EVALUATION OF NUTRITIVE VALUE OF HYDROPONIC FODDER VARIETIES IN SHEEP

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THESIS SUBMITTED TO THE
SRI VENKATESWARA VETERINARY UNIVERSITY
IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE OF

MASTER OF VETERINARY SCIENCE

(ANIMAL NUTRITION)
(IN THE FACULTY OF VETERINARY SCIENCE)

DEPARTMENT OF ANIMAL NUTRITION
COLLEGE OF VETERINARY SCIENCE, TIRUPATI
SRI VENKATESWARA VETERINARY UNIVERSITY
TIRUPATI - 517 502

NOVEMBER, 2016

CERTIFICATE

SHAIK TAHA ANSARI has satisfactorily prosecuted the course of research and that the thesis entitled "**EVALUATION OF NUTITIVE VALUE OF HYDROPONIC FODDER VARIETIES IN SHEEP**" submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examinations. I also certify that the thesis or part of thereof has not been previously submitted by his for a degree of any University.

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CERTIFICATE

This is to certify that the thesis entitled **"EVALUATION OF NUTRITIVE VALUE OF HYDROPONIC FODDER VARIETIES IN SHEEP"** submitted in partial fulfilment of the requirements for the degree of **MASTER OF VETERINARY SCIENCE** of the Sri Venkateswara Veterinary University, Tirupati, is a record of bonafide research work carried out by **SHAIK TAHA ANSARI**, **ID No.TVM/14- 022** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee.

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

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DECLARATION

I, **SHAIK TAHA ANSARI** hereby declare that the thesis entitled **"EVALUATION OF NUTRITIVE VALUE OF HYDROPONIC FODDER VARIETIES IN SHEEP"** submitted to Sri Venkateswara Veterinary University, Tirupati for the degree of **MASTER OF VETERINARY SCIENCE** is the result of original research work done by me. It is further declared that the thesis or any part thereof has not been published earlier.

Date : **(SHAIK TAHA ANSARI)**

Acknowledgements

I earnestly revere the almighty and my Revered Master for his boundless blessings, which accompanied me in all endeavours.

I place my profund etiquette, deep sense of gratitude and abysmal thanks to **Dr. A. Ravi,** *Professor and Head, Department of ILFC, College of Veterinary Science, Tirupati for his meticulous guidance and patience. The untiring interest, endless encouragement and critically going through the manuscript and also spending the precious time in correction, execution, compilation and preparation of the manuscript are invaluable and because of which I have been able to successfully complete the work assigned to me. I consider myself fortunate to have worked under him.*

I heartly express my sincere thanks to **Dr. J. V. Ramana,** *Controller of Examinations, Sri Venkateswara Veterinary University, Tirupati and member of my advisory committee for his whole hearted support, Care, encouragement, constructive critics and valuable suggestions that were profoundly fruitful in the evaluation of manuscript.*

I express my gratitude to **Dr. G. Gangaraju**, *Principal Scientist and Head, NWPSI, Livestock Research Station, Palamner for his interesting ideas, active cooperation with simplicity, advice in all aspects during the course of my research and critical evaluation of manuscript.*

With respectful regards and immense pleasure I wish to express my sincere gratitude to **Dr. D. Srinivasa rao,** *Professor and Head, Department of Animal nutrition and heip extended to me during the conduct of experiment.*

I am extremely grateful to **Dr. B. Devasena,** *Professor, Department of ILFC, Tirupati for timely help, generous co-operation.*

I would like to extend my heartful gratitude to **Dr.M.Yugandharkumar** *Assistant Professor Department of ILFC,* **Dr.P.Kavitha**, *Assistant Professor,* **Dr.K.Rajamma**, *Assistant Professor,* **Dr.P.Sudharani**, *Assistant Professor, Department of Animal Nutrition for their time suggestions during my research work.*

On my personal note, my parents deserve special mention for their inseperable support and prayers. My father, **Shaik Ansar** *in the first place is the person who inspired me in the intellectual pursuit ever since I was a child. My mother,* **Shaik Munni** *is the one who sincerely raised me with her caring, love support throughout my life and my studies.*

I fondly remember seniors **T. Sreekanth Kumar, Dr. Vikram reddy, Dr. Chandrasekhar reddy, Dr. Subbarayudu** *and* **Dr. Kishore kumar** *and words fail in expressing my affection and gratitude towards my colleagues* **Uday kumar, Surya narayana reddy, Mounica, Amit. v. Janbandhu, Vinay kumar, B.Srikanth reddy B. Hanuman Saheb** , **Shafi** *for their help and support in my work at all times. I am thankful to them for assisting me to keep the things in perspective when I really needed.*

My warmest thanks and attention to my friends and juniors **Vishnu, Srikala, Bramaiah, Ashok,** *for their cooperation during the course of my research work.*

I am grateful to **Dr. Munnaiah** *who helped in procuring Sorghum Sudan Grass during the conduct of experiment.*

I want to express my deep love and thanks to **Swetha** *for her support encouragement, quite patience and unwavering love were undeniable in my life.*

At this juncture, I wish to express my thanks to **Sri Nayudu, Shekhar, Ramana, Balu, Smt.Fathima,** *for their help during my research work.*

I place on record my apology and sincere thankfulness to the unmentioned personalities, who have played a role in this study and preparation of this manuscript.

I am thankful to ***Sri Venkateswara Veterinary University,****Tirupati for giving financial support in the form of stipend during the course of investigation.*

Finally and most importantly I wish to express my humble salutations to those little creatures without which this study would not have been possible.

Taha Ansari…….. ✍

LIST OF ABBREVIATIONS

`	: Rupees
%	: Percent
±	: Plus or Minus
>	: Greater than
ADF	: Acid detergent fibre
ADICP	: Acid detergent insoluble crude protein
AOAC	: Association of Official Analytical Chemists
Ca	: Calcium
CF	: Crude fiber
cm	: Centimeter
CP	: Crude protein
DCP	: Digestible crude protein
DE	: Digestible energy
DM	: Dry matter
DMB	: Dry matter basis
DMI	: Dry matter intake
EE	: Ether extract
Ft	: Feet
GE	: Gross energy
g	: Gram
g/d	: Grams/day
HB	: Hydroponic barley
IGFRI	: Indian Grass land and Fodder Research Institute
hr	: Hour
Kg	: Kilogram
L	: Liter
ME	: Metabolizable energy
MJ	: Mega joules
mm	:Millimeter
N	: Nitrogen
NDF	: Neutral detergent fiber
NFC	: Non fiber carbohydrate

NFE	: Nitrogen free extract
NDICP	: Nuetral detergent insoluble crude protein
NIS	: Israeli new sheqel
NPN	: Non protein nitrogen
OM	: Organic matter
OMD	: Organic matter digestibility
P	: Phosphorus
SSG	: Sorghum sudan grass
TA	: Total ash
TDN	: Total digestible nutrients
TMR	: Total mixed ration
W $kg^{0.75}$	: Metabolic body weight

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Degree to which it is submitted	:	**Master of Veterinary Science**
Faculty	:	Faculty of Veterinary Science
Department	:	Department of Animal nutrition
Major Advisor	:	**Dr. A. RAVI** Professor & Head Department of ILFC College of Veterinary Science Tirupati-517 502
University	:	**Sri Venkateswara Veterinary University**
Year	:	November, 2016.

ABSTRACT

The nutritive value of hydroponic fodder produced from six varieties of fodder seeds i.e. SSG, cowpea, horse gram, maize, jowar and barley was evaluated in adult sheep fed on the fodder varieties as sole feed. Four Nellore Jodipi rams were used to study nutrient digestibility, nitrogen, calcium and phosphorus balance, nutritive value and plane of nutrition in 14 day preliminary and 7 day collection period metabolism trials.

The average hydroponic fodder yield (kg) after 7 days of sprouting from SSG, cowpea, horse gram, maize, jowar and barley was 7.17±0.11, 8.07±0.10, 7.10±0.09, 9.13±0.06, 5.38±0.10 and 8.22±0.09, respectively from 1 kg grain. The yield was significantly higher ($P<0.01$) from maize and barley seeds while it was lower from jowar seeds. The chemical composition (%DM) except for DM of the fodder varieties was 12.34, 11.67, 10.64, 12.53, 10.53 and 10.21 % (DM), 95.29, 94.22, 95.08, 95.28,

96.35, 95.99 % (OM), 20.87, 41.09, 33.40, 13.68, 25.77, 17.46 % (CP), 2.57, 1.70,2.29, 3.58, 8.31, 3.02 % (EE) 18.58, 24.08, 20.16, 16.08, 18.25, 23.26 % (CF), 4.71,5.78, 4.92, 4.72, 3.65, 4.01% (TA), 0.36 , 0.04, , 0.17, 0.13, 0.13, 1.05 (AIA) and 53.27, 27.35, 39.23, 61.94, 44.02 and 52.25 % (NFE), for Sorghum Sudan Grass, Cowpea, Horse gram, Maize, Jowar and Barley, respectively.

Nutrient digestibility (%) of the hydroponic fodder varieties were 35.29, 79.90, 40.26, 76.08, 54.17 and 75.07 (DM), 43.64, 81.81, 46.79, 78.26, 58.98 and78.61 (OM), 47.85, 83.94, 71.57, 68.33, 69.50 and 72.95 (CP), 50.82, 68.59, 51.20, 66.96, 75.53 and 75.96 (EE), 34.49, 60.15, 53.43, 72.16, 21.27 and 65.20 (CF), 49.75, 88.46, 78.35, 82.70, 63.96 and 85.28 (NFE), 57.34, 79.59, 57.04, 76, 55.82 and 73.88 (NDF), 41.47, 71.15, 35, 71.61, 46.58 and 69.81(ADF), 49.82, 80.94, 68, 79.32, 65.16 and 78.91(Hemicellulose), 34.24, 76.57, 41.52, 76.44, 44.55 and 76.14 (Cellulose) , respectively and were significantly different among the varieties.

The nitrogen retention (g/d) of sheep was negative ($P<0.01$) in all varieties except cowpea and the values were (-) 2.72, 7.60, (-) 7.77, (-) 2.11, (-) 1.43 and (-) 5.82 for SSG, Cowpea, Horse gram, Maize, Jowar and Barley, respectively.

The calcium retained (g/d) was negative in all varieties and the values were (-) 0.85, (-) 0.55, (-) 1.90, (-) 0.66, (-) 0.51 and (-) 1.15 for SSG, Cowpea, Horse gram, Maize, Jowar and Barley, respectively

The phosphorus retained (g/d) in sheep fed on SSG, Cowpea, Horse gram, Maize, Jowar and Barley was (-) 0.31, (-) 0.34, (-) 0.61, (-) 0.53, (-) 0.26 and (-) 0.79, respectively.

The DCP (%), TDN (%) and DE (kcal/kg DM) were 9.98, 45.83 and 2016.91 (SSG), 34.49, 75.79 and 3334.97 (cowpea), 23.90, 68.08 and 2995.81 (horse gram), 9.34, 77.57 and 3413.13 (maize), 17.91, 64.07, 2819.37 (jowar) and 12.73, 77.63 and 3415.72 (barley).

The DMI g/d was in the order of barley (391.03), maize (371.14), cowpea (314.26), horse gram (205.18), jowar (122.77) and SSG (87.30) and was significantly different. The DMI (g/ $W^{0.75}$) was significantly higher ($P<0.01$) in maize (30.23), barley (26.11), cowpea (25.58), horse gram (16.34), jowar (9.68) and SSG (7.76).

The nutrient requirement of sheep and goat (ICAR, 2013) suggested that sheep weighing 25-35 kg require for maintenance 390-500g TDN, 75-96g CP and a dry matter intake 2.6 to 2.8 % of body weight. In the present study, sheep fed on different hydroponic fodder varieties failed to consume the required quantity of dry matter leading to low plane of nutrition and loss of body weight.

The cost of production of production of hydroponic fodder from SSG, cowpea, horse gram, maize, jowar and barley was `. 1.26, 7.18, 5.20, 1.86, 5.20 and 4.86, respectively taking into account the seed cost only.

It was concluded for hydroponic fodder production Maize followed by Barely were economical based on cost of seed and yield of fodder. Further, hydroponic fodders as a sole feed were not relished by sheep leading to low voluntary intake and loss of body weight.

Chapter – I

Introduction

CHAPTER I

INTRODUCTION

Fodder is an important component in ruminant diet. The non-availability of constant quality green fodder round the year due to decrease in the agricultural land and water resource, production green fodder by the hydroponic system is gaining importance (Diver, 2006).

The green fodder is produced from grains, having high germination rate and grown for a short period of time in a special chamber that provides the appropriate growing conditions (Sneath and McInthosh, 2003). The adoption of this technique has enabled production of fresh forage from oats, barley, wheat and other grains (Rodriguez-Muela *et al.*, 2004). The green fodder yield varies according to type of grain, it was reported that 1 kg barley grain produced a green fodder yield ranging from 7 to 10 kg (Mukhopad, 1994; Shtaya, 2004).

Hydroponic technique can be used for green fodder production of many forage crops in a hygienic environment free of chemicals like insecticides, herbicides, fungicides and artificial growth promoters. It is a technique for high fodder yield, year round production and least water consumption (Mukhopad, 1994).

Fodder produced hydroponically has a short period growth period of 7-10 days and does not require high quality arable land, but only a small piece of land for production to take place (Shtaya, 2004). It has high feed quality, rich with proteins, fiber, vitamins and minerals (Chung *et al.*, 1989). However, determining the best forage crop is an important issue in getting higher fodder yield economically. Sole feeding of green fodder did not support the expected production traits in the animals whereas feeding in conjunction with dry fodder improved its utilization (Prasad *et al*., 1998).

Although there is great potential for using hydroponic technology for fodder production, further studies are required to evaluate different locally available seeds for biomass production and evaluate them for nutritive value (Naik *et al*., 2015). Hence the present study was taken up to grow hydroponic fodder from different locally available seed varieties and evaluate the biomass for nutritive value in sheep with the following objectives.

1) To grow hydroponic fodder using different locally available seeds under low cost green house production system
2) To study the chemical composition and evaluate their nutritive value using adult sheep
3) To study the economics of hydroponic fodder production

Chapter – II

Review of Literature

CHAPTER – II
REVIEW OF LITERATURE

A brief review of the literature published pertaining to the present study is presented in this chapter.

2.0 Need for hydroponic fodder production

Green fodder is an essential component of dairy ration, otherwise the productive and reproductive performance of the dairy animals is adversely affected. Therefore, for sustainable dairy farming, quality green fodder should be fed regularly to the dairy animals (Naik *et al*. 2012a). According to the Ministry of Agriculture, there is a huge gap between demand and supply of feeds and fodders for the livestock in the country (Das, 2012). The current levels of growth in future resources, will lead to a deficit of 18.4% in green fodder and 13.2 % in dry fodder by 2050 (IGFRI, 2015). Conventional method of fodder production is facing many constraints like scarcity of land, water, good quality seeds, higher labour cost, more investment on fertilizers and longer growth period etc. Al-Karaki (2010) reported that 1.5-2 L water is necessary for germination of 1 kg grain in hydroponic system as against 73 L water consumption for 1 kg green fodder under conventional barley production. Hydroponics is now emerging as an alternative technology to grow fodder for farm animals (Naik and Singh 2014; Naik *et al*., 2015). Hydroponic is a method of growing plants without soil. It is a well known technique for high fodder yield, year round production and least water consumption. This technology may be especially important in the regions where forage production is limited (Fazaeli *et. al*., 2012). Development of this planting system has enabled the production of fresh forage round the year from oats, barley, wheat and other grains (Rodriguez-Muela *et al*., 2004). Hydroponic fodder has a short growth period (around 7-10 days) and requires a small piece of land for production (Mooney, 2005). It is of high quality, rich with protein, fiber, vitamins, and mineral (Bhise *et al*., 1988; Chung *et al*., 1989) with health beneficial effects on animals (Boue *et al*., 2003). Hydroponic fodder cultivation provides an opportunity to grow green nutritious fodder with better palatability and digestibility. It can substitute demand of land and water scarcity. The real challenge in producing hydroponic fodder in India lies in devising a system which is viable and adaptable throughout the year in a cost effective and energy sustainable manner. It is visualized that hydroponic system will be more useful in arid and hilly regions, and in areas of high population density where cultivable land and water scarcity prevails. Hydroponic technique can be used for green fodder production of many forage crops in a hygienic environment free of chemicals like insecticides, herbicides, fungicides, and artificial growth promoters (Jensen, 1995; Al-Hashimi, 2008; Al-Karaki and Al-Momani, 2012). It is a well-known technique for high fodder yield, year round production and least water consumption (Al-Karaki and Al-Momani, 2012; Tudor *et al*, 2003; Cuddeford, 1989; Al- Karaki and Al- Hashimi, 2011). It has been reported that hydroponic fodder production requires only about 2-3% of water that is used under field conditions to produce the same amount of fodder (Al-Karaki and Al-Momani, 2012). Water use efficiency and developing strategies maximize the yield per unit area in the conditions of water deficiency. It was reported that the water consumption decreased to 2-3 % levels in hydroponic system than with traditional cultivation method (Al -Karaki and Al- Monani, 2012). Al-Karaki (2010) reported that 1.5-2 L water is necessary for germination of 1 kg grain in hydroponic system, contrasting 73 L water consumption suitable for 1 kg green fodder under conventional barley production.

2.1 Hydroponic fodder production system

Hydroponics is produced in greenhouses under controlled environment within a short period (Sneath and McIntosh, 2003). A greenhouse is a framed or inflated structure covered with a transparent or translucent material in which the crops could be grown under conditions of partially controlled environment. However, the structure should be large enough to permit a person to carry out cultural operations (Chandra and Gupta, 2003). The greenhouse for the production of hydroponics fodder can be of hi-tech greenhouse type or low cost greenhouse type as per the financial status of the farmer and availability of building material.

2.1.1 Type of hydroponics fodder cultivation unit

Hi-tech greenhouse is highly advanced, fully automatic and costly. The requirement for water, light, temperature and humidity is maintained by water fogging or sprinkling and tube lights, controlled automatically through the sensors of the control unit. To save water, provision for recycling of water is made inside the greenhouse with water tank and pump facility. The hi-tech greenhouse may be with or without air conditioner. Even if manufactured in India, the cost of a hi-tech greenhouse without air conditioner and with daily production potential of about 600 kg hydroponics maize fodder is approximately `.15.0 lakhs. Although all types of fodder crops can be grown in the hi-tech greenhouse, the routine operational cost is more, particularly for growing rabi type of crops (barley, oat, wheat etc.) due to requirement of air conditioner in the hydroponics system to maintain cold and dry environment (Naik *et al.*, 2013). Hydroponics fodder can also be produced in low cost greenhouses or devices. The low cost greenhouses or shade net structures costing `. 6000-50,000 can be prepared from bamboo, wood, MS steel or galvanized iron steel. The cost of the shade net structures depends upon the type of fabricating material but is significantly lower than the hi-tech greenhouses.

2.1.2 Crops

Different types of fodder crops viz. barley (Reddy *et al.*, 1988), oats, wheat (Snow et al., 2008); sorghum, alfalfa, cowpea (AI-Karaki and AI-Hashimi, 2011) and maize (Naik *et al.*, 2011; Naik *et al.*, 2012a) can be produced by hydroponics technology. In India, maize grain should be the choice for hydroponic fodder production due to its easy availability, lower cost, good biomass production and quick growing habit (Naik *et al.*, 2012b).

2.1.3 Seed preparation

Soaking of seeds and the rapid uptake of water for facilitating the metabolism and utilization of reserve materials of the seeds for growth and development of the plants is a very important step for production of hydroponics forage. In case of barley (Morgan *et al.*, 1992) and maize (Naik *et al.*, 2012b) seeds, 4 hours soaking in water was beneficial. Under field conditions, farmers producing hydroponics maize forage have the practice of putting the seeds in a gunny bag tightly and then make it wet and keep it for 1-2 days.

2.1.4 Seed rate

The seed rate influenced by the type of seeds, affects the yield of the hydroponic fodder. Most of the commercial units recommend seed rate of 6-8 kg/m^2 (Morgan *et al.*, 1992), however, seed rate of 7.6 kg/m^2 has been suggested by (Naik *et a.,l* 2013) for hydroponics maize fodder for higher output. If seed density is high, there are more chances of microbial contamination in the root mat which affects the growth of the sprouts.

2.1.5 Germination and growth period

The starting of germination and visibility of roots varies with the type of seeds. In case of maize and cowpea seeds, germination starts after 1 or 2 days and the roots were clearly visible after 2 or 3 days, respectively. Photosynthesis is not important for the metabolism of the seedlings until the end of day-5 when the chloroplasts are activated (Sneath and Mclntosh, 2003). Therefore, light is not required for sprouting of cereal grains however, a little light in the second half of the sprouting period encourages photosynthesis and greening of the sprouts. The grains are generally allowed to sprout for about seven days inside the greenhouse and on 8th day these are harvested as a fodder for feeding animals. Frequently, the farmers producing hydroponics fodder using low cost devices in field conditions keep the crop for 7-10 days, however, it enhances the chances of mould growth (Naik *et al.*, 2012a).

2.2 Yield of hydroponic fodder

Gebremedhin *et al.*, (2015) reported that 8-9 kg of hydroponics barley fodder can be produced out of 1kg barley seeds. Sneath and Mc Inthosh (2003) used one kg of grain hydroponically and produced 6 to 10 kilograms of fresh green fodder. Fazaeli *et al.*, (2012) reported a yield of 7.21 kg fodder from 1kg grain at day 8. Saidi and Omar (2015) reported that the net green forage yield was 7.5 kg /kg barley grain. Kruglyakov (1989) reported a production up to 10 kg of fresh green fodder out of 1 kg of barley seeds. Depending to the type of grain, the forage mat reaches 15 to 20 cm high where production rate is about 7 to 9 kg of fresh forage equivalent to 0.9 to 1.1 kg of dry matter (Mukhopad, 1994). Farmers could produce 8-10 kg green fodder from 1 kg maize under low cost devices or greenhouses in 7-10 days (Naik *et al.*, 2013).Naik and Singh (2013) reported that 1 kg seed produced 5-6 kg hydroponic maize fodder. Sneath and McIntosh (2003) reported a yield of 6-10 kg of fodder from 1kg maize seed. Morgan *et al.*, (1992) and Peer and Leeson (1985) reported 4-8 kg fodder can be produced from 1kg maize seed. Al-Karaki and Al-Hashimi (2011) reported that the average green forage yields were 217, 200, 194, 145 and 131 tons/ha for one production cycle (8 days) for cowpea, barley, alfalfa, sorghum and wheat respectively which translated into green fodder : initial seeds weight ratio of 11.5, 7, 5.5, 4.5 and 4.7 for alfalfa, barley, cowpea, sorghum and wheat, respectively. The likely causes for the difference in weight increases could be grain quality and variety used, nutrient solution used during sprouting, lighting, irrigation frequencies, seed treatment, water quality and pH, seeding density or growth duration (Morgan *et al.*, 1992) or simply the degree of drainage of water from freshly irrigated sprouts. Depending to the type of grain, the forage mat reaches 15 to 20 cm high where production rate is about 7 to 9 kg of fresh forage equivalent to 0.9 to 1.1 kg of dry matter (Mukhopad, 1994).

2.3 Nutrient changes

The change in nutrient content of seeds and the respective hydroponic fodder includes an increase in total protein concentration, changes in amino acid composition, a decrease in starch concentration, and increase in sugars, slight increase in crude fat and crude fiber and slightly higher amounts of certain vitamins and minerals in the fodder when compared with the seed (Fazaeli *et al.* 2012). The fresh hydroponic barley sprouts have been reported to have highly soluble proteins and amino acids in response to the enzymatic transformations during early plant growth (chung *et al.*, 1989). These enzymatic activities in the young plant also cause the breakdown of carbohydrates, proteins and lipids into simpler compounds and cause nutrient changes such as an increase in total protein concentration, changes in amino acids composition, decrease in starch, increase in sugars, CF, fat and higher amounts of some vitamins and minerals on a DM basis. Morgan *et al*., (1992) conducted a series of sprout production experiments and concluded that it was not possible to produce a DM gain in just 6 to 8 days. They recorded DM losses ranging from 7–18%, which was mostly from non-fiber carbohydrates portion. On the other hand, the structural carbohydrate increased in the sprouted green forage.

Chung *et al*., (1989) observed that the fiber content increased from 3.75% in un-sprouted barley seed to 6% in 5-day sprouts. The DM content of green fodder was significantly ($p<0.05$) reduced by increasing the growing periods from 6 to 7 days. The amount of fresh green fodder obtained per kg of planted barley grain was several times but this increase was due to the large uptake of water during germination of the seeds, resulted in a sharply reducing of DM percentage in green fodder. According to Peer and Leeson (1985) fresh fodder weight increased from 1.72 times of the original seed weight, after sprouting for 1 day, to 5.7 folds after 7 days but a negative relation was found in DM content with fresh weight yield. Such a low DM content would have a limitation effect on intake of green fodder when fed to animals. Chavan and Kadam (1989) observed that by enhancing the time of sprouting the green fodder contained lower OM and higher ash in sprouted grain because higher organic matter, particularly starch was consumed to support the metabolism and energy requirement of the growing plant. The increase in EE in the green fodder could be due to the production of chlorophyll associated with plant growth that is recovered in ether extract estimation (Snow and Ghaly, 2008). Ash content changed from 2.1 in original barley seed to 3.1 and 5.3 at day 6 and 8 respectively, (Morgan *et al*., 1992). Yields of wet sprouts ranging from 5-10 times the original weight of dry seed have been reported for different commercial hydroponic sheds. DM changes with sprouting have been in the range of 9.4-18% reported as losses (peer and leeson, 1985; hiller and perry, 1969; chung *et al.*, 1989). Flynn and Okiely (1986) found a 24% loss in DM. Peer and Leeson (1985) reported that most of the increases in nutrients are not true increases but simply a reflection of the loss in total DM mainly in the form of carbohydrates due to respiration during sprouting. As total carbohydrate decrease, the percentages of other nutrients increase. The germination of barley resulted in about 18% loss in DM. Shtaya (2004) showed that the germination of wheat for 5 to 7 days resulted in a 17% loss of total DM while the DM loss was 25% in of after 12 days of sprouting. Fiber content, increased from 3.5% in cereal barley grains to 6.5% and 8% in a 5 and 8 day green barley fodder, respectively. Morgan *et al.*, (1992) and Peer and Lesson (1985) reported that protein content of green fodder is similar to barley grain, where the crude protein was higher in the green barley because of the relative decrease of other components. On the other hand, current study is fully agree with study declared that crude Protein as dry matter basis in sprouts significantly(<0.05) recorded higher values in compared to the origin grain ,this might be due to a change in weight of carbohydrate used in providing energy to the seeds through the respiration ,such increasing in the crude protein % was likely due to the loses in the carbohydrate as dry matter since, there was no nitrogen source added externally to the water for irrigation during sprouting ,this crude protein % increase was therefore not a likely true increase Chavan and Kadam (1989), Cuddeford (1989), although true protein showed non significant effects. However, conversion ratio of crude protein and non protein nitrogen in sprouts also was significantly (P< 0.05) increased compared to origin grain , the protein content may be influenced as a result of the level of supplementation and other nutrients changes in sprouting grains Peer and Leeson (1985), Morgan *et.al.*,(1992). Ether Extract also, recorded significantly (P< 0.05) higher in sprouts compared to origin grain , this could be due to the production of chlorophyll associated with plant growth that are recovered in ether extract measurement, however, Ether extract, NDF ,ADF also were increase content with fresh weight produce Peer and Leeson (1985). Neutral detergent fiber (NDF), Acid detergent fiber (ADF) also were increased, but Non-fiber carbohydrates (NFC) decreased in sprouted barley compared to the barley grain on a dry matter basis. Such changes not true, since they only describe the alterations in the proportion of nutrients during seven days of sprout in barley grain Morgan *et al.*, (1992). The crude protein had increasing trend and remained highest on 8th day of growth (13.89%) which was higher (P<0.05) than the percentage in seed form (11.11%). The ether extract content of hydroponics barley fodder in 8th day (3.6%) was highest (P<0.05). The crude fiber content of the barley seed was 8.9% and increased (P<0.05) up to 14.2% on 8th day of growth in hydroponics system. The Neutral detergent fiber content of the barley seed was 20.1 at zero day and increased to 35.3% on 8th day of growth in hydroponics system and was higher (P<0.05) to barley fodder grown under controlled environment (31.25%). The total ash and acid detergent fiber contents are 4.1% and 16.45% in 8th day growth stage respectively (Gebrimedhin *et al.*, 2015).

2.3.1 Protein fractions

Fazaeli *et al.*, (2012) reported that the percentage of soluble protein (SP) was significantly (p<0.05) increased in green fodder harvested at day 7and 8 but no difference was found for the insoluble protein (IP). As a portion of total CP, the NPN content increased but the true protein decreased (p<0.05) in green fodder compared to the barley grain. A trend to an increase in the NDICP and ADICP content of green fodder was observed by extending the sprouting period from 6 to 7 and 7 to 8 day. Contradictory to the B1, fractions B3 and C were increased when the grain transformed to green forage.

The CP, Soluble protein, Insoluble protein, True protein, NDICP and ADICP of barley seed vs. hydroponic barley green fodder were CP (11.73 vs.13.69), Soluble protein (10.49 vs. 12.52), Insoluble protein (1.24 vs. 1.18), True protein (9.39 vs. 7.72), NDICP (8.08 vs. 16.5) and ADICP (2.75 vs. 6.06).

The barley grain contained 3.35 % NPN and 7.10 % true protein where as the hydroponic barley fodder contained 5.89 % NPN and 7.79 % true protein (Fazaeli *et al*., 2012).

2.4 The Proximate and cell wall composition (%) of seeds and their hydroponic fodder

2.4.1 Barley

The average DM, OM, CP, CF, EE, TA and NFE of barley seed as reported by several authors (Table A) were 91.42, 93.54, 11.08, 6.90, 1.86, 2.34 and 77.22(%), respectively and cell wall composition (%) values for NDF, ADF, hemi cellulose, cellulose and lignin of barley seed was 21.37, 7.58, 11.38, 5.25 and 2.0, respectively.

The average DM, OM, CP, CF, EE, TA and NFE barley fodder as reported by several authors (Table D) were 15.27, 92.76, 18.40, 13.78, 3.36, 4.8 and 45.02(%), respectively and cell wall composition (%) values for NDF, ADF, hemi cellulose, cellulose and lignin of barley fodder were 35.02, 14.91, 17.07, 7.43 and 6.51, respectively.

Table A : Proximate composition and cell wall constituents (% DM) of barley seed as reported by different authors

DM	OM	CP	CF	EE	NFE	TA	NDF	ADF	HC	CEL	LIGNIN	REFERENCE
90.40	96.6	10.45	-	1.9	-	-	22.50	8.90	-	-	-	Fazaeli *et al*., (2011)
93.81	-	11.11	8.9	1.68	-	1.81	20.1	8	-	-	-	Gebrimedhin (2015)
92.25	95.83	9.54	7.01	2.06	77.22	-	18.63	7.25	11.38	5.25	2.0	Helal (2015)
90.40	92.60	9.45	-	1.90	-	3.10	32.50	7.90	-	-	-	Al-Saadi (2016)
91.4	97.19	11.73	-	1.9	-	2.81	20.2	7.2	-	-	-	Fazaeli *et al*., (2012)
90.37	88.76	9.58	-	1.32	-	-	21.31	8.55	-	-	-	Al-Saadi and Al-Zubaidi, (2016)
92.3	90.3	13.9	-	-	-	2.0	-	-	-	-	-	Dung *et al*., (2010a)
-	-	12.9	-	-	-	-	14.4	5.30	-	-	-	Hafla (2014)
-	-	8.2	4.8	2.3	-	-	-	-	-	-	-	Al- Karaki and Al-Momani,(2012)
90.5	-	12.6	-	-	-	2.0	-	-	-	-	-	Dung *et al*., (2010b)
91.42± 0.44	93.54± 1.43	11.08± 0.58	6.90± 1.18	1.86± 0.11	77.22	2.34± 0.25	21.37± 2.09	7.58± 0.44	11.38	5.25	2.0	MEAN ± SE

Table B : Proximate composition (% DM) of maize seed as reported by different authors

DM	OM	CP	CF	EE	NFE	TA	AIA	NDF	ADF	HC	CEL	LIGNIN	REFERENCE
-	-	8.60	2.50	2.56	84.49	1.57	0.02	-	-	-	-	-	Naik *et al*., (2015)
-	-	9.12	2.63	2.06	83.77	2.42	-	18.59	5.23	-	4.54	3.85	Ramesh *et al*., (2014)
-	-	9.73	9.43	4.85	71.96	-	-	-	-	-	-	-	Shabaz *et al*.,(2015)
95.08	-	7.6	6.5	2.8	78.67	1.31	0.05	-	-	-	-	-	Gebremedhin (2015)
92.10	98.07	9.87	2.64	3.32	82.24	1.93	-	11.70	3.12	8.58	2.83	-	Sillag *et al*., (2008)
93.59 ± 1.49	98.07	8.86 ± 0.16	2.56 ± 0.04	2.31 ± 0.15	84.13 ± 0.22	1.99 ± 0.30	0.03 ± 0.01	15.14 ± 0.44	4.17 ± 1.05	8.58	3.68 ± 0.85	3.85	MEAN±SE

Table C : Proximate composition (% DM) of sorghum seed as reported by different authors

DM	OM	CP	CF	EE	NFE	TA	NDF	ADF	HC	CEL	REFERENCE
95.08	-	7.98	11.11	2.05	83.60	3.22	-	-	-	-	Sule sale (2015)
92.73	98.02	11.21	2.87	3.13	80.81	1.98	16.21	8.13	8.08	5.13	Sillag *et al.*, (2008)
-	-	13.99	1.93	3.47	78.72	1.89	-	-	-	-	Wall and Blessin (1970)
93.90 ±1.17	98.02	11.06 ±1.73	5.30± 2.91	2.83± 0.42	81.04 ±1.41	2.36± 0.42	16.21	8.13	8.08	5.13	MEAN ±SE

2.4.2 Maize

The average DM, OM, CP, CF, EE, TA, AIA and NFE of maize seed as reported by several authors (Table B) were 93.59, 98.07, 8.86, 2.56, 2.31, 1.99, 0.03 and 84.13(%), respectively and cell wall composition (%) values for NDF, ADF, hemicelluloses, cellulose and lignin of maize seed was 15.14, 4.17, 8.58, 3.68 and 3.85, respectively.

The average DM, OM, CP, CF, EE, TA, AIA and NFE of hydroponic maize fodder as reported by several authors (Table E) were 17.62, 14.29, 10.37, 3.72, 2.45, 0.36 and 70.48(%), respectively.

2.4.3 Sorghum

The average DM, OM, CP, CF, EE, TA and NFE of sorghum seed as reported by several authors (Table C) were 93.90, 98.02, 9.59, 6.99, 2.59, 2.6 and 82.20 (%), respectively and cell wall composition (%) values for NDF, ADF, hemicelluloses and cellulose was 16.21, 8.13, 8.08, 5.13, respectively.

Sule sale (2015) reported that DM, OM, CP, CF, EE, TA and NFE of hydroponic sorghum fodder were 24.61, 11.50, 3.55, 11.02, 3.83 and 70 (%), respectively.

2.4.4 Cowpea

Cowpea seeds contain 25.2, 5.6, 1.6, 4.1,16.6, 6.15,1.1,4.1% CP, CF, EE, TA, NDF, ADF, Ca and P, respectively with a GE content of 18.7 MJ/kg DM . The information on the chemical composition of hydroponic cow pea fodder variety is scanty. However, the conventional cowpea green fodder contains (20.9, 18.1, 24.1, 2.8, 11.3, 38.6, 27.1, 4.6, 1.25 and 0.24 % DM, CP,CF,EE,TA, NDF, ADF, Lignin, Ca and P, respectively (Heuze and Tran, 2015).

Table D : Proximate composition and cell wall constituents (% DM) of hydroponic barley as reported by different authors

DM	OM	CP	CF	EE	NFE	TA	NDF	ADF	HC	CEL	LIGNIN	REFERENCE
13.3	95.89	14.67	-	3.86	-	4.11	35.40	17.15	-	-	-	Fazaeli *et al*., (2012)
-	90.44	15.36	27.38	2.68	45.02	9.56	31.62	14.55	17.07	7.43	7.12	Helal (2015)
10.3	--	18.2	-	-	-	5.3	52.35	23.6	-	-	5.9	Akbag *et al*., (2014)
12.2	-	25.2	12.4	4.2	-	-	29.6	14.3	-	-	-	Al- Karaki and Al-Momani,(2012)
15.3	-	22.5	11.4	3.2	-	-	32.5	13.1	-	-	-	Mysaa Ata (2016)
19.26	96.35	13.69	-	2.25	-	3.65	31.25	14.35	-	-	-	Fazaeli *et al*.,(2011)
-	96.2	14.7	-	4	-	-	30.5	15.5	-	-	-	Hafla *et al*.,(2014)
13.64	-	13.9	14.24	3.62	-	4.1	35.26	16.2	-	-	-	Gebrimedhin *et al*., (2015)
16.50	96.55	26	6.89	3.95	-	3.92	-	-	-	-	-	Swati Verma (2015)
18.3	-	19.8	10.4	-	-	3.6	35.4	11.9	-	-	-	Saidi and Omar (2015)
14.61	93.25	15.58	-	3.25	-	4.15	36.35	8.45	-	-	-	Al-Saadi (2016)
19.31	80.64	13.06	-	2.63	-	-	27.43	13.34	-	-	-	Al-Saadi and Al-Zubaidi, (2016)
15.27±0.96	92.76±2.18	18.40±1.49	13.78±2.89	3.36±0.21	45.02	4.8±0.70	35.02±2.06	14.91±1.23	17.07	7.43	6.51±0.61	MEAN ± SE

Table E : Proximate composition (% DM) of hydroponic maize fodder as reported by different authors

DM	CP	CF	EE	NFE	TA	AIA	REFERENCE
18.30	13.30	6.37	3.27	75.32	1.75	0.57	Naik *et al*., (2014)
18.48	16.5	12.46	4.67	68.47	2.3	0.32	Gebremedhin (2015)
-	13.57	14.07	3.49	66.72	3.84	0.33	Naik *et al*., (2015)
15.39	13.56	8.98	2.46	73.45	1.56	0	Naik *et al*., (2016)
18.25	14.56	10.0	4.67	68.47	2.83	0.32	Weldegerima Kide Gebremedhin (2015)
-	13.6	14.1	3.5	66.7	3.8	0.3	Naik *et al*., (2012b)
17.7	12.9	8.36	4.22	72.21	2.31	0.17	Muthuramalingam *et al*., (2015)
17.62±0.57	14.29±0.49	10.37±1.13	3.72±0.95	70.48±1.39	2.45±0.34	0.36±0.04	MEAN ± SE

2.4.5 Jowar

Sorghum seeds contain 10.8, 2.8, 3.7, 2.1, 11.0, 4.3, 1.1, 0.03 and 0.33% CP, CF, EE, TA, NDF, ADF, lignin, Ca and P, respectively with a GE content of 18.1 MJ/kg DM (Heuze *et al*., 2015). The information on the chemical composition of hydroponic sorghum fodder variety is scanty. However, the conventional sorghum green fodder contains 28.1, 8.2, 5.2, 1.9, 9.1, 57.9, 35.0, 3.3, 0.41 and 0.20 % DM, CP,CF,EE,TA, NDF, ADF, Lignin, Ca and P, respectively (Heuze *et al*., 2015).

2.4.6 Sorghum Sudan Grass

The information on hydroponic SSG green fodder is very scanty. However, as per reports in the Feedipedia (Heuze and Tran, 2015) the conventional SSG fodder contains 20.8, 11,30.9,2.7,9.7,66.4,36.4,4.6, 0.46 and 0.15 % DM, CP,CF,EE,TA, NDF, ADF, Lignin, Ca and P, respectively.

2.5 Hydroponic fodder in livestock feeding

2.5.1 Barley

Mysaa Ata (2016) conducted an experiment using 50 weaned Awassi ram lambs with average body weight 19 ± 1.0 kg and randomly assigned to two treatments with diets containing barley grain (control diet) and diet containing hydroponic barley (HB) to study growth performance. Total gain (Final body weight – Initial body weight) was significantly higher ($p < 0.05$) for lambs fed HB diet with 20.52 kg, when compared to lambs fed control diet with 17.21 kg. Feed intake was higher ($p < 0.05$) for lambs fed control diet than lambs fed HB diet (0.65 kg/day vs. 0.56 kg/day). Average daily gain of 266 g was higher ($p < 0.05$) in lambs fed HB than 191 g in lambs fed control diet.

Saidi and Omar (2015) conducted performance trail for 120 days on 48 lactating Awassi ewes. Ewes were randomly divided into two experimental groups with 24 ewes in each group and 6 replicates for each experimental group in a complete randomized design Group 1 served as control group and fed a regular lactation diet. Ewes in group 2 were fed a total mixed ration where hydroponic barley (45 parts) was incorporated. Body weight gain of ewes fed the regular lactation diet was similar to ewes fed hydroponic barley green fodder.

Al-Saadi (2016) conducted a growth trail of 120 days on 18 Awassi male lambs with average initial body weight of 19.25 kg and split into 3 groups with 6 lambs per group. The second and third groups were fed with 10% and 30% sprouted barley, respectively. It was concluded that lambs fed 30% sprouted barley performed better than lambs of other treatments.

Fayed (2011) conducted a study on 35 Bakri lambs with average initial body weight of 16±51 kg and divided into 5 groups. The lambs were fed on diets containing sprouted barley grain grown on rice straw or Tamarix. The results of animal performance showed that lambs fed on sprouted barley grown on Tamarix performed better due to higher nitrogen retention. In arid season, green fodder could be produced by using dried salt plants and rice straw.

Fazaeli *et al*., (2011) conducted a growth trail using hydroponic fodder barley on 24 cross bred male calves with initial average body weight of 193.1±14.75 kg. The final live weights were 303.9±17.6 and 312.3±14.9 kg and the total body weight gain during the 90 day experimental period averaged 113.28±8.31and 116.72±7.42 kg for the control and treatment groups, respectively. It was concluded that substitution of barley grain with hydroponic barley green fodder did not affect growth performance.

However, the cost of feeding increased due to hydroponic barley green fodder feeding to calves.

Helal (2015) studied the effect of feeding sprouted barley on agriculture byproducts (olive cake & barley straw) and reported better growth rate, nutrient digestibility and nitrogen balance in goats fed sprouted barley.

Swati Verma *et al.*, (2015) conducted a study on 12 Hariana male calves with average body weight of 99.5kg and reported that hydroponic barley fodder could replace concentrate mixture in diets of calves and it was more economical than conventional feeding. The average daily gain was higher 490 to 501g in calves fed hydroponic barely fodder when compared with 490g for the control group. The increase in weight gain was attributed to better intake, digestibility and higher nutritive value of hydroponic fodder based TMR.

2.5.2 Maize

Muthuramalingam *et al.*, (2015) that the average daily feed intake of concentrate, hydroponic fodder and dry fodder were 150 gram, 1.42±0.08 kg and 0.58±0.17 kg with a feed conversion ratio 9.52±0.51 in Tellicherry kids.

Gebremedhin (2015) reported that BW gain of Konkan Kanyal kids supplemented with hydroponic maize fodder ranged from 34.7 to 61.9 g when compared with kids in control group that lost BW at the rate of -1.17 g/day and he concluded that hydroponic maize could be supplemented at 40% in kid diets.

2.5.3 Sorghum

Sule sale (2015) conducted a study using 10 Red Sokoto goats allocated to two dietary treatments containing sorghum grains and sorghum sprouts, respectively with five goats per treatment in a complete randomized design (CRD**)** and concluded that goats fed sprouted barely gained signgificalty higher body weight than the control group**.**

Abbas and Musharaf (2008) determined the effect of days of germination of sorghum grain on the growth performance of broiler birds. They reported that 3 days germinated grains had no effect on the growth performance of broiler birds but when days of germination increased it depressed the growth because tannin contents increased.

Fafiolu *et al.*, (2006) determined the effect of sprouted grains on the performance of layer during growing and laying phase. They reported that inclusion of sprouted sorghum in the diet of pullets at the level of 0, 150 and 300 g/kg of diet did not affect daily feed consumption, average weight gain and age at first egg during growing phase.

Musharaf and Latshow (1991) observed no significant effect on weight gain in layers by the addition of sprouted sorghum. In contrary to this, Adebule (2002) observed decrease in weight gain when the level of sprouted grains increased in the pullets diet.

2.5.4 Hydroponic fodder as a sole feed

Limited research has been conducted to determine the feeding value of hydroponically sprouted grains (Thomas and Reddy, 1962; Peer and Lesson, 1985). These authors noted that the dry matter intake of green fodder by feedlot cattle and dairy cattle were low due to its high moisture content.

Sole feeding of green fodder did not support the expected production traits in the animals whereas feeding in conjunction with dry fodder improved its utilization (Prasad *et al* 1998).

2.6 Nutrient digestibility

2.6.1 Barley

Peer and Leeson (1985) reported significant decrease in dry matter digestibility of barley sprouts as the growing period increased from 4 to 8 days while Cuddeford (1989) reported that the in vivo digestibility of 8-day barely sprouts ranged from 73-76 % with a ME content of 12.2 MJ/kg DM.

Akbag *et al*., (2014) evaluated hydroponic barley fodder harvested at different days (4, 7, 10 and 13) for their OMD and ME content by *in vitro* gas production technique and concluded that with enhancing the harvest period, the OMD and ME content of barley fodder decreased numerically. The OMD (%) decreased from 73.5 to 63.9 while the ME value decreased from 2.61 Mcal/kg to 2.26 Mcal/kg as the harvest period increased from 4 to 13 days.

Fayed (2011) conducted a study using 35 female Bakri lambs to study the effect of sprouted barely feeding that was grown Tamarix or rice straw and reported a significant ($P<0.05$) improvement in OM, CP, EE and cellulose digestibility with an insignificant higher in CF, NDF and hemicellulose digestibility upon inclusion of 40 parts of sprouted barley in the diets of lambs.

Helal (2015) conducted a study on 25 male goats fed barely sprouted on olive cake or barley straw and revealed a significant ($P\leq0.05$) improvement in OM, CP, EE, CF, NFE, NDF, ADF and hemicellulose digestibility in goats fed on barely sprouted on 75% olive cake + 25% barley straw compared to other groups.

Swati Verma *et al.*, (2015) reported digestibility (%) of DM (58.19-60.60), OM (62.33-64.23), CP (77.46-79.57), EE (73.45-73.40), CF (42.74-43.33) and NFE (70.47-72.40) in Haryana male calves fed rations supplemented with 2.5-5.0 kg hydroponic barley fodder.

Al-Saadi and Al-Zubiadi (2016) reported that supplementation of 10-30% barley sprouts resulted in better nutrient digestibility in Awassi male lambs.

2.6.2 Maize

Naik *et al.*, (2016) fed four heifers (body weight 305 kg) with 2 kg concentrate mixture along with 3 kg hydroponic maize fodder and jowar straw adlib. The DM intake by the heifers was 2.25 kg/100 kg BW and the hydroponic maize fodder intake was 3.23(kg/d) and the digestibility of DM, OM, CP, EE, CF, and NFE was 65.62, 68.06, 69.36, 80.95, 59.70 and 69.87%, respectively.

Nugroho *et al.*, (2015) conducted a study on eight dairy cows with average milk production 11.36 ± 2.96 litres /day that were supplemented with 3 kg fresh hydroponic maize fodder /head/day to equal 7% dry matter required and reported digestibility values of 77.0, 78.5, 82.6, 90.9 and 76.0 % for DM, OM, CP, EE and NFE , respectively.

Naik *et al.*, (2014) conducted digestibility trail on six dairy cows (BW 442 kg; milk yield 6.0 kg) offered 15 kg hydroponic maize fodder, 5 kg concentrate mixture and jowar straw ad lib. The digestibility of DM, OM, CP, EE, CF and NFE of the ration was 65.39, 68.47, 72.46, 87.69, 59.21 and 70.47%, respectively.

2.6.3 Sorghum

Sule sale (2015) conducted a study on ten Red Sokoto goats allocated according to their body weights to two dietary treatments containing sorghum grains and sorghum sprouts, respectively with five goats per treatment in a complete randomized design and reported higher ration digestibility due to hydroponic sorghum fodder supplementation.

There is very scanty information on the effect of supplementation or sole feeding of other hydroponic fodder varieties i.e. SSG, Cowpea, Horse gram on nutrient digestibility.

2.7 Nutrient balance

2.7.1 Nitrogen balance

There is very little information on the nitrogen balance of animals fed on hydroponic fodder varieties as sole ration. However improvement in nitrogen balance of animals on supplementation of hydroponic Barely fodder in lambs **(**Fayed, 2011), Merino sheep (Dung *et al.*, 2010a) and in goats (Helal, 2015) was reported.

Similarly improved nitrogen retention and balance was reported upon supplementation of hydroponic maize fodder in cows **(**Nugroho *et al.*, 2015) and in Konkan Kanyal kids (Gebremedhin, 2015) and sorghum hydroponic fodder in Red Sokoto goats (Sule sale, 2015)

2.7.2 Calcium and phosphorus balance

Gebremedhin (2015) reported that the intake and gross retention of minerals (N, Ca and P) was highest in weaned Konkan Kanyal kids of 3 to 7 months of age supplemented with barley hydroponic fodder to a basal diet of mixed maize fodder.

2.8 Plane of nutrition

There is very scanty information on the plane of nutrition of livestock fed hydroponic fodder as a sole feed. However supplementation of hyrodponic fodder to basal diet in Bakri lambs **(**Fayed, 2011), in goats (Helal, 2015) and in Hariana male calves (Swati verma *et al*., 2015) was reported to have increased the DMI, DCP and TDN content of the rations.

Similarly, supplementation of hydroponic maize fodder in dairy cows (Naik *et al*., 2016 and Nugroho *et al*., 2015) was reported to have improved the plane of nutrition of animals in terms of DM, DCP and TDN intake.

The increase in milk yield and weight gain as a result of feeding hydroponic barley sprouts was attributed to the presence of a factor known as the grass juice factor (Cannon and Emerson, 1939). This alleged factor was said to be rich in young rapidly metabolizing plant tissues such as sprouts opposed to mature plants. A report not in a support of the view that hydroponic grain sprouts bring about rapid increase in performance indicated that when beef cattle were given sprouts to replace highly nutritious feeds there was no advantage; it was only when sprouts were given as supplements to protein deficient hay that there was an improvement in efficiency (Thomas and Reddy, 1962; Tudor *et al*., 2003).

Abd Rahim *et al.* (2015) reported that supplementation of poor quality chaff with hydroponic fodder barley sprouts led to an increase in DM intake by sheep.

Tudor *et al*., (2003) reported that most of the trials on livestock performance from hydroponic sprouts showed no advantage to including them in the diet, especially when they replaced highly nutritious feeds such as grain. They reported improvement in the performance of steers when given restricted hay diet plus 15.4 kg fresh hydroponic green fodder. However, Fazaeli *et al*., (2012) reported that when hydroponic fodder was included in the diet, no difference in the performance of finishing calves was noted. Cost of feed was 24% greater than the control diet.

2.9 Cost economics of hydroponic fodder production and feeding to livestock

Saidi and Omar, (2015) reported that the calculated production cost per 1 kg hydroponic barley was 0.21 NIS (Israeli new sheqel) equal to `.3.65 per kg. Compared to the traditional roughage regularly fed to local sheep there was a saving of about 0.79 NIS/kg or `.13.72/kg and they reported that a significant reduction in feed cost could be achieved when feeding rations incorporated with hydroponic fodder of sprouted barley.

Al-Saadi (2016) in his study, reported that it was economically profitable to include hydrophonic green fodder to replace 30% of conventional barley fodder.

Fazaeli *et al*., (2011) reported that the cost of feeding was higher for the animals that received hydroponics green forage diet than those fed barley grain ($P < 0.05$). However, by including the green forage in the experimental diet, the proportion of barley grain and protein rich feeds (cotton seed meal and canola meal) were reduced (5.5 vs. 9.0%).

Swati Verma *et al*., (2015) reported the cost of hydroponic green feed varies with the size of the machine. The operational cost of the green fodder in the machine APH-1000 (Model Number) would range between `. 4.50-5.00 per kg. The cost of green fodder included the cost of barley seed (`.20/kg), cost of nutrient solution, labour cost, electricity charges and miscellaneous expenses.

Fazaeli *et al.*, (2012) suggested that hydroponic green fodder had no advantage over barley grain in feed lot calves, because it increased the cost of feed, however, Naik *et al.*, (2014) found higher net profit of `.12.67/- per cow/day on feeding hydroponic fodder.

Muthuramalingam *et al.*, (2015) concluded that hydroponic fodder may have profitable application in intensive large scale goat farming with high value outputs, where no land is available to produce green fodder and alternative feed costs are high.

Naik *et al.*, (2014) reported that higher cost of the hydroponic maize fodder (`.4/kg) than the conventional green fodder (`.1.50/kg) might lead to higher cost of feeding than feeding conventionally grown fodder (Naik *et al.*, 2012a).

Naik *et al.*, (2012b) reported that with hi-tech greenhouse, the cost of production of fresh hydroponic maize fodder was about `. 4.0 - 4.50/- per kg, in which the seed cost is about 90-98%. However, farmers of the Satara district of Maharashtra revealed that in low cost shade net system with home-grown or locally purchased seeds, the cost of production of the hydroponics fodder is very minimal and reasonable (about `.2.0 -3.50/ per kg).

Sule sale (2015) reported that cost of feed/kg was higher ($P<0.05$) for the animals fed sprouted sorghum was (`. 34.39/kg) compared to goats fed on sorghum grain `. 29.70/kg.

In is concluded that no increase in quantity and quality of DM and nutrients could be obtained by sprouting barley grain still some DM and DOM loss was found in green fodder, therefore economically it is not recommended for animal farming.

Hydroponic fodder may be best suited to non-ruminants (horses, rabbits, pigs, and poultry) that would benefit more from the changes in the feed due to sprouting (e.g. less starch, more sugars) as compared to ruminants (sheep, goats, and cows) that are less efficient at digesting high quality feed. Hydroponic fodder seems ideal for horses, though the research is lacking. A study with rabbits showed no detrimental effect to replacing up to 50 percent of the commercial diet with green fodder (Francisco *et al.,* 2011).

Early workers found lower weight gain when pigs were fed 10-day sprouted maize relative to ground maize, but, when beef cattle were fed with hydroponics green fodder, an average of 200 g higher daily gain was obtained in comparison to those fed with a maize-control diet (Leitch, 1939). Peer and Lesson (1985) found lower growth rate in pigs when fed sprouted barley than ground barley. Farlin *et al*., (1971) found no difference in performance of the cattle fed sprouted or non-sprouted grain.

Chapter – III

Materials and Methods

CHAPTER – III

MATERIALS AND METHODS

The study was conducted to produce hydroponic fodder from maize, barley, cowpea, horse gram, SSG and white jowar seeds. The economics of production and the nutritive value of the fodder was evaluated using adult Nellore jodipi sheep by conducting metabolism trails. The fodder was fed as sole ration.

3.1 Procurement of seeds

All six varieties of fodder seeds were procured from a local market.

3.2 The Hydroponic System

A hydroponic unit (Fig. 1) was fabricated using 75% shade net of 12.0 ft length × 8.0 ft width × 12 ft height; the net was used to cover wooden racks of 10.0 × 7.0 × 10.0 ft length, width and height, with four shelves (1 ft distance each). Plastic trays 1.3 ft length × 1.0 ft width × 0.15 ft height were used to grow fodder. This system constructed as semi- intensive using 75% shed net and the remaining 25% was used for proper aeration. In order to manage and control internal temperature of the green house, proper spraying of water carried out three times per day manually to get a range of 22 – 27^{o} C and up to 70% relative humidity.

3.3 Treatment of seeds before planting

Seeds were cleaned from debris and other foreign materials and sterilized by soaking for 30 minutes in a 2% sodium hypochlorite solution to control the formation of mould. The planting trays were also cleaned and disinfected. The seeds were then

Fig 1 Showing Green net house for hydroponic fodder production

Wooden racks

washed well from residues of bleach and resoaked in tap water overnight (about 12 hours) before and then put in gunny bag for 24 – 36 hours till root emerged.

3.4 Seed Planting and Irrigation

Sprouted seeds were sown in the planting trays (Fig. 2-7) which have holes at the bottom to allow drainage of excess water from irrigation. Thereafter, sprouted seeds were spread on the hydroponic tray to 1.5 – 2.0 cm thickness at the rate of 200 gram seeds per tray. Trays were irrigated manually with tap water thrice a day (early in the morning, afternoon and evening).

3.5 Housing and management of animals

Four Nellore Jodipi adult sheep with average age of one and half to two years and having body weight of 27.82, 27.5, 30.3 and 29.6 kg were housed individually in pens of 2 × 1 m dimensions in a pucca shed. Weighed quantity of fresh hydroponic fodder was offered daily during preliminary period of 14 days and water was provided. The animals were dewormed at the start of the experiment and at regular intervals with broad- spectrum antihelmenthitics. They were also vaccinated against Enterotoxemia, HS, and PPR during the study.

3.5.1 Weighing of animals

The animals were weighed at the start and at the end of each metabolism trail.

3.5.2 Feeding of animals

Weighted quantity of feed was offered to the sheep twice daily at 11.00 am and at 4.00 pm. The left over feed if any was weighed and recorded next day.

Fig 2 Hydroponic SSG sprouts showing stages of growth from Day 1 to 7

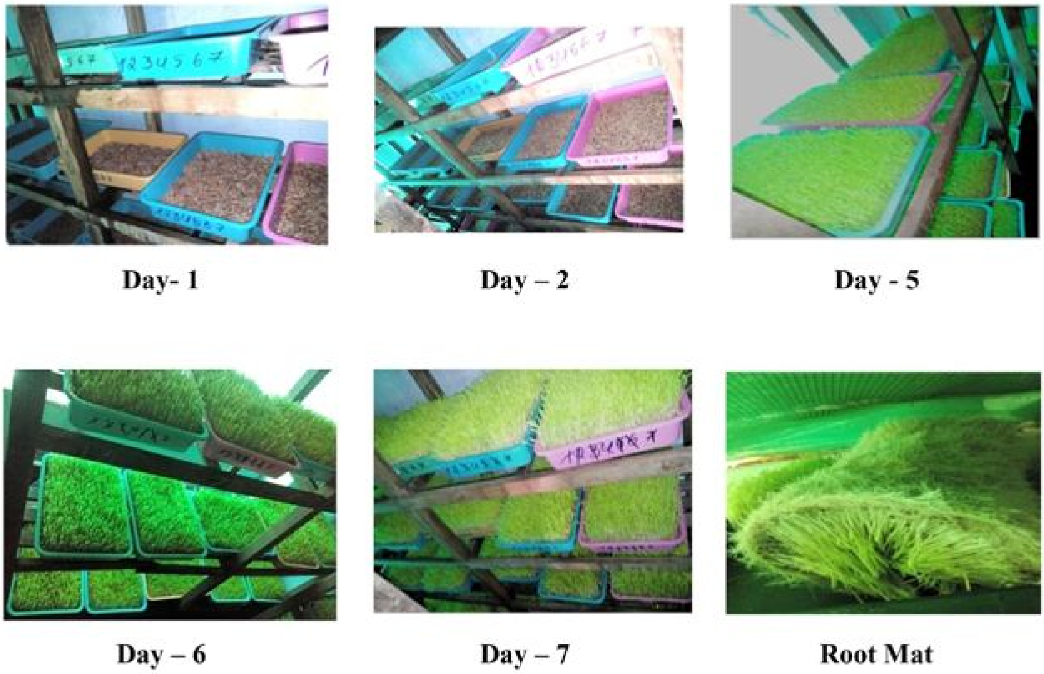
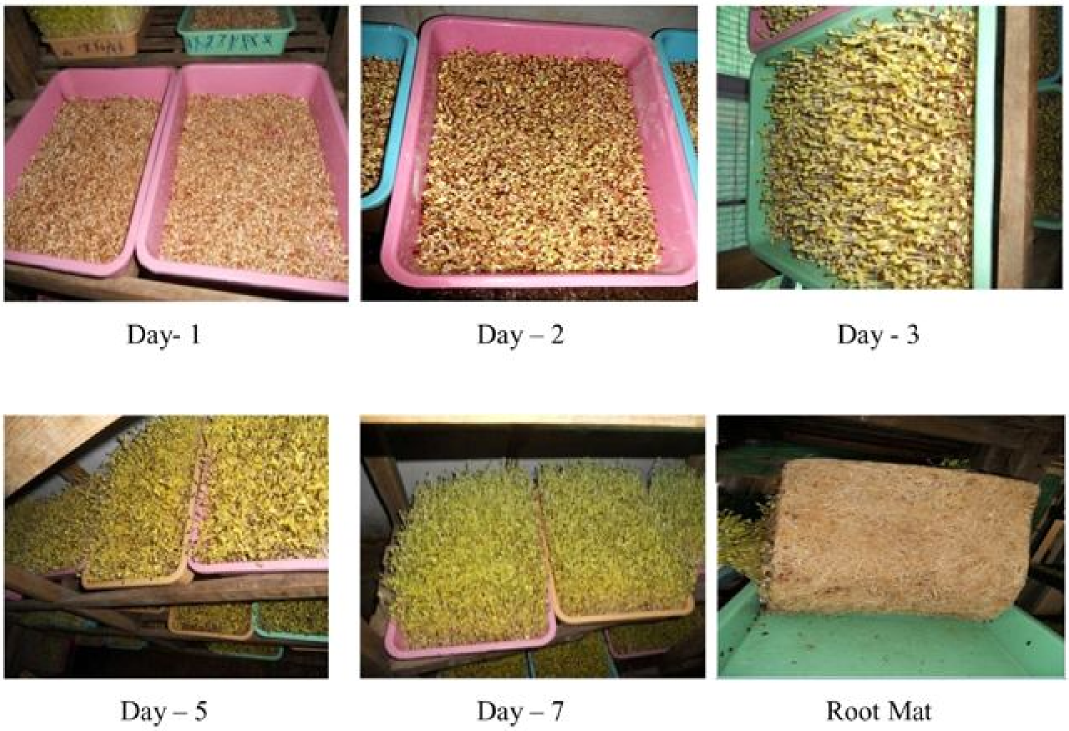


Fig 3 Hydroponic cowpea sprouts showing stages of growth from Day 1 to 7

Fig 4 Hydroponic horse gram sprouts showing stages of growth from Day 1 to 7



Day- 1 Day – 2 Day - 3

Day – 5 Day – 7 Root Mat

Fig 5 Hydroponic maize sprouts showing stages of growth from Day 1 to 7

Day- 1 Day – 2 Day - 4

Day – 5 Day – 7 Root Mat

Fig 6 Hydroponic sorghum sprouts showing stages of growth from Day 1 to 7

Day- 1

Day – 2

Day - 3

Day – 5

Day – 6

Day – 7

Fig 7 Hydroponic barley sprouts showing stages of growth from Day 1 to 7

Day- 1

Day – 2

Day - 3

Day – 5

Day – 7

Root Mat

3.6 Metabolism trial

The preliminary period was conducted for 14 days and then collection period was 7 days. The sheep were kept in metabolism cages and allowed to acclimatize to the cages for 2 days. Weighed quantity of hydroponic fodder was offered each day during collection period and the leftover if any, was recorded. Fresh drinking water was made available throughout the day. The animals were harnessed with faeces collection bags and the 24 hours faeces voided was collected and weighed daily for 7 days. The urine voided was also quantified and collected for 7 days. 2 ml of sulfuric acid was added to each urine collection bottle daily as a preservative and kept in refrigerator till analysed.

3.6.1 Sampling of feeds

Representative samples of hydroponic fodder offered were collected daily and composited during the collection period. DM content of hydroponic fodder was estimated daily during the collection period. The dried samples were pooled, ground in a Willey mill and the ground material was preserved in airtight plastic bottles for subsequent analysis. Similarly, leftover feed of each day of the collection period was weighed and aliquots were collected for DM estimation and of the pooled dried samples.

3.6.2 Faeces

Faeces voided by each animal during 24 hr were weighed at 9 AM and a 5% aliquot was collected daily. DM in faeces was daily estimated and a portion of fresh faeces was composited in polythene bags and frozen in a deep freeze for nitrogen estimation. The dried faecal samples were pooled, ground in the Willey mill and preserved in airtight plastic bottles for further analysis.

3.6.3 Urine

Urine voided by each sheep during 24hr was collected and a 5% aliquot of urine was composited, preserved in glass bottles and kept in a refrigerator till analyzed for N, Ca and P content.

3.7 Chemical analysis

The hydroponic fodder varieties and faecal samples were ground in a willey mill to pass through 2 mm sieve for the chemical analysis. Proximate composition (AOAC, 2005) and cell wall fractions (Goering and Van Soest, 1970) were estimated as per standard methods. The Ca and P content of fodder varieties, faeces and urine were estimated (AOAC, 2005).

3.8 Economics of hydroponic fodder production

The cost of fodder seed per tray and the quantity of fresh fodder and DM per tray were calculated to arrive at the economics of fodder production.

3.9 Statistical analysis

The data were subjected to one way analysis of variance using SPSS version 10.0.

Chapter – IV

Results

CHAPTER – IV

RESULTS

4.1 Yield of hydroponic fodder

The average hydroponic fodder yield (kg) after 7 days of sprouting from SSG, Cowpea, Horse gram, Maize, Jowar and Barley was 7.17±0.11, 8.07±0.10, 7.10±0.09, 9.13±0.06, 5.38±0.10 and 8.22±0.09, respectively from 1 kg grain. The yield was significantly higher ($P<0.01$) from Maize and Barley seeds while it was lower from Jowar seeds.

4.2 Chemical composition of fodder seeds

The chemical composition of different fodder seeds is presented in Table 1.

The DM, OM, CP, EE, CF, TA and NFE content was 89.35, 92.50, 10.22, 3.52, 3.58, 7.50 and 75.18 % (Sorghum Sudan grass seed), 89.27, 94.22, 24.79, 1.26, 20.27, 5.78 and 47.90 % (Cowpea), 90.29, 94.47, 24.85, 1.56, 13.69, 5.53 and 54.37 % (Horse gram), 90.30, 96.64, 9.61, 4.31, 3.53, 3.36 and 79.19 % (Maize), 89.37, 98.62, 9.58, 3.43, 11.15, 1.38 and 74.46 % (Jowar), 92.99, 94.17, 9.99, 2.66, 7.02, 5.83 and 74.50 % (Barley), respectively.

4.3 Chemical composition of hydroponic fodder varieties

The chemical composition of different hydroponic fodder varieties is presented in Table 2.

The DM, OM, CP, EE, CF, TA, AIA and NFE content was 12.34, 95.29, 20.87, 2.57, 18.58, 4.71, 0.36 and 53.27 % (Sorghum Sudan Grass), 11.67, 94.22, 41.09, 1.70, 24.08, 5.78, 0.04 and 27.35 % (Cowpea), 10.64, 95.08, 33.40, 2.29,

Table 1 Chemical composition and cell wall constituents (%) DM of fodder seeds

Particulars	SSG	Cowpea	Horse gram	Maize	Jowar	Barley
DM	89.35	89.27	90.29	90.30	89.37	92.99
OM	92.50	94.22	94.47	96.64	98.62	94.17
CP	10.22	24.79	24.85	9.61	9.58	9.99
EE	3.52	1.26	1.56	4.31	3.43	2.66
CF	3.58	6.8	7.1	3.53	3.1	7.02
TA	3.0	3.18	5.53	3.36	1.38	5.83
NFE	75.18	47.90	54.37	79.19	74.46	74.50

*On dry matter basis except for dry matter

20.16, 4.92, 0.17 and 39.23 % (Horse gram), 12.53, 95.28, 13.68, 3.58, 16.08, 4.72, 0.13 and 61.94 % (Maize), 10.53, 96.35, 25.77, 8.31, 18.25, 3.65, 0.13 and 44.02 % (Jowar), 10.21, 95.99, 17.46, 3.02, 23.26, 4.01, 1.05 and 52.25 % (Barley), respectively.

4.4 Cell wall constituents of hydroponic fodder varieties

The cell wall constituents of hydroponic fodder varieties are presented in Table 2.

The percent NDF, ADF, hemicellulose, cellulose and lignin content was 59.97, 24.60, 35.37, 22.38 and 3.03 (Sorghum sudan grass), 67.62, 39.64, 27.96, 27.65 and 10.94 (Cowpea), 57.71, 28.31, 29.64, 18.59 and 9.42 (Horse gram), 65.66, 28.26, 37.40, 21.75 and 5.82 (Maize), 67.29, 33.79, 33.50, 23.23 and 7.59 (Jowar), 67.40, 37.15, 30.25, 28.57 and 5.78 (Barley), respectively.

4.5 protein fractions of hydroponic fodder varieties

The protein fractions of hydroponic fodder varieties is presented in Table 3

The NPN, NDICP and ADICP (%DM) values were 7.61, 8.09 and 4.05 (SSG), 21.33, 14.71 and 9.92 (Cowpea), 16.79, 12.55 and 8.19 (Horse gram), 4.47, 8.23 and 5.97 (Maize), 8.22, 11.33and 6.95 (Jowar), 6.9, 7.74 and 5.5 (Barley), respectively. The NPN content (% CP) of the hydroponic fodders was 36.7, 51.9, 50.3, 32.7, 31.9 and 39.5% for SSG, Cowpea, Horse gram, Maize, Jowar and Barley varieties, respectively.

Table 2 Chemical composition and cell wall constituents (%) of hydroponic fodder

Particulars	SSG	Cowpea	Horse gram	Maize	Jowar	Barley
DM	12.34	11.67	10.64	12.53	10.53	10.21
OM	95.29	94.22	95.08	95.28	96.35	95.99
CP	20.87	41.09	33.40	13.68	25.77	17.46
EE	2.57	1.70	2.29	3.58	8.31	3.02
CF	18.58	24.08	20.16	16.08	18.25	23.26
TA	4.71	5.78	4.92	4.72	3.65	4.01
AIA	0.36	0.04	0.17	0.13	0.13	1.05
NFE	53.27	27.35	39.23	61.94	44.02	52.25
NDF	59.97	67.62	57.71	65.66	67.29	67.40
ADF	24.60	39.64	28.31	28.26	33.79	37.15
Hemi cellulose	35.37	27.96	29.64	37.40	33.50	30.25
Cellulose	22.38	27.65	18.59	21.75	23.23	28.57
Lignin	3.03	10.94	9.42	5.82	7.59	5.78

*On dry matter basis except for dry matter

Table 3 Protein fractions of hydroponic fodder varieties (% DM)

Particulars	CP	NPN	NDICP	ADICP	NPN (% CP)
SSG	20.87	7.61	8.09	4.05	36.7
Cowpea	41.09	21.33	14.71	9.92	51.9
Horse gram	33.4	16.79	12.55	8.19	50.3
Maize	13.68	4.47	8.23	5.97	32.7
Jowar	25.77	8.22	11.33	6.95	31.9
Barley	17.46	6.9	7.74	5.5	39.5

4.6 Nutrient digestibility (%) sheep fed on hydroponic fodder

The data on nutrient digestibility (%) is presented in Table 4.

The DM digestibility (%) was significantly higher (P<0.01) in sheep fed on Cowpea, Maize and Barley fodder than those fed Jowar, Horse gram and SSG and the values were 79.90, 76.08, 75.07, 54.17, 40.26 and 35.29 respectively. The OM digestibility (%) was significantly higher (P<0.01) in sheep fed on Cowpea and lower (P<0.01) in sheep fed on SSG, than in other varieties. The OM digestibility (%) values for SSG, Cowpea, Horse gram, Maize, Jowar and Barley were 43.64, 81.81, 46.79, 78.26, 58.98 and78.61, respectively. The CP digestibility (%) was significantly higher (P<0.01) in sheep fed on Cowpea and lower (P<0.01) in sheep fed on SSG, than in other varieties. The CP digestibility (%) values for SSG, Cowpea, Horse gram, Maize, Jowar and Barley were 47.85, 83.94, 71.57, 68.33, 69.50 and 72.95, respectively. The EE digestibility (%) was significantly higher (P<0.01) in sheep fed on Barley and lower (P<0.01) in sheep fed on SSG, than in other varieties. The EE digestibility (%) values for SSG, Cowpea, Horse gram, Maize, Jowar and Barley were 50.82, 68.59, 51.20, 66.96, 75.53 and 75.96, respectively. The CF digestibility (%) was significantly higher (P<0.01) in sheep fed on Maize and lower (P<0.01) in sheep fed on Jowar, than in other varieties. The CF digestibility (%) values for SSG, Cowpea, Horse gram, Maize, Jowar and Barley were 34.49, 60.15, 53.43, 72.16, 21.27 and 65.20, respectively. The NFE digestibility (%) was significantly higher (P<0.01) in sheep fed on Cowpea and lower (P<0.01) in sheep fed on SSG, than in other varieties. The NFE digestibility (%) values for SSG, Cowpea, Horse gram, Maize, Jowar and Barley were 49.75, 88.46, 78.35, 82.70, 63.96 and 85.28, respectively.

Table 4 Nutrient digestibility (%) in sheep fed on hydroponic fodder varieties

Particulars	SSG	COWPEA	HORSE GRAM	MAIZE	JOWAR	BARLEY
Proximate principles						
DM	35.29^{c}±3.08	79.90^{a}±1.02	40.26^{c}±2.80	76.08^{a}±2.59	54.17^{b}±2.74	75.07^{a}±2.14
OM	43.64^{c}±2.47	81.81^{a}±0.95	46.79^{c}±2.45	78.26^{a}±2.43	58.98^{b}±2.49	78.61^{a}±1.87
CP	47.85^{c}±2.94	83.94^{a}±0.57	71.57^{b}±1.61	68.33^{b}±3.08	69.50^{b}±2.51	72.95^{b}±1.29
EE	50.82^{b}±8.16	68.59^{ab}±4.50	51.20^{b}±2.09	66.96^{ab}±3.74	75.53^{a}±3.25	75.96^{a}±3.75
CF	34.49^{bc}±2.37	60.15^{ab}±1.38	53.43^{abc}±2.12	72.16^{a}±3.42	21.27^{c}±11.78	65.20^{ab}±2.54
NFE	49.75^{c}±2.99	88.46^{a}±2.34	78.35^{a}±3.24	82.70^{a}±2.13	63.96^{b}±3.36	85.28^{a}±1.49
Cell wall constituents						
NDF	57.34^{b}±2.47	79.59^{a}±1.21	57.04^{b}±1.31	76.00^{a}±2.68	55.82^{b}±3.00	73.88^{a}±2.23
ADF	41.47^{b}±2.80	71.15^{a}±1.81	35^{b}±1.57	71.61^{a}±3.07	46.58^{b}±4.50	69.81^{a}±2.58
Hemi cellulose	49.82^{c}±2.24	80.94^{a}±1.11	68^{b}±2.89	79.32^{a}±2.48	65.16^{b}±3.03	78.91^{a}±1.79
Cellulose	34.24^{b}±5.03	76.57^{a}±2.52	41.52^{b}±2.16	76.44^{a}±2.93	44.55^{b}±5.72	76.14^{a}±1.24

$^{a\ b\ c\ d}$: values in a row with different superscripts differ significantly ** (P<0.01)

The NDF digestibility (%) was significantly higher ($P<0.01$) in sheep fed on Cowpea, Maize and Barley fodder than in SSG, Horse gram and Jowar fed sheep. The NDF digestibility (%) values for SSG, Cowpea, Horse gram, Maize, Jowar and Barley were 57.34, 79.59, 57.04, 76, 55.82 and 73.88, respectively and a similar trend was observed for the ADF digestibility and the values for SSG, Cowpea, Horse gram, Maize, Jowar and Barley were 41.47, 71.15, 35, 71.61, 46.58 and 69.81, respectively. The hemicellulose digestibility was also significantly higher ($P<0.01$) in sheep fed on Cowpea, Maize and Barley and was lowest in SSG fed sheep and the values for SSG, Cowpea, Horse gram, Maize, Jowar and Barley were 49.82, 80.94, 68, 79.32, 65.16 and 78.91, respectively and a similar trend was observed for cellulose digestibility and the values for SSG, Cowpea, Horse gram, Maize, Jowar and Barley were 34.24, 76.57, 41.52, 76.44, 44.55 and 76.14, respectively.

4.7 Nitrogen balance

The nitrogen balance of sheep fed on hydroponic fodder varieties is presented in Table 5.

The nitrogen intake (g/d) in sheep fed on hydroponic fodder varieties was highest ($P<0.01$) in Cowpea and lowest in SSG and the values for SSG, Cowpea, Horse gram, Maize, Jowar and Barley were 2.91, 20.66, 10.96, 8.12, 5.06 and 10.92, respectively. The nitrogen voided in faeces (g/d) in sheep fed Cowpea, Horse gram and Barley was higher ($P<0.01$) than in SSG or Jowar and the values for SSG, Cowpea, Horse gram, Maize, Jowar and Barley were 1.52, 3.33, 3.14, 2.56, 1.52 and 2.95, respectively and a similar trend was observed for the nitrogen voided in urine (g/d) as it was highest ($P<0.01$) in Horse gram and lowest in SSG fed sheep and the values for SSG, Cowpea, Horse gram, Maize, Jowar and Barley were 4.11, 9.72, 15.59, 7.67, 4.96 and 13.79, respectively. The total nitrogen (g/d) voided in sheep fed

Table 5 Nitrogen balance in sheep fed on hydroponic fodder varieties

Particulars	SSG	Cowpea	Horse gram	Maize	Jowar	Barley
N intake (g/d)	2.91^{d}±0.39	20.66^{a}±1.60	10.96^{b}±0.87	8.12^{bc}±0.08	5.06^{cd}±0.35	10.92^{b}±0.05
N excretion (g/d)						
Faecal	1.52^{b}±0.24	3.33^{a}±0.32	3.14^{a}±0.39	2.56^{ab}±0.22	1.52^{b}±0.09	2.95^{a}±0.14
Urinary	4.11^{c}±0.45	9.72^{abc}±1.23	15.59^{a}±3.13	7.67^{bc}±1.53	4.96^{c}±.54	13.79^{ab}±0.85
Total	5.63^{d}±0.66	13.05^{abc}±1.36	18.74^{a}±3.41	10.23^{bcd}±1.50	6.49^{cd}±0.62	16.74^{ab}±0.77
N retained						
g/d	-2.72^{bc}±0.26	7.60^{a}±1.13	-7.77^{c}±2.63	-2.11^{bc}±1.54	-1.43^{b}±0.38	-5.82^{bc}±0.74

$^{a\,b\,c\,d}$: values in a row with different superscripts differ significantly **(P<0.01) on hydroponic fodder varieties was highest (P<0.01) in Horse gram and lowest in SSG and the values for SSG, Cowpea, Horse gram, Maize, Jowar and Barley were 5.63, 13.05, 18.74, 10.23, 6.49 and 16.74, respectively.

The nitrogen retention (g/d) in sheep fed on hydroponic fodder as a sole feed resulted in negative nitrogen retention (P<0.01) in all varieties except Cowpea and the values were (-) 2.72, 7.60, (-) 7.77, (-) 2.11, (-) 1.43 and (-) 5.82 for SSG, Cowpea, Horse gram, Maize Jowar and Barley, respectively.

4.8 Calcium balance

The calcium balance of sheep fed on hydroponic fodder varieties is presented in Table 6.

The calcium intake (g/d) was higher (P<0.01) in Barley than in other varieties and the values were 0.46, 1.38, 1.21, 1.48, 0.76 and 2.22 in sheep fed SSG, Cowpea, Horse gram, Maize, Jowar and Barley, respectively. The calcium voided in faeces (g/d) in sheep fed on hydroponic fodder varieties was highest (P<0.01) in Barley and lowest in Jowar and the values for SSG, Cowpea, Horse gram, Maize, Jowar and Barley were 1.10, 1.41, 2.55, 1.58, 1.02 and 2.71, respectively. The calcium voided in urine (g/d) in sheep fed on hydroponic fodder varieties was highest (P<0.01) in Barley and lowest in SSG and the values for SSG, Cowpea, Horse gram, Maize, Jowar and Barley were 0.20, 0.51, 0.56, 0.56, 0.24 and 0.66, respectively. The total calcium (g/d) voided in sheep fed on hydroponic fodder varieties was higher (P<0.01) in Barley and Horse gram the values for SSG, Cowpea, Horse gram, Maize, Jowar and Barley were 1.31, 1.93, 3.11, 2.15, 1.27 and 3.38, respectively. The calcium retained (g/d) was negative in all varieties and the values were (-) 0.85, (-) 0.55, (-) 1.90, (-) 0.66, (-) 0.51 and (-) 1.15 for SSG, Cowpea, Horse gram, Maize, Jowar and Barley, respectively.

Table 6 Calcium balance in sheep fed on hydroponic fodder varieties

Particulars	SSG	Cowpea	Horse gram	Maize	Jowar	Barley
Ca intake (g/d)	$0.46^{d}\pm0.06$	$1.38^{b}\pm0.10$	$1.21^{b}\pm0.09$	$1.48^{b}\pm0.01$	$0.76^{c}\pm0.05$	$2.22^{a}\pm0.01$
Ca excretion (g/d)						
Faecal	$1.10^{b}\pm0.13$	$1.41^{b}\pm0.11$	$2.55^{a}\pm0.22$	$1.58^{b}\pm0.23$	$1.02^{b}\pm0.18$	$2.71^{a}\pm0.14$
Urinary	$0.20^{b}\pm0.04$	$0.51^{ab}\pm0.13$	$0.56^{ab}\pm0.14$	$0.56^{ab}\pm0.12$	$0.24^{ab}\pm0.01$	$0.66^{a}\pm0.04$
Total	$1.31^{b}\pm0.15$	$1.93^{b}\pm0.13$	$3.11^{a}\pm0.27$	$2.15^{b}\pm0.31$	$1.27^{b}\pm0.18$	$3.38^{a}\pm0.18$
Ca retained						
g/d	$-0.85^{a}\pm0.09$	$-0.55^{a}\pm0.21$	$-1.90^{b}\pm0.22$	$-0.66^{a}\pm0.32$	$-0.51^{a}\pm0.24$	$-1.15^{ab}\pm0.17$

$^{a\,b\,c\,d}$: values in a row with different superscripts differ significantly **(P<0.01)

4.9 Phosphorus balance

The phosphorus balance of sheep fed on hydroponic fodder varieties is presented in Table 7.

The phosphorus intake (g/d) in sheep fed on hydroponic fodder varieties was highest ($P<0.01$) in Barley and lowest in SSG and the values for SSG, Cowpea, Horse gram, Maize, Jowar and Barley were 0.07, 0.47, 0.18, 0.29, 0.17 and 0.58, respectively. The phosphorus voided in faeces (g/d) in sheep fed on hydroponic fodder varieties SSG, Cowpea, Horse gram, Maize, Jowar and Barley was 0.20, 0.19, 0.15, 0.31, 0.17 and 0.35, respectively and there was no significant difference among the varieties. The phosphorus voided in urine (g/d) in sheep fed on hydroponic fodder varieties was highest ($P<0.01$) in Barley and lowest in SSG and the values for SSG, Cowpea, Horse gram, Maize, Jowar and Barley were 0.18, 0.62, 0.64, 0.51, 0.26 and 1.03, respectively. The total phosphorus (g/d) voided in sheep fed on hydroponic fodder varieties was highest ($P<0.01$) in Barley and lowest in SSG and the values for SSG, Cowpea, Horse gram, Maize, Jowar and Barley was 0.39, 0.81, 0.79, 0.83, 0.44 and 1.38, respectively. The phosphorus retained (g/d) in sheep fed on SSG, Cowpea, Horse gram, Maize, Jowar and Barley were (-) 0.31, (-) 0.34, (-) 0.61, (-) 0.53, (-) 0.26 and (-) 0.79, respectively.

4.10 Nutritive value of sheep fed on hydroponic fodder varieties

The nutritive value of sheep fed on hydroponic fodder varieties is presented in Table 8.

The DCP (%) of hydroponic fodder varieties differed significantly ($P<0.01$) with the highest value of 34.49 % in Cowpea and the least value of 9.34 % in Maize

Table 7 Phosphorus balance in sheep fed on hydroponic fodder varieties

Particulars	SSG	Cowpea	Horse gram	Maize	Jowar	Barley
P intake (g/d)	0.07^{e}±0.01	0.47^{b}±0.03	0.18^{d}±0.01	0.29^{c}±0.003	0.17^{d}±0.01	0.58^{a}±0.002
P excretion (g/d)						
Faecal	0.20±0.05	0.19±0.05	0.15±0.01	0.31±0.10	0.17±0.02	0.35±0.05
Urinary	0.18^{b}±0.05	0.62^{ab}±0.16	0.64^{ab}±0.11	0.51^{b}±0.11	0.26^{b}±0.02	1.03^{a}±0.07
Total	0.39^{b}±0.07	0.81^{b}±0.14	0.79^{b}±0.11	0.83^{b}±0.13	0.44^{b}±0.03	1.38^{a}±0.09
P retained						
g/d	-0.31^{ab}±0.06	-0.34^{ab}±0.16	-0.61^{ab}±0.10	-0.53^{ab}±0.13	-0.26^{a}±0.04	-0.79^{b}±0.08

$^{a\,b\,c\,d\,e}$: values in a row with different superscripts differ significantly **(P<0.01)

Table 8 Nutritive value of sheep fed on hydroponic fodder varieties

Particulars	SSG	Cowpea	Horse gram	Maize	Jowar	Barley
DCP (%)	9.98^{e}±0.61	34.49^{a}±0.23	23.90^{b}±.53	9.34^{e}±0.42	17.91^{c}±0.64	12.73^{d}±0.22
TDN (%)	45.83^{c}±2.09	75.79^{a}±1.07	68.08^{ab}±3.50	77.57^{a}±2.44	64.07^{b}±2.17	77.63^{a}±1.44
DE (kcal/kg DM)	2016.91^{c}±92.39	3334.97^{a}±47.16	2995.81^{ab}±154.40	3413.13^{a}±107.56	2819.39^{b}±95.50	3415.72^{a}±63.59

$^{a\,b\,c\,d\,e}$: values in a row with different superscripts differ significantly **(P<0.01) while the values were 9.98, 23.90, 17.91 and 12.73 % for the SSG, Horse gram, Jowar and Barley fodder varieties, respectively. The TDN (%) of hydroponic fodder varieties also differed significantly (P<0.01) and the values for SSG, Cowpea, Horse gram, Maize, Jowar and Barley were 45.83, 75.79, 68.08, 77.57, 64.07 and 77.63, respectively. The DE (kcal/kg DM) of hydroponic fodder varieties was higher (P<0.01) in sheep fed on Barley and lower in SSG and the values for SSG, Cowpea, Horse gram, Maize, Jowar and Barley were 2016.91, 3334.97, 2995.81, 3413.13, 2819.39 and 3415.72, respectively.

4.11 plane of nutrition of sheep fed on hydroponic fodder varieties

The plane of nutrition of sheep fed on hydroponic fodder varieties is presented in Table 9.

The average initial body weight (kg) of sheep at the start of preliminary period on each fodder varieties was 28.80, 31.55, 32.64, 29.01, 31.57 and 37.42 for SSG, Cowpea, Horse gram, Maize, Jowar and Barley, respectively and it was not significant different. The average final body weight (kg) at the end of collection period was higher (P<0.01) in sheep fed with Barley and lower in SSG and the values for SSG, Cowpea, Horse gram, Maize, Jowar and Barley was 21.17, 25.52, 25.89, 28.36, 28.45 and 37.04, respectively. There was body weight loss (P<0.01) ranging from a minimum of 0.38 kg in sheep Barley fodder to a maximum body weight loss of 7.63 kg in sheep fed on SSG fodder.

The average green fodder intake (kg/d) was 0.70, 2.69, 1.92, 2.96, 1.16 and 3.83 for SSG, Cowpea, Horse gram, Maize, Jowar and Barley, respectively and the corresponding DM intake (g/d) of sheep was higher (P<0.01) in sheep fed on Barley and lower in SSG and the values for SSG, Cowpea, Horse gram, Maize, Jowar and

Table 9 Plane of nutrition of sheep fed on hydroponic fodder varieties

Particulars	SSG	Cowpea	Horse gram	Maize	Jowar	Barley
Initial body weight (kg)	28.80±0.67	31.55±2.37	32.64±2.18	29.01±2.11	31.57±1.79	37.42±2.36
Final body weight (kg)	21.17^{b}±0.56	25.52^{b}±2.60	25.89^{b}±2.22	28.36^{b}±1.87	28.45^{b}±1.74	37.04^{a}±1.97
Loss in weight (kg)	- 7.63^{c}±0.23	- 6.02^{c}±0.45	- 6.75^{c}±0.88	- 0.65^{ab}±0.79	- 3.11^{b}±0.13	- 0.38^{a}±0.74
Average body weight (kg)	24.99^{b}±0.61	28.53^{b}±2.48	29.26^{ab}±2.15	28.68^{b}±1.96	30.01^{ab}±1.77	37.23^{a}±2.14
Average fodder intake (kg/d)	0.70^{d}±0.09	2.69^{b}±0 .20	1.92^{c}±0. 15	2.96^{b}±0.03	1.16^{d}±0.08	3.83^{a}±0.01
DMI (g/d)	87.30^{d}±11.87	314.26^{b}±24.35	205.18^{c}±16.34	371.14^{a}±3.79	122.77^{d}±8.57	391.03^{a}±1.86
DMI as % B.wt.	0.34^{c}±0.03	1.11^{a}±0.08	0.70^{b}±0.05	1.31^{a}±0.09	0.41^{c}±0.04	1.06^{a}±0.06
DMI (g/kg $W^{0.75}$)	7.76^{c}±0.93	5.58^{a}±1.74	16.34^{b}±1.12	30.23^{a}±1.62	9.68^{c}±0.93	26.11^{a}±1.18
CP intake (g/kg $W^{0.75}$)	18.69^{c}±0.34	33.73^{a}±1.99	26.81^{b}±1.43	11.14^{d}±0.57	20.24^{c}±0.92	11.62^{d}±0.48
TDN as (g/kg $W^{0.75}$)	41.10^{b}±2.24	62.37^{a}±4.49	54.49^{a}±3.24	62.94^{a}±2.26	50.25^{ab}±2.36	51.79^{ab}±2.11

$^{a\,b\,c\,d}$: values in a row with different superscripts differ significantly **(P<0.01)

Barley were 87.30, 314.26, 205.18, 371.14, 122.77 and 391.03, respectively. The DMI as % of body weight was higher ($P<0.01$) in sheep fed on Maize and lower in SSG and the values for SSG, Cowpea, Horse gram, Maize, Jowar and Barley were 0.34, 1.11, 0.70, 1.31, 0.41 and 1.06, respectively. The DMI intake (g/kg $W^{0.75}$) of hydroponic fodder varieties was higher ($P<0.01$) in sheep fed on Maize and lower in SSG and the values for SSG, Cowpea, Horse gram, Maize, Jowar and Barley were 7.76, 25.58, 16.34, 30.23, 9.68 and 26.11, respectively. The CP intake (g/kg $W^{0.75}$) was higher ($P<0.01$) in sheep fed on Cowpea and lower in Maize and the values for SSG, Cowpea, Horse gram, Maize, Jowar and Barley were 18.69, 33.73, 26.81, 11.14, 20.24 and 11.62, respectively. The TDN intake (g/kg $W^{0.75}$) was higher ($P<0.01$) in sheep fed on Cowpea and lower in SSG and the values for SSG, Cowpea, Horse gram, Maize, Jowar and Barley were 41.10, 62.37, 54.49, 62.94, 50.25 and 51.79, respectively.

The nutrient requirement of sheep and goat (ICAR, 2013) suggested that sheep weighing 25-35 kg require for maintenance 390-500g TDN, 75-96g CP and a dry matter intake 2.6 to 2.8 % of body weight. In the present study, sheep fed on different hydroponic fodder varieties failed to consume the required quantity of dry matter leading to low plane of nutrition and loss of body weight.

4.12 Gain/Loss of nutrients in hydroponic fodder production

Gain/Loss of nutrients in hydroponic fodder production is presented in Table 10.

The nutrient content of seeds / kg DM was calculated and the nutrient yield / kg DM of the hydroponic fodder from the respective seed was also calculated to arrive at the gain or loss of nutrients due to hydroponic fodder production. There was gain in DM from Maize and Cowpea and loss in DM was recorded in SSG, Barley,

Table 10 Gain/Loss of nutrients in hydroponic fodder production

VARIETY	DM	OM	CP	CF	NFE
SSG	-0.96	2.02	102.23	413.97	-29.83
Cowpea	5.53	5.53	74.92	273.70	-39.74
Horse gram	-16.23	-15.69	72.59	137.86	-39.56
Maize	26.78	25	80.48	477.54	-0.83
Jowar	-36.4	-37.96	70.82	273.83	-62.46
Barley	-9.66	-7.91	57.89	199.33	-36.64

Horse gram and Jowar hydroponic fodder production and the values were 26.78, 5.53, (-)0.96,(-) 9.66, (-)16.23 and (-)36.4 % respectively. There was OM gain i.e. the yield of OM due to hydroponic fodder production in Maize, SSG and Cowpea whereas there was loss in Horse gram, Jowar and Barley and the values were 25, 2.02, 5.53, (-)15.69, (-)37.96 and (-)7.91%, respectively. CP gain was observed in all the six varieties of hydroponic fodder and the values were 102.23, 74.92, 72.59, 80.48, 70.82 and 57.89 % for SSG, Cowpea, Horse gram, Maize, Jowar and Barley, respectively. The CF gain was observed in all the six varieties of hydroponic fodder and the values were 413.97, 273.70, 137.86, 477.54, 273.83 and 199.33 for SSG, Cowpea, Horse gram, Maize, Jowar and Barley, respectively. The EE gain was observed in all varieties of hydroponic fodder except SSG and the values were -27.70, 42.39, 22.97, 5.31, 53.85 and 2.57 % for SSG, Cowpea, Horse gram, Maize, Jowar and Barley, respectively. The NFE loss was observed in all the six varieties of hydroponic fodder and the values were (-) 29.83, (-) 39.74, (-) 39.56, (-) 0.83, (-) 62.46 and (-) 36.64 for SSG, Cowpea, Horse gram, Maize, Jowar and Barley, respectively.

4.13 Cost of production of hydroponic fodder

The cost of production of hydroponic fodder is presented in Table 11

Equipment cost common for all varieties

1)	Mesh 28 sq.ft	-	`. 3360
2)	G.I. wire	-	`. 50
3)	Wire cutter	-	`.150
4)	Shade net	-	`.2000
5)	Plastic trays	-	`. 3000
	Total	=	`. 8560

Table 11 Cost of production of hydroponic fodder

Variety	Seed cost /kg	Green fodder yield/kg	Cost/kg of green fodder
SSG	9	7.17	1.26
Cowpea	58	8.07	7.18
Horse gram	37	7.11	5.20
Maize	17	9.14	1.86
Jowar	28	5.39	5.20
Barley	40	8.23	4.86

The cost of production of production of hydroponic fodder from SSG, Cowpea, Horse gram, Maize, Jowar and Barley was `. 1.26, 7.18, 5.20, 1.86, 5.20 and 4.86, respectively taking into account the seed cost only. In the present study there was no investment on electricity, labour, water etc hence only the seed cost was taken to calculate the cost of production per kg of green fodder.

Chapter – V

Discussion

CHAPTER-V

DISCUSSION

The results of the present study on the effect of feeding hydroponic fodder varieties in sheep as sole feed is discussed in this chapter using the literature published pertaining to the parameters of present study.

5.1 Chemical composition of fodder seeds

The chemical composition of the fodder seeds is presented in Table 1. Cowpea and Horse gram being legumes contained higher CP (>24 %), CF (7.0%) and lower NFE (48 -54%) while the other cereal type fodder seeds i.e. SSG, Jowar, Maize and Barley contained 9.5 to 10.2 % CP and 74 to 79% NFE, although the CF and TA content was higher in Barley. Higher CP, DM, OM, EE, CF, TA and lower CP and NFE was observed than the mean of the values reported for Barley fodder seeds by various authors (Table A). Similarly, Maize fodder seed contained higher CP, EE, CF, TA, and lower DM, OM and NFE than the mean of the values reported for Maize fodder seeds by various authors (Table B). The Jowar fodder seed contained higher EE and lower DM, CF, TA, NFE and same OM and CP than the mean of the values reported for Barley fodder seeds by various authors (Table C).

5.2 Chemical composition of hydroponic fodder varieties

The chemical composition of the hydroponic fodder is presented in Table 2. The DM was 10.2 to 12.5 % among the varieties with the CP content ranging from13.7 % in Maize fodder to 41.0% in Cowpea fodder. The CF content was in the range of 16% in Maize to about 23- 24% in Barley and Cowpea varieties. The NFE content was lower in the legume varieties i.e. Cowpea and Horse gram fodder while maximum NFE was observed in Maize fodder (61.94%). The cell wall constituents (%) of the fodder varieties ranged from 57.7 to 67.6 (NDF), 24.6 to 39.6 (ADF), 27.9 to 37.0 (hemicellulose) and 18.6 to 28.6 (cellulose).The lignin content was minimum (3.03%) in SSG and maximum (10.94%) in Cowpea. Comparison of the chemical composition hydroponic Barley fodder of the present study with the published values (Table D) revealed a higher CF, NFE and lower DM, OM, CP, EE and TA content than the mean of the values reported by various authors. Similarly, hydroponic Maize fodder contained higher CF, TA, and lower DM, CP, EE and NFE than the mean of the values reported for by various authors (Table E). The hydroponic Jowar fodder contained higher CP, CF, EE and lower DM, TA, NFE when compared with the values of Sule sale (2015). Similarly hydroponic Barley fodder contained higher NDF, ADF, hemicellulose, cellulose and lower lignin than the mean of the values reported for Barley fodder by various authors (Table D). The percent increase or decrease of nutrients in the fodder than in the seeds revealed (Table 3) that there was an increase of CP (58-102%) and CF (137 to 477%). There was an increase of DM in Maize and cow pea fodder production while in other varieties the DM decreased by 0.96 % in SSG to about 36% in Jowar. The NFE content decreased by 0.83 % in Maize fodder production to a maximum loss of 64 % in production of Jowar fodder. The change in nutrient content of seeds and the respective hydroponic fodder includes an increase in total protein concentration, changes in amino acid composition, a decrease in starch concentration, increase in sugars, slight increase in crude fat and crude fiber and slightly higher amounts of certain vitamins and minerals in the fodder when compared with the seed. (Fazaeli *et al*., 2012). The fresh hydroponic Barley sprouts have been reported to have highly soluble proteins and amino acids in response to the enzymatic transformations during early plant growth. These enzymatic activities in the young plant also cause the breakdown of carbohydrates, proteins and lipids into simpler compounds and cause nutrient changes such as an increase in total protein concentration, changes in amino acids composition, decrease in starch, increase in sugars, CF, fat and higher amounts of some vitamins and minerals on a DM basis (chung *et al*., 1989). Chavan and Kadam (1989) observed that by enhancing the time of sprouting the green fodder contained lower OM and higher ash in sprouted grain because higher organic matter, particularly starch was consumed to support the metabolism and energy requirement of the growing plant. The increase in EE in the green fodder could be due to the production of chlorophyll associated with plant growth that is recovered in ether extract estimation (Snow and Ghaly, 2008). Ash content changed from 2.1 in original Barley seed to 3.1 and 5.3 at day 6 and 8 respectively, (Morgan et *al*., 1992). Shtaya (2004) showed that the germination of wheat for 5 to 7 days resulted in a 17% loss of total DM while the DM loss was 25% after 12 days of sprouting. Fiber content increased from 3.5% in cereal Barley grains to 6.5% and 8% in a 5 and 8 day green Barley fodder, respectively. Dung *et al*., (2010a) reported that, seed soaking apart from causing the leaching of nutrients, also initiates a series of events that lead to oxidation of substrates stored in the grain causing a loss in DM. The loss of DM through respiration in the young plant when compared to the gains of photosynthetic activities brings about net loss in DM when sprouting is completed. In a 7 day sprout, photosynthesis commences around day 5 when the chloroplasts are activated and this does provide enough time for any significant DM accumulation.

5.3 protein fractions of hydroponic fodder varieties

The protein fractions of hydroponic fodder varieties are presented in Table 3. The different protein fractions as % of DM ranged from 4.4 to 21 (NPN), 7.7 to 14.7

(NDICP) and 4.0 to 9.9 (ADICP) with legume varieties i.e. Cowpea and Horse gram fodders containing higher NPN, NDICP and ADICP fractions of protein than the cereal varieties. Fazaeli *et al*., (2012) also reported increase in soluble protein, NPN, NDICP and ADICP content of hydroponic Barley fodder by extending the sprouting period from 6 to 8 days.

5.4 Yield of fodder from different seeds

In the present study, the average hydroponic fodder yield (kg) from 1 kg seed after 7 days of sprouting from SSG, Cowpea, Horse gram, Maize, Jowar and Barley was 7.17±0.11, 8.07±0.10, 7.10±0.09, 9.13±0.06, 5.38±0.10 and 8.22±0.09, respectively.

A total of 8-9kg (Gebrimedhin, 2015), 6-10 kg (Sneath and McIntosh, 2003), 7.2 kg (Fazaeli *et al*., 2012) of hydroponic Barley fodder production out of 1kg Barley seeds was reported. Fazaeli *et al*., (2011) reported that fresh weight of green fodder increased about 4.5 times of the original seed weight, after sprouting Barley grain for 6 days. This increase in fresh weight of forage was due to the large uptake of water during germination, but, numerically some dry matter losses (DML) was found in the green sprout compared to the original grain dry matter.

Naik and Singh (2013) reported an yield of 5-6 kg hydroponic fodder from 1kg Maize seed and although there was increase in fresh weight, the dry matter content decreased during sprouting of seeds. They also reported that famers of the Satara district of Maharashtra produced fresh fodder of up to 8-10 folds for hydroponics Maize fodder in shade-net greenhouse system. An yield of 8 kg hydroponic Maize fodder (Gebrimedhin, 2015) and 4-8 hydroponic fodder (Peer and Leeson, 1985) out of 1kg Maize seed was reported.

5.5 Nutrient digestibility (%) sheep fed on hydroponic fodder

The nutrient digestibility of sheep fed hydroponic fodder varieties is presented in Table 4.

The DM, OM, CP, EE, CF, NFE, NDF, ADF, hemicellulose and cellulose digestibility was significantly higher ($P<0.01$) in Cowpea, Maize and Barley fodder than those fed Jowar, Horse gram and SSG. The digestibility (%) values of the different nutrients in the different varieties of hydroponic fodder indicated that Cowpea, Barley and Maize were superior to horsegram, Jowar and SSG. There is very scanty information on nutrient digestibility of hydroponic fodder fed as sole diet to sheep. Many reports (Reddy *et al*., 1988; Chung *et al*., 1989; Fayed, 2011; Helal, 2015) indicated improved digestibility of whole diet when hydroponic fodder was used as a supplement and formed part of diet of animals and was attributed to highly soluble protein and amino acids in fresh grains sprouts and the tenderness of the fodder due to its lower age. Other report (Cuddeford, D., 1989) indicated that the in vivo digestibility of 8-day barely sprouts ranged from 73-76 percent and the ME content to be around 12.2 MJ/kg DM. Sprouts are the most enzyme rich food on the planet (Shipard, 2005) and the period of greatest enzyme activity in sprouts is generally between germination and 7 days of age (Chavan and Kadam, 1989). Another reason of the increase in the digestibility of the nutrients due to feeding of hydroponics Maize fodder may be its high enzyme activities. Pandey and Pathak (1991) reported that the digestibilities of the nutrients of the hydroponics green fodder are comparable to the highly digestible legumes like Berseem and other clovers.

5.6 Nitrogen balance

The nitrogen intake (g/d) in sheep fed on hydroponic fodder varieties (Table 5) was highest ($P<0.01$) in Cowpea and lowest in SSG and this could be attributed to the higher DMI in Cowpea as well as higher CP content. The nitrogen retention (g/d) was negative in all varieties except Cowpea. This might be related to the higher CP intake and its digestibility in sprouted Cowpea when compared with other experimental forages. The crude protein content presently observed in hydroponic Maize fodder was 14.56 % which is higher as compared to 9.82 % in conventional Maize fodder harvested at 60 days growth period and 7.6 % in Maize seed. Similar trend of higher CP content of fodder than seeds was observed. Sprouting alters the amino acid profile of seeds and increases the crude protein content and nitrogen retention of hydroponic fodder (El-Morsy *et al*., 2013). It was reported (Sule sale, 2015) that supplementation of sorghum hydroponic fodder resulted in lower nitrogen intake, than the animals fed sorghum grain, but the nitrogen absorbed and nitrogen loss was higher in animals fed grains than those fed sprouts. In spite of all these factors, the negative nitrogen balance was principally due to the low intake of fresh fodder in the present study. There is very little information on the nitrogen balance of animals fed on hydroponic fodder varieties as sole ration. However improvement in nitrogen balance of animals on supplementation of hydroponic Barely fodder in lambs **(**Fayed, 2011), Merino sheep (Dung *et al*., 2010a) and in goats (Helal, 2015) was reported. Improved nitrogen retention and balance was reported upon supplementation of hydroponic Maize fodder in cows **(**Nugroho *et al*., 2015) and in Konkan Kanyal kids (Gebremedhin, 2015) and sorghum hydroponic fodder in Red Sokoto goats (Sule sale, 2015)

5.7 Calcium and phosphorus balance

The calcium and phosphorus retained (g/d) was negative in all varieties (Tables 6 and 7) and could be attributed to the low intake of fodder of all varieties.

5.8 Nutritive value and plane of nutrition

Based on the DCP and TDN content (Table 8), Cowpea, Barley and Maize were superior to horsegram, Jowar and SSG. The Jowar varieties were inferior to other varieties.

The voluntary intake (kg/d) of fresh fodder (Table 9) was higher ($P<0.01$) for Barley (3.83 kg) followed by Maize (2.96kg) and Cowpea (2.69kg) while it was 1.92, 1.16 and0.70 kg for horsegram, Jowar and SSG varieties leading to a low DM intake from SSG, Jowar and Horse gram than other varieties . The DMI as % of body weight ranged from 1.31 in Maize to as low as 0.34 % from SSG. This led to the low plan of nutrition and loss of body weight. The DMI, DCP and TDN intake was far below the ICAR (2013) recommended levels of 390-500g TDN, 75-96g CP and a dry matter intake 2.6 to 2.8 % of body weight for maintenance of sheep weighing 25-35 kg. Pandey and Pathak (1991) reported voluntary intake of 50.38 kg fresh hydroponics Barley green fodder/day, which supplied 7.13 kg DM and concluded that DM intake was a limiting factor on sole feeding of hydroponics green fodder. Reddy *et al*.,(1988) observed higher ($P<0.05$) DCP and TDN% in the artificially grown Barley fodder based ration than the NB21 based ration and suggested that the former ration was optimum to meet the production requirement of the lactating cows.

5.9 Cost economics of production

The cost of production of hydroponic fodder from SSG, Cowpea, Horse gram, Maize, Jowar and Barley was `.1.26, 7.18, 5.20, 1.86, 5.20 and 4.86, respectively taking into account the seed cost only (Table11). The yield of green fodder was in the order of Maize > Barley > Cowpea > SSG > Horsegram > Jowar and the least cost for SSG was due to the low seed cost. Saidi and Omar (2015) reported that the calculated production cost per kg hydroponic Barley was 0.21 NIS (Israeli new sheqel) equal to Indian rupees of 3.65/kg. Compared to the traditional roughage regularly fed to local sheep there was a saving of about 0.79 NIS/kg or `.13.72/kg and they noticed a significant reduction in feed cost could be achieved by supplementing hydroponic Barley fodder.

Al-Saadi (2016) in his study, reported that it was economically profitable to include hydrophonic green fodder to replace 30% of conventional Barley fodder.

Swati Verma *et al*., (2015) reported the cost of hydroponic green feed varied with the size of the machine .The operational cost for production of green fodder in the machine APH-1000 would range between `. 4.50-5.00 per kg including the cost of of Barley seed (`. 20.0 /kg), cost of nutrient solution, labour cost, electricity charges and miscellaneous expenses.

Fazaeli *et al*., (2012) suggested that hydroponic green fodder had no advantage over Barley grain in feed lot calves, while it increased the cost of feed, however, Naik *et al*., (2014) found higher net profit of `.12.67/- per cow/day on feeding hydroponic fodder although the cost of hydroponic Maize fodder (`.4.0/kg) was higher than the conventional green fodder (`.1.50/kg). Naik and Singh (2013) reported that with hi-tech greenhouse, the cost of production of fresh hydroponics Maize fodder was about `.4.0 to 4.50/- per kg in which the seed cost was about 90-98%. They also reported that farmers of the Satara district of Maharashtra using low cost shade net system with home-grown or locally purchased seeds could produce hydroponic fodder at a very low price of `.2.0-3.50 per kg.

Chapter – VI

Summary

CHAPTER – VI

SUMMARY

As livestock population increases, large gap exists between requirement and availability of feed and fodder. In India there is a shortage of in dry and green fodder and concentrates Quality green fodder should be fed regularly to the dairy animals. Hydroponic fodder production is considered as one of the ways of overcoming green fodder shortage particularly in urban and peri urban areas and in villages where land and water scarcity is a major constraint for fodder cultivation. In the present study an attempt was made to produce green fodder through hydroponic system and evaluate their nutritive value in sheep along with cost economics of production. Six varieties of fodder seeds i.e. SSG, cowpea, horse gram, maize, jowar and barley were used to green fodder under hydroponic system. Four Nellore Jodipi rams were used to evaluate nutrient digestibility, nitrogen, calcium and phosphorus balance, nutritive value and plane of nutrition on hydroponic fodder as a sole feed.

The average hydroponic fodder yield (kg) after 7 days of sprouting from SSG, cowpea, horse gram, maize, jowar and barley was 7.17±0.11, 8.07±0.10, 7.10±0.09, 9.13±0.06, 5.38±0.10 and 8.22±0.09, respectively from 1 kg grain. The yield was significantly higher ($P<0.01$) from maize and barley seeds while it was lower from jowar seeds.The cost of production of hydroponic fodder from SSG, cowpea, horse gram, maize, jowar and barley was `.1.26, 7.18, 5.20, 1.86, 5.20 and 4.86, respectively taking into account the seed cost only and the yield of green fodder per kg seed was in the order of Maize > Barley > Cowpea > SSG > Horsegram > Jowar.

The DM was 10.2 to 12.5 % among the fodder varieties with the CP content ranging from13.7 % in maize fodder to 41.0% in cowpea fodder. The CF content was in the range of 16% in maize to about 23- 24% in barley and cowpea varieties. The NFE content was lower in the legume varieties i.e. cowpea and horse gram fodder while maximum NFE was observed in Maize fodder (61.94%). The cell wall constituents (%) of the fodder varieties ranged from 57.7 to 67.6 (NDF), 24.6 to 39.6 (ADF), 27.9 to 37.0 (hemicellulose) and 18.6 to 28.6 (cellulose).

The DM, OM, CP, EE, CF, NFE, NDF, ADF, hemicellulose and cellulose digestibility were significantly higher ($P<0.01$) in cowpea, maize and barley fodder than those fed jowar, horse gram and SSG. The digestibility (%) values of the different nutrients in the different varieties of hydroponic fodder indicated that cowpea, barley and maize were superior to horsegram, jowar and SSG. The nitrogen retained (g/d) of sheep was negative in all varieties except those fed Cowpea while the Ca and P balance was negative in all varieties and was due to low dry matter intake . The DMI as % of body weight ranged from 1.31 in sheep fed Maize fodder to as low as 0.34 % in SSG fed sheep. The voluntary intake (kg/d) of fresh fodder was higher ($P<0.01$) for barley (3.83 kg) followed by maize (2.96kg) and cowpea (2.69kg) while it was 1.92, 1.16 and 0.70 kg for horse gram, jowar and SSG varieties.

The DCP (%) of hydroponic fodder varieties differed significantly ($P<0.01$) with the highest value of 34.49 % in cowpea and the least value of 9.34 % in maize while the values were 9.98, 23.90, 17.91 and 12.73 % for the SSG, horse gram, jowar and barley fodder varieties, respectively. The TDN (%) of hydroponic fodder varieties also differed significantly ($P<0.01$) and the values for SSG, Cowpea, Horse gram, Maize, jowar and Barley were 45.83, 75.79, 68.08, 77.57, 64.07 and 77.63, respectively.

It was concluded that hydroponic fodder production is an effective way to produce green fodder where land and water scarcity exists. However, they were not relished by sheep as sole feed. They may be best suited as supplements to the basal ration and can be used to meet part of the DM requirements.

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