detergent fibre	68.35
Cellulose	57.30
Hemicellulose	10.25
Lignin	9.85

*MILKMIN contained calcium 24 per cent, phosphorus 9 per cent, manganese 0.12 per cent, iodine 0.1 per cent, iron 0.6 per cent, copper 0.1 per cent, cobalt 0.02 per cent, sodium chloride 30 per cent and fluorine not more than 0.03 per cent. Manufactured by Sarabhai chemicals.

3.3 Methods:

The small and larger silo's were opened after 21 days and 50 days of ensiling respectively. Physical characteristics like colour, smell, consistency and presence of fungal growth were noted. Samples for analysis were taken in double lined polythene bags, 50 cm deep from the surface of the silo, after discarding the surface layer.

3.3.1 Fermentation characteristics:

The fermentation characteristics of pre-ensiled mixture and silage over twenty first day and fiftieth day of ensiling were studied.

Water extracts of the samples (1:10) were prepared by homogenising 25 g samples with 225 ml of de-ionized water in a blender for 2 minutes. The homogenate was filtered through muslin cloth. The extracts were used for the estimation of pH, lactic acid and water soluble carbohydrates. pH was determined electrometrically using digital pH meter DPH 500. Lactic acid was estimated by the modified method of Penington and Sutherland, 1956. Estimation of water soluble carbohydrates was carried out by the method described by Dubois et al., 1956 and modified by Johnson et al., 1966. Gas liquid chromatography (AIMIL NUCON-5700, using glass column Chromosorb-101) was employed for the estimation of volatile fatty acids viz. acetic, propionic and butyric acids. Trimethylamine was determined titrimetrically after making extracts with 10 per cent trichloro acetic acid, as per the method described by Conway, 1947.

3.3.2 Digestibility studies:

Experimental diets were fed to the animals in three different trials. The animals were subjected to a preliminary feeding period of 21 days in each trial, before the commencement of the actual collection period. Digestibility trials were conducted for each treatment, which involved a collection period of seven days. Every day at 10.00 AM, the animals were given a measured quantity of the respective ration. At the same time, the residue left behind from the previous days feed was removed quantitatively and weighed. Individual records of daily feed intake were maintained throughout the experiment.

3.3.2.1 Grass hay:

Grass hay was procured from the Kerala Livestock Development Board, Dhoni Farm, Palakkad. The animals were fed hay *ad libitum* and the daily intake was recorded for each animal.

3.3.2.2 Grass hay and paddy straw:

The animals were given 3 kg grass hay each and paddy straw *ad libitum* daily. Records of daily intake of hay and paddy straw were maintained for each animal.

3.3.2.3 Grass hay and prawn waste-paddy straw silage:

Each animal was given 5 kg prawn waste-paddy straw silage and grass hay *ad libitum* daily. Records of daily intake of hay and silage were maintained for each animal.

3.3.2.4 Sampling of the rations:

Known quantities of the feed given were taken every day in polythene bags during the collection period for estimation of moisture content and to calculate the dry matter intake of each animal.

3.3.2.5 Collection and sampling of faeces:

All precautions were taken to ensure the collection of dung quantitatively, uncontaminated by urine or any feed residue or dirt. The dung was. collected manually as and when it was voided. At 10.00 AM every day, the dung voided during the previous 24 hours was weighed accurately, mixed thoroughly, and representative samples at the rate of 2 per cent of the total voided quantity was taken and stored in a refrigerator. The process of collection, weighing and sampling of dung was continued till the end of the trials. The samples collected from each animal and preserved during the entire collection period were later pooled and used for further analyses.

3.3.2.6 Digestibility coefficients:

The digestibility of the nutrients of the rations given during the experimental period were determined by the conventional method. Digestibility coefficients of the nutrients of paddy straw and prawn waste-paddy straw silage were calculated by 'difference'.

3.3.3 Chemical analyses:

The different ingredients used for ensiling, the feed samples, dung collected during the digestion trials, pre-ensiled mixture, silage on twenty first day of fermentation and fiftieth day of fermentation were subjected to proximate analyses as per standard procedures (AOAC, 1990). Samples were also analysed for neutral detergent fibre (Van Soest and Wine, 1967), acid detergent fibre and lignin (Van Soest, 1963).

Statistical analysis of the data were carried out as per methods described by Snedecor and Cochran (1967), and results interpreted.

Results

RESULTS

Results of the experiments carried out during the course of the present investigation are detailed under the following separate heads.

4.1 Proximate chemical composition:

The proximate chemical composition of the ingredients used for preparing prawn waste-paddy straw silage are presented in Table 3.

4.2 Prawn waste-paddy straw silage:

4.2.1 Physical characteristics:

The physical characteristics of the prawn waste-paddy straw silage prepared are detailed in Table 4.

4.2.2 Chemical composition:

Results of the chemical analysis of prawn waste-paddy straw silage over different periods of ensiling along with the statistical interpretations are set out in Table 5.

4.2.3 Fermentation characteristics:

Fermentation characteristics and trimethylamine levels of prawn waste-paddy straw silage over different periods of ensiling are shown in Table 6.

4.2.4 Volatile fatty acids:

The concentration of volatile fatty acids viz. acetic, propionic and butyric acids in prawn waste-paddy straw silage over different periods of ensiling are given in Table 7.

4.3 Digestibility experiments:

4.3.1 Dry matter consumption:

The daily average dry matter consumption of animals recorded during the three feeding trials are presented in Table 8.

4.3.2 Digestibility coefficients:

Results of the digestibility trials carried out with grass hay alone (Trial 1), grass hay and paddy straw (Trial 2) and with grass hay and prawn waste-paddy straw silage (Trial 3) are presented in Tables 9 to 14. Summarised data in respect of the digestibility coefficients of the various nutrients of the experimental rations are set out in Table 15. The digestible crude protein and total digestible nutrient values for the three rations are presented in Table 16.

Table 3. Percentage chemical composition of ingredients used for ensiling (Mean values on dry matter basis)

Component	Prawn waste	Paddy straw	Tapioca flour
Dry matter	25.74	89.94	90.24
Crude protein (N x 6.25)	42.21	4.25	3.65
Ether extract	9.80	3.88	0.38
Crude fibre	13.73	29.65	2.60
Nitrogen free extract	6.66	44.02	91.84
Total ash	27.60	18.20	1.53
Neutral detergent fibre	-	70.90	5.90
Acid detergent fibre	-	62.50	3.80
Hemicellulose	-	8.40	2.10
Cellulose	-	52.05	3.30
Lignin	-	4.30	0.55
Chitin	13.50	-	-

Table 4. Physical characteristics of prawn waste-paddy straw silage over different periods of ensiling.

Treatment	Days of ensiling	Colour	Smell	Fungal growth
Prawn waste-paddy straw + tapioca flour (10 per cent)	21	Brownish	Desirable aroma	Absent
	50	Brownish	Desirable aroma	Absent

Plate 1. Prawn waste-paddy straw silage

Table 5. Percentage chemical composition of prawn waste-paddy straw silage over different periods of ensiling (on dry matter basis)

Component	Pre-ensiled	Silage 21d	Silage 50d	CD	F value
Dry matter	45.48±0.39	47.98±0.12	45.54±0.10	0.73	34.77**
Crude protein (N x 6.25)	17.28±0.00	16.56±0.09	14.40±0.00	0.17	718.12**
Ether extract	03.26±0.08	03.36±0.05	02.75±0.04	0.18	29.75**
Crude fibre	17.69±0.13	23.69±0.22	28.87±0.09	0.47	1264.94**
Nitrogen free extract	44.86±0.13	37.51±0.23	35.74±0.30	0.70	428.69**
Total ash	16.91±0.04	18.88±0.03	18.24±0.21	0.38	63.60**
Neutral detergent fibre	49.31±0.38	53.35±0.25	55.09±0.39	1.04	73.87**
Acid detergent fibre	35.03±0.22	37.33±0.31	40.37±0.43	0.99	65.86**
Hemicellulose	14.29±0.31	16.02±0.51	14.72±0.58	1.45	3.51
Cellulose	28.97±0.11	30.03±0.18	30.44±0.22	0.53	18.55**
Lignin	03.32±0.06	4.32±0.09	04.89±0.04	0.19	144.44**

** Significant at 1 per cent level.

Fig.1 **FERMENTATION CHARACTERISTICS OF PRAWN WASTE - PADDY STRAW SILAGE**

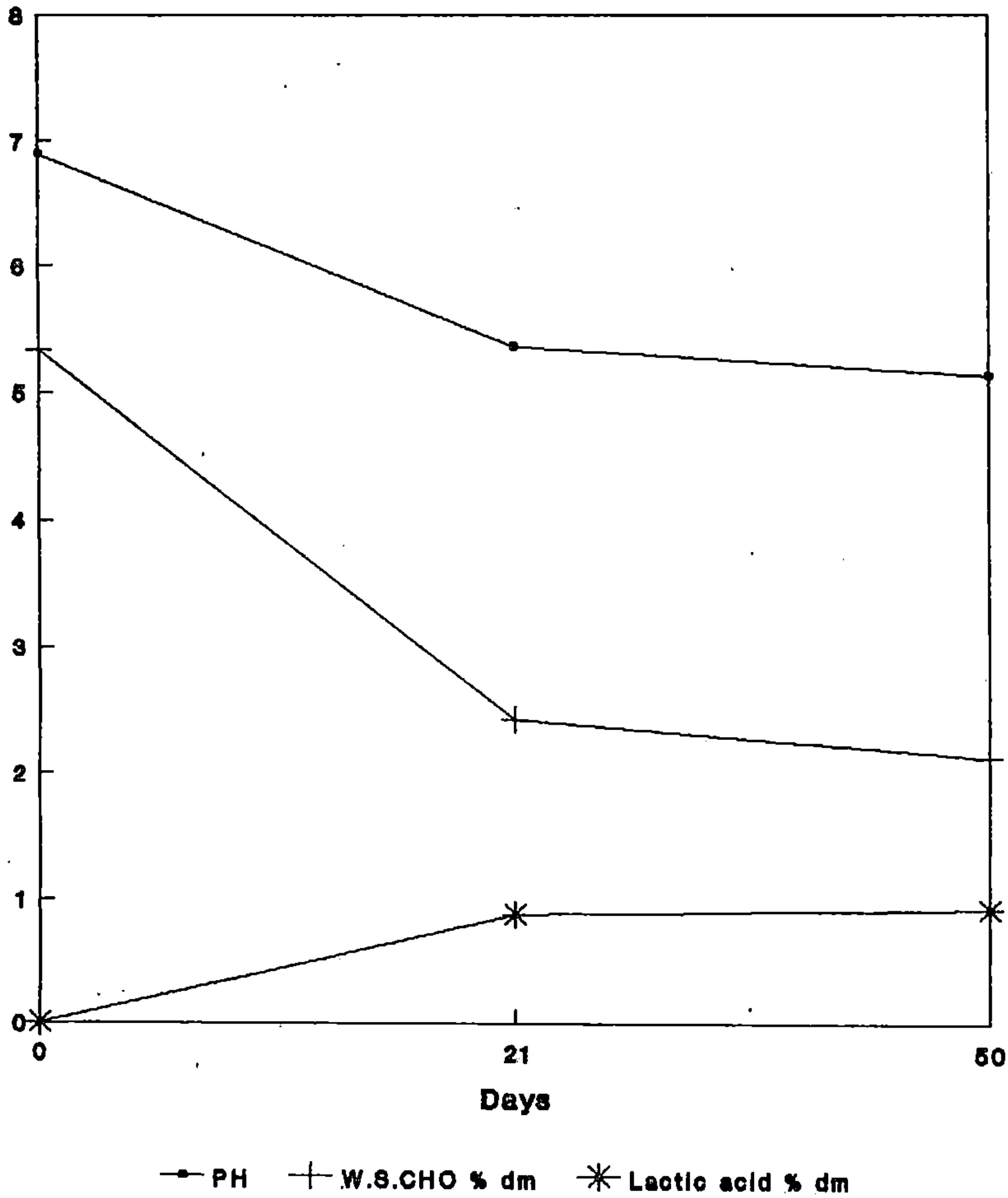

Table 6. Fermentation characteristics and trimethylamine levels of prawn waste-paddy straw silage on dry matter basis

	Pre-ensiled	Silage 21d	Silage 50d	C.D	F value
pH	6.89±0.03	5.37±0.13	5.13±0.01	0.23	160.00 **
Water soluble carbohydrates (per cent)	5.34±0.02	2.43±0.07	2.12±0.10	0.23	547.87 **
Lactic acid (per cent)	-	0.88±0.16	0.92±0.10	-	NS
Trimethylamine (mg per cent)	5.46±0.24	14.19±0.24	18.66±0.72	1.38	214.99 **

** Significant at 1 per cent level
NS Non significant

Fig.2 **TRIMETHYL AMINE LEVELS IN-PRAWN WASTE - PADDY STRAW SILAGE**

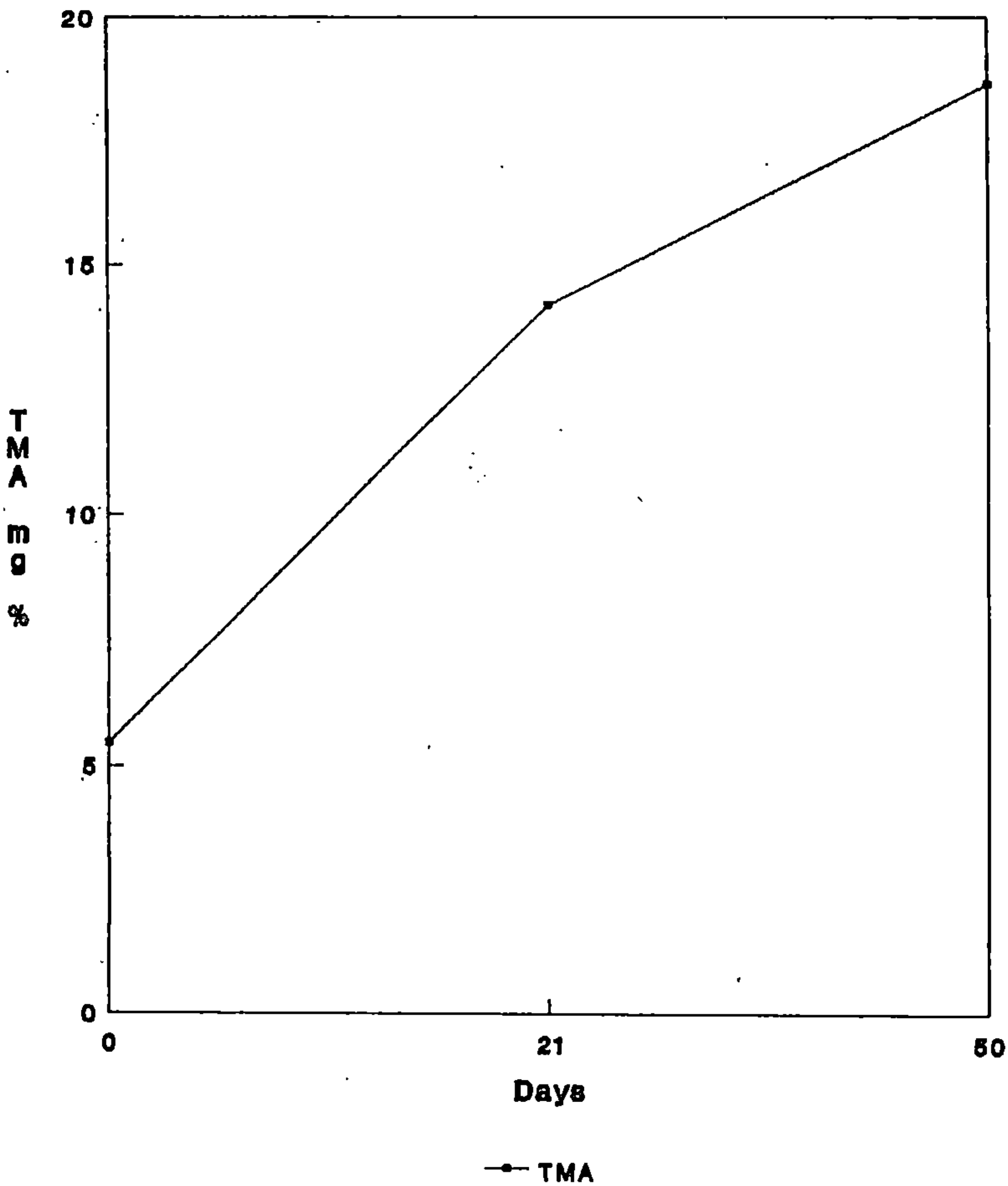

Table 7. Percentage of volatile fatty acids in prawn waste-paddy straw silage (on dry matter basis)

Volatile fatty acid	Silage 21d	Silage 50d
Acetic acid	1.68±0.15	0.84±0.06
Propionic acid	0.22±0.00	0.16±0.01
Butyric acid	0.28±0.25	1.37±0.13

Fig.3 **VOLATILE FATTY ACIDS IN PRAWN WASTE PADDY STRAW SILAGE % ON dm BASIS**

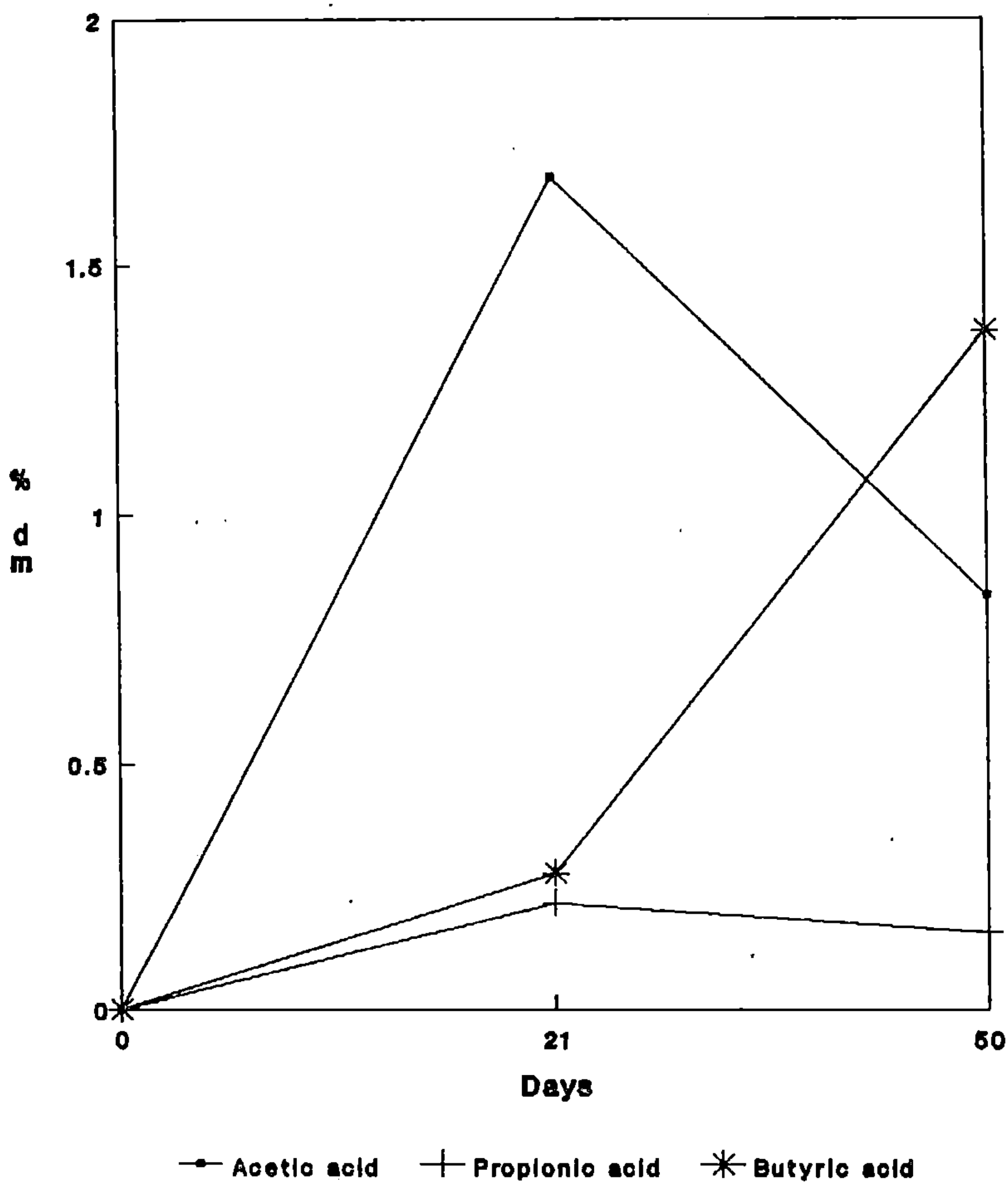

Table 8. Daily average dry matter consumption (in kg) during the feeding trials

Animal No.	Per 100 kg body weight Trial I	Trial II	Trial III	Per kg metabolic body size Trial I	Trial II	Trial III
111	1.00	1.05	1.26	0.041	0.044	0.051
T184	1.54	1.54	2.01	0.061	0.062	0.079
072	1.84	1.71	1.79	0.073	0.067	0.071
T133	1.18	1.26	1.62	0.048	0.051	0.064
180	1.21	1.44	1.74	0.047	0.056	0.066
TM 41	1.19	1.41	1.61	0.047	0.055	0.062
Mean± SE	1.33± 0.130	1.40± 0.090	1.67± 0.100	0.052± 0.004	0.055± 0.003	0.065± 0.004

Fig.4 AVERAGE DAILY DRY MATTER CONSUMPTION PER 100 KG BODY WEIGHT

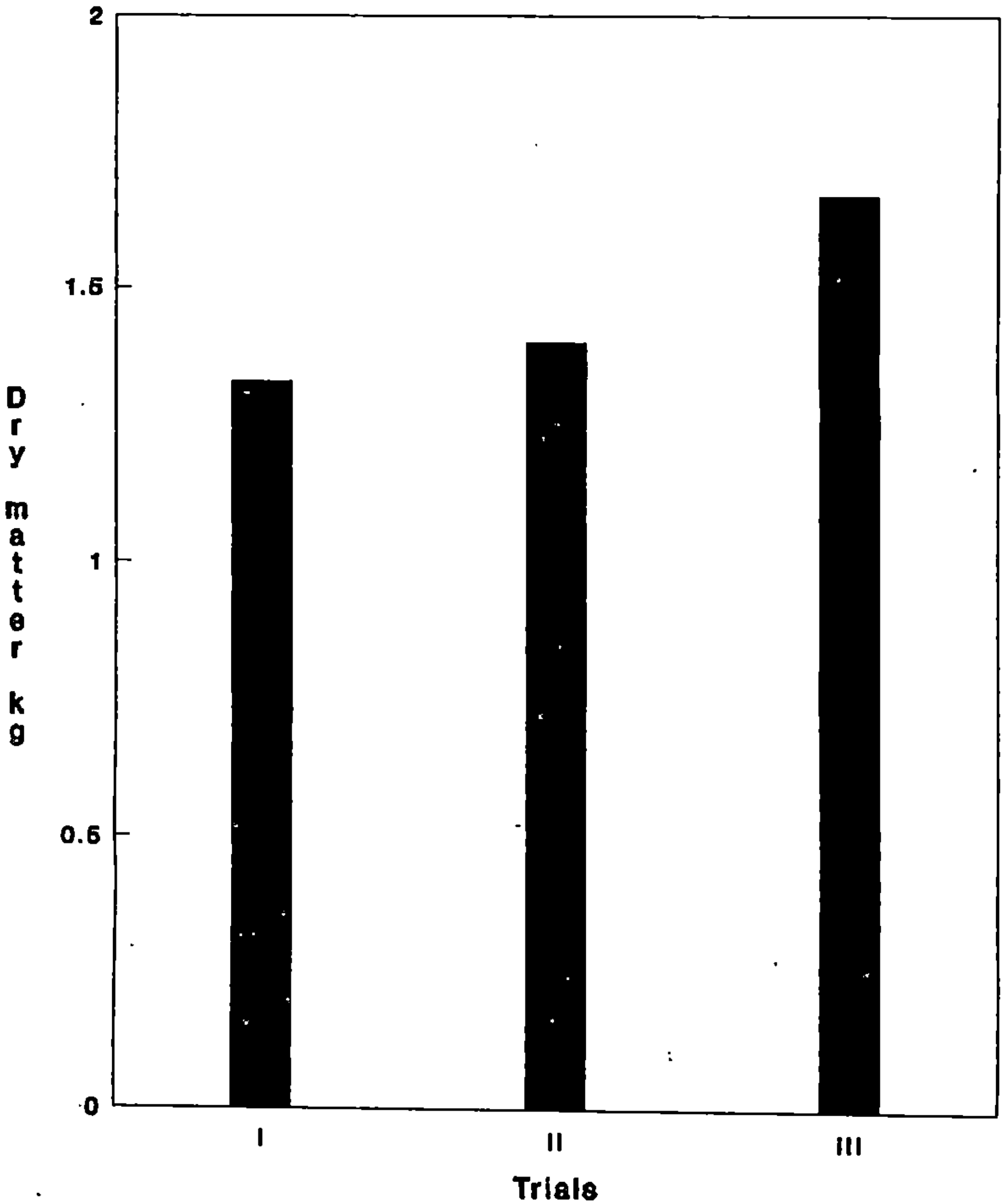

Table 9. Percentage chemical composition of the dung voided by animals fed grass hay alone on dry matter basis.

Component	Animal numbers						Mean±SE
	111	T184	072	T133	180	TM41	
Dry matter	19.32	17.18	19.71	16.03	18.26	17.97	18.07±0.55
Crude protein (N x 6.25)	9.06	8.27	8.88	8.17	8.68	9.13	8.70±0.16
Ether extract	2.73	3.13	2.73	3.23	2.43	2.95	2.87±0.12
Crude fibre	22.88	26.73	26.81	26.23	27.10	26.58	26.06±0.64
Total ash	9.80	9.30	9.35	9.73	9.20	9.25	9.44±0.10
Nitrogen free extract	55.53	52.57	52.23	52.64	52.59	52.09	52.95±0.53
Neutral detergent fibre	55.95	65.95	64.25	61.85	61.38	61.34	61.79±1.39
Acid detergent fibre	50.56	43.54	48.20	49.49	43.74	48.92	47.40±1.23
Cellulose	35.35	30.44	33.69	34.60	30.58	34.20	33.14±0.86

Fig.5 AVERAGE DAILY DRY MATTER CONSUMPTION PER KG METABOLIC BODY SIZE

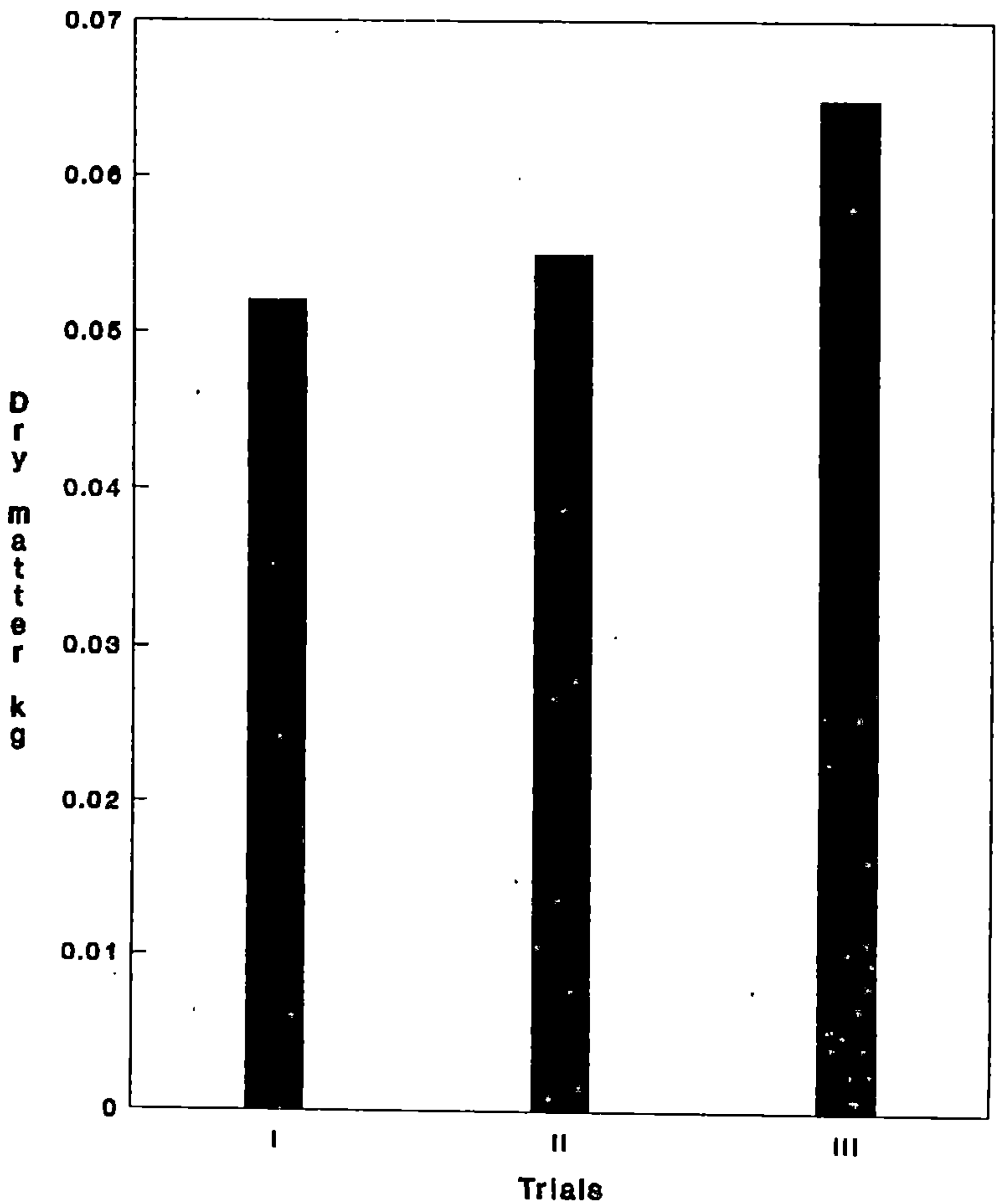

Table 10. Digestibility coefficients of the nutrients of grass hay

Nutrient	Animal numbers						Mean±SE
	111	T184	072	T133	180	TM41	
Dry matter	57.81	53.50	62.45	60.09	56.58	57.62	58.00±1.25
Crude protein	52.88	52.58	58.89	59.79	53.53	52.29	54.99±1.39
Ether extract	65.16	55.96	68.99	61.00	68.09	62.11	63.55±1.99
Crude fibre	67.64	58.33	66.24	64.91	60.55	62.24	63.31±1.53
Nitrogen free extract	57.11	55.25	64.10	61.54	58.21	59.59	59.30±1.30
Neutral detergent fibre	69.97	60.98	69.30	68.60	66.09	66.93	66.97±1.42
Acid detergent fibre	68.79	70.69	73.52	71.10	72.21	69.67	70.99±0.82
Cellulose	73.97	75.29	77.92	75.90	76.83	74.70	75.76±0.77

Table 11. Percentage chemical composition of the dung voided by animals fed grass hay and paddy straw on dry matter basis

Component	Animal numbers						Mean±SE
	111	T184	072	T133	180	TM41	
Dry matter	21.57	16.93	21.45	18.70	22.21	19.09	19.99±0.84
Crude protein (N x 6.25)	9.13	9.06	8.67	9.36	9.85	9.16	9.20±0.16
Ether extract	3.00	3.18	3.01	3.50	3.00	3.20	3.15±0.08
Crude fibre	20.70	20.84	20.60	20.91	22.61	22.60	21.38±0.39
Total ash	19.88	21.63	21.15	20.75	17.64	16.29	19.56±0.87
Nitrogen free extract	47.29	45.29	46.57	45.48	46.90	48.75	46.71±0.58
Neutral detergent fibre	50.99	50.79	50.06	48.69	48.07	50.56	49.86±0.49
Acid detergent fibre	47.00	43.48	45.62	43.37	41.76	43.75	44.16±0.76
Cellulose	28.39	26.23	25.75	27.99	28.67	31.02	28.00±0.77

Table 12. Digestibility coefficients of the nutrients in paddy straw

Nutrient	Animal numbers						Mean±SE
	111	T184	072	T133	180	TM41	
Dry matter	45.12	48.76	45.59	57.31	50.40	48.84	49.34±1.64
Ether extract	53.23	57.44	55.29	59.38	51.52	53.08	54.99±1.21
Crude fibre	65.99	71.01	69.01	74.75	72.36	73.17	71.04±1.29
Nitrogen free extract	52.13	53.36	46.64	60.35	55.87	50.92	53.21±1.89
Neutral detergent fibre	64.65	71.12	68.10	72.60	79.02	77.14	72.10±2.20
Acid detergent fibre	62.09	60.84	61.63	73.04	69.00	71.90	66.41±2.26
Cellulose	77.97	77.14	78.05	80.50	75.15	75.31	77.35±0.81

Plate 2. Experimental animals being fed prawn waste-paddy straw silage

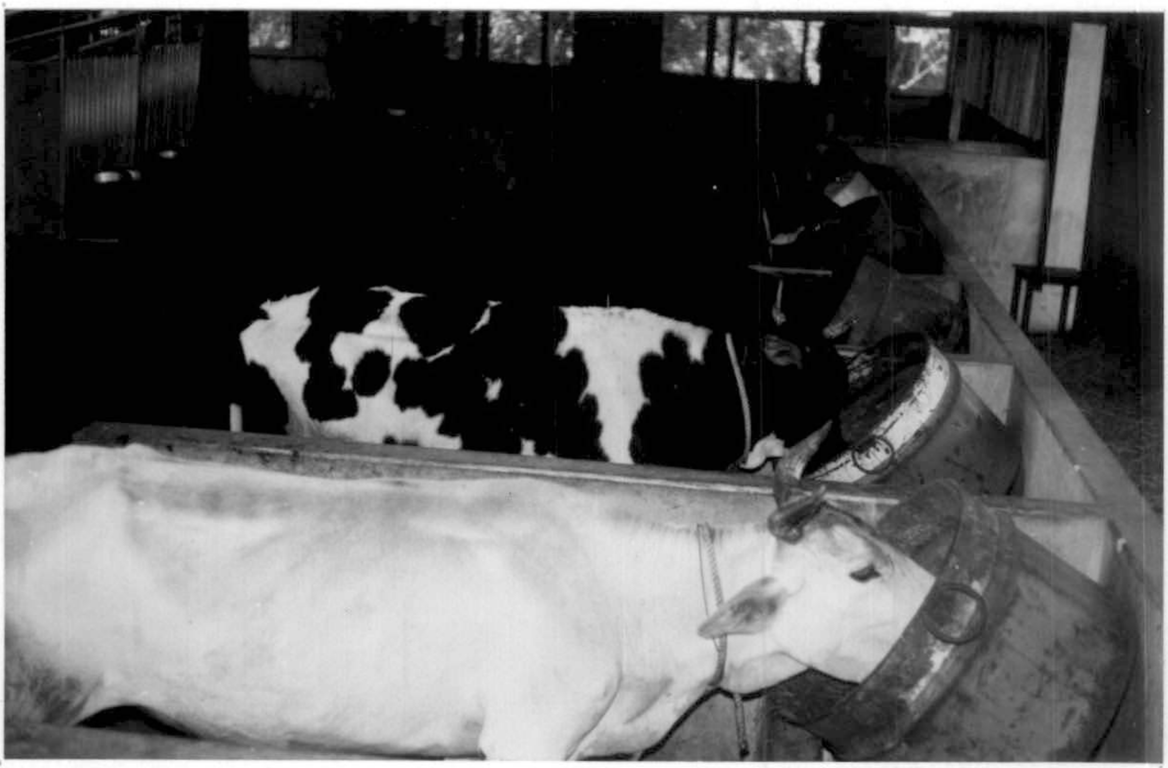

Table 13. Percentage chemical composition of the dung voided by animals fed grass hay and prawn waste-paddy straw silage on dry matter basis

Component	Animal numbers						Mean±SE
	111	T184	072	T133	180	TM41	
Dry matter	25.78	19.39	19.64	20.67	22.36	19.61	21.24±1.01
Crude protein (N x 6.25)	12.51	12.40	13.36	11.90	11.74	11.70	12.27±0.26
Ether extract	2.10	2.19	2.20	2.50	1.97	2.45	2.24±0.08
Crude fibre	22.21	22.60	19.75	22.01	20.91	19.76	21.20±0.51
Total ash	28.21	22.46	26.54	25.48	25.14	25.37	25.53±0.77
Nitrogen free extract	34.97	40.35	38.15	38.11	40.24	40.72	38.76±0.89
Neutral detergent fibre	49.85	51.32	46.16	51.77	50.93	43.70	48.95±1.34
Acid detergent fibre	40.85	34.24	41.11	42.10	35.27	36.65	38.37±1.38
Cellulose	24.57	24.67	21.94	27.03	21.54	21.87	23.60±0.89

Table 14. Digestibility coefficients of the nutrients of prawn waste-paddy straw silage

Nutrient	Animal numbers						Mean±SE
	111	T184	072	T133	180	TM41	
Dry matter	62.38	51.26	57.29	56.39	50.92	48.68	54.48±2.08
Crude protein	60.66	42.23	49.20	49.17	53.95	52.42	51.36±2.50
Ether extract	77.55	80.19	72.69	75.18	69.68	60.29	75.29±2.88
Crude fibre	71.71	69.67	79.51	75.10	70.40	72.50	73.14±1.48
Nitrogen free extract	79.10	63.83	68.61	76.68	53.04	51.90	65.52±4.70
Neutral detergent fibre	69.01	69.22	76.01	69.43	60.02	69.74	68.90±2.08
Acid detergent fibre	68.58	70.72	62.81	64.96	63.08	63.32	65.57±1.35
Cellulose	79.42	70.95	76.52	75.45	73.70	76.35	75.39±1.17

Table 15. Summarised data on the digestibility coefficients of grass hay, paddy straw and prawn waste-paddy straw silage

Nutrient	Grass hay	Paddy straw	Prawn waste-paddy straw silage
Dry matter	58.00±1.25	49.34±1.64	54.48±2.08
Crude protein	54.99±1.39	-	51.36±2.50
Ether extract	63.55±1.99	54.99±1.21	75.29±2.88
Crude fibre	63.31±1.53	71.04±1.29	73.14±1.48
Nitrogen free extract	59.30±1.30	53.24±1.89	65.52±4.70
Neutral detergent fibre	66.97±1.42	72.10±2.20	68.90±2.08
Acid detergent fibre	70.99±0.82	66.41±2.26	65.57±1.35
Cellulose	75.76±0.77	77.35±0.81	75.39±1.17

Table 16. Summarised data on the digestible crude protein and total digestible nutrient values of grass hay, paddy straw and prawn waste-paddy straw silage

Feed stuff	On fresh basis		On dry matter basis	
	DCP	TDN	DCP	TDN
Grass hay	3.91	52.99	4.46	60.46
Paddy straw	NIL	44.32	NIL	49.28
Prawn waste-paddy straw silage	3.37	25.77	7.39	56.58

Discussion

DISCUSSION

The results obtained during the course of the present study are discussed hereunder.

5.1 Proximate chemical composition:

From the data presented in Table 3, it can be seen that the proximate chemical composition of the ingredients used for preparing prawn waste-paddy straw silage are comparable with the values already reported in this regard.

5.1.1 Prawn waste:

The nutrient composition of prawn waste used for ensiling is almost similar to that reported by other workers (Madhavan and Nair, 1975; AICRP Report, 1991; Syammohan, 1991). However, the comparatively higher concentration of ether extract obtained in the samples presently used may be due to the variation in the species of prawns used (Meyers et al., 1973).

5.1.2 Paddy straw:

The percentage nutrient contents in paddy straw used for ensiling in the present study, excepting for fibre fractions and crude protein, are similar to those already reported by other workers (Sen, 1953; Kunjikutty, 1969; Ali, 1970; Jackson, 1977; Ranjhan, 1980; Vadiveloo, 1992). Sen (1953) reported protein values ranging from 2.4 to 6.3 per cent for paddy straws obtained from different parts of India. Kunjikutty (1969) in her studies on the digestibilities of nutrients in paddy straw, also reported a higher percentage of 6.2 for crude protein. The relatively higher crude protein and lower contents of fibre fractions in paddy straw used for the present study, can be explained on the basis of difference in nutrient contents between different varieties of paddy straw. Jackson (1977) reported variation in chemical composition in paddy straw depending on varieties as well as on the location of cultivation of the crop. Devassia et al. (1978) reported higher levels for crude protein and lower contents of crude fibre in their studies with six hybrid varieties of paddy straw, compared to traditional varieties.

5.1.3 Tapioca flour:

The proximate chemical composition of tapioca flour used as additive for ensiling is also quite comparable with the values already available in literature (Ranjhan, 1980; Morrison, 1984).

5.2 Prawn waste-paddy straw silage:

The present study clearly indicated that prawn waste mixed with paddy straw in suitable proportions using tapioca flour as additive, can be converted into a good quality silage, with optimum desirable physical and fermentation characteristics.

5.2.1 Physical characteristics:

The physical characteristics of the silage formed, in terms of appearance, colour and smell (Table 4), are satisfactory and quite comparable to those already recorded in this regard (AICRP Report, 1991). The material was brownish in colour having a desirable, characteristic aroma. Also there was no pungent ammoniacal odour or evidence of any fungal growth. The results further indicate that there are no major differences in the physical characteristics of the silage after 21 days and 50 days of fermentation. It was also observed that even after 21 days of fermentation, there was sufficient softening of the hard, sharp and chitinous appendages of the prawns.

5.2.2 Chemical composition:

It is seen from the data presented in Table 5, that the chemical composition of prawn waste-paddy straw silage is almost similar to that reported earlier in this regard, recorded after 42 days of fermentation (AICRP Report, 1991). But significant differences in nutrient levels were observed in prawn waste-paddy straw silages, after different periods of ensiling viz. 21 days and 50 days. While the crude fibre, neutral detergent fibre, acid detergent fibre, cellulose and lignin contents showed a significant linear increase post ensiling in different periods, crude protein content showed a linear decrease. Linear increase in fibre fractions in the post ensiled mass was reported in earlier studies also (AICRP Report, 1991). The increase in fibre fractions with period of time can be attributed to a proportionate increased fermentation and subsequent disappearance of the soluble portion of carbohydrates, while the decrease in crude protein indicates an unfavourable microbial degradation occurring in the silage over different periods of time.

5.2.3 Fermentation characteristics:

5.2.3.1 pH:

As presented in Table 6 and represented by Fig. 1, the pH showed a significant linear decline with periods of ensiling, the reduction being at a higher rate during the first 21 days from 6.89 to 5.37 and thereafter at a slower rate to 5.13 on fiftieth day of ensiling. The decline in pH subsequent to ensiling is in agreement with similar observations recorded in previous studies. A reduction in pH from 8.72 to 5.18 was recorded in prawn waste-paddy straw silage after 42 days of fermentation

(AICRP Report, 1991). They have also reported a linear decrease in pH from 6.72 to 5.10 after 21 days of ensiling and then to 5.05 after 42 days with prawn waste-rice bran silage, Addition of molasses was reported to reduce the post ensiled pH (Abazinge et al., 1986 c; Ramachandran, 1990). On the contrary, Samuels et al. (1982) reported a higher pH of 8.1 with silages made from crab waste and low quality roughages. Working on the same line, Abazinge et al. (1984) also found that crab waste when ensiled with wheat straw showed a rise in post ensiled pH, which they opined may be due to the combined buffering action of protein, minerals and trimethylamine in the silage.

5.2.3.2 Water soluble carbohydrates:

The data showing the extent of reduction of water soluble carbohydrates in prawn waste-paddy straw silage at different periods of fermentation (Table 6 and Fig. 1), clearly indicates that the concentration of water soluble carbohydrates was significantly lower in the post ensiled material compared to that in the pre-ensiled mixture, with a linear decrease over period of time. As observed in the case of pH, the rate of reduction in the content of water soluble carbohydrates was at a higher scale during the first 21 days of ensiling, but at a lower rate of decline during the later periods of fermentation. These observations are essentially in agreement with those reported in earlier studies. A reduction in the water soluble carbohydrate content from 6.51 to 2.00 per cent was observed when prawn waste was ensiled with rice bran and tapioca flour (10 per cent) for 42 days (AICRP Report, 1991). They also noticed a similar reduction in the amount of water soluble carbohydrates from 2.84 to 1.27 per cent when prawn waste was ensiled with paddy straw and 10 per cent tapioca flour for the same period of fermentation. Significant reduction in the level of water soluble carbohydrates after ensiling crab waste or fish waste with low quality roughages in different proportions was observed by Samuels et al. (1982) and Abazinge et al. (1984). Ramachandran (1990) recorded a greater utilisation of water soluble carbohydrates with urea treatment of crab waste-wheat bran mixtures compared to sodium hydroxide treatment, indicating that sodium hydroxide restricted bacterial growth in spite of the availability of substrate. Greater disappearance of water soluble carbohydrates supports the occurrence of efficient bacterial growth and high rate of fermentation in the silage.

5.2.3.3 Lactic acid:

It can be seen from the data presented in Table 6 and represented by Fig.1, that the lactic acid content in prawn waste-paddy straw silage was lower than that reported earlier in this regard. The results indicate that the lactic acid levels on twenty first day and fiftieth day of ensiling were 0.88 and 0.92 per cent respectively and that the increase in its concentration between periods of ensiling was not significant. The present results are in keeping with those reported by Samuels et al. (1982) who observed lower lactic acid levels in crab waste-wheat straw silage. Abazinge et al. (1984) also recorded a lower lactic acid level of 0.8 per cent in crab waste-wheat straw silage as compared to a higher level of 3.0 per cent in fish waste-wheat straw silage. Lactic acid levels were found to increase linearly with the proportion of molasses in crab waste-straw silages (Abazinge et al. 1986a). Ramachandran (1990) also reported higher levels of lactic acid when crab waste and wheat bran were ensiled with molasses, but he recorded lower levels of lactic acid in the silage when treated with sodium hydroxide. Lactic acid levels upto 3.48 per cent were reported after ensiling prawn waste and rice bran with 10 per cent tapioca flour for 42 days, with a linear increase over period of time (AICRP Report, 1991). They also observed a similarly higher lactic acid level of 3.37 per cent when prawn waste was ensiled with paddy straw and 10 per cent tapioca flour as additive for 42 days.

5.2.4 **Trimethylamine:**

The data on the concentration of trimethylamine in prawn waste-paddy straw silage presented in Table 6 and represented by Fig. 2 clearly shows a significant linear increase in levels of trimethylamine with period of time. Trimethylamine contents in the pre-ensiled mixture and in silages after 21 days and 50 days of fermentation were found to be 5.46, 14.19 and 18.66 mg per cent respectively. The concentration of trimethylamine showed a rapid increase during the first 21 days of ensiling but at a lower rate of increase subsequently. Similar observations in respect of trimethylamine levels were also reported in earlier studies (AICRP Report, 1991), where the concentration of trimethylamine increased from 7.59 to 18.41 mg per cent after 42 days of ensiling of prawn waste and paddy straw. They also reported a similiar increase in the level of trimethylamine from 7.65 to 23.69 mg per cent after 42 days ensiling of prawn waste and rice bran with 10 per cent tapioca flour as additive. Abazinge et al. (1984) found that, while trimethylamine levels in fish waste-straw silages tended to remain relatively constant, the same in crab waste-straw silages showed a three fold increase after 42 days of ensiling. Lower levels of trimethylamine were reported (Abazinge et al., 1986 a) when crab waste and wheat straw were ensiled with 20 per cent molasses. Trimethylamine is a volatile product formed as a result of the reduction of trimethylamine oxide- a component of marine life and it imparts offensive odour to the mixtures containing them. Higher levels of trimethylamine indicate bacterial degradation taking place in prawn waste-paddy straw silage.

5.2.5 Volatile fatty acids:

From the data presented in Table 7 and represented by Fig. 3, it is clear that the proportion of volatile fatty acids in prawn waste-paddy straw silage was optimum at 21 days of fermentation, acetic acid being the predominant one with a concentration of 1.68 per cent. Acetic acid levels showed a declining trend to about half the above concentration on fiftieth day of ensiling while propionic acid levels remained almost static and butyric acid levels showed about five fold increase over the two periods. Samuels et al. (1982) recorded substantial levels of acetic acid in crab waste-wheat straw silages even after 42 days of ensiling. But, the above authors reported higher levels of butyric acid with silages containing crab waste, similar to that observed in the present study with prawn waste. Abazinge et al. (1986 a) also observed that the predominant volatile fatty acid was acetic acid, when crab waste and wheat straw were ensiled with different additives. Substantial levels of acetic acid were also reported when crab waste was ensiled with wheat bran (Ramachandran, 1990) and with corn forages (Viswanathan, 1990). Results of the present study on the volatile fatty acid profile of prawn waste-paddy straw silage, clearly indicate that optimum fermentation occurs during the first 21 days period after ensiling, as evidenced by a significant decline in acetic acid and increase in butyric acid levels after 50 days of fermentation.

5.3 Digestibility experiments:

Results of the three digestibility trials conducted using grass hay alone (Trial I), grass hay plus paddy straw (Trial II) and grass hay plus prawn waste-paddy straw silage (Trial III) are discussed as follows:

5.3.1 Dry matter intake:

It can be seen from the data presented in Table 8 and represented by Fig. 4 and 5, that the daily average dry matter intake by the animals during the three feeding trials, expressed per 100 kg body weight and per kg metabolic body size were 1.33, 1.40 and 1.67 kg and 0.052, 0.055 and 0.067 kg respectively. As per the AICRP Report (1991), an average dry matter consumption of 1.73 kg per 100 kg body weight and 0.07 kg per kg metabolic body size were recorded during investigations using prawn waste-rice bran silage in cattle. Prawn waste-rice polish silage was well relished by growing calves, when 50 per cent of the total protein requirement was replaced by the silage, with an average feed conversion efficiency of 7.7 compared to 4.62 for the control diets. (AICRP Report, 1992). Samuels et al. (1991) also reported a higher dry matter intake by sheep fed crab waste-wheat straw silage. The highest dry matter intake in cattle, obtained under Trial III using prawn waste-paddy straw silage, lend evidence to support the fact that, the silage is palatable and well relished by animals.

5.3.2 Digestibility coefficients:

From the summarised data on the digestibility coefficients of the various nutrients in the experimental rations presented in Table 15, it can be seen that the values are consistent with those already reported earlier in this regard.

5.3.2.1 Grass hay:

It can be seen from the data presented in Table 2, that the nutrient chemical composition of the grass hay used as basal ration in the present study is almost similar to those already reported in literature for different grass hays in general (Morrison, 1984). Results of the digestibility trial (Trial I) using grass hay as the basal ration, indicated that the material is palatable and the nutrients are well digested, the digestibility coefficients in respect of dry matter, crude protein, ether extract, crude fibre, nitrogen free extract, neutral detergent fibre, acid detergent fibre and cellulose being 58.00, 54.99, 63.55, 63.31, 59.30, 66.97, 70.99 and 75.76 respectively. Almost similar digestibility coefficients for the nutrients in grass hay were reported by other workers also (Crampton and Harris, 1969; Morrison, 1984). The digestible crude protein and total digestible nutrient values obtained for grass hay in the present study are also in full agreement with those already reported for mixed hays (Morrison, 1984). The above author also reported digestible crude protein and total digestible nutrient values of 1.9 and 41.6 and 3.8 and 50.1 for para grass hay and Panicum grass hay respectively.

5.3.2.2 Paddy straw:

The digestibility coefficients of dry matter, ether extract, crude fibre, nitrogen free extract, neutral detergent fibre, acid detergent fibre and cellulose in paddy straw were found to be 49.34, 54.99, 71.04, 53.24, 72.10, 66.41 and 77.35 respectively, with a digestible crude protein content of zero and total digestible nutrient value of 49.28 on dry matter basis. Similar values for digestibility coefficients of nutrients in paddy straw were reported by several other workers (Sen 1953; Kunjikutty, 1969; Ali, 1970; Morrison, 1984). The relatively higher values for digestibility coefficients in respect of the fibre fractions in paddy straw, obtained in the present study, can be attributed to the difference in the type of straw since most of the short term varieties of paddy straw are reported to contain lower levels of crude fibre and higher levels of crude protein (Devassia et al., 1978).

5.3.2.3 Prawn waste-paddy straw silage:

Data presented in Table 15 shows that the digestibility coefficients of the different nutrients in prawn waste-paddy straw silage namely dry matter, crude protein, ether extract, crude fibre, nitrogen free extract, neutral detergent fibre, acid detergent fibre and cellulose were 54.48, 51.36, 75.29, 73.14, 65.52, 68.90, 65.57 and 75.39 respectively. The palatability as well as the higher dry matter intake and digestibility coefficients of nutrients, recorded in the present study indicate that prawn waste-paddy straw silage is a potential source of digestible nutrients. Ayangbile et al. (1987 c) obtained lower digestibilities for dry matter, crude protein, neutral detergent fibre and acid detergent fibre in crab waste-straw silage fed to sheep, when compared to those for the control diet. Samuels et al. (1991) reported higher digestibilities for dry matter and crude protein with crab waste-straw silage in sheep, compared to fish waste-straw silage. The apparent digestibilities of different nutrients obtained with crab waste-straw silages containing crab waste and wheat straw in two proportions of 60:40 and 40:60 were: 60.7 and 58.9, 62.3 and 59.3, 82.1 and 82.7, 56.0 and 55.9, 57.8 and 50.8, 58.7 and 55.2 and 71.1 and 64.4 for dry matter, crude protein, ether extract, neutral detergent fibre, acid detergent fibre, cellulose and hemicellulose respectively. Studies carried out to evaluate the nutritive value of prawn waste-rice bran silage in cattle (AICRP Report, 1991) revealed that the material is also well digested, the digestibility coefficients of nutrients being 61.66, 80.55, 91.41, 77.78 and 36.83 for dry matter, crude protein, ether extract, crude fibre and nitrogen free extract respectively. The digestible crude protein and total digestible nutrient contents of prawn waste-rice bran silage were reported to be 13.85 and 71.0 per cent respectively. The relatively lower values for digestible crude protein and total digestible nutrients obtained for prawn waste-paddy straw silage in the present study, compared to that for prawn waste-rice bran silage may be due to the lower nutrient density of paddy straw than that of rice bran.

From an overall assessment of the results obtained during the course of the present investigation, it can be seen that prawn waste can be ensiled satisfactorily with paddy straw and tapioca flour as additive on a large scale with least loss of nutrients. The digestibility studies carried out showed that prawn waste-paddy straw silage is well relished by cattle and that the material is well digested, the digestible crude protein and total digestible nutrient values being 7.39 and 56.58 respectively. Since very few studies have been so far carried out, either in India or abroad, on the nutritive evaluation of prawn waste-paddy straw silage and since encouraging results have been obtained during the present investigation, it is imperative that further long term studies are taken up through animal feeding trials with prawn waste-paddy straw silage, so that this potential by-product can be used as an alternate source of nutrients for our livestock.

Summary

SUMMARY

An investigation was carried out to evaluate the physico-chemical and fermentation characteristics of prawn waste-paddy straw silage and to assess its feeding value in cattle. Prawn waste was ensiled with chopped paddy straw in equal proportions (1:1 wet basis) using 10 per cent tapioca flour as additive in concrete tanks of dimensions 3.3 x 1.2 x 0.9 m, and allowed to ferment for a period of 50 days. The same proportions of ingredients were mixed and ensiled in smaller silos to study the silage characteristics after 21 days of ensiling. Three feeding trials were carried out using six, adult, dry, nonpregnant cows to find out the digestibility coefficients of the nutrients in the experimental rations. The animals were fed grass hay (basal ration) alone, grass hay plus paddy straw and grass hay plus prawn waste-paddy straw silage during Trial I, Trial II and Trial III respectively. Records of daily intake of each ration were maintained for each animal during the experimental period.

The silage formed was brown in colour, with a desirable aroma and had no evidence of any fungal growth. No major differences were observed in the physical characteristics between silages after 21 days and 50 days

of fermentation. Significant ($P < 0.01$) differences in nutrient levels were observed in prawn waste-paddy straw silage after different periods of ensiling. Ensiling resulted in an increase in fibre fractions and decrease in crude protein compared to pre-ensiled mixtures. pH showed a significant ($P < 0.01$) decline from 6.89 to 5.37 during the first 21 days and thereafter at a slower rate to 5.13 upto 50 days of ensiling. The content of water soluble carbohydrates showed a significant ($P < 0.01$) linear decrease with period of ensiling indicating efficient bacterial growth and high rate of fermentation in the silage. Increase in lactic acid concentration between periods of ensiling was not significant, Trimethylamine levels showed a significant ($P < 0.01$) linear increase with period of time. The proportion of volatile fatty acids in prawn waste-paddy straw silage was optimum at 21 days of fermentation, acetic acid being the predominant one though it showed a declining trend by fiftieth day of ensiling. While the propionic acid concentration in the silage remained almost same, butyric acid levels showed about five fold increase over the two periods.

Results of the digestion experiments using grass hay alone (Trial I) indicated that, the material is palatable and the nutrients are well digested providing a digestible crude protein content of 4.46 and total digestible nutrient value of 60.46 on dry matter basis. Compared to reported values, higher figures were obtained for the digestibility coefficients of fibre components in paddy straw. The relatively higher dry matter intake recorded during Trial III indicates that prawn waste-paddy straw silage is well relished by animals. The digestibility coefficients of the different nutrients in prawn waste-paddy straw silage were 54.48, 51.36, 75.29, 73.14, 65.52, 68.90, 65.57 and 75.39 for dry matter, crude protein, ether extract, crude fibre, nitrogen free extract, neutral detergent fibre, acid detergent fibre and cellulose respectively, with a digestible crude protein content of 7.39 and total digestible nutrient value of 56.58 per cent on dry matter basis.

From an overall assessment of the results obtained during the course of the present investigation, it is reasonably concluded that prawn waste can be ensiled satisfactorily with paddy straw and tapioca flour as additive on a large scale and that the material is well relished and digested by cattle. In as much as promising results have been obtained during the present investigation, it is imperative that further long term studies are taken up through animal feeding trials using prawn waste-paddy straw silage.

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ABSTRACT

Prawn waste was ensiled with chopped paddy straw in equal proportions (1:1 wet basis) using 10 per cent tapioca flour as additive for a period of 50 days. The same proportions of ingredients were mixed and ensiled in smaller silos for 21 days to study the silage characteristics. The prawn waste-paddy straw silage formed after both the periods of ensiling were similar with a characteristic brownish colour and desirable aroma and had no evidence of any fungal growth. Ensiling resulted in an increase in fibre fractions and decrease in crude protein contents, with significant ($P < 0.01$) differences in nutrient levels between silages after 21 days and 50 days of fermentation. The water soluble carbohydrate content and pH declined significantly ($P < 0.01$) over different periods of ensiling. Lactic acid concentration showed no significant increase after different periods of ensiling. The volatile fatty acid proportion in prawn waste-paddy straw silage was optimum after 21 days of fermentation, acetic acid being the predominant one. With increase in period of ensiling, acetic acid levels declined while butyric acid levels increased about five fold, without any change in propionic acid concentration.

Trimethylamine levels showed a significant ($P < 0.01$) increase after different periods of ensiling. Three digestion experiments (Trial I, II and III) were carried out using six, adult, dry, nonpregnant cows with grass hay (basal ration) alone, grass hay plus paddy straw and grass hay plus prawn waste-paddy straw silage respectively. The overall results of the feeding experiments indicated that prawn waste-paddy straw silage is relished and well digested by cattle as evidenced by a relatively higher feed intake and digestibility coefficients of nutrients. A critical evaluation of the results obtained during the course of the present investigation indicated that prawn waste can be satisfactorily ensiled with paddy straw and tapioca flour as additive and that the material can form a potential alternate feed source for cattle, worth studying in detail.