ASSESSMENT OF AMMONIA GAS EMISSION IN BROILER HOUSE BY USING *Yucca schidigera* PLANT EXTRACT AND ITS IMPACT ON PRODUCTIVITY

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CERTIFICATE

This is to certify that the thesis entitled **"ASSESSMENT OF AMMONIA GAS EMISSION IN BROILER HOUSE BY USING *Yucca schidigera* PLANT EXTRACT AND ITS IMPACT ON PRODUCTIVITY"** submitted to the Faculty of Animal Science & Veterinary Medicine, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **Master of Science in Animal Nutrition**, embodies the result of a piece of bona fide research work carried out by **Md. Mahfuj Ullah Patoary**, Registration No. **12-04885** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.

Dated:

Place: Dhaka, Bangladesh

(Prof. Dr. Md. Mufazzal Hossain)
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Dedicated To
My Beloved Parents

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The Author

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ACRONYMS AND ABBREVIATIONS

Abbreviation		Full meaning
A.M	=	Ante meridian
AMM	=	Ammonix
ANOVA	=	Analysis of Variance
BARC	=	Bangladesh Agricultural Research Council
BBS	=	Bangladesh Bureau of Statistics
BCR	=	Benefit Cost Ratio
BDT	=	Bangladeshi Taka
BER	=	Bangladesh Economic Review
BLRI	=	Bangladesh Livestock Research Institute
BW	=	Body weight
BWG	=	Body weight gain
$CaCO_3$	=	Calcium Carbonate
CaO	=	Calcium Oxide
$Ca(OH)_2$	=	Calcium Hydroxide
CF	=	Crude Fibre
Cm	=	Centimeter
cm^2	=	Squre Centimeter
CO_2	=	Carbon Dioxide
CONT'D	=	Continued
CP	=	Crude Protein
DLS	=	Department of Livestock Services
DM	=	Dry Matter
DMI	=	Dry Matter Intake
DOC	=	Day Old Chick
DCP	=	Di-calcium phosphate
e.g.	=	For Example
et al.	=	And others/Associates
ER	=	Emission rate
FC	=	Feed Consumption
FCR	=	Feed Conversion Ratio
G	=	Gram
GDP	=	Gross Domestic Product
GRAS	=	Generally Recognized as Safe
i.e.	=	That is
IB	=	Infectious Bronchitis
IBD	=	Infectious Bursal Disease
iNOS	=	Inducible Nitric Oxide Synthase
Kcal	=	Kilo-calorie

ACRONYMS AND ABBREVIATIONS (CONT'D)

Abbreviation		Full meaning
Kg	=	Kilogram
LDL	=	Low Density Lipoprotein
LSD	=	Least Significant Difference
Ltd.	=	Limited
M.S.	=	Master of Science
ME	=	Metabolizable Energy
Ml	=	Mililitre
Mm	=	Milimeter
MT	=	Metric ton
N	=	Nitrogen
NDV	=	Newcastle Disease Vaccine
NH_3	=	Ammonia
NH_4	=	Ammonium
Nm	=	Nanometer
No.	=	Number
NS	=	Non-significant
PLT	=	Poultry Litter Treatment
P.M	=	Post meridian
Pp	=	Page to page
Ppm	=	Parts per Million
PPB	=	Profit per Bird
Rh	=	Relative Humidity
RH	=	Rice Husk
SAU	=	Sher-E-Bangla Agricultural University
SE	=	Standard Error
SPSS	=	Statistical Package for Social Sciences
STD	=	Spent Tea Dust
UAP	=	University of Asia Pacific
USM	=	Ultrasonic Motor
viz.	=	Such as
Vs	=	Versus
VFA	=	Volatile fatty acid
YE	=	Yucca Extract
YSE	=	*Yucca Schidigera* Extract
WPSA	=	World's Poultry Science Association

LIST OF SYMBOLS

Symbols		Full meaning
:	=	Ratio
@	=	At the rate of
+	=	Plus
-	=	Minus
<	=	Less than
>	=	Greater than
°C	=	Degree Celcius
°F	=	Degree Fahrenheit
™	=	Trade Mark
%	=	Percentage
&	=	And
*	=	5% level of significance
**	=	1% level of significance
/	=	Per

ABSTRACT

A trial of 240 day old "Cobb-500" commercial broiler chicks was carried out on littered floor for a period of four weeks at Sher-e-Bangla Agricultural University Poultry Farm, Dhaka. The study was designed to investigate the efficacy of *Yucca schidigera* plant extract (commercially available as "Bio-Ade super") on ammonia gas emission from litter of the broiler house, to evaluate the bird's performance, carcass characteristics and economic utility on broiler rearing that includes production cost, profit per bird (PPB) and benefit cost ratio (BCR). The experimental birds were allocated randomly to 3 treatments and a control group with three replications having 20 broilers per replication. Commercial starter and grower feed were used as basal diet which contained minimum 21% CP, 3000 ME Kcal/Kg and 19% CP, 3200 ME Kcal/Kg respectively. The chemical yucca extract (YE) was mixed with drinking water to the birds at three concentration levels: 1ml YE per 16 liters of drinking water (T_1), 1ml YE per 20 liters of drinking water (T_2), 1ml YE per 24 liters of drinking water (T_3) and the group without YE supplementation was control (T_0). The result demonstrated that the ammonia level in treated groups T_1 (11.87 ppm), T_2 (15.13 ppm) and T_3 (20.17 ppm) were significantly ($P<0.05$) lower at the 4^{th} week of rearing period than control group T_0 (25.87 ppm). A significant difference ($P<0.05$) was noted on body weight, feed consumption, body weight gain (BWG) and feed conversion ratio (FCR) value of the birds treated with YE. The better FCR was significantly ($P<0.05$) observed in YE treated groups T_2 (1.45), T_1 (1.46) and T_3 (1.47) than the control group T_0 (1.56). A statistically insignificant ($P>0.05$) difference was noted on survivability of the broilers between the treatment groups and control. Carcass percentage was significantly ($P<0.05$) higher in all treatment groups than control group. Edible portion of birds was significantly ($P<0.05$) high in T_2 (73.64%) than T_3 (72.86%), T_1 (72.07%) and T_0 (67.14%). PPB and BCR were significantly higher ($P<0.05$) in treatment groups than control group and among the treatment groups T_2 performed better than others. However, though *Yucca schidigera* plant naturally not found in our country but it is commercially available with various trade names. The study therefore recommends for conducting repeated field trial on commercial poultry farm to fix up inclusion level of YE. Hence, it could be safely used in broiler rearing for higher economical return without any adversity.

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ABSTRACT

A trial of 240 day old "Cobb-500" commercial broiler chicks was carried out on littered floor for a period of four weeks at Sher-e-Bangla Agricultural University Poultry Farm, Dhaka. The study was designed to investigate the efficacy of *Yucca schidigera* plant extract (commercially available as "Bio-Ade super") on ammonia gas emission from litter of the broiler house, to evaluate the bird's performance, carcass characteristics and economic utility on broiler rearing that includes production cost, profit per bird (PPB) and benefit cost ratio (BCR). The experimental birds were allocated randomly to 3 treatments and a control group with three replications having 20 broilers per replication. Commercial starter and grower feed were used as basal diet which contained minimum 21% CP, 3000 ME Kcal/Kg and 19% CP, 3200 ME Kcal/Kg respectively. The chemical yucca extract (YE) was mixed with drinking water to the birds at three concentration levels: 1ml YE per 16 liters of drinking water (T_1), 1ml YE per 20 liters of drinking water (T_2), 1ml YE per 24 liters of drinking water (T_3) and the group without YE supplementation was control (T_0). The result demonstrated that the ammonia level in treated groups T_1 (11.87 ppm), T_2 (15.13 ppm) and T_3 (20.17 ppm) were significantly ($P<0.05$) lower at the 4^{th} week of rearing period than control group T_0 (25.87 ppm). A significant difference ($P<0.05$) was noted on body weight, feed consumption, body weight gain (BWG) and feed conversion ratio (FCR) value of the birds treated with YE. The better FCR was significantly ($P<0.05$) observed in YE treated groups T_2 (1.45), T_1 (1.46) and T_3 (1.47) than the control group T_0 (1.56). A statistically insignificant ($P>0.05$) difference was noted on survivability of the broilers between the treatment groups and control. Carcass percentage was significantly ($P<0.05$) higher in all treatment groups than control group. Edible portion of birds was significantly ($P<0.05$) high in T_2 (73.64%) than T_3 (72.86%), T_1 (72.07%) and T_0 (67.14%). PPB and BCR were significantly higher ($P<0.05$) in treatment groups than control group and among the treatment groups T_2 performed better than others. However, though *Yucca schidigera* plant naturally not found in our country but it is commercially available with various trade names. The study therefore recommends for conducting repeated field trial on commercial poultry farm to fix up inclusion level of YE. Hence, it could be safely used in broiler rearing for higher economical return without any adversity.

CHAPTER 1

INTRODUCTION

1.1 General Background

Poultry is an important sub-sector of present agriculture, which contributes significantly to the economy of Bangladesh. It is one of the promising and emerging agribusiness which started practically during 1980s. Now-a-days broiler industries have become a rapidly developing enterprise among all other sectors of poultry production and a large number of farms are being established in whole the country. This profitable business is responsible for employment of rural masses particularly small and marginal farmers. According to recent statistics, total poultry population in our country is 337.99 million from where about 282.15 million chicken and 55.85 million duck in number (DLS, 2018). During 1970-80, the poultry population growth rate was 0.7% which increased to 4% per year during 1990-2005. Since 1995, a significant annual average growth rate of commercial poultry has been achieved 15-20% until 2007 and slow downed after due to avian influenza outbreak. According to Department of Livestock Service (DLS), there are 8820 registered poultry farms in Bangladesh up to 3 August 2018.

In Bangladesh, the per capita requirements of meat and eggs are 120 g/day and 104 eggs/ year, respectively however the average per capita availability of meat and eggs are 121 g/day and 95.27 eggs/ year (DLS, 2018). The demand of meat consumption per head almost able to fulfill the requirement but egg consumption still lack behind. Poultry can play a pivotal role to retain in meat production level and to achieve the expected egg production.

Chicken meat is an important source of dietary protein, and the industry has developed high grade because of intensive farming techniques, comprehensive and balanced feeding, automation equipment, and other new technologies. Total output from poultry is coming from broiler sector because of its commercialization and also rapid return to the farmers. However, diseases in production are problematic especially with the development of antibiotic-resistant bacteria. Lowered immunity arise the chance of disease occurrence into the farm. Therefore exploring safe, green and efficient addictive that increase immunity in broilers has become a research priority.

1.2 State of the Problems

The NH_3 concentration in broiler house is a major concern of this modern poultry industry. Excess NH_3 in broiler house is frequently claimed for growth retardation, ascites, conjunctivitis and poor feed utilization. Therefore, farmers are trying to mitigate the NH_3 burden in broiler house by using some chemical compounds available in the market.

Ammonia emissions in poultry houses are mainly due to high protein formulated chicken diets. The chickens have no storage mechanisms for amino acids consumed beyond the requirement for protein synthesis, so the excess amino acids are deaminated and the derived nitrogen is excreted in the urine mainly as uric acid (80%), ammonia (10%) and urea (5%). High levels of ammonia in a poultry house have negative impact on poultry growth particularly at an early age. So it is very important to maintain ammonia level on broiler farming. Feed conversion and weight gains in poultry are also affected by high levels of ammonia. Not only does indoor ammonia pollution affect the chickens but also pose a risk to the health of the agricultural workers in these facilities. Ammonia gas has a characteristic pungent odor. High ammonia levels in broiler houses can reduce bird performance and increase susceptibility to disease and increase subsequent mortality. Thus we can easily understand the harmful effect of ammonia to broiler, agricultural workers & environment.

1.3 Justification of the study

Yucca schidigera (Agavaceae), commonly named yucca, a native plant in arid deserts of American southwest and Mexico, is also in Zhejiang Province, China grown as an ornamental. It is recognized as a source of sustenance and drug by native Indians due to its health-promoting activity (Patel, 2012) and already has possessed GRAS label as food supplements. Yucca powder and juice are available in the market, and their main applications are in animal nutrition, in particular as a feed additive to reduce fecal odors and ammonia, hydrogen sulfide and some other harmful volatile compounds in domestic animal excreta (Kelly and Kohler, 2003; El-Saidy and Gaber, 2004; Gaber, 2006).

Yucca extract (YE) contains steroidal saponins and polyphenols. The former fractions are involved in the reduction of ruminal ammonia as kinds of urease inhibitor, and have antiprotozoal activity due to their ability to complex with cholesterol of protozoal cell membranes causing cell lysis and death, furthermore, they also reduce total cholesterol and LDL levels in blood plasma. The latter fractions that founded in *Y. schidigera* bark contain resveratrol, which possesses antioxidant, antiplatelet, antimutagenic, antiviral, antiinflammatory and iNOS expression-inhibiting, also cancer preventing activities (Piacente *et al.*, 2005).

The dietary supplementation with YE has positive effects on the growth rates, feed efficiency, and livestock health (Colina and Chang, 2001; Duffy *et al.*, 2001; Flaoyen *et al.*, 2002; Kaya *et al*., 2003; Liang *et al*., 2009).

If we implement this study successfully we hope every people in our country will able to meet the requirement of broiler meat by increasing its production.

1.4 Objectives

From the above consideration, the present study was under taken to determine the efficacy of *Yucca schidigera* plant extract with the following specific objectives:

- ✓ To assess ammonia gas emission from litter of the broiler house.
- ✓ To evaluate the production performance and carcass characteristics of broiler.
- ✓ To estimate the economical utility in broiler rearing.

CHAPTER 2

REVIEW OF LITERATURE

It is essential to review the previous research works which are related to the proposed study before conducting any type of survey or experiment. The literatures reviewed here have been limited to those which are considered pertinent and related to the objectives of the present study. Ammonia is considered the most harmful gas in broiler chicken housing. It can cause environmental problems, which is detrimental to the health and performance of birds. However, some of the important and informative works and research findings related to this study have been reviewed in this chapter under the following headings-

2.1 Present status of poultry farming in Bangladesh

Bangladesh Economic Review reported that there are about 65,902 poultry farms up to February 1013 in the country (BER, 2013).

Daily Star (2013) reported that in two years since 2011, nearly 25,000 farms were closed mainly due to the outbreak of the diseases.

Raha (2013) reported that 6 Grand Parent farms which supply 80% of the total demand for parent stock and rest 20% are imported. In the country 82 parent stock farms are operating and of producing 55-60 lakh DOC of broiler and 5 lakh Layer DOC per week.

Daily Star (2017) reported that there are 300 billion taka has been invested in the poultry industry. There is an estimated 150,000 poultry farms in Bangladesh. It also reported that the farms annually produce 570 million ton of meat and 7.34 billion eggs.

Hossain *et al.* (2019) reported that total 198 feed mills are registered from DLS in Bangladesh up to 27 September 2018, which are involved in producing commercial poultry and cattle feed. Among 198 feed mills 96 are actively producing and marketing poultry and cattle feed. Based on internal estimates, current demand for poultry feed has been estimated to be 5.08 million MT/year (Fuad, 2017).

WPSA-BB (2017) currently reported that 6 grandparent farms producing about (60-70) thousand parent stocks per week and 140 parent stock farms producing 10.1 Million Day Old Chicks (DOC) per week. About 100,000 commercial farms produce over 15,000 MT of broiler meat and 2.4 Million eggs per week.

News Today (2018) reported that there are 16 grandparent farms are producing about 60-70 thousand parent stocks per week and 206 parent stock farms are producing 13 million Day Old Chicks (DOC) per week. About 100,000 (registered farms no 80,802) commercial farms produce over 15,000 MT of broiler meat and 2.4 million eggs per week. Annual per capita consumption of eggs in the country is 94 against the minimum requirement of 104 eggs. Per capita broiler meat consumption is 3.74 kg and the share of broiler meat out of total meat consumption is 54 percent. It is expected that per capita poultry meat consumption to be reached 8.42 kg in 2021 and contribution of poultry meat could increase to 78 percent. Besides commercial poultry, the growth of dairy industry has not been achieved a remarkable stage

DLS (2018) reported that there are 16 grandparent stock, 208 parent stock, 18774 layer farms and 54107 broiler farms in Bangladesh.

2.2 Ammonia affects performance of broiler chickens

Patrick *et al.* (2015) carried out an experiment and the results showed that Chickens deaminate excess amino acids and excrete the derived nitrogen in the urine mainly as uric acid, which is readily converted to ammonia. This gas has adverse effects on the health of chickens and air quality. The f-test results from the study showed that there was a significant effect of ammonia concentration on chicken growth rate ($P<0.05$). The results obtained from excreta-litter mixture analysis showed a significant adsorption of ammonia by bamboo charcoal ($P<0.05$). The study further indicated a direct dependency of ammonia concentration in excreta on chicken age, moisture content and pH.

Shlomo YAHAV (2004) carried out an experiment to study the effect of various atmospheric ammonia concentrations (X ± S.E.; 16 ± 2; 28 ± 3; 39 ± 4; and 54 ± 5 ppm) at high ambient temperature (Ta = 32 °C) and relative humidity (rh = 60–65%) on the performance and thermoregulation of male broiler chickens. Body weight declined significantly and proportionally with increasing ammonia concentration in the air. The decline in body weight coincided with a similar pattern in feed intake. Feed efficiency did not differ significantly among treatments, but the broilers exposed to the lowest concentration of ammonia showed the highest feed efficiency. Chickens exposed to the lowest ammonia concentrations regulated Tb at significantly lower levels (41.5 °C at 16 ppm and 41.9 °C at 28 ppm) than those at the highest concentrations (42.3 °C at 39 and 54 ppm). Arterial pH increased with increasing ammonia concentration and was similar in the upper 2 concentrations of ammonia. It can be concluded that exposure to increased ammonia concentrations impairs broiler performance. It may also be suggested that ammonia can affect the ability of the chickens to control Tb effectively.

Lacey *et al.* (2004) conducted experiments and reported that odors from broiler production facilities are the consequence of odorant molecules produced by microbial activity in the litter. The impact of odor on the public can be evaluated by the frequency, intensity, duration, and offensiveness of the odors. Currently, much of the work reported in the scientific literature is directed toward measurement of odor intensity by determination of the odor concentration through threshold olfactometry. This paper briefly reviews measurement methods for odor concentration and intensity, summarizes the values reported in the literature for odor concentration for broiler houses, discusses the relationship between odor concentration measurements and odor intensity, and reviews the literature to determine if a correlation between odor concentration and ammonia and dust emissions exists.

2.3 Influence of different types of litter of NH_3 levels in broiler house

The maintenance of litter quality will certainly minimize the harmful and hazardous effect on birds and attendants. The optimum level of moisture in the litter should be around 20-35% (Ritz *et al.*, 2005). While Miles *et al.* (2009) stated that in well managed broiler house litter moisture normally averages between 25 to 35 percent. The higher level of moisture enhances ammonia production. Generally the moisture percentage of rice husk (RH) is higher than other litters which are commonly used in poultry house. The moisture percentage of rice husk, sawdust and spent-tea dust on 35 days rearing was

54.5, 53.7 and 53.3% respectively. The detrimental effects of ammonia in poultry production have been known for years. Numerous studies have shown that ammonia levels as low as 10 ppm affect bird health and performance. Ammonia levels above 25 ppm in the poultry house can damage the birds respiratory system and allow infectious agents to become established, leading to declining flock health and performance. *E. coli* bacteria can be significantly increased in the lungs, air sacs and livers of birds exposed to ammonia because of damaged that occurs to the tracheal cilia. Resistance to respiratory disease may be decreased. In addition, body weight, feed efficiency and condemnation may be higher in birds exposed to level of ammonia exceeding 10 ppm. The volatilization of ammonia has been attributed to microbial decomposition of nitrogenous compounds, principally uric acid in poultry house litter (Blake, 2008).

Ammonia emissions from broiler litter may vary depending to litter moisture content. Elliot and Collins (1982) found that wet litter can lead to high ammonia levels in broiler houses. Tucker and Walker (1992) reported that wet litter can lead to high ammonia levels in broiler houses and may cause bird health problems such as hock burn. Elwinger and Svensson (1996) reported that higher litter dry matter content and lower ammonia emissions were measured from broilers using nipple drinkers than those using traditional bell drinkers. High ammonia levels in poultry houses can result in poor bird performance and health and a loss of profits to the grower and integrator. When broilers and turkeys are raised on litter, amendments can be used to reduce ammonia levels in the houses and improve productivity.

Tinur *et al.* (2011) conducted a trial of Cobb-500™ broiler reared on littered floor to investigate the possibility of using spent-tea-dust (STD) in place of commercial ammonix™ (AMM) on the efficacy of reducing ammonia (NH_3) emission, maintaining of the qualities of litter including the moisture content, pH levels, microbial contents and N_2 contents. The bird's overall performances such as body weight gain, feed conversion ratio (FCR), survivability, performance index, dressing percentage and cost of litters per bird were also taken into account. Results suggested that the AMM treatment was best to maintain the optimum litter qualities, better bird's performance and minimize the NH_3 emissions in the broiler house. STD can be suggested to some extent as a replacer of the commercial and chemical AMM for maintaining the litter qualities and providing comfort to the birds.

2.4 Different techniques used in reduction of NH_3 from poultry litters

Ammonia concentration in poultry houses is a production issue of concern. Birds housed in environments with NH_3 present do not perform as like as birds not exposed to NH_3. Ventilation has been the key means of removing and controlling NH_3 from poultry houses but poultry producers also use litter and manure treatment products that lower pH, bind N_2 and dry the litter (Kling and Quarles, 1974). The ferric sulfate amendment was an average, superior to the aluminum sulfate amendment in reducing NH_3 emissions and concentrations in the houses during the first 10 to 12 days after bird placement (Miles *et al.*, 2009; Caveny and Quarles, 1978).

The agents or approaches used to mitigate the NH_3 emission are summarized below:

Acidifiers

This type of amendment creates acidic conditions (pH less than 7) in the litter, resulting in more of the ammoniacal-N_2 being retained as ammonium rather than NH_3. The acidity also creates unfavorable conditions for the bacteria and enzymes that contribute to ammonia formation, resulting in reduced ammonia production. Many different types of acidifiers, such as alum, sodium bisulfate, ferrous sulfate and phosphoric acid were found to be effective in controlled studies. However, some acidifiers are not recommended for use in poultry houses for reasons such as bird toxicity (ferrous sulfate) or increased phosphorous (P) levels in the already P-rich litter (phosphoric acid).

Al + Clear (Alum)

Moore *et al.* (2000) compared the ammonia levels in Arkansas broiler houses treated with alum (0.2 pounds per bird or about 285 pounds per thousand square feet) with broiler houses that received no alum (the untreated houses). Ammonia concentrations during the first three weeks were 6 to 20 ppm in the alum-treated houses, compared with 28 to 43 ppm in the untreated houses. Birds were 4 percent heavier and feed conversion was 3 percent better in the alum-treated houses than in the control houses due to lower ammonia levels in the early growth stage. The alum-treated houses also had lower electric and propane bills, as extra ventilation was not required to reduce ammonia. Alum likely reduced ammonia emissions from the houses, both by reducing its production in the litter and by reducing ventilation needs; it also reduced losses of soluble and total P in runoff from land-applied poultry litter, both by 73 percent. The amount of aluminum added to the litter through alum was unlikely to reduce soil productivity. Overall, Moore *et al.* (2000) reported that the benefits of using alum to both the producer and integrator were nearly twice as great as the cost of buying and applying it.

Poultry Guard

McWard and Taylor (2000) evaluated the impact of poultry guard on ammonia levels and broiler performance in Colorado over 48 days. When applied at 112 pounds per thousand square feet to litter, Poultry Guard-treated pens had ammonia concentrations of about 12 to 20 ppm, compared with 60 to 85 ppm in the untreated pens during the first 28 days. For the remainder of the study, the treated pens had ammonia concentrations of 40 ppm, at least 20 ppm lower than the untreated pens. The litter amendment increased broiler body weight by 5 percent, improved carcass quality, and reduced breast blisters, foot-pad dermatitis and air-sac lesions. McWard and Taylor (2000) attributed improved bird performance to reduced ammonia levels in the house. They also found Poultry Guard offered the potential to reduce darkling beetle populations.

Poultry Litter Treatment (PLT)

Pope and Cherry (2000) compared the impact of using PLT on ammonia levels and bacterial loads in broiler houses in Texas. PLT was applied at 50 pounds per thousand square feet in the half-house brooding area one day prior to placement, at 50 pounds per thousand square feet to the off chamber (non-brooded area) just before migration and then at 50 pounds per thousand square feet to the whole house one week before processing. During weeks 0, 1 and 2, the PLT-treated houses had ammonia concentrations of 6, 18 and 11 ppm, compared with 62, 28 and 20 ppm respectively, in the untreated houses. No ammonia data were presented for the later weeks. Due to litter acidification, bacterial loads in the litter were greatly reduced prior to stocking.

Acidifiers reduce ammonia levels in the poultry house and improve in-house air quality. While some studies have shown that ammonia suppression below 25 ppm may last from

3 to 4 weeks after application, other studies have shown that some ammonia suppression may last even longer, up to 7 weeks. The extent off ammonia suppression may depend on age and moisture content of poultry litter, application rate of amendment and selection of amendment. Reduced ammonia levels not only improve bird performance and health but also may positively impact worker health.

Alkaline materials

Materials such as agricultural lime ($CaCO_3$), hydrated or slaked lime ($Ca\ (OH)_2$) or burnt lime (CaO) increase litter alkalinity (to a pH greater than 7) and convert more of the ammonium in the litter into ammonia gas. The amount of produced is governed by the litter pH, which depends on the amount and type of amendment. Burnt lime is the most effective in raising pH and lime is the effective. Combining ventilation and heating with application of alkaline material between flocks can lead to the venting of large amounts of ammonia, which will result in lower ammonia levels later when the chicks are placed in the house. However, when this method is used and ammonia is released into the atmosphere, the fertilizer value of the litter diminishes and there may be a negative impact on the environment.

Absorbers

Naturally occurring materials like clinoptilolite (a type of zeolite, a natural clay mineral) and peat tend to absorb ammonia (i.e bind on the surface instead of absorb). However, the performance of clinoptilolite has been mixed. Nakaue *et al.* (1981) reported modest reductions in ammonia levels in the poultry house, while Amon *et al.* (1997) reported large increases in ammonia levels when clinoptilolite was applied to litter. Researchers in Finland used peat as litter material in poultry houses and reported lower ammonia levels.

Inhibitors

Inhibitors slow the conversion of uric acid and urea to ammonia by inhibiting enzymes and microorganisms. Phenyl phosphorodiamidate inhibits urease activity, reducing conversion of urea into ammonia (McCrory and Hobbs, 2001). However, they also reported that inhibitors are currently too expensive and too easily broken down to be practical or economical to growers.

Microbial and enzymatic treatments

Such treatments may consist of beneficial microbes and enzymes that create the right environment in the litter to convert uric acid and urea rapidly into ammonia. The manufacturers of these products say that such treatments allow microbes to work in suboptimal conditions in the litter or improve the conditions in the litter to enhance performance of the microbes or the enzymes. Venting the produced ammonia during layout will result in lower ammonia levels when the chicks are placed in the house later. One microbial product, USM-98, marketed by UAP Southwest ((903) 855-0481) of Pittsburg, Texas was evaluated in North Carolina by UAP Southwest which reported that the product reduced ammonia levels, improved bird weight and reduced mortality and crust loads.

2.5 Method for measuring ammonia emissions from poultry houses

Gates *et al.* (2005) carried out an experiment and presented a measurement method for NH_3 emissions from mechanically ventilated poultry buildings, which has been successfully used in a multistate, multidisciplinary research project to establish baseline values for the United States. To accurately determine building emission rate (ER, the product of pollutant concentration and exhaust airflow rate), accurate measurements must be made over representative periods and production phases. We present an innovative, low cost, and accurate methodology that allows multiple buildings to be sampled in sequential order, provided that appropriate biosecurity measures are taken. Direct ventilation measurement is used in broiler houses, and in some layer operations, the number of fans is few enough that each fan can be individually calibrated *in situ* with a fan assessment numeration system device. For larger layer buildings with more than 15 fans, building ventilation is obtained from a tracer gas balance, utilizing CO_2 generated by birds and feces. Other methods to determine building ventilation rate, which do not account for mechanical condition and degree of maintenance, both of which significantly affect actual fan capacity, introduce large errors. Twenty-eight portable monitoring units were fabricated and used for field acquisition of exhaust NH_3 and CO_2 concentrations and building static pressure. Ammonia is measured with redundant electrochemical sensors that are cyclically purged to eliminate errors caused by saturation from continuous exposure to air laden with NH_3. The redundant NH_3 unit minimizes missing data due to sensor failure.

Reeves *et al.* (2002) conducted a field experiment to test the ability of various available quick tests to determine ammonia concentration of poultry litters. A total of 136 samples were collected from brood chambers of poultry houses. Samples were equally divided between surface samples (top 25 mm) and core samples. Samples were frozen until analysis but received no further processing. Samples were analyzed for ammonia by auto analyzer (standard) and several quick tests (conductivity, Quantofix N Volumeter, and Reflectoquant). In addition, samples were analyzed by near-infrared spectroscopy by scanning samples using a large-sample transport device on a FOSSNIR Systems model 6500 (64 co-added scans from 400 to 2,498 nm). Results showed that, although ammonia could be determined with reasonable accuracy by near infrared spectroscopy using data in the 1,100 to 2,498 nm spectral range, none of the quick tests, including near-infrared, worked as well as previously found with dairy manures. The best results were found using the Quantofix or Reflectoquant, and conductivity worked only with the core samples. It is believed that interferences due to the presence of uric acid (spectroscopy, Quantofix, and Reflectoquant) and sodium bisulfate used to treat the litter (conductivity) were the cause of the decreased accuracies as compared to results achieved previously with dairy manures.

2.6 *Yucca schidigera* plant

Yucca schidigera (YS), also named as yucca, is a member of Agavaceae family. The potential of YS has been valued since it was used to treat inflammatory illnesses effectively (Cheeke, 2000). Being a tropical plant, YS originally grows in North America, especially in arid Mexican dessert (Cheeke *et al*., 2006). Beneficial effects of *Yucca schidigera* extracts (YSE) are covering many aspects such as producing desired nutritional attribute that improving feed conversion efficiency thus enhancing animal growth, contributing to environmental control in commercial rearing conditions, and participating in microbial activity modification (e.g., anti-protozoal activity) (Piacente, 2005).

As a rich source of phytochemicals with promising bioactive functions (Francis, 2002), YS has several components such as steroidal saponins, polyphenolics (e.g., resveratrol and some other stilbenes including yuccaols A, B, C, D and E) (Patel, 2012). Saponins have been considered to be vital components of YS in odor control in intensive farming industry (Xu *et al*., 2010). In addition, new steroidal saponins with different structures included in YS have been detected continuously (Kowalczyk *et al*., 2011). Future analysis of the YS molecule structures, isolation of YS bioactive components, and ascertaining its purity will provide more evidence for YSE application in terms of ameliorating the environmental pollution from livestock industry, and increase the feed efficiency in diets at the same time (Sun *et al.*, 2017).

2.7 Effects of *Yucca schidigera* on gas mitigation

In Monogastric Animals

A number of studies have been carried out to determine the effects of YSE on reducing ammonia in poultry farms. Cabuk *et al.* (2004) reported that feeding of 120 mg/kg dietary YSE resulted in a decreased ammonia concentration of broiler houses at day 19 without impairing broiler performance. However, in another experiment, the supplementation of 100 ppm of YSE and *Quillaja saponaria* was added in a corn-soybean control diet, and ammonia emission of broiler chicken litters was not altered compared with control in the 42 days experimental period (Corzo *et al*., 2007). When YSE was applied to laying-hens, 100 ppm inclusion in diets significantly reduced ammonia emission by 44% and 28% for the first two days of manure storage (Chepete *et al*., 2012). However, an experiment showed that ammonia N concentrations and microorganism levels of litter materials (half was wood shavings, the other was rice hull) among examined groups did not show statistical difference when pulverized YSE was applied to different litter materials at the level of 0, 4 and 8% (Onbasilar *et al.*, 2013). It was hypothesized that the efficiency of YSE could be amplified if litter was used in farming houses under bad situations. As a study to evaluate the effects of YSE on poultry manure alone or together with microbial preparation, YSE showed highest potentials in reducing volatile odorous compounds concentrations after 96 h of the process. This study also confirmed the ability of YSE to decrease the concentrations of odorous compounds emitted from poultry manure such as ammonia, trimethylamine, dimethylamine, isobutyric acid and hydrogen sulfide.

Only few studies have been carried out using swine as experimental animals. Panetta *et al.* (2006) observed no significant effect of dietary YSE (0, 62.5, 125 mg/kg) on ammonia emission during 72 h of consecutive measurement after 4 days dietary adjustment. A decreasing tendency (P>0.05) in ammonia gas production of fecal samples was shown during a 30 days experiment period (Hong *et al*., 2001). However, Liang *et al.* (2009) indicated that YSE added in the feed (125 mg/kg) decreased the emission of ammonia and hydrogen disulfide in the 35 days trials.

In Ruminants

Singer *et al.* (2008) reported that with increased feeding of YSE to lactating dairy cows, 4 h and 24 h gas production generated through these collected rumen fluids were increased, exhibiting a strong linear effect (P<0.05). A similar result was observed in another *in vitro* experiment which involved different ruminal substrates including soluble potato starch, cornstarch, or hay plus concentrate (1.5:1) in the incubation process (Lila *et al*., 2003). Total gas productions at 6 h and 24 h were increased as dietary sarsaponin increased from 1.2 to 3.2 g/L, and the methane reduction rate was statistically up to different substrates. Methane production was decreased (P<0.05) by YSE addition in both gas production rate (mL/min) and extent (L) in the study of Pen *et al.* (2006). In another research, methane production at 24 h was decreased (P<0.05) by 110 g/kg of YSE addition, although *in vitro* gas production was not affected. Holtshausen *et al.* (2009) indicated that in order to avoid the potential side effects of YSE on ruminal fermentation and feed digestion, saponin levels were reduced (10 g/kg of DM) that resulted in a non-significant difference of methane production *in vitro* among different treatments. However, when sarsaponin concentration was 1% of DM (22.4 g), YSE addition in diets resulted gas reduction in steers effectively, in which methane was inhibited by approximately 12.7% (P<0.05) from day 6 to day 9 of the 10 days feeding period without impairing animal performance (Lila *et al*., 2005).

There are also some studies showed inconsistent results. YSE supplementation of 3 g/kg of DM did not reduce methane production in lactating dairy cows, as suggested by Zijderveld *et al.* (2011). Similar results were also observed by Li and Powers (2012) who measured gaseous emissions in room exhaust air of steers. In their study even the 1.5% YSE inclusion groups failed to alter either methane, or ammonia, or nitrous oxide emissions on a daily basis (per unit DMI). Methanol extract of YSE was used in an experiment *in vitro*, and YSE decreased ($P<0.05$) methane production when calculated by per unit of dry matter, but not by per unit of true digested dry matter (Narvaez *et al*., 2013).

Most researches using sheep as experimental animals were conducted to measure ruminal fermentation parameters related to gas production such as ruminal ammonia concentration. The results of an experiment *in vitro* showed that 100 mg/kg dietary sarsaponin of DM (600 mg/kg CP) reduced the ruminal ammonia over 21% throughout the measurements from day 5 to day 10 (Sliwinski *et al*., 2002a). In the subsequent study *in vivo*, only 2 and 30 mg/kg of DM YSE were added in the diets (Sliwinski *et al*., 2002b). The results showed that dietary YSE only had slight trends to reduced gas emission without statistical effect over a 15 days period. Feeding the diets with 120 ppm YSE in sheep resulted that YSE reduced N losses in urine and total N losses, leading to a 50% higher retained N, and ammonia N concentration was lowered by 11.9% although not significant. In the subsequent experiment, the supplementation of YSE in the basal diet was 240 ppm DM per day and dietary YSE feeding lasted 14 days in which it comprised of 8 days of dietary adjustment. Compared to the control diet, YSE reduced rumen ammonia N concentrations ($P<0.05$) in Cheviot wethers (Santoso *et al*., 2006). A decline of rumen ammonia N was explained that caused by dietary YSE (Pen *et al*., 2007).

Wang *et.al* (2009) reported that an increase in VFA concentration and a decrease in acetate:propionate ratio ($P<0.05$), while ammonia N concentration ($P<0.05$) and average methane production ($P<0.05$) were reduced compared to the control. A later experiment *in vivo* reported that ruminal ammonia concentration, ammonia N concentration and protozoa population in sheep were suppressed especially by the 200 and 300 mg/kg YSE treatment groups in the experimental conditions where dietary YSE levels were 100, 200, 300 mg/kg (Liu and Li, 2011).

2.8 Gas mitigation mechanisms of *Yucca schidigera*

In Monogastric animals

According to Liang *et al*. (2009), urease activity might be inhibited efficiently with YSE inclusion, which would decrease the speed of ammonia N formation from urea, so the increasing trends of ammonia N concentrations would be reduced. The dynamic balance of N would be broken in this moderate manner, hence ammonia emission rate would be lowered down. As for hydrogen disulfide reduction, it is hypothesized that YSE may decompose the generation of dissolvable sulfide by inhibiting sulfate reducing bacteria or involves in the process where sulfate reductase participate. It is speculated that antimicrobial abilities of saponins may also accounted for the high efficiency of YSE in dealing with odor from poultry feces. The positive effect of YSE on ammonia reduction may also due to the readily volatilized ability of urinary ammonium which is part of ammonia emitted from manure (Panetta *et al*., 2006).

Uric acid also has a positive effect on ammonia volatilization (Pratt *et al*., 2002). Moisture concentration in manure, which can be changed by YSE, is linked to the transformation of decomposition of uric acid directly (Chepete *et al.*, 2012). But these conversions (solid urea dissolution and urea hydrolysis) need to be finished prior to ammonia emission (Nahm, 2003). Higher pH levels (above 7.0) which can be observed with YSE inclusion, is favorable for ammonia release since ammonia is a major form of gas emitted under this condition (Choi and Moore, 2008). Factors such as different collection time correspond with varying degrees of manure moisture (Chepete *et al.*, 2012), which need to be noticed to minimize the inaccuracy of experiment as well. Onbasilar *et al.* (2013) attributed the lack of effect in the experiment to exactly relatively low moisture and pH levels.

In Ruminants

Based on the research of Headon *et al.* (1991), the two components of *Yucca schidigera*, the glycocomponent and the saponin fraction, act differently in binding ammonia in rumen. The glycocomponent has an ability to bind ammonia directly, while saponin fraction may inhibit ammonia concentrations by membranolytic properties through altering rumen ciliate protozoa, as it (saponin fraction) can cause cell lysis by acting with cholesterol in membranes of protozoal cell (Cheeke *et al*., 2006). However, the indirect way to reduce ammonia concentration through saponin may contribute most to ammonia reduction since the suppressing potential of glycocomponent is limited. The most convincing mechanism for methane suppressing effects of steroidal saponins containing plants, YSE specifically, is that methane is possibly reduced through an inhibition of the growth of H2-producing bacteria (Wang *et al*., 1998). It has been demonstrated that ciliate protozoa, which provides substrate (H2) for methanogens, is associated with 9-25% of ruminal methanogens. Reduced methane emission due to saponin addition is regarded as the result of its toxicities towards protozoa population (Guo *et al.*, 2008). The symbiotic relationship between methanogens and protozoa in the ruminal environment accounts at least partially for decrease in methane production due to YSE inclusion in diets. When YSE is added in diets, the balance between methanogens and protozoa would be broken which will lead to methanogens reduction, and eventually influence the production of the emitting methane (Lila *et al.*, 2005).

According to Lila *et al.* (2003), YSE addition can only decrease protozoal populations at 6 h of fermentation in *in vitro* batch cultures since samples collected at 24 h had no detectable protozoa. It seems that YSE has a short lived effect on protozoa *in vitro*, which gives us a partly explanation about reduction of methane with YSE addition.

Rumen ammonia N levels tended to reduce with the increasing levels of YSE at high application rates (Singer *et al*., 2008). However, it remains a question about the mechanisms of ammonia reduction in response to YSE when short incubation time was incorporated in the experiment (Hristov *et al*., 2004).

2.9 Evaluation of *Yucca schidigera* extract as feed additive on production performance of birds

Ahmed (2018) conducted an experiment to study the effect of adding three different levels of local yucca leaf powder in the production performance of quail birds in growth stage. There are 192 of quail birds with one-day age and their weight 8.5 g. which were distributed randomly into four treatments and four replicates 12 birds in one replicate. The powder was added for the experiment treatments as follows: 1st (T1) the control treatment without adding yucca powder in the diet. 2nd (T2) 50 mg /kg in the diet. 3rd (T3) 100 mg /kg in the diet. 4th (T4) 150 mg /kg in the diet. The results of the statistical analysis showed a significant increased (P<0.05) in live body weight, body weight gain, and no significant differences in feed conversion ratio and feed intake compared to control treatment.

Sahoo *et al.* (2015) conducted an experiment and the result showed that Yucca supplementation can effectively enhance growth of 173 g in 6^{th} week by utilizing lesser feed intake than control group, which ultimately proves better feed conversion rate, protein efficiency ratio, and energy efficiency ratio in broiler production. Eviscerated weight of 58.50% for the treatment group was significantly higher (P<0.05) than 54.10% in the control group. The breast meat yield of Yucca group (32.23%) was significantly higher (P<0.05) than control (30.33%). More frequency of agonistic behavioral expressions was noticed in the control group than the treatment group. A profit of 43.68% was received by usage of Yucca supplementation in the diet on live weight basis. Numerically, lower percentage of moisture was present in Yucca treated group than the control. They concluded that Yucca supplementation has an important role in augmenting broiler‘s growth performance, efficiency to utilize feed, protein and energy, and survivability. Hence, use of Yucca powder in broiler ration could be beneficial to maintain the litter quality, which directly enhances the productivity in broiler production without any adverse effect.

Jun-Ling *et al.* (2016) found a result of feeding Yucca extract, birds’ BW had a trend to increase at day 42. The BWG of 100 mg/kg YE treatment was significantly higher from day 28 to 42 (P<0.05) and tended to be higher from day 14 to 42 (P = 0.072) than the others. There was no difference among all the treatments in average feed intake (P > 0.05). The feed efficiency value of 100 mg/kg YE treatment was significantly upgraded at the latter period (P<0.05), what’s more, diets added 100 and 200 mg/kg YE enhanced feed efficiency compared to the control during the whole experiment (P<0.05)

Cabuk *et al.* (2004) conducted a field experiment to investigate the effects of dietary supplementation of *Yucca schidigera* and natural zeolite on broiler performance, ammonia concentration of broiler house, litter moisture, fecal dry matter and fecal crude ash were investigated. One day-old, nine hundred and sixty unsexed broiler chicks obtained from a commercial hatchery were divided into 4 treatment groups of 240 birds each. Birds were randomly assigned to the four treatment diets consist of control, 15 g natural zeolite /kg, 25 g natural zeolite /kg and 120 mg *Yucca schidigera* /kg. Body weights of birds were significantly ($P<0.05$) different among the treatments, birds fed on diet containing 120 mg *Yucca schidigera* /kg being the highest and this treatment was followed by chicks fed diet control at days 21 to 42 and 42nd day. Feed conversion ratio was not affected by the supplementation of *Yucca schidigera* and natural zeolite at days 21 to 42. From 21 to 42 and 42nd day of age, the feed intake was not significantly different between the treatments. Ammonia concentration of house was significantly ($P<0.05$) decreased by adding *Yucca schidigera* and natural zeolite to diet. The supplementation of *Yucca schidigera* and natural zeolite to the diet reduced significantly ($P<0.01$) fecal dry matter and crude ash. On the other hand, dry matter of the broiler litter and livability were not affected by treatments. Result concluded that the supplementation of *Yucca schidigera* to the diet reduced ammonia concentration in broiler house, fecal dry matter and crude ash without any adverse effect of broiler performance.

2.10 Saponins and phenolics of *Yucca schidigera* plant

Sonia *et al.* (2005) conducted an experiment and revealed that *Yucca schidigera* (Agavaceae) is one of the major commercial sources of steroidal saponins. Two products of yucca are available on the market. These include dried and finely powdered logs (yucca powder) or mechanically pressed and thermally condensed juice (yucca extract). These products possess the GRAS label which allows their use as foaming agent in soft drink (root beer), pharmaceutical, cosmetic, food, and feeding-stuffs industries. The main application of yucca products is in animal nutrition, in particular as a feed additive to reduce ammonia and fecal odors in animal excreta. The positive effects of dietary supplementation with yucca products on the growth rates, feed efficiency, and health of livestock seem to be due not only to the saponin constituents but also to other constituents. These observations prompted to investigate the phenolic constituents of *Y. schidigera*.

2.11 Research gap and reasons for considering the current study

From the above review of the literature, it is clear that a lot of works had been done on using different types of litter materials and chemicals for reducing NH_3 and to investigate the bird's performance. So far as author's knowledge, no papers had published about the efficacy of using *Yucca schidigera* plant extract for controlling NH_3 emissions with economic utility from broiler house in Bangladesh before.

Therefore, On the basis of previous research, the current study has been undertaken to investigate the potentiality of *Y. schidigera* for controlling NH_3 gas emission with production performance, carcass quality and economical utility in broiler rearing. The author also expect that Bangladeshi farmers will be benefited by the use of *Y. schidigera* in the farm at proper concentration level.

CHAPTER 3

MATERIALS AND METHODS

3.1 Statement of the experiment

A trial on commercial broiler rearing on littered floor was carried out at Sher-e-Bangla Agricultural University (SAU) Poultry Farm during the period of 8th October and 5th November 2018, for a period of 4 weeks using *Yucca schidigera* plant extract commercially available as “Bio-Ade super”. The experiment was performed by applying different concentration levels of *Yucca schidigera* plant extract.

3.2 Collection of experimental broilers

A total of 240 day old chicks of “Cobb-500” strain having 43.2±0.3g average body weight were obtained from Kazi hatchery, Gazipur, Dhaka.

3.3 Experimental materials

The collected chicks were carried to the university poultry farm early in the morning. They were kept in electric brooders equally by maintaining standard brooding protocol. Among 240 DOC, 180 chicks were selected and distributed randomly in three treatments of Yucca extract providing with drinking water; remaining 60 chicks were distributed another treatment for control.

For proper handling and data collection, the chicks of each treatment group were divided into three replications and in each replication there were 20 birds. After 28 days of nursing and feeding, data were collected for the following parameters: ammonia level, feed intake, live weight, body weight gain, feed conversion ratio, carcass characteristics, profit per bird and benefit-cost ratio.

3.4 Experimental treatments

To find out the effect of *Yucca schidigera* plant extract on broiler farm, an initial screening experiment was carried out with sufficient number of one day old chicks. The chemical was mixed with drinking water to the birds at three concentration levels. The experimental treatments were followings:

T_0: No Yucca extract supplement/ Control group

T_1: 1ml Yucca extract per 16 liters of drinking water

T_2: 1ml Yucca extract per 20 liters of drinking water

T_3: 1ml Yucca extract per 24 liters of drinking water

Table 1: Lay out of the experiment

Treatment groups	No. of Replications			Total
	R_1	R_2	R_3	
T_0	20	20	20	60
T_1	20	20	20	60
T_2	20	20	20	60
T_3	20	20	20	60
Total	80	80	80	240

3.5 Collection of Ammonia test kit

For assessment of ammonia emission in broiler house and to differentiate the effect of the treatment groups, ammonia test kit was collected from abroad. It was not easy to collect the test kit because of its unavailability in the market of our country.

3.5.1 Ammonia test kit description

To assess ammonia level in broiler house, the commercially available ammonia test kit was Micro Essential Hydrion ammonia meter tester paper. The paper was packaged as a 15 foot roll in a pocket sized plastic dispenser with a polypropylene case. It comes complete with a specially calibrated color chart. Per each: 10/ Carton. Micro Essential Labs #: AM-40.

The commercially available ammonia test kit that was used in this study described below:

Brand Name	Micro essential
Weight	120.0 grams

Model Number	MIC-AM-40
Number of Items	1
Part Number	AM-40
pH Range	0 To 100 ppm

3.5.2 Ammonia assessment procedure

Ammonia present in the air was detected using test strips of ammonia test kit. For that reason, 1 inch strip of paper was tear off and wet it with 1 or 2 drops of distilled water. Excess water was shaken in the paper and exposed for 15 seconds in air being tested. Then it was compared with the color chart of the test kit. If color change matched then it was recorded as data.

3.6 Collection of experimental chemical (*Yucca schidigera* plant extract)

Yucca schidigera (Agavaceae) is a native plant in arid deserts of American southwest and Mexico. It also found in Zhejiang Province, China grown as an ornamental. Yucca powder and juice are available in the market of our country as various commercial names. The extract concentrate from *Yucca schidigera* plant that commercially available “Bio- Ade super” was collected from Savar, Dhaka.

3.6.1 Chemical composition of *Yucca schidigera* plant extract

Yucca schidigera plant extract contains saponin steroids and glycocomponents. Glycocomponents are complex, highly thermo stable, molecules that include some compounds of sugars or glycosides. These molecules have an affinity to join ammonia, bind and neutralize it, convert it into a non-toxic nitrogenous compound; Thus, reducing the high levels of this toxic element. The mechanism of action is through the physical molecular union of these compounds with ammonia. When the glycocomponent-ammonia compound is formed, it can be used by the microorganisms of intestinal flora as a nitrogen source, therefore, improving digestion Saponins have highly surfactant properties, as they are amphipathic, meaning they have a water-soluble and fat-soluble component. Saponion helps the absorption of nutrients, stimulate microflora; Thus improves the digestion.

3.7 Preparation of broiler house

The broiler shed was an open sided natural house. Cross ventilation system was provided by using wire-net. It was a tin shed house with concrete floor. There was 1ft. side wall around the shed with no ceiling. The floor was above 1ft. from the ground and the top of the roof was above 15ft. from the floor. Polythene sheet was hanged around the side wall to protect the chicks from cold, storm, dusts and heavy rainfall. The house was properly cleaned, rubbed with bleaching powder and washed the floor by using tap water and then disinfected by n-alkyl dimethyl benzyl ammonium chloride (Timsen^{TM}) solution before starting the experiment. After proper drying, the house was divided into pens as per lay-out of the experiment by polythene sheet so that air cannot pass one pen to another. The height of pens was 5ft. Before placement of chicks the house was fumigated by formalin and potassium permanganate @500 ml formalin and 250 g potassium permanganate (i.e. 2:1) for 35 m^3 experimental area.

3.8 Experimental diets

Starter and grower commercial Kazi broiler feed were purchased from the market. Starter diet was enriched with minimum:-

Name of ingredients in starter diet	Minimum percentage (%) present
Protein	21.0
Fat	6.0
Fiber	5.0
Ash	8.0
Lysine	1.20
Methionine	0.49
Cysteine	0.40

Tryptophan	0.19
Threonine	0.79
Arginine	1.26
Name of ingredients in grower ration	**Minimum percentage (%) present**
Protein	19.0
Fat	6.0
Fiber	5.0
Ash	8.0
Lysine	1.10
Methionine	0.47
Cysteine	0.39
Tryptophan	0.18
Threonine	0.75
Arginine	1.18

Feed were supplied 4 times daily by following Cobb 500 Management Manual and *ad libitum* drinking water 2 times daily. Appendix 1 and 2.

3.9 Management procedures

Different aspects of the management of chicks, experimental events and management procedures are described in detail below:

3.9.1 Litter management

High absorbing bedding material was used as litter on floor. Fresh, clean and sundried rice husk was used as shallow litter to absorb moisture from fecal discharge of broiler chicken. The shallow litter was 5 cm (2 inch) in depth. About 250g calcium oxide powder was mixed with rice husk in every pen as disinfectant. At the end of each week the litter was harrowed to prevent accumulation of toxic gases and to reduce moisture and parasitic infection. At 3rd and 4th week of rearing period, droppings were cleaned from the surface level by removing a thin layer of litter and same amount new litter was placed in each pen.

3.9.2 Care of day old chicks

Just after arrival of day old chicks to the poultry house the initial weight of the chicks were recorded by a digital electronic balance, vaccination was done and distributed them under the hover for brooding. The chicks were supplied glucose water with vitamin-C to drink for the first 3 hours to overcome dehydration and transportation stress. Subsequently small feed particles were supplied on the newspapers to start feeding for the first 24 hours.

3.9.3 Brooding of baby chicks

Electric brooder was used to brood chicks. Partitioning brooding was done due to different experimental treatment. Each brooder had one hover and a round chick guard to protect chicks and four portioning chambers. Thereafter healthy baby chicks were randomly distributed to the pen according to the design of the experiment. The recommended brooding temperature was 35-21^{0}C from 1st to 4th weeks of age. Sometimes day temperature was 31-35^{0}C. So, at that time there was no need of extra heat to brood the baby chicks, but at night a 100 watt bulb was used in each pen to rise up low temperature according to heat requirement of brooding schedule. In case of high temperature cross ventilation was allowed by folding wall polythene and electric fans were used to reduce heat. But, in winter season the average maximum and minimum temperatures at birds' level were 29.6-22.3^{0}C. Due to low temperature of winter brooding was done for one week to rise up brooder temperature. After one week a 200 watt electric bulb was hanged in every pen up to the market age of birds. Moreover, at that time the wall polythene sheet spread over the net-wire to protect the broiler chicks from cold and wind.

3.9.4 Feeding and drinking

Crumble feed was used as starter (0-2 wks.) and pellet feed for grower (3-4 wks.) ration. *Ad libitum* feeding was allowed for rapid growth of broiler chicks up to the end of the four weeks. Fresh clean drinking water was also supplied *Ad libitum*. Feeds were supplied 3 times: morning, noon and night; water 2 times: morning and evening daily. Left over feeds and water were recorded to calculate actual intake. Digital electronic balance and measuring plastic cylinder was used to take record of feed and water. Daily water consumption (ml) and weekly feed consumption (gm)/bird were calculated to find out weekly and total consumption of feed and water. All feeders and drinkers were washed and sundried before starting the trial. One plastic made round feeder and one drinker were kept in the experimental pen. Feeder and drinker size were changed according to the age of the birds. Feeders were washed at the end of the week and drinkers once daily.

3.9.5 Lighting

At night there was provision of light in the broiler house to stimulate feed intake and rapid body growth. In summer, rainy and winter season at night 4 energy lights were provided to ensure 24 hours light for first 2 weeks. Thereafter 23 hours light and one hour dark was scheduled up to marketable age. At night one hour dark was provided in two times by half an hour.

3.9.6 Ventilation

The broiler shed was south facing and open-sided. Due to wire-net cross ventilation it was easy to remove polluted gases from the farm. Besides, on the basis of necessity ventilation was regulated by folding polythene screen.

3.9.7 Biosecurity measures

Biosecurity is a set of management practices that reduce the potential for introduction and spread of diseases causing organisms. To keep disease away from the broiler farm the following vaccination, medication and sanitation program was undertaken. All groups of broiler chicks were supplied Vitamin B-Complex, Vitamin-ADEK, Vitamin-C, Ca and Vitamin-D enriched medicine and electrolytes.

3.9.8 Vaccination

The vaccines collected from medicine shop (Ceva Company) and applied to the experimental birds according to the vaccination schedule. One ampoule vaccine was diluted with distilled water according to the recommendation of the manufacturer. The cool chain of vaccine was maintained strictly up to vaccination. The vaccination schedule of broiler is shown in Table 2.

Table 2. Vaccination schedule

Age	Name of Disease	Name of vaccine	Route of vaccination
0 day	Infectious Bronchitis + Newcastle Disease (IB+ND)	CEVAC BI L	One drop in eye
09 day	Gumboro (IBD)	CEVAC IBDL	Drinking water
17 day	Gumboro (IBD)	CEVAC IBDL	Drinking water

3.9.9 Medication

The broiler chicks were fed antibiotic drug against bacterial diseases. Ampicillin and oxytetracycline antibiotics were used only for antibiotic groups of birds. Besides vitamin-B complex, vitamin-A, $D_{3,}$ E and sinacal-D were used against deficiency diseases. Electromin and vitamin-C also used to save the birds from heat stress. The medication program is presented in the table below:

Table 3. Medication program

Medicine	Purpose	Dose	Period
Ultravit B+C	Vitamin B-complex + Vit C	1g/1L water	3-5 days (all groups)
Revit AD_3E	Vitamin A, D & E	1 ml/5L water	3 -5 days (all groups)
Electromin Powder	Electrolytes	1g/2L water	Only in hot climate (all groups)

Medicine	Purpose	Dose	Period
Revit-C	Vitamin-C Premix	1g/5L water	Only in hot climate (all groups)
Calplex	Ca, P and Vit-D	10 ml/100 bird	3-5 days (all groups)
Oxytertacycline	Against bacterial diseases	1 ml/L water	Only for treatment purpose
COCCI-OFF (water soluble powder)	Anticoccidial	1g/ L water	Only for treatment purpose

3.9.10 Sanitation

Proper hygienic measures were maintained throughout the experimental period. Cleaning and washing of broiler shed and its premises were under a routine sanitation work. Flies and insects were controlled by spraying Phenol and Lysol to the surroundings of the broiler shed. The attendants used farm dress and shoe. There was a provision of Foot Bath at the entry gate of the broiler shed to prevent any probable contamination of diseases. Strict sanitary measures were followed during the experimental period.

3.10. Recorded parameters

Weekly live weight, weekly feed consumption and death of chicks to calculate mortality percent were taken during the study. FCR was calculated from final live weight and total feed consumption per bird in each replication. After slaughter carcass weight and gizzard, liver, spleen and heart were measured from each broiler chicken. Dressing yield was calculated for each replication to find out dressing percentage.

3.11 Data collection

3.11.1 Ammonia emission

During the study, the data of ammonia emission from broiler litter was collected daily at several times from the each replication of all treatment groups and untreated also. The average of the daily recorded ammonia emission was calculated.

3.11.2 Live weight

The initial day-old live weight and weekly live weight of each replication was kept to get final live weight record per bird.

3.11.3 Dressing yield

Dressing yield of bird was obtained from live weight subtracting blood, feathers, head, shank and inedible viscera.

3.11.4 Feed consumption

Daily feed consumption record of each replication was kept to get weekly and total feed consumption record per bird.

3.11.5 Survivability of chicks

Daily death record for each replication was counted up to 28 days of age to calculate mortality if occurred that indicated the survivability of the bird.

3.11.6 Dressing procedures of broiler chicken

Three birds were picked up at random from each replicate at the 28th day of age and sacrificed to estimate dressing percent of broiler chicken. All birds to be slaughtered were weighed and fasted by halal method or overnight (12 hours) but drinking water was provided *ad-libitum* during fasting to facilitate proper bleeding. All the live birds were weighed again prior to slaughter. Birds were slaughtered by severing jugular vein, carotid artery and the trachea by a single incision with a sharp knife and allowed to complete bleed out at least for 2 minutes. Outer skin was removed by sharp scissor and hand. Then the carcasses were washed manually to remove loose singed feathers and other foreign materials from the surface of the carcass. Heart and liver were removed from the remaining viscera by cutting them loose and then the gall bladder was removed from the liver. Cutting it loose in front of the proventriculus and then cutting with both incoming and outgoing tracts removed the gizzard. Dressing yield was found by subtracting blood, feathers, head, shank and digestive system from live weight.

3.12 Calculations

Each data were collected by the following formulae:

3.12.1 Live weight gain

The average body weight gain of each replication was calculated by deducting initial body weight from the final body weight of the birds.

Body weight gain = Final weight – Initial weight

3.12.2 Feed intake

Feed intake was calculated as the total feed consumption in a replication divided by number of birds in each replication.

$$\text{Feed intake (g/bird)} = \frac{\text{Feed intake in a replication}}{\text{No. of birds in a replication}}$$

3.12.3 Feed conversion ratio

Feed conversion ratio (FCR) was calculated as the total feed consumption divided by weight gain in each replication.

$$\text{FCR} = \frac{\text{Feed intake (kg)}}{\text{Weight gain (kg)}}$$

3.12.4 Dressing percentage

Dressing yield was found by subtracting blood, feathers, head, shank and digestive system from live weight. Liver, heart, gizzard and neck were considered as giblet. Dressing percentage of bird was calculated by the following formula-

$$DP = \frac{Dressing\ yield\ (g)}{Live weight\ (g)} X100$$

$$Dressing\ yield = breast,\ thigh,\ drumstick, back,\ wing,\ giblet,\ abdominal\ fat\ weight\ (g)$$

3.13 Economic analysis

3.13.1 Cost record

The economic viability of *Y. schidigera* supplement for broiler production was evaluated on the basis of total expenditure incurred on the used inputs and the return from the sale of live birds. The production cost was calculated by considering the expenses involved in chicks, feed, vaccine and medication, litter materials, disinfectant, electricity, labor and Bio-Ade super™ (Yucca extract). Being common in both the groups, the general inputs and outputs during the whole study were not considered for economic analysis. Feed cost was calculated by the average amount of feed consumed in each treatment on phase basis. Litter cost was calculated with the required amount of rice husk bags multiplying price divided by number of birds in each replication. Cost of Yucca extract was calculated with the required amount multiplying price divided by number of replicated birds in each treatment groups. All expenses and income were calculated on the basis of market price (BDT) at the time of experimental period.

3.13.2 Benefit Cost Ratio (BCR)

The capital expenditure, recurring expenditure and depreciation cost were considered to calculate total expenditure. The major expenditure included cost of chick, feed, litter, medicine, vaccine, labor and electricity charges. The common expenditure per bird was found out from the total expenditure of one batch. Feed consumption, litter cost and Yucca extract were not same in different replications, so expenditures were calculated for every individual replication. Similarly, due to differences of live weight gain, the sale value of birds was calculated for every individual replication. The sale value of poultry manure and feed bags were also considered to compute income. Number of live birds in each replication considered here to calculate average value. Finally treatment wise production cost and income was calculated. Net profit was found out by deducting the total expenditure from the total income according to replication under each treatment.

$$BCR = \frac{Total\,income}{Total\,cost\,of\ \ production}$$

3.13.3 Profit per bird (PPB)

The benefit cost ratio was analyzed considering stocking density and feeding regime. The capital expenditure, recurring expenditure and depreciation cost were considered to calculate total expenditure. The major expenditure included cost of chick, feed, litter, medicine, vaccine, labor, electricity, yucca extract and ammonia test kit. The common expenditure per bird was found out from the total expenditure of one batch. The consumption of feed was not same in different replications, so feed expenditure was calculated for every individual replication. Similarly due to differences of live weight gain, the sale value of birds was calculated for every individual replication. The sale value of poultry manure and feed bags were also considered to compute income. Number of live birds in each replication considered here to calculate average value. Finally treatment wise production cost and income was calculated. Net profit per bird was found out by deducting the total expenditure from the total income according to replication under each treatment.

$$PPB = Total\ income / bird - total\ expenditure / bird$$

3.14 Statistical Analysis

Total data were compiled, tabulated and analyzed in accordance with the objectives of the study. Excel Program was practiced for preliminary data calculation. The collected data was subjected to statistical analysis by applying one way ANOVA using Statistical Package for Social Sciences (SPSS version 16.0). Differences between means were tested using Duncan's multiple comparison test and significance was set at $P<0.05$.

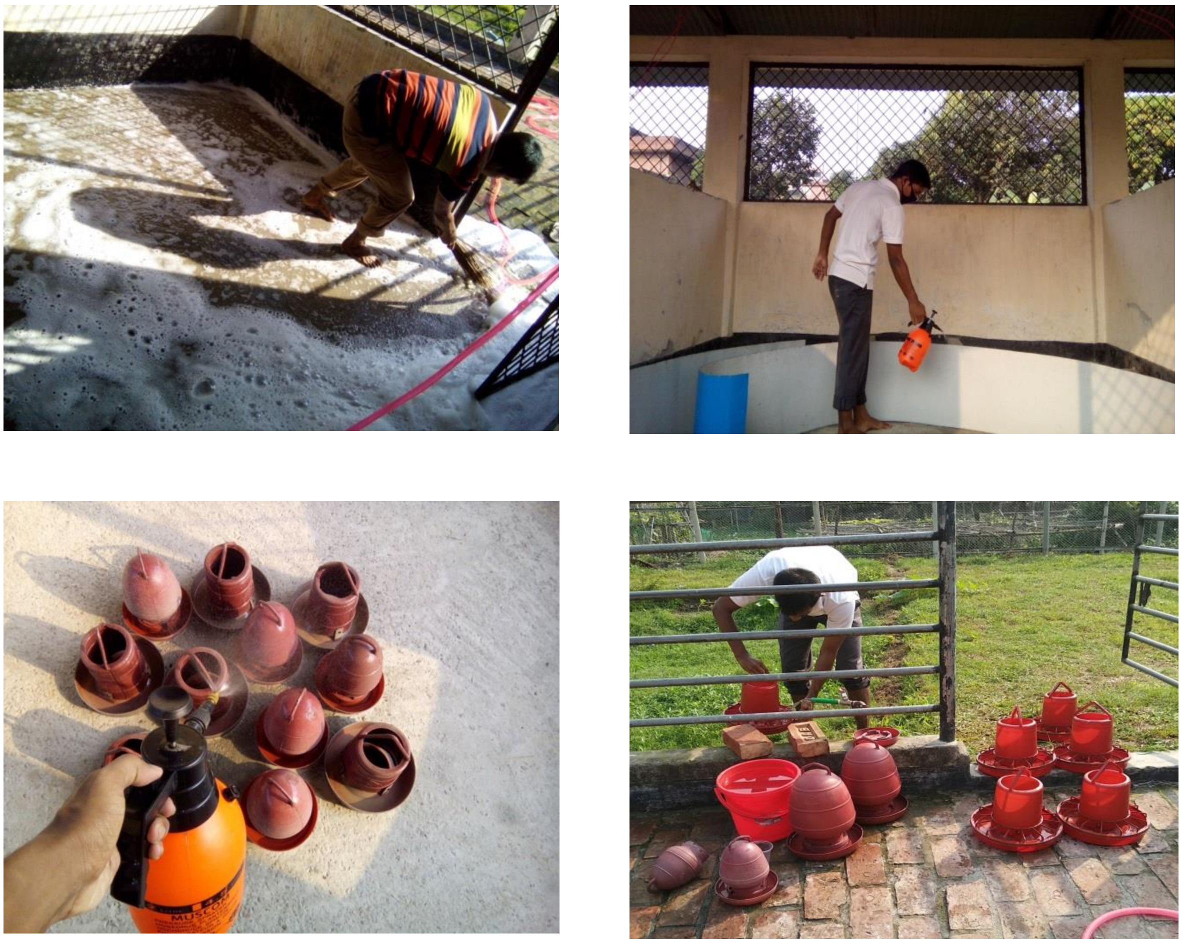

Plate 1. Sanitary activities before arrival of day old chick (DOC)

Plate 2. Collection of experimental chemical (yucca extract) & ammonia test kit

Plate 3. Arrival of DOC

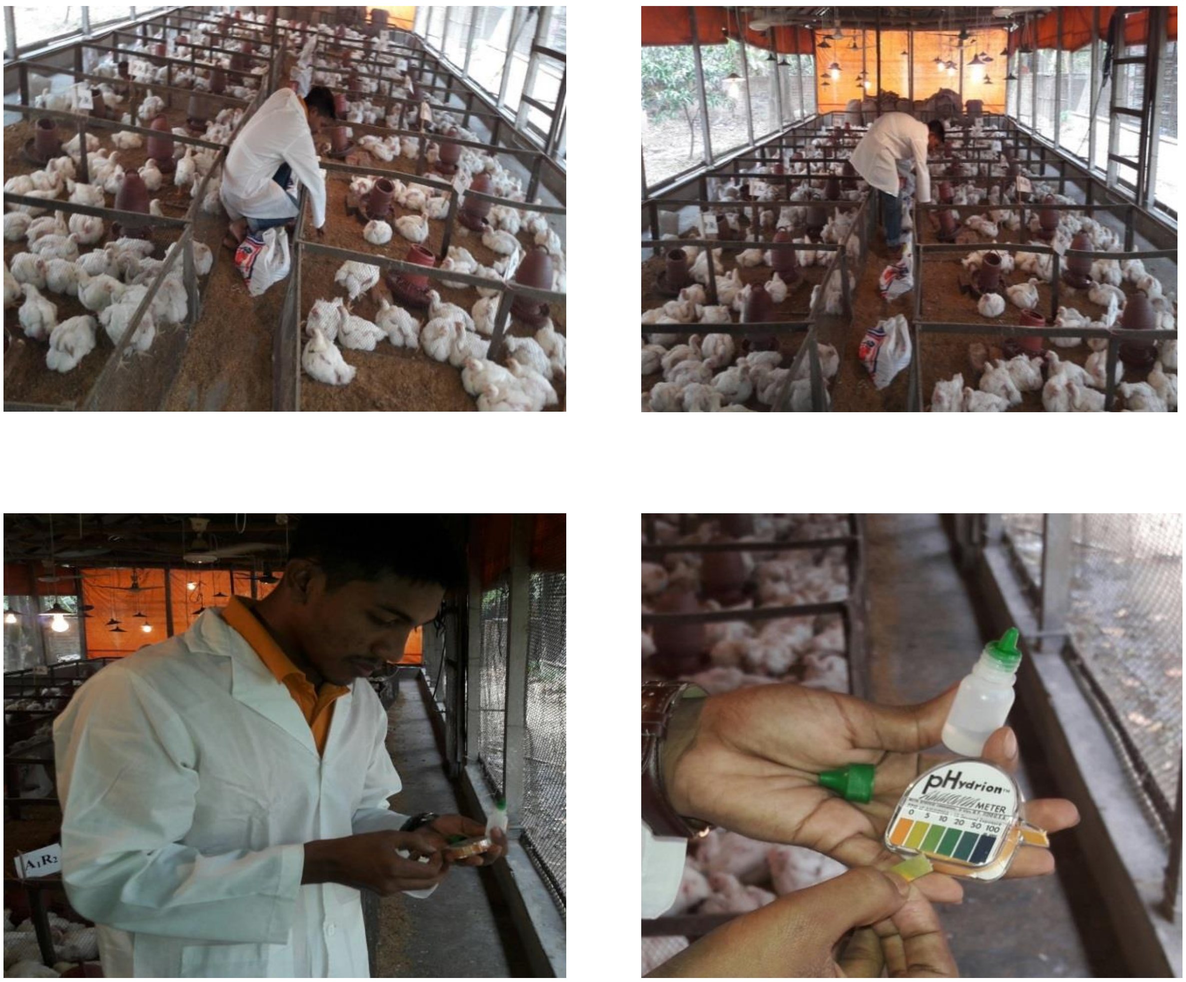

Plate 4. Activities of ammonia gas level assessment in the farm

Plate 5. Monitoring of research activities by the supervisor.

Plate 6. Different types of medication and vaccine used in experiment.

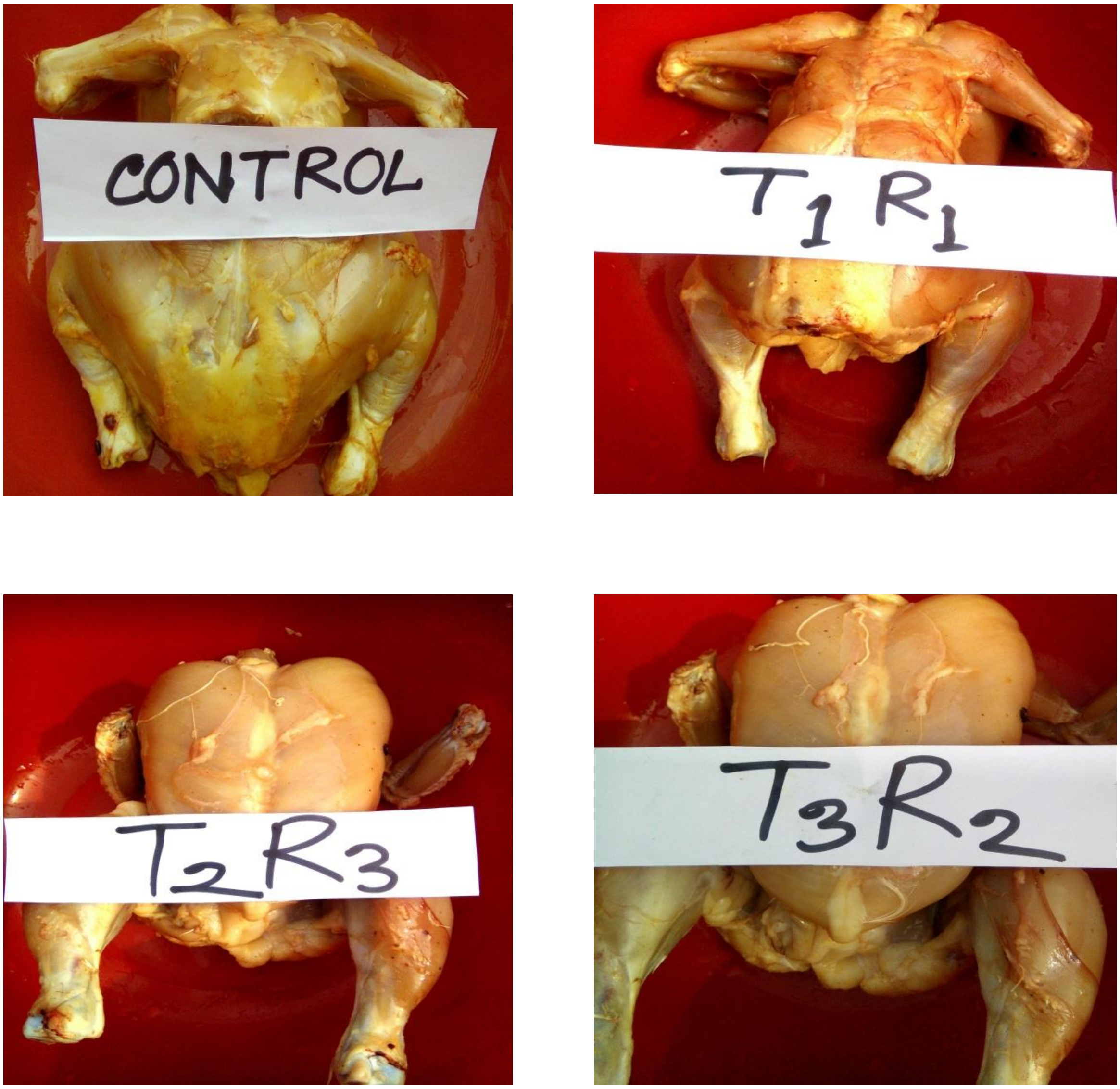

Plate 7. Monitoring and weighing of dressed broiler chicken

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Ammonia gas emissions from broiler litter treated with yucca extract

The rate of NH_3 emissions against the 28 days of rearing period of birds in different concentration level of yucca extract had shown in Table 4 and Figure 1. Results demonstrated that the rate of NH_3 emissions was reduced at all the treatments of yucca extract providing with different concentration level, when compared with the untreated emission. In untreated group, the rate of NH_3 generation was higher gradually after 15 days of rearing period compared with the treated groups. However, the rate of NH_3 emission from broiler litter was reduced when concentration level of yucca extract was high. ANOVA analysis revealed that the average NH_3 levels in treated groups and untreated group were insignificant ($P>0.05$) in 1st three weeks but it varied statistically ($P<0.05$) at 4th week of rearing period. The T_1 reduced the rate of NH_3 emission to 1/2 of the untreated level, whereas the T_2 reduced this rate to 2/3rd and T_3 reduced 1/5th of the untreated level. Figure 1 also illustrated that the rate of NH_3 emissions were consistently increased in different concentration level of yucca extract with the increased ages of birds. The highest level of NH_3 was found in untreated control group (25.87±0.73 ppm) followed by 11.87±0.37, 15.13±1.57 and 20.17±1.53 in T_1, T_2 and T_3 respectively at 28 days of rearing period.

These results are in agreement with those obtained by Cabuk *et al*. (2004) who concluded that the supplementation of *Yucca schidigera* to the diet reduced ammonia concentration in broiler house, fecal dry matter and crude ash without any adverse effect of broiler performance. Chepete *et al*. (2012) reported that when YSE was applied to laying-hens, 100 ppm inclusion in diets significantly reduced ammonia emission by 44% and 28% for the first two days of manure storage. However, Corzo *et al*. (2007) in another experiment reported that the supplementation of 100 ppm of YSE and *Quillaja saponaria* was added in a corn-soybean control diet, and ammonia emission of broiler chicken litters was not altered compared with control in the 42 days experimental period. Some relevant experiments were also done in other species and the results are in agreement with those obtained by Santoso *et al.* (2006) who reported that the supplementation of YSE in the basal diet reduced rumen ammonia N concentrations ($P<0.05$) compared to the control diet in sheep. Wang *et al.* (2009) also reported that an increase in VFA concentration and a decrease in acetate:propionate ratio ($P<0.05$), while ammonia N concentration ($P<0.05$) and average methane production ($P<0.05$) were reduced compared to the control. In swine as experimental animals, Panetta *et al.* (2006) observed no significant effect of dietary YSE (0, 62.5, 125 mg/kg) on ammonia emission during 72 h of consecutive measurement after 4 days dietary adjustment. A decreasing tendency ($P>0.05$) in ammonia gas production of fecal samples was shown during a 30 days experiment period. However, Liang *et al.* (2009) indicated that YSE added in the feed (125 mg/kg) decreased the emission of ammonia and hydrogen disulfide in the 35 days trials.

4.2 Production performances of broiler chicken

4.2.1 Final Live weight

The relative final live weight (g) of broiler chickens in the different groups $T_{0,}$ $T_{1,}$ T_2 and T_3 presented in (Table 5 & Figure 2) were 1515.60±2.47, 1621.87±9.76, 1632.03±3.40 and 1607.87±5.16 respectively. The highest result was found in T_2 (1632.03g) and lowest result was in T_0 (1515.60g) control group and that was statistically significant ($P<0.05$). Results also demonstrated that the body weights also varied among the treatment groups having statistical significance ($P<0.05$) and all the treated groups had higher live weight than control group.

These results are in agreement with those obtained by Sahoo *et al.* (2015) who found that Yucca supplementation can effectively enhance growth by utilizing lesser feed intake than control group. Ahmed (2018) found a result of feeding local yucca leaf powder in quail birds and the results of the statistical analysis showed a significant increased ($P<0.05$) in live body weight compared to control treatment. Shlomo YAHAV (2004) reported that body weight declined proportionally with increasing ammonia concentration in the air. The broilers exposed to the lowest concentration of ammonia showed the highest feed efficiency and body weight. Jun-Ling *et al.* (2016) found a result of feeding Yucca extract, birds' BW had a trend to increase at day 42. Miles *et al.* (2009) stated that body weight and condemnation may be higher in birds exposed to level of ammonia exceeding 10 ppm. Cabuk *et al.* (2004) reported that body weights of birds significantly ($P<0.05$) higher in *Yucca schidigera* treated group than control group.

4.2.2 Weekly Body weight gains (WBWG)

The data of weekly body weight gains of broiler chicks presented in (Table 6 & Figure 3). The mean body weight gains (g) at the 1^{st}, 2^{nd} and 4^{th} week of different treatment groups were significantly higher ($P<0.05$) than control group. At the 3^{rd} week there were also higher body weight gain value recorded in treatment groups than control, but was statistically insignificant ($P>0.05$). The mean body weight gain of at the end of 4^{th} week showed also significant ($P<0.05$) difference among the treatment groups.

These results are in agreement with those of previous researcher Ahmed (2018) found a result of feeding local yucca leaf powder in quail birds and the results of the statistical analysis showed a significant increased ($P<0.05$) in body weight gain compared to control treatment. Jun-Ling *et al.* (2016) reported that the BWG of treated group was significantly ($P<0.05$) higher than the control group at later period of rearing. Sonia *et al.* (2005) also reported that the positive effects of dietary supplementation with yucca products on the growth rates of livestock.

4.2.3 Total Feed consumption (FC)

Total feed consumption of different treated groups and control group have been cataloged in Table 5. T_2 consumed higher amount of feed (2308.63 g ±1.02) and T_0 (control) group consumed lower amount of feed (2296.27 g±3.73), whereas T_1 and T_3 consumed 2306.80 g±1.38 and 2306.40 g±1.15 respectively. Result in total feed consumption demonstrated that treatment groups showed significant ($P<0.05$) difference than control group, but no significant ($P>0.05$) difference among them.

These results are in agreement with those of previous researchers (Sahoo *et al.*, 2015) reported that total feed consumption relatively higher in Yucca group than control group chicks. Shlomo YAHAV (2004) also reported that the broilers exposed to the lowest concentration of ammonia showed the highest feed efficiency and increased feed intake. Jun-Ling *et al.* (2016) also reported that there was no difference among the Yucca treated groups in average feed intake (P>0.05). These results are in contradictory with Ahmed (2018) found a result of feeding local yucca leaf powder in quail birds and the results of the statistical analysis showed no significant differences (P>0.05) in feed intake compared to control treatment.

4.2.4 Weekly Feed consumption (WFC)

The mean of weekly feed consumption of broiler chicks in different groups T_0, T_1, T_2 and T_3 showed in Table 7 & Figure 4. The result presented that feed consumption of the 1st two weeks (starter phase) significantly (P<0.05) higher in Yucca treated groups than control group, whereas at the last two weeks (3rd and 4th) feed consumption significantly (P<0.05) higher in control group than Yucca treated groups. There was no significant (P>0.05) difference in weekly feed consumption among the YE treated groups.

These results are in harmony with those of previous researchers (Sahoo *et al*., 2015) reported that feed intake during the starter phase indicated numerically higher consumption in Yucca group than control group chicks. However, a reversed trend was recorded at finishing stage. These results are contradictory to Cabuk *et al.* (2004) who reported that from 21 to 42 and 42nd day of age, the feed intake was not significantly (P>0.05) different.

4.2.5 Feed Conversion Ratio (FCR)

The data of feed conversion ratio (FCR) of broilers under different treatment groups have been shown in Table 5. The lowest (1.45±0.03) feed conversion ratio (FCR) was significantly (P<0.05) found in birds supplemented 1ml Yucca extract/ 20L drinking water (T_2) than control birds (1.56±0.01). However, feed conversion ratio (FCR) was significantly (P<0.05) lower in T_1 (1.46±0.07) and T_3 (1.47±0.03) groups compared to control group but higher than T_2 group.

These results are in agreement with those of previous researchers (Sahoo *et al*., 2015) reported that the efficiency of utilization of feed was significantly better in Yucca group than control group in both the starter and finisher phase of growth, which led to significantly (P<0.05) better FCR value of 1.91 in Yucca group than that of control (2.10). Shlomo YAHAV (2004) reported that the broilers exposed to the lowest concentration of ammonia showed the highest feed efficiency. Lundeen (2000) reported that Yucca extract improves feed efficiency in broilers and helps to improve the FCR value. Sonia *et al.* (2005) reported that the positive effects of dietary supplementation with yucca products on feed efficiency and health of livestock. Miles *et al.* (2009) stated that feed efficiency and condemnation may be higher in birds exposed to level of ammonia exceeding 10 ppm. These results are in contradictory with those of previous researcher Ahmed (2018) who found a result of feeding local yucca leaf powder in quail birds and reported no significant differences in feed conversion ratio compared to control treatment.

4.2.6 Weekly Feed Conversion Ratio (WFCR)

The mean weekly FCR of broiler chicks in different groups were presented in Table 8 and Figure 5. The FCR of 1st two weeks were insignificant (P>0.05) among the treated groups with control also, but at the last two weeks (3rd and 4th) control group showed significantly (P<0.05) higher value than the treated groups.

These results are in agreement with those of previous researcher (Jun-Ling *et al.*, 2016) who reported that the feed efficiency value of YE treatment was significantly upgraded at the latter period (P<0.05) compared to the control that contribute to better FCR. Sahoo *et al.* (2015) reported that the efficiency of utilization of feed was significantly better in Yucca group than control group in both the starter and finisher phase of growth, which led to significantly (P<0.05) better FCR value of 1.91 in Yucca group than that of control (2.10). Lundeen *et al.* (2000) reported that yucca extract improves feed efficiency in broilers and helps to improve the FCR value. These results are contradictory to Cabuk *et al.* (2004) who reported that feed conversion ratio was not affected by the supplementation of *Yucca schidigera* and natural zeolite at days 21 to 42.

4.2.7 Survivability

Result presented in Table 5 revealed that the survivability of the broilers in the treatment groups were higher than control group but that was statistically insignificant (P>0.05).

These results are in agreement with those of previous researchers (Sahoo *et al*., 2015)) who reported that lower survivability percentage was recorded in the control group (95%) as compared to the treatment group (98.33%). Similar pattern of mortality with the Yucca supplementation in the layer diet were noticed in the Yucca treated groups while comparing yeast cell walls and *Y. schidigera* extraction in layer hen's diets.

4.3 Carcass characteristics

Carcass characteristics of the birds had shown in (Table 9 and Figure 6), the result demonstrated that dressing percentage significantly (P<0.05) higher in all the treatment groups than control group. Among the treatment groups, T_2 had a greater carcass percentage (68.39 %±.568) compared with the others T_3 (67.05 %±0.705), T_1 (65.82 %±0.404) and control group T_0 was 59.83% ±1.081 respectively. Giblet percentage was significantly (P<0.05) higher in control group. Breast meat percentage was significantly (P<0.05) high in T_2, T_3, T_1 and T_0 sequentially. Drumstick percentage found higher in T_2 and lower in control group but was insignificant (P>0.05). Edible portion of birds was found significantly (P<0.05) higher in T_2 (73.64 %±0.32) than T_3 (72.86 %±0.69), T_1 (72.07 %±0.34) and control T_0 (67.14 %±0.32).

These results are in agreement with those of previous researchers (Sahoo *et al*., 2015) reported that eviscerated weight percentage for the treatment group significantly higher in Yucca treated group (P<0.05) than the control group. The breast meat yield of Yucca group (32.23%) was significantly higher (P<0.05) than control (30.33%). Similarly, thigh yield was also significantly higher in Yucca group than that of the control group. Thus overall yield of edible meat was significantly higher in Yucca group (63.40%) than the control group (59.50%). There was no significant (P>0.05) difference observed in drumstick and giblet.

4.4 Economics

The cost of different treatment groups and control group presented in Table 10 and Figure 7. Production cost included feed cost, cost of Yucca extract and common costs (litter cost, vaccine, medicine, electricity etc) for both the treated groups and untreated group. Total expenditure per bird was significantly higher ($P<0.05$) in treated groups T_1, T_2 and T_3 were 168.53 TK±0.43, 168.36 TK±0.21 and 167.70 TK±0.29 than control group T_0 (166.03 TK±0.30). Feed cost was comparatively higher in treated groups, but that was statistically insignificant ($P>0.05$).

The price of Yucca extract was BDT 250 /100 ml bottle and the charge for incorporation in feeding was calculated. Cost of Yucca extract was added with the treatment groups and it was high in T1 (1.83 Tk/ bird) group than T2 (1.5 Tk/ bird) and T3 (1.17 Tk/ bird) as according with concentration level. Profit per bird (PPB) and benefit cost ratio (BCR) also presented in Table 10, demonstrated the economic impact of the treatment groups compared with the untreated group. Return was calculated after selling the live birds per kg weight and profit was computed by subtracting the expenditure.

Profit per bird was significantly higher ($P<0.05$) in treatment groups T_2 (43.80 TK±0.66), T_1 (41.31 TK±0.97) and T_3 (40.49 TK±1.07) than control group T_0 (30.99 TK±0.61). Among the treatment groups T_2 performed better than others. BCR was also statistically higher ($P<0.05$) in treatment groups T_1 (1.24±0.06), T_2 (1.25±0.03) and T_3 (1.24±0.01) compared with the control T_0 (1.18±0.03) (Table 10 and Figure 8).

These results are in agreement with those of previous researchers (Sahoo *et al.*, 2015) reported the application of yucca supplement on economic analysis revealed that it could be cost-effective management practice to improve shed environment and in turn performance of broiler chicks. The benefits of litter treatment and Yucca supplementation include (1) heavier birds (2) improved feed conversion (3) lower mortality which proves efficiency of Yucca in the improvement of economic traits that in turn develops better economy of production.

Table 4. Effects of YE on ammonia gas emissions from broiler litter

Treatment	7 days	14 days	21 days	28 days
T_0	8.37±0.98	10.23±1.50	14.97±3.79	25.87^{a} ±0.73
T_1	6.87±0.27	8.33±0.91	9.67±0.84	11.87^{c} ±0.37
T_2	7.10±0.30	8.43±0.58	10.37±1.02	15.13^{c} ±1.57
T_3	7.33±0.21	9.37±1.49	11.53±0.54	20.17^{b} ±1.53
Mean ± SE	7.42±0.28	9.09±0.55	11.63±1.06	18.26±1.67

Here, T_0 = (Control), T_1= (1ml Yucca extract per 16 liters of drinking water), T_2 = (1ml Yucca extract per 20 liters of drinking water), T_3 = (1ml Yucca extract per 24 liters of drinking water). Values are Mean ± SE (n=12).

- ✓ Mean with different superscripts are significantly different (P<0.05)
- ✓ Mean within same superscripts don't differ (P>0.05) significantly
- ✓ SE= Standard Error
- ✓ *means significant at 5% level of significance (P<0.05)

Table 5. Effects of YE on production performances of broiler chicken

Treatment	Final Live weight (g/bird)	Average BWG (g/bird)	Total FC (g/bird)	Final FCR	Survivability (%)
T_0	$1515.60^{c}\pm2.47$	$1472.40^{c}\pm2.47$	$2296.27^{b}\pm3.73$	$1.56^{a}\pm0.01$	98.33±1.66
T_1	$1621.87^{ab}\pm9.76$	$1575.33^{ab}\pm7.48$	$2306.80^{a}\pm1.38$	$1.46^{b}\pm0.07$	100.00±0.00
T_2	$1632.03^{a}\pm3.40$	$1588.83^{a}\pm3.40$	$2308.63^{a}\pm1.02$	$1.45^{c}\pm0.03$	100.00±0.00
T_3	$1607.87^{b}\pm5.16$	$1564.67^{b}\pm5.16$	$2306.40^{a}\pm1.15$	$1.47^{b}\pm0.03$	100.00±0.00
Mean ± SE	1594.34±14.17	1550.31±13.97	2304.52±1.72	1.49±0.01	99.58±0.41

Here, T_0 = (Control), T_1= (1ml Yucca extract per 16 liters of drinking water), T_2 = (1ml Yucca extract per 20 liters of drinking water), T_3 = (1ml Yucca extract per 24 liters of drinking water). Values are Mean ± SE (n=12).

- ✓ Mean with different superscripts are significantly different (P<0.05)
- ✓ Mean within same superscripts don't differ (P>0.05) significantly
- ✓ SE= Standard Error
- ✓ *means significant at 5% level of significance (P<0.05)

Table 6. Effects of YE on body weight gain (BWG) (g/bird) of broiler chickens at different weeks

Treatment	1st Week	2nd Week	3rd Week	4th Week
T_0	138.43b±1.22	276.87b±2.96	480.53±1.57	576.57c±3.15
T_1	147.00a±1.62	291.83a±0.58	483.77±1.54	652.73ab±3.57
T_2	149.80a±1.49	293.27a±2.88	485.00±2.57	660.77a±4.64
T_3	146.27a±0.81	290.87a±1.67	485.67±1.20	641.87b±4.85
Mean ± SE	145.38±1.39	288.21±2.21	483.74±0.97	632.98±10.17

Here, T_0 = (Control), T_1= (1ml Yucca extract per 16 liters of drinking water), T_2 = (1ml Yucca extract per 20 liters of drinking water), T_3 = (1ml Yucca extract per 24 liters of drinking water). Values are Mean ± SE (n=12).

- ✓ Mean with different superscripts are significantly different (P<0.05)
- ✓ Mean within same superscripts don't differ (P>0.05) significantly
- ✓ SE= Standard Error
- ✓ *means significant at 5% level of significance (P<0.05)

Table 7. Effects of YE on feed consumption (g/bird) of broiler chickens at different weeks

Treatment	1st Week FC	2nd Week FC	3rd Week FC	4th Week FC
T_0	172.20b±0.83	393.60b±1.60	724.47a±2.71	1006.00a±1.17
T_1	184.37a±2.30	414.13a±1.96	713.70b±0.43	995.27b±0.82
T_2	184.37a±0.75	416.10a±3.08	715.70b±1.09	992.47b±1.22
T_3	183.47a±2.47	413.33a±1.29	718.10b±1.38	996.03b±1.11
Mean ± SE	181.10±1.72	409.29±2.89	717.99±1.40	997.44±1.61

Here, T_0 = (Control), T_1= (1ml Yucca extract per 16 liters of drinking water), T_2 = (1ml Yucca extract per 20 liters of drinking water), T_3 = (1ml Yucca extract per 24 liters of drinking water). Values are Mean ± SE (n=12).

- ✓ Mean with different superscripts are significantly different (P<0.05)
- ✓ Mean within same superscripts don't differ (P>0.05) significantly
- ✓ SE= Standard Error
- ✓ LSD= Least Significant Difference
- ✓ *means significant at 5% level of significance (P<0.05)

Table 8. Effects of YE on feed conversion ratio (FCR) of broiler chickens at different weeks

Treatment	1st Week FCR	2nd Week FCR	3rd Week FCR	4th Week FCR
T_0	1.24±0.01	1.43±0.01	1.51^{a}±0.02	1.75^{a}±0.01
T_1	1.25±0.02	1.42±0.02	1.48^{b}±0.01	1.50^{c}±0.02
T_2	1.23±0.01	1.42±0.03	1.48^{b}±0.01	1.50^{c}±0.02
T_3	1.25±0.02	1.42±0.01	1.48^{b}±0.02	1.54^{b}±0.03
Mean ± SE	1.25±0.01	1.42±0.02	1.48±0.02	1.57±0.03

Here, T_0 = (Control), T_1= (1ml Yucca extract per 16 liters of drinking water), T_2 = (1ml Yucca extract per 20 liters of drinking water), T_3 = (1ml Yucca extract per 24 liters of drinking water). Values are Mean ± SE (n=12).

- ✓ Mean with different superscripts are significantly different (P<0.05)
- ✓ Mean within same superscripts don't differ (P>0.05) significantly
- ✓ SE= Standard Error
- ✓ *means significant at 5% level of significance (P<0.05)

Table 9. Effects of YE on carcass characteristics of broiler chickens

Treatment	Eviscerated weight (%)	Giblet (%)	Breast meat (%)	Drumstick (%)	Edible (%)
T_0	59.83^{c}±1.08	7.40^{a}±0.57	33.75^{c}±0.45	16.80±0.35	67.14^{c}±0.32
T_1	65.82^{b}±0.40	6.50^{ab}±0.26	35.09^{bc}±0.34	17.00±0.25	72.07^{b}±0.34
T_2	68.39^{a}±0.56	5.51^{b}±0.28	37.14^{a}±0.58	17.17±0.38	73.64^{a}±0.32
T_3	67.05^{ab}±0.70	6.11^{ab}±0.46	35.67^{b}±0.33	17.13±0.31	72.86^{ab}±0.69
Mean ± SE	65.27±1.03	6.38±0.27	35.41±0.41	17.03±0.14	71.43±0.78

Here, T_0 = (Control), T_1= (1ml Yucca extract per 16 liters of drinking water), T_2 = (1ml Yucca extract per 20 liters of drinking water), T_3 = (1ml Yucca extract per 24 liters of drinking water). Values are Mean ± SE (n=12).

- ✓ Mean with different superscripts are significantly different (P<0.05)
- ✓ Mean within same superscripts don't differ (P>0.05) significantly
- ✓ SE= Standard Error
- ✓ *means significant at 5% level of significance (P<0.05)

Table 10. Effects of YE on economic impact on broiler rearing

Parameter	Treatment T_0	T_1	T_2	T_3	Mean ± SE
Feed cost (BDT) per Bird	97.70±0.30	98.37±0.29	98.53±0.21	98.20±0.43	98.20±0.16
Cost of Yucca extract (BDT) per Bird	0	1.83	1.5	1.17	1.12±0.22
Common expenditure (BDT) per Bird	68.33	68.33	68.33	68.33	68.33
Total Expenditure (BDT) per Bird	166.03^{b}±0.30	168.53^{a}±0.43	168.36^{a}±0.21	167.70^{a}±0.29	167.66±0.32
Receipt per bird when sold (130 BDT/ Kg Live weight)	197.03^{c}±0.32	209.84^{b}±1.2	212.16^{a}±0.44	209.02^{b}±0.67	207.26±1.84
Profit per bird (BDT)	30.99^{c}±0.60	41.31^{ab}±0.97	43.80^{a}±0.66	40.49^{b}±1.07	39.61±1.58
Benefit Cost Ratio (BCR)	1.18^{b}±0.03	1.24^{a}±0.06	1.25^{a}±0.03	1.24^{a}±0.01	1.23±0.01

Here, T_0 = (Control), T_1= (1ml Yucca extract per 16 liters of drinking water), T_2 = (1ml Yucca extract per 20 liters of drinking water), T_3 = (1ml Yucca extract per 24 liters of drinking water). Values are Mean ± SE (n=12).

- ✓ Mean with different superscripts are significantly different (P<0.05)
- ✓ Mean within same superscripts don't differ (P>0.05) significantly
- ✓ SE= Standard Error
- ✓ *means significant at 5% level of significance (P<0.05)

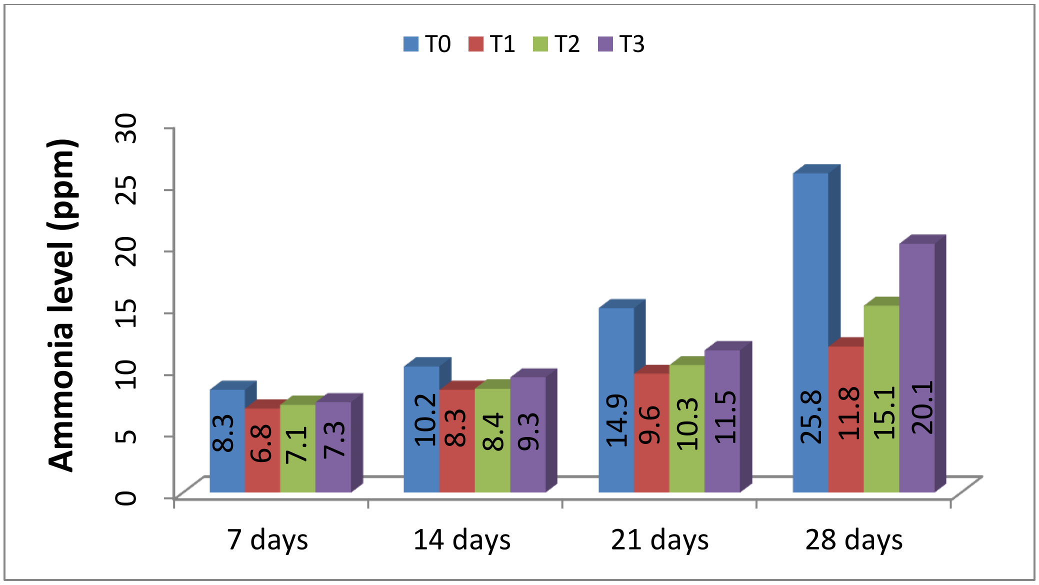

Figure 1. Effects of YE on ammonia gas emission from broiler litter

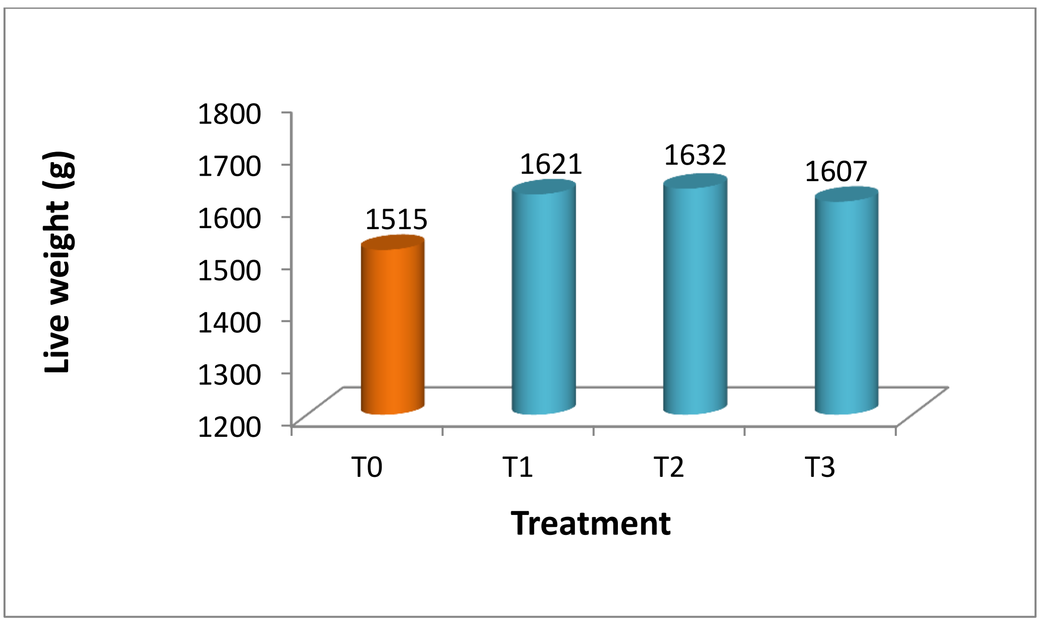

Figure 2. Effects of YE on live weight of broiler chickens

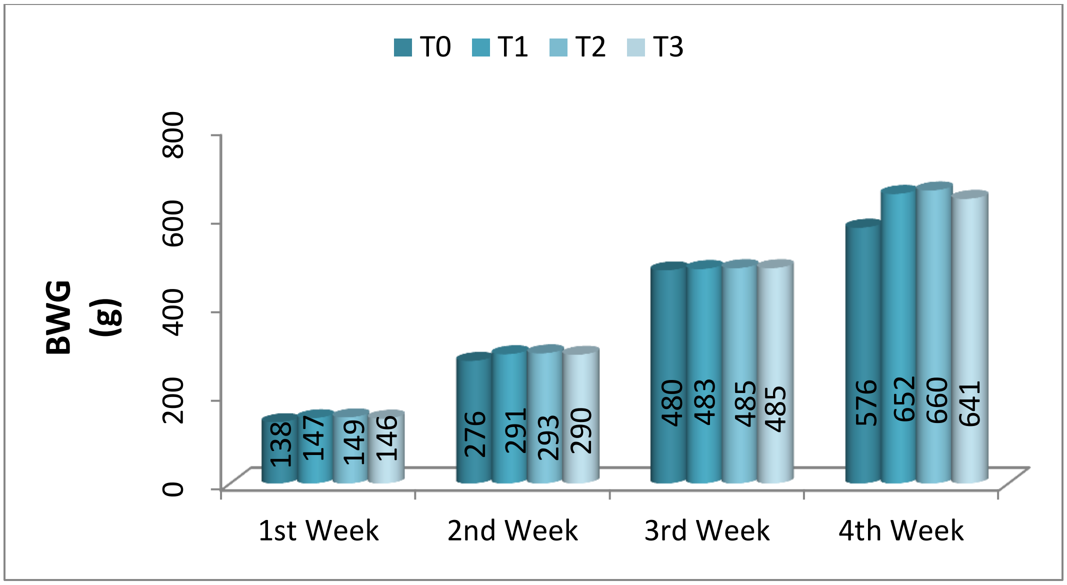

Figure 3. Effects of YE on BWG of broiler chickens at different weeks

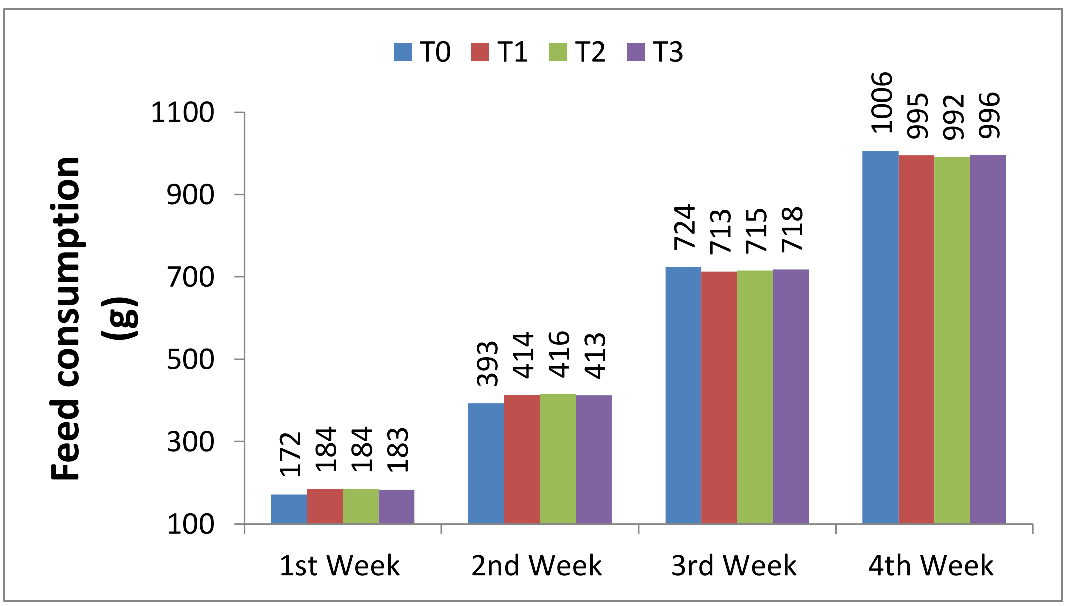

Figure 4. Effects of YE on feed consumption of broiler chickens at different weeks

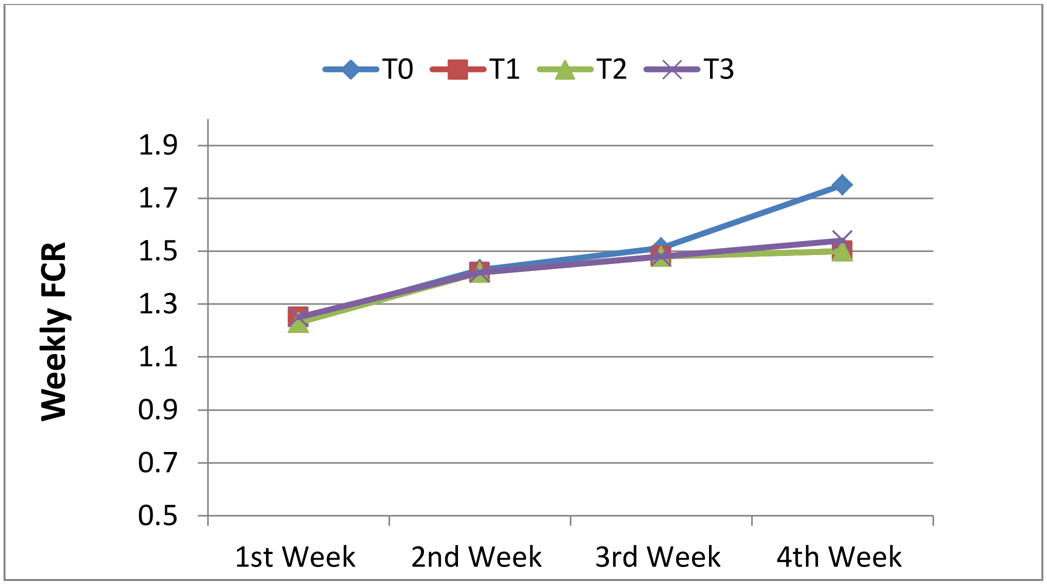

Figure 5. Effects of YE on FCR of broiler chickens at different weeks

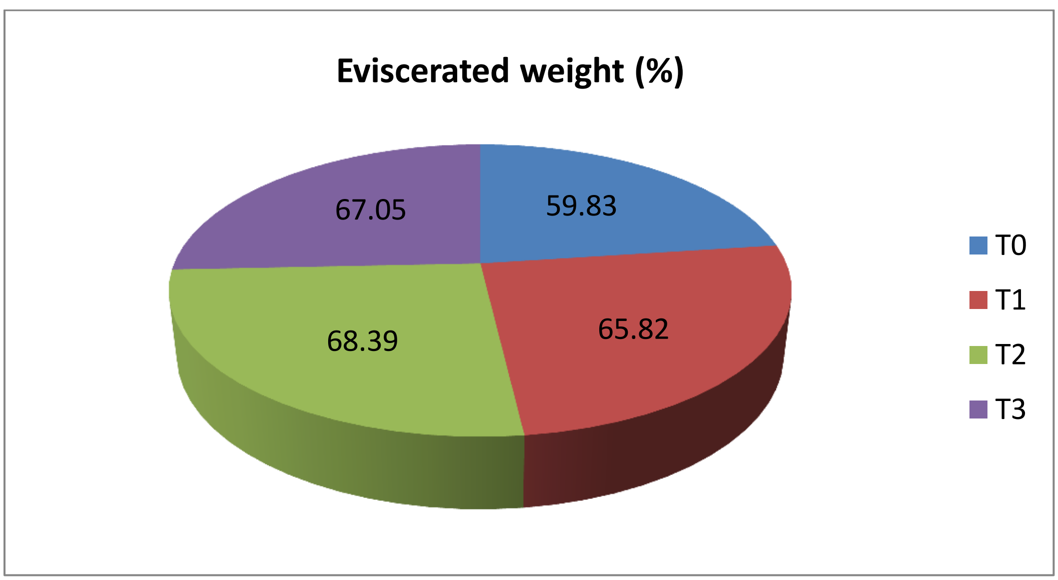

Figure 6. Effects of YE on eviscerated weight (%) of broiler chicken

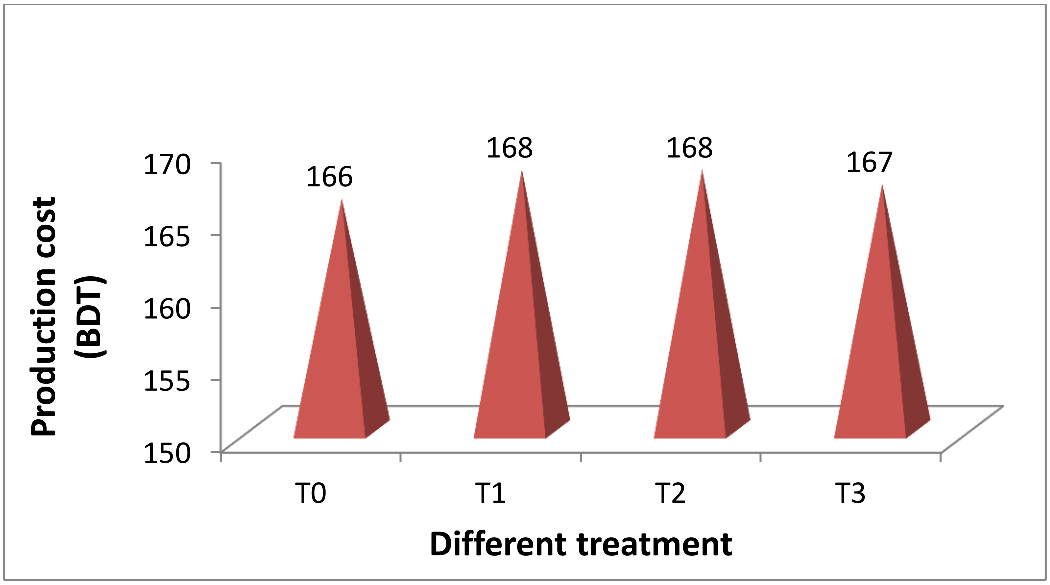

Figure 7. Effects of YE on production cost per broiler chicken

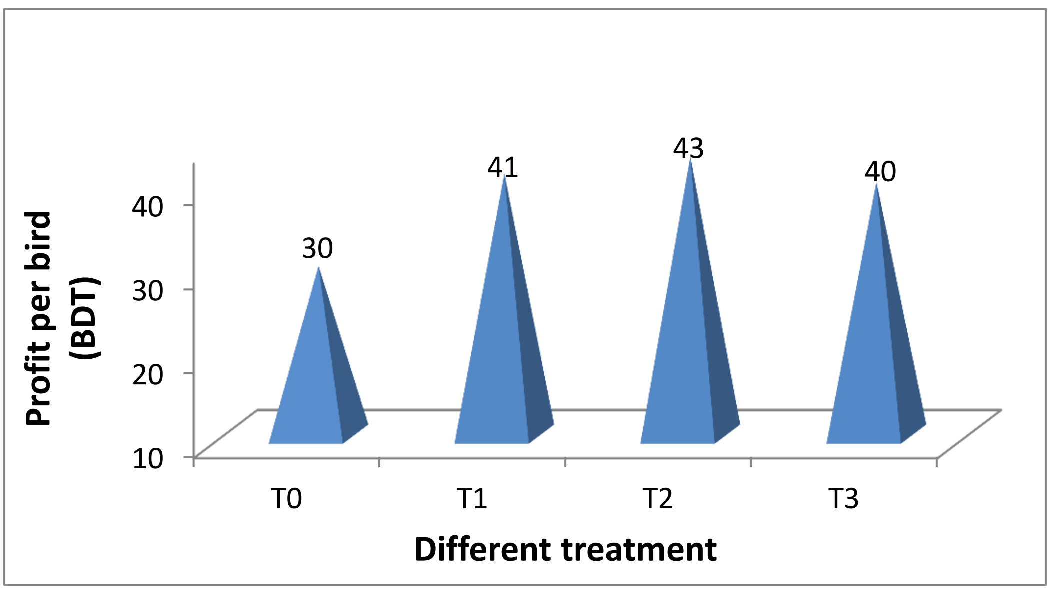

Figure 8. Effects of YE on profit per broiler chicken

CHAPTER 5

SUMMARY AND CONCLUSION

The present study was conducted at the Sher-e-Bangla Agricultural University (SAU), Dhaka Poultry Farm for a period of four weeks using *Yucca schidigera* plant extract commercially available as “Bio-Ade super”. The experiment was performed by applying different concentration levels of *Yucca schidigera* plant extract with drinking water. The specific objectives of this study was under taken to determine the efficacy of *Yucca schidigera* plant extract i) to assess ammonia gas emission from litter of the broiler house, ii) to evaluate the production performance of broiler, iii) to determine the carcass quality of broiler, iv) to estimate the economical utility in broiler rearing. A total of 240 day-old Cobb-500 broiler chicks were purchased from Kazi hatchery, Gazipur, Dhaka. The experimental broilers were allocated randomly to 3 treatments and a control group with three replications having 20 broilers per replication. The experiment lasted for 4 weeks and the treatment of various groups consisted of (group T_1)1ml YE per 16 liters of drinking water, (group T_2) 1ml YE per 20 liters of drinking water, (group T_3) 1ml YE per 24 liters of drinking water and (group T_0) No YE supplement i.e Control group. The parameters evaluated in this study were the NH_3 emission from broiler litter, the bird’s performance like body weight, feed consumption, FCR, survivability, carcass characteristics and economic impact on broiler rearing that includes production cost, profit per bird (PPB) and benefit cost ratio (BCR).

Result demonstrated that the average ammonia level in treated groups and untreated group were insignificant ($P>0.05$) in 1st three weeks but it varied statistically ($P<0.05$) at the 4th week of rearing period. YE treated groups showed lower amount of NH_3 gas emission in broiler house than control group. A statistically significant difference ($P<0.05$) was noted on body weight, feed consumption, BWG and FCR value of the birds treated with YE. Feed consumption of the 1st two weeks (starter phase) significantly ($P<0.05$) higher in Yucca treated groups than control group, whereas at the last two weeks (3rd and 4th) feed consumption significantly ($P<0.05$) higher in control group than Yucca treated groups. There was no significant ($P>0.05$) difference in weekly feed consumption among the YE treated groups. The mean body weight gains (g) at the 1st, 2nd

and 4th week of different treatment groups were significantly higher ($P<0.05$) than control group. The better FCR was significantly ($P<0.05$) observed in YE treated groups than the control group and best value found in T_2 group. At the last two weeks (3rd and 4th) control group showed significantly ($P<0.05$) higher FCR value than the treated groups. A statistically insignificant ($P>0.05$) difference was noted on survivability of the broilers between the treatment groups and control. Carcass percentage significantly ($P<0.05$) higher in all the treatment groups than control group and T_2 showed a greater carcass percentage value. Breast meat percentage and edible portion of birds was significantly ($P<0.05$) high in T_2, T_3, T_1 and T_0 sequentially. Giblet percentage was significantly ($P<0.05$) higher in control group. Drumstick percentage found higher in T_2 and lower in control group but was insignificant ($P>0.05$). Total expenditure per bird was significantly higher ($P<0.05$) in treated groups T_1, T_2 and T_3 than control group. Feed cost was comparatively higher in treated groups, but that was statistically insignificant ($P>0.05$). Profit per bird was significantly higher ($P<0.05$) in treatment groups than control group. Among the treatment groups T_2 performed better than others. BCR was also statistically higher ($P<0.05$) in treatment groups compared with the control T_0.

Analyzing the above research findings, this study suggested that the 1ml of *Yucca schidigera* plant extract with 20 L drinking water was best to minimize the NH_3 gas emission, for better production performance, to improve carcass quality and more economic benefit in broiler rearing. Though Yucca extract naturally not found in our country but it is now commercially available with various trade names. The study therefore recommends for hematological parameters on birds immunity and conducting field trial on commercial poultry farm to fix up inclusion level of Yucca extract. Hence, Yucca extract could be safely used in broiler rearing for higher economical return without any adversity.

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APPENDICES

Appendix 1. Recommended level of nutrients for broiler

Components	Starter	Grower
ME (kcal/kg)	3000	3100
% CP	22	20
% Ca	1.0	0.85
% P (Available)	0.5	0.4
% Lysine	1.2	1.0
% Methionine	0.5	0.45
% Tryptophane	0.21	0.18

Source: Cobb500 Broiler Management Guide, 2016

Appendix 2. Nutrient composition of the ingredients used to formulate experimental diets

Ingredients	DM (%)	ME (K. Cal/kg)	CP (%)	CF (%)	Ca (%)	P (%)	Lys (%)	Meth (%)	Tryp (%)
Soybean meal	90.0	2710	44.50	7.5	0.26	0.23	2.57	0.76	0.57
Maize	89.5	3309	9.2	2.4	0.25	0.40	0.18	0.15	0.09
DCP					22	17.21			
Soybean oil	100.0	8800							
Protein concentrate (Jeso-prot)	91.64	2860	63.30	8.1	6.37	3.24	3.87	1.78	0.53
Meat and Bone meal	95.5	1044	14.6	2.5	7.0	12.11	0.66	0.24	0.12

Source: Cobb500 Broiler Management Guide, 2016

Appendix 3. Recorded temperature (^{0}C) during experiment

Age in weeks	**Period**	**Room temperature (^{0}C)**						
		8 A.M	12 A.M	4 P.M.	8 P.M.	12 P.M.	4 A.M	Average
1st	O8.10.18-15.10.18	28.9	30.5	32.6	32.5	29.2	27.4	30.1
2nd	16.10.18-22.10.18	28.1	28.5	33.1	32.6	28.3	27.5	29.6
3rd	23.10.18-29.10.18	27.4	26.9	31.8	28.2	27.4	26.8	28.1
4th	30.10.18-05.11.18	25.8	27	30.6	29.5	27.4	25.2	27.5

Appendix 4. Relative humidity (%) during experiment

Age in weeks	**Period**	**Relative humidity (%)**						
		8 A.M	12 A.M	4 P.M.	8 P.M.	12 P.M.	4 A.M	Average
1st	O8.10.18-15.10.18	84	82	75	74	78	80	78.83
2nd	16.10.18-22.10.18	84	82	73	72	78	79	78
3rd	23.10.18-29.10.18	86	84	74	74	81	83	80.33
4th	30.10.18-05.11.18	87	85	83	78	84	85	83.66

Appendix 5. Ammonia content (ppm) in litter using different concentration levels of *Yucca schidigera* in different rearing periods

Day	T_0			T_1			T_2			T_3		
	R_1	R_2	R_3	R_1	R_2	R_3	R_1	R_2	R_3	R_1	R_2	R_3
0	5.3	5.1	5.0	5.1	5.0	5.2	5.0	5.1	5.2	5.1	5.3	5.7
1	5.4	5.2	5.2	5.3	5.2	5.1	5.1	5.2	5.32	5.3	5.5	5.3
2	5.2	5.1	5.7	5.3	5.2	5.3	5.5	5.4	5.2	5.6	5.3	5.4
3	6.3	5.3	5.2	5.9	5.3	5.7	5.2	6.5	5.3	5.3	5.4	5.3
4	5.4	5.3	5.4	6.3	6.5	7.4	6.9	6.6	7.5	6.8	5.7	7.5
5	5.3	5.2	6.4	6.6	6.6	5.8	7.2	6.5	7.5	6.3	6.4	6.7
6	6.8	7.4	6.8	7.5	6.8	6.6	8.3	5.7	7.7	7.4	6.8	6.3
7	9.3	6.4	9.4	6.5	7.4	6.7	7.4	6.5	7.4	7.5	6.9	7.6
8	7.3	9.3	9.2	7.5	5.8	6.1	7.2	7.6	6.5	7.7	9.6	5.7
9	6.3	8.4	8.7	8.2	8.3	5.9	7.7	5.6	8.4	7.5	8.6	6.6
10	6.7	7.5	10.2	6.4	8.1	8.5	8.8	5.5	6.5	8.4	7.5	7.8
11	8.5	9.6	10.5	6.9	8.9	7.8	9.2	6.2	6.6	8.8	7.4	9.5
12	7.2	10.4	9.6	8.9	9.3	6.8	7.8	6.3	6.3	9.3	9.4	8.3
13	7.8	11.4	12.3	9.9	6.8	7.7	6.8	6.2	8.8	10.9	10.5	7.6
14	8.3	9.2	13.2	9.2	6.5	9.3	7.9	7.8	9.6	12.3	8.4	7.4
15	10.4	12.3	11.4	9.4	7.5	9.8	9.6	8.8	8.9	11.2	7.5	6.5
16	12.3	11.8	13.5	8.6	8.7	8.8	9.9	7.7	8.7	11.2	10.5	9.6
17	10.1	14.2	12.9	8.9	7.9	8.9	10.3	9.6	10.2	10.3	12.7	10.4
18	13.8	14.6	16.4	8.1	10.6	8.2	12.3	10.4	10.4	13.2	13.4	10.6
19	15.3	17.9	15.6	8.1	10.1	10.2	11.9	10.2	10.1	9.9	10.5	9.4
20	16.3	15.2	18.2	8.6	10.2	11.3	8.4	11.3	9.4	12.1	14.2	11.4
21	17.9	18.2	19.3	8.3	9.5	11.2	12.4	9.5	9.2	11.5	10.6	12.5
22	19.2	19.1	17.7	9.2	9.9	9.4	10.9	9.2	8.8	15.2	12.4	9.2
23	18.4	16.4	19.3	10.3	9.4	9.8	11.4	9.9	9.2	13.3	15.2	13.2
24	23.1	21.9	22.2	10.5	8.6	8.9	13.2	10.4	11.5	16.5	11.7	12.2
25	21.4	22.1	21.8	12.2	10.6	8.7	12.8	12.1	10.4	17.1	19.3	17.4
26	25.1	24.2	23.3	11.3	11.7	12.1	14.2	15.2	13.1	16.9	18.5	20.6
27	23.6	26.3	25.5	10.9	10.3	10.5	16.2	18.2	15.3	24.1	21.8	19.6
28	27.3	25.4	24.9	12.5	11.9	11.2	15.9	17.4	12.1	23.1	19.5	17.9

Appendix 6. Feed consumption (g/bird) of 1st, 2nd, 3rd and 4th week under different treatment groups

Treatment	Replication	1st Week FC	2nd Week FC	3rd Week FC	4th Week FC	Total FC
T_0	R_1	173.7	395.3	725.6	1005.3	2299.9
	R_2	170.8	390.4	719.3	1008.3	2288.8
	R_3	172.1	395.1	728.5	1004.4	2300.1
T_1	R_1	184.1	412.3	717.9	994.3	2305.0
	R_2	187.4	411.8	720.6	995.7	2305.5
	R_3	178.9	415.9	715.8	998.1	2308.7
T_2	R_1	184.3	413.8	714.1	994.4	2306.6
	R_2	185.7	412.3	715.2	990.2	2309.4
	R_3	183.1	422.2	717.8	992.8	2309.9
T_3	R_1	179.9	416.2	714.4	996.5	2307.0
	R_2	185.6	416.0	713.8	993.7	2309.1
	R_3	187.6	410.2	712.9	995.6	2304.3

Appendix 7. Body weight gain (BWG) (g/bird) of 1st, 2nd, 3rd and 4th week under different treatments

Treatment	Replication	1st Week	2nd Week	3rd Week	4th Week
T_0	R_1	140.8	280.5	477.5	577.5
	R_2	136.7	271.0	481.3	581.5
	R_3	137.8	279.1	482.8	570.7
T_1	R_1	148.1	292.6	480.8	656.6
	R_2	143.8	292.2	484.5	645.6
	R_3	149.1	290.7	486.0	656.0
T_2	R_1	147.5	288.3	485.8	662.5
	R_2	152.6	293.2	489.0	652.0
	R_3	149.3	298.3	480.2	667.8
T_3	R_1	147.8	288.0	484.0	649.0
	R_2	145.0	290.8	488.0	632.6
	R_3	146.0	293.8	485.0	644.0

Appendix 8: Feed Conversion Ratio (FCR) of birds under different treatments

Treatment	Replication	1st Week	2nd Week	3rd Week	4th Week
T_0	R_1	1.23	1.41	1.52	1.73
	R_2	1.25	1.44	1.49	1.77
	R_3	1.25	1.43	1.51	1.74
T_1	R_1	1.21	1.42	1.49	1.49
	R_2	1.29	1.42	1.47	1.52
	R_3	1.26	1.41	1.47	1.50
T_2	R_1	1.25	1.44	1.47	1.50
	R_2	1.21	1.41	1.46	1.51
	R_3	1.23	1.42	1.49	1.48
T_3	R_1	1.25	1.43	1.48	1.57
	R_2	1.29	1.42	1.48	1.53
	R_3	1.23	1.42	1.47	1.54

Appendix 9. Average live weight, eviscerated weight and dressing percentage of broiler chicken under different treatments

Treatment	Replication	live weight (g)	eviscerated weight(g)	dressing percentage (%)
T_0	R_1	1648.5	1025.5	62.20
	R_2	1596.3	1052.7	65.94
	R_3	1607.1	1018.3	63.36
T_1	R_1	1702.7	1160.2	68.14
	R_2	1557.2	1086.9	69.79
	R_3	1678.5	1066.7	63.55
T_2	R_1	1630.3	1145.7	70.27
	R_2	1671.3	1155.5	69.13
	R_3	1502.7	988.2	65.76
T_3	R_1	1604.2	1111.3	69.27
	R_2	1656.3	1128.7	68.14
	R_3	1593.3	1047.4	65.74

Appendix 10. Production performance of broiler chicken under different treatments

Treatment	Replication	final live weight (g/bird)	total FC (g/bird)	total BWG (g/bird)	final FCR	survivability (%)
T_0	R_1	1519.5	2299.9	1476.3	1.55	100
	R_2	1511.0	2288.8	1467.8	1.56	95
	R_3	1516.3	2300.1	1473.1	1.56	100
T_1	R_1	1637.0	2307.0	1583.8	1.44	100
	R_2	1603.6	2309.1	1560.4	1.48	100
	R_3	1625.0	2304.3	1581.8	1.45	100
T_2	R_1	1629.3	2306.6	1586.1	1.45	100
	R_2	1628.0	2309.4	1584.8	1.46	100
	R_3	1638.8	2309.9	1595.6	1.45	100
T_3	R_1	1614.0	2305.0	1570.8	1.46	100
	R_2	1597.6	2305.5	1554.4	1.48	100
	R_3	1612.0	2308.7	1568.8	1.47	100

Appendix 11. Effect of different treatments on carcass parameter of broiler chicks

Treatment	Replication	Eviscerated weight (%)	Giblet (%)	Breast meat (%)	Drumstick (%)	Edible (%)
T_0	R_1	59.20	7.4	33.8	16.4	66.75
	R_2	61.94	6.4	32.9	17.5	67.78
	R_3	58.36	8.4	34.5	16.5	66.90
T_1	R_1	65.14	7.7	35.4	17.3	72.70
	R_2	65.79	6.1	35.5	16.5	71.52
	R_3	66.54	6.4	34.4	17.2	72.81
T_2	R_1	67.27	6.3	36.6	17.5	73.81
	R_2	69.13	5.7	37.5	17.6	74.10
	R_3	68.76	5.5	37.9	16.4	73.78
T_3	R_1	67.27	6.4	36.7	17.4	73.99
	R_2	68.14	5.2	35.7	17.5	73.52
	R_3	65.73	6.7	36.2	16.5	71.59

Appendix 12. Weight of internal organs of broiler chicken under different treatment groups

Treatment	Replication	liver weight (g)	spleen weight (g)	gizzard weight (g)	heart weight (g)
T_0	R_1(1)	39.0	3.5	40.5	5.5
	R_1(2)	37.0	3.3	43.5	7.8
	R_1(3)	54.3	2.5	39.5	7.5
	R_2(1)	37.5	1.8	49.0	8.3
	R_2(2)	35.7	1.4	44.6	7.6
	R_2(3)	34.5	2.5	38.3	10.9
	R_3(1)	34.2	1.5	49.1	6.5
	R_3(2)	39.1	1.5	25.7	7.5
	R_3(3)	35.8	2.0	41.0	6.5
T_1	R_1(1)	38.5	3.0	38.5	5.7
	R_1(2)	35.5	1.5	40.5	6.2
	R_1(3)	34.5	1.5	42.5	5.4
	R_2(1)	33.6	2.2	36.8	7.2
	R_2(2)	38.2	2.6	39.5	5.5
	R_2(3)	34.5	1.5	41.0	6.6
	R_3(1)	32.3	1.6	39.2	5.9
	R_3(2)	34.5	1.5	36.2	6.2
	R_3(3)	29.3	1.6	35.5	4.7
T_2	R_1(1)	37.5	3.5	29.5	6.4
	R_1(2)	32.5	2.0	34.5	6.2
	R_1(3)	34.3	2.0	53.0	7.5
	R_2(1)	32.5	1.5	32.0	4.7
	R_2(2)	30.8	1.0	28.5	6.2
	R_2(3)	34.6	2.0	39.0	5.5
	R_3(1)	33.2	1.5	29.0	5.3
	R_3(2)	25.5	1.3	34.5	5.4
	R_3(3)	30.0	1.2	47.0	6.5
T_3	R_1(1)	34.4	1.5	46.0	6.0
	R_1(2)	40.0	3.0	33.5	7.6
	R_1(3)	31.1	1.5	32.0	6.7
	R_2(1)	31.5	2.5	38.5	5.3
	R_2(2)	29.8	1.0	34.2	6.5
	R_2(3)	28.6	1.0	33.0	5.8
	R_3(1)	31.4	1.5	33.0	4.8
	R_3(2)	34.0	0.5	22.5	6.4
	R_3(3)	35.0	2.0	35.0	6.9

Appendix 13. Economic impact of treatments on broiler production

Treatment	Replication	feed cost (BDT) per bird	cost of yucca extract (BDT) per bird	common expenditure (BDT) per bird	total expenditure (BDT) per bird
T_0	R_1	97.1	0	68.33	165.43
	R_2	98.1	0	68.33	166.43
	R_3	97.9	0	68.33	166.23
T_1	R_1	98.8	1.83	68.33	167.73
	R_2	97.8	1.83	68.33	169.23
	R_3	98.5	1.83	68.33	168.63
T_2	R_1	98.7	1.50	68.33	168.53
	R_2	98.8	1.50	68.33	168.63
	R_3	98.1	1.50	68.33	167.93
T_3	R_1	97.4	1.17	68.33	168.13
	R_2	98.9	1.17	68.33	167.13
	R_3	98.3	1.17	68.33	167.83

Production cost of the birds at 28 days of rearing period.

Parameter	Amount (BDT)
Day old chick cost (240 no.)	7200
Feed cost (10 bag)	21500
Litter cost	4200
Yucca extract (Bio-Ade super) cost (100 ml bottle)	250
Ammonia test kit cost	1000
Medicine cost	500
Vaccine cost	1000
Others cost	3000
Total	**38,150/-**

Appendix 14: Selling price of the birds uner different treatment groups

Treatment	Replication	average live body weight /bird (Kg)	selling price (BDT) per bird (130 Tk/ Kg live weight)	selling price (Tk) per replication (20 Birds)
T0	R1	1.519	197.53	3950.79
	R2	1.511	196.43	3928.63
	R3	1.516	197.12	3942.38
T1	R1	1.637	212.81	4256.24
	R2	1.604	208.46	4169.36
	R3	1.625	211.25	4225.07
T2	R1	1.629	211.80	4236.23
	R2	1.628	211.64	4232.82
	R3	1.639	213.04	4260.86
T3	R1	1.614	209.82	4196.43
	R2	1.598	207.68	4153.81
	R3	1.612	209.56	4191.24

Appendix 15: Net return of the birds under different treatment groups

Treatment	Replication	receipt per bird when sold (130 BDT/ Kg live weight)	profit per bird (BDT)	Benefit Cost Ratio
T0	R1	197.53	32.10	1.19
	R2	196.43	30.00	1.18
	R3	197.11	30.88	1.18
T1	R1	212.81	42.09	1.25
	R2	208.46	41.45	1.23
	R3	211.25	43.93	1.24
T2	R1	211.80	43.27	1.25
	R2	211.64	43.01	1.25
	R3	213.04	45.11	1.26
T3	R1	209.81	42.68	1.24
	R2	208.46	41.33	1.24
	R3	209.25	41.42	1.25