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Research project report

INCREASING THE NUTRITIVE VALUE OF WHEAT STRAW THROUGH SUPPLEMENTATION

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DECLARATION

I declare that I did this research the best way I knew how and hope the information will be helpful to anybody who would be interested to venture in livestock industry.

Kemboi Evans

Signature …… Date……

Supervisor: Prof Wanyoike

Signature …… Date……..

ACKNOWLEDGEMENT

I acknowledge Prof. Wanyoike for the advice she provided to me making my research successful, also Mr .Benjamin Kyalo for his assistance with the lab analysis and the entire body of technologist of the department of Animal Production for giving me an enabling environment for my research.

I also acknowledge my family for financial support in making the research successful not forgetting my colleagues for giving me moral support and assistance during the write up of this report. GOD BLESS YOU ALL.

DEDICATION

I avail this document to any person who is interested and to farmers and trainers who would like to use the information.

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LIST OF ABREVIATION

WS – Wheat straw

C.S.C – Cotton seed cake

S. F.C – Sunflower cake

M – Molasses

ABSTRACT

Wheat straws are by products of wheat which are obtained after harvesting wheat . In many areas where wheat is grown, the straws are left in the field , a consequence of using modern combine harvesters which automatically separate the grain and put out straws and chaff together . On a world scale total production of straws is sufficient to meet the maintenance needs of ruminant livestock and is becoming increasingly important to livestock production for its availability. However, as is true of many cereal by products, wheat straws are of low nutritional value in terms of available nutrients and digestibility thus low potential intake in animals. The attempts that have been used to enhance the nutritional value of straws for animals have included supplementation with protein and other concentrates. Determination of the nutritive value of wheat straw through proximate analysis showed clearly that it has low nutritive value and its degradability, an indicator of potential digestibility, was low but when supplemented with different feedstuffs the *in sacco* DM degradability increased.

The data in Microsoft excel; presented in graphs showed that degradation increased with level of supplementation and time of incubation in the rumen. Of the supplements tested, cottonseed cake resulted in the highest improvement in DM degradability at an average of 25.67% while the sunflower seed residue gave the lowest at 24.28% both at 7.5% level of supplementation. From the results of this study it was concluded that supplementation with feedstuffs available to farmers in areas where wheat straws was viable as a means of improving their utilisation. Documentation of this information will be beneficial to farmers animal health practitioners and trainers.

CHAPTER ONE

1.0 INTRODUCTION

Livestock production depends on the nutritional status of the animal. The animal diet should encompass protein, carbohydrates , minerals ,vitamins and provision of adequate quantity and quality water.

Wheat straw and other fibrous crop byproducts have become increasingly important due to increased human population thus more land being used for food production. This has led to reduced available land for growing fodder for animals. Though the byproducts are of low quality they are seen a potentially cheap source of feed especially for ruminant animals. Wheat straw is most available in wheat growing areas of Kenya. Among the different methods that have been used to enhance the nutritional value of these byproducts as animal feed including physical, chemical and biological treatments, supplementation appears to be the most practical in many farming situations of the developing countries. Different supplements have been used. In this study the effects of protein supplements; cottonseed cake, sunflowerseed cake and Leucaena leaf hay, and an energy source; molasses, on *in sacco* rumen degradability of wheat straw will be assessed. Rumen degradability is widely accepted as a means of establishing potential feed value for ruminants **(Orskov and Macdonald 1979**).

1.1 PROBLEM STATEMENT

The pressure to provide feed to ruminant animals is increasing with the ever decreasing grazing land availability. Thus, fibrous crop byproducts, previously used as bedding litter and even burnt on some large farms, are contributing more to the animals' diets. Due to the low feed value of the residues, this has resulted in reduced livestock production. At the same time most farmers lack the technical information on the appropriate supplements that would complement these residues.

This research aims to evaluate the potential of some locally available feedstuffs as supplements to enhance nutritive value of straw as feed. The emphasis was on 'locally available feedstuffs' because their use would more sustainable as such are expected to be cheaper.

1.2 OBJECTIVES

1.2.1 General objective

To enhance the nutritive value of the wheat straw through supplementation

1.2.2 Specific objectives

1. To determine the nutritive value of wheat straw
2. To determine effects of different supplements on rumen DM degradability of the wheat straw

1.3 HYPOTHESIS

Wheat straw has low nutritive value which can be enhanced by use of supplements.

CHAPTER TWO

2.0 LITERATURE REVIEW

Straws consist of stems and leaves of plants after the removal of the ripe seeds by threshing and are produced from most cereals crops and some legumes. All the straws and related by – products are extremely fibrous, most have a high content of lignin, and are of low nutritive value. (**By McDonald , Edwards, Greenhalgh and Morgan, Animal Nutrition, page 473-474).** Cereal straws are characterized by their low content of fermentable energy, protein and minerals and high content of fiber, resulting in low digestibility. When legumes are intercropped with cereals, the soil and the residues are enriched. (**LPP PROJECT, R 6610**) (**Livestock and wealth creation edited by E. Owen, A. Kitalyi, N Jayasuriya and T Smith**).

As more land comes under cereal crops to feed the ever increasing human population and thus a decrease in land under pastures, efforts have been made to enhance the contribution of the fibrous residues to animal nutrition. Such efforts have included use of chemicals like sodium and other hydroxides and ammonia to treat wheat straws as well as use of supplements. Ammonia or sodium hydroxide raises the digestibility of the straw and also act as a preservative by preventing mould growth. Supplementation aims to enhance microbial breakdown of the fibrous feed in the rumen and thereby increase the digestibility and intake by the animals.

Treatment of wheat straws with alkali was done such that when straws is exposed to an alkali the ester linkages between lignin and the cell wall polysaccharides. The cellulose and hemicelluloses, are hydrolyzed, thereby causing the carbohydrates to become more available to rumen micro-organism. This effect was first used to improve the digestibility of the wheat straws in Germany in 1900s.

In the Beckman's process straw was soaked for 1-2 days in a dilute solution (15-30g/l) of sodium hydroxide and then washed exhaustively to remove excess alkali. This process increased the dry matter digestibility from 0.4 to 0.5-0.7 despite the fact that the washing removed a considerable proportion of soluble and presumably more digestible constituent of the straws (**Animal Nutrition by McDonald, Edwards , Greenhaigh and Morgan**). The treatment also leaves residues of sodium which increases the water intake of the animals fed on the treated straw.

2.0.1 Ammonia treatment

Ammonia has been applied to straws in the anhydrous form or as a concentrated solution. As both forms are volatile, the process has to be carried out in a sealed container which may be formed by wrapping a stack of straw bales in polyethylene sheet. The time required for treatment ranges from one week, if heat is applied to raise the temperature to 85^0C, to one month at winter temperatures. The ammonia is added at 30-35 kg/t of straw and when straw is exposed to air after the treatment about 2/3 of this is lost by volatilization. The remainder is bound to the straw and raises its crude protein content by about 50g /kg. The danger arising from ammonia treatment is that, it may sometimes cause the production of toxic imidazoles which arise from reactions between ammonia and sugars.

Urea treatment

Urea can be used as a source of ammonia to treat straw. It is often cheaper and easier to handle than ammonia. When exposed to the enzyme urease, urea is hydrolyzed to yield ammonia.

$$CO(NH_2)2 + H_2O \longrightarrow 2NH_3 + CO_2$$

Straws normally carry bacteria that secrete the necessary urease, however, it's important that the straw should be wet enough, at about 300g water per kg, to allow the hydrolysis to take place. After the application of urea, straws are sealed in the same way as for the treatment with ammonia. Improvement in digestibility of straw treated in such a manner is reported to be about 8 to 12 % units and intake by 25-50% (***www.fao.org/docrep/003/w4988e/w4)***.

Other chemicals that have been used effectively to improve the digestibility of straw include alkaline hydrogen peroxide and mineral acids, but these are probably too expensive for practical use.The foregoing chemical methods for improving the nutritive value of fibrous crop residues though effective are very rarely used in many developing countries for reasons probably including expense, availability and ease of application. In contrast, supplementation using locally available feedstuffs is widely practiced [**McDonald, Edwards, Greenhalgh and Morgan. Animal nutrition page 476-479**].

Supplementation of straws

The first type of supplement required for straw is one that provides adequate supplies of nutrients for the rumen micro-organism, the critical nutrients being nitrogen and sulphur and perhaps phosphorous, sodium and cobalt. The nitrogen supplement should provide a reasonably constant rumen ammonia concentration. If the nitrogen is in a soluble and rapidly degradable form, such as urea the supplement needs to be taken frequently in small quantities.

The second type of supplement required for straws is one that provides the animal with additional protein that is not degraded in rumen but digestible. This often stimulates intake and ensures a proper balance between the protein and energy supplied to the animal tissues.

Choice of supplements is limited by the high cost of the conventional supplements such as grain-based concentrates feeds, oil seed cakes, urea and minerals. However, some of the supplements such as leguminous forages can be grown on the farm thus easily available while others are easily sourced locally as agricultural products processing byproducts.

This review will be for some of these common supplements viz. Leuceana, molasses and oil crop processing byproducts (sunflower seed and cottonseed cakes).

Leucaena

Leucaena leucocephala is among forage legumes which have been widely used as a supplement to fibrous feeds. These supply nitrogen to rumen micro -organisms, thus enhancing digestion and increasing the intake of N- deficient feeds for example straws. **Kaitho et al., (1998)** fed different protein rich forages including Leucaena to sheep on teff straw and reported improved DM, OM and N digestibility which increased with increasing level of supplementation. While the animals on the control (teff straw alone) diet lost weight those receiving the browse supplements gained weight at levels which increased with supplement levels.

However, Leucaena contains a toxic amino acid mimosine. In the rumen this is converted to dihydroxypyridine [DHP} a compound with goitrogenic properties. Ruminants consuming large quantities of Luecaena may suffer from weight loss , thyroid dysfunction and loss of hair or wool [**Animal nutrition by McDonald , Edwards, Greenhalgh and Morgan page 447**]

Molasses

Sugarcane molasses is used extensively in feeding ruminants both as binder for compound feeds or to supply additional energy to the diet [Pat***et al,*** **1989**}. It is usually mixed with feed, but it may be sprayed on low quality roughage to improve its palatability and intake [**Leclarc ,2003**]. Low amounts of molasses in roughage- based diet stimulates rumen fermentation and rumen cellulolytic potential is maintained or improved with low quality forage diets. {**Feedipedia, Animal feed resources information system INRA CIRAD AFZ and FAO 2012-2015**}. However, being a source of readily available energy, at high levels it may depress the fiber digestibility and thus the fibrous feed intake. Feeding ruminants on high non-fibrous carbohydrates may negatively affect the populations of the micro-organisms responsible for fiber digestion thereby affecting utilization of fibrous feeds

OIL SEED CAKES

Oilseed cakes such as cotton seed and sunflower seed cakes even in the undecorticated state are good protein supplements for ruminants. Several studies have shown increased intake and a positive response in growth rate and N retention when oilseed cakes are incorporated into high fibre forages **(Yilala, 1988; Alhassan et al., 1989)**. Oilseed cakes contain both degradable protein, which supports rumen microbial activity thus enhanced fibre and overall digestibility of the forage, as well as un-degradable protein both of which improves supply of amino acids to the ruminant animal.

CHAPTER 3.0

3.0 MATERIALS AND METHODS

3.0.0 Study area

My project was done at the University of Nairobi, upper Kabete campus Department of Animal production.

3.0.1 Study design

The project involved use of the nylon bag technique where a fistulated steer was used and proximate analysis. The wheat straw was sourced from a farm in Uasin Gishu, the protein cakes (cotton and sunflower seed) and molasses from commercial animal feed sellers and the Leucaena from the university farm.

3.0.2 Data management and analysis

The data were collected and entered in a spread sheet, stored in a computer and then tables and graphs drawn using Microsoft excel.

3.1 PREPARATION OF FEEDSTUFFS SAMPLES

Samples were dried in an oven at 60^{o}c to a constant weight and then ground in Wiley mill to a particle size of 1mm. The particle size is important but for routine analyses, samples milled to pass through 1 mm mesh sieve for nylon bag degradability is recommended. Grinding exposes internal cell material to microbial enzymes attack in the rumen, thus speeding up digestion of the feed. The ground sample is stored in plastic containers with lids to keep out dust and other potential contaminants awaiting analysis.

3.2 PROXIMATE ANALYSIS FOR WHEATSTRAW

This analysis includes the determination in biological materials of moisture, ether extract, crude protein, ash, crude fiber and nitrogen free extract [NFE]. This was done according to the AOAC, (1998) procedures.

Moisture is determined by drying the sample in an oven at 60^{0}c to assess air- dry moisture content and at 105^{0}c for absolute moisture content of samples.

Ash is the inorganic non-combustible fraction of the sample and is obtained by combusting the sample in a muffle furnace at 550^{o}c. The percent of ash is used in calculating the organic matter by difference. The ash obtained is the starting point in the determination of specific analysis of minerals [calcium, phosphorous, magnesium, trace elements etc]

Ether extract is extracted with diethyl ether and includes simple lipids,[neutral fats, sterols],fat soluble vitamins, fat soluble hormones, cholesterol, chlorophyll, lecithin, resins, and volatile oils.

Crude fiber is that portion of carbohydrates that resists digestion when boiled for 30 minutes in dilute sulfuric acid, filtered, and the residue boiled in dilute potassium hydroxide. It includes cellulose and a portion of some of the other polysaccharides {araban, mannan , galactan] hemicelluloses and lignin.

Crude protein is determined by kjeldahl method which evaluates the total nitrogen content of the sample after it has been digested in sulphuric acid with a mercury or selenium catalyst. The nitrogen is then multiplied by the factor of 6.25to give an estimate of the crude protein content a conversion factor based on the assumption that the average protein contains about 16% nitrogen by weight. This method does not differentiate between proteinaceous and non-proteinaceous nitrogen and includes nitrogen of amino acid and amines. It gives no information of the kinds and amounts of amino acids.

Nitrogen free extract is an indirect measure of the ‘soluble’ or ‘digestible’ carbohydrate present within a food stuff estimated by subtracting the percentage content of the above

determinations from 100%. NFE consists of carbohydrates, sugars, starches, and a major portion of materials classified as hemicellulose in feeds.

3.3 NYLON BAG TECHNIQUE

This is a technique used for measuring degradability of feed in ruminants. In this technique a known weight of sample is placed in bags made of indigestible material. The bags are sealed tightly and incubated in the rumen of a fistulated animal and removed after specified periods of time, washed, dried and weighed again. Degradability of the substrate is determined as the weight loss during the incubation period. In this study the incubation durations were 0, 8, 16 and 24 hours. The test samples were:

1. Wheat straw (control)
2. Wheat straw + 5% molasses
3. Wheat straw +7.5% molasses
4. Wheat straw + 5% cottonseed cake
5. Wheat straw + 7.5% cottonseed cake
6. Wheat straw + 5% sunflowerseed cake
7. Wheat straw + 7.5% sunflower cake
8. Wheat straw + 5% Leucaena foliage
9. Wheat straw + 7.5% Leucaena foliage.

3.3.0 PROCEDURE

Weigh 5gm of sample into nylon bag {20-40 microns pore size] of known weight

Incubate bag and contents into the rumen of fistulated animal (steer in this study)

Remove bag at prescribed time.

Clean bag with running tap water [warm] until water coming from the bag is clear.

The bag and contents is then dried in oven at 60^0c

Weigh bag and record the weight

Loss in weight represents the material degraded [dry matter loss].

To determine the DM loss at 0hr, the test sample is treated as above but without incubation in the rumen. The weight loss when the bag is cleaned under the warm running tap water represents what is immediately soluble in the rumen.

CHAPTER FOUR

4.0 RESULTS AND DISCUSION

The chemical composition of the wheat straw is shown in Table 1.

Table 1 : Chemical Composition of wheat straw

	'As is' basis	DM basis
Moisture	8.8172	91.1828
Ash	9.4644	10.3796
Ether extract	2.0468	2.2447
Crude protein	2.95	3.24
Crude fiber	40.3429	44.2440
Nitrogen free extract	36.3788	39.8966

The amount of crude protein in wheat straw is low at 2.95%. This is below the critical level of 6-8% and would constrain rumen microbial activity (**AFZ, 2011 ,Lopez et al, 2005**). This would mean a low digestibility leading to low intake and animal performance on the straw diet. Thus a correction of this deficiency by providing supplemental protein would enhance the nutritional value of the straw as feed. However, the protein level of 2.95% is within the range of 2.6 to 6.0 reported for wheat straws (**feedipedia Animal feed resources information system INRA CIRAD AFZ and FAO 2012- 2015).**

The amount of crude fiber is high at 44.2% but within the range of 36.6 (minimum) to 46.6 (maximum) for wheat straws **(AFZ, 2011).** The crude fibre content of forages is affected by many factors including agronomic practices but the most important factor is stage of maturity. As a plant matures the crude fibre content increases. Wheat straws become

available as feed for ruminants after seed ripening and will therefore have high levels of crude fibre.

The ether extract content is also low at 2.24% but again within the range of 0.7 (minimum) to 2.8% (maximum) reported by **Lopez et al (2005)** for fibrous crop residues**.** In contrast the ash content at 10.4% was just beyond the normal range of 4.4 (minimum) to 10.0%(maximum) according to **the Animal feed resources information system (INRAD CIRAD AFZ and FAO 2012- 2015).** The high ash content may reflect contamination with soil during handling of the straw post seed harvest.

Rumen Dry Matter degradability

Results of the degradability of the test samples at the different incubation times are shown in Table 2

: Rumen Dry Matter loss (%) for the test samples

Time	**Ws**	**5% m +ws**	**7.5% m+ ws**	**5% s.f.c+ ws**	**7.5% s.f.c+ ws**	**5% c.s.c + ws**	**7.5% c.s.c +ws**	**5% luecaena + ws**	**7.5% luecaena + ws**
0 hours	15.68	17.96	22.67	16.82	17.14	17.4	24.01	17.79	17.73
8hours	19.79	22.76	23.82	20.61	23.08	24.01	24.15	21.41	22.77
16hours	20.19	23.61	26.21	23.21	23.59	25.26	26.18	24.09	24.51
24hours	21.6	24.35	27.04	24.28	26.41	26.2	28.33	24.73	25.61
average	19.32	22.17	24.94	21.23	22.56	23.22	25.67	22.01	22.66

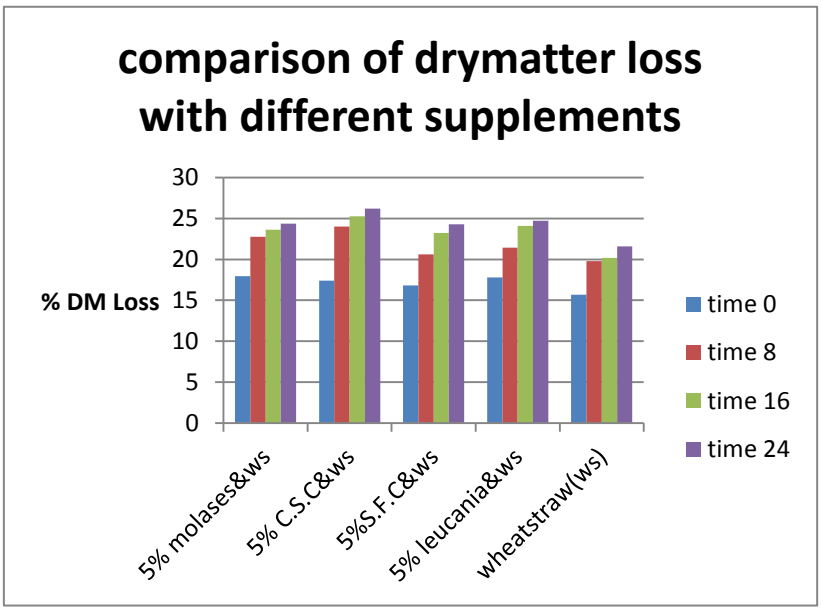

Figure 1: Comparison of dry matter loss with different supplements at 5%

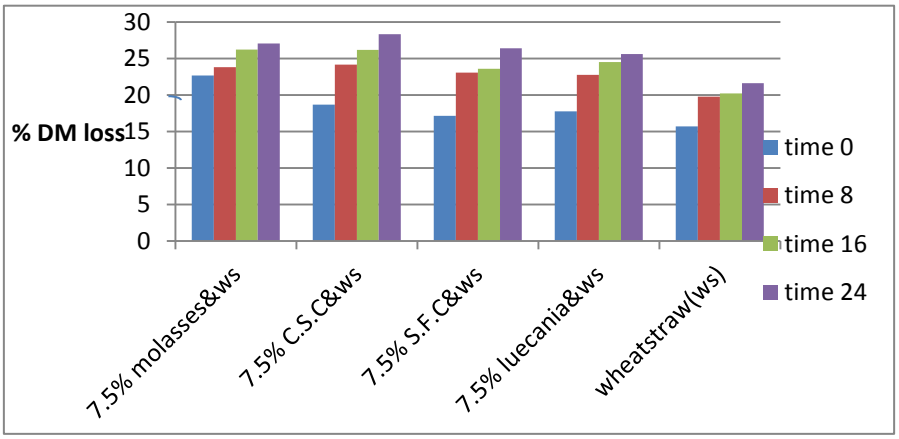

figure 2: Comparison of dry matter loss with different supplements at 7.5%

The dry matter loss for wheat straw alone was lowest at all the incubation times compared to others where supplements were added. This reflected the low nutrient content available for rumen micro flora activity on the wheat straw alone. But with increased time for incubation, the dry matter loss increased for all test samples, as shown in the graphs. This reflected the increased opportunities of degradation by the rumen microbes with exposure time. With addition of the supplements, nutrients available to the rumen micro flora increased, microbial activity was thus enhanced resulting in higher DM degradability of the wheat straws and the total sample. DM disappearance also increased for all the samples with increasing level of supplementation which would be expected to provide even higher nutrient levels and thus support higher microbial activity.

Of the two oilseed protein supplements, cotton seed cake supplement resulted in higher dry matter loss at all incubation times compared with sunflower seed cake. Although not analyzed in this study, cottonseed cake is reported to have higher protein content than sunflower seed residue (**Feedipedia Animal feed resources information system INRA CIRAD AFZ and FAO 2012- 2015).** This may explain the better response to supplementation of the straw with cottonseed cake. Luecaena is a forage protein, and as a supplement for the fibrous feed would provide rumen degradable protein expected to increase N supply as well as digestible energy and elements such as Sulfur and Phosphorus which would enhance microbial activity. Leucaena supplementation increased DM degradability of the straw to a level similar to that of the sunflower seed cake but lower than the cottonseed residue. The results indicate that Leucaena can be effectively used as supplement to enhance nutritional value of fibrous feeds. Compared to the other two protein supplements, Leucana is

more viable as a supplement especially for resource poor farmers because it can be grown on the farm and without using cultivable land as hedgerow or homestead agroforestry.

Molasses is a soluble carbohydrate supplement which has been widely used to increase the palatability of the wheat straw (**Leclerc, 2003, animal feed resources information system INRAD CIRAD AFZ and FAO 2012-2015).** The response in DM disappearance to supplementation with molasses was high and similar and/or higher than for straw supplemented with sunflower seed cake at all the incubation times and supplementation levels. Molasses is high in soluble carbohydrates and would readily dissolve in the water which may explain the high DM disappearance at 0 (zero) hours compared to all the other supplements at similar levels. At low levels (<20 percent of the diet dry matter), the effect of the soluble carbohydrates in the molasses tends to be complementary rather than competitive and there appears to be little or no depression in the degree to which the basal feed resource is fermented in the rumen. However, at levels >20% there is increasing competition for substrate by the rumen microorganisms and molasses may depress the degradation of fibre components of the diet. Additionally, the steer into whose rumen the test samples were incubated was feeding on lush grass which would be high in non-protein nitrogen and by providing a readily available source of energy the molasses may have provided a more favorable environment for microbial activity.

The average dry matter loss was highest for cotton seed cake, followed by molasses, Luecaena, sunflower cake at both levels of supplementation and lowest for wheat straw (Table 2). The dry matter loss increased with incubation time for all the test samples.

CHAPTER FIVE

5.0 CONCLUSION

This study confirmed that wheat straw is of low nutritional value as indicated by the low Crude Protein level of 3.2% and the high Crude Fibre content of 44.2 and a low average DM degradability of 19.35%. Supplementation with different feedstuffs improved the potential nutritional value of the wheat straw as indicated by the improvement in the *in sacco* DM disappearance by an average of 20.3%. The research findings indicate that use of locally available supplements including Leucaena which can be grown on farm can enhance the contribution of wheat straw to the feed base for ruminants in wheat growing areas.

5.1 RECOMMENDATION

Wheat straw, according to the research, should be supplemented with feedstuffs like oil seed cakes and Luecaena and molasses.

Luecaena tree can be grown as part of the on-farm agroforestry and hedges around the homestead; leaves harvested and used either fresh or conserved as hay and fed together with straws and other high fibre roughages at appropriate amounts not in large amount due to the effect of mimosine. The use of molasses is good for palatability but should be in appropriate amount to avoid the negative associative effects on digestibility of high fibre roughages.

REFERENCES

1. Alhassan, W.S., Fhoche, O.W. And Adu, I.F. (1989). Influence of Graded Levels of Cotton Seed Cake Supplementation on the Nutritive Value of Cereals Traws Feed to Sheep and Goats. *Journal of Animal Production Research*, **6** (1): 39 – 13.

2. Animal nutrition fifth edition by Edward, Green Halgh, Macdonald, Morgan

3. Association of analytical chemist [AOAC] . 1990 .*Official methods of analysis* . 15th edition. AOAC Inc., Arlington, Virginia, USA.

4. Feedipedia ; Animal feed resources information system INRA CIRAD AFZ And FAO (2012- 2015)

5. Fodder shrubs for dairy farmers in East Africa page 145

6..Kaitho, R.J., Umunna, N.N., Nsahlai, I.V., Tamminga, S.,and Bruchem, J. van (1998). Effect of feeding graded levels of Leucaena leucocephala, Leucaena pallida, Sesbania sesban and Chamaecytisus palmensis supplements to teff straw given to Ethiopian highland sheep.

7. Livestock feeds and feeding by Kellem R.O and Church D.C

8. Yilala, K. (1988). The effect of supplements of oilseed byproducts on utilization of low-nitrogen fibrous diets by sheep. Proceedings of the First joint workshop held in Lilongwe,Malawi 5-9 December,1988.