DIETARY EFFECTS OF HYDROPONIC WHEAT SPROUTED FODDER ON GROWTH PERFORMANCE OF TURKEY

A THESIS

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HUSSEIN SULEIMAN ALI

Registration No. 1705195

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Semester: January -June, 2018

MASTER OF SCIENCE (MS)

IN

ANIMAL NUTRITION

DEPARTMENT OF GENERAL ANIMAL SCIENCE AND NUTRITION

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITYDINAJPUR-5200

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Dedicated to

My beloved parents and siblings

For their celestial affection and endless sacrifices in each and every stage of my life

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June, 2018 *The Author*

ABSTRACT

The present study determined nutritional composition and investigated the effect and economic value of hydroponic wheat sprouted fodder (HWSF) replaced by commercial concentrate feed (CCF) on growth performance of turkey. The study was conducted at the Advance Animal Research Farm of the Faculty of Veterinary and Animal Science, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur, Bangladesh. A total of seventy-five poults (8-weeks old) having uniform body weight (1297.88g/poults)were selected and randomly assigned into five dietary treatment groups (T_1, T_2, $T_{3,}$ T_4 and T_5), each group consisting of 3 replications having 15 birds in each. T_1 considered as the control group and fed only CCF, where$T_{2,}$ $T_{3,}$ T_4, and T_5groups fed 95, 90, 85 and 80% CCF along with 5, 10, 15 and 20% hydroponic wheat sprouted fodder, respectively. The percentage of dry matter (DM), ash, organic matter (OM), crude protein (CP), crude fibre (CF), ether extract (EE) and nitrogen free extract (NFE) on dry matter basis contents of hydroponic wheat, maize and sesbania sprouted fodder were 8.64, 14.79, 9.46, 4.09, 2.50, 3.41, 95.91, 97.5, 96.6, 18.10, 10.92, 37.26, 3.40, 5.30, 7.21, 3.29, 2.94, 3.71, 71.12, 78.34 and 48.41%, respectively. The amount of DM was significantly higher ($P<0.01$) in hydroponic maize sprouted fodder than hydroponic wheat and sesbania sprouted fodder and the amount of CP was significantly higher ($P<0.01$) in hydroponic sesbania sprouted fodder than hydroponic wheat and maize sprouted fodder. However, NFE was significantly differed ($P<0.05$) among the hydroponic wheat, maize and sesbania sprouted fodder. But the amount of Ash, OM, CF and EE were not significantly differed among the hydroponic wheat, maize and sesbania sprouted fodder. Total DM intake was almost similar among the groups of turkey T_1 (74.44 g/d), T_2 (76.94 g/d), T_3 (79.35 g/d), T_4 (79.18 g/d) and T_5 (81.53 g/d).Live weight of turkey among the dietary treatment groups T_1 (2074.86 g), T_2 (2130.4 g), T_3 (2125.75 g) and T_4 (2085.53 g) were

increased except T_5 (1959.4 g) groups. The live weight gain was almost similar in the turkey of T_2 (29.55 g/d), T_3 (29.26 g/d), T_4 (28.44 g/d) and T_1 (27.69 g/d) groups except T_5 (23.85 g/d) group. The feed efficiency of dietary treatment groups T_1, T_2, T_3, T_4 and T_5 were 2.68, 2.60, 2.70, 2.78 and 3.42, respectively. The best performance regarding feed efficiency was observed in T_2 (2.60) group compared to other groups. On the other hand, cost benefit analysis showed higher benefit in $T_{2,}$ T_3 and T_4 than in T_1 and T_5 group. Therefore, the overall results revealed that dietary supplementation of HWSF up to15% may improve live weight, feed efficiency of turkey as well as reduce total feed cost.
ey words: Turkey, hydroponic wheat sprouted fodder, growth performance

LIST OF ABBREVIATIONS

AIA	:	Acid Insoluble Ash
ANOVA	:	Analysis of Variance
CCF	:	Commercial Concentrate Feed
CF	:	Crude Fibre
CP	:	Crude Protein
CTO	:	Capital Turnover
DM	:	Dry Matter
EE	:	Ether Extract
FAO	:	Food and Agricultural Organization
FCM	:	Fat Corrected Milk
FCR	:	Feed Conversion Ratio
FI	:	Feed Intake
FMS	:	Finger Millet Straw
GLM	:	General Linear Model
GR	:	Gross Revenue
HB	:	Hydroponic Barley
HBF	:	Hydroponic Barley Fodder
HF	:	Hydroponic Fodder
HGF	:	Hydroponic Green Fodder
HMF	:	Hydroponic Maize Fodder
HSF	:	Hydroponic Sprouted Fodder
HWSF	:	Hydroponic Wheat Sprouted Fodder
NDF	:	Neutral Detergent Fiber
NFE	:	Nitrogen Free Extract

NFI	:	Net Farm Income
NS	:	Not Significant
OM	:	Organic Matter
PF	:	Prairie Forage
PI	:	Profitability Index
RRI	:	Rate of Return on Investment
SEM	:	Standard Error of Mean
SPSS	:	Statistical Package for the Social Sciences
TA	:	Total Ash
TC	:	Total Cost
TCF	:	Treatment Conventional green Fodder
TDN	:	Total Digestible Nutrients
TFC	:	Total Fixed Cost
TMR	:	Total Mixed Ration
TR	:	Total Revenue
TVC	:	Total Variable Cost

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CHAPTER I

INTRODUCTION

Livestock is an integral component of the complex farming system in Bangladesh, as it not only serves as a source of meat protein but also a major source of farm power services as well as employment. The livestock sub-sector provides full time employment for 20% of the total population and part-time employment for another 50% of the total population in Bangladesh (Begum *et al.*, 2011). The poultry sector also is an integral part of farming systems and has created both direct and indirect employment opportunity, improved food security and enhanced supply of quality protein to people’s meals, contributing countries economic growth and reducing poverty level in rural and urban areas of Bangladesh. The present meat and egg production can meet only 68and 64%of the national demand where, poultry meat alone contributes 37% of the total meat production in Bangladesh (Begum *et al.*, 2011).

In fact, poultry keeping is an important part of the rural household that provides family income for the small, marginal and landless poor. The farmers who cannot afford to rear cattle and goat, can easily rear poultry. However, among the livestock sector, the poultry industry (specially, commercial broiler and layer) is in the line to be destroyed due to severity of avian influenza (bird flu) in Bangladesh. Thus, it is crying need to find out the alternatives of animal protein sources to meet up the increasing demand. In order to maximize food production and meet protein requirements in developing countries like Bangladesh, variable options need to be explored and evaluated (Owen *et al.*,2008).

Turkey meat may be a one of the best options for alternative protein source. Turkey production is an important and highly profitable agricultural industry with a rising global demand for its products (Yakubu *et al.*, 2013), and they are adaptable to wide range of climatic conditions (Ogundipe and Dafwang, 1980). Consumption of turkeys and broilers as white meat was rising world-wide and a similar trend also existed in developing countries (Karki, 2005). In the whole world, total production of turkey meat was 5.6 million ton in 2012, which was higher than 5.1 million ton in 2003, a decade earlier (FAOSTAT, 2012). Turkey is an excellent insect forager and most crops that are troubled by insect population including vegetables are candidates for insect control by turkeys (Grimes *et al*., 2007). Turkey thrives better under arid conditions, tolerates heat better, ranges farther and has higher quality meat (Yakubu *et al.*, 2013). But turkey production has not yet been fully exploited in developing countries despite its huge potential over other poultry species.

In fact, turkey is a newly introduced poultry species in Bangladesh. Farmers are rearing turkey with a limited extent without having prior experience or sufficient knowledge. Mainly interested farmers started turkey farming by importing day-old turkey chicks (Poult) from neighboring countries. Its popularity is increasing gradually because of gamey flavor of meat with lower fat and higher protein contents. So, it may have high potential for production and marketing in developing countries. However, there is scanty study conducted previously regarding turkey production in Bangladesh and Somaliland.

Presently turkey farmers depend on commercial concentrated feed that incurs high feeding cost. Therefore, an alternative way of replacing expensive concentrate feed by green fodder can lower the feeding cost, which may help to expand the turkey farming for alleviating poverty and ensure animal protein consumption at lower cost in developing countries including Bangladesh as well as Somaliland. However, the major constraints in production of green fodder by farmers are unavailability of land for fodder cultivation due to small land holding size, scarcity of water or saline water, labor required for cultivation (ploughing, sowing, weeding, harvesting etc.), requirement of manure and fertilizer, more growth time (approx. 45–60 days), fencing to prevent fodder crops from wild animal and natural calamities etc. (Naik *et al.,* 2014).

The word hydroponic has been derived from the Greek word 'water working' where hydro means 'water' and ponic means 'working'. Thus, forage produced by growing plants without soil in water or nutrient rich solution is known as hydroponic forage or fodder or sprouted grains, which are produced generally in greenhouses under controlled environmental conditions within a short period (Sneath and McIntosh, 2003; Dung *et al.,*2010a). However, hydroponic fodder can be well produced with the use of fresh water only and the use of nutrient rich solution is not obligatory. The added expenses of the nutrient solution also do not justify its use rather than the fresh water unless there is significant improvement in the feeding value of the hydroponic fodder due to the use of the nutrient solution. The metabolism of the nutrient reserves of the seeds is enough to fuels the growth of the fodder plant for a short duration. It has high feed quality, rich with proteins, fiber, vitamins and mineral (Chung *et al.*, 1989). As a reason, hydroponic culture is one of the most important agricultural techniques currently in use for green fodder production in many countries.

However, there is a limited studies conducted on the feeding effect of HWSF on turkey production. Therefore, the present study has been designed under Bangladesh condition with the following objectives:

- To know the nutrient composition of hydroponic sprouted fodder
- To investigate the productive performance of turkey by supplementation of hydroponic wheat sprouted fodder and
- To study the cost-benefit of using hydroponic wheat sprouted fodder for turkey production in Bangladesh.

CHAPTER II

REVIEW OF LITERATURE

The productive and reproductive efficiency of the livestock is adversely affected due to the unavailability of good quality green fodder. Besides, the unavailability of land, more labour requirement for cultivation (sowing, earthing up, weeding, harvesting etc.), more growth time, non-availability of same quality feed round the year, requirement of manure and fertilizer, the uncertain rain fall, water scarcity and natural calamities due to climate change are the major constraints for green fodder production by the livestock farmers. Furthermore, the non-availability of constant quality of fodder round the year aggravates the limitations of the sustainable farming. Due to the above constraints of the conventional method of fodder cultivation, hydroponic technology is coming up as an alternative to grow fodder for farm animals (Naik *et al.*, 2011; Naik *et al.*, 2013a).

Hydroponic green fodder is produced from cereal grains that are grown for a short period of time in soilless facilities (Sneath and McIntosh, 2003). Several types of cereal grains can be used in the production of green fodder, wheat, barley, oat, corn and several other cereal grains (Rodriguez-Muela *et al.*, 2004). Recent research showed that green fodder yield can reach 10 kg depending on type of grain and the growing conditions (Fazaeli *et al.*, 2012*;* Al-Ajmi *et al.*, 2009; Mukhopad, 1994; Buston *et al.*, 2002) indicating that barley and wheat were the most appropriate.

Cuddeford (1989) showed that the nutrient composition of green fodder changed by the growing cycle. Fiber content, for example, was reported to be increased from 3.75% in cereal barley grains to 6% in a 5-d green barley fodder (Chung *et al.*, 1989). Peer and Lesson (1985) showed that dry matter digestibility changed with growing period, where digestibility at d-4 was superior.

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 (Morgan *et al.,* 1992; Peer and Lesson, 1985a).

Several researches have been conducted to determine the feeding value of green fodder, (Peer and Lesson, 1985a; Shtaya, 2004; Fazaeli *et al.*, 2012). However, results were not consistent. These authors noted that the dry matter (DM) intake of green fodder by feedlot cattle and dairy cattle were low due to its high moisture content. Tudor *et al.* (2003) reported an improvement in the performance of steers when given restricted hay diet plus 15.4 kg fresh hydroponic green fodder (about 1.8 kg added DM). It can be concluded that the biological and economical viabilities of production of green fodder will depend on sprouting systems, type and quality of the grain, particularly the germination rate, culturing conditions, management, and the local conditions (Fazaeli *et al.,* 2011). However, using some by-products (olive cake) as media proved to be of certain advantage as increasing the dry matter and green fodder nutritive value (Shtaya, 2004). This chapter presents review of the relevant literature which is consist of replacement of commercial concentrate feed by hydroponic wheat sprouted fodder (HWSF) in turkey production. This research was conducted in a few researches in worldwide however there is limited literature of this research but in Bangladesh this research was not conducted and even though there has been no research recorded of this topic. However, the literature of this research was collected from different research conducted in the world, so that the steps mentioned in the following paragraphs state the literature of the study.

2.1 History of hydroponic fodder cultivation

The background of hydroponic fodder production has been provided by Sneath and McIntosh (2003). In mid-1800, Jean Boussingault, a French chemist verified nutritional requirement of plants grown without soil. By 1860, the techniques of 'nutriculture' were perfected by Sachs and Knop working independently in England. During this time, European farmers sprouted cereal grasses to feed their cows in winter. 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. In 1969, Woodward, an English scientist, made attempt to grow plants in various sources of water. In 1970s, a range of units were designed and manufactured in many countries including Europe and USA to produce hydroponic fodder. In 1973, Harris of South Africa questioned the economics of the hydroponic system. In late 1980s, attempts were made in India for propagating hydroponic technology for forage production and research works were undertaken by several workers (Reddy *et al.,* 1988; Pandey and Pathak, 1991; Rajendra *et al.,* 1998). Hydroponic technology was introduced in Goa in 2011 by establishing numbers of hydroponic fodder production units under Rashtriya Krishi Vikas Yojana (RKVY), Govt. of India by Goa Dairy at different dairy cooperative societies including one unit at ICAR-ICAR Research Complex for Goa, Old Goa and research works were carried out (Naik, 2013a; Naik; 2013b; Naik *et al.,* 2013c; Naik *et al.,* 2014).

2.2 Hydroponic fodder production

2.1.1 The sprouting process

Producing sprouts involves placing soaked barley, wheat, Oats and maize in trays after being full saturated for sprouting for 7 days. Soaking process is important as facilitates metabolism of reserve materials which is utilized for growth and development (Morgan *et al.,* 1992). Grain is often soaked or washed with a sterilizing solution to help minimize the risk of mould.

The yield and quality of sprouts produced is influenced by many factors such as soaking time, grain quality, grain variety and treatments, temperature, humidity, nutrient supply, depth and density of grain in troughs and the incidence of mould. Maximum sprout yield can be achieved through using clean and free of broken grains. Cereal seeds germinate equally well under dark or light conditions (Chavan and Kadam, 1989). Several sprout production systems are available worldwide. These systems are furnished with suitable tools and equipment that facilitate production of sprouts. Access to water, electricity, nutrients and sterilizing agents is required.

2.1.2 Choice of grain

There are many types of grains grown hydroponically. Grains such as oats, barley, wheat, sorghum and corn have all been tried. The main characteristics of choosing grain that come into play are their nutritional value, speed of grain growth and protein levels. The grain that has all these qualities is - Malt Barley as it is highly nutritious with a very high protein level and under the right conditions can grow to a height of 30 cm. Calder stated that 'when all of the necessary items are put into the equation such as – size of the grain, germination, price, availability, protein increase, nutritional value etc, then malt barely comes out on top. Naik *et al.* (2015) suggested that maize is the grain of choice for production of hydroponic fodder because of its easy availability, lower cost, good biomass production and quick growing habit.

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 hydroponic forage. In case of barley (Morgan *et al.*, 1992) and maize (Naik, 2012b) seeds, 4 hours soaking in water is beneficial. Under field conditions, farmers producing hydroponic maize forage have the practice of putting the seeds in a gunny bag tightly and then make it wet and keep for 1-2 days in nutrient solution and water. The use of nutrient solution for production of hydroponic forage is not mandatory as it can also be produced by tap water. There are reports of non-significant improvement in the nutrient content of the sprouts which do not justify the added expense of using nutrient solution rather than fresh water (Sneath and Mclntosh 2003; Dung *et al.,* 2010a). However, a positive response to added nutrient solution has been reported. The nutrient solution (Dung *et al.,*2010a) for hydroponic fodder production contained Ca, K, N, Fe, Mg, S, P, Zn, Mn, Cu, Bo and Na at a level of 89.20, 81.90, 75.10, 1.80, 20.80, 43.20, 3.20, 0.40, 0.50, 0.01, 0.10 and 0.10 ppm, respectively. It is quite interesting to note that the hydroponic forage production requires only about 3-5% of water needed to produce same amount of forage produced under field condition (AI-Karaki *et al.,* 2012). For producing one kg of maize fodder, about 1.50 litres (if water is recycled) to 3.0 litres (if water is not recycled and drained out) of water is required (Naik *et al.,* 2013c).

2.1.4 Soaking time

Morgan *et al.,* (1992) studied that germination rates were assessed for three days for cultivar Triumph barley grain that were soaked between 1 to 24 hours at 21ºC and then placed on moist filter paper in petridishes at 24ºC. Soaking periods of 1-4 hours resulted in germination rates in excess of 80%with a 4-hour soak giving 88% germination. If the soaking period is prolonged, the germination rates will be below 60%. Thus, he achieved better results at 4-hour soaking treatment. Naik *et al.* (2013) suggested that 4 hours of soaking is beneficial for maize grain.

2.1.5 Pre-soaking water temperatures

The effect of water temperature used for soaking on germination amount was studied by Morgan *et al.* (1992). He also observed that water temperatures of 12ºC, 23ºC and 30ºC during 4 hours of soaking made little difference on germination amount after 72 hours, but grain soaked at 23ºC appeared to germinate more rapidly.

2.1.6 Chemical treatments of grain

It was observed that initial chemical treatments to reduce mould also reduced germination and growth. Morgan *et al.*(1992) found that 1-hour treatment in 1% 'domestos' (equivalent to 0.1% hypochlorite) was effective in reducing contamination without adversely affecting germination amount. It was reported by Sneath and McIntosh (2003) that one-hour treatment of grain with 0.1% hypochlorite is effective in reducing the contamination without adversely affecting the germination rate. Al-Karaki *et al.*, (2012) reported that all crops grain can be cleaned from debris and other foreign materials and then treated with 20% sodium hypochlorite solution (household bleach) to control the formation of mould. The grain should then be washed well from residues of bleach and resoaked in tap water overnight (about 12 hours) before planting.

2.1.7 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 hydroponic fodder using low cost devices in field conditions keep the crop for 7-10 days; however, it enhances the chances of mould growth.

2.1.8 Seed rate

The seed rate also affects the yield of the hydroponic fodder which varies with the type of seeds. 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^2has been suggested by Naik (2013a) for hydroponic 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.

2.1.9 Light schedule

Light is not important to sprout cereal grains. But some light in the second half of the sprouting period encourages photosynthesis and greening of the sprouts. If the seedlings are grown without light or too low a light intensity, photosynthesis is non-existent or minimal (Hillier and Perry, 1969; Bidwell, 1974) and seedlings must depend on their starch and fat reserves to meet their energy demand. Where sprouts are stacked inside a shed many sprouts may be heavily shaded as cited in O'Sullivan (1982). Morgan *et al.* (1992) reported that no light causes increased losses of DM. They found that the rate of decrease of DM content slowed down after the fourth day in lighted experiments, when leaves began photosynthesizing. Lighting prior to day 3 was of little significance Morgan *et al.* (1992). El-Deeba *et al.*(2009) indicated that root length dose not influence with lighting operating hours, however its value was about 6 cm under all treatments of lighting (8, 12, 16, and 24 hours/day). The vegetative length of barley had been significantly affected by lighting operating hours. However, the increasing of the vegetative length was about 5.88, and 16.67 % with application of 8-12, 12-16 and 16-24 lighting time (hours/day) (O'Sullivan 1982). The above mentioned results are in agreement with those observed by Morgan *et al.* (1992). The increasing rate of yield with about 109.73 g was obtained when the lighting operating hours increased from 8 up to 12 hours/day, after then, decreased with a little value of about 6.96% with increasing the lighting hours from 12 up to 16 hours/day and the yield reduction amount was about 35.13% when increasing the lighting hours from 16 h up to 24 h/day. This means that the most suitable lighting hours ranged from 12 up to 16 h/day for barley fodder production under closed hydroponic system. This may be due to that after the 16 h lighting; the highest light level caused a decrease in rate of grass height, due to diminishing efficiency of light use.

2.1.10 Nutrient solution and water

The use of nutrient solution for production of hydroponic forage is not mandatory as it can also be produced by tap water. There are reports of non-significant improvement in the nutrient content of the sprouts which do not justify the added expense of using nutrient solution rather than fresh water (Sneath and Mclntosh, 2003; Dung *et al.,* 2010a). However, a positive response to added nutrient solution has been reported. The nutrient solution for hydroponic fodder production contained Ca, K, N, Fe, Mg, S, P, Zn, Mn, Cu, Bo and Na at a level of 89.20, 81.90, 75.10, 1.80, 20.80, 43.20, 3.20, 0.40, 0.50, 0.01, 0.10 and 0.10 ppm, respectively (Dung *et al*., 2010a). It is quite interesting to note that the hydroponic forage production requires only about 3-5% of water needed to produce same amount of forage produced under field condition (AIKaraki *et al*., 2012). For producing one kg of maize fodder, about 1.50 litres (if water is recycled) to 3.0 litres (if water is not recycled and drained out) of water is required (Naik *et al*., 2013c).

2.3 Dry matter changes with sprouting

The germination process causes losses in dry matter (DM), however, some gain in DM from photosynthesis (Morgan *et al.,* 1992). The DM losses vary between 7 and 47%. The sprouting yield depends on several factors such as irrigation, water quality and pH, grain preparation, grain quality and variety, seeding density, temperature and growing duration (Al Karaki 2011a).

2.4 Nutrients in cereal grain and sprout

The metabolizable energy (ME) levels of sprouts on DM basis were similar to grain which was around 10 to 13 mega joules (MJ)/ kg. Crude protein (CP) ranges from 14 to 24.9%. Both sprouts and grain are low in calcium and require additional calcium in the diet to correct the Ca: P ratio (Fazaeli *et al.*, 2012).

2.5 Nutrient changes with sprouting grain

Enzymes included in grains would be activated by the soaking process then breakdown storage compounds in grains into more simple and digestible fractions as simple sugars, amino acids and free fatty acids (Cuddeford, 1989). There is an overall reduction in dry matter (DM) and total energy. Total weight of protein stays similar, however due to DM loss, the protein percentage increases giving an apparent increase in protein. There is an increase in fiber and some vitamins and a reduction in anti-nutritional compounds (Cuddeford, 1989). The desirable nutritional changes that occur during sprouting are mainly due to the breakdown of complex compounds into a more simple form, transformation into essential constituents and breakdown of nutritionally undesirable constituents (Chavan and Kadam, 1989). Increased lipolytic activity during germination and sprouting causes hydrolysis of triacylglycerols to glycerol and constituent fatty acids. Chavan and Kadam (1989) and Lorenz (1980) concluded that the sprouting of grains resulted in the following: increased enzyme activity, a loss of total DM, increase in total protein, change in amino acid composition, decrease in starch, increases in sugars, a slight increase in crude fat and crude fiber and increase the amounts of certain vitamins and minerals. Most of the increase in nutrients is not true ones; they simply reflect the loss of DM, mainly in the form of carbohydrates, due to respiration during sprouting. As total carbohydrates decrease, the percentage of other nutrients increases. Chung *et al.* (1989) found that the fiber content increased from 3.75% in un-sprouted barley seed to 6% in a 5-day sprout. The growing conditions and barley variety can have a large effect on the composition of the grass at any particular stage of development, so grass produced from different hydroponic units will almost certainly vary in composition even if harvested at the same age (Cuddeford, 1989).

2.6 Changes in protein due to sprouting

Chavan and Kadam (1989) reported an increase in protein, during the sprouting process, others a decrease in protein, while few researchers indicated a non-significant difference due to sprouting cereals (Chung *et al.*, 1989). The increase in protein content has been attributed to loss in dry weight, particularly carbohydrates, through respiration during germination. Higher germination temperature and longer sprouting time means greater losses in dry weight and increases in protein content (Chavan and Kadam, 1989). Thus, the increase in protein is not true, but only apparent (Peer and Leeson, 1985a). Longer soaking periods were also found to reduce protein attributable to the loss of low molecular weight nitrogenous compounds during soaking and rinsing of the seeds. Chung *et al.* (1989) found that leakage of solutes to be fastest at the start of germination and coming to a halt after about one day. Solutes that leaked include proteins, amino acids, sugars, organic acids, and inorganic ions. Chavan and Kadam (1989) observed a decrease in water-soluble proteins when wheat seeds were soaked at 10ºC for 2 days prior to sprouting. Similarly, Chavan and Kadam (1989) observed a decrease in soluble protein of barley grains after prolonged soaking until the second day of germination. Losses were attributed to solubilization and leaching of proteins by the germinating embryo during the early germination period when there is little proteolytic activity developed in the seed. Morgan *et al.* (1992) found that changes in the ash and protein contents occur rapidly from day 4 corresponding with the extension of the radicle (root), which allows mineral uptake. The absorption of nitrates facilitates the metabolism of nitrogenous compounds from carbohydrate reserves, thus increasing the levels of crude protein (CP). Morgan *et al.* (1992) showed that the CP content increases progressively with age, reaching a maximum of 48% at day 8. These increases are due partly to the absorption of nitrogen from the nutrients solution and to the concentration of nitrogenous compounds in a reduced mass of DM. Flynn *et al.* (1986) calculated the weights of CP at the beginning and end of an 8-day cycle where they found that the recovered weights of CP and true protein had actually decreased significantly by 7% and 24%, respectively. Chung *et al.* (1989) found an initial depression in protein content by the second day of sprouting, followed by a return to pre-germination protein levels with the same trend observed in the ash (minerals) content.

Although the net change in total protein content is usually non-significant, very complex qualitative changes are reported to occur during soaking and sprouting of seeds. The storage proteins of cereal seeds are partially hydrolyzed by proteolytic enzymes, which are evidenced by an increase in water soluble proteins and free amino acids (Nielson *et al.*, 1977; Chavan and Kadam, 1989). In wheat, the water soluble proteins were found to increase six folds after 10 days of sprouting. The storage proteins of cereal grains are classified as albumins (water soluble), globulins (salt soluble), prolamins (alcohol soluble), glutelins (acid or alkali soluble) and residue or insoluble proteins (Chavan and

Kadam, 1989). The prolamins and glutelins together with residue proteins constitute more than 80% of the total seed proteins (Chavan and Kadam, 1989). These protein fractions, particularly prolamin, are known to be deficient in lysine and are inversely correlated with the seed protein content (Kent-Jones and Amos 1967; Salunkhe *et al.*, 1984; Chavan and Kadam, 1989). Hence, the conversion of this fraction into albumins and globulins during sprouting may improve the quality of cereal proteins. Many studies have shown an increase in lysine with sprouting with the suggested mechanism being the degradation of prolamins into lower peptides and free amino acids to supply the amino groups, which are possibly used through transamination to synthesize lysine (Chavan and Kadam, 1989).

2.7 Changes in anti-nutritional factors

Phytic acid occurs primarily in the seed coats and germ of plant seeds. It forms insoluble or nearly insoluble compounds with minerals including Ca, Fe, Mg and Zn. Diets high in phytic produces mineral deficiency symptoms in experimental animals (Chavan and Kadam, 1989). The sprouting of cereals has been reported to decrease the levels of phytic acid. Polyphenols and tannins usually present in cereals like sorghum, barley and millet have been recognized as anti-nutritional factors. These are known to inhibit several hydrolytic enzymes, such as trypsin, chymotrypsin, amylases, cellulases and β-galactosidase (Chavan and Kadam, 1989). In addition, they bind with proteins and form tannin-protein complexes, thus making protein unavailable. Detrimental effects of polyphenols and tannins on the availability of minerals and vitamin have been reported (Chavan and Kadam, 1989). Chavan and Kadam (1989) concluded that sprouting treatment does not decrease the tannin content of grain, but favours the formation of complexes between tested tannins and endosperm proteins. The problem of tannin however is not significant in low tannin types and other cereals that do not contain appreciable amounts of tannins.

2.8 Effect of hydroponic fodder supplementation on livestock performance

Mysaa (2016) conducted a study to investigate the effect of feeding hydroponic barley (HB) on the performance of Awassi ram lambs. A total of 50 weaned lambs were used in a feeding trial by dividing it into two groups. The first was fed a total mixed ration diet (control) while lambs in the second group were fed similar ration except that barley grain was totally replaced by HB for 90 days feeding trial. Results of the experiment showed that HB had a positive effect on feed intake, final live weight, total gain, average daily gain and FCR on lambs fed the HB diet when compared to lambs fed the control diet. In conclusion, HB can be used as feed for lambs in the fattening period to enhance their growth performance. Weldegerima *et al.* (2015) conducted an experiment to investigate the effect of feeding hydroponically maize and barley sprouted fodder for Konkan Kanyal goats. Eighteen growing male kids of 3-7 months old with initial live weight of 11.01±0.26 kg were divided into six treatments (3 animals each) randomly to receive one of the treatment diets *viz.* T_0-Finger millet straw (FMS) 100%; T_1- FMS + hydroponic maize fodder (HMF) 80%: 20%; T_2-FMS + hydroponic barley fodder (HBF) 80%: 20%; T_3-FMS + HMF 60%:40%; T_4-FMS + HBF 60%:40%; T_5-FMS + HMF + HBF 60%: 20%: 20% for 97 days. Results denoted a significant improvement in DM intake in T_5 (504.51 g/day) and T_3 (415.36 g/day) than control (317.54 g/day) and DM digestibility co-efficient was highest in T_5 (68.44%) and T_3 (67.28%) while feed conversion efficiency in T_3 (12.15%) and T_5 (10.56%) was higher than T_0 (-0.47%) and average body weight gain in T_3 (61.93g/day) and T_5 (56.70g/day) was significantly higher than T_0 (-1.17g/day). Therefore, it can be concluded that feeding of hydroponically sprouted maize and barley fodder to growing goats increased the digestibility of nutrients, live weight gain and feed conversion efficiency. Williams (1956) supplemented 20 lb of 6-day-old hydroponic oats grass two sets of lactating identical twin cows (Holsteins and Guernseys) for 30 days. He observed that there was no change in milk production or fat amount. In another study by Tinley and Bryant (1938) at Wye (England) found in experiment that there was no significant difference in milk yield between the sprout-fed and control groups. Bartlett *et al.* (1938) concluded that feeding sprouted maize showed no advantage in either milk yield or quality. Badran *et al.* (2017) investigated the effect of feeding different levels of hydroponic barley (HB) on general performance, milk yield and quality of lactating Awassi ewes. A total of 48 lactating ewes were used in a feeding trial in three groups. The first was fed a regular lactation total mixed ration (TMR) while ewes in the second and third treatments were fed similar ration except that regular wheat hay was replaced by HB at levels of 50 (HB_1) and 100% (HB_2), for 120 days feeding trial. Results of the experiment showed that HB yield in 8 days germination cycle was 8.0 kg per 1 kg barley grains. HB at two levels had no effects on feed intake (FI), live weight changes, milk yield and milk composition; however, HB had positive effects on ewe's health conditions, mortalities, conception rates and abortion. Reddy *et al.* (1988) used eight cross-bred (Ongole × Holstein) milch cows into two groups of 4 animals each fed in individual stalls with artificial green fodder (group-1) and natural barley fodder (NB-21, group-2) fodder at the rate of 10kg/animal/day with concentrate mixture at the rate of 1 kg for every 2.5 kg milk produced and maize silage *ad libitum* as bulk of ration. It was observed that an increase of 7.8% in milk production, 9.3% in fat corrected milk (FCM) and 10.5% in fat yield in animals of group 1 fed artificial green fodder. They suggested that artificially grown fodder was supplying more nutrients than NB-21. Pandey and Pathak (1991) fed artificially grown barley fodder to five cross bred (*Bostaurus* × *Bosindicus*) cows (3-4 years old and 350 – 410 kg live weight) *ad libitum* *during* the 3rd to 5th month of their second lactation in a feeding experiment. The fresh sprouts intake was 50.38 kg/day or 7.13 kg DM. The intake of mean dry matter was 1.93% of live weight and milk yield was 9.13 kg/day. Gebremedhin (2015) identified the nutritional benefit and economic values of feeding hydroponically grown maize and barley fodder for Konkan Kanyal goats. Eighteen growing male kids of 3-7 months old with initial body weight of 11.01±0.26 kg were grouped randomly into six treatments (3 animals each) and receive treatment diets viz. T_0-Finger millet straw (FMS)100%; T_1-FMS + hydroponic maize fodder (HMF) 80:20; T_2-FMS + hydroponic barley fodder (HBF) 80:20; T_3-FMS + HMF 60:40; T_4-FMS + HBF 60:40; T_5-FMS + HMF + HBF 60:20:20% for 90 days feeding trial and 7 days metabolic trial period. After completion of 97 days, a significant improvement in DM intake was observed in T_5 and T_3 than control and feed conversion efficiency was highest in T_3 and T_5 than T_0 and highest live weight gain in T_3 and T_5 than T_0 as well as economically profitable in T_3 than T_0. Therefore, it can be concluded that feeding of hydroponically grown maize and barley fodder for growing goats increased the total DM intake, feed conversion efficiency, live weight gain and it was economically valid. Reddy *et al.* (1991) conducted an experiment with 8 crossbred cows to observe the effect of supplementation of machine grown barley fodder on paddy straw-based rations of lactating cross bred cows and reported that average milk yield, 4 % fat corrected milk (FCM), fat and SNF percent were similar in all groups. Tudor *et al.* (2003) conducted a study on drought master steers of 15–18 months old and average 330 kg live weight fed with low quality hay and barley sprouts fodder over 70 days. During first 48 days cattle were eaten 1.9 kg DM/head/day of sprouts (15.4 kg wet weight) and 3.1 kg DM/head/day of poor quality hay and gained1.01 kg/head/day. Muela *et al.* (2005) analyzed the effect of hydroponic green fodder (HGF) on the productive and reproductive behavior of lactating Salers cows with calf. There were 35 cows used with 42 days and randomly assigned into two treatment groups, range land forage plus HGF as supplement plus green fodder (GF) and range land forage plus irrigated prairie forage (PF). The consumption of forage was 1.07 and 1.32 kg/DM/d of GF and 2.66 and 0.88 kg/DM/d of PF in May and June, respectively. Both groups were bred with fertility tested registered Salers bulls. The cows on PF lost weight from day 28 to day 56 of the experiment; the GF cows maintained the live weight on the same period. The cows showed daily live weight lost on PF and daily weight gain on GF. The calves showed differences between treatments in live weight at day 56. The daily average weight gain of calves from day 0 to 56 was 0.535 vs. 0.759 kg/d on PF and GF, respectively. Miscera *et al.* (2009) made three homogeneous groups of 45 lactating Comisana sheep (4^{th}-5^{th} parity), 15 in each, to evaluate the effects of two different levels of partial substitution of a complete feed with hydroponically germinating grain on the plasma cortisol and milk production responses. They concluded that, integration with hydroponically germinating at in partial substitution of the complete feed does not modify biochemical and hematological parameters and seems to produce an improvement in animal welfare and production of milk. Hillier and Perry (1969) conducted a study by feeding of cattle with four levels of supplemental oat sprouts (0, 0.63, 0.95, 1.26 kg DM) on both low and high-energy diets. They found no effect on digestibility of DM, protein, fibre, ether extract, nitrogen free extract or energy. Hillier and Perry (1969) also found the effect of hydroponic fodder on growth responses for poultry and also increased gains for cattle when sprouted corn was added to the ration (Patterson, 1937; McCandlish, 1939). Marsico *et al.*,(2009) studied plasma levels of cortisol and milk production of 30 Jonica breed goats, divided into three homogeneous groups in lactation (4^{th}-5^{th} parity) to evaluate the effects of two different levels of partial dietary substitution with hydroponically germinating oat. They found that there was no relevant change in the milk yield among the groups. Deveder and Kumari (2016) evaluated the yield and feeding value of hydroponic barley fodder (HBF) in growing lambs. The results indicated that, replacement of concentrate mixture with hydroponic barley fodder at 50 percent level in the ration of growing lambs improved the nutrient utilization, N_2balance, plane of nutrition and growth performance and also reduced the production cost. However, though replacement of concentrate mixture with HBF up to 75 per cent has no beneficial affect but it could be comparable with control in nutrient utilization and plane of nutrition. Fazaeli *et al.* (2011) conducted an experiment to study the effect of hydroponic barley green fodder on the performance of feedlot calves where 24 cross bred (Holstein × Local) male calves were assigned randomly into two treatment groups that were either control (grain barley) or hydroponic barley green fodder (BGF) that was included to provide 22.8 percent of the total diet on dry matter basis. They found that live weight gain was not significantly different between the treatments, but the animals that had received the control diet had higher dry matter intake than those fed BGF diet. Sharif *et al.* (2013) observed increased digestibility by using sprouted grain in the diet of broilers and large animals. This was achieved possibly by changes in rate and extent of digestion and absorption. Addition of sprouted grain has improved milk yield up to 8.7% in ruminant animals. Grigor'ev *et al.* (1986) conducted an experiment to investigate the effect of hydroponic barley on two groups of 8 cows, at the same stage of lactation, for 101 days on mixed feeds based on maize silage. Replacement of 50% of the maize silage with 18 kg of hydroponic barley grass increased milk yield by 8.7% although milk fat was depressed.

2.9 Effect on feed intake

Although sprouting of the grains has been reported to increase the nutritional value of the grains, the effect on feed intake is not very encouraging. For example, Hamid (2001) reported that the addition of sprouted grains in the diet of broilers lowered feed consumption. This was also confirmed by Abbas and Musharaf (2008). However, it has been observed that it's not the sprouting but the level of sprouted grains used that might be responsible for reduced intake (Fafiolu *et al.*, 2002). In this study inclusion of sprouted sorghum in the diet of layer hen at the level of 300 g per kg of diet reduced feed intake but 150 g per kg diet did not affect the intake. The reduced feed intake is probably due to reduced palatability, taste or smell. According to Oduguwa and Farolu (2004), feed intake was reduced in broiler birds because sprouting caused bitterness in taste. Anganga and Adogla-Bessa (1999) pointed that decrease in feed intake was due to the presence of tannins which depressed palatability. There are certain studies that report no reduction in feed intake. For example Scott (2002) and Fafiolu *et al.*, (2006) determined that feed intake was not affected by the addition of sprouted grains in poultry diet. The above studies indicate that sprouted grains can be successfully used in the poultry diet without affecting intake provided birds are not put off due to poor palatability, bitter taste or bad smell.

2.10 Effect of hydroponic fodder usage in livestock feeding on cost economics

Naik *et al.* (2014) studied the cost benefit effect of hydroponic maize fodder of 7 days growth fed to 6 dairy cows divided into two equal groups (BW 442 kg; avg. milk yield 6.0 kg). They observed that there was higher net profit of Rs.12.67/- per cow/d on feeding hydroponic maize fodder (HMF). The cost of the feed/d and feed cost per kg milk production was higher in the T-HF (hydroponic fodder) group (Rs. 144.88 and Rs. 34.98) than the T-CF (conventional green fodder) group (Rs. 137.51 and Rs. 33.69). The higher cost of the hydroponic maize fodder (Rs.4/kg) than the conventional green fodder (Rs. 1.50/kg) might be the reason for higher cost of the feed in the T-HF group than T-CF group. It was concluded that feeding of HMF to lactating cows increased the digestibility of nutrients and milk production leading to increase in net profit. Rahim (2015) investigated the biological and economical values of hydroponic barley (HB) on lactating Awassi ewes. A total of 48 lactating ewes were used in a feeding trial in two groups. The first was fed a regular lactation total mixed ration (TMR) while ewes in the second treatment were fed similar ration except that regular wheat hay was totally replaced by HB for 120 days feeding trial. Results of the experiment showed that the green fodder yield in 8 days germination cycle was 7.5 kg per 1 kg barley grains of green fodder. HB had no effects on feed intake (FI), live weight changes, milk yield and milk composition; however, HB had positive effects on ewe's health conditions, mortalities, conception rates and abortion. In conclusion, HB can be used as feed for lactating sheep as cost of feed can be reduced by 42 %. Fazaeli *et al.* (2012) conducted an experiment to evaluate the effect of barley green fodder produced by hydroponic system on the performance of feedlot calves. These findings suggest that green fodder had no advantage over barley grain in feedlot calves, while it increased the cost of feed.

2.11 Nutrient content of hydroponic fodder

There are changes in the nutrient content of the cereal grains and hydroponic fodder (Hillier and Perry 1969; Peer and Leeson 1985b; Sneath and Mclntosh, 2003; Dung *et al.*, 2010a; Dung *et al.*, 2010b; Fazaeli *et al.*, 2011; Fazaeli *et al.*, 2012; Naik *et al.*, 2012a; Naik *et al.*, 2014). 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. During sprouting, starch is catabolized to soluble sugars for supporting the metabolism and energy requirement of the growing plants for respiration and cell wall synthesis, so any decrease in the amount of starch causes a corresponding decrease in DM and OM. The CP (8.60-13.90 vs. 11.38-24.90%), NPN (3.35 vs. 5.89%), SP (10.49 vs. 12.30%), IP (1.24 vs. 2.37%) contents are mostly increased, 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 hydroponic fodder higher than the tap water which may be due to the uptake of nitrogenous compounds (Dung *et al.*, 2010a). 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, 1985a; Morgan *et al.*, 1992). There is increase in the lysine (0.39 vs. 0.54%) content of the hydroponic fodder as there may be degradation of prolamins into lower peptides and free amino acids which supply the amino groups for the transamination to synthesize lysine (Peer and Leeson1985b; Chavan and Kadam, 1989). The increase in EE content (1.90-4.90 vs. 2.25- 9.27%) of the hydroponic fodder may be due to the increase in the structural lipids and production of chlorophyll associated with the plant growth. The concentrations (as percent of the total fatty acid content of the triglyceride fraction of the fat) of linolenic acid (0.59 vs. 0.97) and stearic acid (0.07 vs. 0.13) increased with the sprouting time (Peer and Leeson, 1985b). The increase in the percentage of CF (2.50-10.10 vs. 7.35-21.20), NDF (20.20-22.50 vs. 31.25-35.40) and 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 *et al.* (1992) 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 increase more if nutrient solution is used rather than water which may be due to the absorption of minerals by the roots (Dung *et al.*, 2010b).

2.12 Potential health benefits of hydroponic fodder

The potential health benefits of hydroponic fodder are well known since long (Sneath and Mclntosh, 2003). Dry grains contain abundant 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. Further, these are used to synthesis new compounds or transport to the other parts of the growing seedling including the breakdown of nutritionally undesirable constituents (Chavan and Kadam, 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; Koehler *et al.*, 2007). Sprouts are rich source of anti-oxidants in the form of b-carotene, vitamin-C, E and related trace minerals such as Se and Zn. As sprouted grains (hydroponic fodder) are rich in enzymes and enzyme-rich feeds are generally alkaline in nature, therefore, feeding of the hydroponic 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, hydroponic fodders are good source of chlorophyll and contain a grass juice factor that improves the performance of the livestock (Finney, 1982; Chavan and Kadam, 1989; Sneath and Mclntosh, 2003; Shipard, 2005).

2.13 Feeding value of hydroponic fodder

Hydroponic 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). Sometimes, animals take the leafy parts of the hydroponic fodder and the roots portions are not consumed which can be avoided by mixing the hydroponic fodder with the other roughage components of the ration (Reddy *et al.*, 1988; Naik *et al.*, 2014).

CHAPTER III

METHODS AND MATERIALS

3.1 Experimental site and animals

The study was conducted at the Advance Animal Research Farm of the faculty of Veterinary and Animal Science at Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur, Bangladesh. The experiment was conducted for 6 months from January and June, 2018. There were two sheds used under the study, one shed was used for production of hydroponic wheat sprouted fodder (HWSF) and another one was for feeding trial.

3.2 Preparation of hydroponic sprouted fodder shed

The hydroponic sprouted fodder shed was made by polythene, bamboo and wood at the farm yard. Polythene Shed of 20×12 square feet was set-up with a number of stacks to keep trays. The trays of 2.5×2 square feet were made by aluminum sheet for sprouting fodder.

3.3 Preparation of turkey shed

Turkey shed was cleaned thoroughly with water and disinfectant. Five pens were made in the Shed by using bamboo and net for 5 dietary treatment groups. All necessary equipment was set properly and performed complete fumigation. A foot bath was made in front of the door of the house and it was dipped with potassium permanganate to maintain strict bio-security.

Photo 1. Experimental site and turkeys used in the experiment

3.4 Production of hydroponic sprouted fodder

3.4.1 The hydroponic system

Hydroponic sprouted fodder was produced under intensive care at the hydroponic sprouted fodder shed, as described by Saidi and Abo Omar (2015).

3.4.2 Preparation and treatment of seeds

Wheat seeds were bought from the Wheat Research Institute, Dinajpur and that were subjected to test of the germination rate of before using. The result of the germination rate was >80%. The seeds were cleaned fully from debris and other foreign materials. The dead and broken seeds were removed from the seeds. The trays for planting materials were cleaned and disinfected. Then the seeds were washed and cleaned well. The seeds were soaked with fungicide (Provax, HECCL) mixed with clean tap water for 12 hours. After 12 hours the excess water was removed from the seed and then the seeds were wrapped by clean cloth and kept under a clean and dark environment with anaerobic condition before planting.

3.4.3 Seed sowing and irrigation

The germinated seeds of hydroponic wheat sprouted fodder were planting in the trays uniformly; the trays have holes in the bottom for excess water going out during irrigation. The required amount of wheat seed (200g/tray) was sown in 6 trays for each day. The hydroponic sprouted fodder was irrigated four times a day, two times before the noon and two times of the afternoon. The irrigation was performed by manual hand spraying machine (capacity 20 litre).

Photo 2.a) Weighing b) soaking wheat seed c) subjecting to germination and

d) Germinated seed

Photo 3. Sowing and irrigation of wheat seed

Day 1

Day 2

Day 3

Day 4

Day 5

Day 6

Photo 4. Growth phase of hydroponic wheat sprouted fodder

Photo 5. Hydroponic wheat sprouted fodder harvesting, sprouting mat, weighing concentrate feed and hydroponic wheat fodder

Photo 6. Data recording, weighing of turkey, feed distribution and experimental birds

3.5 Experimental birds

A total of 100 fertile heritage turkey eggs were purchased from Mamun Turkey Farm, Sirajganj, Bangladesh. The eggs were incubated and hatched by an incubator (Brinsea, Brinsea products Ltd.), finally got 96 poults. Then they were vaccinated with BCRDV and brooded for 4 weeks maintaining proper temperature. Birds were housed in proper atmospheric and hygienic condition. All the birds involved in the experiment were treated equally in all respects, except supplying amount of concentrate feed and hydroponic fodders. Turkeys of all dietary treatment groups were fed with isocaloric and isonitrogenous diet. Broiler starter up to 7 weeks of old and then broiler grower feed manufactured by Aftab Bahumukhi Farms Limited, Bangladesh was fed to the turkeys of all dietary treatment groups. The experimental feed was prepared using: HWSF and commercial concentrate feed.

3.6 Experimental layout

A total of seventy-five poults (8-weeks old) having uniform body weight (1297.88g/ poult) were selected and randomly assigned into five dietary treatment groups (T_1, T_2, T_3, T_4 and T_5), each group consisting of 3 replications having 15 birds in each. T_1 considered as control group and fed only commercial concentrate feed, whereT_2, T_3, T_4 and T_5 groups fed 95, 90, 85 and 80% commercial concentrate feed (CCF) along with 5, 10, 15 and 20% hydroponic wheat fodder respectively. Initial live weight of each bird was recorded just prior to grouping and kept them into separate bamboo-made chambers; the birds were reared on slatted floor with deep litter. Live weight at 7 days interval, daily feed intake and mortality were recorded during the experimental period.

3.7 Experimental diets

T_1 = 100% commercial concentrate feed (CCF)

T_2 = 95% CCF + 5% hydroponic wheat sprouted fodder

T_3 =90% CCF +10% hydroponic wheat sprouted fodder

T_4=85% CCF + 15% hydroponic wheat sprouted fodder

T_5=80% CCF+20% hydroponic wheat sprouted fodder

3.8 General management practices

The turkeys of both control and experimental groups were housed in well-ventilated conventional sheds maintained in good hygienic condition and are stall fed throughout the experimental period. Feed and water were supplied in plastic feeders and waterers. Fresh, clean drinking water was made available all day throughout the experimental period by using hanging drinkers. Before starting the experiment, the birds were kept as adjustment period to be comfortable with their respective experimental diets. To avoid wastage and reduce the quantities of leftover supply of feed was adjusted every week on the basis of consumption pattern of birds. The amount of hydroponic fodder was determined on the basis of DM requirement supplied to the treatment groups except control group (T_1). Feed and fodder were supplied two times in a day; in the morning between at 8:30 to 9:00 AM and in the afternoon between at 3:30 to 4:00 PM. To ensure freshness, fodder was supplied directly from the fodder growing shed both in the morning and afternoon. Rice husk was used as litter. Each turkey was marked with colored plastic beads for proper identification. The environmental conditions of the experimental unit such as ventilation and illumination were supplied both naturally and mechanically. The experimental temperature was between 28-35°C and lighting schedule was 16 h light and 8 h dark. Hygienic measures were taken during the experimental period to prevent diseases. Entrance of personnel was restricted except researcher, supervisor, co-supervisor and labor who visited the farm following special care. Hands and feet were washed with soap and $KMnO_4$ was sprayed thoroughly just prior to entrance the shed.

3.9 Record keeping

A standard record book was maintained throughout the experimental period. Following parameters were recorded in the record book.

- Daily supplied amount commercial concentrate feed and hydroponic wheat sprouted fodder
- Amount of residual commercial concentrate feed and hydroponic sprouted fodder
- Weight of the turkey in each group per week
- Feed conversion ratio (FCR)
- No. of dead turkeys
- Any diseases or abnormal condition of the turkeys

3.10 Data collection procedure

3.10.1 Calculation of parameters

The feed and fodder were supplied every day to the experimental birds in different amount used by weighing digital balance and the leftover feed was collected from each group then weighed daily. All experimental birds were weighed to get initial weight however, every week the birds were weighed to find live weight gain of birds. The parameters were measured during the experiment period including the following feed intake, feed conversion ratio, live weight and live weight gain.

The following formulas are used to obtain the calculation of feed efficiency and growth rate.

$$\text{Growth rate} = \frac{\text{Total weight gain in certain time}}{\text{Total days of the experiment}} \text{ (Equation 1)}$$

$$\text{FCR} = \frac{\text{Feed Intake}}{\text{Live weight gain}} \text{ (Equation 2)}$$

Where, FCR = feed conversion ratio

3.10.2 Live weight gain of turkey (LWGT)

It was calculated at 56 days of period by using the following formula.

$$LW\,T_{56} = LW\,T_{56} - LW\,T_0 \text{ (Equation 3)}$$

Where, $LW\,T_0$ = initial weight of turkey at the time of start the experiment

$LW\,T_{56}$= final live weight of turkey at 56 days of experiment

3.10.3 Profitability index

Profitability index (PI) means the net farm income (NFI) per unit of gross revenue (GR) and the ratio is calculated as follows-

$$\text{PI} = \frac{\text{NFI}}{\text{GR}} \text{ (Equation 4)}$$

3.10.4 Rate of return on investment (RRI)

Rate of the return on investment is the performance measure which is used to evaluate the efficiency of an investment or to compare the efficiency of different investments. It is the net farm income divided by total cost of investment and is usually expressed as an amount or ratio. It was calculated using the following equation (4):

$$\text{RRI} = \frac{\text{NFI}}{\text{TC}} \text{ (Equation 5)}$$

Where, RRI = Rate of return on investment, NFI = Net farm income and TC = Total cost.

3.10.5 Depreciation cost

To calculate the worth of each of the fixed cost items, the straight line method of depreciation was used. Depreciation cost was measured using the following equation (7):

$$\text{Depreciation cost} = \frac{\text{Purchase Price}}{\text{Number of useful years of the asset}} \quad \text{(Equation 7)}$$

3.10.6Capital turnover (CTO)

Capital turnover is the ratio of total revenue to total cost. It measures the efficiency of a business and provides information about the business capability to deliver a return per taka of its capital investment. It was measured using the following equation (5):

$$\text{CTO} = \frac{\text{TR}}{\text{TC}} \text{(Equation 6)}$$

Where, CTO = Capital turnover, TR = Total revenue and TC = Total cost

3.11Statistical analysis

Effect of treatment on live weight gain, feed intake and feed efficiency were analyzed using the One-way ANOVA following the GLM procedure of SPSS computer software 22.00. Significance of differences among the means of treatments was compared by using Duncan's Multiple Range test of the same package. All data were expressed as Mean ± Standard Error of Mean (SEM). Differences were considered significant at level of $P<0.01$ and $P<0.05$. The following linear model summarizes the statistics employed to analyze the data:

$$Y_i = \mu + TR_i + E_i,$$

Where,

Y_i=is the dependent variable,

μ=is the overall mean,

TR_i=is the treatment effect, and

E_i=is the error.

CHAPTER IV

RESULTS

The present study was undertaken to evaluate the effects of replacement of concentrate feed with hydroponic wheat sprouted fodder (HWSF) on growth performance of turkey. Performance of turkey was studied in terms of weight gain, feed intake and feed efficiency along with cost-benefit of feeding HWSF for turkey production. The turkeys of different dietary treatment groups (T_1, T_2, T_3, T_4 and T_5) were fed 0, 5, 10, 15 and 20% hydroponic wheat sprouted fodder, respectively.

4.1 Comparison of nutritional composition of hydroponic sprouted fodder (s)

Dry matter (DM), organic matter (OM), ash, crude protein (CP), crude fiber (CF) and ether extract (EE) of hydroponic wheat, maize and sesbania sprouted fodder were determined by proximate analysis using following methods of AOAC (2007) at Bangladesh Livestock Research Institute (BLRI), Savar; however, during the experiment, HWSF was used to fed the turkeys. The comparison of nutritional composition of hydroponic wheat, maize and sesbania sprouted fodder is presented in Table 1.The amount of dry matter (DM) was significantly higher ($P<0.01$) in hydroponic maize sprouted fodder than hydroponic sesbania and wheat sprouted fodder and the amount of crude protein (CP) was significantly higher ($P < 0.01$) in hydroponic sesbania sprouted fodder than hydroponic wheat and maize sprouted fodder. However, the amount of nitrogen free extract (NFE) was significantly differed ($P < 0.05$) in hydroponic maize sprouted than hydroponic wheat and sesbania sprouted fodder, respectively. But the amount of ash, organic matter (OM), ether extract (EE) and crude fiber (CF) were not significantly ($P>0.05$) differed among hydroponic wheat, maize and sesbania sprouted fodder.

Table 1.Comparison of nutritional composition of hydroponic sprouted fodder (s)

Hydroponic Fodder	DM	Ash	OM	% DM basis			
				CP	CF	EE	NFE
Wheat	8.64±1.04[b]	4.09±0.02	95.91±11.01	18.10±3.01[b]	3.40±0.04	3.29±0.04	71.12±7.03[b]
Maize	14.79±1.52[ab]	2.50±0.02	97.5±11.02	10.92±1.12 [a]	5.30±0.02	2.94±0.04	78.34±7.02[b]
Sesbania	9.46±1.01[a]	3.41±0.03	96.6±10.03	37.26±4.2[c]	7.21±0.01	3.71±0.05	48.41±4.43[a]
Level of significance	**	NS	NS	**	NS	NS	*

Values are Means ± SEM; NS-non-significant; statistically significant difference is expressed as *(P < 0.05) or ** (P < 0.01).

4.2 Effect of hydroponic wheat sprouted fodder on feed intake (g) in turkey

Effects of dietary supplementation of hydroponic wheat sprouted fodder on feed intake (g/d) in turkey are presented in Figure 1. The present study revealed that the total DM intake of the turkey among the dietary treatment groups (T_2, T_3, T_4 and T_5) were not significantly (P>0.05) differed by the feeding of hydroponic wheat sprouted fodder. Total DM intake was almost similar among the turkey of T_1 (74.44 g/d), T_2 (76.94 g/d), T_3 (79.35 g/d), T_4 (79.18 g/d) andT_5 (81.53 g/d) group, whereas the intake of hydroponic wheat sprouted fodder was increased as accordance with the increasing level of its supply.

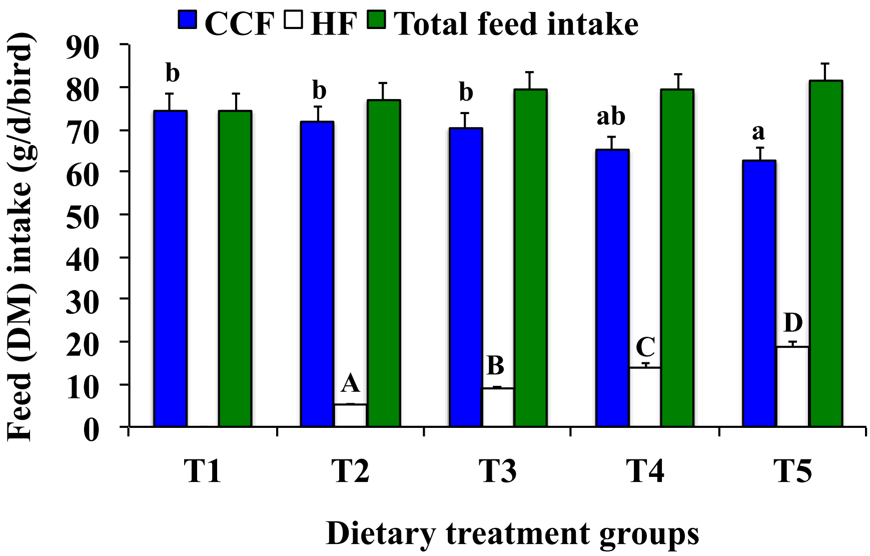

Figure 1. Effect of feeding hydroponic wheat sprouted fodder (HWSF) on DM intake of turkey. Here, T_1= 100% commercial concentrate feed (CCF), T_2= 95% CCF + 5% HWSF, T_3 = 90% CCF +10% HWSF, T_4 = 85% CCF +15% HWSF and T_5 = 80% CCF + 20% HWSF. Each bar with error bar represents Mean ± SEM value. Differences were significant at 5% level of significance (P<0.05).

4.3 Effect of hydroponic wheat sprouted fodder on live weight and live weight gain in turkey

Dietary effect of hydroponic wheat sprouted fodder on live weight and live weight gain in turkey during the experiment is shown in Figure 2. The initial live weight of the turkey in different dietary treatment groups was almost similar. The results also express that there was no significant effect of feeding hydroponic wheat sprouted fodder on the live weight of turkey among the dietary treatment groups T_1 (2074.86 g), T_2 (2130.4 g), T_3 (2125.75 g) and T_4 (2085.53 g) were increased except T_5 (1959.4 g) groups. The live weight was decreased in the turkey fed 20% of hydroponic wheat sprouted. On the other hand, the live weight gain was almost similar in the turkey of T_2 (29.55 g/d), T_3 (29.26 g/d), T_4 (28.44 g/d) and T_1 (27.69 g/d) groups except T_5 (23.85 g/d) group.

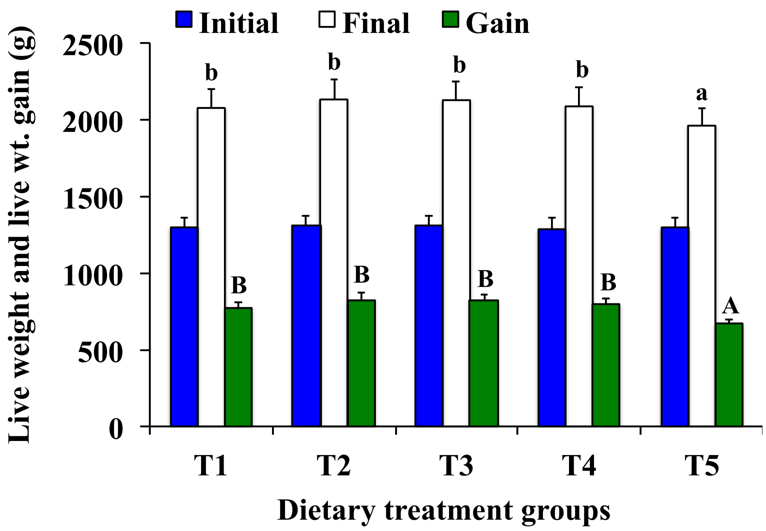

Figure 2. Effect of hydroponic wheat sprouted fodder (HWSF) on initial live weight (g), final live weight (g) and live weight gain (g) in turkey. Here, T_1= 100% commercial concentrate feed (CCF), T_2= 95% CCF + 5% HWSF, T_3= 90% CCF +10% HWSF, T_4 = 85% CCF +15% HWSF and T_5 = 80% CCF + 20% HWSF. Each bar with error bar represents Mean ± SEM value. Differences were significant at 5% level of significance ($P<0.05$).

4.4 Effect of hydroponic wheat sprouted fodder on feed efficiency in turkey

Effects of dietary supplementation of hydroponic wheat sprouted fodder on feed efficiency in turkey are presented in Figure 3. The results also revealed that the live weight gain was almost similar in the turkey of T_2 (29.55 g/d), T_3 (29.26g/d), T_4 (28.44 g/d) and T_1 (27.69 g/d) groups except T_5 (23.85 g/d) group. Live weight gain was lower in T_5group due to feeding 20% hydroponic wheat sprouted fodder. The feed efficiency was also almost similar in T_1 (2.68), T_2 (2.60), T_3 (2.70), T_4 (2.78) except T_5 (3.42). The feed efficiency was significantly ($P<0.05$) better in T_2 (2.60) group.

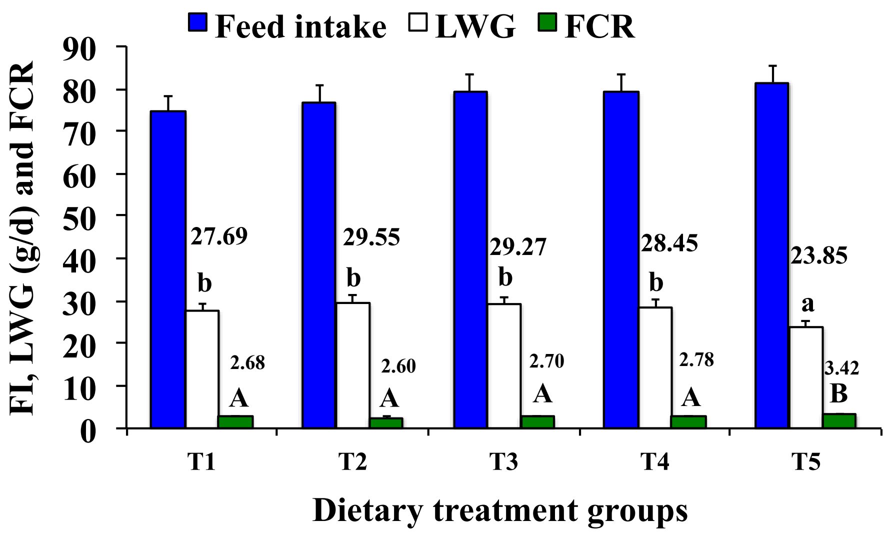

Figure 3. Effect of hydroponic wheat sprouted fodder (HWSF) on feed efficiency in turkey. Here, T_1= 100% commercial concentrate feed (CCF), T_2= 95% CCF + 5% HWSF, T_3= 90% CCF +10% HWSF, T_4 = 85% CCF +15% HWSF and T_5 = 80% CCF + 20% HWSF. Each bar with error bar represents Mean ± SEM value. Differences were significant at 5% level of significance ($P<0.05$).

4.5 Cost benefit analysis of turkey production (calculation was made in BDT)

The cost benefit analysis for turkey production based on hydroponic wheat sprouted fodder replaced by commercial concentrate feed at different levels in the dietary treatment groups are expressed in Table 2. Total cost per bird was higher in control group than other dietary treatment groups. Total cost per bird was T_1 (1715.87 Tk.), T_2 (1701.65 Tk.), T_3 (1698.71 Tk.), T_4 (1697.4 Tk.) and T_5 (1692.55 Tk.) group. Total revenue per bird was higher in T_2 (3011.00Tk.) while 2645.00 Tk., 2911.00 Tk., 2801.00 Tk., and 2741.00 Tk. were for T_1, T_3, T_4 and T_5 groups, respectively. However, the higher net farm income was found in T_2 (1309.35 Tk.), T_3 (1212.29 Tk.) and T_4 (1103.6 Tk.) while the lowest net farm income was found in T_1 (929.13 Tk.) and T_5 (788.45 Tk.) groups. Capital turnover (CTO) per bird was higher in T_2 (1.77) group when compared to T_1 (1.54), T_3 (1.71), T_4 (1.65) and T_5 (1.46) groups.

Table 2: Cost and returns for turkey production (calculation was made in BDT)

Parameters	Dietary treatment groups					Level of significance
	T_1	T_2	T_3	T_4	T_5	
A. Variable Costs						
Labor	200	200	200	200	200	NS
Feeds	164.00 ± 1.53^{c}	127.10 ± 1.24^{b}	111.79 ± 1.35^{a}	104.53 ± 1.56^{a}	99.43 ± 1.24^{a}	*
Hydroponic fodder	-	23.66 ± 0.55^{a}	35.48 ± 0.51^{b}	40.68 ± 1.65^{c}	41.68 ± 1.75^{c}	*
Medication	15.00	15.00	15.00	15.00	15.00	NS
Miscellaneous	152.00	152.00	152.00	152.00	152.00	NS
Total Variable Cost (TVC)	531.43 ± 1.55^{b}	517.21 ± 1.79^{a}	514.27 ± 1.86^{a}	512.96 ± 2.57^{a}	508.11 ± 2.99^{a}	*
B. Fixed Costs						
Cost of poult	1150	1150	1150	1150	1150	NS
Depreciation on housing @5%	35.22	35.22	35.22	35.22	35.22	NS
Depreciation on equipment@10%	2.22	2.22	2.22	2.22	2.22	NS
Total Fixed Cost (TFC)	1184.44	1184.44	1184.44	1184.44	1184.44	NS
Total cost	1715.87 ± 1.55^{b}	1701.65 ± 1.79^{a}	1698.71 ± 1.86^{a}	1697.4 ± 2.57^{a}	1692.55 ± 2.99^{a}	*
C. Revenue						
Sales of per turkey	2634 ± 9.45^{b}	3000 ± 8.44^{e}	2900 ± 7.51^{d}	2790 ± 8.27^{c}	2460 ± 0.81^{a}	*
Sales of litter	11.00	11.00	11.00	11.00	11.00	NS
Total revenue (TR)	2645.00 ± 6.58^{b}	3011.00 ± 6.57^{e}	2911.00 ± 7.53^{d}	2801.00 ± 8.47^{c}	2471.00 ± 0.81^{a}	*
Net farm income (NFI)	929.13 ± 3.02^{b}	1309.35 ± 4.78^{e}	1212.29 ± 1.51^{d}	1103.6 ± 5.9^{c}	788.45 ± 2.18^{a}	*
Profitability index (PI)	0.35 ± 0.03^{a}	0.43 ± 0.01^{b}	0.42 ± 0.01^{b}	0.39 ± 0.02^{ab}	0.31 ± 2.69^{a}	NS
Rate of return on investment (RRI)	58.41 ± 1.33^{b}	78.00 ± 1.11^{cd}	70.07 ± 1.23^{d}	65.96 ± 1.53^{c}	45.44 ± 0.7^{a}	NS
Capital turnover (CTO)	1.54 ± 0.07^{a}	1.77 ± 0.05^{b}	1.71 ± 0.01^{b}	1.65 ± 0.07^{b}	1.46 ± 0.27^{a}	*

Values are Means ± SEM, $^{a, b, c, d, e}$ Means within a row without common superscripts differ significantly; NS-non-significant; statistically significant difference is expressed as *($P < 0.05$). Here, T_1=100% commercial concentrate feed (CCF), T_2= 95% CCF + 5% HWSF, T_3= 90% CCF +10% HWSF, T_4=85% CCF + 15% HWSF and T_5 = 80% commercial concentrate feed (CCF) + 20% of HWSF.

CHAPTER V

DISCUSSION

The effect of feeding hydroponic wheat sprouted fodder (HWSF) replaced with commercial concentrate feed on growth performance of turkey. Performance of turkey was studied in terms of comparison of nutritional composition of hydroponic sprouted fodder weight gain, live weight gain, feed intake and feed efficiency along with cost benefit of feeding HWSF for turkey production is discussed with the available literature. The percentage of dry matter (DM), ash, organic matter (OM), crude protein (CP), crude fibre (CF), ether extract (EE) and nitrogen free extract (NFE) on dry matter basis contents of hydroponic, wheat, maize and sesbania sprouted fodder were 8.64, 14.79, 9.46, 4.09, 2.50, 3.41, 95.91, 97.5, 96.6, 18.10, 10.92, 37.26, 3.40, 5.30, 7.21, 3.29, 2.94, 3.71, 71.12, 78.34, 48.41%, respectively. The present study is in agreement with the results reported by Kantale *et al.* (2017) who observed to evaluate the protein content of hydroponics wheat fodder and it was highest on 8^{th} day (15.75%) which was higher than conventional green fodder wheat (11.02%). The ether extract content of hydroponics fodder wheat was highest on 8^{th} day (2.80%). The crude fiber content of the wheat seed was 2.40% and increased up to 5.20% on 8^{th} day of growth. The crude fibre content in hydroponics system was much lower than the conventional fodder. The total ash content of the hydroponics fodder wheat was 3.00% on 8^{th} day, which was lower t (P <0.01) than conventional fodder (8.28%). The nitrogen free extract content of the wheat seed decreased to (73.25%) on 8^{th} day of growth as compared to seed (83.40%), however it was more than conventional cereal fodders. However, Chung *et al.* (1989) also reported by the increase in crude fiber content during sprouting of wheat might be due to the synthesis of structural carbohydrates such as cellulose and hemicelluloses. The present results are line with the results reported by Dung *et al.* (2010) who demonstrated the increase in protein content may be attributed to the loss in dry weight, particularly carbohydrates, through respiration during germination and thus longer sprouting time was responsible for the greater losses in dry weight and increasing trend in protein content. The CP content of hydroponics wheat in the present study was more than hydroponics reported by Naik *et al.* (2016).

The present study revealed that the total DM intake was almost similar among the turkey of T_1 (74.44 g/d), T_2 (76.94 g/d), T_3 (79.35 g/d) and T_4 (79.18 g/d) and T_5 (81.53 g/d) group, whereas the intake of HWSF was increased as accordance with increasing level of its supply. This is an agreement with the findings of Shtaya (2004) who found that feed intake was not affected by feeding ewes at different levels of hydroponic sprouted fodder. The present results are line with study reported by Saidi and Omar (2015) who observed that hydroponic fodder had no effect on feed intake (FI) and weight gain during investigation of biological and economical value hydroponic fodder on lactating Awassi ewes. Similarly, Shanti *et al.* (2017) studied that dry matter, feed intake and growth rate decreased linearly by 1.16±0.080 g/d ($P<0.001$) and 0.998±0.062 g/d ($P<0.001$) per unit of hydroponic fodder increase. The present results are line with the results reported by Oduguwa and Farolu (2004) who found reduced feed intake in broiler birds because sprouting caused bitterness in taste. Anganga and Adogla-Bessa (1999) reported that decrease in feed intake was due to the presence of tannins which depressed palatability. The present results are not in agreement the results of Hamid (2001) who reported that the addition of hydroponic sprouted fodder in the diet of broilers lowered feed consumption. This was also confirmed by Abbas and Musharaf (2008). It has been observed that it's not the hydroponic fodder but the level of sprouted grains used that might be responsible for reduced intake (Fafiolu *et al.*, 2002). Inclusion of hydroponic fodder in the diet of layer hen at the level of 300 g per kg of diet reduced feed intake but

150 g per kg diet did not affect the intake. The reduced feed intake is probably due to reduced palatability, taste or smell. The present result is not in agreement with the results reported by Badran *et al.* (2017). They concluded that hydroponic fodder supplementation had no effects on feed intake (FI), body weight changes, milk yield, and milk composition; however, hydroponic fodder had positive effects on ewe's health conditions, mortalities, conception rates and abortion. Mysaa (2016) demonstrated that hydroponic fodder had a positive effect on feed intake, final body weight, total gain, average daily gain and FCR on lambs fed. On the other hand, Saidi *et al.* (2015) found from an earlier study that the feed intake of ewes fed hydroponic fodder and the concentrate diet was similar.

In the present study, the results also express that there was no significant effect of feeding HWSF on the live weight and live weight gain of turkey among the dietary treatment groups T_1 (2074.86g), T_2 (2130.4g), T_3 (2125.75g) and T_4 (2085.53g) were increased except T_5 (1959.4g) groups. The live weight was decreased in the turkey fed 20% of hydroponic wheat sprouted fodder. On the other hand, the live weight gain was almost similar in the turkey of T_2 (29.55 g/d), T_3 (29.26g/d), T_4 (28.44 g/d) and T_1 (27.69 g/d) groups except T_5 (23.85 g/d) group. On the other hand, live weight was lower inT_5group of turkey which was provided with 20% HWSF. According the present results hydroponic wheat sprouted fodder has positive effects up to 15% of HWSF but at 20% level have negative effects on final live weight and live weight gain of turkey. This is an agreement with the of results Gebremedhin (2015) who reported that highest live weight gain was found in Konkan Kanyal goats fed with Finger millet straw 60% and 40% hydroponic fodder. Similarly, Deveder and Kumari (2016) observed that 50% replacement of concentrate mixture with hydroponic fodder had significantly improved the average daily weight gain and live weight gain of ram lambs. Naik *et al.* (2014) also noticed that, the higher performance in the body weight gain of animals supplemented with 40% hydroponic fodder could be due to the ability of the supplements to supply necessary nutrients. However, the present results are lines with the result reported by Fayed *et al.* (2011) who determined that addition of hydroponic sprouted fodder improved weight gain in lambs. This was in line with the concept of Naik *et al*. (2013) who coined out hydroponic sprouts are rich sources of bioactive enzymes and contain grass juice ingredients that improves the performance of livestock. This is an agreement with the findings of Fayed (2011) who demonstrated that feeding of hydroponic sprouted fodder with rice straw in growing Barki lambs enhanced lambs growth performance. The better performance in the live weight gain of lambs supplemented with hydroponic fodder could be due to the ability of the hydroponic fodder to supply necessary nutrients. Similar findings also reported by Tudor *et al*. (2003) who reported that an increase in weight gain of lambs received hydroponic sprouts fodder may be attributed to enhancing of microbial activity in the rumen. Other researchers also revealed that hydroponic sprouted fodder improve the performance of birds and animals up to 8%. Moreover, feeding hydroponic sprouted fodder mixed with poor quality hay to drought master steers gained more by 1.01 kg/head/day when compared to steers fed concentrate diets (Muhammad *et al.*, 2013; Tudoe *et al.*, 2003). The present results are not lines with the findings reported by Mohsen *et al.* (2015) who used hydroponic sprouted fodder (HSF) at the levels of 0, 10, 20 and 30% in diets of growing New Zealand rabbits and concluded that feed intake and growth rate decreased linearly with hydroponic sprouted fodder increase. The present results are not in agreement with the result of Saidi and Omar (2015) who reported that hydroponic fodder had no effect on feed intake (FI) and body weight changes but hydroponic fodder had effects on ewe's health conditions, mortalities, conception rates and abortion during the investigation of the biological and economical values of hydroponic barley (HB) on lactating Awassi ewes. Baker *et al*. (2002) reported that the live weight gain depends on several factors such as breed characteristics, age, initial live weight and nutrition and management practice.

The present findings revealed that the feed efficiency was also almost similar in T_1 (2.68), T_2 (2.60), T_3 (2.70), T_4 (2.78) except T_5 (3.42). The feed efficiency was significantly ($P<0.05$) better as well as best in T_2 (2.60) group. The present findings are related with the result of Gebremedhin (2015) who reported that feeding hydroponic barley sprouted fodder for growing goats increased total DM intake, FCR and live weight gain than goats fed concentrate diets. Similarly, Weldegerima *et al.* (2015) also concluded that feeding of hydroponically sprouted fodder up to 40 % substitution (DMI) increased the digestibility of nutrients, better FE and live weight gain of growing goats. However, the present results are lines with the finding reported by Intissar and Eshtayeh (2004) who observed that using hydroponic sprouted grains with olive cakes fed to ewes gave highest FE results than ewes fed the control diets and that might be due to the higher crude protein and energy contents of the hydroponic barley diet which provided absorbable nutrients. Naik *et al.* (2014) revealed that FCR in terms of DM, CP and TDN were better in lactating cows fed hydroponic maize fodder than control group. The slightly improved efficiency observed in lactating graded Murrah buffaloes fed rations supplemented with hydroponic maize fodder might be attributed to the higher digestibility and tenderness of fodder (Naik *et al.*, 2014) or high enzyme activity in 7-day- old hydroponic sprouted fodder (Chavan and Kadam, 1989). It is also reported that the hydroponic sprouts are rich source of nutrients and contain a grass juice factor that improves the performance of livestock (Finney, 1982). But Reddy *et al.* (1988) reported that the DM required per kg milk production decreased by 11.6% in milch cattle when fed rations containing hydroponically grown fodder.

In the present study, total cost per bird was higher inT_1 than other dietary treatment groups. Total cost per bird was T_1 (1715.87 Tk.), T_2 (1701.65 Tk.), T_3 (1698.71 Tk.), T_4 (1697.4 Tk.) and T_5 (1692.55 Tk.) groups. Total revenue per bird was higher in T_2 (3011.00Tk.) while 2645.00 Tk., 2911.00 Tk., 2801.00 Tk. and 2741.00 Tk. The higher net farm income was found in T_2 (1309.35 Tk.), T_3 (1212.29 Tk.) and T_4 (1103.6 Tk.) while the lowest net farm income was found in T_1 (929.13 Tk.) and T_5 (788.45 Tk.) groups. However, Capital turnover (CTO) per bird was higher in T_2 (1.77) group when compared to T_1 (1.54), T_3 (1.71), T_4 (1.65) and T_5 (1.46) groups. Feeding hydroponic wheat sprouted fodder up to 15% may improve the growth performance of turkey and as well as reduce feed cost and total production cost. Similar findings were observed by Helal (2015) who stated that feed cost was improved by 34.15% in goats supplemented with hydroponic sprouted fodder. The present results are similar with results reported by Naik *et al*. (2014) who conducted a research on effect of feeding hydroponic sprouted fodder on digestibility of nutrients and milk production in lactating cows. There was higher net profit of Rs. 12.67 per cow/d on feeding hydroponic fodder. They concluded feeding of HF to lactating cows increased the digestibility of nutrients and milk production leading to increase in net profit. However, the present related to the findings reported by Naik *et al.* (2014) who observed that there was higher net profit of Rs. 12.67/- per cow/d on feeding hydroponic sprouted fodder (HSF). The present study are in agreement with the findings of Naik *et al.* (2014). They revealed that there was higher net profit of Rs. 12.67/- per cow/d on feeding hydroponic maize fodder (HMF).It was concluded that feeding of HMF to lactating cows increased the digestibility of nutrients and milk production leading to increase in net profit. Chinnam (2015) reported that the average cost of feed/kg 6% fat corrected milk (FCM) of lactating buffaloes in the control and treatment groups were 15.28 and 15.15, respectively. The lower cost of feed/kg 6%

FCM observed in the treatment group was due to increased average6% FCM per day although higher cost was involved in the production of hydroponic maize fodder (16.80/- per 7 kg) as compared to farm made concentrate mixture (15.24/- per kg). However, higher feed cost per kg milk production with hydroponic fodder was also reported earlier due to higher costs involved in hydroponic fodder production (Naik *et al.*, 2014; Reddy *et al*., 1988). However, Rahim (2015) found that when hydroponic barley can be used as feed for lactating sheep as cost of feed can be reduced by 42%. Fazaeli *et al.* (2012) conducted an experiment his findings suggest that green fodder had no advantage over in feedlot calves, while it increased the cost of feed. In conclusion, hydroponic cultivation of wheat fodder in a semi-intensive hydroponic unit saved land, water, labor and cost effective which fodder also contains sizeable nutrients such as fresh fodder weight, CP, EE, and NFE. Therefore, dietary supplementation of CCF replaced by hydroponic wheat sprouted fodder up to15% may improve live weight, feed efficiency of turkey as well as reduce total feed cost and total production cost.

CHAPTER VI

SUMMARY AND CONCLUSION

Livestock is an integral component of the complex farming system in Bangladesh, as it not only serves as a source of meat protein but also a major source of farm power services as well as employment. Turkey production is an important and highly profitable agricultural industry with a rising global demand for its products and they are adaptable to wide range of climatic conditions. Turkey is an unfamiliar poultry species to be reared for commercial purpose in Bangladesh. The present experiment was conducted to study the dietary effects of hydroponic wheat sprouted fodder (HWSF) on growth performance of turkey, its effect on voluntary feed intake, body weight gain and feed conversion efficiency in terms of DM intake per kg weight gain along with the economics of feeding. The experiment was carried out in Advance Animal Research Farm of the Faculty of Veterinary and Animal Science, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur, Bangladesh. A total of seventy-five poults (8-weeks old) having uniform body weight (1297.88 g/poult) were selected and randomly assigned into five dietary treatment groups ($T_{1,}$ T_2, T_3, T_4 and T_5), each group consisting of 3 replications having 15 birds in each. T_1 considered as control group and fed only commercial concentrate feed, where T_2, T_3, T_4 and T_5 groups fed 95, 90, 85 and 80% commercial concentrate feed (CCF) along with 5, 10, 15 and 20% HWSF, respectively. The present study revealed that the total DM intake (g/d) was almost similar among the dietary treatment groups T_1 (74.44 g/d), T_2 (76.94 g/d), T_3 (79.35 g/d) and T_4 (79.18 g/d) and T_5 (81.53 g/d) group. The results also expressed that, there was significant ($P>0.05$) effect of feeding HWSF on live weight gain and live weight of turkey among the dietary treatment groups. The final live weight of turkey (g) among the dietary treatment groups

T_1 (2074.86 g), T_2 (2130.4 g), T_3 (2125.75 g) and T_4 (2085.53 g) were increased except T_5 (1959.4 g) group. The live weight was decreased in the turkey fed 20% of hydroponic wheat sprouted. On the other hand, the live weight gain was almost similar in the turkey of T_2 (29.55 g/d), T_3 (29.26 g/d), T_4 (28.44 g/d) and T_1 (27.69 g/d) groups except T_5 (23.85 g/d) group. The results also demonstrated that, the feed efficiency was also almost similar in T_1 (2.68), T_2 (2.60), T_3 (2.70), T_4 (2.78) except T_5 (3.42). The feed efficiency was significantly ($P<0.05$) better as well as best in T_2 (2.60) group. Total cost per bird was T_1 (1715.87 Tk.), T_2 (1701.65Tk.), T_3 (198.71Tk.), T_4 (1697.4 Tk.) and T_5 (1692.55 Tk.) group. Total revenue per bird was higher in T_2 (3011.00 Tk.) while 2645.00 Tk., 2911.00 Tk., 2801.00 Tk. and 2741.00 Tk. were for T_1, $T_{3,}$ $T_4$and $T_{5,}$ respectively. However, the higher net farm income was found in T_2 (1309.35 Tk.), T_3 (1212.29 Tk.) and T_4 (1103.6 Tk.) but highest net farm income was found in T_2 group while the lowest net farm income was found in T_1 (929.13 Tk.) and T_5(788.45 Tk.) groups respectively. Capital turnover (CTO) per bird was higher in T_2 (1.77) group when compared to T_1 (1.54), T_3 (1.71), T_4 (1.65) and T_5 (1.46) groups. In conclusion, the feeding of HWSF up to 15% may improve the growth performance of turkey and as well as reduce feed cost and total production cost; finally, increase net farm income.

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APPENDICES

Appendix-I

Concentrate commercial feed (CCF) intake record of turkey

Date: ---------------------

Treatment groups	Animal No.	Amount of CCF provided (g)	Amount of CCF wastage (g)	Amount of CCF intake (g)
T_1				
T_2				

T_3				
T_4				
T_5				

Appendices

Appendix – II

Hydroponic wheat sprouted fodder (HWSF) intake record of turkey

Date: ---------------------

Treatment groups	Animal No.	Amount of HWSF provided (g)	Amount of HWSF wastage (g)	Amount of HWSF intake (g)
T_1				
T_2				

T_3				
T_4				
T_5				

Appendices

Appendix – III

Live weight record of turkey

Date: ---------------------

Treatment groups	Animal No.	Initial live weight at..........	Live weight at.......... week	Live weight at.......... week	Live weight at.......... week	Live weight at.......... week	Live weight at.......... week	Live weight at.......... week
T_1								
T_2								

T_3								
T_4								
T_5								