Biomass Production and Nutritive Value of Different Hydroponic Fodder Species and their Effects on Growth Performance on Rabbits

A THESIS

BY

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DEDICATED

TO

MY

BELOVED PARENTS

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ABSTRACT

Both hydroponic fodder production and rabbit growth experiments were conducted at Dr. Purnendu Gain Field Laboratory, Agrotechnology Discipline, Khulna University, Bangladesh during the period from 1st January, 2023 to 31st April, 2013. The objective was to observe the biomass yield of hydroponically grown forages and their effect on growth performance of rabbits. The experiment was laid out in a completely randomized design (CRD) with four treatments viz. control group fed regular vegetable diet without including hydroponic fodder (T_1), inclusion of corn hydroponic fodder (T_2), inclusion of wheat hydroponic fodder (T_3) and inclusion of jumbo hydroponic fodder with regular diet (T_4). A total of 12 rabbits were divided into 4 treatment groups with 3 replications in each and randomly assigned to 4 experimental diets. Body weight data were measured on a weekly basis. The biomass yield of each forage species was recorded and the chemical composition of the forage was determined. After 15 days the biomass yield was obtained from wheat hydroponic fodder to be 766.0±4.0 g from 250 g seed and the lowest yield was obtained from maize hydroponic fodder to be 574.0±14.0 g from 250 g seed. The highest crude protein (CP) content was found in wheat hydroponics fodder (18.71±0.28) %. The results of this study showed that the growth performance of rabbits on different hydroponically grown forage feeding practices under intensive systems was found to be better than without hydroponically grown forage feeding practices. Group of rabbits fed jumbo hydroponic fodder showed significantly highest weight gain and better feed conversion ratio (FCR). The highest growth rate was found in jumbo hydroponics fodder-feeding rabbits because the highest fiber content and good palatability helped their bodies digest and utilize the feed properly. Further studies should be conducted to determine the appropriate hydroponic fodder for rabbit farmers recommending these practices.

Keywords: Biomass, Feeding, Hydroponic fodders, Nutritive value, Rabbits

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CHAPTER-I

INTRODUCTI0N

In Bangladesh, the population growth is numerically high. With the increase of high population, the nutritional demand for protein is increasing day by day. Our country is doing great in the production of the livestock sector. Livestock is considered a trust sector for poverty reduction in our country, income generation, and nutrient deficiency. Its contribution to the national GDP is 1.60% in 2016-17 (Bangladesh Economic Review, 2017). But due to the high price of feeds and fodder, the livestock rearing becomes very expensive and the price of meat, milk & egg is high as a result of the high price of animal protein people can't afford to buy them. So, it is urgent to open a new source of protein that will be reasonable and much nutritious. Domestic rabbit (*Oryctolagus cuniculus*) meat can be a good source of cheap animal protein. Since the early civilizations of the Mediterranean basin, rabbit meat-based food dishes have been regularly produced and consumed. Rabbit rearing is simple and environment-friendly on farms and in backyards. Asia accounted for 70.5% of worldwide rabbit meat production quantity in 2020, followed by Europe (FAOSTAT, 2022). A wide range of inventive rabbit meat substitutes are accessible in the market, with smoked, canned, frozen, cured, sauce-picked, dried, and roasted products as well as rabbit meat sausages.

Rabbits are capable to convert 20% of the protein they ingest in their diet into muscle mass, an alteration that is close to those of poultry (22%). The effectiveness of protein alteration into meat is higher in rabbits than in other livestock such as beef, where it varies between 8% and 12%, and in swine, where it ranges between 16% and 18% (Suttle, 2010). Thus, the ability of animals to convert feed into meat is a key representative for calculating the economic performance and ecological sustainability of the farming system. Moreover, rabbits can adjust to a variety of environments and can also feed on food waste and agricultural by-products.

Rabbit meat is richer in calcium (21.4 mg/100 g) and phosphorus (347 mg/100 g) than other types of meat and lower in fat (9.2 g/100 g) and cholesterol (56.4 mg/100 g). The beef had the highest cholesterol content (114.5 mg/100 g), almost double that of rabbit meat, while pork was rich in fat (28.2 g/100 g). It can be concluded that rabbit meat is healthier than other meats frequently used in human nutrition, high in protein, and low in fat.

The lack of grassland in Bangladesh is a major problem for farmers to raise any type of herbivore animal. Rabbit farming is now very popular in our country. But the high cost of concentrated feed and inadequate grass supply made this rearing very expensive for farmers. Hydroponic fodder would be a great solution for them. Hydroponic fodder is a type of feed produced by seed germination in a system called a hydroponic. Hydroponic fodder is an interesting and exclusive way of growing grass. It is a process where water is used to grow grass in lieu of soil. The young hydroponic fodder is a tender grass grown from cereal grain, mostly maize in Bangladesh. It is also rich in high nutrients, making it an excellent nutritious and healthy diet. In a hydroponic system no soil is needed only plastic trays are used to grow the fodder with the additional spray of water.

This process of growing grass is highly efficient, it requires less water and space rather than traditional methods. Moreover, the hydroponic fodder can be grown all the year round, nevertheless of the weather conditions. As a result, a hydroponic fodder system is an outstanding option for those searching for a reliable and reasonable source of livestock feed. The hydroponic fodder farming system offers the perfect growing atmosphere for the seeds, letting them to germinate hurriedly and produce a high yield of nutritious foliage.

Hydroponic fodder can be a great source of nutritious feed for livestock animals as well as for rabbits, hydroponic fodder consuming animals produce less manure rather than traditional feed and fodder consuming animals in farming system. Hydroponic plant foliage contains less nitrogen than traditional feeds. Hydroponic fodder can be a great source of fodder for rabbits in town area where the owners have no grass land. But by this system they can produce sufficient green fodder within a very short time without use of soil. In hydroponic system, the fodder height become 12 to 20 cm within 12-15 days in the tray system with the help of water spraying. Fodder can be grown 8 to 10 times much than the given number of seeds for this production.

1.1 Research objectives

1.1.1 Research Goal

Biomass production and nutritional evaluation of different hydroponic fodders and monitoring its effect on growth performance of rabbits.

1.1.2 Specific Objectives

(i) Determination of biomass production of hydroponic maize, wheat and jumbo fodders.

(ii) Assessment of the nutritional value of three hydroponic fodders by proximate analysis.

(iii) To find out the effect of hydroponic maize, wheat and jumbo fodders on growth performance of rabbits.

CHAPTER-II
REVIEW OF LITERATURE

2.1.1 Hydroponic Fodder

The word hydroponics has been derived from two Greek words hydro means 'water' and ponic means 'working'. Thus, fodder produced by growing plants in water or nutrient rich solution but without using any soil is known as hydroponics fodder or sprouted grains or sprouted fodder (Dung *et al.,* 2010). In 1969, Woodward, an English scientist, attempted to grow plants in many sources of water. Gericke (1920- 1930) developed procedures to grow plants in nutrient solution on a large scale. In 1939, Leitch reviewed a range of experiments using sprouted fodder for different livestock and poultry and stated that sprouted fodder was the commercial exploitation of water culture processes of plants to produce stock fodder. Hydroponics technology was introduced in Goa in 2011 by establishing numbers of hydroponics fodder production units under Rashtriya Krishi Vikas Yojana (RKVY), Govt. of India by Goa Dairy at different dairy cooperative societies (Naik *et al.*, 2011; Naik *et al.*, 2012a; Naik *et al.*, 2012b). Hydroponic cultivation is an eco-friendly method of growing fodder and hydroponically grown cereals grow up to 50% faster and produce higher yields of better-quality fodder. (Kide *et al.*, 2015). Hydroponic fodder production is a method of fodder production, in which fodder seeds are germinated into a high quality, highly nutritious, disease-free animal food in a hygienic environment (Jensen and Malter, 1995; Al-Hashmi, 2008). Hydroponic fodder production takes place in an intensive hydroponic growing unit in which only water and nutrients are used to produce nutrient rich grass and root combination (Emam, 2016). Hydroponically grown green fodder is highly water efficient and reduces water waste and essential natural and manmade resources required to grow fodder while controlling the effects of climate and growing conditions (Anonymous, 2015). There is a great nutritional benefit provided by hydroponic sprouted fodder to optimize the general health and performance of young animals while minimizing feed costs (Anonymous, 2013). Different types of fodder crops *viz.* barley (Reddy *et al.*, 1988), oats, wheat (Snow *et al.*, 2008); sorghum, alfalfa, cowpea (Al-Karaki and Al-Hashimi, 2012) and maize (Naik *et al.*, 2011; Naik *et al.*, 2012) can be produced by hydroponics technology. However, the choice of the hydroponics fodder to be produced depends on the geographical and agro-climatic conditions and easy availability of seeds. In India, maize grain should be the choice as the grain for production of hydroponics fodder due to its easy

12availability, lower cost, good biomass production and quick growing habit (Naik *et al.*, 2015). Growing of hydroponic maize fodder proved improved nutrient content with less water, less space used and cost effective (Kide *et al.*, 2015). The concepts of hydroponic fodder are date back tothe 1800s (Kerr *et al.* 2014) or earlier, from the 'Hanging Gardens of Babylon' era, when European dairy farmers fed sprouted grains to their cows during winter to maintain milk production and improve fertility (Anonymous, 2008). The word hydroponic is derived from two Greek words: 'hydro' meaning water and 'ponos' meaning labour *i.e.,* water working. It is a viable friendly alternative technology for landless farmers for fodder production without soil. It is also called fresh fodder biscuits, sprouted fodder or sprouted grain or alfa-culture (Dung *et al.* 2010). Fodders including maize, barley, oats, sorghum, rye, alfalfa, horse gram, ragi, bajra, jowar and triticale can be produced by hydroponic technology (Rachel Jemimah *et al.* 2015). This fodder seems like a mat with probably a height of 20-30cm consisting of roots, seeds and plants with highly palatable, digestible and nutritious for animals.

2.1.2 Principles of Hydroponic Fodder Production

Hydroponics is growing of cereal grains with necessary moisture, nutrient without solid growing medium. Germination is a response for the supplied moisture and nutrient and produce 20-30 cm long forage green shoot with interwoven roots within 7-10 days. Different cereal grains *i.e.,* maize, bajra, millets, horse gram etc. can be used for fodder production with varied chemical and structural changes throughout the growing processes. Enzyme activation is found necessary for hydrolysis of nutrients to their simpler forms. Grain variety, quality, treatments like nutrient supply, pH, water quality, soaking time etc. are influencing factors for the amount of sprouted and quality fodder (Sneath and McIntosh, 2003).

2.1.3 Reasons for Hydroponic Fodder Production

2.1.3.1 Conservation of water

Hydroponic system minimizes water wastage since itis applied directly to the roots and is often recycled and used several times. The research findings concluded that hydroponic system equates to only 2-5% of water use din traditional fodder production system (Al-Karaki, and Al-Hashimi, 2012; Naik and Singh, 2014). It has been reported that only 1.5 - 2 litre of water is enough for 1 kg hydroponic fodder production compared to 73, 85, and 160 litres of water to produce 1 kg green fodder of barley, alfalfa, and Rhodes grass under conventional field conditions respectively (Rachel Jemimah *et al.* 2015; Yvonne Kamanga 2016). This is especially important in those areas suffering from chronic water shortages or where the infrastructure for irrigation does not exist.

2.1.3.4 Precise use of Space

Hydroponic systems require much less space and makes ideal for urban dwellers with limited yard space. Using hydroponics technology, up to1000 kg maize fodder can be produced daily from 45-50m2 area which is equivalent to conventional fodder produced in 25 acres of cultivable land (Naik and Singh, 2013; Rachel Jemimah *et al.* 2015). It is also easy to start a hydroponic system indoors where number of racks with multiple tiers thereby resulting in land preservation. Practically, one square meter area can produce ample fodder for two cows per day and the milk yield was increased by 13% (Yvonne Kamanga, 2016).

2.1.3.5 Reduces growth time

Hydroponic technology takes only 8days to develop from seed to fodder where it took at least 45 days for a conventional fodder to grow.

2.1.3.6 Fodder yield

Fodder production is accelerated by as much as 25%by bringing the nutrients directly to the plants without developing large root systems to seek out food. One kg of un-sprouted seed yields 8-10 kg green forage in 7-8days (Sneath and McIntosh, 2003). The hydroponics maize fodder yield on fresh basis is 5-6 times higher than that obtained in a traditional farm production and is more nutritious (Naik *et al.,* 2014).

2.1.3.7 Source of essential nutrients

Compared to the un-sprouted seed, the content (DM basis) of crude protein (CP), neutral detergent fibre (NDF), acid detergent fibre (ADF) and Calcium increased but organic matter and non-fibrous carbohydrates (NFC)decreased in the hydroponic green forage (Kide *et al.,* 2015; Mehta and Sharma 2016). Hydroponic fodder is a rich source of vitamin A, vitamin E, vitamin C, thiamin, riboflavin, niacin, biotin, free folic acid, anti-oxidants like -carotene (Finney 1983, Cuddeford 1989; Naik *et al.* 2015) and minerals (Bhise *et al.*1988; Chung *et al.*1989; Fazaeli *et al.,* 2011). The biomass conversion ratio is as high as 6-7 times that of the conventional green fodder grown for 65-80 days. Besides, hydroponic fodder is a good source of bioactive enzymes, essential fatty acids, chlorophyll and minerals (Table 1) which directly responds fodder growth and improves the performance of livestock (Chavan *et al.*, 1989; Naik *et al.*, 2015).

2.1.3.8 Persistent flow of green fodder

Fodder can be produced round the year irrespective of the failure of the monsoon, land availability, natural calamities and labour shortage that leads to sustainable agriculture and livestock production. This consistency perhaps ensures promising milk production and better quality of meat and other animal produce. Hydroponic fodder production is a way to substantially improve the quality of animal products (Maxwell Salinger, 2013).

2.1.3.9 Reduced carbon footprints

Hydroponic is more environment friendly compared to traditional agriculture in relation to use of inorganic chemicals. This condenses GHGs emissions and lessens considerable global warming (Anonymous, 2016). Hydroponic systems help in reducing the fuel consumption for transportation of product from distant agricultural farms and carbon emissions in turn.

2.1.3.10 Limits of pesticides, insecticides and herbicides

Traditional outdoor farming must rely on herbicides, fungicides and/or insecticides for optimum production. Hydroponic fodder is grown in a controlled environment without soil and therefore no soil borne disease resulting minimizing use of pesticides, insecticides and herbicides. The susceptibility of any infection can easily be ruled out with specific compound in hydroponically grown fodder.

2.1.3.11 Impact on animal production

Hydroponic fodders are highly digestible, palatable and relished by the animals. They are highly succulent and can intake 1-1.5% of body weight (Jeton, 2016) or 15-25, 0.25 - 2.0, 1.5 -2.0 and 0.1 - 0.2 kg/animal/day in large ruminants, adult pigs, small ruminants and rabbits respectively (Naik *et al.,* 2013; Rachel Jemimah *et al.,* 2015). Saidi and Abo Omar (2015) reported that hydroponic barley fodder (HBF) had no effect on feed intake, body weight change, milk yield, and milk composition but had positive effects on ewe's health, mortality, conception rate and abortion. No adverse effect was noticed on average daily gain (ADG) and feed conversion ratio (FCR) in kids and rabbit kittens fed hydroponic horse gram or sunn hemp fodder replacing50% of a concentrate mixture (Rachel Jemimah *et al.,* 2015). Reddy *et al.* (1988) observed significant increases in the digestibility of nutrients in lactating cows fed hydroponic fodder compared to those fed Napier bajra (NB-21) green fodder. The daily milk yield was 8.0-14.0%higher in animals fed total mixed ration (TMR) containing hydroponic maize or barley fodder than those fed conventional green fodder (Rachel Jemimah *et al.* 2015; Yvonne Kamanga 2016). The hydroponic fodder tunes longer lactation period, improve fat percentage and general herd health. Besides increased milk yield, conception rate, herd health and longevity were also improved as well as reduce the cost of veterinary aids (Naik *et al.* 2015). The fast-growing poultry industry gains some benefits on hydroponic fodder *i.e.,* faster weight gain, good quality carcass, lower feed cost per kg of weight gain and improve health and production potentials (Rachel Jemimah *et al.* 2015). Nutritional composition of different hydroponic fodders and their nutrient digestibility are well evident for the better livestock use and production.

2.1.3.12 Health Hazzard of Infected Hydroponic Fodder

Hydroponic fodder heavily infested with *Aspergillus clavatus* should not be fed to dairy/beef cattle. Animals may develop posterior ataxia, knuckling of fetlocks, dragging of hind legs, high stepping in the hind limbs, stiff gait, tremors, progressive paresis, hypersensitivity, recumbency, clonic convulsions, decreased milk yield and possibly death (McKenzie *et al.* 2004).

2.1.3.13 Production of Hydroponic Fodder

Hydroponics is produced in greenhouses under controlled environment within a short period (Sneath and McIntosh, 2003). A framed or inflated structure covered with a translucent material in which the crops could be grown under the conditions of at least partially controlled environment is called greenhouse. However, the structure should be large enough to permit a person to carry out cultural operations (Chandra and Gupta, 2003). Two types of greenhouses are available 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.

2.1.3.14 Crops

Different types of fodder crops viz. barley Reddy alfalfa, cowpea (AI-Karaki and AI-Hashimi, 2012) and maize (Naik *et al.*, 2011; Naik *et al.*, 2012a) can be produced by hydroponics technology.

Though, the selection of the hydroponics fodder to be produced depends on the topographical and agro climatic circumstances and easy accessibility of seeds. In India, maize grain is the primary choice as the grain for production of hydroponics fodder due to its easy accessibility, lower cost, good biomass production and rapid growing habit. The grain should be clean, sound, unspoiled or free from insect infestation, raw, viable and of good quality for healthier biomass production.

2.1.3.15 Seed Preparation

Soaking of seeds and the quick uptake of water for helping the metabolism and utilization of spare materials of the seeds for growth and development of the plants is a very significant step for production of hydroponics forage. In case of barley (Morgan and Hunter, 1993) and maize (Naik, 2012b) seeds, 4 hours soaking in water is helpful. Under field conditions, farmers producing hydroponics maize forage have the practice of tying the seeds in a gunny bag tightly and then make it wet by water and keep for 24-48 hours.

2.1.3.16 Seed Rate

The seed rate also distresses the yield of the hydroponics fodder which differs with the type of seeds. Most of the commercial units recommend seed rate of 6-8 kg/m^2 (Morgan and Hunter, 1993), however, seed rate of 7.6 kg/m2 has been suggested by Naik (2013a) for hydroponics maize fodder for higher output. If seed density is high, there are more probabilities of microbial contamination in the root mat which disturbs the growth of the sprouts.

2.1.3.17 Water

It is quite interesting to note that the hydroponics forage production requires only about 3-5% of water needed to produce same amount of forage produced under field condition (AI-Karaki, and AI-Hashimi, 2012). For producing one kg of maize fodder, about 1.50 litres (if water is recycled) to 3.0litres (if water is not recycled and drained out) of water is required (Naik *et al.*, 2013a).

2.1.3.18 Germination and Growth Period

Germination starting time and visibility of roots varies with the type of seeds. In case of maize and jumbo seeds, germination starts after 1 or 2 days and the roots were clearly visible after 2 or 3 days, respectively in summer season. But during winter season they needs more than 3-5 days for germination. In case of wheat seed it starts germination within 2 days during winter season. 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). Light is not required for sprouting of cereal grains however, a little light in the second half of the sprouting period insists photosynthesis and making green of the sprouts. The grains are commonly allowed to sprout for about seven days inside the greenhouse and on 8th day these are harvested in summer season but during winter season it takes 12-15 days as a fodder for feeding animals. Often, the farmers producing hydroponics fodder using low-cost devices in field conditions keep the crop for 7-10 days, however, it increases the chances of mould growth.

2.1.3.19 Yield of Hydroponics Fodder

Fresh yield and DM content of the crops are important for successful hydroponics fodder production. During sprouting of the seeds, there is an increase in the fresh weight and a consequent decrease in the DM content which is mainly attributed to the imbibition of water (leaching) and enzymatic activities (oxidation) that depletes the food reserves of the seed endosperm without any adequate replenishment from photosynthesis by the young plant during short growing cycle (Sneath and Mclntosh, 2003). In a 7-day sprout, photosynthesis commences around day-5 when the chloroplasts are activated and this does not provide enough time for any significant DM accumulation (Dung *et al.*, 2010). Fresh yield of 2.8-8 folds in 6-8 days with DM content of 8-19.7% in hydroponics barley and fresh yield of 3.5-6.0 folds in 7-8 days with DM content of 10.3-18.5% in maize fodder, has been reported (Hillier and Perry 1969; Peer and Leeson 1985). Farmers producing hydroponics maize fodder under low-cost devices or greenhouses revealed fresh yield of 8-10 kg from one kg locally grown maize seeds in 7-10 days (Naik *et al.,* 2013b). The fresh yield and DM content of the hydroponics fodder are mainly influenced by the type of crops, days of harvesting, degree of drainage of free water prior to weighing, type and quality of seed, seed rate, seed treatment, water quality, pH, irrigation frequencies, nutrient solution used, light, growing period, temperature, humidity, clean and hygienic condition of the greenhouse etc. (Trubey *et al.*, 1969).

2.1.3.20 Feeding Values of Hydroponics Fodder

Sometimes, animals take the leafy parts of the hydroponics fodder and the roots portions are not consumed which can be avoided by mixing the hydroponics fodder with the other roughage components of the ration (Reddy *et al.,* 1988, Naik *et al.*, 2014). Hydroponics fodder is palatable and the germinated seeds embedded in the root system are also consumed along with the shoots of the plants without any nutrient wasting (Pandey and Pathak, 1991). However, there are reports of decrease in the DM intake of the animals when hydroponics fodder is fed (Fazaeli *et al.,* 2011; Naik *et al.,* 2014). Feeding of hydroponics fodder increased the digestibility of the nutrients of the ration which could be attributed to the tenderness of the fodder (Reddy *et al.*, 1988; Naik *et al.*, 2014). The digestibility of the nutrients of the hydroponics fodder was comparable with the highly digestible legumes like berseem and other clovers (Pandey and Pathak, 1991). The DCP and TDN contents of the hydroponics barley fodder were optimum to meet the production requirement of the lactating cows (Reddy *et al.,* 1988). The milk yield was improved by 7.8-13.7% by feeding of hydroponics fodder which might be due to the higher nutrient digestibility (Reddy *et al.*, 1988; Naik *et al.*, 2014). The cost of the hydroponics fodder is mainly influenced by the seed cost as it contributes about 90% of the total cost of production (Naik *et al.,* 2012b). In cheap cost devices where seed is grown at the farmers' field, the cost of the hydroponics fodder is quite cheaper. The farmers' feedback revealed increase in milk production, improvement in general fertility, conception rates, appearance of coats or fleece, general animal health etc. (Anonymous, 2012; Anonymous, 2013; Naik *et al.*, 2013b).

2.1.3.21 Nutrient Content of Hydroponics Fodder

There are changes in the nutrient content of the cereal grains and hydroponics fodder (Hillier and Perry, 1969). The DM (89.7 vs. 13.4%) and OM (96.60-97.19 vs. 96.35%) content is decreased which may be due to the decrease in the starch content. The CP (8.60-13.90 vs. 11.38-24.90%), NPN (3.35 vs. 5.89%), however, the TP (7.10-9.39 vs. 7.79-8.24%) content either decreased or not affected. The increase in CP content may be attributed to the loss in DM, particularly carbohydrates, through respiration during germination and thus longer sprouting time is responsible for greater losses in DM and increase in protein content. Besides, the absorption of nitrates facilitates the metabolism of nitrogenous compounds and thus increases the CP levels. The use of nutrient solution enhances the CP content of the hydroponics fodder higher than the tap water which may be due to the uptake of nitrogenous compounds (Dung *et al.*, 2010). The total protein content remains similar though the percentage of protein increases in the sprouted grains because of the decrease in the other components (Peer and Leeson, 1985; Morgan and Hunter, 1993). There is increase in the lysine (0.39 vs. 0.54%) content of the hydroponics fodder as there may be degradation of prolamins into lower peptides and free amino acids which supply the amino groups for the trans-amination to synthesize lysine (Peer and Leeson 1985). The upsurge in EE content (1.90-4.90 vs. 2.25- 9.27%) of the hydroponics fodder may be due to the proliferation in the structural lipids and production of chlorophyll linked with the plant growth. The increase in the percentage of CF (2.50-10.10 vs. 7.35-21.20), ADF (7.00-8.90 vs. 14.35-28.20); and decrease in the NFE (27.00-84.49 vs. 48.90-68.85) and NFC (61.55-64.65 vs. 43.00-49.03) may be attributed to the increase in the number and size of cell walls for the synthesis of structural carbohydrates. During the sprouting process, the total ash content (1.57-3.40 vs.3.65-5.50%) is increased due to the decrease in the OM. Morgan and Hunter (1993) found that the ash content of sprouts increased from day-4 corresponding with the extension of the root which allowed the mineral uptake. The ash content of the sprouts increases more, if nutrient solution is used rather than water which may be due to the absorption of minerals by the roots (Dung *et al.,* 2010). The nutrient contents of hydroponics fodder are superior to certain common non-leguminous fodders but comparable to leguminous fodders (Reddy *et al*., 1988; Pandey and Pathak, 1991; Naik *et al*., 2012a) in terms of available OM, CP, EE and NFE content.

2.1.3.22 Health Benefits of Hydroponics Fodder

The potential health benefits of hydroponics fodder are well known since long (Sneath and Mclntosh, 2003). Dry grains contain rich amount of enzymes which are mostly inactive due to the enzyme inhibitors. During sprouting, the activities of the inactive enzymes of the grains are increased due to the neutralization of the enzyme inhibitors and these enzymes ultimately break down the reserve chemical constituents such as starch, protein and lipids into various metabolites *viz.* sugars, amino acids and free fatty acids. Furthermore, these are used to synthesise new compounds or transported to the other parts of the growing seedling including the breakdown of nutritionally undesirable constituents (Chavan *et al*., 1989). The enzymes cause the inter-conversion of these simpler components leading to increase in the quality of the amino acids and concentration of the vitamins (Plaza *et al*., 2003). Sprouts are rich source of anti-oxidants in the form of β-carotene, vitamin-C, E and related trace minerals such as Se and Zn. As sprouted grains (hydroponics fodder) are rich in enzymes and enzyme-rich feeds are generally alkaline in nature, therefore, feeding of the hydroponics fodder improves the animals' productivity by developing a stronger immune system due to neutralization of the acidic conditions. Besides, helping in the elimination of the anti-nutritional factors such as phytic acid of the grains, hydroponics fodders are good source of chlorophyll and contain a grass juice factor that improves the performance of the livestock (Finney,1983).

2.1.3.23 Maize Hydroponic Fodder

The cost of maize (*Zea maize*) is much less than barley in Northwestern part of Ethiopia. Maize has also been used by Indian farmers for hydroponic fodder production (Naik *et al.*, 2015). Studies (Naik *et al.*, 2015, Weldegerima, 2015) showed that about 6 kg of fresh fodder per kg seed with crude protein (CP) content of 13.57 and water efficiency of 1.7 to 4, in as fresh basis, or 0.22 to 0.60 DM fodder per liter water was produced from a kg of maize grain in India. Similarly, barley produced 4.1 to 6.55kg fresh fodder per kg seed with CP content of 9.16 to13.2% (Emam, 2016) and water efficiency of 1.55, in as fresh basis, or 0.11 kg barely fodder per kg water (Al-Karaki, and Al-Hashimi, 2012).

2.1.3.24 Experimental Animals

Rabbits (*Oryctolagus cuniculus*) are herbivorous non ruminant animals with functional caecum, which have the capacity to extract nutrients of fibrous aliments and convert them in high value proteins. As pseudo-ruminants, rabbits are capable of valorizing large quantities of feed and forages rich in crude fiber content. Fiber regulates digestive disorder that can retard performance or even cause fatal diarrheas, mainly at the growing phase (Santomia *et al.*, 1993 & Ferreira *et al.*, 2008). A decrease in crude fiber content in rabbit diet leads to an increase of risk of digestive disorders through the decrease of volatile fatty acids concentration in the Caecum. Conversely, high levels of crude fiber intake haven't adverse effect on the efficiency of feed utilization (Yu and Chiou, 1994) but the mechanism is unclear. After long-term feeding of high- fiber diet in rats, the absorption of nutrients was significantly decreased (Freeman, 1984).

2.1.3.25 New Zealand White Rabbit

Agricultural by-products contain high levels of fiber (Cheeke, 1986). There are about 35 million tons of plants by-products annually produced that can be used in animal, rabbits and poultry diets (El-Manylawi *et al.*, 2005). Dietary fibers are the main constituent of a rabbit feed and, depending of the analytical technique also, sufficient dietary fiber supply is essential to prevent digestive troubles in growing rabbits (Chao and Li, 2008). There is a huge potential for rabbit meat industry in Nepal. Nepal's currency is going out though the meat is produced in Nepal. But rabbit meat can be produced utilizing the local resources of Nepal itself. It's easy to start rabbit farming, and doesn't need huge investment to begin. There are not social and cultural taboo to restrict rabbit meat consumption. Dhakal (2017) stated that these days, many people are interested in rabbit farming in Nepal. Rabbit meat, rabbit dishes are now available in dozens of restaurants in Kathmandu, and rabbit-meat restaurants have opened. Despite having high cholesterol levels, wild rabbit has less saturated fat (Lama, 2019). The highest live body weight, weight increase, and feed conversion ratio were achieved by rabbits fed fresh hydroponic barley fodder (Abouelezz & Hussein, 2017). Since weaning rabbits have a slow rate of starch and fiber digestion, adding enzymes to the diet improved both the performance and dietary digestion of weaning rabbits on starter diets (Abdel-Aziz *et al.*, 2016; Gutiérrez *et al.*, 2002; Marounek *et al.*, 1999).

CHAPTER-III

MATERIALS AND METHOD

3.1 Site of the experiment

The experiment was conducted at Dr. Purnendu Gain Field Laboratory of Agrotechnology Discipline, Khulna University, Khulna.

3.2 Preparation of plot

Nine (09) plastic trays having the same dimension of 12 cm×18cm= 216 cm^2 space for each plot was arranged for hydroponic fodder production. Each rack contained 3 trays. Rack-1 was used for maize hydroponic fodder production, rack-2 was used for wheat hydroponic fodder and rack-3 was used for jumbo hydroponic fodder production.

3.3 Experimental animal collection

Total 12 male rabbits of New Zealand White breed ageing nearly 1 month were collected from the local market of Khulna.

3.4 Layout and design of the Experiment

CRD-Completely Randomized Design was selected for the experiment.

Treatment	Replication		
	R_1	R_2	R_3
T_1	T_1R_1	T_1R_2	T_1R_3
T_2	T_2R_1	T_2R_2	T_2R_3
T_3	T_3R_1	T_3R_2	T_3R_3
T_4	T_4R_1	T_4R_2	T_4R_3
T_1 = Control (Vegetables + no grass); T_2= hydroponic maize+ vegetables; T_3=hydroponic wheat + vegetables; T_4 =hydroponic jumbo fodder + vegetables.			

Treatments

T_1 = Control (Vegetables + no grass)

T_2 = (Hydroponic maize fodder + vegetables)

T_3 = (Hydroponic wheat fodder +vegetables)

T_4 = (Hydroponic jumbo fodder + vegetables)

3.5.1 Soaking, Germination and Plantation

The first work was started at 15th December 2022 by soaking the seeds of wheat, maize and jumbo in water lime solution. Wheat needed 2 days for sprouting but in-case of jumbo and maize it took 5 days. So, we have placed the wheat seeds on 17th December 2022. Maize and Jumbo seeds were spouted at 20th December 2022 and were placed on the tray.

3.5.2 Harvesting

After every 15 days we had collected hydroponic maize fodder, 15 days for hydroponic wheat fodder, 15 days for hydroponic jumbo fodder.

3.5.3 Collection of Data

Agronomic data such as plant height, biomass production & nutritional data e.g., percentage of dry matter, crude protein, ash and ether extract were collected after harvesting the hydroponic fodders.

3.5.3.1 Plant Height

Five plants from one tray were selected randomly for the measurement of plant height. The height of each plant was measured from the tray ground to the top of the upper most leaf of the plant and mean value of plant height was recorded.

3.5.3.2 Biomass Yield

Each tray's total plant quantity was measured and was compared with the seed mass.

3.5.3.3 Proximate Analysis

The chemical composition of dried fodder samples was determined as per the standard method of the Association of Analytical Communities (AOAC, 1990).

3.5.3.3.1 Crude Protein Analysis

3.5.3.3.2 Test Procedures

3.5.3.3.3 Digestion

Digestion was completed by using DK 8 Heating Digester VELP SCIENTIFICA. 1g of sample was weighted with an accuracy of ±0.1mg. For each sample, 2 catalysts and 12ml H_2SO_4 were added and then placed into the digestion block. The temperature of the digestion block was maintained at 420°C and the sample was heated for 60 minutes until the fumes stopped. Then the sample was taken to cool at 50-60°C.

3.5.3.3.4 Distillation

The distillation process was conducted by using UDK 129 Distillation Unit VELP SCIENTIFICA. After cooling the sample, it was mixed with 50ml distilled water. 50ml NaOH was added to the solution. The digestion flask was then given into the distillation chamber. 30ml Boric acid solution was taken in a conical flask and 3 drops of indicator were added into it. The water flow was previously adjusted. The distillation process was done until the colour of the indicator mixture solution did not turn into green colour.

3.5.3.3.5 Titration

The sample of the flask was then taken for titration. Then 0.1% H_2SO_4 was taken in the burette pipe and added dropwise. The procedure was continued until the colour of the solution of the conical flask turn from green to blue. When the solution colour had changed the titration procedure ended. The strength of the titrate was then recorded.

3.5.3.3.6 Calculation

$$= \frac{(\text{ml H2SO4 sample} - \text{ml H2SO4 blank}) \times \text{conc.H2SO4 } 14.007 \times 100}{\text{Wight of sample} \times 1000}$$

3.5.3.4 Crude Fibre Analysis:

3.5.3.4.1 Test Procedures:

Crude fibre analysis was conducted by using VELP SCIENTIFICA FIWE Raw Fibre Extractor. 1g sample was taken in crucibles were fixed with the channels. 150 ml 1.25% H_2SO_4 was taken in the flask of the analyser adding 3-5 drops n-octanol as anti-foam agent. The switch of the fibre analyser was turned on. Boiled exactly for 30 minutes. After 30 minutes, filter the remaining agent. Washing should be done three times with 30 ml (crucible filled to the top) of hot deionized water, connecting each time to compressed air for stirring the content of crucible. After draining last wash,150 ml 1.25% KOH and 3-5 drops of the anti-foam agent were added. Again, after boiling for 30 minutes then washing 3 times, a last washing was done with cold deionized water to cool the crucible and then wash three times the crucible content with 25ml of acetone and stirring by compressed air. The crucible content with 25 ml of acetone was washed. After that crucible were dried at 105° C for one hour in oven and then cooled down in a desiccator to take the dry weight (F_1). The crucibles were placed into a muffle and heated up to 550° C for three hours to reweight after cooling in a desiccator (F_2).

3.5.3.4.2 Calculation:

Crude Fibre (%) = $\frac{F1-F2}{F0} \times 100$

Where,

F_0 = Weight of sample in gram

F_1= Weight of oven dried sample in gram

F_2= Weight of ash containing crucible in gram

3.5.3.5 Ether Extract Analysis

3.5.3.5.1 Test Procedure:

Ether extract analysis was conducted by using VELP SCIENTIFICASER 148 Solvent Extractor.

Sample: 3 g (F1) of grounded and homogenized material was weighed in an extraction thimble with 1 mg proximation. Total weight- thimble weight = wet sample weight.

Chemicals: petroleum ether 40-60° C with an evaporation of residue not higher than 10mg/l.

Sample drying dried the thimble one hour in a 125° C oven.

Immersion: sample containing thimble or the glass crucible containing dry hydrolysed sample were introduced into the extraction equipment. After weighing extract collecting vessel (F2), 40ml of petroleum ether was added. Thimble with sample, assembled with thimble connector to extraction unit. After closing the extraction unit, the cooling water flow started and the heating. When the solvent started boiling, the thimble or glass crucibles were placed into "Immersion" position for 30 minutes.

Washing: after 30 minutes extracted, thimble or glass crucible were placed into "Washing" position for 60 minutes.

Recovery: after washing, the stopcock located under the water, was closed and cooled in condenser and evaporated completely the solvent from the extraction vessel.

Weighing: the extract containing cups were dried in oven at 125° C for 30 minutes and weighed (F3) it after cooling a desiccator.

3.5.3.5.2 Calculation:

Ether Extract (%) = $\frac{W3-W2}{W1} \times 100$

Where,

W_1 = Weight of sample in gram

W_2 = Weight of empty vessel in gram

W_3 = Weight of vessel and ether extract in gram

3.5.3.6 Dry Matter

3.5.3.6.1 Test procedure

Envelopes were weighted (W1) and weight was recorded to 0.001g. After harvesting, fresh shoot weight (W2) of forage was taken and the envelope was filled with sample and dried in oven for 24 hours at 105°C. Thereafter the dried sample containing envelope (W3) is weighted.

3.5.3.6.2 Calculation:

Dry Matter (%) = $\frac{W3-W1}{W2} \times 100$

Where,

W_1 = Weight of envelope in gram

W_2 = Weight of fresh sample in gram

W_3 = Weight of envelope and dried sample in gram

3.5.3.7 Ash Analysis

3.5.3.7.1 Test Procedure

Crucibles were placed in muffle furnace, allowing 30 minutes to reach 600°C. Weight of crucible was recorded to 0.0001g (W_1). About 3g sample was weighted into a crucible which had been tarred. Weight of sample was recorded to 0.0001g (W_2). Ash crucibles containing samples in muffle furnace at 600°C for 6 hours after the furnace had reached the temperature. Crucibles were allowed to cool in furnace to less than 20°C and crucibles were placed in desiccator with a vented top. Crucibles were cooled in desiccator to room temperature and were weighed immediately. Weight was recorded to 0.0001g (W_3). Ash% was calculated and reported to one decimal place.

3.5.3.7.2 Calculation

Ash (%) = $\frac{W3-W1}{W2} \times 100$

Where,

W_1 = Weight of crucible in gram
W_2 = Weight of sample in gram
W_3 = Weight of crucible and ash in gram

3.5.4 Feeding Trial of Rabbits:

Control group T_1 was fed regular feed. 200 grams of vegetables every day and night. Group T_2 was fed 150 grams of hydroponic maize fodder and 50 grams of vegetables daily. Group T_3 was fed 150 hydroponic wheat fodder and 50 grams of vegetables daily. Group T_3 was fed 150 hydroponic jumbo fodder and 50 grams of vegetables daily. I collected the body weight of rabbits every 7 days interval to judge the effects of different hydroponic fodders on rabbit growth.

3.5.5 Statistical Method and Analysis:

The data generated from this experiment was edited and then **entered into a Microsoft Excel worksheet**. The data were analysed using **one-way ANOVA**. The tabular technique was applied for the analysis of data using descriptive statistical tools such as **average and standard error** etc. through **SPSS** computer software.

CHAPTER-IV

RESULTS AND DISCUSSION

4.1 Biomass Production and Other Characteristics of Hydroponics Fodder

The mean height of maize hydroponics fodder was recorded at 13.6±0.6 cm in 15 days (Table-1) at a significance level ($p<1\%$), which was within the range (11-30 cm) given by Naik *et al.* (2015). In the case of wheat hydroponics fodder, the mean height was recorded at 15.9±0.1 at a significance level ($p<1\%$), which was within the range (11-30 cm) given by Naik *et al.* (2015). Jumbo hydroponics fodder showed a mean height of 6.25±0.05 which was lower than (11-30cm) given by Naik *et al.* (2015). Among those fodder, the wheat hydroponics fodder showed the highest growth rate on the 15th day. Another vital thing was biomass production was highest in the case of wheat hydroponics fodder 766±4gm from 250gm seeds at the significance level ($p<1\%$) on the 15th day. In the case of maize hydroponics fodder and jumbo hydroponics fodder, the values were 574±14gm and 695±15gm from 250gm seeds at the significance level ($p<1\%$) on the 15th day.

Table 1. Average plant height and average biomass production of hydroponic fodders

Parameters		Mean ± Std. Error			F-value	Sig.
		HMF	**HWF**	**HJF**		
Plant Height(cm)	**Day 5**	3.15±0.15	4.4±0.3	2.8±0.1	17.327	0.022
	Day 7	4.9±0.1	6.9±0	4.6±0.2	93.8	0.002
	Day 10	8.4±0.1	9.25±0.05	5.7±0.1	458.111	0
	Day 15	13.6±0.6	15.9±0.1	6.25±0.05	204.611	0.001
Biomass(gm)		574±14	766±4	695±15	64.698	0.003

Notes: MHF=Maize Hydroponic Fodder, WHF=Wheat Hydroponic Fodder, JHF=Jumbo Hydroponic Fodder.

4.2 Chemical Composition of the Hydroponics Fodder

The percent analysed of the chemical composition of hydroponics fodder was presented in Table 2. The DM was (14±0.32)% in maize hydroponic fodder whereas wheat hydroponic fodder consisted of (8.56±0.1)%. Similarly jumbo hydroponic fodder consisted (25±0.03)%. In the case of CP, the highest percentage found in jumbo hydroponic fodder (was 18.71±0.28)% in comparison with maize and wheat hydroponic fodder. The highest CF was found in jumbo hydroponic fodder (21.65±0.55)%. The highest EE was also found in jumbo hydroponic fodder (3.74±0.07)%. The highest NFE was recorded in maize hydroponic fodder (78.58±0.18)%.

Table 2. Nutritional compositions of hydroponic fodders.

Parameters	Mean ± Std. Error			F-value	Sig.
	HMF	HWF	HJF		
DM%	14.66±0.32	8.56±0.1	25±0.03	1848.982	0
CP%	10.49±0.04	17.71±0.28	18.71±0.06	690.183	0
CF%	5.44±0.04	3.92±0.02	21.65±0.55	953.721	0
EE%	2.64±0.04	3.22±0.1	3.74±0.07	58.494	0.004
ASH%	2.87±0.07	4.15±0.03	3.21±0.03	231.291	0.001
NFE%	78.58±0.18	70.02±0.33	54.7±0.7	700.869	0

Notes: DM=Dry matter, CP=Crude protein, CF=Crude Fibre, EE=Ether extract, NFE=Nitrogen free extract

4.3 Weekly Weight Gains of Rabbit

The weekly mean weight gains trend of experimental rabbits is presented in Table: 3. The weight gains in 1st 7 weeks were found to be non-significant. Whereas the 8th week's body weight gain was highly significant. 9th & 10th-week body weight gain also become non-significant. And on the 11th week, the body weight gain was highly significant. In the first two weeks, we found body weight gain became negative in the case of controlled feeding and maize hydroponic fodder. From my observation at that time on that time the weather condition was too cold and the temperature was below 10 degrees centigrade. As a result, their digestibility was hampered and diarrhoea occurred. But that time the highest body weight gain was found in the case of HWF feeding rabbits (2.09±1.32) gm & (8.48±5.48) gm. In the case of the controlled group, we found that there were many negative body weight gains. My research found that as they were fed only vegetables like cabbage, cauliflower, carrot etc. lacked the necessary amount of fibre in their body and that group faced chronic diarrhoea. And the research indicated that rabbits fall in life risk without fibre intake. In the 8th week, we found the highest body weight gain in the case of HJF feeding rabbit (13.38±2.07) gm and the lowest gain in the case of controlled feeding rabbit (-0.05±1.19) gm. Finally, on the 11th week, we found the highest body weight gain in the case of HJF feeding rabbit (4.15±0.46) gm because of higher digestibility and the higher fibre content helped them to do good microbial digestion and the lowest gain in the case of HMF feeding rabbit (1.14±0.38) gm.

Table 3. Effect of hydroponic fodder on the mean growth performance of rabbits

Parameters Weeks	Body Weight Gain(gm)				F-value	Sig. or P-value
	Controlled	HMF	HWF	HJF		
1st	-8.57±3.88	-3.43±2.7	2.09±1.32	1.14±1.08	3.782	0.059
2nd	-9.14±6.7	-4.24±18.7	8.48±5.48	2.48±0.7	0.559	0.657
3rd	3.95±3.64	1.76±18.03	6.05±9.18	5.14±2.84	0.032	0.992
4th	-4.38±4.31	3.76±2.68	2.91±1.2	-0.24±2.73	1.568	0.271
5th	-0.05±1.67	3.33±0.84	4.14±1.98	4.9±1.03	2.243	0.161
6th	1.43±0.81	1±2.14	2.1±0.17	2.71±1.32	0.323	0.809
7th	3.86±1.87	3.1±0.5	3.62±1.44	4.57±2.48	0.126	0.942
8th	-0.05±1.19	1.53±3.37	0.28±1.21	13.38±2.07	8.933	0.006**
9th	-1.52±1.87	1.19±0.45	1.86±0.83	2.86±0.68	2.896	0.102
10th	2.95±1.34	0.86±0.08	1.29±0.14	3.72±0.64	3.271	0.08
11th	1.95±0.47	1.14±0.38	2.24±0.42	4.15±0.46	8.658	0.007**

** = 1% level of significance (*p*-value<0.01), HMF=Hydroponic Maize Fodder, HWF=Hydro ponic Wheat Fodder, HJF=Hydroponic Jumbo Fodder.

Average weekly body weight gain was presented in the Table: 4. this table identified the initial and the final body weight after the treatments. The highest weight gain found in the case of HJF feeding rabbit in the 11^{th} week (702±60) gm and the lowest body weight gain found in the case of controlled feeding rabbit (533±59) gm.

Table 4. Weekly mean body weight gain

R4BW	Mean ± Std. Error				Sig.
	Controlled	HMF	HWF	HJF	
1^{st}	614±84	554±145	354±84	417±74	0.305
2^{nd}	554±63	530±134	368±77	425±67	0.461
3^{rd}	490±30	500±102	428±68	442±69	0.863
4^{th}	518±23	513±42	470±46	478±56	0.822
5^{th}	487±50	539±26	490±38	477±44	0.707
6^{th}	487±61	562±32	519±24	511±48	0.679
7^{th}	497±66	569±33	534±25	530±52	0.754
8^{th}	524±76	591±34	559±16	562±58	0.831
9^{th}	523±74	602±10	561±19	656±60	0.325
10^{th}	513±68	610±9	574±24	676±63	0.193
11^{th}	533±59	616±9	583±24	702±60	0.127

Note: HMF=Hydroponic Maize Fodder, HWF=Hydroponic Wheat Fodder, HJF= Hydroponic Jumbo Fodder

CHAPTER-V

SUMMARY & CONCLUSION

From this study, it was concluded that the growth performance of rabbits on the inclusion of hydroponically grown jumbo fodder on the feeding diet was found better than without hydroponics forage feeding at an intensive housing system. Therefore, hydroponically grown jumbo fodder was the best alternative feed resource for the growth performance of rabbits. Again, we found the supreme necessity of fiber-type feed in the digestion system of rabbits. As rabbits are herbivorous animals, fiber-type feed is very much essential for them, we used only regular vegetables for the controlled group of rabbits as a result due to low fibrous feed content the controlled group faced chronic diarrhea and which affected their growth performances. So, from this experiment, it was suggested that a great number of fibrous feeds must be supplied in the daily ration of rabbits. Jumbo hydroponic fodder was a great source of fiber content for the diet of rabbits. The outcome of this experiment will help further the research program to the researcher.

CHAPTER-VI

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Appendix

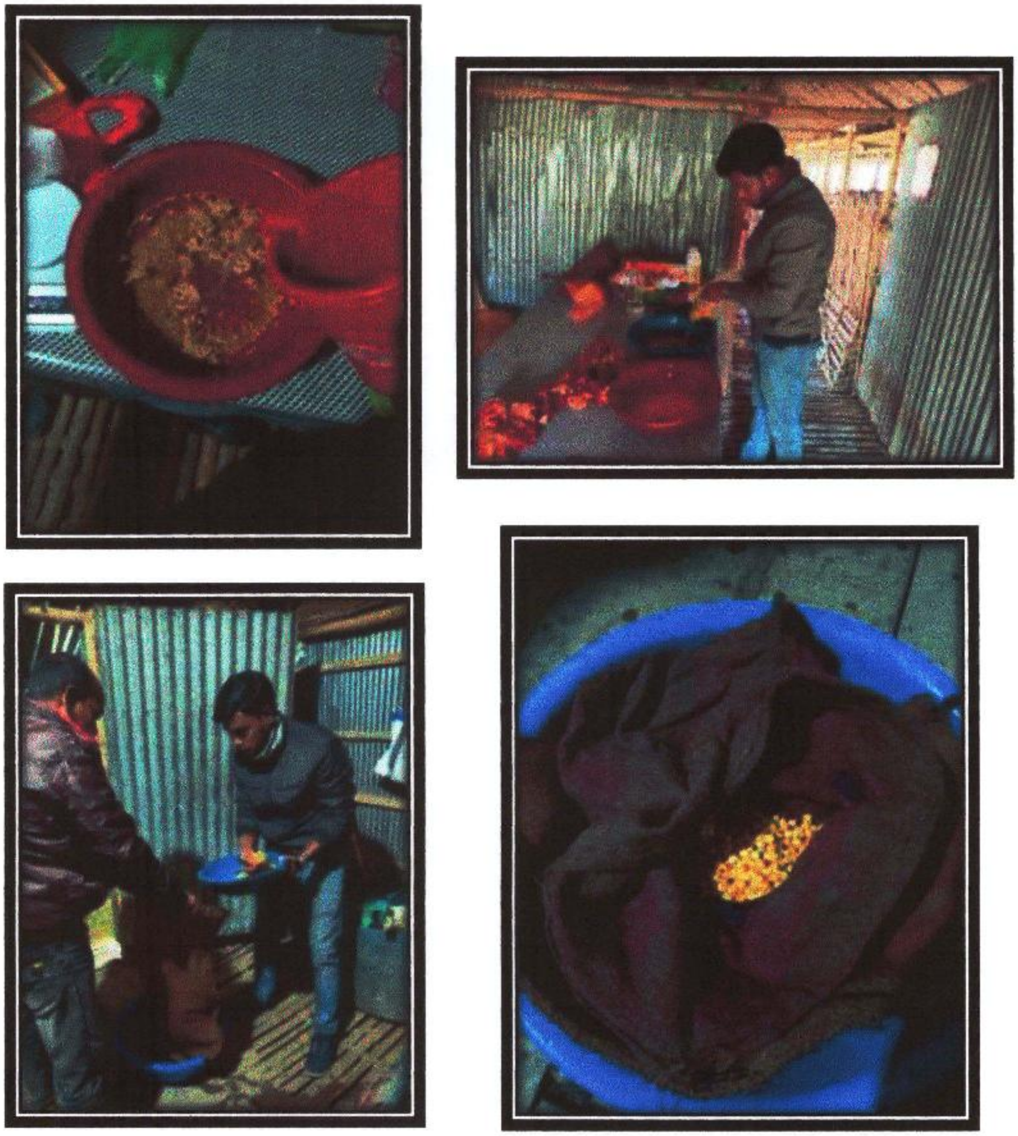

Figure:1 Soaking and Germination

Figure: 2 Germinated seed transfer to trays

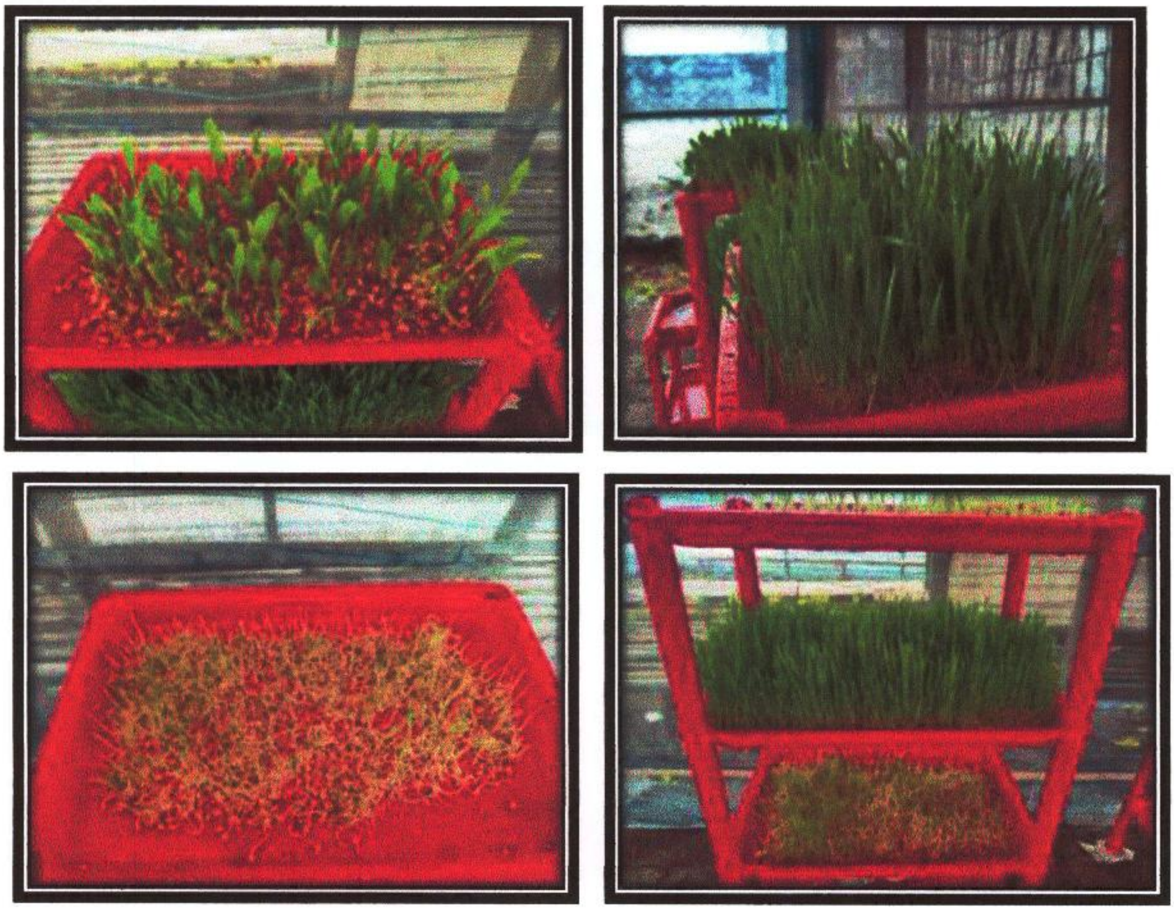

Figure: 3 Plant Growth

Figure 4 Plant height measurement

Figure 5 Biomass yield calculation

Figure: 6 Chopping and moisture removal

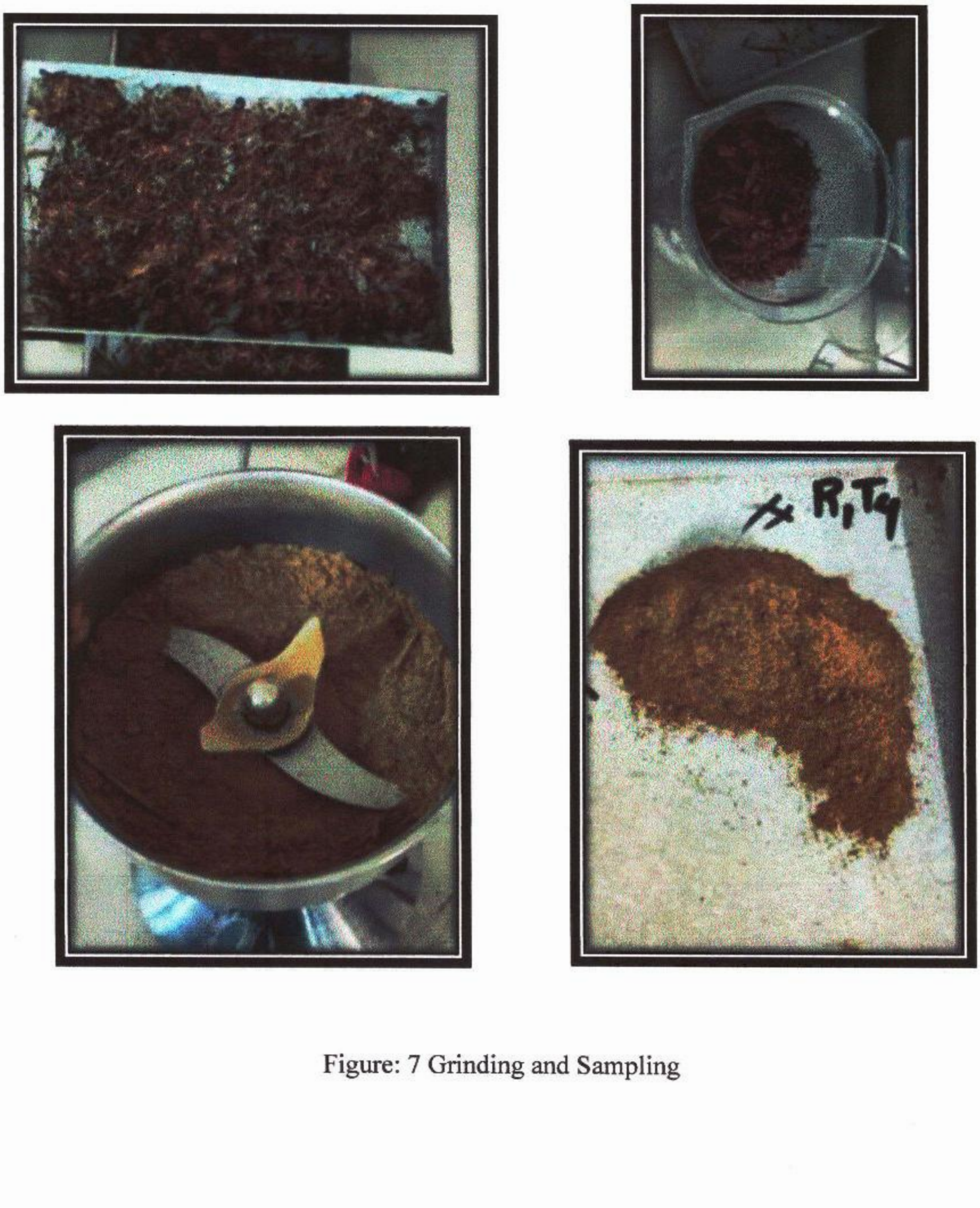

Figure: 7 Grinding and Sampling

Figure: 8 proximate analyses

Figure: 9 Rabbit collection and Casing

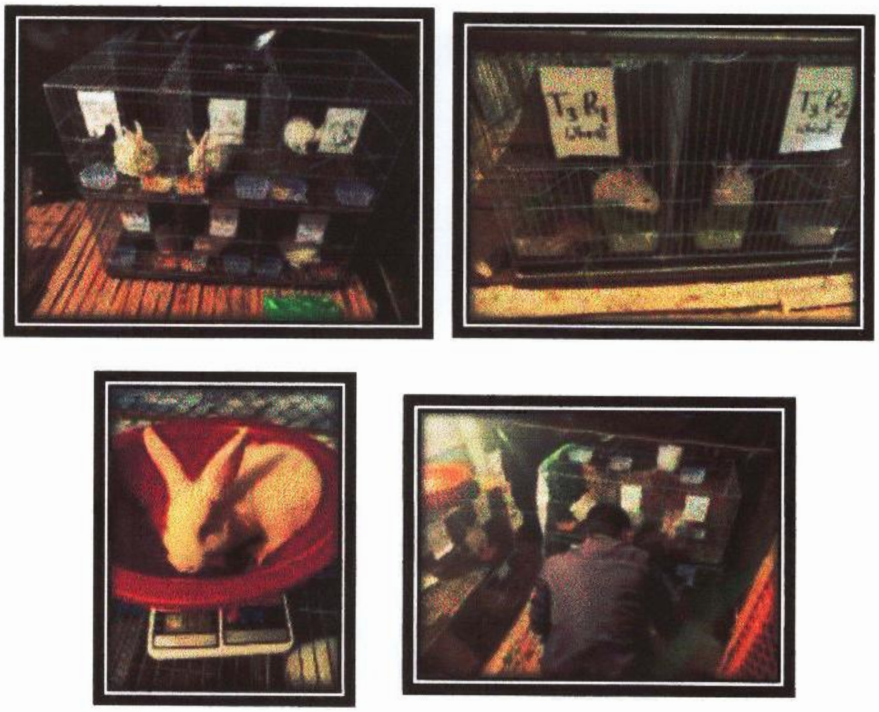

Figure:10 Feeding trial and weight measurement