UTILISATION OF PALM PRESS FIBRE, AN IMPORTANT BY-PRODUCT OF OIL PALM INDUSTRY AS AN ALTERNATIVE ROUGHAGE SOURCE FOR BUFFALOES THROUGH UREA-AMMONIATION TREATMENT

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CERTIFICATE

Mr. J. SYAMA DAYAL, has satisfactorily prosecuted the course of research and that the thesis entitled, **"UTILISATION OF PALM PRESS FIBRE, AN IMPORTANT BY-PRODUCT OF OIL PALM INDUSTRY AS AN ALTERNATIVE ROUGHAGE SOURCE FOR BUFFALOES THROUGH UREA-AMMONIATION TREATMENT"** submitted, is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part thereof has not been previously submitted by him for a degree of any other University.

DATE: Dec 31, '97

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CERTIFICATE

This is to certify that the thesis entitled "**UTILISATION OF PALM PRESS FIBRE, AN IMPORTANT BY-PRODUCT OF OIL PALM INDUSTRY AS AN ALTERNATIVE ROUGHAGE SOURCE FOR BUFFALOES THROUGH UREA-AMMONIATION TREATMENT**" submitted in partial fulfilment of the requirements for the degree of **DOCTOR OF PHILOSOPHY** in Veterinary Science of the Acharya N.G. Ranga Agricultural University, Hyderabad is a record of the bonafide research work carried out by **Mr. J.SYAMA DAYAL** under my guidance and supervision. The subject of the thesis has been approved by the student's Advisory Committee.

No part of the thesis has been submitted by the student for any degree or diploma. The published part has been fully acknowledged. All assistance and help received during the course of the investigations have been duly acknowledged by the author of the thesis.

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I, **J. SYAMA DAYAL**, hereby declare that the thesis entitled **"UTILISATION OF PALM PRESS FIBRE, AN IMPORTANT BY-PRODUCT OF OIL PALM INDUSTRY AS AN ALTERNATIVE ROUGHAGE SOURCE FOR BUFFALOES THROUGH UREA-AMMONIATION TREATMENT"**, submitted to the Acharya N.G. Ranga Agricultural University for the award of degree of **DOCTOR OF PHILOSOPHY**, is a result of the original research work done by me. I also declare that the thesis or part thereof has not been published earlier elsewhere in any manner.

Date: 31st December, 1997.

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(SYAMA DAYAL J)

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(SYAMA DAYAL J)

LIST OF ABBREVIATIONS

ADF	:	Acid detergent fibre
ADL	:	Acid detergent lignin
CF	:	Crude fibre
CP	:	Crude protein
DCP	:	Digestible crude protein
DE	:	Digestible energy
DM	:	Dry matter
DMB	:	Dry matter basis
DMD	:	Dry matter digestibility
DMI	:	Dry matter intake
EDDM	:	Effective degradable dry matter
EDP	:	Effective degradable protein
EE	:	Ether extract
EFB	:	Empty fruit bunches
g	:	grams
hr	:	hour
IVDMD	:	*In vitro* dry matter digestibility/disappearance
IVNDFD	:	*In vitro* neutral detergent fibre digestibility
IVOMD	:	*In vitro* organic matter digestibility
kg	:	kilogram(s)
kg $W^{0.75}$	:	Metabolic body size

contd..

L	:	litre
M.cal	:	Mega calories
ME	:	Metabolizable energy
MJ	:	Mega Joules
m t	:	million tonnes
N	:	Nitrogen
NPN	:	Non protein nitrogen
OM	:	Organic matter
PKC	:	Palm kernel cake
POME	:	Palm oil mill effluent
POS	:	Palm oil sludge
PPF	:	Palm press fibre
TDN	:	Total digestible nutrients
Urea-N	:	Urea nitrogen

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ABSTRACT

Palm Press Fibre (PPF) which is an important agro-industrial by-product of oil palm industry has been evaluated to explore its potential feeding value as a replacement for conventional roughage sources. Standard conditions for urea-ammoniation technique were established and optimum level of feeding treated PPF in the buffalo rations was determined.

On DM basis PPF contained 8.02% CP, 9.04% EF, 41.12% CF, 32.22% NFE and 9.60% total ash. Fractionation of cell wall constituents revealed 72.48% NDF, 53.09% ADF, 19.39% hemicellulose, 33.64% cellulose and 18.46% lignin. The IVDMD and EDDM values of PPF were 26.90 and 25.32%, respectively. Ammoniation was attempted through urea treatment at 3,4, and 5% urea concentrations at moisture levels of 30, 40 and 50% and incubation periods of 10, 20 and 30 days. Laboratory scale ammoniation of PPF through urea treatment at 4% urea concentration at 40% moisture level of 20 days increased the CP, IVDMD, *in sacco* DM disappearance and EDDM values from 8.02, 26.90, 33.98 and 25.32% to 16.82, 44.85, 43.12 and 38.5%, respectively as compared to untreated PPF. Results of chemical, *in vitro* and *in sacco* evaluation studies have indicated that 4% urea treatment at 40% moisture for 20 days was found to be optimum for effective ammoniation of PPF.

Nine complete rations were formulated replacing paddy straw with untreated or urea treated PPF at a gradient of 25%. Positive effects of inclusion of treated PPF in the rations of buffaloes were reflected with increased *in vitro* and *in sacco* DMD and EDDM values with increased level of its inclusion. There was depression in DMD as the level of untreated PPF inclusion increased.

In vivo evaluation studies indicated that DCP and TDN values of untreated and urea treated PPF were 3.7, 42.3 and 8.8 and 52.7%, respectively as determined by differential technique with buffalo bull calves. The effect of urea treatment and subsequent effect of inclusion of PPF to replace paddy straw in the rations of buffaloes was studied in a 4 x 4 latin square designed metabolism trial using four buffalo bull calves. The calves were fed rations containing paddy straw plus concentrate mixture (R_1), untreated PPF plus concentrate mixture (R_2), paddy straw, urea treated PPF plus concentrate mixture (R_3) and urea treated PPF plus concentrate mixture (R_4). The digestibilities of DM, CP, NDF, ADF, hemicellulose and cellulose increased by 6.84, 10.08, 8.58, 2.94 and 6.64 percentage units when urea treated PPF served as a sole roughage source replacing paddy straw in the rations of buffaloes. N balance data revealed that the N intake through roughage source proportionately increased in calves fed R_4 at the cost of N intake from concentrate component with decreased dependence on lower input of concentrate mixture. The DCP and TDN values were 7.60, 55.60; 6.96, 60.13; 9.4, 66.67 and 10.43, 60.5% in calves fed R_1 to R_4, respectively. Urea treatment increased the DCP and TDN intake by 2.75 and 4.45 percentage units, respectively as compared to paddy straw based ration (R_1).

The results of the present study revealed that palm press fibre appeared to be a potential roughage source for buffaloes. Urea concentration of 4%, moisture content of 40% and incubation period of 20 days were found to be optimum for improving the nutritional status of PPF with an improvement of 5.1 DCP and 10.4 TDN percentage units over that of untreated PPF. Based on the overall evaluation criteria, by feeding urea treated PPF at standard conditions it is possible to replace paddy straw at 100% level in the conventional rations of buffaloes with a 90% saving on concentrate investment.

INTRODUCTION

CHAPTER I

INTRODUCTION

Increased growth rate of livestock population in association with decreased land availability for fodder production led to quantitative and qualitative shortage of feed and fodder resources for livestock feeding in India. Current requirements of nutrients were estimated to be 40.9 mt of digestible crude protein (DCP) and 454.8 mt of total digestible nutrients (TDN) against the availability of 22.01 mt of DCP and 253.9 mt of TDN (Mudgal and Pradhan, 1988). The gap between the availability and requirement of DCP and TDN ranged to an extent of 46.2 and 44.2%, respectively. The availability of cereal straws in India is about 311.10 mt providing only 1.44 and 109.22 mt of DCP and TDN, respectively (Jain et al. 1996). Hence, there is a need to tap new agro-industrial by-product to narrow down the existing gap. One such emerging agro-industrial by-products is palm press fibre (PPF) which has recently been identified with the introduction of oil palm cultivation on commercial scale in the coastal belt of Southern India.

The Technology Mission on oil seeds was started in 1986 with an aim to increase the production of oil seeds in India. Oil palm cultivation is being encouraged and the area under its cultivation is fast expanding in the recent past. It is essential to explore the possibility of effective utilisation of oil palm by-products as an alternate feed resource for ruminant livestock in areas where intensive oil palm cultivation is being taken-up. Development of viable feeding system based on oil palm by-products will also reduce the pollution problems in the vicinity of oil extraction plants.

In Andhra Pradesh state alone 4 lakh ha. of coastal belt has been identified to be ideal to take up oil palm cultivation. As estimated by Raghava Rao and Krishna (1997) in addition to oil, about 4.59, 8.26 and 6.86 mt of palm press fibre (PPF), palm oil sludge (POS) and palm kernel cake (PKC), respectively will be available for livestock feeding in the near future.

Potential of PKC as a substitute for conventional energy and protein sources has been fully explored and optimum levels of inclusion in ruminant rations were fixed (Vasanthalakshmi and Krishna, 1995 a,b). PPF is the fibrous residue of pericarp after separation of nut from fresh fruit bunch. Due to the introduction of high grain yielding and dwarf varieties of paddy, as well as diversion of paddy straw for industrial uses, livestock is likely to face shortage of dry fodder in paddy growing areas in future. Hence, there is a greater need to exploit PPF as an alternate roughage source to substitute paddy straw to reduce pressure on conventional cereal straws.

As reported by Malaysian workers, PPF has been included in ruminant rations at levels ranging from 10-40% with varying results in different ruminant species (Devendra and Muthurajah, 1976). It is evident that no systematic studies have been carried out in India to determine the optimum level of its inclusion in ruminant rations. In view of its low CP and high fibre level there is a need for enrichment of this poor quality roughage to improve its nutritive value. Urea-ammoniation technique has been proved to be the most practicable method of enrichment of cereal straws under tropical conditions. Hence, there is an urgent need to find out the scope of using the urea- ammoniation technique and to standardise the treatment for its nutritional upgradation.

In India about 55% of milk production is contributed by buffaloes (Mudgal and Pradhan, 1988). Buffaloes have been found to utilise coarse roughages quite efficiently in comparison to other ruminant species and buffalo being the most widely reared animal in coastal belt of Andhra Pradesh, it is proposed to undertake the research studies on PPF in buffaloes.

With the back ground information available on hand it is proposed to take up studies to improve the feeding value of PPF keeping the following objectives in view.

1. To determine the nutritional quality of palm press fibre (PPF) through chemical, *in vitro* and *in sacco* evaluation techniques.

2. To standardize the urea-ammoniation technique to improve the nutritive value of sun dried PPF in terms of optimum levels of urea concentration, moisture and period of incubation:

3. To study the effect of urea treatment on the nutritive value of PPF in buffaloes and

4. To determine the effective level of incorporation of PPF in the ration of buffaloes based on the overall evaluation criteria.

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

2.1 AVAILABILITY OF OIL PALM BY-PRODUCTS

Oil palm fruit yields a number of by-products of potential importance for live stock feeding besides the oil. These include palm press fibre (PPF), palm oil sludge (POS) and palm Kernel cake (PKC). PPF is the fibrous residue of the pericarp after separation of the nut and crude oil and PKC is a solid residue left behind after the extraction of oil from the kernel of the palm fruits (Mustaffa Babjee, 1988[a]). POS is the oily waste material (or) sludge separated out of these by-products in terms of their current utilization as feed.

The detailed programme for oil palm cultivation reflecting its current status at global, national and state level is presented in Table 1, 2 and 3, respectively (Indian oil palm Journal, 1996).

Quantities of principal and by-products available from oil palm were estimated by Devendra (1977). Fresh fruit bunches (FFB) on an average yield 55-58% bunch trash, 12% palm press fibre, 18- 20% palm oil, 2% palm oil sludge and 4-5% palm kernel. Palm nut shells constitute 8% of the total weight of the bunch. Palm kernel oil and PKC contribute to 45-46% of the total palm kernels.

As reported by Mustaffa Babjee 1988a nuts constitute 67% of palm fruit while kernel forms about 4% of nuts and kernel meal about 2.0 to 2.2% of palm kernels.

Table 1: Area under oii palm cultivation in the world

Country	1000 ha
Cameron	42.0
Ghana	31.0
Ivory coast	135.0
Nigeria	285.0
Zaire	77.0
Castarica	21.0
Henduras	30.0
Brazil	37.0
Colombia	90.0
Ecuador	55.0
Peru	9.0
Indonesia	715.0
Malaysia	1713.0
Phillippines	26.0
Thailand	104.0
Soloman Island	6.0
Papua	0.4
Others	107.0
Total area	3525.0

Source: Indian oil palm Journal (1992).

Table 2: Progress of oil palm cultivation in India

State	Target upto 1995-96 (ha)	Approximate level of achievement upto Sept'96 (ha)
Andhra Pradesh	35200	15743
Karnataka	16500	6473
Tamilnadu	6000	4000
Gujarath	2600	300
Goa	900	570
Tripura	400	72
Orissa	700	360
Assam	300	360
Total area	62900	27878

Source:Indian oil palm Journal (1996).

Table 3: Area under oil palm cultivation in Andhra Pradesh

Organised firms	Area Planted (ha)
Palm Tech India Ltd.	4082
Godrej Soaps Ltd.	2045
Mac industries Ltd	1846
Nava Bharat Enterprises Ltd.	1984
A.P. Co-op oil seeds Growers Federation	1293
Foods, fats and fertilizers Ltd	897
Duncans Bio-Tech Ltd.	467
Radhika Veg-oils Ltd.	574
Godavari Perennial oil Ltd.	140
Vikki agro Tech Ltd.	130
S & S Industries	115
Environ Extractions Ltd.	103
Simha puri Agro Products Ltd.	111
Dept. of Horticulture	1956
Total area	15743

Source: Indian Oil Palm Journal (1996).

2.2 CHEMICAL COMPOSITION AND NUTRITIVE VALUE

Palm kernel cake was reported to contain 90.6% DM, 19.0% CP, 16.0% CF, 2.0% EE, 4.2% ash, 58.8% NFE, 0.34% calcium, 0.69% phosphorus and 0.16% magnesium. PKC was reported to have a gross energy value of 17.3 MJ/Kg DM (Devendra 1977). It was further reported to contain 88.18% DM, 14.80% CP, 1.28% EE, 33.20% CF, 41.72% NFE, and 9.00% ash (Vasantha Lakshmi and Krishna, 1995). It has been reported that palm oil sludge had 90.3% DM, 9.6% CP, 11.5% CF, 21.3% EE, 11.1% ash, 46.5% NFE, 0.28% calcium, 0.26% phosphorus and 0.25% magnesium with a gross energy value of 18.7 MJ/Kg DM. Palm press fibre had 86.2% DM, 4.0% CP, 36.4% CF, 21.0% EE, 9.0% ash, 29.6% NFE, 0.3% calcium, 0.1% phosphorus and 0.5% magnesium with gross energy value of 18.1 MJ/Kg DM (Devendra, 1977).

2.3 PALM BY-PRODUCTS AS LIVE STOCK FEED

Palm oil has been used in the diet of both non-ruminants and ruminants as an energy source. Palm oil was added at 2 to 6% level in the diets of pigs and poultry, depending on the stage of development and productivity.

As reported by Hutagalung *et al* (1975) that palm oil wastes pose a potential disposal problem of 4 mt of liquid effluent out of which about 2 mt is being drained into water courses in Malaysia. By improved processing techniques like centrifugal solids recovery (CENSOR) a good amount of it is being used as animal feed in Malaysia. Muthurajah and Devendra (1975) reviewed the nature of palm oil waste materials of nutritional value that could be converted into salable products for inclusion in animal feed industry. By using tapioca meal, palm kernel, grass meal and dried poultry manure meal as adsorbent for the waste sludge, Webb *et al* (1975) produced an acceptable animal feed with a potential market value worth about M$ 200/tonne.

Devendra and Muthurajah (1976) reported the effect of inclusion of palm press fibre at levels varying from 10 to 60% on the ration digestibility in sheep. The digestibility of dry matter was highest with 10% inclusion of PPF. Significant treatment differences were reported in the digestibilities of DM, OM, CP, EE, and NFE with no significant difference in the CF digestibility when 6 and 8% levels of PPF were used along with calcium hydroxide.

As reported by Webb *et al* (1975) liquid waste can be converted into a valuable animal feed which would substitute for maize. Fermentation by an anaerobic process could improve utilization of materials, improve the end product quality and reduce input costs. Feeding trials demonstrated that palm oil sludge recovered by the centrifugal solids recovery (CENSOR) process could be used as animal feed. Performance and carcass characteristics of pigs and poultry fed CENSOR supplemented diets compared favourably to those fed conventional diets with improvement in the nutritive value of palm oil sludge, particularly in the reduction of ash and fibre content with increased protein level.

Devendra (1977) studied the oil palm by-products and determined the extraction rates of each. Projected availability, chemical composition, together with fatty acid composition of palm oil and amino acid profiles of POS and PKC were also tabulated. The biological value of PKC was calculated to be 61- 80. Assessment of nutritive value of PPF, POS and POS + PPF was carried out in balance trials with sheep by feeding at 10 to 60% level of the three categories. Optimal levels of dietary inclusion based on the digestibility of DM were found to be 40, 30 and 40%, respectively. Treating PPF with NaOH or $Ca(OH)_2$ did not improve digestibility of crude fibre due to formation of soaps.

Hutagalung *et al* (1977) fed two types of processed palm oil mill effluents to pigs. Both effluent based diets replaced 50 or 100% maize fraction in a conventional maize- soyabean ration. The rate of gain of pigs fed 50% effluent based diet was relatively same, but the feed intake and feed conversion ratios were significantly higher than those on control diets. At 100% replacement of maize by effluent based diets, the performance was poorer than those of 0 and 50% effluent based diets.

By feeding crossbred steers with oil palm, green feed along with rice bran supplementation, Samuel (1978) obtained a live weight gain of 364 Kg within 2 1/2 years of age. Sudin (1988) surveyed the performance of Sahiwal and Friesian growing heifers containing varying levels of dried palm oil sludge in the concentrate rations. Heifers fed ration containing 15% dried sludge had similar performance in terms of average daily gain, feed efficiency (kg DM/Kg gain), energy efficiency (Kg TDN/Kg gain) and cost of feed per kg gain in comparison to animals fed rations without or with 15% sludge. The performance of animals was significantly higher than those containing 30 or 65% sludge.

Shibata and Osman (1988) evaluated the feeding value of oil palm by-products. The percentage disappearance of PPF from nylon bags after 40 hr incubation was lower than that of PKC and POS in terms of DM, CP and CF.

Dry matter digestibility of diets containing 10-60% of POS was reported to be high with significant differences existing between treatments (Devendra, 1977). However, ration containing 10% POS gave best results with consistently higher digestibility of energy when PPF and POS were combined and fed in equal proportions. At increasing levels, the digestibility of DM decreased with maximum value obtained at 40% level of inclusion.

Mustaffa Babjee (1988b) also reported the effective levels of PKC inclusion in the rations of goats. He concluded that PKC could be incorporated upto 20% level in the rations of goats without any adverse effect on the reproductive performance.

Copper toxicity was observed in sheep when PKC was included at higher level. The performance of growing lambs fed grass and PKC at levels of 0, 0.45, 0.90, 1.35 and 1.80% of their live weight was studied by Mustaffa Babjee (1988b). The average weight gains were 27.5, 51,0, 53.0, 69.0 and 68.0 g/day, respectively, with grass and PKC rations. Zamirsaa *et al* (1990) reported significant weight gains with increased levels of PKC supplementation upto 1.35% live weight.

Onwudike (1986) compared the chemical composition and availability of amino acids to chicks between palm kernel meal and groundnut cake. Diets containing native forage were supplemented with PKC and POME in proportion of 70:30(A), 60:40(B) 50:50(C) and 40:60(D), in local Sumatra sheep by Boer and Sanchez (1989). There was an increase in the average daily gain with increase in POME upto a proportion of 50:50 (C). Feed intake and efficiencies of conversion were reduced to a level inter-mediate between A and B. Further, it was observed that males performed better than females but the differences were not significant.

Feeding value of PKC based on number of feeding trials was compiled by Yusoff (1985). Four groups of 12 Sahiwal x Friesian heifers were fed diets containing varying levels of PKC with urea solutions of different concentrations and fed at the rate of 2 kg/day with napier or guinea grass to appetite. Average daily gain was reported to be 0.64 kg and feed intake 10.56 kg/kg gain.

Mak *et al* (1987) recorded the performance of Kedals and Kelanton cattle fed Palm Kernel cake. The average daily gain was reported to be 0.583 kg with feed intake of 6.55 kg/kg gain. According to Yusoff and Suoin (1988), supplementation of PKC with molasses or cassava was not necessary for normal growth in heifers.

Sahiwal x Friesian cattle were fed solvent extracted and expellar processed PKC by Mustaffa Babjee (1988a). No significant difference was found in the performance of animals between the 2 groups. In the same trial animals of the same breed were fed two types of PKC but in combination with dried sago pith at 80:20 ratio. Significant differences were not observed in daily weight gain between the solvent extracted PKC/sago and the expellar pressed PKC/sago fed groups. The performance of local indigenous Kedah and Kelaten cattle under feedlot experiment with rations involving both solvent extracted and expellar pressed PKC was investigated by Mustaffa Babjee (1988a). The daily gains were 0.60, 0.45, 0.52 and 0.38 kg/day with feed conversion efficiency of 6.29, 7.04, 5.75 and 7.54, respectively among different treatments.

Mustaffa Babjee (1988a) studied that the animals fed PKC plus POME ration obtained 0.81 kg daily gain compared to 0.25 kg by the pasture grazed animals. Rojas *et al* (1989) reported the effect of inclusion of whole palm nut on production parameters of dual purpose cattle. There was no significant difference due to inclusion of palm nut meal among groups I (0%), II (0.15kg) and III (0.33kg) on milk fat content but the average daily milk yield, yield of FCM and milk fat were significantly higher ($P<0.01$) in group II in comparison to other groups.

Wong *et al* (1990) observed the degradability of DM, CP and CF of PKC in the rumen representing 48 hr incubation in nylon bags as 59.6, 60.9 and 45.6% with rice straw and 69.3, 74.4 and 47.9% with napier grass, respectively. Respective values, were 17.7, 49, 10.5 and 21.8, 51.6 and 11.9% for PPF, 67.5, 61.9, 58.0 and 82.6, 85.09 and 78.5% POME, respectively.

Vasanthalakhmi and Krishna (1993) recorded the proximate composition of PKC on DM basis. The per cent CP, EE, CF, NFE, total ash, NDF, ADF, hemicellulose, cellulose and lignin values were 14.80, 1.28, 33.20, 41.72, 9.00, 73.56, 38.55, 35.01, 18.39 and 20.50, respectively. *In vitro* and *in vivo* studied revealed that PKC is a potential source of energy and protein for replacement of conventional feedstuffs in the rations of sheep. Devasena and Krishna (1996) investigated the beneficial effects of supplementation of maize + PKC to colonial grass in comparison to maize + GNC premix supplementation.

Ramana Reddy *et al* (1996) studied the effect of urea treatment and PKC supplementation on nutritive value of anjan grass hay in lambs. They concluded that the energy and protein requirements of growing Nellore ram lambs could be met by feeding urea treated anjan grass hay supplemented with PKC. Supplementation of PKC increased the DCP and TDN values by 1.6, 4.7 and 8.0 and 13.6 percentage units respectively as compared to untreated hay feeding.

2.4 PALM PRESS FIBRE (PPF) AS LIVE STOCK FEED

Devendra and Muthurajah (1976) reported that the effective utilisation of the palm by-products can be mainly achieved by the addition of molasses in the ratio of 1:1.2. Based on this ratio the optimal levels of inclusion of PPF, POS and PPF + POS in the diet were found to be 30, 40 and 40%, respectively.

Shibata and Osman (1988) evaluated the feeding value of PPF, PKC and POS. Dry matter and CF disappearance of PPF was low, (17.7 to 22.4% for DM and 10.5-11.9% for CF). It was further reported that it is necessary to improve OM digestibility of PPF by steaming or explosive depressurizing treatment.

Studies was carried out by Kume *et al* (1990) studied to findout the effect of pastuerization of oil-palm wastes by gamma irradiation, inoculation of micro-organisms and subsequent microbial digestion of cellulosic material and protein enrichment. Empty fruit bunch (EFB) and palm press fibre (PPF) samples collected from various mills were highly contaminated with bacteria and fungi. Bacteria in both the types of samples were radio resistant needing gamma-irradiation dose of over 15 KGY for elimination below detectable levels. Fungi were eliminated by a dose of 5-6

KGY. Irradiation had little effect on the chemical composition of EFB and PPF. Total contents of cellulose and lignin were about 60% and 25%, respectively.

Ho *et al* (1991) compared the fungal colonization and development in rice straw and PPF which were similar in cattle and buffaloe. In both the animal species attachment to rice straw by rumen fungal zoo spores was rapid. With in 15 min at 6 hr of rumen incubation, thin and thick walled tissues were colonized by fungal hyphae and at 24 hr fungal colonization was extensive. Colonization and development of fungi on untreated or treated PPF with ammonium hydroxide was slow.

Pressure transtudor gas production technique was used by Ho *et al* (1994) to evaluate the feedstuffs without using fistulated animals. They ranked nine feedstuffs in the order of descending rate of fermentability as sago meal, sago waste, PKC, guinea grass, coconut waste, rice straw, oil palm trunk, PPF (treated with ammonia) and PPF (untreated). This order of fermentability was similar to the order obtained by *in sacco* method.

Shamsudin *et al* (1994) studied the effect of Bospro (made from Aspergillus biomass) on diets containing 78% solvent extracted PKC, 10% PPF, 10% molasses, 1% calcium carbonate and 1% salt. Use of Bospro in buffaloe feed was found to be unprofitable due to increase in the production cost and also lack of effect on average daily gain, feed conversion efficiency and DM intake.

Choo-Yuenmay *et al* (1996) studied the nutritional quality of PPF as a source of carotenoids, vit E and Sterols. Residual oil (5-6%) (on dry basis) extracted from palm press fibre contained significant quantity of carotenoids (4000-6000), vitamin E (2400-3500) and sterols (4500-8500 mg/kg). The major identified carotenoids were alpha carotene (19.5%), beta-carotene (31.0%), lycopene (14.1%) and pytoene (11.9%). Alpha-tocopherol constituted about 61% of the total vitamin E content, the rest being toco-trienols. The major sterols present were beta- sitosterol (47%), scampsterol (24%) and stigmasterol (15%). The oil extracted from PPF was contaminated with about 30% of palm kernel oil. The quality of this oil was slightly lower than that of crude palm oil in terms of free fatty acids, peroxide value and antisidine value.

Ho *et al* (1996) reported the microbial colonization and degradation of several crop residues in the rumen of goats. Colonisation by rumen bacteria and fungi was already established on all the crop residues by 8 hr of incubation. Bacterial growth was similar to that at 24 hr but fungal growth was less on PPF, microbial colonization was more extensive than at 24 hr but degradation of the fibres was still limited. Degradation of all crop residues at 72 hr was some what similar to that at 48 hr of overall microbial colonization. Degradation was most extensive on sago-waste, followed by rice straw and oil palm trunk shavings but least on PPF (treated or untreated).

2.5 ENRICHMENT OF POOR QUALITY ROUGHAGES

Most of the crop residues and agro-industrial by-products do not support the maintenance requirements of protein and energy when fed alone in unprocessed form. Numerous efforts have been made to improve the nutritive value of poor quality roughages by physical, chemical or biological methods. Upgrading of crop residues by chemical methods include treatment with alkalies, ammonia, urea/urine or a combination of them. Sommer (1981) surveyed various methods of physical and chemical treatments of straws for feeding cattle and reported that consumption of ammoniated straw was 17.4% higher than that of untreated straw. Han and Garrett (1986) reported that urea, urine or ammonia treatments are one of the most practicable and beneficial ways to improve the feeding value of crop residues.

In India ammoniation of crop residues and agro-industrial by-products through urea treatment was found to be effective, practicable and economical since urea is available on subsidy to the farmers and does not require skilled personnel for its adoption.

2.5.1 Ammoniation for improved performance

Jayasuriya and Perera (1982) concluded that 4% urea with ensiling period of 3 to 4 weeks was the best method of treating rice straw. *In vitro* digestibility was found to increase significantly with increase in the level of urea during 3 to 4 weeks treatment period. Gupta *et al* (1985) reported that 5% urea treatment with a storage period of 4 weeks was an effective way for improving the nutritive value of paddy straw.

Urea-wheat straw mixture in a 3.5 : 96.5 ratio was stacked with 40, 50, 60 and 70% moisture for 9 days by Bakshi *et al* (1986). By 9th day the decline in cellulose and hemicellulose contents followed the trend of increase in moisture level. The results of the study revealed that for effective ammonia treatment with urea, low moisture and urea levels with short stacking period of 9 days was more suitable than high urea with 28 days stacking.

Jaiskishan *et al* (1987) attempted ammoniation of paddy straw with or without molasses using 1 to 5% urea levels for periods varying from 1 to 5 weeks. Urea treatment at 5% level increased the CP content 3 times and rendered about 60% of N of the ammonia treated paddy straw into water soluble form. Moisture level of 38% and incubation at 38^{o}C favoured optimum ammoniation. The *in sacco* DM digestibility was reported to be highest in ammoniated straw with 5% urea in comparison to 3% urea treatment.

The CP content of rice straw treated with 5% urea for 3 days was lower compared to that of 10 and 20 days storage which was attributed to undegraded urea remaining intact. However, Saadullah *et al* (1988) stated that the intact urea will be available with the straw in the rumen which can be made use of by the rumen microbes when straw is consumed.

Yadav and Yadava (1988) treated wheat straw and chaffed paddy straw with five concentration gradients of urea (0, 3, 4, 5 and 6 g per 100 g straw), four moisture gradients (30, 40, 50 and 60% if straw) and four treatment periods (1,2, 3 and 4 weeks). The results of *in vitro* studies disclosed that a combination of 4% urea at 30% moisture level and 4 week treatment was optimum and suitable for ammoniation of wheat and paddy straws.

Venkataramana *et al* (1989) treated bajra stalks with 4 concentration gradients of urea (3, 4, 5 and 6 g per 100 g straw), 3 moisture levels (30, 40 and 50% of straw) and 3 treatment periods (10, 20 and 30 days). Based on the results of chemical, *in vitro* and *in sacco* evaluation studies they recommended 4% urea solution, 30% moisture level and 20 days of treatment for improving the nutritional quality of bajra stalks.

Ramana Reddy *et al.* (1996) observed the effect of 4% urea treatment on Cenchrus hay at moisture gradients of 30, 40 and 50% and incubation intervals of 10, 15 and 20 days. Based on the results of chemical, *in vitro* and *in sacco* evaluation studies they recommended 4% urea at 40% moisture level with 10 days of incubation for enriching the nutritional quality of Cenchrus hay.

2.5.2 Optimum conditions for ammoniation

Thermo-ammoniation caused greater increase in N content than ammoniation at ambient temperature (Mowat, 1981). In an earlier study Oji *et al.* (1979) reported increased IVDMD of 5 units for maize stover ammoniated at 90°C for 6 hr as compared to treatment at 21°C for 30 days.

Chaffed wheat straw of 3.5 cm with 40% moisture was treated with 5% urea with or without urease by Singh and Makkar (1986). The treated samples were stored for 2, 4, 12, 16, 25, 40 and 60 days at 4, 21 and 36°C. Only 25% of the added urea was reported to be hydrolysed at 4°C compared to 98% hydrolysation at 37°C by 10th day.

Results of Mikami *et al.* (1986) showed that *in vitro* digestibility of straw increased proportionately up to 30% moisture. While the digestibility of hay in sheep did not differ among moisture levels of 14, 20 and 35%. Mattoo *et al.* (1986a) treated chaffed paddy straw samples with 0, 4, 5 and 6% urea at 50% moisture level and stored for a period of 1, 2, 3 and 4 weeks to generate ammonia to interact with paddy straw. Significantly higher CP content of 22.5% was reported for samples treated with 6% urea at 4th week of incubation compared to 16.89% with 5% urea level and 3.61% with untreated sample.

Urea treatment increased the CP content by 100.9 and 159.2% by stacking and ensiling, respectively (Reddy *et al.*, 1988). Mikami *et al.* (1986) reported that the quantity of ammonia which was adhered firmly to wheat straw increased proportionately with moisture content up to 30% in straw and 20% in hay.

Venkataramana *et al.* (1989) treated bajra stalks with 4 levels of urea, 3 moisture gradients and incubated for a period of 10, 20 and 30 days. Level of urea did not influence the proximate components except CP and cell-wall constituents of bajra stalks. Highest CP (11.9%) was observed for the bajra stalks treated with 5% urea at 30% moisture for 10 days. The IVDMD of straw increased from 19.6 to 29.2% with 4% urea treatment of straw moistened to 30% and incubated for 20 days. Urea treatment increased the DM disappearance of bajra stalks up to 4% level with the highest soluble DM fraction of 10% and EDDM of 28.08% as compared to 18.40% for the untreated stalks.

Ramana Reddy *et al.* (1996) treated Cenchrus ciliaris hay with 4% urea, at moisture levels of 30, 40 and 50% for 3 incubation periods of 10, 15 and 20 days. The average IVDMD increased ($P<0.01$) from 27.68 to 41.98% due to urea treatment of hay for 10 days at 40% moisture level. Higher ($P<0.01$) average *in sacco* DM disappearance value of 52.13% was observed for hay subjected to 40% moisture level as compared to 30 or 50% moisture levels. Higher effective degradable dry matter (EDDM) values ranging from 39.55 to 40.32% were observed when Cenchrus hay was incubated at 40% moisture for 10 to 20 days.

Reddy *et al.* (1996) treated ground sunflower straw with 4% urea at different moisture (30, 40, 50 and 60%) levels and incubated for different periods (1, 2, 3 and 4 weeks) to evaluate optimum moisture and incubation periods. Moisture level of 50% with 2 weeks incubation period was found to be optimum for urea treatment of sunflower straw based on different physical (colour, odour, texture) and chemical (proximate principles, cell wall constituents, pH and NH_3-N) characters and IVDMD.

2.5.3 Effect of ammoniation on chemical composition

Ammoniation decreased the concentration of hemicellulose in Tall Fescue hay by 5.2% units and increased the total N from 1.27 to 2.61% (Buettner *et al.*, 1982). It was further reported that ammoniation has significantly reduced ester bond absorbance and increased amide bond absorbance in the fibre fraction of hay resulting from the breaking of ester bonds through aminolysis. The lower NDF of the treated hay presumably reflected on the decrease in hemicellulose and lignin contents associated with ammoniation. Apparently, these constituents were partially solubilized by ammoniation.

Ammoniation through 4% urea treatment at 30% moisture level for 4 weeks increased the CP content of wheat straw from 3.17 to 8.64% and paddy straw from 5.14% to 12.17% (Yadav and Yadava, 1986a). Rahman *et al.* (1987) sprinkled 4% aqueous urea solution over 100 kg of wheat straw at moisture level of 55% and after 4 weeks storage the CP content of treated straw was 9.53% as against 2.59% for untreated straw.

Toro and Majgaonkar (1986) reported a 3-fold increase in the CP content of paddy straw when treated with urea for 30 days. Urea treatment decreased the CF and NFE contents of paddy straw from 32.60 to 30.62% and 44.16 to 39.83%, respectively due to loss of lignin through solubilization by ammoniation.

Urea treatment promoted major chemical changes in the composition of cell walls in Meadow hay samples of H_1 and H_2 when treated with 6% urea at 25°C for 3, 6, 9, 45 and 60 days, concentrations of NDF, hemicellulose and lignin have been reduced significantly with increase in cellulose content. These effects were increased by treatment time. Concomitantly, the amount of soluble phenolics increased and the number of saponifiable groups reduced resulting in increased IVNDFD and IVOMD values. After 60 days of storage urea treated samples showed an increase in total N content from 16.4 and 12.1 to 28.9 and 29.8 g/kg DM for H_1 and H_2, respectively (Mascarenhas Ferreira *et al.*, 1989).

The effect of urea at 5% concentration as a source of ammonia on chemical composition of Sorghum hay was studied by Reddy *et al.* (1993). Urea treatment has increased the CP and ash levels by 111 and 14% and decreased the NDF, hemicellulose, ADF and ADL by 10, 18, 5 and 20%, respectively. However, urea treatment did not influence the CF and cellulose contents.

Venkata Ramana *et al.* (1989) treated bajra straw with 3, 4, 5 and 6% urea at moisture level of 30, 40 and 50% for a period of 10, 20 and 30 days. The CP content of bajra straw increased from 5.44% to a maximum of 21.9% with 6% urea treatment at 40% moisture level. Increasing the moisture level from 40 to 50% decreased the CP content of straw with all levels of urea treatment. The differences in the chemical composition of other proximate principles and cell-wall constituents were negligible.

2.5.4 Effect of ammoniation on rumen degradability

Singh (1986) reported that nylon bag digestibility of treated wheat straw was higher than for the untreated straw, irrespective of temperature and period of storage. Significantly higher degradibilities of DM and protein were recorded by Dutta *et al.* (1988) with increasing levels of urea and periods of storage. Values of straws treated with 6% urea for 6 weeks and that of untreated straw were 65.26, 54.95 and 30.26, 3.40%, respectively at 36 hours of incubation in fistulated bullocks.

Chaffed paddy straw samples were treated with 0, 4, 5 and 6% urea at 50% moisture level and incubated for a periods of 1,2,3 and 4 weeks by Mattoo *et al.*(1986b). Significantly higher DM and CP degradabilities were recorded with increasing concentration of urea compared to untreated straw. With increase in weeks of storage and hours of incubation a corresponding linear increase in both DM and protein degradabilities were also recorded.

Ramanaiah and Krishna (1993) studied the effect of urea treatment on DM and protein degradibilities of paddy straw using nylon bag technique. Urea treatment increased the soluble DM and protein fractions of paddy straw with an increase in insoluble but degradable fraction of protein by 100%. These effects have inturn increased the EDDM value from 34 to 40% and EDP value from 4 to 64%. In a similar study Ramana *et al.* (1990) observed an increase in EDP value from 27 to 59%

due to urea treatment in treated bajra stalks. The effect of urea treatment was further felt through increase in EDDM value by 18.5% with paddy straw in comparison to an increase of 5.3% in pearl millet straw as reported by Venkataramana *et al.*(1989).

Reddy *et al.*(1993) fitted the nylon bag data of sorghum hay treated with 5% urea to the model of $P = a + b\ (1\text{-}e^{-ct})$ and reported that the rate (c) constant and extent of degradibilities (a+b) were increased by urea treatment.

2.5.5 Methods of feeding urea treated feeds

Balasubramanya *et al* (1980) fed maize straw to surti buffalo heifers, supplemented with 1 kg concentrate or sprayed with 1 percent urea mixed with either 10 or 5 percent molasses for 30 days. There were no significant differences in intake and digestibility of DM with none of the treatments supplying the nutrient requirements of heifers.

Jayal and Jain (1982) dissolved 1.5 kg urea in 4 litres of water and mixed with 8 kg sugarcane molasses to be and sprinkled over 100 kg paddy straw. The treated straws were given to appetite to crossbred bull calves together with 600 g of concentrate and 20 g of mineral mixture. Those receiving paddy straw were also given 1 kg of green fodder daily. The treated straws were found to be quite palatable and the bull calves gained in body weight with the balances of nitrogen, calcium and phosphorus being positive.

In Bangladesh, Saadullah *et al* (1982) fed native cattle to appetite for 84 days with untreated rice straw, untreated straw + urea, straw treated with 5 percent urea, straw treated with 4 percent slaked lime + urea and straw treated with 3 percent NaOH + slaked lime + urea. The average daily intake of DM was reported to be 86.6, 81.9, 91.6, 78.3 and 76.6 g/kg $W^{0.75}$ with the DM digestibilities of 40, 46, 51, 48 and 52 percent, respectively, with urea treatment being the best method of ammoniation for improving the feeding value of rice straw.

Buffalo steers were fed with untreated rice straw, rice straw ensiled for 3 weeks in a 1:1 ratio with 5 percent urea or urea ensiled straw + dried cassava leaves by Wanapat *et al* (1985a). It was reported that the digestibilities of all the nutrients were increased by urea ensiling of rice straw. Addition of cassava leaves gave a further increase in the apparent digestibilities of OM, ADF and CP.

Singh and Negi (1985) fed rams with untreated or treated straw *ad libitum* and supplemented with 300 g of concentrate mixture and reported a dry matter intake of 1.97 and 1.93 kg per 100 kg body weight. Significant differences were not observed in the apparent digestibilities of DM, CP, CF, EE and NFE as well as NDF, ADF, hemicellulose, while cellulose and lignin digestibility decreased after ammoniation.

Singh and Barsaul (1985) tried to improve the palatability and nutritive value of wheat straw by impregnating 2 kg urea, 20kg molasses and 1 kg each of common salt and mineral mixture/100 kg of wheat straw. Heifers in the control group were offered 1.5 kg concentrate mixture and *ad libitum* feeding of molasses treated wheat straw without urea while 63 percent of concentrate mixture was reduced in the experimental group fed with urea treated wheat straw *ad libitum*. Palatability of urea treated straw increased by 12 percent along with higher digestibilities of DM, EE, CF and NFE in the combined ration as compared to control.

Reddy *et al.*(1992) fed rumen fistulated Murrah buffaloes on a diet of ammoniated wheat straw, molasses, wheat bran and fish meal alone or with 3 or 6 kg berseem. They reported that the ration containing 3 kg berseem increased the DM intake compared to the other 2 diets. Shankar Rao *et al.*(1994) supplemented urea treated sunflower straw with mulberry hay in the rations of cross bred cattle and concluded that there was no significant difference on DMI between treated and untreated straws.

Rice straw was treated with 5 percent urea at 50 percent moisture level and stored in a stack for 30 days. The performance of crossbred heifers fed urea treated rice straw *ad libitum* with 1.5 kg concentrate mixture was compared to those fed untreated rice straw *ad libitum* + 2kg concentrate mixture and a control group fed 10kg green fodder with 1.5 kg concentrate mixture and dry grass *ad libitum*. No significant differences in the performance of crossbred heifers was observed among different groups (Toro and Majgaonkar, 1986).

2.5.6 Effect of ammoniation on DM intake and animal performance

In trials with crossbred steers Wanapat *et al.*(1983) observed an increase in daily DM intake from 4.93 kg per head without urea treatment to 6.82 kg when urea was used for ensiling for 3 weeks. In another study urea treatment has been found to improve rice straw from a submaintenance to a maintenance ration for buffaloes (Wanapat *et al.*, 1984).

Feeding of rice straw ensiled with 4% urea to Sahiwal heifers over a period of 10 weeks resulted in higher intake for ensiled straw than for the untreated straw (Perdok *et al.*,1984). Singh and Barsaul (1985) reported significantly higher digestibility coefficients for DM, EE, CF and NFE of the ration containing urea treated wheat straw with reduced intake of concentrate mixture by 63% as compared to feeding untreated straw without any effect on CP digestibility. Yadav and Yadava (1986a) conducted a growth trial using crossbred male calves by feeding untreated or ammoniated wheat straw or paddy straw with varying levels of concentrate mixture. Digestibilities of DM, OM, hemicellulose, CF, NDF, ADF and cellulose increased in animals fed ammoniated straw.

Attempts were made by Rahman *et al.*(1987) to improve the palatability and nutritive value of wheat straw by urea treatment. Digestibility coefficients for DM, CP, EE, CF and NFE were 48.15, 67.04, 64.65, 59.07 and 44.95 with DCP and TDN values of 6.36 and 47.98%, respectively for treated straw which was comparable to any maintenance type non-legume forage.

Three groups of Nellore rams were fed untreated, 4 and 5% urea treated bajra straw *ad libitum* + 150 g concentrate pre-mix (Venkataramana *et al.*, 1989). Urea treatment at 4 and 5% levels increased total DMI from 51 to 57 and 61 g/kg $W^{0.75}$/day, respectively. Ammoniation with 4 and 5% urea treatments significantly increased the digestibilities of CP, CF, NDF, ADF, hemicellulose, Cellulose, lignin and TDN and DCP intakes. Urea treatment significantly increased the N retention but the differences in the N retention of rams fed 4 and 5% urea treated straw based rations were non-significant.

Puri and Gupta (1990) fed 3 groups of crossbred calves with untreated, 4% urea + 40% moisture and 5% urea + 30% moisture treated rice straw with concentrate mixture and reported that the mean live weight gains (g/day) were 416.67, 562.50 and 541.67, respectively. The apparent digestibilities of DM, CF, NDF, ADF and Cellulose were significantly higher in animals fed treated straw as compared to those fed untreated straw. However, the digestibility of CP was not affected. The TDN and ME intakes increased significantly in ammoniated rice straw fed animals.

Feeding of untreated paddy straw and urea treated straw plus concentrate mixture at 100, 75 and 50% maintenance requirements to cows increased the DMI by 25, 45 and 36% and milk yield by 18, 40 and 38%, respectively (Deepak Kumar *et al.*,1991). The cost of milk production has been reported to be reduced by 6, 3 and 26%, respectively due to inclusion of urea treated paddy straw in the rations. Feeding of urea treated grass resulted in higher weight gains and reduced the cost/kg live weight gain of heifers as compared to those fed with untreated grass ration (Singh and Taparia, 1992).

Shankar Rao *et al.*(1994) fed urea treated sunflower straw with or without mulberry hay to crossbred bulls and concluded that urea treatment has significantly increased the digestibilities of DM, CP and cell-wall contents and N balance.

Ramana Reddy *et al.*(1996) studied the effect of urea treatment of Anjan grass hay and PKC supplementation in growing lambs. They concluded that the urea treatment increased ($P<0.01$) the digestibilities of DM, CP, NDF, ADF, hemicellulose and cellulose from 47.98, 55.13, 51.93, 42.78, 60.31 and 53.52 to 56.92, 66.52, 58.74, 51.08, 67.51 and 61.35 per cent, respectively. Supplementation of urea treated hay with PKC increased the digestibilities of DM and CP by 2.98 and 4.26 percentage units, respectively.

Based on the information available an attempt has been made in the present study to standardise the urea-ammoniation of PPF and its inclusion in the rations of buffaloes was undertaken.

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

3.1 PROCUREMENT OF PALM PRESS FIBRE AND OTHER FEED STUFFS

Required quantity of Palm Press fibre (PPF) was procured from oil palm processing plant of M/s.Andhra Pradesh Oil Federation, Pedavegi, West Godavari district which is the only plant currently put to operation in Andhra Pradesh. The rest of the feed ingredients were procured from the local market. Fertilizer grade urea (Nagarjuna brand) was purchased locally for ammoniation of PPF.

3.2 UREA TREATMENT OF PPF

To standardise the technique of urea-ammoniation for the enrichment of PPF initially, laboratory scale evaluation was undertaken followed by field scale ammoniation for animal experimentation.

3.2.1 Laboratory scale ammoniation

PPF was subjected to urea treatment in round bottomed 2 L capacity screw capped plastic jars to optimise the standard conditions of urea, moisture level and period of incubation. Three gradations of urea solutions of 3, 4 and 5%, moisture levels of 30, 40 and 50% and incubation periods of 10, 20 and 30 days were choosen to select the effective levels of urea, moisture and period of incubation for *in vivo* evaluation studies.

For initial screening, 500 g of PPF treated with 3, 4 and 5% urea at three moisture levels was tightly packed in each jar and screw capped. Based on the original moisture content of PPF 3, 4 and 5 g of fertilizer grade urea was dissolved in 29, 50 and 80 ml of water to treat 100 g each of PPF to attain 3, 4 and 5% urea concentrations and final moisture levels of 30, 40 and 50%, respectively, for treating PPF samples. The jars were opened at the end of 10, 20 and 30 days and dry matter was determined for each treatment combination prior to the collection of representative samples materials for further analysis. The dried samples were ground in a willey mill using medium mesh (2 mm) screen and were sealed in polythene bags till analysis was carried out.

Based on the results of preliminary investigation carried out, urea level of 4 per cent, optimum moisture content of 40% and incubation period of 20 days were selected for further evaluation studies.

3.2.2 Bulk ammoniation of PPF

500 kg of PPF treated with 4% urea at 40 per cent moisture level was compacted in an unused shed of 3.6x2.0x1.2m walls with concrete flooring. Each 100 kg of PPF was treated with 4 kg urea dissolved in 50 l of water. The treated material was covered with yellow polythene sheet all around and at the top before sealing. At the end of 20 day incubation the polythene sheet was removed and the treated PPF was exposed to open air overnight prior to feeding on the next day to minimize the irritant effect of residual ammonia entrapped in the treated straw when fed to animals.

3.3 FORMULATION OF EXPERIMENTAL RATIONS

3.3.1 Formulation of concentrate mixture

Concentrate mixture was formulated (Table 4) using locally available and conventional feed ingredients.

Table 4: Ingredient composition of concentrate mixture.

Ingredient	%
Maize	25
Groundnut Cake	12
Deoiled Rice Bran	35
Cotton Seed Cake	15
Sunflower Cake	10
Mineral Mixture	02
Salt	01

Table 6: Ingredient composition of rations fed to buffaloes for *in vivo* evaluation.

Ration	Paddy straw (kg)	Untreated PPF (kg)	Treated PPF (kg)	Concentrate mixture (kg)
R_1	3.0	-	-	2.0
R_2	-	3.0	-	1.3
R_3	1.5	-	1.5	1.1
R_4	-	-	3.0	0.2

Table 5: Composition of rations containing untreated/urea treated PPF at varying levels replacing paddy straw.

Ration	% Replacement	Paddy straw (kg)	Untreated PPF (kg)	Urea treated PPF (kg)	Concentrate Mixture(kg)
1.	0	3.00	0.00	-	2.0
2.	25	2.25	0.75	-	1.8
3.	50	1.50	1.50	-	1.7
4.	75	0.75	2.25	-	1.5
5.	100	0.00	3.00	-	1.3
6.	25	2.25	-	0.75	1.5
7.	50	1.50	-	1.50	1.1
8.	75	0.75	-	2.25	0.6
9.	100	0.00	-	3.00	0.2

3.3.2 Formulation of rations for laboratory scale evaluation

Nine different rations were formulated (Table 5) using untreated and urea treated PPF along with paddy straw and concentrate mixture. The rations were screened through *in vitro* and *in sacco* evaluation studies to determine the effective level of its incorporation in the rations of buffaloes.

3.3.3 Formulation of rations for *in vivo* evaluation

Four promising rations (Table 6) were selected and used for animal experimentation in a 4 x 4 latin square design.

3.4 *IN VITRO* DRY MATTER DIGESTIBILITY OF EXPERIMENTAL RATIONS

3.4.1 Collection of rumen liquor

Rumen liquor was collected from a rumen cannulated Murrah buffalo bull which was maintained on a standard ration. Rumen liquor was collected at 8.00 AM before offering feed and water. Sampling was done by drawing rumen contents from different portions of the rumen and filtering through a four layered muslin cloth. The collected rumen liquor was transferred to flasks flushed with Co_2 and maintained at 37 to 39^oC in an insulated jug.

3.4.2 *In vitro* experimental procedure

Both urea treated and untreated PPF and whole rations were evaluated using Tilley and Terry (1963) two stage *in vitro* technique. Uniformly ground samples of 0.5g each were taken into 100 ml centrifuge tubes fitted with rubber stoppers having bunsen gas release valve. To each tube 40 ml of Mc Doughals buffer solution was added followed by 10 ml of SRL. Tubes designated as reagent blanks were included to which only buffer nutrient solution and rumen liquor were added. Carbon dioxide was flushed into the tubes for 10 seconds and the tubes were immediately stoppered and incubated at 39°C. The tubes were swirled gently during incubation at 6 hr interval to resuspend the substrate.

After 48 hr of incubation, the tubes were centrifuged at 3000 rpm for 15 minutes. The supernatent fluid was discarded and 50 ml freshly prepared pepsin solution was added to the residue in each tube and the tubes were incubated for an additional 36 hr. At the end of incubation, the tubes were centrifuged and the residue was transferred to a crucible with minimum of water. Crucible and the residues were dried over night at 100°C, and the weights were recorded. The per cent IVDMD was calculated using the formula:

$$\%IVDMD = \frac{\text{Sample dry matter-(undigested dry matter residue-dry matter of blank)}}{\text{Sample dry matter}} \times 100$$

3.5 *IN SITU* EVALUATION OF EXPERIMENTAL RATIONS

3.5.1 Experimental animals

Three growing Murrah buffalo bull calves fitted with permanent rumen cannulae were used for *in situ* evaluation of experimental rations. The average body weight of the buffalo bull calves was 127 ± 0.05 kg. The nutrient requirements of the calves were calculated as per the recommendations of Kearl (1982). The experimental animals were housed in individual stalls having provision for feeding and watering.

3.5.2 Feeding regimen

The calves were maintained on a feeding regimen comprising of roughage and concentrate at 67:33 ratio. The animals were also offered 2 kg of non-legume green

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fodder. Concentrate mixture was offered daily at 9 AM and 2 PM while paddy straw was offered throughout the day. Fresh drinking water was offered to animals twice daily.

3.5.3 Preparation of nylon bags

Nylon cloth (140s) having a pore size of 30-35 um was procured in the local market. Bags of 15 x 7 cm size were stitched with nylon thread to maintain bag area of 21 cm^2/g DM of sample. Pore size of the bags was large enough to allow the entry of rumen microbes, to prevent the accumulation of gas during incubation and to keep the losses of solid particles to a minimum.

3.5.4 Sample size

Representative samples of 3 g of dried and ground experimental rations were used for *in situ* evaluation.

3.5.5 Position of bags in the rumen

Bags filled with experimental rations and a glass marble to prevent floating due to gas accumulation in each bag were closed and tied with branded nylon fishing line. Each of the bag was secured to the rumen cannulae with the help of a nylon fishing line of 60 cm length to allow the bags move freely within the rumen contents. The bags were incubated in the ventral sac of rumen as suggested by Orskov *et al* (1980) in order to ensure that the bags were completely exposed to the rumen digesta.

3.5.6 Incubation Intervals

Incubation intervals of 12, 24, 36, 48 and 72 hr were followed uniformly as recommended by Kempton (1980).

3.5.7 Incubation procedure

After allowing the bags to remain in the rumen for specific time intervals, one bag from each of the animals was removed and gently washed under running tap water till the outcoming fluid was clear. After a mild squeeze the nylon tie line was cut and marble removed. The bags were dried to a constant weight at 70°C for 24 hr in a forced draft oven. The per cent D M disappearance from each bag at different incubation intervals was determined by using the formula:

$$DMD(\%) = \frac{\text{sample dry matter - undigested dry matter residue}}{\text{sample dry matter}} \times 100$$

3.6 EFFECTIVE DEGRADABLE DRY MATTER (EDDM)

Effective degradable DM of experimental rations was calculated using the computer model as per Mc Donald (1981) at assumed rumen outflow rate of 0.04 per hour.

3.7 *IN VIVO* EVALUATION OF PPF

Nutritive values of untreated and urea treated PPF were determined.

3.7.1 Nutritional evaluation of untreated and urea treated PPF

Nutritive values of untreated PPF and urea treated PPF were determined by conducting separate digestion trials on four growing buffaloe bull calves sequentially on groundnut haulms, groundnut haulms plus untreated PPF and groundnut haulms plus urea treated PPF.

3.7.2 Nutrient utilization and Nitrogen balance studies

To findout the optimum level of incorporation of PPF in the buffalo rations, a 4 x 4 latin square designed metabolism trial was conducted using four buffalo bull calves.

3.7.3 Selection of animals

Four growing buffalo bull calves with an average body weight of 100 ± 0.05 kg were selected from Dairy Experimental Station, Rajendranagar, Hyderabad.

3.7.4 Housing, feeding and management

Before starting the experiments, the animals were dewormed with fenbendazole (Hoechst). The experimental animals were maintained in individual housing system, with feeding and watering arrangements throughout the experimental period. The digestion trial consisted of 15-day preliminary period followed by a 5-day collection period.

3.7.5 Sampling of feed and feed residues

Daily record of feed intake and residue was maintained individually during the collection period. Representative samples were taken daily before feeding and were pooled to represent 5-day collections. The samples were ground in a laboratory willey mill and preserved in polythylene bags for subsequent analysis.

3.7.6 Collection and aliquoting of faeces and urine

<u>3.7.6.1</u> <u>Faeces</u>: Faeces from each animal was collected in separate containers. The total quantity of dung voided during each preceeding 24 hr was weighed, mixed thoroughly and placed in a wide mouthed stoppered bottle before shifting to the laboratory for analysis.

For dry matter determination aliquots of 1/10th of daily faeces voided were taken for each animal in previously weighed petri-dishes and dried overnight in hot air oven at 100 ± 5°C. Daily dung samples of each animal for the 5-day collection period were pooled, ground in a willey mill and stored in polythylene bags for further analysis.

For nitrogen determination 1/100th part of the faeces voided each day was weighed and preserved in previously weighed airtight stoppered bottle and kept in a deep freeze. After 5-day collection period the samples were used for determining nitrogen content of samples.

3.7.6.2 Urine: For urinary nitrogen measurement, 1/100th part of total urine voided daily by individual animal after thorough mixing was pipetted out in duplicate into Kjeldhal flasks containing 30 ml of concentrated sulphuric acid. The aliquots thus pooled in the flasks were maintained separately for each animal.

3.8 METHODS OF ANALYSIS

The methods recommended by AOAC (1990) were followed for the determination of proximate principles. Fibre fractionation was done as per the method proposed by Goering and Van Soest (1970). The gross energy value of PPF was determined by Gallonkemp adiabatic bomb calorimeter.

3.9 STATISTICAL ANALYSIS

The data was subjected to statistical analysis as per the methods suggested by Snedecor and Cochran (1968).

RESULTS

CHAPTER IV

RESULTS

Palm Press Fibre (PPF) , an important by-product of oil palm industry has been subjected to chemical, *in vitro* and *in sacco* evaluation techniques to assess its nutritional quality and later *in vivo* studies were conducted to deterimine its effective level of incorporation in buffalo rations after enriching by urea- ammoniation technique.

4.1 CHEMICAL COMPOSITION OF PALM PRESS FIBRE

The chemical composition of palm press fibre (PPF) used in the present study is presented in Table 7 and 8. PPF contained 8.02% CP, 9.04% EE, 41.12% CF, 32.22% NFE and 9.60% total ash, 0.65% Ca, 0.21% P and 0.17% Mg on DM basis (Table 7). Analysis of cell wall constituents (Table 8) revealed 72.48% NDF, 53.09% ADF, 19.39% hemicellulose, 33.64% cellulose, 18.46% lignin and 3.68% silica on DM basis. Gross energy value of PPF was determined to be 20.40 MJ/kg DM.

Table 7: Chemical composition* of palm press fibre interms of Proximate principles and important major minerals

Nutrient	%
CP	8.02
EE	9.04
CF	41.12
NFE	32.22
Total Ash	9.60
Ca	0.65
P	0.21
Mg	0.17

* On DM basis

Table 8: Cell-Wall constituents* of PPF

Nutrient	%
NDF	72.48
ADF	53.09
Hemicellulose	19.39
Cellulose	33.64
Lignin	18.46
Silica	3.68

* On DM basis

4.2 *IN VITRO* EVALUATION OF PPF

In vitro studies of PPF using buffalo rumen liquor revealed an average IVDMD value of 26.90%.

4.3 *IN SACCO* EVALUATION OF PPF

In Sacco dry matter disappearance of PPF was carried out by suspending the nylon bags containing ground samples of PPF in the rumen of three fistulated buffalo bulls for 12, 24, 36, 48 and 72 hr. The average DMD values of PPF were 20.10, 34.21, 36.44, 38.63, 40.50% at the end of 12, 24, 36, 48 and 72 hr of incubation, respectively (Table 9). There was a positive trend in the DM disappearance values by extending the period of incubation.

The effective DM disappearance (EDDM) of PPF was determined by subjecting the above data to least square analysis as per the software obtained from Orskov. The readily soluble fraction (a), insoluble but degradable with time (b) and rate constant/h (c) were 12.19, 28.70 and 0.0875, respectively. EDDM of PPF with rumen outflow rate of 0.04/h was 25.32% (Table 9 & 10).

Table 9: Average *in sacco* DM disappearance of PPF

Incubation interval(hr)	% DM disappearance
12	20.10
24	34.21
36	36.44
48	38.63
72	40.50
Average	33.80

Each value is an average of 3 measurements

Table 10: Constants (a, b, c) and EDDM of PPF

Parameter	Value
a	12.19
b	28.70
c	0.0875
EDDM	25.32

a = readily soluble
b = insoluble but degradable with time
c = rate constant/hr
EDDM represents effective degradability of dry matter (orskov and Mc Donald, 1979) at an assumed outflow rate (k) of 0.04/hr.

4.4 LABORATORY EVALUATION OF UREA-AMMONIATED PPF

To standardise the technique of urea treatment adoptable to PPF, effective levels of urea, moisture and optimum period of incubation were initially established prior to *in vivo* evaluation. Urea levels of 3,4 and 5%, moisture levels of 30, 40 and 50% were selected to incubate 500 g of PPF in 2L capacity screw capped plastic jars for a period of 10, 20 and 30 days.

4.4.1 Chemical Composition

The effect of varying levels of urea, moisture and incubation interval on chemical composition of urea treated PPF was studied and the data are presented in Tables 11, 12 and 13, respectively. Among the several chemical constituents considered, CP content alone showed marked increase when treated with urea solution. The CP content increased with the increase of urea level. It was further observed that the CP content increased when the moisture level was increased from 30 to 40% followed by reduction with further increase in the moisture level to 50%.

A decreased trend in NDF content of urea treated PPF was observed as the period of incubation increased from 10 to 30 days. The lignin content decreased when PPF was treated with urea. The differences in the chemical composition of other cell-wall constituents were negligible.

4.4.2 *In vitro* Evaluation

The effect of levels of urea, moisture and period of incubation on the digestibility of dry matter was studied by *in vitro* analysis. The average per cent IVDMD values of urea treated PPF are presented in Table 14. The average IVDMD value was 44.85% and highest for PPF subjected to 4% urea, 40%

Table 11: Effect of level of urea concentration on chemical composition (%) of urea treated PPF.

Nutrient	Untreated	Urea treated		
		Urea (%)		
		3	4	5
CP	8.02	11.80^{a}±1.21	14.78^{b}2.63	15.21^{b}±1.62
NDF	72.48	72.90±1.62	71.41±1.88	72.66±2.01
ADF	53.09	53.69±1.58	54.11+1.62	54.62+1.92
Hemicellulose	19.39	18.91±0.79	19.62±0.82	20.01±1.06
Cellulose	33.64	34.66±1.01	35.19±1.19	34.86±1.08
Lignin	18.46	16.19±1.06	17.63±1.10	16.86±0.98
Silica	3.68	3.81±0.53	3.62±0.50	3.53±0.53

Values for untreated PPF represent duplicate analysis.
Each value among treated PPF samples is the average of 18 observations.
a, b values in the row bearing different superscripts differ significantly ($P<0.01$)

Table 12: Effect of level of moisture on chemical composition (%) of urea treated PPF.

Nutrient	Untreated	Treated		
		Moisture (%)		
		3	4	5
CP	8.02	13.80^{a}±2.21	15.12^{b}3.01	12.84^{a}±2.91
NDF	72.48	73.18±1.81	70.60±2.06	73.192.21
ADF	53.09	54.16±1.96	53.82±1.62	54.62±1.92
Hemicellulose	19.39	19.06±1.66	19.42±1.50	20.06±1.43
Cellulose	33.64	35.21±1.01	34.83±1.32	34.67±1.20
Lignin	18.46	17.32±0.58	17.61±0.91	15.75±0.82
Silica	3.68	3.62±0.32	3.50±0.62	3.84±0.86

Values for untreated PPF represent duplicate analysis.
Each value among treated PPF samples is the average of 18 observations.
a, b values in the row bearing different superscripts differ significantly ($P<0.01$)

Table 13: Effect of period of on chemical composition (%) of urea treated PPF.

Nutrient	Untreated	Treated		
		Period (days)		
		3	4	5
CP	8.02	12.54^{a}±1.26	14.52^{b}2.63	14.73^{b}±1.62
NDF	72.48	73.21±2.01	72.62±2.73	71.14±1.80
ADF	53.09	53.81±1.66	54.08±2.20	54.53±1.80
Hemicellulose	19.39	19.01±1.06	18.86±0.98	20.67±1.10
Cellulose	33.64	34.91±1.21	35.53±1.31	34.37±1.62
Lignin	18.46	16.53±0.77	16.96±0.83	17.19±0.93
Silica	3.68	3.62±0.31	3.84±0.28	3.50±0.50

Values for untreated PPF represent duplicate analysis.
Each value among treated PPF samples is the average of 18 observations.
a, b values in the row bearing different superscripts differ significantly ($P<0.01$)

Illustration 1: Effect of level of urea on chemical composition (%) of PPF.

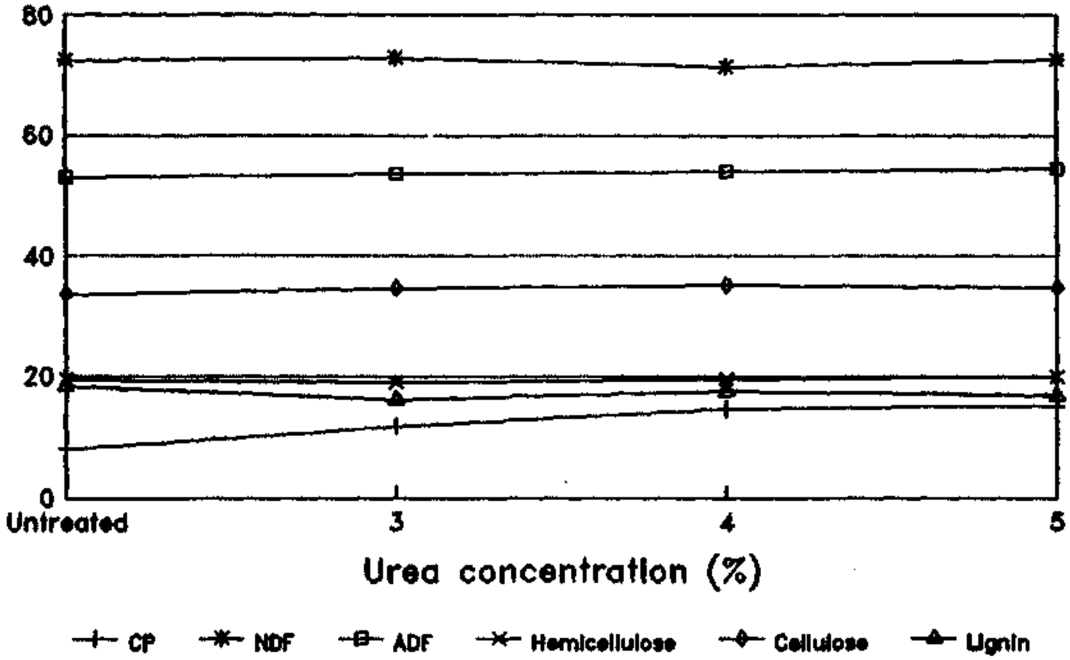


Illustration 2: Effect of level of moisture on chemical composition (%) of PPF.

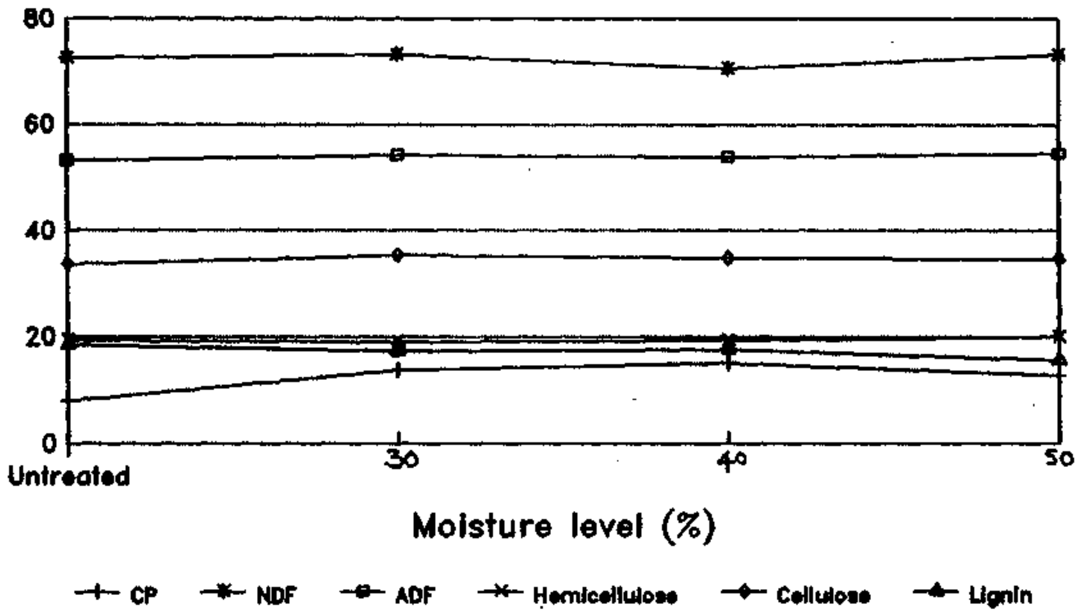


Illustration 3: Effect of period of incubation on chemical composition (%) of PPF.

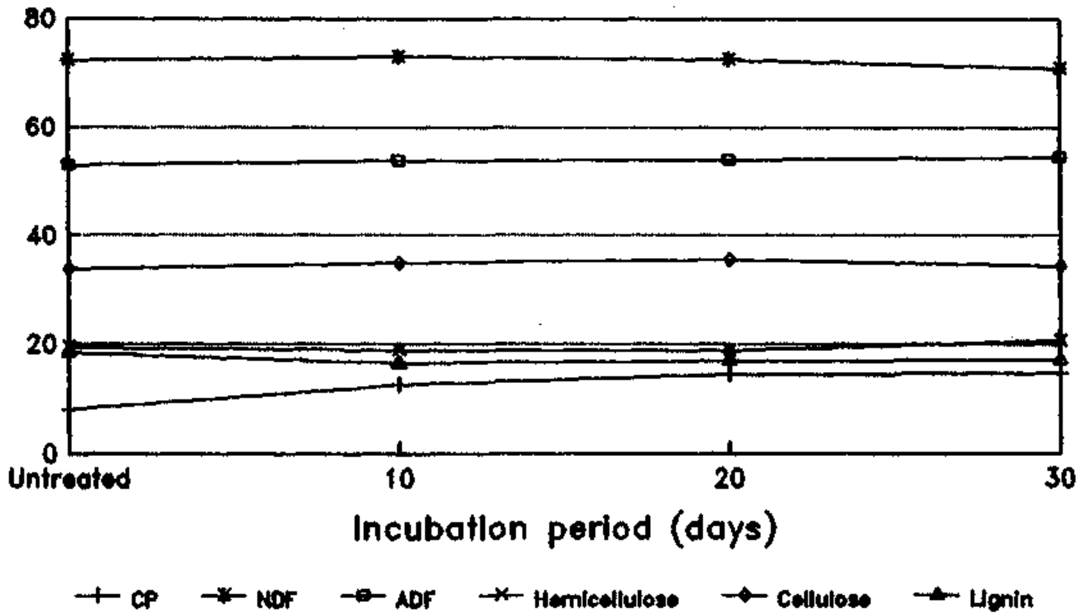


Table 14: Effect of varying conditions of urea treatment on average IVDMD (%) of treated PPF

Incubation periods (days)	urea (%)								
	3			4			5		
	Moisture %								
	30	40	50	30	40	50	30	40	50
10	29.48 ±0.24	32.29 ±0.81	31.51 ±0.72	36.31 ±0.18	33.93 ±0.21	31.37 ±0.19	31.19 ±0.71	32.47 ±0.52	33.42 ±0.46
20	34.54 ±1.52	35.64 ±1.71	33.35 ±0.72	41.61 ±0.81	44.85 ±1.51	41.29 ±0.76	40.43 ±0.71	41.51 ±0.46	41.67 ±0.51
30	40.57 ±0.40	42.51 ±0.32	39.04 ±0.26	40.49 ±0.34	41.48 ±0.31	41.38 ±0.71	41.29 ±0.92	41.69 ±0.10	42.78 ±0.26

Each value is the average of triplicate analysis.

moisture when incubated for 20 days as compared to 26.90% for untreated PPF. Signifiantly ($P<0.01$) higher IVDMD values were observed as the level of urea increased from 3 to 4%. Further increase of urea level to 5% did not show any improvement in IVDMD. Similar trend was observed with the increase of moisture from 30 to 40% and then to 50%. The average IVDMD values increased ($P<0.01$) as the period of incubation extended from 10 to 30 days.

4.4.3 *In sacco* Evaluation studies

The nylon bag technique offers the possibility of measuring the extent of DM degradation of feedstuffs at specific intervals of time, since the values simulate the fermentation that normally occurs in the rumen. The *in sacco* DM disappearance of urea treated PPF was determined by nylon bag technique in an attempt to further evaluate the urea treated PPF subjected to varying levels of urea, moisture and periods of incubation.

4.4.3.1 *In sacco* DM disappearance: Data on the effect of level of urea, moisture and period incubation on DM disappearance of PPF are presented in Tables 15, 16 and 17, respectively. The effect of level of urea on the average *in sacco* DM disappearance of urea treated PPF was studied and the data are presented in Table 15. There was a significant ($P<0.01$) increase in the DM disappearance of urea treated PPF upto 4% level and no further improvement in the DM disappearance was noticed by increasing the concentration of urea beyond 4% level.

The effect of level of moisture on the average *in sacco* DM disappearance of urea treated PPF is presented in Table 16. Significantly ($P<0.01$) higher value of 43.04% was observed for PPF subjected to 40%

Table 15: Effect of level of urea on *in sacco* DM disappearance (%) of treated PPF.

Incubation intervals (hr)	Untreated	Treated Urea (%) 3	4	5	Mean
12	20.10	23.94 ±1.72	27.90 ±1.96	25.61 ±2.14	25.82[c] ±1.95
24	34.21	36.98 ±2.03	40.19 ±1.68	38.14 ±2.21	38.44[d] ±2.10
36	36.44	42.42 ±2.26	44.66 ±2.18	44.01 ±2.34	43.70[e] ±2.13
48	38.63	46.62 ±3.01	48.08 ±2.68	47.91 ±3.12	47.54[f] ±2.76
72	40.50	52.38 ±3.01	54.02 ±3.08	52.88 ±2.96	53.09[g] ±3.01
mean	33.98 ±3.25	40.47[a] ±4.26	42.97[b] ±5.53	41.71[ab] ±5.71	

Values for untreated PPF is the average of three observations.
Each value among treated PPF samples is the average of 27 observations.
a, b values in the row, c, d, e, f, g values in the column differ significant (P<0.01).

Table 16: Effect of level of moisture on *in sacco* DM disappearance (%) of treated PPF.

Incubation intervals (hr)	Untreated	Treated: Moisture (%) 30	40	50	Mean
12	20.10	21.88 ±1.06	28.43 ±1.71	27.14 ±2.08	25.82[c] ±1.95
24	34.21	35.16 ±1.77	41.33 ±0.99	38.82 ±2.03	38.44[d] ±2.10
36	36.44	43.62 ±2.52	45.02 ±2.21	42.45 ±2.16	43.70[e] ±2.13
48	38.63	47.20 ±1.98	46.35 ±2.26	49.06 ±2.51	47.54[f] ±2.76
72	40.50	53.16 ±2.62	54.09 ±2.18	52.03 ±1.98	53.09[g] ±3.01
mean	33.98 ±3.25	40.20[a] ±5.26	43.04[b] ±4.54	41.90[b] ±5.32	

Values for untreated PPF is the average of three observations.
Each value among treated PPF samples is the average of 27 observations.
a, b values in the row, c, d, e, f, g values in the column differ significant ($P<0.01$).

Table 17: Effect of period of incubation on *in sacco* DM disappearance (%) of urea treated PPF

Incubation intervals (hr)	Untreated	Treated			
		Days			
		10	20	30	Mean
12	20.10	22.16 ±1.32	28.41 ±1.62	26.88 ±2.02	25.82[c] ±1.95
24	34.21	34.43 ±1.43	39.42 ±1.71	41.46 ±2.22	38.44[d] ±2.10
36	36.44	41.58 ±1.62	44.32 ±0.89	45.19 ±1.76	43.70[e] ±2.13
48	38.63	45.52 ±1.77	48.14 ±1.63	48.95 ±1.92	47.54[f] ±2.76
72	40.50	50.91 ±2.08	55.62 ±1.81	52.75 ±2.32	53.09[g] ±3.00
Mean	33.98 ±3.25	38.92[a] ±5.89	43.18[b] ±6.71	43.05[b] ±5.21	

Values for untreated PPF represent dupliate analysis.
Each value among treated PPF samples is the average of 27 observations.
a,b values in the row and c,d,e,f,g values in the column differ significantly (P<0.01).

moisture level as compared to 40.20% observed with 30% moisture level. However, no significant difference was observed between 40 and 50% moisture levels. Data on the effect of period of incubation on the average *in sacco* DM disappearance of urea treated PPF are presented in Table 17. The average DM disappearance value was significantly (P<0.01) higher (43.18%) for 20 days incubation compared to the value (38.92%) for 10 days incubation. However,no further improvement was noticed by increasing the period of incubation beyond 20 days.

4.4.4 Effective Degradable Dry Matter (EDDM)

The constants `a' (readily soluble), `b' (insoluble but degradable with time) and `c' (rate constant/hr) for untreated and urea treated PPF were calculated by using the soft ware obtained from Orskov and the data is presented in Table 18 and 19. Urea treatment increased the `a' value from 12.19 for untreated PPF (Table 10) to a maximum of 17.58 in urea treated PPF. The `b' fraction has not shown much variation. The outflow rate of 0.04/hr was used to calculate the EDDM of urea treated PPF.

The average EDDM value was 39.5% and highest for PPF subjected to 4% urea, 40% moisture and incubated for 20 days as compared to 25.32% for untreated PPF (Table 10 & 19). Higher EDDM values were obtained as the level of urea increased but the results were not significant. As the level of moisture increased from 30 to 40% there was a slight increase in EDDM value, but further increase of moisture showed a declining trend (Table 21). Similar trend was observed as the period of incubation increased from 10 to 20 and then to 30 days (Table 22).

4.4.5 Selection of optimum levels of urea, moisture and period of incubation

The effective levels of urea, moisture and incubation periods were selected based on the average values(%) of CP, IVDMD and EDDM.

Table 18: Effect of varying conditions of urea treatment of PPF on constants 'a', 'b' and 'c'.

Varying treatments		a	b	c
Urea concentration (%)	3	12.56±0.08	42.5±3.16	0.089±0.01
	4	16.26±0.10	44.5±2.02	0.076±0.02
	5	15.24±0.09	43.1±1.98	0.062±0.02
Moisture level (%)	30	12.62±0.07	43.2±1.06	0.071±0.04
	40	17.58±0.12	44.8±2.31	0.076±0.03
	50	13.86±0.02	41.6±3.08	0.086±0.06
Period of incubation (days)	10	15.89±0.09	42.3±2.56	0.065±0.05
	20	16.32±0.07	45.9±2.62	0.078±0.04
	30	11.85±0.04	41.4±1.66	0.082±0.06

Each values is the average of three observations.
a = soluble fraction; b = insoluble but digredable fraction;
c = rate constant per hr.

Table 19: Effect of varying treatment conditions on EDDM values of PPF

Period of Incubation (days)	urea (%) 3			4			5		
	Moisture (%) 30	40	50	30	40	50	30	40	50
10	30.60 ±0.25	27.80 ±0.46	28.50 ±0.91	28.80 ±0.97	31.60 ±1.04	31.30 ±0.81	30.80 ±0.47	33.10 ±0.71	32.80 ±0.66
20	30.70 ±1.10	32.70 ±0.43	33.80 ±0.77	31.70 ±0.43	39.50 ±0.51	32.20 ±0.62	32.60 ±0.44	32.80 ±0.91	34.00 ±0.82
30	35.70 ±0.82	30.80 ±034	31.50 ±1.01	32.10 ±0.81	35.10 ±1.90	32.40 ±1.32	33.90 ±0.91	34.30 ±0.63	33.10 ±0.96

Each value is the average of 3 observations

The effect of level of urea concentration (Table 20) on CP and EDDM showed a positive trend with the increase of urea level. The average IVDMD value was significantly (P<0.01) higher at 4% urea level when compared to 3%. With the increase in moisture from 30 to 40%, the CP, IVDMD and EDDM values also increased (Table 21) but a further raise in the level of moisture to 50% did not improve the nutritional quality of urea treated PPF.

The period of incubation also showed a positive trend with the increase of period of incubation from 10 to 30 days for CP and IVDMD (Table 22).

Based on the results of chemical, *in vitro* and *in sacco* evaluation studies, 4% urea concentration at 40% moisture level and incubation period of 20 days were selected for treating the PPF for *in vivo* evaluation studies.

4.4.6 *In vitro* and *in sacco* evaluation of complete rations

Nine complete rations were formulated (Table 5) replacing paddy straw with untreated and urea treated PPF at graded level of 25%. Using buffalo rumen liquor, IVDMD values of these rations were determined (Table 23). Average IVDMD ranged from 44.22 to 60.22%. There was a consistent decreasing trend in the DMD of the rations as the level of untreated PPF increased in the complete rations. With the incorporation of urea treated PPF a positive trend was observed in the DMD as the level increased upto 50%. However, further increase in the level of urea treated PPF did not affect significantly the IVDMD value.

The above nine complete rations were evaluated for *in sacco* DM disappearance by suspending the nylon bags filled with ground samples of complete rations in the rumen of three fistulated buffalo bulls for 12, 24, 36, 48 and 72 hr of incubation. The average DM disappearance ranged from 35.96 to 52.41 per cent (Table23).

Table 20: Effect of urea level on CP, IVDMD and EDDM values (%) of urea treated PPF

Parameter	Urea level (%)		
	3	4	5
CP	11.80^{a} ±1.21	14.78^{b} ±2.63	15.21^{b} ±1.62
IVDMD	35.66^{a} ±1.86	39.13^{b} ±2.02	38.60^{b} ±1.98
EDDM	31.34 ±1.61	32.74 ±1.42	33.04 ±1.69

Each value is an average of 27 observations.
a, b values in the row bearing different superscripts differ significantly (P<0.01).

Illustration 4: Effect of urea concentrations on per cent CP, IVDMD and EDDM values.

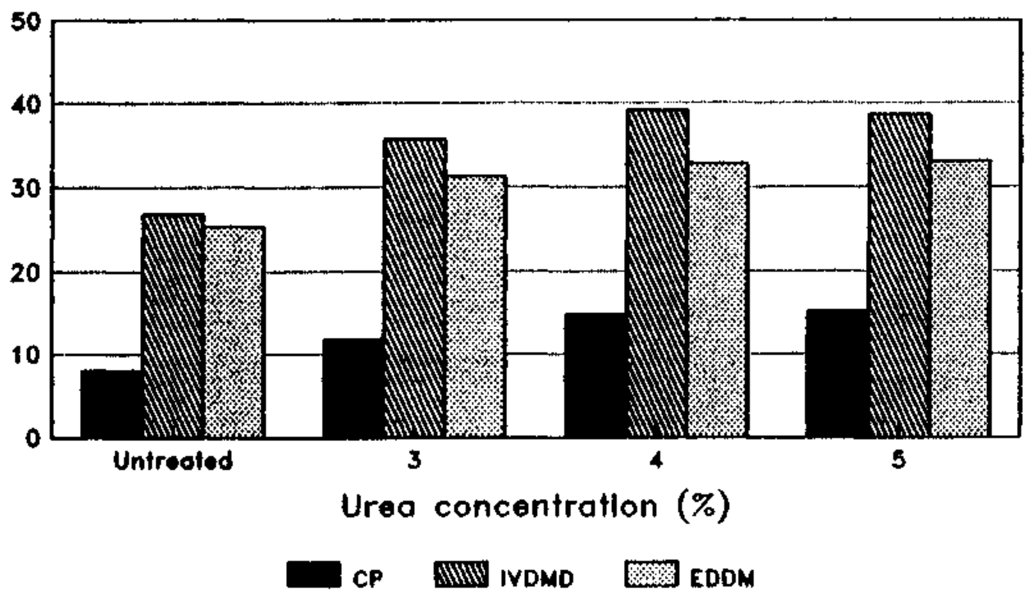


Table 21: Effect of moisture level on CP, IVDMD and EDDM values (%) of urea treated PPF

Parameter	Moisture (%)		
	30	40	50
CP	13.83^{a} ± 2.62	15.12^{b} ± 3.01	12.84^{a} ± 2.91
IVDMD	37.17^{a} ± 2.02	38.56^{b} ± 1.91	37.65^{a} ± 1.07
EDDM	31.88 ± 2.02	33.08 ± 1.91	32.18 ± 1.07

Each value is an average of 27 observations.
a,b values in the row bearing different superscripts differ significantly ($P<0.01$)

Illustration 5: Effect of moisture level on per cent CP, IVDMD and EDDM values.

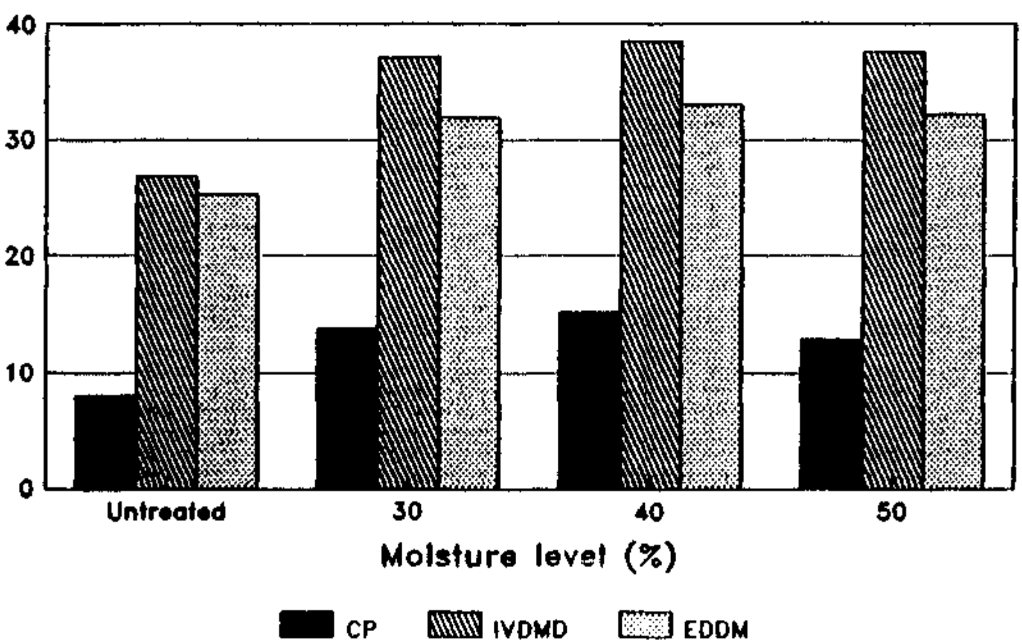


Table 22: Effect of period of incubation on CP, IVDMD and EDDM values (%) of urea treated PPF.

Parameter	Period of Incubation (days)		
	10	20	30
CP	12.54^a ±1.26	14.52^b ±1.51	14.73^b ±1.62
IVDMD	32.45^a ±1.76	39.56^b ±2.04	41.39 ±1.92
EDDM	30.59 ±1.23	33.33 ±1.71	33.20 ±1.84

Each value is an average of 27 observations.
a, b values in the row bearing different superscripts differ significantly ($P<0.01$).

Illustration 6: Effect of period of incubation on per cent CP, IVDMD and EDDM values.

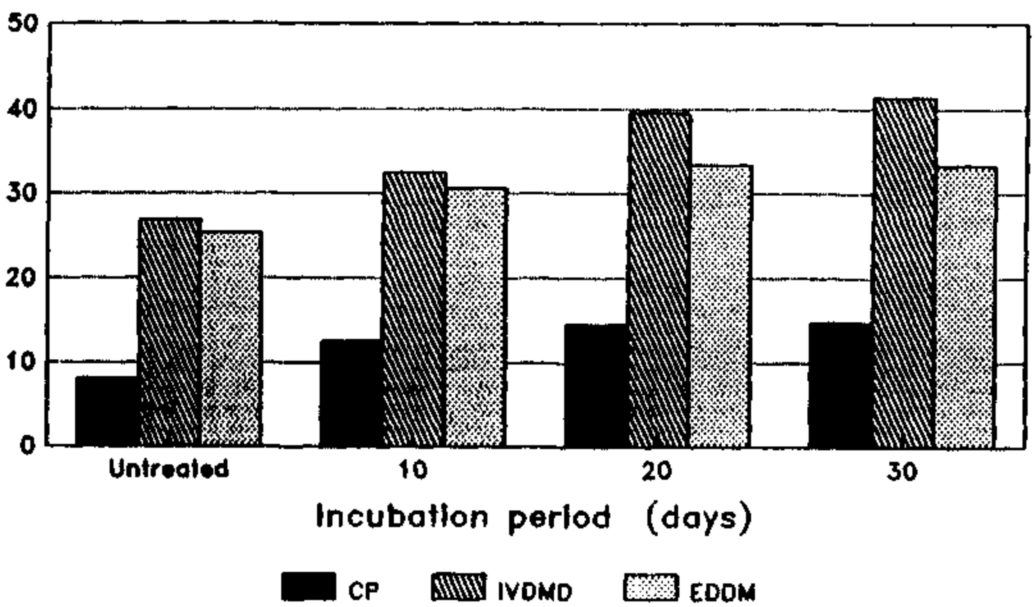
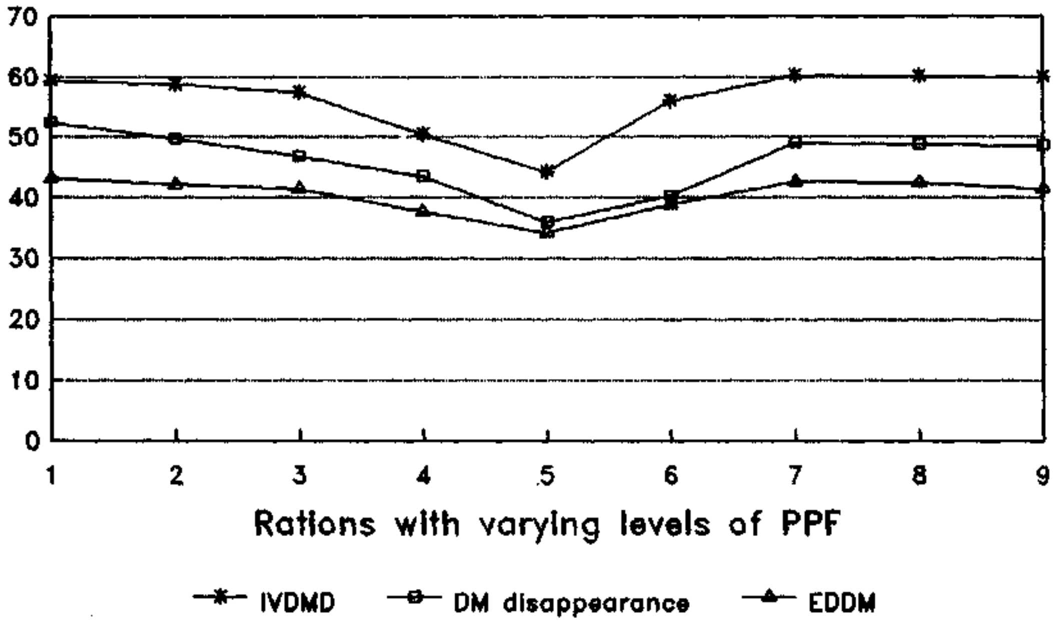


Table 23: Effect of level of inclusion of untreated/urea treated PPF in complete rations replacing paddy straw on *in vitro* and *in sacco* DM disappearance.

Rations	IVDMD value	In sacco DM disappearance	Constants a	b	c	EDDM
1	59.42 ±0.32	52.41 ±5.19	16.12 ±0.08	47.61 ±1.02	0.0676	43.22 ±0.22
2	58.81 ±0.28	49.66 ±4.34	16.10 ±0.10	47.53 ±1.51	0.0632	42.18 ±0.31
3	57.58 ±0.51	46.83 ±6.09	15.71 ±0.09	46.22 ±1.66	0.0761	41.36 ±0.22
4	50.46 ±0.48	43.46 ±5.12	15.25 ±0.10	47.18 ±1.02	0.0662	37.72 ±0.51
5	44.22 ±0.31	35.96 ±5.19	14.98 ±0.31	45.72 ±1.56	0.0712	34.24 ±0.48
6	56.12 ±0.38	40.26 ±3.13	15.02 ±0.06	46.67 ±1.05	0.0634	38.82 ±0.39
7	60.22 ±0.32	48.91 ±5.16	15.31 ±0.07	46.52 ±1.20	0.0671	42.56 ±0.26
8	60.18 ±0.42	48.62 ±6.09	15.24 ±0.18	47.08 ±2.02	0.0672	42.52 ±0.62
9	59.96 ±0.52	48.52 ±4.16	15.07 ±0.24	47.22 ±2.12	0.0663	41.43 ±0.22

Illustration 7:Effect of replacing paddy straw with varying levels of PPF on in vitro *and in* sacco *parameters*



The constants 'a' (readily soluble), 'b' (insoluble but degradable with time) and 'c' (rate constant/hr) for rations containing untreated and urea treated PPF were derived from *in sacco* DM disappearance data. EDDM per cent of the above nine rations were calculated by using the soft ware obtained from Orskov and is presented in Table23. The EDDM values ranged from 34.24 to 43.22.

Both IVDM disappearance and EDDM followed a similar trend. As the level of untreated PPF increased, these values showed decreasing trend. But, by replacing paddy straw with urea treated PPF there was improvement in DM disappearance and EDDM upto 50% replacement. Further increase with level of replacement upto 100% did not affect significantly the DM disappearance and EDDM values.

4.5 NUTRITIVE VALUE OF UNTREATED AND UREA TREATED PPF

Nutritive values of untreated and urea treated PPF in terms of digestible crude protein (DCP) and total digestible nutrients (TDN) were determined by conducting separate digestion trials in four growing buffalo bull calves sequentially on groundnut haulms, groundnut haulms plus untreated PPF and groundnut haulms plus urea treated PPF. In calves fed groundnut haulms (3.0 kg DM) an average digestibility coefficients (Table 24) of 64.20, 54.12, 61.22 and 62.10 for CP, EE, CF and NFE were observed, respectively. By feeding untreated PPF (1.5 kg DM) with groundnut haulms (1.5 kg DM) daily, the average digestibility coefficients of untreated PPF were calculated by difference method (Table 24). The average digestibility coefficients were 46.24, 63.23, 2[illegible].12 and 47.82 for CP, EE, CF and NFE, respectively.

By feeding urea treated PPF (1.5 kg DM) in combination with groundnut haulms (1.5 kg DM) daily, the average digestibility coefficients of urea treated PPF were calculated by difference method (Table 24). Digestibility coefficients of organic nutrients were calculated to be 52.12, 64.40, 38.88 and 58.98 for CP, EE, CF and NFE, respectively.

Table 24: Average digestibility coefficients of organic nutrients and nutritive values of untreated/treated PPF by difference technique.

Feed	Digestibility coefficients				Nutritive value	
	CP	EE	CF	NFE	DCP	TDN
Groundnut haulms (alone)	64.20 ±1.28	54.12 ±1.53	61.22 ±2.02	62.10 ±1.89	7.10 0.10	56.90 ±1.81
Untreated PPF (By difference method)	46.24 ±1.57	63.23 ±1.88	25.12 ±1.92	47.82 ±1.67	3.70 ±0.23	42.30 ±1.09
Urea treated PPF (By difference method)	52.12 ±1.62	64.40 ±1.21	38.88 ±1.32	58.98 ±1.86	8.80 ±0.52	52.70 ±1.58

The average DCP and TDN values were calculated to be 7.10, 56.90; 3.70, 42.30 and 8.80, 52.70 for groundnut haulms, untreated PPF and urea treated PPF, respectively.

4.6 NUTRIENT UTILIZATION AND NITROGEN BALANCE STUDIES

To find out the optimum level of incorporation of PPF in buffalo rations, a 4 x 4 Latin square designed digestion-cum- nitrogen balance trial was conducted using four buffalo bull calves.

4.6.1 Chemical composition of feed stuffs

4.6.1.1 Urea treated PPF: Chemical composition of urea treated PPF at 4% urea concentration, 40% moisture level and incubated for 20 days, is presented in Table 25. The DM content in urea treated PPF was 63.60 per cent. The CP content of urea treated PPF was 16.82% as compared to 8.02% for untreated PPF on DM basis. On DM basis, treated PPF contained 9.01% EE, 39.20% CF, 24.77% NFE and 10.20% total ash. Fractionation of cell-wall constituents disclosed the presence of 70.42% NDF, 52.61% ADF, 17.81% hemicellulose, 33.18% cellulose, 17.13% lignin and 3.51% silica in the urea treated PPF on DM basis.

4.6.1.2 Paddy straw: The chemical composition of paddy straw used in the present study is presented in Table 25. On DM basis, Paddy straw contained 3.62, 1.78, 40.56, 36.94 and 17.10 per cent for CP, EE, CF, NFE and total ash, respectively. The NDF, ADF, hemicellulose, cellulose, lignin and silica content of paddy straw were 72.90, 51.60, 21.30, 31.63, 8.22 and 11.42 per cent on dry matter basis, respectively.

4.6.1.3.Concentrate Mixture: The CP, EE, CF, NFE and total ash for concentrate mixture used in the present study were 22.01, 4.21, 3.60, 60.54 and 9.64 per cent on

Table 25: Chemical composition (%) of feed stuffs used for *in vivo* evaluation of PPF.

Nutrient	Untreated PPF	Urea treated PPF	Paddy straw	Concentrate Mixture
DM	91.40	63.60	90.50	92.20
OM	91.98	89.80	82.90	90.36
CP	8.02	16.82	3.62	22.01
EE	9.04	9.01	1.78	4.21
CF	41.12	39.20	40.56	3.60
NFE	32.22	24.77	36.94	60.54
Total ash	9.60	10.20	17.10	9.64
NDF	72.48	70.42	72.90	25.56
ADF	53.09	52.61	51.60	6.96
Hemicellulose	19.39	17.81	21.30	18.60
Cellulose	33.64	33.18	31.63	5.10
Lignin	18.46	17.13	8.22	0.90
Silica	3.68	3.51	11.42	1.16

* on dry matter basis except for dry matter.

DM basis, respectively. The concentrate mixture contained 25.56% NDF, 6.96% ADF, 18.60% hemicellulose, 5.10% cellulose, 0.90% lignin and 1.16% silica on DM basis.

4.6.2 Effect on DM intake of buffalo calves

Murrah buffalo bull calves were fed rations containing paddy straw plus concentrate mixture (R_1), untreated PPF plus concentrate mixture (R_2), paddy straw plus urea treated PPF and concentrate mixture (R_3) and urea treated PPF plus concentrate mixture (R_4) to meet the nutrient requirements of buffalo calves as per Kearl (1982).

The daily DM intake from different roughage sources and concentrate mixture were calculated and presented in Table 26. The average DM intakes worked out to be 3.20, 2.85, 2.57 and 1.96 kg/day for R_1, R_2, R_3 and R_4 fed calves, respectively.

4.6.3 Effect on water intake and urine output

The average water consumption of calves expressed as L/day and L/kg DMI was 10.20, 3.19; 10.80, 3.79; 9.00, 3.50 and 7.80, 3.98 fed on R_1, R_2, R_3 and R_4 rations, respectively. The average urine output expressed as L/day and L/kg $W^{0.75}$/day was 4.42, 0.14; 4.89, 0.15; 4.62, 0.14 and 3.88, 0.13 in calves fed on R_1, R_2, R_3 and R_4, respectively (Table 26).

4.6.4 Effect on Nutrient Digestibility

The effect of urea treatment and replacement of paddy straw by untreated or urea treated PPF was studied in a metabolism trial and the data on the digestibilities of organic nutrients of proximate principles and cell-wall constituents of rations are presented in Tables 27 and 28, respectively.

Table 26: Effect of urea treatment of PPF and its inclusion to replace paddy straw as a roughage source on DMI, water consumption and urine output in Murrah buffalo calves.

	R_1	R_2	R_3	R_4
Live weight (kg)	103.00 ±1.63	101.00 ±1.02	102.00 ±1.06	104.00 ±1.26
Metabolic body weight	32.33 ±0.62	31.86 ±0.41	32.10 ±0.37	32.66 ±0.42
DMI through (kg/day)				
Paddy straw	1.36 ±0.18	-	0.73 ±0.31	-
Untreated PPF	-	1.65 ±1.01	-	-
Urea treated PPF	-	-	0.83 ± 0.52	1.78 ±0.96
Concentrate Mixture	1.84	1.20	1.01	0.18
Total DMI				
kg/day	3.20 ±0.18	2.85 ±1.01	2.57 ±0.43	1.96 ±0.96
kg/kgW$^{0.75}$/day	0.10 ±0.04	0.09 ±0.01	0.08 ±0.02	0.06 ±0.01
Water intake				
L/day	10.20 ±1.26	10.80 ±1.82	9.00 ±1.23	7.80 ±2.01
L/kg DMI	3.19 ±0.32	3.79 ±0.28	3.50 ±0.26	3.98 ±0.22
Urine out put				
L/day	4.42 ±0.96	4.89 ±0.82	4.62 ±0.64	3.88 ±0.34
L/kgW$^{0.75}$/day	0.14 ±0.02	0.15 ±0.06	0.14 ±0.02	0.13 ±0.04

The average DM, OM, CP, EE, CF and NFE digestibilities were 52.26, 56.58, 54.02, 52.20, 48.19 and 69.21 for R_1 as compared to 48.92, 50.92, 50.10, 58.19, 38.41, 56.22; 56.12, 62.25, 62.08, 63.13, 47.36 and 75.38 and 55.76, 59.75, 60.18, 62.12, 46.11, 74.12 for R_2, R_3 and R_4, respectively (Table 27).

Significantly ($P<0.01$) lower digestibilities of nutrients except ether extract digestibility were observed for R_2 in comparison to R_1, R_3, or R_4. No significant difference was observed between 50% (R_3) and 100% replacement (R_4) of paddy straw by urea treated PPF. Except for CF digestibility, all nutrient digestibilities were significantly ($P< 0.01$) higher for urea treated PPF containing rations compared to paddy straw based ration (R_1).

The average digestibility coefficients of NDF, ADF hemicellulose, cellulose and lignin were 54.32, 43.18, 62.71, 53.16, and 12.42 for R_1 fed calves as compared to 50.23, 42.33, 57.54, 52.66, 10.42; 58.02, 46.19, 63.26, 61.23, 22.61 and 58.81, 45.27, 64.18, 60.36, 20.42, respectively for calves fed on R_2, R_3 and R_4 (Table 28). Ammoniation through urea treatment has significantly increased the digestibilities of NDF, ADF, cellulose, lignin ($P<0.01$) and hemicellulose ($P<0.05$). Replacement of paddy straw by urea treated PPF has significantly ($P<0.01$) increased the digestibilities of all cell-wall fractions except for hemicellulose. However, no significant differences were observed on the digestibilities of fibre fractions between R_3 and R_4.

4.6.5 Nitrogen Balance Study

Data showing the effect of urea treatment and replacement of paddy straw by untreated and urea treated PPF on N-utilisation of calves are present in Table 29. The average total-N intake expressed as g/day or g/kg $w^{0.75}$/day were 72.80, 2.25; 63.32, 1.99; 62.16, 1.94 and 54.42, 1.67, respectively in calves fed R_1, R_2, R_3 and R_4. Significantly ($P < 0.01$) higher N intake was observed in calves fed R_1 while significantly lower ($P < 0.01$) N intake was observed in R_4 fed calves.

Table 27: Effect of urea treatment of PPF and replacement of paddy straw on nutrient digestibility (%) of rations in Murrah buffalo bull calves.

Nutrient	R_1	R_2	R_3	R_4
Dry matter	52.26[b] ±0.87	48.92[a] ±1.36	56.12[c] ±1.78	55.76[c] ±1.19
Organic matter	56.58[b] ±1.96	50.92[a] ±0.92	62.25[c] ±1.08	59.75[c] ±1.98
Crude protein	54.02[b] ±1.92	50.10[a] ±1.96	62.08[c] ±2.26	60.18[c] ±2.20
Ether Extract	52.20[a] ±1.86	58.19[b] ±1.81	63.13[c] ±1.62	62.12[c] ±1.81
Crude Fibre	48.19[b] ±0.97	38.41[a] ±1.42	47.36[b] ±1.58	46.11[b] ±1.62
Nitrogen Free Extract	69.21[b] ±2.22	56.22[a] ±0.92	75.38[c] ±2.56	74.12[c] ±2.01

Each value is the average of 4 observations.

[abc] values in the rows bearing different supersripts differ significantly ($P<0.01$).

Table 28: Effect of urea treatment of PPF and replacement of paddy straw on digestibility (%) of cell-wall constituents in buffalo bull calves.

Nutrient	R_1	R_2	R_3	R_4
Neutral detergent fibre	54.32[b] ±1.38	50.23[a] ±2.26	58.02[c] ±3.01	58.81[c] ±2.35
Acid detergent fibre	43.18[a] ±1.32	42.33[a] ±2.35	46.19[b] ±4.08	45.27[b] ±2.62
Hemicullose	62.71[b] ±1.73	57.54[a] ±3.01	63.26[b] ±3.52	64.18[b] ±3.16
Cellulose	53.16[a] ±1.38	52.66[a] ±1.58	61.23[b] ±3.12	60.36[b] ±4.18
Lignin	12.42[a] ±1.36	10.42[a] ±1.72	22.61[b] ±2.02	20.42[b] ±1.18

Each value is the average of 4 observations.

[abc] values in the rows being different superscripts differ significantly.

Table 29: Effect of urea treatment of PPF and replacement of paddy straw on nitrogen utilisation in Murrah buffalo bull calves.

Parameters	R_1	R_2	R_3	R_4
N intake through (g/day)				
Paddy straw	7.86 ±0.98	-	4.19 ±1.02	-
Untreated PPF	-	21.11 ±1.18	-	-
Ureatreated PPF	-	-	22.15 ±0.96	47.93 ±2.36
Concentrate Mixture	64.94	42.21	35.72	6.49
Total N intake				
g/day	72.80[c] ±0.98	63.32[b] ±1.18	62.06[b] ±0.99	54.42[a] ±2.36
g/kg $w^{0.75}$/day	2.25[c] ±0.40	1.99[b] ±0.56	1.94[b] ±0.46	1.67[a] ±0.98
N excretion (g/day)				
Faeces	33.47 ±1.85	31.62 ±1.76	23.54 ±2.06	21.70 ±1.76
Urine	31.66 ±0.96	29.52 ±1.42	30.18 ±1.71	29.51 ±1.83
Total	65.13[b] ±2.01	61.14[b] ±1.83	53.72[a] ±1.66	51.21[a] ±2.32
N retention				
g/day	7.63[b] ±1.12	2.18[a] ±1.32	8.44[b] ±1.61	3.21[a] ±0.32
g/kg $W^{0.75}$/day	0.24[b] ±0.06	0.07[a] ±0.01	0.26[b] ±0.08	0.10[a] ±0.04
Percent of intake	10.48[b] ±0.12	3.40[a] ±0.03	13.58[a] ±0.28	5.90[a] ±0.06

Each value is the average of 4 observations.

[abc] values in the rows being different superscripts differ significantly.

Total N excretion through faeces and urine were 65.13, 61.14, 53.72 and 51.21 g/day, respectively for R_1 to R_4 fed animals. The N excretion through urine was higher than that excreted through faeces in calves fed rations containing urea-ammoniated PPF. The N retention expressed as g/day, g/kg $w^{0.75}$/day and as per cent of intake was 7.63, 0.24, 10.48; 2.18, 0.07, 3.4; 8.44, 0.26, 13.58 and 5.21, 0.10, 5.90, respectively for R_1, R_2, R_3 and R_4 fed calves. Significantly higher ($P<0.05$) N retention was observed in calves fed R_1 and R_3 when compared to R_2 and R_4.

4.6.6 Nutritive Value of Rations

The DCP, TDN, DE and ME values of rations fed to calves are presented in Table 30. The DCP and TDN contents were 7.68, 55.60; 6.96, 60.13; 9.4, 66.07 and 10.43, 60.05, per cent for R_1, R_2, R_3 and R_4, respectively. Significantly ($P<0.01$) higher DCP and TDN values were observed for R_4 followed by R_3.

It was further observed in the present study that urea treatment has narrowed down the nutritive ratio of rations from 1:7.6 for untreated PPF to 1:4.8 for treated PPF. The calculated DE and ME (M Cal/kg DM) values were 2.45, 2.01; 2.65, 2.17; 2.94, 2.41 and 2.65, 2.17 for R_1 to R_4, respectively. Significantly higher ($P<0.01$) DE and ME values were found for R_3 followed by R_4.

Table 30: Effect of urea treatment of PPF and replacement of paddy straw on the nutritive value of PPF fed to Murrah buffalo bull calves.

Parameter	R_1	R_2	R_3	R_4
Digestible crude protein (%)	7.68^{b} ±0.06	6.96^{a} ±0.07	9.40^{c} ±0.10	10.43^{c} ±0.23
Total Digestible Nutrients (%)	55.60^{a} ±1.09	60.13^{b} ±0.83	66.07^{c} ±1.26	60.05^{b} ±1.68
Nutritive ratio	1:6.24	1:7.64	1:6.09	1:4.75
Digestible energy (DE) M cal/kg DM	2.45^{a} ±0.06	2.65^{ab} ±0.06	2.94^{b} ±0.05	2.65^{ab} ±0.07
Metabolizable energy (ME) M cal/kg DM	2.01^{a} ±0.05	2.17^{ab} ±0.06	2.41^{b} ±0.04	2.17^{ab} ±0.06

Each value is the average of 4 observations.

^{abc} values in the rows being different superscripts differ significantly.

DISCUSSION

CHAPTER V

DISCUSSION

Oil palm by-products are good examples of un-conventional feedstuffs which are emerging as important new feed resources in southern India. Of late the importance of these new feed resources is increasing with the rapidly expanding area under oil palm cultivation, especially in coastal parts of south India. The availability of these by-products in the near future will be quite substantial. For their effective utilisation it is essential to determine their potential feeding values and to develop suitable processing techniques to further enhance their nutritional quality for feeding to appropriate livestock species. PPF is one of the three by-products available from oil processing industry is having a great potential for exploitation as an un- conventional roughage source for ruminants.

Huge quantities of PPF are available in the premises of oil palm extraction plants posing environmental pollution problems. Evaluation of this emerging agro-industrial by-product and its enrichment to use as potential feed resource for farm live stock is of paramount importance in India in view of acute shortage of feed and fodder resources.

5.1 AVAILABILITY OF PALM BY-PRODUCTS

Besides oil, by products such as palm press fibre (PPF), palm kernel cake (PKC) and palm oil sludge (POS) are available from the oil palm extraction plants. Extensive studies have been conducted in Malaysia to assess the potential feeding value of oil palm by-products in ruminants as well as in non-ruminants. Results of these studies have been reviewed by Devendra *et al* (1982). Based on the estimated extraction rates of oil palm by-products in Malaysia, quantities that could be available from Andhra Pradesh state have been worked out. About 4.6 m t of PPF, 8.3 m t of

POS and 6.9 m t of PKC would be available if oil palm cultivation is extended to the estimated 4 lakhs hectares of area in Andhra Pradesh to replace conventional feed sources for farm livestock. Vasantha Lakshmi and Krishna (1995) reported the feeding value of PKC and its future role as a protein source in sheep rations.

5.2 CHEMICAL COMPOSITION OF PPF

Chemical analysis of data from the present study revealed that the dry matter content of sundried PPF was 91.40%. On DM basis the CP, EE, CF, NFE, total ash, Ca, P and Mg content of PPF were 8.02, 9.04, 41.12, 32.22, 9.60, 0.65, 0.21 and 0.17%, respectively (Table 7). The present values of CP, CF, NFE and total ash were more than the values of 4.0, 36.4, 29.6 and 9.0 per cent reported by Devendra (1977). There was a wide variation in EE value observed in the present study in comparison to 21.0% reported by Devendra (1977). Variation in the chemical composition may be due to the differences in the processing technique employed for oil extraction, soil profile, environmental conditions, varietal differences among samples tested.

Fractionation of cell wall constituents of PPF (Table 8) revealed 72.48% NDF, 53.09% ADF, 19.39% hemicellulose, 33.64% cellulose, 18.46% lignin and 3.68% silica, indicative of its high fibre and lignin contents. The gross energy value of PPF was determined to be 20.40 MJ/kg DM which was marginally higher than the reported value of 18.10 MJ/kg DM by Devendra (1977).

5.3 *IN VITRO* EVALUATION OF PPF

The IVDMD of PPF in the present study was 26.90% which was higher than the value (18.78%) reported for PKC by Vasantha Lakshmi *et al* (1995). Nageswara Rao *et al* (1995) reported the *In vitro* DM digestibility (%) of various locally available roughage sources such as nendra grass hay (14.80), spear grass hay (14.07), Jowar straw (15.38), ground nut hulls (16.60) and cotton straw (16.33), are lower than that of PPF. This may be indicative of its superiority over most of the range grasses and conventional crop residues. *In vitro* DM digestibility of paddy straw was found to be 26.34% (Vasant Kumar *et al.* 1980) which is nearer to the IVDMD value of PPF. Based on the relatively higher IVDMD value PPF appears to be a potent roughage source for feeding ruminants.

Because of its high fibre content, PKC was preferred for lactating cattle to raise the fat content of milk in UK and Europe (Devendra, 1988). Similarly PPF can also be used as a good roughage source to lactating cattle to raise the milk fat content.

5.4 *IN SACCO* EVALUATION OF PPF

Dry matter degradability of PPF was determined by *In situ* nylon bag technique by incubating ground samples in the rumen of three fistulated buffalo bulls. There was a linear increase in the DM disappearance of PPF samples by extending the period of incubation in the rumen from 12 to 72hr (Table 9). In a similar study Wong *et al.* (1990) reported that DM and CP degradability values were 59.6 and 60.9% in steers fed rice straw as compared to 69.3 and 74.4%, respectively on napier grass feeding with 48 hr of incubation in the rumen. The per cent DM loss at 48 hr of rumen incubation of rice straw was 49.3 and 53.2 in cattle and buffaloes, respectively.

In the present study the readily soluble fraction 'a' of PPF was 12.19% and that of insoluble but degradable 'b' fraction was 28.70%. The constant 'c' which denotes the fractional rate constant at which 'b' is degraded per hour was calculated to be 0.0876 (Table 10).

The EDDM value of PPF was calculated to be 25.32%. The corresponding values for paddy straw were 12.0, 46.1, 0.0372 for a, b, c constants, respectively, with an EDDM value of 33.91% as reported by Ramanaiah and Krishna (1993). In a comparative evaluation study Shibata and Osman (1988) reported higher disappearance values of DM, CP and CF in PKC in comparison to PPF from nylon bags suspended in the rumen of cattle for 40 hr. EDDM of PPF (25.32%) was lower than that of paddy straw (33.91) as reported by Ramanaiah and Krishna (1993). It may be due to higher lignin (18.46%) and EE (9.04%) levels in PPF compared to paddy straw.

5.5 UREA TREATMENT OF PPF

In view of low DCP (3.7%), high fibre (41.12%) and lignin (18.46%) contents in the PPF, an attempt has been made in the present study to enrich and improve the feeding value by urea- ammoniation treatment. PPF was initially treated with 3,4 and 5% urea concentrations at 30, 40 and 50% moisture levels for 10, 20 and 30 days in 2L capacity plastic jars to hold about 500 g treated material. The effect of varying levels of urea, moisture and period of incubation on the nutritional quality of PPF was studied by using data on chemical composition, *in vitro* and *in sacco* evaluation techniques as the criteria of evaluation.

5.5.1 Chemical Composition of Urea Treated PPF

The effect of varying levels of urea, moisture and incubation interval on chemical composition of urea treated PPF (Tables 11, 12 & 13 and illustrations 1, 2 & 3) revealed that CP alone showed marked increase with urea ammoniation.

The effect of urea concentration on the average CP content of treated PPF (Table 11) revealed that the CP values were increased by 43, 84 and 90% over that of untreated PPF (8.02%) for 3,4 and 5% urea levels, respectively. With the increase of urea level from 3 to 4% the CP content was raised by 2.98 percentage units while further increasing the urea level to 5%, improvement in CP level was only 0.43 percentage units reflecting only marginal improvement, which indicates that 4% urea level is enough for enriching the PPF. While attempt to improve the nutritive value of bajra straw Ramana *et al.* (1990) observed that raising the urea level beyond 5% did not show any improvement in CP level.

Studies on the effect of moisture level on the average CP content of treated PPF (Table 12) showed that CP values were higher by 5.81, 7.10 and 4.82 percentage units for PPF subjected to 30, 40 and 50% moisture levels, respectively as compared to untreated PPF. Increasing the moisture level from 30 to 40% enhanced ($P<0.01$) the average CP value by 1.29 percentage units. Raising the moisture level from 40 to 50% was however, found to reduce ($P<0.01$) the CP value by 2.28 percentage units indicating that 40% moisture was adequate for ammoniation of PPF through urea-treatment.

Optimum level of moisture is essential to dissolve and hydrolyse urea during ammoniation. Several researchers have tried varying moisture levels in an attempt to standardise the technique of urea treatment for several crop residues. Ramana Reddy *et al.* (1996) reported that 40% moisture level was optimum for enriching Cenchrus hay. Chandrasekharaiah (1993) also reported that 40% moisture was optimum for improving the nutritional quality of maize stover.

The study on the effect of period of incubation (table 13) revealed an increase in CP value by 56, 81 and 84% for 10, 20 and 30 days period of incubation, respectively which shows that extending the period beyond 20 days had limited advantage. This fact was confirmed by the calculation of per cent incorporation of urea-N which increased from 28.25% for samples incubated for 10 days to 40.63% by extending the period of incubation to 20 days which was increased by only 1.27 percentage units by further extending the incubation period to 30 days.

The per cent incorporation of N in ammoniated straws is influenced by the ambient temperature (Horton, 1978). Ammoniation at laboratory scale was carried out in the present study during the month of December, 1996 having a maximum day temperature ranging from 29.5 to 36.8°C and a minimum temperature ranging from 12.5 to 20.20°C. The relative humidity ranged from 40 to 85% during the above period. Hence, the maximum period of incubation for ammoniation in the present study was restricted to 30 days keeping in view the ambient temperature of this region. For adoption of the technique by the small holders, shorter treatment periods are more practicable due to limited infrastructure facilities available to treat huge masses at each time.

As evident from the findings of Mascareinhars - Ferreira (1989) increasing the treatment period reduces the amount of un hydrolysed urea. Cottyn and de Boever (1988) reported that the material need optimum exposure to ammoniation to exhibit maximum beneficial effects since ammonia treatment improves the quantity of enzymatic assailable cellulose, because small ammonia molecules are able to penetrate the inter-fibroid spaces of the crystalline cellulose in order to breakdown the hydrogen bridges.

The findings of the present study show that minimum period required to enrich the PPF through urea treatment is 20 days. Mascarenhas - Ferriere *et al.* (1989) reported decrease in NDF, hemicellulose and lignin and increase in cellulose content of urea treated meadow hay. In the present study a decreased trend in NDF was observed irrespective of level of moisture as the period of incubation increased from 10 to 20 days (Table 13).

Based on the chemical composition studies 4% urea concentration at 40% moisture level and 20 days incubation period appeared to be optimum for enrichment of PPF through urea- ammoniation.

5.5.2 *In Vitro* Evaluation

Studies on the effect of levels of urea, moisture and period of incubation on IVDMD of PPF (Table 14) revealed that *in vitro* values were higher by 8.76, 12.23 and 11.70 percentage units for PPF subjected to 3, 4 and 5% urea levels, respectively as compared to untreated PPF. Increasing the urea level from 3 to 4% increased the average IVDMD by 3.47 percentage units. Raising urea level further to 5% however was found to reduce the IVDMD value indicating 4% urea was adequate for effective ammoniation of PPF through urea treatment.

The average IVDMD values were higher by 10.27, 11.66 and 10.75 percentage units for urea treated PPF at 30, 40 and 50 % moisture levels, respectively as compared to untreated PPF. Raising the moisture level from 30 to 40% increased the average IVDMD value by 1.39 percentage units. Increasing the moisture level further to 50% was, however found to reduce the IVDMD value indicating 40% moisture level was adequate for optimum ammoniation.

The mean IVDMD values were higher by 7.11 and 1.83 percentage units, respectively by extending the period of incubation from 10 to 20 and 30 days indicating that extending the period of incubation beyond 20 days had only marginal additional advantage in improving the nutritional quality of PPF through urea ammoniation adequate for ammoniation of PPF for effective utilization.

In a similar study Tripathi *et al.* (1987) reported higher IVDMD values for rice straw treated with 5% urea solution when incubated in plastic buckets or earthern pits for 4 weeks. Among the three factors viz. urea level, moisture gradient and treatment period and their interactions affecting the feeding value of treated roughages, moisture gradient and treatment periods as well as their interactions were reported to play a significant role on *in vitro* DM loss of straw as reported by Yadav and Yadava

(1986b). They considered the DM loss during straw treatment as one of the important factors helpful in the selection of optimum time and method of treatment having water involvement.

It has been reported that different straws respond differently to gradients of moisture treatment during ammoniation. Yadav and Yadava (1988) observed significant ($P<0.01$) increase in IVDMD between moisture gradients in wheat straw but not for the paddy straw. The DM loss during the treatment was reported to occur in a linear manner with minimum loss at 30% moisture level.

Mikami *et al.* (1986) reported differences in response to moisture treatment between straws and hays. The IVDMD of straw was reported to increase proportionately upto 30% moisture level followed by gradual increase upto 40% but the digestibility of hay did not increase beyond 20% level. Based on the results of urea treatment of Cenchrus hay Ramana Reddy *et al.* (1996) observed the higher IVDMD values at 40% moisture level irrespective of period of incubation.

In the present study the IVDMD values were significantly ($P<0.01$) higher with 4% urea gradient, at 40% moisture level. Extending the period of incubation from 20 to 30 days had no added advantage on IVDMD of urea treated PPF.

5.5.3 *In sacco* Evaluation

Samples of PPF subjected to three urea levels at varying levels of moisture and periods of incubation were analysed by *in sacco* evaluation using nylon bag technique (Tables 15, 16 & 17). The average DM disappearance data of untreated and urea treated PPF incubated in the rumen of fistulated buffalo bull calves revealed that as the period of incubation was extended from 12 to 72 hr in the rumen, the per cent *in sacco* DM disappearance values of PPF progressively increased. Among the treated PPF, higher ($P<0.01$) average DM disappearance values were observed for the PPF subjected to 3, 4 and 5% urea levels irrespective of moisture level and period of incubation (Table 15). The average *in sacco* DM disappearance of urea treated PPF was higher (P<0.01) by 2.5 and 1.26 percentage units with 4% urea-ammoniation in comparison to 3 and 5% urea concentrations, respectively.

Ramana *et al.* (1990) also observed that increasing the urea level above 4% did not improve DM disappearance of urea treated bajra straw. Through similar study by Jaikishan *et al.* (1987) optimised decided the levels of urea application for proper ammoniation of paddy straw in order to improve its nutritional quality. The level of urea significantly (P<0.01) influenced the *in sacco* DM disappearance and the values were highest with 5% urea treatment.

Among the treated PPF, higher (P<0.01) average DM disappearance values were observed for the PPF subjected to 40% moisture irrespective of urea concentration and period of incubation (Table 16). The average DM disappearance values were higher by 6.22, 9.06 and 7.96 percentage units for the PPF subjected to 30, 40 and 50% moisture levels, respectively as compared to untreated PPF. Increasing the moisture level from 30 to 40% enhanced (P<0.01) the average DM disappearance values by 2.84 percentage units. Raising the moisture level from 40 to 50% was however, found to reduce the mean DM disappearance value by 1.14 percentage units indicating that 40% moisture was quite adequate and optimum level for ammoniation of PPF through urea-treatment. In an attempt to standardise the technique of urea-ammoniation of cenchrus hay, Ramana Reddy *et al.* (1996) also reported 40% moisture level was optimum with regard to *in sacco* DM disappearance values.

The average DM disappearance values at varying periods of ammoniation during urea treatment of PPF indicated that extending the period of incubation from 10 to 20 days showed 11% improvement in DM disappearance value and incubation beyond 20 days was however, found to reduce the DM disappearance value, suggesting that 20 days of incubation is enough for effective ammoniation of PPF through urea-treatment.

Since the *in sacco* DM disappearance values are relevant to the specific periods of incubation in the rumen, effective degradable dry matter (EDDM) values were calculated from the *in sacco* DM disappearance data to determine optimum levels of urea, moisture and period of incubation while ammoniating PPF through urea treatment. Soluble DM fraction `a' increased from 12.19% for untreated PPF to a maximum of 17.58% indicating 45% improvement in solubilising dry matter of PPF. It was evident from the study that the influence of urea treatment in improving the insoluble but degradable fraction `b' was marginal. Among the different moisture levels compared, higher `b' values were observed for PPF subjected to 40% moisture level irrespective of period of incubation. The overall effect of ammoniation was mediated in the form of `a', `b' and `c' constants of PPF which ultimately reflected in the form of higher EDDM values.

The EDDM values increased from 25.32 per cent for untreated PPF to a maximum value of 38.65% showing 53% improvement with 4% urea concentration at 40% moisture level when incubated for 20 days. Venkataramana *et al.* (1989) earlier reported an improvement in EDDM values by 56% with 4% urea treatment of bajra stalks at 30% moisture level for 20 days while Ramana Reddy *et al.* (1996) observed an improvement in EDDM values by 38% with 4% urea treatment of cenchrus hay at 40% moisture level for 10 days indicating that different roughage sources respond differently to ammoniation through urea treatment probably due to changes in the chemical structure of the substrate and the conditions prevailing at the time of treatment.

Based on the chemical, *in vitro* and *in sacco* evaluation studies 4% urea concentration, 40% moisture level and 20 days of incubation period were choosen for ammoniation of PPF through urea-treatment.

5.6 *IN VITRO* AND *IN SACCO* EVALUATION OF COMPLETE RATIONS

Nine complete rations were formulated (Table 5) replacing paddy straw with untreated and urea treated PPF at graded levels of 25%. These rations were evaluated using *in vitro* and *in sacco* techniques to determine the effective level of incorporation of PPF in the rations of buffaloes.

In vitro DM digestibility followed a decreasing trend as the level of PPF increased which may be due to higher lignin (18.46%) content of PPF. The results were in accordance with the findings of Devendra (1977) who reported the optimum level of dietary inclusion of PPF to be 40%, beyond which drastic reduction in DM digestibility was observed. With the incorporation of urea treated PPF IVDMD values were increased upto 75% level indicating that urea-ammoniation of PPF has got a positive and significant effect on nutrient utilization of PPF containing rations.

The pattern of *in sacco* DM disappearance and EDDM followed similar trend (Table 23). The values decreased with increase in the level of untreated PPF inclusion in the rations. It may be due to higher lignin (18.41%) and EE (9.04%) levels present in PPF compared to paddy straw. In a study conducted, ether extractive level of PPF was reduced by solvent extraction process from 9.04 to 1% at laboratory level. As the level of EE decreased, there was progressive increase in the DM disappearance of PPF from 26.90 (9.04% EE) to 34.5% (1% EE). At 1% EE level, EDDM of PPF was higher than that of paddy straw. Inclusion of urea treated PPF in the rations significantly ($P<0.01$) improved the DM disappearance and EDDM values.

The results of *in vitro* and *in sacco* evaluation of rations containing untreated and urea treated PPF confirmed that urea treated PPF can be included in the rations of buffaloes as an alternate roughage source with substantial reduction in the concentrate component of rations meant for buffaloes. .pa

5.7 *IN VIVO* STUDIES

PPF treated with 4% urea at a moisture level of 40% with an incubation period of 20 days was further evaluated *in vivo* interms of its nutritive value and to find out the effect of its inclusion in the rations of buffaloes.

5.7.1 Nutritive Value of Untreated and Urea Treated PPF

Nutritive values of untreated and urea treated PPF interms of DCP and TDN were determined by differential technique using four buffalo bull calves. The average DCP and TDN values (Table 24) of untreated and urea treated PPF were 3.7 and 42.3% and 8.8, 52.7%, respectively. Urea-ammoniation treatment of PPF has improved the DCP and TDN values by 138 and 25%, respectively.

Studies conducted on the nutritional value of untreated and urea treated cereal straws revealed that urea-ammonia treatment has significantly improved the DCP and TDN values of cereal straws. Reddy *et al.* (1989) reported that urea treatment of paddy straw through ensiling has improved the DCP and TDN by 450 and 23%, respectively.

5.7.2 Nutrient Utilization and Nitrogen Balance Studies

To study the effect of urea treatment and subsequent inclusion of PPF to replace paddy straw in the rations of buffaloes, a 4 x 4 latin square designed metabolism trial was conducted using four buffalo bull calves.

For *in vivo* evaluation of PPF, urea treatment was carried out in the month of February, 1997, when the maximum and minimum temperatures ranged from 32.5 to 38.2°C and 14.6 to 21.5°C, respectively. The relative humidity was within the range of 45 to 75% during the treatment period for *in vivo* evaluation. There was not much difference in the average temperatures and relative humidity values prevailing at the time of urea treatment of PPF during initial screening as well as during *in vivo* evaluation study.

5.7.3 Chemical Composition of Treated PPF

Average DM of treated PPF with 4% urea at 40% moisture level and incubated for 20 days was 63.60% (Table 25). On DM basis CP, EE, CF, NFE and total ash values of treated PPF were 16.82, 9.01, 39.20, 24.77 and 10.20, respectively. The CP content of urea treated PPF increased by 2.1-fold as compared to untreated PPF. Increase in protein content decreased the NFE content of treated PPF from 32.22 to 24.77%. The total ash content of urea treated PPF (10.20%) was higher as compared to untreated PPF (9.60%) due to the presence of minerals dissolved in added water.

Determination of cell-wall constituents of treated PPF (Table 25) revealed 70.42% NDF, 52.61% ADF, 17.81% hemicellulose, 33.18% cellulose, 17.13% lignin and 3.51%, silica on DM basis. The NDF, hemicellulose and lignin fractions of urea treated PPF were less by 2.06, 1.58 and 1.33 percentage units, respectively as compared to untreated PPF.

5.7 4 Dry matter Intake of Calves

Calves with average initial body weights of 103, 101, 102 and 104 kg with metabolic body weights of 32.33, 31.86, 32.10 and 32.66 kg were fed with rations R_1, R_2, R_3 and R_4, respectively. The calves were offered feed to meet the energy and protein requirements according to Kearl (1982).

The average DMI expressed as kg/day and as kg/kg $W^{0.75}$/day was 3.20, 0.10; 2.85, 0.09; 2.57, 0.08 and 1.96, 0.06, respectively in calves fed R_1, R_2, R_3 and R_4. The DMI from different roughage sources was 1.36, 1.65, 1.56 and 1.78 kg/head/day for R_1, R_2, R_3 and R_4, respectively. Drymatter from concentrate mixture contributed to 58, 42, 39 and 9% of the total DMI in calves fed R_1, R_2, R_3 and R_4, respectively.

The results revealed that inclusion of urea treated PPF has drastically reduced the dependence on concentrate component of the total ration. Higher DMI from urea treated PPF could be due to increased rate of breakdown of feed particles in the rumen thus resulting in higher rate of passage of indigestible matter (Oji *et al.*, 1979). Venkataramana *et al.* (1989) reported that urea treatment of bajra straw at 4 and 5% levels though increased the voluntary DMI by 50 and 70g/day in sheep, the differences in DMI were not significant. In the present study urea treatment did not significantly increase total DMI of the rations. The reason probably could be due to restriction of PPF inclusion to 3 kg and maintaining concentrate mixture at levels to keep the rations isonitrogenous.

Water intake and urine out put did not differ significantly among different treatments. Agarwal and Rai (1986) had reported that water consumption was unaffected by ammoniation in buffaloes fed wheat straw treated with 4% urea. Ramana Reddy *et al.* (1996) also observed insignificant differences in water intake in animals fed untreated or urea treated cenchrus hay.

5.7.5 Nutrient Digestibility of Rations

Digestibility of all the organic nutrients differed significantly ($P<0.01$) among treatments. Lowest ($P<0.01$) digestibilities were observed in R_2 fed calves in comparison to R_1, R_3 and R_4 except EE digestibility which was lowest in R_1 ration. Similar trend was observed when the rations containing varying levels of untreated

PPF were included in the test rations and evaluated through *in vitro* and *in sacco* studies (Table 23). This may be due to higher lignin (18.46%) and EE (9.04%) content in PPF compared to paddy straw (8.22 and 1.78%, respectively).

Urea treatment in (R_4) increased ($P<0.01$) the digestibilities of DM, OM, CP, EE, CF and NFE by 6.84, 8.83, 10.08, 3.93, 7.70 and 17.90 percentage units, respectively as compared to feeding of untreated PPF (R_2). Higher digestibility of nutrients from urea treated PPF could result from a sustained release of added N into the rumen allowing a more intense microbial fermentation (Dias-Da Silva and Sundstol,1986) and increased solubilization of structural constituents (Yadav and Yadava, 1986 a). A slower release of bound N was observed by Oji *et al.* (1979) with ammonia treated straws. It was also possible that ammonium hydroxide production that followed urea hydrolysis in the sealed containers might have led to cleavage of alkali labile linkages existing between lignin and structural carbohydrates (Buettner *et al.*, 1982). It was a clear indication that such cleavage increases fibre degradability as was observed in the present study. Results of Wanapat *et al.* (1985a) revealed that the digestibility coefficients of all fractions of nutrients were increased by urea ensiling of rice straw.

In the present study ammoniation through urea treatment was found to increase ($P<0.01$) the digestibilities of NDF, ADF, cellulose and lignin by 8.58, 2.94, 7.7 and 10.0 and hemicellulose by 6.64 ($P<0.05$) percentage units, respectively (Table 28). Increased ($P<0.01$) digestibilities of NDF, ADF and cellulose by 5.8, 4.7 and 5.8 units, respectively were reported by Horton (1981) due to ammoniation in straws. The results of Buettner *et al.* (1982) with ammoniated Tall Fescue hay revealed higher ($P<0.01$) digestibility coefficients for NDF, ADF, cellulose and hemicellulose ($P<0.05$). Buettner *et al.* (1982) have further reported that ammoniation had significantly reduced ester bond absorbance and increased amide bond absorbance in the fibre fraction of the hay resulting from the breaking of ester bonds through aminolysis.

5.7.6 Nitrogen Utilization in Calves

The total N intake expressed as g/day and g/kg $W^{0.75}$/day was 72.80, 2.25; 63.32, 1.99; 62.06, 1.94 and 54.42, 1.67, respectively for rations R_1 to R_4 (Table 29). The average daily N intake in R_4 from urea treated PPF was 26.82 g higher than in R_2 from untreated PPF and N intake from concentrate mixture in R_4 was lesser by 58.45 g than that of R_1. N retention as percentage of intake or percentage of absorbed were higher for urea treated PPF (5.9 and 9.8%) when compared to untreated PPF (3.4 and 6.9%).

Lawlor *et al.* (1981) reported that approximately 58% of anhydrous ammonia added to the straw was irreversibly bound to the treated material. The N - retention studies further revealed that ammoniation of straw has slightly increased N retention of animals. The more conclusive aspect of their study was that when ammoniated straw was fed in conjunction with a concentrate of medium to low CP content it could be possible to maintain a positive N balance. As reported by Dias- Da-Silva *et al.* (1988) more than 90% of the retained N was water soluble when barley straw was treated with anhydrous ammonia. Further they have concluded that the N retained following urea treatment of maize stover represents a source of readily available N for rumen microbes.

The method of urea treatment also appeared to affect the N retention of urea treated straws. The N retained by urea treatment was reported to be 29.9% on stacking and 46.7% on ensiling (Reddy *et al.*, 1988). In the present study urea treatment was attempted in unused concrete floored shed ensuring optimum conditions for ammoniation.

5.7.7 **Nutritive Value of Rations**

The nutritive values expressed interms of digestible crude protein (DCP) and total digestible nutrients (TDN) were 7.68, 55.60; 6.96, 60.13; 9.4, 66.07 and 10.43,60.05, respectively in calves fed R_1, R_2, R_3 and R_4 (Table 30). The urea treatment increased ($P<0.01$) the DCP and TDN intake by 2.75 and 4.45 percentage units, respectively as compared to paddy straw based ration (R_1). In an earlier study Rahman *et al.* (1987) reported the DCP and TDN values to be 6 and 48%, respectively for treated wheat straw which were comparable to any maintenance type of non-legume forage. In the present study, the response to urea- treatment was higher in comparison to that observed with several straws tested earlier. Venkataramana *et al.* (1989) reported that ammoniation of bajra stalks increased the DCP and TDN intake in rams fed 4 or 5% urea treated bajra stalk rations. Venkataramana (1988) reported that urea treatment had narrowed down the nutritive ratio of straw from 1:7.4 to 1:4.1. In the present study it was observed that the nutritive ratio has narrowed down from 1:7.6 to 1:4.8 due to 4% urea treatment at 40% moisture level and incubated for 20 days, as compared to untreated PPF.

The calculated DE and ME expressed in terms of M cal/kg DM were higher ($P<0.01$) by 2.45, 2.01,; 2.65, 2.17; 2.94, 2.41 and 2.65, 2.17, respectively in calves fed R_1, R_2, R_3 and R_4 (Table 30) Puri and Gupta (1990) has earlier reported that feeding of urea treated rice straw increased the ME intake in cross bred calves. In the present study higher DE and ME intakes were observed in calves fed rations containing urea treated PPF as compared to those fed untreated PPF.

In the present study the daily intake of DCP was worked to be 246, 198, 241 and 205 g and TDN 1.78, 1.71, 1.71 and 1.18 kg in R_1, R_2, R_3 and R_4 fed calves, respectively. All the calves were on positive nitrogen balance. It was evident that all the rations could able to meet the DCP requirements (Kearl, 1982) and the calves fed on R_1, R_2 and R_3 rations only could meet the TDN requirements of growing calves (ICAR, 1985). The calves on R_4 could not meet the TDN requirements of growing calves (ICAR 1985 and Kearl 1982). The lower TDN intake in R_4 fed calves might be due to lower DMI. The PPF offered to calves was restricted to 3 kg in the present study as a safeguard against the high residual oil content in the PPF.

Generally rations are formulated to feed cattle and buffaloes in India to have not more than 4% EE level since high fat content leads to depressed fibre digestibility due to oil coating over feed particles. Currently oil is extracted from palm kernels through screw pressed process based on the technology developed in Malaysia. Ether extractive level of 9.04% observed in the present study is an indication of loss of valuable edible oil. Any attempt to prevent the percolation of residual oil into the PPF not only leads to substantial saving of oil for human consumption but also leads to the release of a valuable by- product in the form of PPF for animal feeding. This has been well established at laboratory scale, wherein reduction in oil content substantially improved the DMD of rations meant for buffalo feeding.

CONCLUSIONS

Based on the results of the present investigations the following conclusions are drawn.

1. PPF appeared to be a potential roughage source to be enriched by ammoniation through urea treatment.

2. Urea concentration of 4%, moisture content of 40% and incubation period of 20 days were found to be optimum conditions for ammoniating PPF through urea treatment.

3. The DCP and TDN values of untreated and urea treated PPF were 3.70, 42.30 and 8.80, 52.70%

4. Urea treatment significantly increased the nutrient digestibility, nitrogen utilization and nutritive value of PPF in Murrah buffalo bull calves.

SUMMARY

CHAPTER VI

SUMMARY

Palm Press Fibre (PPF) is one of the three important oil palm by-products available at oil palm extraction plants. It is the fibrous residue of the pericarp after separation of the nuts. In view of increased area being brought under oil palm cultivation in Andrha Pradesh, substantial quantities of oil palm by-products will be available as alternate feed resource for feeding ruminant livestock in areas where oil palm cultivation is being taken-up on commercial scale. Further, accumulation of huge heaps of PPF is likely to cause pollution problems in the vicinities of oil palm extraction plants, unless they are effectively put to use or disposed off. Till now, no work has been carriedout in India to determine the potential feeding value of PPF and the optimum level of its inclusion in livestock rations as an alternative roughage source.

In the present study besides studying the detailed chemical composition,an attempt has also been made to standardise the urea-ammoniation technique to exploit the potential feeding value of PPF for growing buffalo bull calves using chemical composition, *in vitro* and *in sacco* techniques followed by detailed *in vivo* studies as criteria of evaluation.

On DM basis PPF contained 8.02% CP, 9.04% EE, 41.12% CF, 32.22% NFE and 9.60% total ash. Fractionation of cell wall constituents of PPF revealed 72.48% NDF, 53.09% ADF, 19.39% hemicellulose, 33.64% cellulose, 18.46% lignin and 3.68% silica. The IVDMD and EDDM values of PPF were determine to the 26.90 and 25.32%, respectively with buffaloes. Ammoniation was attempted through urea treatment at 3,4 and 5% urea concentrations at moisture levels of 30, 40 and 50% with incubation intervals of 10, 20 and 30 days. Pilot scale studies were carriedout in the laboratory by incubating 500 g of PPF under each treatment using 2 l capacity screw capped plastic containers.

Among the several chemical constituents considered, CP content showed higher positive response. Urea ammoniation increase the CP content of PPF from 8.02% to a maximum of 16.82% with a treatment combination of 4% urea, 40% moisture and 20 days incubation. Highest IVDMD value of 44.85% was observed for PPF subjected to 4% urea treatment at 40% moisture for 20 days as compared to 26.90% for untreated PPF, with buffalo rumen liquor.

Urea treated PPF was further evaluated by nylon bag technique using *in sacco* DM disappearance data. Higher (P<0.01) average *in sacco* DM disappearance values of 42.97, 43.04 and 43.18% were obtained for the standard conditions of 4% urea, 40% moisture and 20 days of incubation, respectively. The constants `a', (readily soluble), `b' (insoluble but degradable) and `c' (rate constant/hr) values were calculated by using the softaware obtained from Orskov of Rowette Research Institute UK from *in sacco* DM disappearance data. Rumen outflow rate (K) of 0.04/hr was used to calculate the effective degradable drymatter (EDDM) values to compare the effect of varying treatment conditions on the DM degradability in the rumen of buffaloes. The soluble DM fraction (19%) and insoluble but degradable DM fraction (46.2%) were higher for PPF treated with 4% urea for 20 days at 40% moisture level in comparison to other treatment combinations. EDDM value (38.5%) was also higher for the treatment combinations of 4% urea concentration, 40% moisture and 20 days of incubation.

Based on the chemical, *in vitro* and in sacco evaluation studies, urea concentration of 4%, moisture level of 40% and incubation period of 20 days were choosen as the optimum conditions for ammoniation of PPF for *in vivo* evaluation.

Nine complete rations were formulated replacing paddy straw with untreated or urea treated PPF at graded levels of 25%. These rations were evaluated using in vitro and *in sacco* techniques to determine the optimum level of incorporation of PPF in the rations of buffaloes. Beneficial effects of inclusion of treated PPF in the rations of buffaloes were reflected through increased *in vitro* and *in sacco* DMD and EDDM values as the level of its inclusion increased while the values decreased as the level of untreated PPF inclusion was increased.

Nutritive values of untreated and urea treated PPF interms of DCP and TDN was determined by differential technique using four buffalo bull calves. The average DCP and TDN values of untreated and urea treated PPF were 3.7, 42.3% and 8.8 and 52.7%, respectively. The effect of urea treatment and subsequent inclusion of PPF to replace paddy straw in the rations of buffaloes was studied in a 4 x 4 latin square designed metabolism trial using four buffalo bull calves. The calves were fed rations containing paddy straw plus concentrate mixture (R_1), untreated PPF plus concentrate mixture (R_2), paddy straw, urea treated PPF plus concentrate mixture (R_3) and urea treated PPF plus concentrate mixture (R_4).

On DM basis, urea treated PPF prepared for *in vivo* evaluation studies had 16.32% CP, 39.20% CF, 24.77% NFE, 70.42% NDF, 52.61% ADF, 17.81% hemicellulose, 33.18% cellulose and 17.13% lignin. The total DMI and DMI from different roughage sources were 3.2, 1.36; 2.85, 1.65, 2.57, 1.56 and 1.97, 1.78 kg/day for R_1, R_2, R_3 and R_4, respectively. It was further obtained that the daily average water consumption and urine output were unaffected by urea treatment of PPF prior to feeding.

Feeding regimen with urea treated PPF under R_4 had higher digestibilities of DM, OM, CP, EE, CF and NFE by 6.84, 8.83, 10.08, 3.93, 7.7 and 17.9 percentage units and that of NDF, ADF, cellulose and lignin by 8.58, 2.94, 7.7 and 10.0

percentage units respectively ($P<0.01$)and hemicellulose by 6.64 percentage units ($P<0.05$) as compared to untreated PPF (R_2) feeding.

The total N intake expressed as g/day was 72.8, 63.32, 62.19 and 54.42, respectively for calves fed rations R_1 to R_4. As seen from N balance data it was observed that the N intake through roughage source was proportionately increased in calves fed R_4 at the cost of N intake from concentrate component. It is evident that substantial amount of concentrates could be saved, cost of feeding reduced when urea treated PPF constituted the sole roughage source in buffaloes. N retention as percentage of intake or percentage of absorbed was higher for urea treated PPF (6.0 and 9.8%) when compared to untreated PPF (3.4 and 6.9%) reflecting efficient N utilization from treated PPF in comparision to untreated PPF.

The nutritive values expressed interms of DCP and TDN were 7.66, 55.60; 6.96, 60.13; 9.4, 66.67 and 10.43, 60.5%, respectively in calves fed R_1, R_2, R_3 and R_4. Urea treatment R_4 increased($P<0.01$) the DCP and TDN intake by 2.75 and 4.45 percentage units, respectively as compared to paddy straw based ration (R_1).

The results of the present study revealed that palm press fibre appeared to be a potential roughage source for feeding buffaloes. Urea concentration of 4%, moisture content of 40% and incubation period of 20 days were found to be optimum conditions for improving the nutritional status of PPF with an improvement of 5.1 and 10.4 percentage units of DCP and TDN values over that of untreated PPF. Based on the overall evaluation criteria, by feeding urea treated PPF under standard conditions, it is possible to replace paddy straw completely in the conventional rations of buffaloes with a 90% saving on the investment of concentrate mixture in buffaloes. Based on the encouraging results obtained in the present investigation it is recommended to extend the studies on to determine the optimum levels of feeding this valuable roughage resource in the rations of growing and lactating buffaloes to reduce the cost of feeding.

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