NUTRITIVE EVALUATION OF PRAWN WASTE AS CATTLE FEED

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "**NUTRITIVE EVALUATION OF PRAWN WASTE AS CATTLE FEED**" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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CERTIFICATE

Certified that this thesis, entitled "**NUTRITIVE EVALUATION OF PRAWN WASTE AS CATTLE FEED**" is a record of research work done independently by **Shri. George Varughese**, 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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Introduction

INTRODUCTION

Animal husbandry in India is closely associated with agriculture and is the second most important agricultural activity representing 21.3 per cent of total output from agriculture. India has a fabulous cattle wealth and is the second largest producer of milk in the world (Tomer, 1995) A major portion (80 per cent) of milk produced in the country comes from small and marginal farmers and landless labourers. Dairying is a gainful employment to rural population as evidenced by a reduction in the percentage of people under poverty line from 51 to 37 per cent during seventh plan period (Anon, 1987). In view of the contributions to rural economy, livestock production is emerging as a major component of development programmes. The national economy can be strengthened only by scientific exploitation of all resources including livestock asset in a time bound manner.

Feed accounts for 65 to 75 per cent of the total cost of livestock and poultry production. Acute shortage of quality feeds and fodders is one of the major constraints in the development of economic livestock farming in India. The area under fodder cultivation in the country is around four per cent of the total cultivable land and there is little scope for further increase in the area under fodder crops. Genetically improved livestock and efficient management must

get the support from feed industry to ensure optimum production from livestock. The estimated requirements of protein and energy for the year 1996, in terms of digestible crude protein (DCP) and total digestible nutrients (TDN) were 40 and 450 million tonnes respectively, whereas the availability from all sources were only 20 and 241 million tonnes with a deficit of about 50 and 46 per cent respectively. Further, in the year 2000 AD the deficit of feeds and fodder predicted is about 52.0 per cent of the requirement. The projected gap in the availability of feeds in Kerala amounts to 77.4 per cent of DCP and 77.0 per cent of TDN (Tomer, 1995).

Crop residues are presently the staple roughage in our country, of which paddy straw forms the bulk. The shortage of essential feed ingredients and the escalating prices of feed stuffs are the two main problems faced by feed industry today. It is the challenging need of the day to explore all the potential alternate feed sources and to evaluate them in terms of quantity and quality so as to improve the nutritional status of Indian livestock.

Aquatic animal (prawn) wastes is an unconventional feed source which can be exploited to a large extent as a livestock feed ingredient. India ranks seventh or eighth in total fish landings in the world (Sripathy, 1989). Global annual

crustacean waste was estimated as 1.46×10^6 tonnes (Knorr, 1991) and substantial quantities of this valuable waste are discarded.

With about 600 km of coastal line, 400 km of back waters, rivers, lakes, reservoirs and with potential for inland aquaculture development, Kerala stands first among Indian states in production of sea foods. The export oriented shrimp based seafood industry is one of the organised fish processing industries in India. The extent of fish landings in Kerala is around 3 lakh tonnes annually (Fisheries Statistics, 1991). The quantity of wastes from fish industry vary from 10 to 50 per cent depending upon the method of processing and variety of fish. The annual availability of prawn waste in Kerala is estimated as 0.9 lakh tonnes (Fisheries Statistics, 1991). Handling of prawn waste poses problems of disposal, due to their moisture content, quick deterioration, offensive odours and the pollution hazards. The common practice in Kerala is to use the major portion of the fish processing wastes, including prawn waste as manure or to throw back the waste to sea. The situation has changed to certain extent in recent years, as the waste is either being lifted by local people to feed ducks or being put into different uses ranging from horticulture to pharmaceuticals (Ramachandran *et al.*, 1986; Barratt and Montano, 1986). Prawn waste is a good source of chitin. The growth promoting effect of chitin in pure form or

as present in prawn shell has also been reported in broiler chicken (Ramachandran *et al.*, 1987) and in laboratory rats (Mathew *et al.*, 1989). Pure chitin is reported to have growth promoting, hypolipidemic and hypocholestremic effect in growing pigs (Pradhan, 1993). Chitosan is the deacetylated derivative of chitin. Chitosan films are having applications like dialysis membrane and artificial skin, and chitosan-gelatin films have better wound and burn healing properties. Development of appropriate and viable technology for processing and preserving this marine waste will contribute towards augmenting feed resources of the country in general and Kerala in particular.

As a corollary to the extensive investigations conducted, on unconventional feeds in the Department of Nutrition of College of Veterinary and Animal Sciences, Mannuthy, aquatic animal (prawn) waste was subjected to a series of feeding experiments in different species of animals. Prawn waste was found to be a potential source of nutrient such as proteins and minerals for cattle (Ramachandran *et al.*, in press) and poultry (Menachery *et al.*, 1978). In swine the results were not satisfactory (Anon, 1988; Shyam Mohan and Sivaraman, 1993). Prawn waste can be converted to a satisfactory silage with proper additives (Ramachandran *et al.*, 1992; James, 1993). However, further comprehensive studies are warranted

to assess the suitability of processed prawn waste as livestock feed.

The present investigation was envisaged to ascertain the nutrient composition and rumen degradability of dry processed prawn waste from different localities in Kerala and to find out the nutritive value of prawn waste incorporated rations in adult cattle.

Review of Literature

REVIEW OF LITERATURE

Aquatic animal wastes are the by-products of seafood industry and consist mainly of crustacean wastes. Properly processed aquatic animal wastes are wholesome in appearance, smell and taste. In India, prawn waste (shrimp meal) is the main aquatic waste. It consists of the waste from shrimp peeling viz. the head, appendages and shell. A major part of the waste material is presently either being discarded and presents a waste disposal problem, or is being marginally utilized as a fertilizer or as an ingredient in the diets of aquatic animals. Crab meal, the chief crustacean waste in the west is the by-product prepared from undecomposed dried waste of crab industry and consists of shell, viscera and part or all of flesh (AAFCO, 1992).

2.1 Prawn waste

Decapod crustaceans of the sub order Natantia (shrimps or prawns) are found in fresh and salt waters all over the world. The important species of sea water shrimps in India include *Penaeus merguiensis* (Banana prawn), *Penaeus indicus* (Indian prawn), *Penaeus monodon* (Giant tiger prawn), *Penaeus semisulcatus* (Green tiger prawn), *Metapenaeus brevicornis* (Yellow prawn) *Metapenaeus ensis*, *Metapenaeus burkenroadi* and

Metapenaeus dobsoni whereas the chief fresh water shrimp is *Machrobrachium rosenbergi* (Bardach *et al.*, 1972).

Prawn waste is a good source of protein as well as minerals. Chitin-N forms about 20 per cent of total N content of prawn waste (Lovell *et al.*, 1968; Rutledge, 1971). Chitin, which is a component of exoskeleton of crustaceans is a (1-4) ß linked homopolysaccharide of N-acetyl-D-glucosamine, an analogue of cellulose. The ADF content of crustaceans is a measure of its chitin content (Stelmoch *et al.*, 1985).

2.1.1 Dried prawn waste/shrimp meal

In tropical countries solar energy is the chief source of energy for drying various types of fish and aquatic wastes. Sun-dried materials are generally contaminated with extraneous matter, mainly sand and dust. Drying of fish and the wastes in hot-air oven or steam drier was found to be highly efficient as revealed by less moisture content and chemical indices of available lysine and pepsin digestibility, provided enough precautions were taken to avoid scorching during drying process (Rao *et al.*, 1971). Microwave heating, which is endowed with some special characteristics such as penetrating quality which results in uniform heating of materials, selective absorption of radiation by water and capacity for easy control, is a viable commercial alternative for drying of aquatic wastes. Generators using 896-915 MH_z and having

conversion efficiencies in the region of 85 per cent are acceptable in terms of running cost for most continuous heating process (Everington, 1989).

2.1.1.1 Chemical composition

Variability in proximate composition of different processed shrimp meals were noted by Meyers *et al.* (1973), due to difference in condition and species involved and also different processing and recovery techniques used. Fox *et al.* (1994) reported that separated shrimp head meals contained around 6 per cent less ash, 5 per cent less chitin and 7.5 per cent more protein than unseparated meals. Separated meals also contained higher levels of astaxanthin and n-3 polyunsaturated fatty acids. Shrimp head meals were found to be deficient in arginine and methionine plus cystine (Fox *et al.*, 1994). Data available on chemical composition of prawn waste, differently processed are set out in tabular form along with the references in Table 1.

It can be concluded from the chemical composition that the crude protein content of prawn waste varies from 30 to 48 per cent depending upon the type of sample and the proportion of head and shell. About 20 per cent of this total nitrogen, which forms the chitin nitrogen, may not be available to animals. The crude fiber content varies from 6 to 13 per cent Ca:P ratio is very wide, reaching upto 11:1.

Table 1. Chemical composition of prawn waste reported by various authors (on dry matter basis)

Type of sample	Dry matter	Crude protein	Ether extract	Crude fibre	Nitrogen free extract	Total ash	Acid insoluble ash	Chitin	Calcium	Phosphorus	Reference
Shrimp meal-body plus tail	N.R	47.5	N.R	N.R	N.R	34.3	N.R	N.R	2.43	1.07	Jarquin *et al.* (1972)
Shrimp head meal	N.R	37.4	N.R	N.R	N.R	29.2	N.R	N.R	5.25	1.3	Jarquin *et al.* (1972)
Dried prawn waste	N.R	32.1	5.6	6.0	15.4	40.9	17.4	N.R	9.3	1.3	Menachery *et al.* (1978)
Dried shrimp meal	N.R	46.7	2.8	11.1	1.3	27.8	N.R	N.R	N.R	N.R	Morrison (1984)
Dried shrimp shell	N.R	30.2	5.3	6.0	18.3	40.2	17.5	N.R	9.1	1.2	Anon (1988)
Dry prawn shell	N.R	29.76	5.05	N.R	N.R	31.13	N.R	23.08	N.R	N.R	Mathew *et al.* (1989)
Deproteinised prawn shell	N.R	N.R	0.05	N.R	N.R	53.0	N.R	33.38	N.R	N.R	Mathew *et al.* (1989)
Demineralised prawn shell	N.R	45.45	2.95	N.R	N.R	3.23	N.R	37.80	N.R	N.R	Mathew *et al.* (1989)
Fresh prawn waste	18.2	41.8	N.R	N.R	N.R	29.0	N.R	N.R	11.65	1.92	Anon (1992)
Dried prawn waste	N.R	34.6	2.3	13.1	8.2	41.8	4.8	N.R	13.52	1.21	Shyam Mohan and Sivaraman (1993)
Dried prawn waste	25.7	42.2	9.8	13.7	6.7	27.6	N.R	13.5	N.R	N.R	James (1993)
Dried shrimp waste	86	48.3	5.75	12.9	N.R	12.0	N.R	N.R	3.5	1.0	Islam *et al.* (1994)

N.R: Not reported

2.1.1.2 *In situ* rumen degradability

Newer animal rationing models (eg. metabolisable protein system) require an accurate determination of the dynamic aspects of rumen nitrogen degradation and degradation kinetics of various feed fractions (AFRC, 1992; Fox *et al.*, 1992; Russel *et al.*, 1992; Sniffen *et al.*, 1992). Nylon bag or *in situ* or *in sacco* rumen degradability technique has been widely adopted around the world to evaluate the rate and extent of degradation in the rumen since it was first developed by Quin *et al.* (1938). This technique has been shown to give best comparison with *in vivo* results and has been adopted by AFRC (1992) as the standard method of characterising rumen degradability of nitrogen. This method can be used to describe the degradation characteristics of both fiber (cellulose) (Aerts *et al.*, 1977; Navaratre *et al.*, 1990) and protein (nitrogen) fractions (Stern and Satter, 1984; Madsen and Hvelplund, 1985) in feeds of ruminants.

The major criticism of the *in situ* technique is the low repeatability as suggested by the diversity of values obtained by different researchers for similar feed samples (Nocek, 1988; Madsen and Hvelplund, 1994). Various factors like bag porosity, particle size, sample size, contamination by rumen bacteria, location of the bag in the rumen and host diet can influence the results.

A significant increase in particle wash out occurs with increasing pore size (Lindberg and Knutsson, 1981; Weakley *et al.*, 1983; Uden and VanSoest, 1984). Reduced pore size can result in inhibited removal of degradation end products (Lindberg *et al.*, 1984; Marinucci *et al.*, 1992) and inefficient washing procedure post-incubation leading to an under estimation and possibly negative degradability values (VanHellen and Ellis, 1977; Lindberg and Varvikko, 1982).

Increased dry matter and N degradation with reducing particle size was observed by Mohamed and Smith (1977), Weakley *et al.* (1977), and Freer and Dove (1984). But Ehle *et al.* (1982) noted that there was no consistent pattern for the influence of particle size on dry matter and N degradation within a feed sample. Considerable differences in mean particle size exist between feeds ground through the same sized screen (Michalet-Doreau and Cerneau, 1991).

A sample weight to bag surface area ratio (SW:SA) of 16 mg/cm^2 is considered optimum for dry samples. Cell wall degradability was reported to be reduced from 54 to 38 per cent when SW:SA increased from 6.5 to 60 mg/cm^2 (Uden *et al.*, 1974). SW:SA ratios less than 4 mg/cm^2 can lead to over estimation of sample degradability (Nocek, 1985).

Potential contamination of test feed with ruminal microflora has been reported (Kennedy *et al.*, 1984).

Microbial contamination of forage residues can result in a substantial under estimation of degradability value (Mathers and Aitchison, 1981; Varvikko and Lindberg, 1985; Michalet-Doreau and Ould-Bagh, 1989) as well as erroneous lag and rate estimation of N degradation (Nocek and Grant, 1987).

The effect of bag location on dry matter digestibility in cattle involved a reduction of 6 to 10 per cent units from the free to cannula end (Hawley, 1981). Stritzler *et al.* (1990) found a linear response in dry matter disappearance to increased cord length for incubation periods upto 24 h.

Host diet exerts a significant effect on *in situ* degradation, decreased dry matter disappearance from bags has been reported by Ganev *et al.* (1979) as the cereal content of the basal diet increased. A significant interaction between dietary protein supplement and sample protein source after 12 h of incubation was observed by Loerch *et al.* (1983).

Limited work has been carried out to evaluate the *in situ* degradability of shrimp meal. Patton and Chandler (1975) evaluated the *in vivo* rumen digestibility of shrimp meal using cannulated steers. The solubility of dry matter and crude protein of shrimp meal was 17.4 per cent and 27.5 per cent respectively.

2.1.1.3 Feeding value

The feeding value of dried prawn waste was assessed in various species of animals by scientists in different parts of the world. Feeding experiments carried out in different species are reviewed.

Cattle

Until recently animal protein supplements were not included in adult ruminant rations. Hence large animal feeding experiments with prawn waste in practical rations for ruminants are rather few.

In a preliminary feeding experiment to test the nutritional value of waste products generated in Panama, 25 young Holstein heifers between the ages of 14 to 22 weeks were fed an experimental ration containing 14 per cent shrimp meal for 33 days. The heifers gained, on an average, 0.846 kg/per day which was nearly 45 per cent above the performance of heifers receiving a domestic control of 100 per cent hay (Zikakis *et al.*, 1988).

Swine

Fish meal or dried fish forms an essential food ingredient in swine diets. Many workers have tried partial or complete substitution of fish meal with dried prawn waste.

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.

Feeding experiments carried out in the Nutrition Department of the College of Veterinary and Animal Sciences, Mannuthy in Large White Yorkshire growing pigs of 11 weeks of age replacing fish meal with shrimp shell indicated that replacement of 50 or 100 per cent of fish meal with shrimp shell adversely affected growth, reducing the average daily gain, increasing the feed gain ratio and cost of feed per unit body weight gain. It was concluded that shrimp shell could not be recommended as a either partial or complete substitute to fish meal in the ration of growing pigs (Anon, 1988).

Partial (5 per cent) or complete (10 per cent) replacement of unsalted dried fish with dried prawn waste in the rations of growing and finishing pigs adversely affected body weight gains, feed conversion efficiency and carcass characteristics (Shyam Mohan and Sivaraman, 1993). No significant differences in growth rate, body measurements,

average age at slaughter and carcass characteristics were observed in pigs fed diets at the two levels of replacement. Replacement of 50 per cent of dried fish with prawn waste increased the digestibility of dry matter and nitrogen free extract, whereas 100 per cent replacement decreased the digestibility of crude protein in the ration.

Poultry

Shrimp by-product meals produced slower growth rate when compared with fish meal at equal protein levels in the diets of growing chicken (Jarquin *et al.*, 1972). Supplementation of shrimp meal with lysine improved weight gain, but the addition of methionine produced no further response.

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

Growth studies in commercial broiler chicken for 8 weeks with dried prawn waste (32 per cent crude protein) indicated that dried fish was superior to prawn waste in terms of live weight gain, feed efficiency and cost of production. However, replacement of half of the dried fish in broiler ration with prawn waste did not produce statistically significant differences in weight gain at six weeks and was economical (Menachery *et al.*, 1978).

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

When a meal of 1.00:1.15 dry mixture of shark filleting by-product and shrimp by-product was included in the diet of growing chicken at 3, 6, 9 or 12 per cent levels, no difference in feed efficiency was noticed between diets, though diets with 3 and 6 per cent levels of the meals were considered better, nutritionally and economically (Rua *et al.*, 1985).

Other species

Shrimp waste is as good as amino acid fortified soya as the sole source of protein for rats (Lovell, 1968).

Toma and James (1975) determined the protein efficiency ratio for three proteins, caesin, isolated soybean protein and shrimp waste protein and a mixture of equal proportions of shrimp waste protein and isolated soybean protein. Shrimp waste protein promoted rat growth 80 per cent as efficiently as caesin. Moreover, shrimp waste protein improved protein

quality 74 per cent in a soybean diet when shrimp waste protein replaced half the soybean protein in the diet.

Johnson and Peniston (1982) reported that protein recoverable from shrimp and crab waste by mild alkaline extraction and isoelectric precipitation had an amino acid profile similar to casein except for a low cystine and methionine. Feeding trials with rats and mink indicated it to be of good nutritional value when supplemented with a small amount of methionine.

Crustacean waste products can be satisfactory protein supplements for mink, provided the protein and energy concentration of the diet are maintained at sufficient levels and dietary calcium at optimum level (Watkins *et al.*, 1982).

Mathew *et al.* (1989) studied the effect of addition of pure chitin from prawn shell, deproteinised prawn shell, demineralised prawn shell and dry prawn shell in casein based control diet on albino rats. Weight gain and feed conversion were maximum in the control diet. Rats fed deproteinised prawn shell showed the least weight gain. They also reported that the presence of minerals in prawn shell adversely affected the feed consumption and live weight gain in albino rats.

2.1.2 Prawn waste silage

Taking into consideration the highly perishable nature of aquatic animal wastes, the wet processing method viz. ensiling was tried and found effective by several workers in preserving the material (Abazinge *et al.*, 1986; Samuels *et al.*, 1991; Ramachandran *et al.*, 1992).

Fresh prawn waste can be satisfactorily ensiled with rice bran (1:1 wet basis) along with additives such as tapioca flour or coconut cake at 10 or 20 per cent levels. The optimum period for producing a satisfactory silage is 21 days (Ramachandran *et al.*, 1992).

Studies on the palatability and digestibility of prawn waste-rice bran silage in cattle (Ramachandran *et al.*, in press) 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, 80.55, 91.41, 77.78 and 36.83 respectively. The digestible crude protein and total digestible nutrient contents of prawn waste-rice bran silage on dry matter basis were shown to be 13.9 and 71.0 per cent, respectively.

Evaluation of the nutritive value of prawn waste-rice polish silage in growing calves (Anon, 1992) by replacing 50 per cent of the total protein requirements 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 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.

Ensiling of prawn waste with chopped paddy straw in equal proportions (1:1 wet basis) with 10 per cent tapioca flour as additive for 21 days produced satisfactory silage as evidenced from physical, chemical and fermentation characteristics (James, 1993). Nutritive evaluation of prawn waste-paddy straw silage in cattle indicated that it has a DCP and TDN content of 7.4 and 56.6 per cent respectively, on dry matter basis and the material can form a potential alternate feed for cattle.

2.2 Crab processing waste

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.

2.2.1 Crab meal

Crab meal is the undecomposed dried waste of crab industry and consists of shell, viscera and part or all of

flesh. It should contain 25 per cent protein and not more than 3 per cent salt (AAFCO, 1992).

2.2.1.1 Chemical composition

Reported data on chemical composition of crab meal (Lubitz *et al.*, 1945; Lovell *et al.*, 1968; Samuels *et al.*, 1982; Anon, 1990; Velez *et al.*, 1991; Nicholson *et al.*, 1996) indicated that the material had higher dry matter and ash contents than prawn waste, ranging from 30 to 40 per cent and 40 to 46 per cent respectively. Crude protein varied from 20 to 44 per cent, out of this about 20 per cent was chitin nitrogen. Calcium content was comparatively higher, with values ranging from 7 to 16 per cent. This waste also contained 11 to 13 per cent acid detergent fibre.

2.2.1.2 *In situ* rumen degradability

Most of the reported values of *in situ* dry matter and nitrogen degradabilities of crab meal varied from 18 to 36 per cent and 35 to 50 per cent respectively (Patton and Chandler, 1975; Velez *et al.*, 1991; Viswanathan, 1995) whereas Nicholson *et al.* (1996) recorded that less than 18 per cent of crab meal protein disappeared from the bags suspended in the rumen for 24 hour. Viswanathan (1995) obtained 60 per cent increase in chitin degradability from steam exploded crab meal.

2.2.1.3 Feeding value

Ruminants

Patton and Chandler (1975) reported that crab meal could be incorporated upto a level of 20 per cent in the diets of young calves. Laflamme (1988) observed that inclusion of crab meal at 15 and 25 per cent levels in the rations of heifer calves reduced the feed consumption and growth rate initially, and these measures improved with time. Beef calves fed crab meal supplement recorded lower feed intake, lower average daily gain and poor feed efficiency as compared to those fed full fat canola seed or soybean supplements (Nicholson *et al.*, 1996). Crab meal was found to be a potential source of protein in concentrates for lactating cows (Brundage *et al.*, 1981). Lactating cows fed 15 per cent crab meal containing rations recorded highest feed intake and gained the highest amount of weights (Brundage *et al.*, 1984). Viswanathan (1995) from a growth trial in Angus x Hereford and Angus x Simmental steers for 126 days with crab meal and other protein supplements included in high roughage diet concluded that crab meal was comparable to soybean meal as a protein supplement for steers. Diets containing crustacean waste meals had lower dry matter, crude protein and acid detergent fibre digestibilities than soybean meal diets in Holstein heifers (Velez *et al.*, 1991).

Metabolism trials with 24 Wether lambs indicated that crab meal supplemented diets were comparable with other protein supplemented diets with regard to dry matter and organic matter digestibilities but had lower acid detergent fibre and crude protein digestibilities (Viswanathan, 1995). Nicholson *et al.* (1996) fed mature, crossbred wethers a barley-based basal diet, 85:15 basal diet: crab meal or 70:30 basal diet:crab meal and found that only the apparent digestibility of dry matter differed significantly, which decreased progressively as the crab meal level in the diet increased.

Pigs

Anderson and Van Lunen (1986) observed that the body weight gains of the growing Yorkshire pigs fed different isocaloric and isonitrogenous diets containing 0, 5, 10 or 15 per cent crab meal were not significantly different while feed consumed per day and feed/gain ratio were higher for 10 per cent crab meal fed group, compared to the 5 per cent crab meal diet. Carcass index was significantly better with less back fat in pigs fed 15 per cent crab meal than those on 5 per cent crab meal diets.

Poultry

Parkhurst *et al.* (1944) 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 source were included in the ration.

Potter and Shelton (1973) found that inclusion of crab meal at 3 or 6 per cent in the diets of day old turkey poults resulted in a significant increase in body weight with no effect on feed conversion efficiency.

Mercy (1995) conducted an experiment using 180 day old broiler chicks to assess the nutritive value of crab waste protein supplement at 0, 25 and 50 per cent levels in the diet. Feed intake, body weight gain, protein efficiency ratio and gain/feed decreased linearly with increasing levels of crab waste protein supplement. It was concluded that digestion and utilisation were lower for crab waste protein supplement than soybean meal. However, differences in performance was less with 25 per cent crab waste protein supplement diets, indicating that crab waste protein

supplement can be incorporated in the diets of chicks upto25 per cent level.

2.2.2 Crab waste silage

Crab waste can be satisfactorily ensiled with maize stover, groundnut hulls, cornforage, wheat bran or wheat straw with or without addition of additives like molasses, sodium hypochlorite or hydrogen peroxide (Samuels *et al.*, 1982; Abazinge *et al.*, 1986; Anon, 1990).

Ayangible and Fontenot (1987) found that in yearling steers fed with finishing diet containing 0, 15 or 30 per cent crab waste-straw silage, the daily gain and feed efficiency were numerically and carcass weights significantly greater with 30 per cent crab waste-straw silage. Samuels *et al.* (1991) compared silage prepared from fish waste/crab waste with straw in different proportions. The apparent digestibility of dry matter and crude protein were higher for diets containing fish waste than those containing crab waste.

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 DM 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 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.

Materials and Methods

MATERIALS AND METHODS

An investigation was carried out in the Department of Nutrition, College of Veterinary and Animal Sciences, Mannuthy to evaluate prawn waste as an ingredient in cattle feed. The three steps by which the suitability of prawn waste was assessed are as follows:

1. Chemical analysis of prawn waste samples
2. *In situ* degradability studies
3. Metabolism trial using adult non-producing cattle

The economics of incorporation of dry processed prawn waste in concentrate mixture for cattle was also studied during the investigation.

3.1 Chemical analysis of prawn waste samples

Prawn waste samples were collected from the peeling centres at the three major fish landing areas viz., Kochi, Kodungalloor and Kozhikode. The samples were dried in a hot air oven at 60°C for 48 hours. Six pooled samples from each area were analysed for crude protein, acid detergent fibre, total ash, acid insoluble ash, calcium and phosphorus as per standard procedures (AOAC, 1990). Crude protein was determined using a Kjeltec 2000 digestor and distillation system (Tecator, Sweden) and acid detergent fibre by Fibertec

2 M system (Tecator, Sweden). Calcium estimation was carried out using an atomic absorption spectrophotometer (Model 3110, Perkin-Elmer, USA) and phosphorus by a photometric procedure using a spectronic-20 (Milton Roy Co., USA).

3.2 *In situ* degradability studies

3.2.1 Preparation of prawn waste samples

Pooled prawn waste samples from each fish landing area, viz. Kochi, Kodungalloor and Kozhikode were dried in a hot air oven to 60°C for 48 hours ground in a mixer grinder and passed through 1 mm seive (Scientific Engineering Corporation, Delhi) and stored in airtight containers for the degradability studies using polyester bag.

3.2.2 Polyester bags

Polyester bags of 10x23 cm size with 59±2 μm porosity were used. Calculated sample size to bag surface area was 15 mg/cm² (Nocek, 1985).

3.2.3 Experimental animals and their diets

Three adult non-producing cows obtained from the University Livestock Farm, Mannuthy formed the experimental subjects for the *in situ* degradability studies. The animals were operated at the left flank region and fitted with large

rumen cannulae (100 mm diameter) with screw caps. The three rumen fistulated animals were kept individually under identical conditions of management. All animals received standard concentrate mixture and paddy straw as roughage at maintenance level (Ranjhan, 1991). Fresh clean drinking water was provided *ad libitum*.

3.2.4 Incubation of feed samples in the rumen

Pooled samples of prawn waste (in duplicate) from each fish landing area viz. Kochi, Kodungalloor and Kozhikode were incubated in the rumen of each animal twice within an interval of two weeks. The sample size was six grams each and the bags were closed using a double knot and tied to 75 cm long nylon strings. The bags were soaked in water for 15 minutes (Rodriguez, 1994) and were introduced into the ventral sac by hand. Time intervals for incubation were 0, 3, 6, 9, 12 and 24 hour and was in the reverse order. After 24 hours all bags were retrieved, washed thoroughly in running tap water until rinse water was clear. Bags were dried at 60°C for 48 hours and were weighed to calculate the dry matter disappearance. Residues in the bag were subjected for nitrogen analysis by Kjeldahls method (AOAC, 1990).

3.2.5 Determination of degradability

Ruminal degradation of dry matter (DM) and crude protein (CP) were classified into three main fractions as proposed by Armentano *et al.* (1986). For CP, the fractions are A, B and C which are as follows:

A = Non protein nitrogen or true protein that is solubilised rapidly in warm water and is calculated by subtracting the per cent remaining at 0 time from 100.

B = Protein that is degraded at a rate similar to the rate of passage and is calculated by subtracting sum of A and C from 100.

C = Protein that is undegraded in the rumen, which is per cent remaining at 24 hours.

For DM, the definition was the same as above. Degradability of DM or CP depends on rate of passage of digesta (K_{pb}) which is expressed as percentage per hour (%/h) and rate of degradation (K_{db}). The rate of passage in this study was assumed to be 5%/h. The residue at 24 h incubation was considered as C fraction and there was no change for this fraction. The B fraction was calculated as the difference between 0 h and 24 h sample weight. Then, the residues (expressed as percentage of the material inserted) at each

incubation time minus C fraction were converted into natural log, and subjected to linear regression. The degradation constant (K_{db}) is represented by the slope of this line. The *in situ* ruminal degradability of DM and escape of CP of prawn waste were estimated applying the model as prescribed by Orskov and McDonald (1979) considering the ruminal passage rate (K_{pb}).

$$D = A + \frac{(B \times K_{db})}{(K_{db} + K_{pb})}$$

where,

D = Protein degradability, (%)

A = Fraction A, readily degradable, (%)

B = Fraction B, slowly degradable, (%)

K_{db} = Degradation rate constant of degradable B

K_{pb} = Rate of passage (assumed to be 5%/h)

The escape of protein was also estimated by applying the model proposed by Orskov and McDonald (1979).

$$\text{Escape} = \frac{K_{pb} \times B}{(K_{db} + K_{pb})} + C$$

where,

B, K_{db} and K_{pb} are stated as in above model

C = fraction that is undegraded

The data was analysed statistically using a completely randomised design as per method suggested by Snedecor and Cochran (1980).

3.3 Metabolism trials

The nutritive value of prawn waste containing rations were assessed by conducting three metabolism trials.

3.3.1 Animals

Six crossbred, adult non-producing cows of body weight ranging from 361 to 442 kg, belonging to the University Livestock Farm, Mannuthy formed the experimental animals for the study. All the animals were kept under identical conditions of management.

3.3.2 Rations

The feed ingredients required for the study were procured as per rate contract fixed by the college for the year. Large quantities of prawn waste was collected, dried in hot air oven at 60°C for 48 hours and was used for the feeding trial. Standard concentrate mixtures were compounded with 0, 10 and 20 per cent of dried prawn waste as per BIS specifications as follows:

T_1 (Control) : Standard concentrate mixture

T_2 (Experimental I) : Standard concentrate mixture incorporating dried prawn waste at 10 per cent level

T_3 (Experimental II): Standard concentrate mixture incorporating dried prawn waste at 20 per cent level

Paddy straw formed the roughage for all treatments. The ingredient composition and the chemical composition of the three rations are given in Tables 2 and 3 respectively.

3.3.3 Experimental design

The feeding experiment was conducted in a Randomised Block Design in a switch over trial. The three pairs of animals received the three rations at three different periods with an interval of two weeks between collection periods in order to avoid carry over effect. The distribution of treatments were as follows:

Animal pairs

	1	2	3
Period			
I	T_1	T_2	T_3
II	T_2	T_3	T_1
III	T_3	T_1	T_2

Table 2. Percentage ingredient composition of concentrate mixtures used for metabolism trials

Ingredients	Concentrate mixtures		
	Control	Experimental I (10% PW)	Experimental II (20% PW)
Yellow maize	18	39	48
Ground nut cake (expeller)	19	18	15
Coconut cake (expeller)	10	10	10
Wheat bran	50	20	4
Prawn waste (dried)	0	10	20
Mineral mixture*	2	2	2
Common salt	1	1	1
Total	100	100	100
To 100 kg of the above mixture add			
Vitamin mixture** (g)	10	10	10
Calculated composition:			
DCP	16.3	16.8	17.3
TDN	71.0	72.0	70.0

* KEYES mineral mixture (Kerala Solent Extractions Ltd., Irinjalakuda) composition per 100 g:24 g Ca; 12 g P; 6.5 g Mg; 0.15 g Mn; 0.15 g Cu; 0.386 g Zn; 0.5 g Fe; 0.03 g I and 0.02 g Co

** INDOMIX vitamin supplement (Piramal Health Care, Mumbai) composition per gram:

Vitamin A 40,000 i.u.
Vitamin D3 5,000 i.u.
Vitamin B2 20 mg

Table 3. Percentage chemical composition of concentrate mixtures and paddy straw (DM basis)

Nutrients	Concentrate mixtures			Paddy straw
	T_1 Control	T_2 Experimental	T_3 Experimental	
Dry matter	88.9	89.3	89.5	87.8
Crude protein	19.4	19.2	19.3	3.8
Ether extract	5.4	4.8	5.9	1.6
Crude fibre	8.2	7.0	7.6	30.3
Nitrogen free extract	58.7	59.8	56.2	48.9
Total ash	8.3	9.2	11.0	15.4
Calcium	0.91	2.43	3.51	0.51
Phosphorus	0.80	0.94	0.93	0.14

The preliminary period for the first trial was conducted for three weeks. The animals were fed individually twice daily (Ranjhan, 1991). Fresh clean drinking water was provided twice daily.

3.3.4 Collection period

3.3.4.1 Sampling of feeds

Each day a fixed quantity of feed from each ration and paddy straw were collected and pooled at the end of the collection period and used for chemical analysis. The balance of paddy straw in the manger was weighed everyday in order to record the actual intake.

3.3.4.2 Sampling of dung and urine

Dung and urine were collected separately and quantitatively for one week each at three periods during the experimental duration of 10 weeks. Manual collection was practised. Urine was collected in plastic buckets of 15 litres capacity containing 100 ml of 25% H_2SO_4. At 10 A.M. every day the dung voided during the preceding 24 hours was weighed; mixed thoroughly and representative samples (1 per cent) were taken in polythene bags and stored in deep freezer. Similarly out of the total volume of urine passed during the 24 hour, representative samples (2 per cent) in plastic bottles were stored in deep freezer. At the end of each

collection period the dung and urine samples were pooled, subsampled and analysed.

3.3.4.3 Digestibility coefficients

The digestibility of nutrients in the three rations were determined and the different concentrate mixtures were assessed based on the digestibility of the materials.

3.3.4.4 Nitrogen balance

Nitrogen balance of the animals on all rations were arrived at by subtracting the nitrogen output through faeces and urine from the nitrogen intake through feed.

3.3.5 Economics

From the cost of feed ingredients in each treatment the economics of incorporation of prawn waste in maintenance ration was studied.

3.3.6 Statistical analysis

The data was analysed statistically in a switch over design as described by Federer (1967).

Results

RESULTS

4.1 Chemical composition of prawn waste

The chemical composition of prawn waste procured from three main fish landing areas viz. Kochi, Kodungalloor and Kozhikode are presented in Table 4.

4.2 *In situ* degradability studies

The percentage disappearance of dry matter and crude protein at different time intervals in nylon bags in the rumen of fistulated cows with respect to prawn waste collected from peeling centers at Kochi, Kodungalloor and Kozhikode are setout in Tables 5 and 6 and depicted in Fig.1 and 2. The data on fractions A, B and C, degradation rate constant of B fraction and degradability of dry matter and crude protein are presented in Tables 7 and 8. The data on statistical analysis are given in Table 9 to 19.

4.3 Metabolism studies

The initial and final body weights of the experimental animals are given in Table 20. The chemical composition of the whole rations (concentrate mixture + paddy straw) are presented in Table 21. The digestibility coefficients of

various nutrients in the entire ration of animals on three treatments viz. T_1 (control), T_2 (10% prawn waste) and T_3 (20% prawn waste) and the summarised data are setout in Tables 22 to 25 and statistically analysed in Tables 26 to 30. The DCP and TDN intake of animals fed different rations are presented in Tables 31 to 33. The nitrogen balance of the animals fed various rations and their summarised data are given in Tables 34 to 37. The data on statistical analysis are presented in Table 38.

4.4 Economics of incorporation of prawn waste in cattle feed

The price per kg of the different concentrate mixtures for the three treatments viz., control, experimental I and experimental II are presented in Table 39.

Table 4. Chemical composition of prawn waste (percentage on DM basis)

Area of collection	Sample No.	Dry matter	Crude protein	Total ash	Acid insoluble ash	Acid detergent fibre	Calcium	Phosphorus
	1.	24.7	38.8	22.1	1.6	18.5	8.08	2.46
	2.	23.5	36.1	22.3	0.6	26.2	7.38	2.30
	3.	25.4	37.6	23.4	1.7	25.2	8.42	2.27
Kochi	4.	26.0	37.3	23.8	1.3	18.5	7.77	2.49
	5.	29.7	31.3	39.0	2.3	18.2	15.31	2.43
	6.	30.3	30.4	37.2	1.5	17.9	13.12	2.07
	7.	23.4	36.6	19.5	1.0	14.6	8.68	1.40
	8.	16.2	37.9	26.1	3.9	17.5	8.43	1.31
Kodungalloor	9.	19.3	37.8	25.4	3.4	14.7	9.04	1.54
	10.	18.1	36.7	27.6	4.3	14.2	9.78	1.62
	11.	19.1	39.8	23.8	0.7	17.1	10.33	1.44
	12.	14.8	42.7	19.9	2.2	16.1	6.89	1.56
	13.	21.1	41.3	20.2	2.1	16.3	7.29	1.22
	14.	20.0	40.8	19.6	2.3	15.8	7.02	1.02
Kozhikode	15.	17.7	40.6	19.3	1.9	16.0	7.33	1.05
	16.	19.4	38.9	23.4	1.6	16.3	9.00	1.58
	17.	23.2	34.6	24.2	5.8	15.1	9.86	1.51
	18.	22.1	38.2	22.7	3.1	15.8	6.57	1.66
Mean±SE		21.9± 1.01	37.6± 0.75	24.4± 1.30	2.3± 0.32	17.4± 0.77	8.91± 0.53	1.72± 0.12

Table 5. *In situ* degradability studies with prawn waste - percentage DM disappearance

Area of collection	Period of incubation (h)					
	0	3	6	9	12	24
Kochi	27.8± 0.80	33.1± 0.60	35.3± 0.72	35.8± 0.64	37.2± 0.78	40.1± 0.71
Kodungalloor	38.1± 1.36	44.1± 1.15	46.2± 1.13	47.1± 1.40	48.7± 1.30	52.2± 1.30
Kozhikode	31.9± 1.14	39.8± 0.68	42.8± 0.69	44.5± 0.62	46.1± 0.50	50.3± 0.50
Mean	32.6± 0.96	39.0± 0.95	41.4± 0.94	42.5± 0.99	44.0± 0.98	47.5± 1.03

Table 6. *In situ* degradability studies with prawn waste - percentage CP disappearance

Area of collection	Period of incubation (h)					
	0	3	6	9	12	24
Kochi	37.4± 1.00	43.8± 0.48	45.1± 0.93	45.4± 0.73	46.8± 0.91	51.9± 0.78
Kodungalloor	46.4± 2.20	52.2± 2.40	54.3± 2.30	55.1± 2.30	56.4± 2.00	62.0± 2.10
Kozhikode	42.3± 1.1	49.6± 0.51	53.0± 0.52	55.3± 0.64	56.9± 0.56	62.4± 0.65
Mean	42.0± 1.06	48.5± 1.00	50.8± 1.05	51.9± 1.12	53.7± 1.08	58.8± 1.12

Table 7. *In situ* degradability of prawn waste - dry matter[1]

Item	Area of collection		
	Kochi	Kodungalloor	Kozhikode
Dry matter fractions %			
Soluble A*	27.8 a	38.1 b	31.9 c
Degradable B*	12.3 a	14.1 a	18.2 b
Undegradable C**	59.9 a	47.8 b	48.9 b
Degradation rate constant Kdb (%/h)*	10.1 a	9.3 a	10.0 a
Degradability, %**	35.7 a	47.2 b	44.6 b

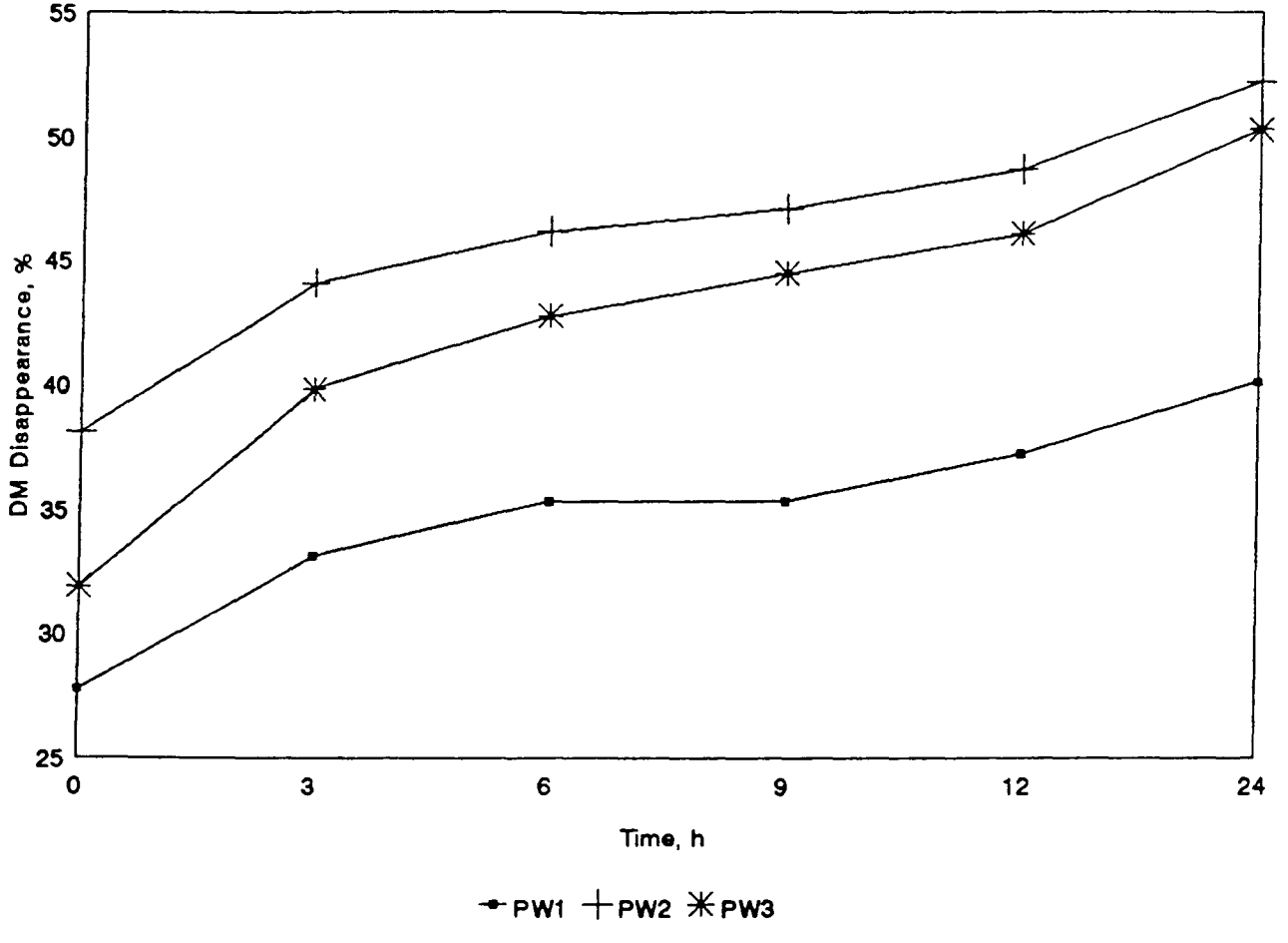
1 Least-squares mean

* Significant at 5% level

** Significant at 1% level

a,b,c Values in the same row with different superscripts differ

Fig.1 In situ dry matter degradability of prawn waste



PW1 - Prawn waste procured from Kochi
PW2 - Prawn waste procured from Kodungalloor
PW3 - Prawn waste procured from Kozhikode

Table 8. *In situ* degradability of prawn waste - crude protein[1]

Item	Area of collection		
	Kochi	Kodungalloor	Kozhikode
Crude protein fractions %			
Soluble A*	37.4 a	46.4 b	42.3 b
Degradable B*	14.5 a	15.6 a	20.1 b
Undegradable C**	48.1 a	38.0 b	37.6 b
Degradation rate constant Kdb (%/h)*	5.9 a	6.0 a	10.1 b
Degradability, %**	44.6 a	54.4 b	55.3 b
Escape**, %	55.4 a	45.6 b	44.7 b

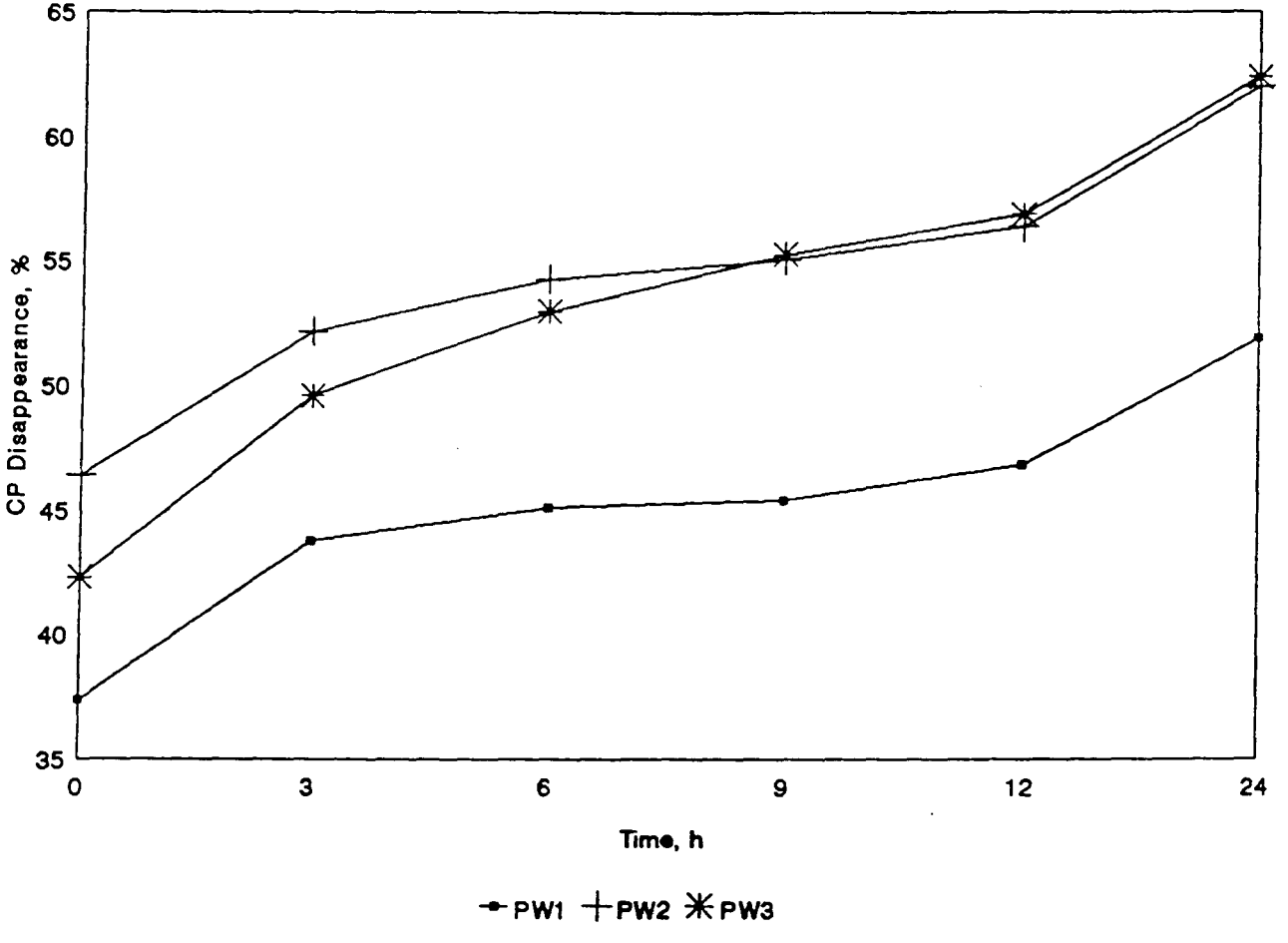
1 Least-squares mean

* Significant at 5% level

** Significant at 1% level

a,b,c Values in the same row with different superscrips differ

Fig.2 In situ crude protein degradability of prawn waste



PW1 - Prawn waste procured from Kochi
PW2 - Prawn waste procured from Kodungalloor
PW3 - Prawn waste procured from Kozhikode

Table 9. Analysis of variance - dry matter fraction A

Source	Degrees of freedom	Sum of squares	Mean sum of squares	F value
Between	2	670.495	335.248	21.752 **
Within	33	508.594	15.412	
Total	35	1179.090		

** Significant at 1% level

Table 10. Analysis of variance - dry matter fraction B

Source	Degrees of freedom	Sum of squares	Mean sum of squares	F value
Between	2	226.617	113.309	8.537 **
Within	33	437.999	13.273	
Total	35	664.616		

** Significant at 1% level

Table 11. Analysis of variance - dry matter fraction C

Source	Degrees of freedom	Sum of squares	Mean sum of squares	F value
Between	2	988.361	494.18	50.945 **
Within	33	320.109	9.700	
Total	35	1308.47		

** Significant at 1% level

Table 12. Analysis of variance - dry matter degradability rate constant, K_{db}

Source	Degrees of freedom	Sum of squares	Mean sum of squares	F value
Between	2	0.000	0.000	0.120 NS
Within	33	0.064	0.002	
Total	35	0.064		

NS - Not significant

Table 13. Analysis of variance - degradability of dry matter

Source	Degrees of freedom	Sum of squares	Mean sum of squares	F value
Between	2	866.573	433.287	39.865 **
Within	33	358.675	10.869	
Total	35	1225.248		

** Significant at 1% level

Table 14. Analysis of variance - crude protein fraction A

Source	Degrees of freedom	Sum of squares	Mean sum of squares	F value
Between	2	478.022	239.011	8.416 **
Within	33	937.168	28.399	
Total	35	1415.19		

** Significant at 1% level

Table 15. Analysis of variance - crude protein fraction B

Source	Degrees of freedom	Sum of squares	Mean sum of squares	F value
Between	2	216.242	108.121	5.810 **
Within	33	614.067	18.608	
Total	35	830.309		

** Significant at 1% level

Table 16. Analysis of variance - crude protein fraction C

Source	Degrees of freedom	Sum of squares	Mean sum of squares	F value
Between	2	842.354	421.177	18.638 **
Within	33	745.712	22.597	
Total	35	1588.066		

** Significant at 1% level

Table 17. Analysis of variance - crude protein degradability rate constant K_{db}

Source	Degrees of freedom	Sum of squares	Mean sum of squares	F value
Between	2	0.014	0.007	4.596 *
Within	33	0.050	0.002	
Total	35	0.064		

* Significant at 5% level

Table 18. Analysis of variance - crude protein degradability

Source	Degrees of freedom	Sum of squares	Mean sum of squares	F value
Between	2	849.164	424.582	21.372 **
Within	33	655.585	19.866	
Total	35	1504.749		

** Significant at 1% level

Table 19. Analysis of variance - escape protein

Source	Degrees of freedom	Sum of squares	Mean sum of squares	F value
Between	2	849.165	424.582	21.372 **
Within	33	655.585	19.866	
Total	35	1504.750		

** Significant at 1% level

Table 20. Body weights of experimental animals (kg)

Animal No.	Initial body weight	Final body weight
987	476	480
967	437	442
T140	384	399
934	379	392
935	389	398
927	474	486
Mean±SE	423±18.46	433±17.47

Table 21. Percentage chemical composition of rations (concentrate mixture + paddy straw) on DM basis

Type of ration	DM	CP	EE	CF	NFE	Total ash
Control (standard concentrate + paddy straw)	88.2± 0.02	8.6± 0.19	2.8± 0.07	23.6± 0.37	51.9± 0.22	13.1± 0.14
Experimental I [concentrate (10% pw) + paddy straw]	88.3± 0.12	8.4± 0.10	2.6± 0.08	23.3± 0.17	52.2± 0.25	13.5± 0.11
Experimental II [concentrate (20% pw) + paddy straw]	88.4± 0.12	8.6± 0.22	2.9± 0.05	23.3± 0.34	51.1± 0.16	14.1± 0.18

Table 22. Digestibility coefficients of nutrients in rations - T_1 - control

Animal No.	Dry matter	Crude protein	Ether extract	Crude fibre	Nitrogen free extract
987	54.56	52.80	46.91	66.07	63.69
967	52.91	52.85	50.35	66.03	64.50
935	56.76	57.16	67.53	62.28	61.19
927	54.66	58.16	74.67	59.88	57.72
T140	53.03	58.43	77.22	61.55	57.65
934	51.86	46.16	68.03	58.68	59.38
Mean±SE	53.96± 0.71	54.26± 1.19	64.12± 5.15	61.42± 1.07	60.09± 1.09

Table 23. Digestibility coefficients of nutrients in rations - T_2 - Experimental I (10% PW)

Animal No.	Dry matter	Crude protein	Ether extract	Crude fibre	Nitrogen free extract
987	55.59	56.81	71.18	63.89	59.23
967	49.68	54.62	65.31	52.13	57.77
935	52.35	46.97	69.52	60.62	60.13
927	61.64	49.35	79.57	66.06	65.93
T140	58.27	54.90	52.27	66.30	67.82
934	50.86	50.41	42.54	58.25	63.41
Mean±SE	54.73± 1.89	52.18± 1.56	63.4± 5.54	61.21± 2.22	62.38± 1.68

Table 24. Digestibility coefficients of nutrients in rations - T_3 - Experimental II (20% PW)

Animal No.	Dry matter	Crude protein	Ether extract	Crude fibre	Nitrogen free extract
987	51.55	48.41	69.12	63.09	58.92
967	58.62	58.07	70.64	69.48	61.87
935	55.83	48.53	61.04	66.93	65.72
927	53.03	52.09	53.96	64.45	64.22
T140	59.65	68.52	74.35	60.39	65.27
934	53.87	53.25	72.44	58.59	58.73
Mean±SE	55.81± 1.31	54.81± 3.10	66.92± 3.20	63.82± 1.65	62.45± 1.27

Table 25. Summarised data on digestibility coefficient of nutrients in whole ration of animals receiving various rations

Ration	Dry matter	Crude protein	Ether extract	Crude fibre	Nitrogen free extract
T_1 (control)	53.96± 0.71	54.26± 1.92	64.12± 5.15	61.42± 1.07	60.69± 1.09
T_2 (10% pw)	54.73± 1.89	52.18± 1.56	63.40± 5.54	61.21± 2.22	62.38± 1.68
T_3 (20% pw)	55.81± 1.31	54.81± 3.10	66.92± 3.20	63.82± 1.65	62.45± 1.27

Table 26. Analysis of variance - dry matter digestibility

Source	Degrees of freedom	Sum of squares	Mean sum of squares	F value
Between	2	2.31	1.15	0.01 NS
Period	2	2.14	1.07	
Sequence	2	18.07	9.04	
Error	11	1055.18	95.9	
Total	17	1077.7		

NS - Not significant

Table 27. Analysis of variance - crude protein digestibility

Source	Degrees of freedom	Sum of squares	Mean sum of squares	F value
Between	2	23.18	11.59	0.47 NS
Period	2	31.68	15.84	
Sequence	2	170.77	85.39	
Error	11	270.18	24.56	
Total	17	495.81		

NS - Not significant

Table 28. Analysis of variance - Ether extract digestibility

Source	Degrees of freedom	Sum of squares	Mean sum of squares	F value
Between	2	41.67	20.84	0.90 NS
Period	2	90.58	45.29	
Sequence	2	1679.55	839.78	
Error	11	254.50	23.14	
Total	17	2066.30		

NS - Not significant

Table 29. Analysis of variance - crude fibre digestibility

Source	Degrees of freedom	Sum of squares	Mean sum of squares	F value
Between	2	25.32	12.66	0.78 NS
Period	2	23.38	11.69	
Sequence	2	62.40	31.2	
Error	11	178.34	16.21	
Total	17	289.44		

NS - Not significant

Table 30. Analysis of variance - Nitrogen-free-extract digestibility

Source	Degrees of freedom	Sum of squares	Mean sum of squares	F value
Between	2	11.99	6.0	0.83 NS
Period	2	7.01	3.51	
Sequence	2	85.13	42.57	
Error	11	79.31	7.21	
Total	17	183.44		

NS - Not significant

Table 31. DCP and TDN intake per day by animals fed control ration (T_1)

Animal No.	DCP (kg)	TDN (kg)
987	0.267	3.42
967	0.267	3.36
T140	0.266	2.62
934	0.231	3.14
935	0.296	3.38
927	0.298	3.21
Mean±SE	0.271±0.01	3.19±0.12

Table 32. DCP and TDN intake per day by animals fed experimental ration containing 10% PW (T_2)

Animal No.	DCP (kg)	TDN (kg)
987	0.297	3.33
967	0.285	3.09
T140	0.251	3.12
934	0.245	3.27
935	0.241	3.27
927	0.251	3.52
Mean±SE	0.262±0.01	3.27±0.06

Table 33. DCP and TDN intake per day by animals fed experimental ration containing 20% PW (T_3)

Animal No.	DCP (kg)	TDN (kg)
987	0.252	3.26
967	0.302	3.50
T140	0.317	2.82
934	0.269	3.12
935	0.240	3.50
927	0.255	3.36
Mean±SE	0.273±0.01	3.26±0.11

Table 34. Nitrogen balance of animals fed control ration (T_1)

Item	Animal No.						Mean± SE
	987	967	T140	934	935	927	
N intake (g/d)	80	80	73	80	80	80	78.33±1.17
Excretion (g/d)							
Fecal	38	38	30	40	35	34	35.83±1.47
Urinary	34	26	20	24	18	16	23.00±2.67
Total	72	64	50	64	53	50	58.83±3.73
N balance (g/d)	08	16	23	16	27	30	20.00±3.34

Table 35. Nitrogen balance of animals fed experimental ration containing 10% pw (T_2)

Item	Animal No.						Mean± SE
	987	967	T140	934	935	927	
N intake (g/d)	80	80	73	78	80	80	78.50±1.15
Excretion (g/d)							
Fecal	36	38	33	39	43	41	38.33±1.45
Urinary	25	22	30	24	22	30	25.50±1.50
Total	61	60	63	63	65	71	63.83±1.60
N balance (g/d)	19	20	10	15	15	9	14.70±1.84

Table 36. Nitrogen balance of animals fed experimental ration containing 20% pw (T_3)

Item	Animal No.						Mean± SE
	987	967	T140	934	935	927	
N intake (g/d)	80	80	74	80	80	78	78.67±0.99
Excretion (g/d)							
Faecal	43	35	23	38	41	38	36.33±2.89
Urinary	26	25	19	19	21	33	23.83±2.20
Total	69	60	42	57	62	71	60.17±4.24
N balance (g/d)	11	20	32	23	18	7	18.50±3.62

Table 37. Summarised data on nitrogen balance of animals on different treatments

Item	Treatments		
	T_1	T_2	T_3
N intake (g/d)	78.83±1.17	78.50±1.15	78.67±0.99
Excretion (g/d)			
Faecal	35.83±1.47	38.33±1.45	36.33±2.89
Urinary	23.00±2.67	25.50±1.50	23.83±2.20
Total	58.83±3.73	63.83±1.60	60.17±4.24
N balance (g/d)	20.00±3.34	14.70±1.84	18.50±3.62

Table 38. Analysis of variance - Nitrogen balance

Source	Degrees of freedom	Sum of squares	Mean sum of squares	F value
Between	2	73.45	36.73	2.43 NS
Period	2	520.78	260.39	
Sequence	2	52.78	26.39	
Error	11	165.77	15.07	
Total	17	812.78		

NS - Not significant

Table 39. Cost of feed ingredients and concentrate mixtures (Rs.)

Ingredients	Cost/ 100 kg (Rs.)	Control	Experi-mental I (10% pw)	Experi-mental II (20% pw)
Yellow maize	609	115.71	237.51	292.32
Groundnut cake (expellar)	1234	222.12	222.12	185.10
Coconut cake (expellar)	987	98.70	98.70	98.70
Wheat bran	469	234.50	93.80	18.76
Prawn waste	100	-	10	20
Mineral mixture	2864	57.28	57.28	57.28
Salt	189	1.89	1.89	1.89
Vitamin mixture/kg	477.84	4.78	4.78	4.78
Paddy straw	249			
Total		734.98	726.08	678.83
Cost per kg		7.35	7.26	6.79

Discussion

DISCUSSION

5.1 Chemical composition of prawn waste

The prawn waste procured from different areas in Kerala state shows on an average 21.9 per cent dry matter 37.6 per cent crude protein, 24.4 per cent total ash 17.4 per cent acid detergent fibre, 8.9 per cent calcium and 1.72 per cent phosphorus (Table 4). The chemical composition of the prawn waste from different localities exhibited minor differences. The waste from peeling centres at Kochi contained more of dry matter; total ash; acid detergent fibre; calcium and phosphorus and less of crude protein in comparison with the other two areas of collection. It is understood that the peeling centres at Kochi, over and above the local catch also cater to that from other states, viz., Andhra Pradesh and Orissa, through Kochi harbour, which is usually beheaded before transportation. Thus the waste available at Kochi includes higher proportion of shell and less of head than the waste from other two localities from where prawn waste samples were procured for analyses. This may be the main reason for differences in chemical composition observed among samples.

Out of a total of 49 samples of sea food/wastes analysed for proximate composition in the Department of Nutrition (Anon, 1992), fresh prawn waste contained 18.2; 41.8; 29.0;

11.65 and 1.92 per cent dry matter; crude protein; total ash; Ca and P respectively. Survey of literature on chemical composition of prawn waste (Meyers, 1973; Menachery *et al.*, 1978; Anon, 1988; Mathew *et al.*, 1989; Fox *et al.*, 1994) revealed that the changes in nutrient content are mainly as a result of the extent of head, shell and appendages in the waste. It may also vary because of differences in size, species (Naran, Poovalan, Karikady, Tiger, etc.), pattern of processing and the drying procedure. Sun drying of prawn waste on sea shore resulted in higher acid insoluble ash due to contamination with sand and lower crude protein because of invasion by ants and ants eating up the meat portion in the waste. Consequently the oven-dried sample is better in nutrient composition than the sun dried waste (Menachery, 1978; Anon, 1988). The crude protein values obtained in the present study are comparable with the previous work carried out in the Department of Nutrition with oven-dried prawn waste (Anon, 1992; James, 1993).

The acid detergent fibre content in the prawn waste represents the chitin fraction and it amounts to 17.4 per cent. The chitin nitrogen in the crude protein overestimates the true protein content of crustacean meals (Rutledge, 1971). The high calcium carbonate content may possibly act as a good buffer in ruminant diet (Nicholson *et al.*, 1996).

The oven dried prawn waste is a potential source of supplementary protein and essential minerals to livestock.

5.2 *In situ* degradability studies

The percentage dry matter disappearance of prawn waste at various time intervals of incubation in rumen viz. 0, 3, 6, 9, 12 and 24 h are 32.6, 39.0, 41.4, 42.5, 44.0 and 47.5 respectively while the crude protein disappearance at the above periods were 42.0, 48.5, 50.8, 51.9, 53.7 and 58.8 per cent respectively (Tables 5 and 6). The data on the fractions, A, B and C of dry matter and crude protein (Table 7 and 8) show a high soluble fraction A for dry matter (27.8 to 31.9%) and crude protein (37.4 to 46.4%). The degradation rate constant ranged from 9 to 10 per cent per hour for dry matter and 6 to 10 per cent per hour for crude protein. The dry matter degradability of various samples ranged from 35 to 45 per cent and the crude protein degradability from 44 to 56 per cent.

Prawn waste collected from Kochi area (PW_1) had a lower ($P<0.01$) dry matter degradability than those collected from Kodungalloor (PW_2) and Kozhikode (PW_3). The soluble fraction A was highest ($P<0.05$) for PW_2 (38.1%) which was higher ($P<0.05$) than PW_3 (31.9%) and PW_1 (27.8%). The degradable fraction B for PW_3 was higher ($P<0.05$) than PW_1 and PW_2. The

undegradable fraction C was highest for PW_1 (59.8%) which was higher ($P<0.01$) than PW_2 (47.6%) and PW_3 (48.9%). The degradation rate constants (Kdb) of the three samples did not show any significant variation ($P<0.05$).

The degradability of crude protein of prawn waste followed a similar trend. The crude protein degradability of PW_1 was lower ($P<0.01$) than those for PW_2 and PW_3. The soluble fraction was lower ($P<0.05$) for PW_1 (37.4%) than PW_2 (46.4%) and PW_3 (42.3%). PW_3 had higher ($P<0.05$) degradable fraction (20.1%) than PW_1 (14.5%) and PW_2 (15.6%). Undegradable fraction was highest for PW_1 (48.1%) which was higher ($P<0.01$) than PW_2 (38.0%) and PW_3 (37.6%). The degradable crude protein fraction was degraded at a much rapid rate ($P<0.05$) for PW_3 (10.1%/h) than for PW_1 (5.9%/h) and PW_2 (6.0%/h). The crude protein degradability was lower ($P<0.01$) for PW_1 (44.6%) when compared with PW_2 (54.4%) and PW_3 (55.3%). Escape protein followed a similar trend with PW_1 having higher ($P<0.01$) escape potential (55.4%) than PW_2 (45.6%) and PW_3 (44.7%).

The results of the *in situ* studies do not agree with those reported by Patton and Chandler (1975) who had observed that the percentage dry matter disappearance of shrimp meal at 12, 24, 36, 48 and 60 h were 11.9, 15.5, 20.4, 21.6 and 22.3 per cent respectively with an average dry matter degradability of 17.5 per cent. They had also reported that the average

crude protein solubility of shrimp waste protein was 27.5 per cent. The results of this study do not agree with the degradabilities reported for similar crustacean wastes by Velez *et al.* (1991) and Nicholson *et al.* (1996). Velez *et al.* (1991) observed a lower degradability of dry matter and crude protein (18.3% and 34.9% respectively) while Nicholson *et al.* (1996) recorded less than 18 per cent crab waste protein disappearance from nylon bags suspended in the rumen of cattle for 24 h. Madsen and Hvelplund (1994) found considerable variation in *in situ* degradability of feed between laboratories which may be attributed to the bag type, pore size, sample preparation and processing. The results in the present study are comparable with the dry matter and crude protein degradabilities reported for crab meal (29.1% and 48.4% respectively) by Viswanathan (1995) in cattle.

The zero hour losses denote the rapidly soluble dry matter or crude protein fractions. The high zero hour losses obtained in this study may be partly attributed to the considerable differences in mean particle size between feed ground through the same sized screen (Mechalet-Doreau and Cerneau, 1991).

The rate of degradation of dry matter and crude protein of prawn waste (9-10%/h and 6-10%/h) are much higher than those reported by Velez *et al.* (1991) (0.57%/h and 0.79%/h)

and Viswanathan (1995) (5%/h and 5.2%/h). The differences observed might be explained by the differences in the ruminal environment due to the diet variation or due to the difference in procedures.

Ruminal dry matter degradability of prawn waste was lower (35 to 45%) when compared to that of crude protein (45 to 56%). A similar trend was observed by Velez *et al.* (1991) and Viswanathan (1995) for crab meal. The low degradability of dry matter relative to crude protein might be due to the high level of ash which may be poorly soluble in the rumen.

The difference in degradabilities of dry matter and crude protein between prawn waste samples collected from various areas may be explained by the differences in sample type and the proportion of shell and head in the sample. Samples collected from Kochi had a higher shell content as denoted by their lower crude protein and higher acid detergent fibre and ash contents, consequently degraded to a lesser extent.

The high escape potential (45-55%) of prawn waste coupled with relatively high crude protein digestibility by sheep (Nicholson *et al.*, 1996) suggest it as a good source of digestible undegradable protein (DUP).

5.3 Metabolism studies

The digestible nutrients in the whole ration was calculated. There were slight changes in the intake of paddy straw by the animals. The chemical composition of the whole rations (Table 21) were almost similar.

5.3.1 Feed intake

The experimental animals consumed the prawn waste incorporated concentrate mixtures readily indicating that prawn waste at 10 or 20 per cent levels in the feed did not affect the palatability of the feed. No problem regarding palatability of prawn waste silage was observed in the previous trials conducted in the Department of Nutrition, College of Veterinary and Animal Sciences, Mannuthy. The average daily intake of prawn waste-rice bran silage by adult cattle was 1.75 kg (Ramachandran *et al.*, in press) and prawn waste-paddy straw silage was 1.67 kg (James, 1993) per 100 kg body weight. However, a decrease in dry matter intake in cattle was observed when crab meal incorporated rations were fed (Velez *et al.*, 1991; Nicholson *et al.*, 1996).

5.3.2 Digestibility of nutrients

The digestibility coefficients for dry matter, crude protein, ether extract, crude fibre and nitrogen free extract

in the treatments T_1 (control), T_2 (10% PW) and T_3 (20% PW) were in the range of 53 to 56, 52 to 55, 63 to 67, 61 to 64 and 60 to 63 per cent respectively. The digestibilities of various nutrients dry matter, crude protein, ether extract, crude fibre and nitrogen free extract were more or less similar (Table 25), the differences among rations being marginal and statistically not significant ($P<0.05$) (Tables 26 to 30). The three concentrate mixtures were formulated as per BIS specifications. There is numerical improvement in the digestibilities of various nutrients in T_3 (20% PW) either due to better nutrient combination or due to a better digestible nutrients obtained in the present study for prawn waste than expected, which became more evident when higher proportions of prawn waste were included in the feed.

Similar experiments with fermentation products of prawn waste had been carried out in the Department of Nutrition. James (1993) carried out digestion trials in adult non-producing cattle at three steps; viz., basal hay ration, basal hay + paddy straw and basal hay + paddy straw + prawn waste - paddy straw silage. He reported almost identical values for prawn waste - paddy straw silage viz., dry matter (54.48), crude protein (51.36) and nitrogen free extract (65.62) and better digestibilities for ether extract (75.29) and crude fibre (73.14) than those obtained for the present study. Rations constituted with prawn waste - rice bran silage and

paddy straw had similar digestibility coefficients for DM (52.48) and crude fibre (65.59) while that of ether extract was better (84.01) and nitrogen free extract lower (46.7) than those obtained in the present study (Ramachandran *et al.*, in press). By difference method prawn waste-rice bran silage was found to contain digestibile dry matter, crude protein, ether extract, crude fibre and nitrogen free extract to the extent of 61.66, 80.55, 91.41, 77.78 and 36.83 per cent respectively.

Another crustacean waste, crab meal, was found to decrease DM digestibility when incorporated in diets of cattle (Velez *et al.*, 1991; Nicholson *et al.*, 1996). However, Viswanathan (1995) obtained comparable DM and organic matter digestibilities for crab meal and other protein supplemented diets in cattle. A lower crude protein digestibility for crab meal incorporated diet was reported by Velez *et al.* (1991) whereas Viswanathan (1995) and Nicholson *et al.* (1996) found no significant difference in crude protein and acid detergent fibre digestibilities when crab meal was included in the rations.

5.3.3 Nutritive value

The daily intake of digestible crude protein (DCP) and total digestible nutrient (TDN) by animals in the three treatments T_1 (control), T_2 (10% PW) and T_3 (20% PW) were 0.271, 0.262 and 0.273 kg and 3.19, 3.27 and 3.26 kg

respectively. Throughout the period of study the animals were receiving protein and energy as per recommendations (Ranjhan, 1991). The DCP and TDN content of T_1, T_2 and T_3 were 4.7, 4.38 and 4.71 and 54.7, 54.9 and 53.4 per cent respectively. All the animals gained body weight during the experimental period of 10 weeks indicating the suitability of all the three rations for maintenance of adult cattle. No adverse effect was noted when dried prawn waste was incorporated in the concentrate mixtures of adult cattle.

Digestion trials in adult non-producing cattle with the fermentation products viz., prawn waste-rice bran silage (Ramachandran *et al.*, in press) and prawn waste-paddy straw silage (James, 1993) recorded 13.9 and 71.0 and 7.4 and 56.6 per cent for DCP and TDN respectively.

5.3.4 Nitrogen balance

The animals on different rations viz. T_1 (control), T_2 (10% PW) and T_3 (20% PW) were on positive nitrogen balance, the average daily retention was 20, 14.7, and 18.5 g respectively. There was no significant difference ($P<0.05$) in nitrogen retention by animals fed different rations. All animals gained weight as evident from Table 20. Viswanathan (1995) had observed that lambs fed crab meal incorporated rations gained weight and retained about 0.95 g nitrogen/day.

5.4 Economics of incorporation of prawn waste in concentrate mixtures

The cost per kg of the various concentrate mixtures viz. control, experimental I (10% PW) and experimental II (20% PW) were Rs.7.35, Rs.7.26 and Rs.6.79 respectively (Table 39) indicating a saving of Rs.56/100 kg on incorporation of prawn waste at 20 per cent level in concentrate mixtures for cattle.

From the above results it can be concluded that prawn waste can be safely and economically incorporated in the concentrate mixtures for adult cattle upto 20 per cent level.

Summary

SUMMARY

An investigation was carried out in the Department of Nutrition, College of Veterinary and Animal Sciences, Mannuthy to evaluate prawn waste as an ingredient in cattle feed. The suitability of prawn waste was assessed in three steps viz., chemical analysis of dried prawn waste from different localities, *in situ* rumen degradability of the waste and metabolism trials with prawn waste incorporated rations using adult, non-producing cattle. The economics of incorporation of prawn waste in cattle feed was also assessed.

Chemical analysis of prawn waste procured from different localities revealed on an average 21.9, 37.6, 24.4, 17.4, 8.91 and 1.72 per cent dry matter, crude protein, total ash, acid detergent fibre, calcium and phosphorus respectively. The waste from peeling centres at Kochi contained more of dry matter, total ash, acid detergent fibre, calcium and phosphorus and less of crude protein. The differences in the nutrient content of the waste from the different localities are attributed to the variations in the proportions of head, shell and appendages in the wastes.

The percentage dry matter disappearance of prawn waste in rumen at 0, 3, 6, 9, 12 and 24 h of incubation were 32.6, 39.0, 41.4, 42.5, 44.0 and 47.5 respectively whereas crude

protein disappearance at various periods of incubation were 42.0, 48.5, 50.8, 51.9, 53.7 and 58.8 per cent respectively. Prawn waste collected from Kochi area recorded significantly lower ($P<0.01$) dry matter and crude protein degradabilities than those from the other two localities.

Prawn waste when incorporated at 10 or 20 per cent levels in the feed did not affect the palatability of the feed. The digestibility coefficients of dry matter, crude protein, ether extract, crude fibre and nitrogen free extract calculated for animals fed three rations viz., T_1 (control), T_2 (10% prawn waste) and T_3 (20 per cent prawn waste) were in the range of 53 to 56, 52 to 55, 63 to 67, 61 to 64 and 60 to 63 per cent respectively. The numerical improvement in digestibilities of various nutrients observed in T_3 over the other two treatments viz., T_1 and T_2 was not significant ($P<0.05$). The animals under the three treatments maintained positive nitrogen balance, the nitrogen retention being 20, 14.7 and 18.5 g per day for T_1, T_2 and T_3 respectively. The difference between the three treatments in this regard was not significant ($P<0.05$).

The cost per kg of the various concentrate mixtures viz., control, experimental I (10% prawn waste) and experimental II (20% prawn waste) were Rs.7.35, Rs.7.26 and Rs.6.72 respectively indicating a saving of Rs.56/100 kg for ration containing prawn waste at 20 per cent levels.

It can be concluded that prawn waste is a valuable source of protein and minerals and can be safely and economically incorporated upto 20 per cent level in the concentrate mixtures for adult non-producing cattle.

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* Originals are not seen

NUTRITIVE EVALUATION OF PRAWN WASTE AS CATTLE FEED

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ABSTRACT OF A THESIS

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ABSTRACT

Prawn waste collected from three major fish landing areas viz., Kochi, Kodungalloor and Kozhikode contained on an average 21.9 per cent dry matter, 37.6 per cent crude protein, 24.4 per cent total ash, 17.4 per cent acid detergent fibre, 8.91 per cent calcium and 1.72 per cent phosphorus. Prawn waste procured from Kochi area had higher dry matter, total ash, acid detergent fibre, calcium and phosphorus and less of crude protein. The results of *in situ* degradability studies carried out in three rumen fistulated cows indicated that the dry matter and crude protein degradabilities of prawn waste ranged from 35 to 45 and 44 to 56 per cent respectively. Prawn waste from Kochi area had lower ($P<0.01$) dry matter and crude protein degradabilities than the other two areas. Metabolism trials conducted in adult, non-producing cattle using standard concentrate mixtures containing 0, 10 or 20 per cent prawn waste registered in the ration digestibility coefficients to the extent of 53 to 56, 52 to 55, 63 to 67, 61 to 64 and 60 to 63 per cent for dry matter, crude protein, ether extract, crude fibre and nitrogen free extract respectively. There was no significant difference ($P<0.05$) in the digestibilities of nutrients in the three treatments. The animals on all the rations were on positive nitrogen balance. It is inferred that prawn waste can be safely and economically incorporated upto 20 per cent level in the concentrate mixtures of adult non-producing cattle.