COMPARISON OF ACIDIC AND ALKALINE WATER ON THE GROWTH PERFORMANCE AND CARCASS CHARACTERISTICS OF COMMERCIAL BROILER

A THESIS

BY

ESARATUZ ZAHAN EMA

Registration No. 1504035

Semester: July-December, 2023

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MASTER OF SCIENCE (MS)

IN

POULTRY SCIENCE

DEPARTMENT OF DAIRY AND POULTRY SCIENCE

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJPUR – 5200

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DEPARTMENT OF DAIRY AND POULTRY SCIENCE

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DEDICATED TO

MY

BELOVED PARENTS

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The author

ABSTRACT

This study was conducted to determine the comparative effects of acidic and alkaline drinking water containing Acetic acid and Sodium Bicarbonate on growth performance, feed conversion ratio (FCR), livability, mortality and carcass traits in commercial broilers. The study location was the Central Poultry farm of Hajee Mohammad Danesh Science and Technology University, Dinajpur, from 16 August to 12 September (28 days), 2023. A total of 210, day old broiler chicks (Efficiency Plus-Hubbard) were randomly and equally distributed to 7 groups having 3 replicates of 10 birds in each. The birds were grouped as T_0, T_1, T_2, T_3, T_4, T_5 and T_6 group of which T_0 was with normal water (control group) and T_1, T_2 and T_3 drinking water was treated with 0.25ml/L, 0.33ml/L and 0.5ml/L Acetic Acid respectively. T_4, T_5 and T_6 group was treated with Sodium Bicarbonate Powder at the rate of 0.5gm/L, 1gm/L and 1.5gm/L drinking water. Data were analyzed by using ANOVA with SPSS version 22. The highest environmental temperature during research period was 38.7^0C with 96% humidity. The feed intake (gm/broiler) at the age of 28 days in T_0, T_1, T_2, T_3, T_4, T_5 and T_6 was 2327.33, 2362.33, 2330.66, 2323.00, 2235.33, 2412.00 and 2293.33, respectively. The live body weight in T_0, T_1, T_2, T_3, T_4, T_5 and T_6 was 1609.00, 1772.00, 1741.33, 1698.00, 1653.33, 1727.00 and 1629.33, respectively. The feed conversion ratio (FCR) in T_0, T_1, T_2, T_3, T_4, T_5 and T_6 was 1.44, 1.33, 1.34, 1.36, 1.35, 1.39 and 1.40, respectively. The carcass weight in T_0, T_1, T_2, T_3, T_4, T_5 and T_6 was 986.00, 1051.33, 1041.33, 1022.00, 995.33, 1036.00 and 1002.00, respectively. In T_0, T_1, T_2, T_3, T_4, T_5 and T_6 livability was 93.33%, 100%, 96.67%, 100%, 96.67%, 96.67% and 93.33% respectively and mortality was 6.67%, 0.00%, 3.33%, 0.00%, 3.33%, 3.33% and 6.67% respectively. Considering the above facts it may be concluded that Acetic Acid is better than Sodium Bicarbonate in production performance of commercial broiler and specifically supplementation of 0.33ml/L of Acetic Acid had positive significant effect on feed intake, live body weight, carcass weight, FCR, livability and mortality. Therefore, Acetic Acid can be used in broiler diet for better performance than Sodium Bicarbonate.

Keyword: Acetic acid, Sodium Bicarbonate, Broiler, FCR, Livability, Mortality.

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CHAPTER 1

INTRODUCTION

The demand for broiler chickens is increasing worldwide and efforts are being made to produce broiler chickens of heavy body weight at a short period of time. This is to reduce cost of production and mortality due to long confinement of broilers in congested environment which modern broiler production is known. Though good feed and ad libitum feeding have been suggested as good management practices to achieve this (Oluyemi and Roberts, 2000) but due to challenges posed by both the micro and macro environment of the chicken, extra nutritional strategy is required. This is because though good feed and ad libitum feeding are essential for adequate growth, it may not guarantee adequate utilization of the feed by the chicken. One of the nutritional strategies towards enhancing the rapid growth of broilers had been the addition of additives like the pharmaceutical antibiotics to feed (Windisch *et al.*, 2007). But recent concerns about the antibiotics resistance in livestock industry have indicated the need for alternative strategies to improve animal health and performance without the use of antibiotics (Chen *et al.*, 2005). Some dietary products are there for being evaluated to replace antibiotics in poultry diets. These products include probiotics, prebiotic (Patterson and Burkholder, 2003), yeast culture (Gao *et al.*, 2008; Oyede *et al.*, 2008), essential oils, spices, herbs and organic acids. Organicacids (carboxylic acids) have been used for decades in feed preservation, protecting feed from bacterial and fungal destruction (Paul *et al.*, 2007). Evidence of potentials of organic acids to support growth of broilers has been reported to be due to their antibacterial effect and stimulation of villi growth (Canibe *et al.*, 2008).

Poultry sector is one of the most vibrant segments of agriculture sector in Bangladesh. Currently, drinking water acidification is another implementation in the broiler industry used for improving performance (Cornelison *et al.*, 2005). Organic acids are widely accepted as an alternative to in-feed antibiotics in poultry production, the addition of organic acid to the drinking water helps to reduce the level of pathogens in the water crop and proventriculus, to regulate gut microflora, to increase the digestion of feed and to improve growth performance (Philipsen, 2006) and used for dual purposes-as feed preservatives as well as growth promoters. Reducing the pH of the feed organic acids can decrease bacterial contamination of feeds prior to consumption by birds, making them useful as feed preservatives. Hudha *et al.*, (2010) showed the supplementation of acetic acid in drinking water might improve growth, feed conversion and meat yield of broilers, such an improvement in biological performance would be counteracted by the cost of acetic acid making poultry rearing non-profitable. Supplementing layer feed with acetic acid may provide an effective, cost efficient method of achieving significant reductions in the negative effects of heat-stress, resulting in major improvements in egg production and quality, according to Anitox, a world-leader in pathogen elimination and mould control products for the feed milling and primary meat, egg and fish production industries, Acetic acid is an organic acid which is used primarily to control mold and reduce bacterial growth in feed, but it can also inhibit the growth of micro-organisms in the gastrointestinal tract, modify pH levels and improve feed utilization (Cooksley, 2011).

It has been estimated that there will be a lack of clean water in almost half of the world by 2025 (Micciche *et al.,* 2018). Water is the most important nutrient and is physiologically required in all animals, including poultry. Therefore, the quantity and quality of water should be supplied daily according to the age and breed of the birds to maintain all physiological functions. Moreover, from a health perspective, the amount of water consumed on a daily basis by commercial poultry birds is considered as a prime indicator (Manning *et al.,* 2007). In addition to the production perspective, providing adequate and good quality water is listed as a basic animal welfare criterion (NCC, 2010). The use of acidifiers in poultry is relatively new. Almost all acidifiers were considered safe for animal use. A wide range of acidifiers with variable physical and chemical properties are available for poultry, many of which are used in the drinking water or mixed with the feed (Menconi *et al.,* 2014). It has been documented that the use of acidifiers benefit the young chickens by their role in competitive exclusion, improving intestinal health and nutrient utilization, and the performance of birds (Saki *et al.,* 2012). The acidifiers penetrate the cell wall of certain bacteria in non-dissociated form and disrupt their physiology (Dhawale, 2005). Besides antimicrobial activity, acidifiers decrease gut pH, increase secretions from pancreas and exert trophic impact on mucosa of gastro-intestinal tract (Dibner and Buttin, 2002).

Birds are able to maintain their body temperature within narrow limits and an increase in body temperature due to higher ambient temperature or excessive metabolic activities may cause irreversible thermoregulatory events that could be harmful to the existence of the birds (Abbas *et al.,* 2017). Different researchers have found good result on the performance by the supplementation of AA in chickens and heat stress has shown detrimental effects on feed intake, growth and feed conversion ratio of the birds (Mohammed *et al.,* 2018). This reduction of performance might be explained by decreased digestibility of nutrients, increased heat production and reduced protein retention (Orhan *et al.,* 2018). Birds exposed to heat stress has shown reduced amylase and maltase activities, decreased protein and amino acid digestibility of complete diets and individual feed ingredients (Bayati *et al.,* 2017) and reduced minerals absorption. The gastrointestinal size was also reported to decrease in heat-exposed chickens (Orhan *et al.,* 2018).

Sodium bicarbonate ($NaHCO_3$) is a white solid crystalline compound soluble in water, which is commonly used as an antacid to treat acid indigestion. It is commonly added as a simple solution for restoring the pH of water that has a high level of chlorine. Sodium bicarbonate in feed or water has shown potential benefits on production performance egg characteristics (Jiang *et al.,* 2015) and blood profile in poultry birds exposed to heat stress.

As water is an important nutrient which helps in the assimilation of feed, if consumed less may lead to poor digestion of feed. (Borges *et al.,* 2004) reported that ambient temperature and diet can influence the acid base balance in poultry. Moreover, the forages of tropical locations are often low in their Na content than the plants produced in the temperate zones of the world. So far as the animal class and physiology status is concerned the rapidly growing and high producing animals require more NaCl. It may be assumed that whether it is hot or cold, under both condition birds can lose its sodium content of diet. Sodium (Na+) is a least expensive nutrient and its dietary change does not bring any major effect on feed price. Insufficient Na lowers the utilization of digested protein and energy. Sodium requirement for growing chicken is 0.15% according to the recommendation of NRC (1994). Na requirement for the best chicken performance was estimated 0.20% of ration from 21 to 49 d of age and 0.15% from 42 to 56 d of age. The same authors reported no difference between NaHCO3 and NaCl as Na sources. Whereas requirement of Na+ for maximum body weight gain (BWG) and for the best feed conversion ratio (FCR) was estimated 0.25% and 0.29%, respectively. As described by previous workers sodium is a mineral with important physiological functions. Optimum dietary balance of this mineral allows better chicken performance and may reduce leg problems. To determine nutritional requirements it is important to keep this balance. The NRC (1994) recommended a minimum requirement of 0.15% Na. for young broiler chickens. Sodium bicarbonate (SBC) has advantage over sodium chloride because it provides sodium, which favorably affects blood pH and supplies beneficial bicarbonate. A survey of SBC use in broiler feeds in Western Europe reported that “0.2% was the most common level used, in conjunction with 0.1% added NaCl; and the main purpose was to lower dietary chloride and reduce wet litter problems (Merrill, 1993). Optimal levels of dietary SBC is reported to be 0.20 to 0.30% for broilers fed ionophores, grown on built-up litter, and given a coccidial inoculation, based on significant improvements in weights, feed efficiencies, coccidial lesion scores, mortalities, and carcass yields, compared to control results in several dose response studies (Hooge *et al.*, 1999).

Objectives

With aforesaid ideas in consideration, the current study was undertaken the following objectives.

1. To evaluate the comparative efficacy of Acetic acid and Sodium Bicarbonate on the growth performance and carcass characteristics of commercial broiler.
2. To achieve economic broiler production without using antibiotics.
3. To determine the cost benefit ratio.

CHAPTER 2

REVIEW OF LITERATURE

In the review of literature there is discussed about Acetic acid as a source of acidic supplement and Sodium Bicarbonate as a source of alkali thoroughly.

2.1 Nomenclature of Acetic acid

Acetic acid systematically named ethanoic acid is an acidic, colourless liquid and organic compound with the chemical formula CH_3COOH (also written as CH_3CO_2H, $C_2H_4O_2$, or $HC_2H_3O_2$). Vinegar is at least 4% acetic acid by volume, making acetic acid the main component of vinegar apart from water. It has been used, as a component of vinegar, throughout history from at least the third century BC. The trivial name "acetic acid" is the most commonly used and preferred IUPAC name. The systematic name "ethanoic acid", a valid IUPAC name, is constructed according to the substitutive nomenclature. The name "acetic acid" derives from the Latin word for vinegar, "*acetum*", which is related to the word "acid" itself.

"Glacial acetic acid" is a name for water-free (anhydrous) acetic acid. Similar to the German name "Eisessig" ("ice vinegar"), the name comes from the solid ice-like crystals that form with agitation, slightly below room temperature at 16.6 °C (61.9 °F). Acetic acid can never be truly water-free in an atmosphere that contains water, so the presence of 0.1% water in glacial acetic acid lowers its melting point by 0.2 °C (Armarego *et al.*, 2009).

2.2 History of acetic acid

Vinegar was known early in civilization as the natural result of exposure of beer and wine to air, because acetic acid-producing bacteria are present globally. The use of acetic acid in alchemy extends into the third century BC, when the Greek philosopher Theophrastus described how vinegar acted on metals to produce pigments useful in art, including *white lead* (lead carbonate) and *verdigris*, a green mixture of copper salts including copper (II) acetate. Ancient Romans boiled soured wine to produce a highly sweet syrup called sapa. Sapa that was produced in lead pots was rich in lead acetate, a sweet substance also called sugar of lead or sugar of Saturn, which contributed to lead poisoning among the Roman aristocracy (Martin, 1917).

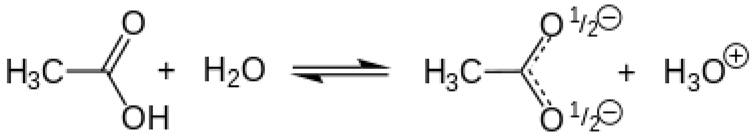
In the 16th- century German alchemist 'Andreas Libavius' described the production of acetone from the dry distillation of lead acetate, ketonic decarboxylation. The presence of water in vinegar has such a profound effect on acetic acid's properties that for centuries chemists believed that glacial acetic acid and the acid found in vinegar were two different substances. French chemist Pierre Adet proved them identical (Martin, 1917 and Adet, 1798).

2.3 Properties of acetic acid

The hydrogen centre in the carboxyl group (−COOH) in carboxylic acids such as acetic acid can separate from the molecule by ionization:

$CH_3COOH \rightleftharpoons CH_3CO{-}2 + H^+$

Because of this release of the proton (H^+), acetic acid has acidic character. Acetic acid is a weak monoprotic acid. In aqueous solution, it has a pK_a value of 4.76. Its conjugate base is acetate (CH_3COO^-). A 1.0 M solution (about the concentration of domestic vinegar) has a pH of 2.4, indicating that merely 0.4% of the acetic acid molecules are dissociated. However, in very dilute (< 10^{-6} M) solution, acetic acid is >90% dissociated.



2.4 Uses of acetic acid

Acetic acid is a chemical reagent for the production of chemical compounds. The largest single use of acetic acid is in the production of vinyl acetate monomer, closely followed by acetic anhydride and ester production. The volume of acetic acid used in vinegar is comparatively small (Cheung, 2000).

2.4.1 Vinyl acetate monomer

The primary use of acetic acid is the production of vinyl acetate monomer (VAM). In 2008, this application was estimated to consume a third of the world's production of acetic acid (Cheung, 2000). The reaction consists of ethylene and acetic acid with oxygen over a palladium catalyst, conducted in the gas phase (Roscher, 2000).

2.4.2 Ester production

The major esters of acetic acid are commonly used as solvents for inks, paints and coatings. The esters include ethyl acetate, n-butyl acetate, isobutyl acetate, and propyl acetate. They are typically produced by catalyzed reaction from acetic acid and the corresponding alcohol.

2.4.3 Acetic anhydride

The product of the condensation of two molecules of acetic acid is acetic anhydride. The worldwide production of acetic anhydride is a major application, and uses approximately 25% to 30% of the global production of acetic acid. The main process involves dehydration of acetic acid to give ketene at 700–750 °C. Ketene is thereafter reacted with acetic acid to obtain the anhydride (Held *et al.,* 2000).

2.4.5 Solvent

As a polar protic solvent, acetic acid is frequently used for recrystallization to purify organic compounds. Acetic acid is used as a solvent in the production of terephthalic acid (TPA), the raw material for polyethylene terephthalate (PET). In 2006, about 20% of acetic acid was used for TPA production (Held *et al.,* 2000).

2.4.6 Medical use

Acetic acid injection into a tumor has been used to treat cancer since the 1800s (Barclay, 1866 and Shibata, 1998)

Acetic acid is used as part of cervical cancer screening in many areas in the developing world. The acid is applied to the cervix and if an area of white appears after about a minute the test is positive (Fokom-Domgue *et al.,* 2015).

Acetic acid is an effective antiseptic when used as a 1% solution, with broad spectrum of activity against streptococci, staphylococci, pseudomonas, enterococci and others. It may be used to treat skin infections caused by pseudomonas strains resistant to typical antibiotics (Nagoba *et al.,* 2013).

2.4.7 Foods

Acetic acid has 349 kcal (1,460 kJ) per 100 g. Vinegar is typically no less than 4% acetic acid by mass. Legal limits on acetic acid content vary by jurisdiction. Vinegar is used directly as a condiment, and in the pickling of vegetables and other foods. Table vinegar tends to be more diluted (4% to 8% acetic acid), while commercial food pickling employs solutions that are more concentrated. The proportion of acetic acid used worldwide as vinegar is not as large as commercial uses, but it is by far the oldest and best-known application (Armstrong *et al.,* 1964).

2.5 Effect of acetic acid (AA) on feed intake

Ndelekwute *et al.,* (2011) reported that improved Final weight observed could be connected to the better nutrient digestibility. Other reported factors that could have resulted to this include reduction in gram negative pathogenic bacteria populations in the gut and the pH. Positive effect of organic acids fed through drinking water on body weight as observed in this study has been reported (Leeson *et al.,* 2005; Oviedo, 2006; Islam *et al.,* 2008). Organic acids did not significantly (P>0.05) influence feed intake (Leeson *et al.,* 2005) feeding 0.2% butyric acid through the drinking water observed no significant difference in feed intake. However, at 0.4% they noticed a significant reduction in feed intake. Contrary to this result, acetic and citric acids were reported to favour feed intake when added to the drinking water (Islam *et al.,* 2008). There were no significant differences (P>0.05) in daily feed intake indicating that the organic acids except butyric acid achieved better final weight over the control without significant increase in feed intake. Hence, it could be opined that apart from feed intake which is known to have significant influence on body weight, other factors such as conditions of the gut ecosystem (such as microbiota population and endogenous secretions which influence nutrientutilization) could have influenced the growth performance of the birds.

Leeson *et al.,* (2005) indicated that organic acids in drinking water improved final weight with insignificant feed intake. However, low feed intake resulting to poor growth was reported by Oviedo (2006). Feed: gain ratio was significantly (P<0.05) better in acetic, citric and formic acids than in the control and butyric acid groups. The superior feed: gain ratios reflected in their final body weight. Butyric acid group and the control statistically posted the same values. (Lesson *et al.,* 2005) had also reported better feed: gain ratio of birds feed formic acid treated water. Though protein intake was not significant, addition of acetic, citric and formic acids significantly influenced protein utilization ($P<0.05$).

Oluyemi and Roberts, (2000), reported that birds that consumed acetic, citric and formic acid significantly ($P<0.05$) utilized protein better than the control and butyric acid treated group. Both the control and butyric acid had similar protein efficiency ratios. The improved final weight of acetic, citric, and formic acids could be linked to the efficient utilization of protein. The importance of protein for the growth performance of young broiler chicks has been stressed. The reduction in feed intake (g / chicks / d) was noticed during the starter and finisher period, this may be due to the decrease in palatability of acidified diets during experimental diets. They had a low tendency to free their $H+$ ions and thus tended to have a strong taste associated with them which might have decrease the palatability feed and resulted in reduced feed intake Abdel Fattah *et al.*, (2008); Adil *et al.*, (2010) and Allahdoa *et al.*, (2018). Also, organic acids increase the availability of nutrients from the feed which in turn decrease the feed consumption (sultan *et al.*, (2015).

Abdel Razek *et al.*, (2016) reported that chicks fed diets supplemented citric acid and acetic acid significantly consumed less feed ($P \leq 0.05$) compared to control group. It was observed that the lowest ($P \leq 0.05$) amount of feed intake was recorded for birds fed diets containing (1.61 and 1.70) of CA and (1.98 and 2.30) of AC. (Ali *et al.*, (2019); Mirdrikvandi *et al.*, (2019 and Stamilla *et al.*, (2020) reported decreased feed intake with higher level of organic acids such as citric and acetic acids application. Wickramasinghe *et al.*, (2014), Seifi *et al.*, (2015) and Araujo *et al.*, (2018) reported that adding different levels of citric acid and acetic acid to broilers did not have effect on feed intake.

2.6 Effect of acetic acid on water intake

Marco, (2008) and Islam *et al.*, (2008) reported that the ability of the organic acids in drinking water to increase water consumption. Using butyric acid as a drinking water sanitizer, (Leeson *et al.*, 2005) observed increased water intake at 0.1%, non significant effect at 0.2% and reduced water intake at 0.4%. This is an expression that effect of organic acids is depended on their concentration in water and relative to the acid. This reduction could have emanated from the foul odour (butyric acid treated water smelled like fermented cassava) produced by butyric acid. Generally, the performance of the organic acid fed-birds could be ascribed to the reported capacity of organic acids in general to sanitize water, activate pancreatic activities (Dibner, 2004). Daily water intake was significantly ($P<0.05$) lowered by butyric, citric and formic acids. There was no significant difference ($P>0.05$) between that of the control and acetic acid. Control group significantly ($P<0.05$) produced the highest water: feed ratio.

Oviedo, (2006), reported that within the organic acid groups, butyric acid had the least, while that of acetic, citric and formic acids were statistically the same. The reduction in water consumption by birds fed acid treated water could be ascribed to change in taste. Butyric and formic acids were reported to add strong taste to drinking water.

2.7 Effect of acetic acid on body weight

The positive effect of providing acidified drinking water on growth performance of broiler chicken may be due to the relatively healthy intestinal tract of the chickens. The drinking water has been suggested a prominent risk factor for the spread of microbial infection in broiler flocks (Gibbens *et al.*, 2001). Indeed Chaveerach *et al.*, (2004) reported that drinking water supplemented with organic acids could prevent bacterial infection in chickens as the organic acids in drinking water were able to keep the water free from pathogenic organism. Griggs and Jacob (2005) also confirmed that the organic acids have the potential to reduce bacterial colonization in the gut of poultry. There is a possibility that the improvement may be associated with improvement in nutrient digestibility as organic acid supplementation has been attributed to a positive effect on the ileal digestibility of nutrients (Hernndez *et al.*, 2006).

Drinking water supplementation of organic acids has been effective in reducing pathogens in the water and the digestive tract, regulating gut microflora, increasing feed digestion and improving growth performance (Philipsen, 2006). Providing organic acids in the water for broilers resulted in increased body weight compared to the broilers offered normal drinking water (Pesti *et al.*, 2004). It has also been reported that organic acids in drinking water administered during feed withdrawal reduced Campylobacter contamination in the crop and carcass (Byrd *et al.*, 2001).

Recently, organic acids were reported to improve both digestibility and growth of broiler chickens when added to the feed at the starter phase (Ndelekwute *et al.*, 2010; Ndelekwute *et al.*, 2011). More also, some other reports on effectiveness of organic acids to enhance the growth of broiler chickens showed that feeding of birds with treated diets started at the starter phase was feasible (Leeson *et al.*, 2005; Paul *et al.*, 2007). The conventional way of feeding organic acids has been through the feed hence it has been suggested that drinking water for birds should be sanitized with organic acids for better performance (Marco, 2008).

2.8 Effect of acetic acid on body weight gain

The improvement in body weight (BW), body weight gain (BWG) and ADG of broilers fed diet contain of citric acid, acetic acid or their mixture may be due to the following reasons a) acetic acid acts on pepsinogen and convert it to pepsin and increased the activity of pepsin and improves protein digestibility in broiler chicks. b) the antimicrobial property and low pH of organic acid inhibits the pathogenic intestinal bacteria and decreases the level of toxic bacterial products. So, energy and protein digestibility were improved (Adil *et al.,* 2011 and Sultan *et al.,* 2015), c) organic acids improve the protein digestibility by decreasing endogenous nitrogen losses and production of ammonia as well as other growth depressing metabolites (Dibner and Buttib 2002) d) intestinal cell proliferation and hence more available nutrients for absorption (Samanata *et al.,* 2010), and the acidic condition increases the nutrients availability for better performance (Boling *et al.,* 2001). Acetic acid has more effects on performance of broiler, addition of acetic acid to mash diet may lead to increase in palatability and improve mixing ration items (Mohammadagheni *et al.,* 2016). Youssef *et al.,* (2017) recorded that an improvement in BW and BWG for birds fed diets supplemented with organic acids meantime the growing period, which was due to the effect of keeping the beneficial bacteria population, improving nutrient digestion and may be impact the safety of microbial cell membrane or prohibit the nutrient transport and energy metabolism causing the bactericidal effect (Ricke, 2003). Many investigators reported that single or mixture of organic acid (CA and AC) can improve performance of chicks and had a significant effect of mean BW, WG and ADG on broiler chicks (Sabour *et al.,* (2019); Adhikari *et al.,* 2020; Sharifuzzaman *et al.,* 2020 and Stamilla *et al.,* (2020). On the other hand, Flamand *et al.,* (2014) showed that organic acid (citric and acetic acids) addition to the corn- soybean diet did not affect chick body weight, body weight gain and average daily gain.

2.9 Effect of acetic acid on feed conversion ratio (FCR)

A modernistic challenge in the poultry production is to exploit the use of specific dietary supplements to boost the intrinsic potential of poultry for better growth. The nutritional and health status of birds are largely influenced by their gut health, which affects digestion, absorption, and metabolism of nutrients, as well as disease resistance and immunity (Yegani and Korver, 2008). High levels of production and efficient feed conversion are critical to modern poultry industry, which could be achieved by using specific feed additives. Some of the commonly used feed additives are organic acids, probiotics, prebiotics, medicinal extract and exogenous enzymes. These feed additives were used as antimicrobial, antioxidants, emulsifiers, binders and pH control agents in the poultry diet (Attia *et al.,* 2018 and Adhikari *et al.,* 2020).

Acetic acid are among greater attention for poultry industry (Kral *et al.,* 2011 and Mohammadi *et al.,* 2018). It is generally belived that use of acetic acid in broiler diets may inhibit pathogens like salmonella in both raw material and feed. The lower PH created can protect the animal from infection especially at their younger ages (Mohammadi *et al.,* 2018). Acetic acid at a wide dose range from 0.5 to 5% has been implemented in diets for broiler chickens which mainly reduced growth of many pathogenic or non- pathogenic intestinal bacteria, therefore, reduced the risk of intestinal colonization and infectious processes, ultimately decrease inflammatory processes at intestinal mucosa, a phenomenon which in turn, increase villus highet and function of secretion, digestion and absorpition of nutrients by the mucosa (Pelicano *et al.,* 2005). Acetic acid (AC) supplementation in diet improves growth performance (Seifi *et al.,* 2015 and Abdel Razek *et al.,* 2016), quicken intestinal tissue, resulting in changes in villus width, height and area of the duodenum, jejunum and ileum, which all are the promising factors for the better intestinal health and nutrient digestion and absorpition (Mohammadagheni *et al.,* 2016 and Saleem *et al.,* 2016). Citric acid (CA) and acetic acid (AC) have been used in diets due to their positive effect on bird's health and growth (Islam *et al.,* 2008).

The significant improvement in FCR by the addition CA and AC may be due to: a) organic acids as the plays a very important role that acidification increasing gastric proteolysis and protein / amino acid digestibility by enhancing digestive system enzyme activities (Langhout, 2000). The reason why protein is better used when CA is added to diets is due to the fact that pepsinogen is converted to pepsin, which increases pepsin activity and improves protein digestibility. Morever, peptides a rising from pepsin proteolysis trigger the release of hormones (including gastrin and cholecystokinin) which regulate the digesion and absorption of protein, b) organic acids due to the increasing efficiency of nutrients (Chowdhury *et al.,* 2009), c) the numerical reduction in feed intake and concomitent increase in BWG (Dehghani and Jahanian 2012) and d) organic acids due to the metabolic role of CA and AC in many metabolic path ways (Attia *et al.,* 2013).

(Adil *et al.,* 2011; Sultan *et al.,* 2014; Banday *et al.,* 2015), who reported that the addition of acidifiers and sanitizers improved the feed conversion ratio in poultry birds. The improvement in the FCR could possibly be due to better use of nutrients, which leads to in increased body weight gain in the birds since the water was used based on acidifying and sanitizer agents.

2.10 Effect of acetic acid on mortality and survivability

Allahdoa *et al.,* (2018); Adhikari *et al.,* (2020) and Stamilla *et al.,* (2020) observed that overall mortality was lower in organic acid supplementation compared to control groups. Generaly the positive impact of dietary organic acids as citric acid (CA), acetic acid (AC) or their mixture on growth performance may be attributed to: a) A reduction of the pH values in the feed and digestive tract, serving as a barrier against pathogenic micro - organisms which are sensitive to low pH values. b) The direct antimicrobial effect. Our results are disagree with the results of (Flamand *et al.,* 2014 and seifi *et al.,* 2015) who reported that there were no significant differences in mortality rate by adding levels of organic acids (0.5, 1, 1.5 and 2%) than control group during 22- 42 d. in broiler chickens.

2.11 Effect of acetic acid on carcass traits

Organic acid treatments composed of individual acids or blends of several acids to perform antimicrobial activities similar to those of antibiotics (Wang *et al.,* 2009). The European Union allowed the use of organic acids and their salts in poultry production because these are generally considered safe (Adil *et al.,* 2010). Organic acids are week acids, which modulate the intestinal pH. When these compounds are used correctly a long with good nutritional, management and biosecurity measures, they could be a powerful tool in maintating the health of the gastrointestinal tract (GIT) in poultry thus improving the performance (Sabour *et al.,* 2019 and Adhikari *et al.,* 2020). Organic acids had higher globulin concentration and better immune response and reduced serum cholesterol and total lipid (Youssef *et al.,* 2017; Ali *et al.,* 2019 and Mirderikvandi *et al.,* 2019).

Adil *et al.,* (2011) also reported that acidifiers resulted in remarkable increase in the intestinal weight and length of broiler chicken. These results could be attributed to the fact that acidifiers have direct stimulatory effect on the gastro-intestinal cell proliferation as was reported by other workers with short chain fatty acids. The short chain fatty acids are believed to increase plasma glucagon-like peptide 2 (GLP-2) and ileal pro-glucagon mRNA, glucose transporter (GLUT2) expression and protein expression, which are all signals which can potentially mediate gut epithelial cell proliferation (Le Blay *et al.,* 2000 and Fukunaga *et al.,* 2003) also reported that short chain fatty acids can accelerate gut epithelial cell proliferation, thereby increase improve intestinal morphology. Besides antibacterial activity, this improved intestinal morphology effect augments performance of birds by improved digestion of nutrients.

The relative increase in weight organs of bursa, spleen and two primary lymphoid organs were conciderd as an indication of immunological advances. The establishment of immune response associated with dietary acidification could be on account for their inhibitory effects against the pathogenic microorganisms throughout the GI tract providing scope for improved nutrient absorption. The higher immunity due to organic acids can also be attributed to higher nutrient efficiency, which might have triggened immunogenic cells to record higher immune response (Ram Rao *et al.,* 2004). The results of the peresnt experiment reported herein were also in agreement with those of (Mohammadi and Khosravinia, 2015) and Attia *et al.,* (2018) who noted that the use of organic acid leads to an increase in the number of contributing cells in immune and then increase the bursa of fabricius weight.

2.12 Antimocrobial effect of acetic acid

A significant decrease in the number of total and gram-negative bacteria has been reported when using acidifiers (Gunal *et al.*, 2006). (Samanta *et al.,* 2010) also reported that acidifiers reduce E. coli and other harmful bacteria which may enhance poultry growth. Antibacterial effect of acidifiers has been associated with the fact that undissociated organic acids pass through the cell membrane of the bacteria and afterward dissociate forming H + ions and this, in turn, decreases the pH value of the bacterial cell. In order to restore the normal balance, bacteria use its energy. Whereas RCOO- anions produced from the acid can disrupt DNA, hampering protein synthesis and putting the organism in stress. As a result the organism cannot multiply rapidly and decrease in number. The use of acidifiers resulted in decreased pH in crop and duodenum of broiler chicken. The reduced pH is helpful for the growth of favorable bacteria and at the same time prevented the growth of harmful bacteria which require a relatively higher pH for growth (Adil *et al.,* 2011).

The poultry scientists are searching for alternatives to antibiotics such as organic acids, prebiotics, probiotics and plant extracts that can give similar results in the prevention or control of infectious diseases and ultimately promote growth and improve feed efficiency. In poultry organic acids are not only used as growth promoter but also are helpful in controlling entrintic bacteria, both pathogenic and non-pathogenic (Wolfenden *et al.,* 2007). In addition organic acids have ability to lower the pH of chyme and improve the digestion of protein (Gauthier, 2002). Reduction in gastric pH increases pepsin activity (Afsharmanesh and Pourreza, 2005). Peptides in turn activate the release of hormones, including gastrin and cholecystokinin, which regulate the digestion and absorption of protein (Hersey, 1987). Therefore, acid anions have been shown to make complex with calcium, phosphorous, magnesium and zinc which results in an improved digestibility of minerals like Ca, P, Mg and Zn (Kishi *et al.,* 1999). Organic acids like acetic, butyric, lactic and propionic are produced by anaerobic, facultative and obligative micro-flora in the GI-tract which decreases pH of the tract and thus they provide protection against pathogens. One of the main factors governing bird's performance is gut health and hence profile of gut microflora of poultry plays a significant role in gastro intestinal tract health (Samik *et al.,* 2007). Single organic acid or the combination of organic acids increases the average daily weight gain, average live weight, average daily feed consumption and decreases mortality rate (Al-Kassi and Mohssen, 2009). Organic acid blend is considered to decrease the feed intake, increases body weight and weight of internal organs (Akyurek *et al.,* 2011). Furthermore, organic acids are added in poultry feed either in uncoated form or in coated form. Uncoated forms of organic acids are thought to exert their action mainly in feed by stopping the growth of moulds and thus preventing the feed from fungal destruction and in the upper portion of the digestive tract like crop due to their rapid absorption. This may limit the horizontal transmission pathogenic bacteria like Salmonella. Drinking water acidification is used for improving growth performance of broilers (Cornelison *et al.,* 2005). Addition of organic acid to drinking water reduces the load of pathogens in water and crop or proventriculus and regulate gut microflora to increase digestion of feed and ultimately improve the growth performance (Philipsen, 2006). Combination of formic and propionic acids in drinking water improve weight gain and feed conversion in broilers (Desai *et al.,* 2007).

Organic acid treatments composed of individual acids or blends of several acids to perform antimicrobial activities similar to those of antibiotics (Wang *et al.,* 2009). The European Union allowed the use of organic acids and their salts in poultry production because these are generally considered safe (Adil *et al.,* 2010). Organic acids are week acids, which modulate the intestinal pH. When these compounds are used correctly a long with good nutritional, management and biosecurity measures, they could be a powerful tool in maintating the health of the gastrointestinal tract (GIT) in poultry thus improving the performance (Sabour *et al.,* 2019 and Adhikari *et al.,* 2020). Organic acids had higher globulin concentration and better immune response and reduced serum cholesterol and total lipid (Youssef *et al.,* 2017; Ali *et al.,* 2019 and Mirderikvandi *et al.,* 2019).

2.13 Nomenclature of sodium bicarbonate

Sodium bicarbonate (IUPAC name: sodium hydrogen carbonate, commonly known as baking soda or bicarbonate of soda, is a chemical compound with the formula $NaHCO_3$. It is a salt composed of a sodium cation (Na^+) and a bicarbonate anion (HCO_3^-). Sodium bicarbonate is a white solid that is crystalline, but often appears as a fine powder. It has a slightly salty, alkaline taste resembling that of washing soda (sodium carbonate). The natural mineral form is nahcolite. It is a component of the mineral natron and is found dissolved in many mineral springs (IUPAC, 2004).

2.14 Chemistry of sodium bicarbonate

Sodium bicarbonate is an amphoteric compound. Aqueous solutions are mildly alkaline due to the formation of carbonic acid and hydroxide ion:

$$HCO^-{}_3 + H_2O \rightarrow H_2CO_3 + OH^-$$

2.15 History of sodium bicarbonate

The word *natron* has been in use in many languages throughout modern times (in the forms of *anatron, natrum* and *natron*) and originated (like Spanish, French and English *natron* as well as 'sodium') via Arabic *naṭrūn* (or *anatrūn*; cf. the Lower Egyptian "Natrontal" Wadi El Natrun, where a mixture of sodium carbonate and sodium hydrogen carbonate for the dehydration of mummies was used) from Greek *nítron (νίτρον)* (Herodotus; Attic *lítron (λίτρον)*), which can be traced back to ancient Egyptian *ntr*. The Greek *nítron* (soda, saltpeter) was also used in Latin *(sal) nitrum* and in German *Salniter* (the source of *Nitrogen, Nitrat* etc.) (Alfred Götze, 1967).

2.16 Uses of sodium bicarbonate

2.16.1 Cooking

In cooking, baking soda is primarily used in baking as a leavening agent. When it reacts with acid, carbon dioxide is released, which causes expansion of the batter and forms the characteristic texture and grain in cakes, quick breads, soda bread, and other baked and fried foods. The acid–base reaction can be generically represented as follows (Bennion *et al.*, 1997).

$$NaHCO_3 + H^+ \rightarrow Na^+ + CO_2 + H_2O$$

Acidic materials that induce this reaction include hydrogen phosphates, cream of tartar, lemon juice, yogurt, buttermilk, cocoa, and vinegar. Baking soda may be used together with sourdough, which is acidic, making a lighter product with a less acidic taste.

2.16.2 Baking powder

Baking powder, also sold for cooking, contains around 30% of bicarbonate, and various acidic ingredients that are activated by the addition of water, without the need for additional acids in the cooking medium. Many forms of baking powder contain sodium bicarbonate combined with calcium acid phosphate, sodium aluminium phosphate, or cream of tartar. Baking soda is alkaline; the acid used in baking powder avoids a metallic taste when the chemical change during baking creates sodium carbonate Yaron (2022).

2.16.3 Pyrotechnics

Sodium bicarbonate is one of the main components of the common "black snake" firework. The effect is caused by the thermal decomposition, which produces carbon dioxide gas to produce a long snake-like ash as a combustion product of the other main component, sucrose. Sodium bicarbonate also delays combustion reactions through the release of carbon dioxide and water, both of which are flame retardants, when heated.

2.16.4 Mild disinfectant

It has weak disinfectant properties and it may be an effective fungicide against some organisms. Because baking soda will absorb musty smells, it has become a reliable method for used book sellers when making books less malodorous (Altman, 2006).

2.16.5 Neutralization of acids

Sodium bicarbonate reacts spontaneously with acids, releasing CO_2 gas as a reaction product. It is commonly used to neutralize unwanted acid solutions or acid spills in chemical laboratories. It is not appropriate to use sodium bicarbonate to neutralize base even though it is amphoteric, reacting with both acids and bases (Goura *et al.,* 2023).

2.16.6 Sports supplement

Sodium bicarbonate is taken as a sports supplement to improve muscular endurance. Studies conducted mostly in males have shown that sodium bicarbonate is most effective in enhancing performance in short-term, high-intensity activities (Goura *et al.,* 2023).

2.16.7 Agriculture

Sodium bicarbonate can prevent the growth of fungi when applied on leaves, although it will not kill the fungus. Excessive amounts of sodium bicarbonate can cause discolouration of fruits (two percent solution) and chlorosis (one percent solution).

2.16.8 Medical uses and health

Sodium bicarbonate mixed with water can be used as an antacid to treat acid indigestion and heartburn. Its reaction with stomach acid produces salt, water, and carbon dioxide:

$NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2(g)$

A mixture of sodium bicarbonate and polyethylene glycol such as PegLyte, dissolved in water and taken orally, is an effective gastrointestinal lavage preparation and laxative prior to gastrointestinal surgery, gastroscopy, etc.

Intravenous sodium bicarbonate in an aqueous solution is sometimes used for cases of acidosis, or when insufficient sodium or bicarbonate ions are in the blood. In cases of respiratory acidosis, the infused bicarbonate ion drives the carbonic acid/bicarbonate buffer of plasma to the left, and thus raises the pH. For this reason, sodium bicarbonate is used in medically supervised cardiopulmonary resuscitation. Infusion of bicarbonate is indicated only when the blood pH is markedly low (< 7.1–7.0) Miermon, C. (2022).

2.16.9 Personal hygiene

Sodium bicarbonate is also used as an ingredient in some mouthwashes. It has anticaries and abrasive properties. It works as a mechanical cleanser on the teeth and gums, neutralizes the production of acid in the mouth, and also acts as an antiseptic to help prevent infections. Sodium bicarbonate in combination with other ingredients can be used to make a dry or wet deodorant. Sodium bicarbonate may be used as a buffering agent, combined with table salt, when creating a solution for nasal irrigation (Metson, *et al.,* 2005).

2.16.10 Veterinary uses

Sodium bicarbonate is used as a cattle feed supplement, in particular as a buffering agent for the rumen (Paton, *et al.,* 2006).

2.17 Effect of sodium bicarbonate on feed intake

Fethiere *et al.,* (1994), and Borges *et al.,* (2003) reported that Sodium bicarbonate in the diet of layers may improve nutrient digestibility by increasing sodium ions concentration; improving electrolyte balance in poultry diets; meeting the requirements for the HCO_3^- ions (Gorman & Balnave, 1994) and decrease the losses caused by heat stress (Abbas *et al.,* 2017). It is cheap, easily available and easy to handle, therefore, can be safely incorporated in poultry diets to ameliorate the adverse effects caused by heat stress.

Fouad *et al.,* (2016), reported that **t**here is some evidence on the beneficial effect of $NaHCO_3$ on immune response and nutrient digestibility (Lin *et al.,* 2006), in broilers exposed to high ambient temperature. However, information on the effect of $NaHCO_3$ on immune response and nutrient digestibility in caged layers during summer are scanty. Therefore, the present trial was carried out to study the effects of dietary inclusion of sodium bicarbonate on immune response against Newcastle disease virus and *in vivo* digestibility of DM, CP, CF, and EE. The effect of the addition of this compound in poultry diets was also studied on the absorption of some minerals *i.e.* calcium, phosphorus, sodium, potassium, and iron, in caged layers during the summer.

Leeson & Summers (2001), found that dietary inclusion of $NaHCO_3$ significantly influenced the absorption of all the minerals (Ca, P, Fe, Na and K), which were studied in this trial. Birds using diets containing $NaHCO_3$ exhibited better absorption of these minerals as compared to those of the untreated group.

Borges *et al.,* 2003 reported that minerals and trace elements are essential for optimum performance of poultry birds. Therefore, increased mineral absorption in $NaHCO_3$ fed birds may probably be due either to more availability of minerals as a result of increased feed intake or due to improved electrolyte balance or both.

2.18 Effect of sodium bicarbonate on water intake

Mahmud *et al.,* (2010), reported that data on water intake, water: feed and litter moisture as affected by various levels and sources of sodium. The water intake was increased significantly ($P < 0.05$) among the treatments. Maximum water intake was observed in group fed with diet C and minimum on diet A. However, the ratio between water and feed showed somewhat different trend as maximum water: feed was noticed on diet F and minimum on diet A. In this way water data demonstrate that control diet having 0.15% sodium in the form of sodium chloride has minimum water consumption as well as water to feed ratio and with increasing level of sodium water intake significantly ($P < 0.05$) increased. This increase was more pronounced when sodium chloride was used as a source as compared to sodium bicarbonate. High litter moisture contents ($P < 0.05$) were determined in groups having high level of sodium. However source of sodium has no effect.

2.19 Effect of sodium bicarbonate on body weight

Fethiere *et al.*, (1994), reported that diets containing $NaHCO_3$ exhibited better digestibility of DM in layers. Increase in digestibility of dry matter (DM) of the treated groups may be due to more sodium ions concentration in the rations containing $NaHCO_3$.

Borges *et al.,* 2003**;** Mahmud *et al.,* 2010 found that a similar effect of increased sodium ions concentration in broilers. Dietary inclusion of $NaHCO_3$ might have improved the electrolyte balance in the diet by creating favorable conditions for improvement in digestibility of nutrients.

Leeson & Summer, (2001), also reported that another probable explanation of better digestibility of DM in the birds fed diets containing $NaHCO_3$ may be that pancreatic juices which are involved in digestion of most of the nutrients essentially contain $NaHCO_3$. The presence of $NaHCO_3$ in pancreatic juice, neutralizes the high acidity of chyme and raises it to be alkaline to prepare the chyme for the process of nutrient absorption, which takes place in the small intestine. Therefore, increased digestibility of DM in treated groups may have been due to higher bicarbonate and sodium levels.

2.20 Effect of sodium bicarbonate on body weight gain

Peng, *et al.*, (2013), observed that SB level were found for FI ($P<0.01$), and only linear effect for BWG ($P<0.01$) and F:G ($P<0.01$) during day 1 to 21; Supplementation of 4.0% SB decreased BWG ($P<0.001$) and FI ($P<0.001$), but increased F:G ($P<0.001$) comparing with the control treatment. From day 22 to 42, linear and quadratic response were described for BWG ($P<0.01$), and linear effect for F:G ($P<0.001$) with the rising of SB level; broilers fed with SB had greater BWG ($P<0.001$) and lower F:G ($P<0.001$) than the control group. From day 1 to 42, both linear and quadratic trend were revealed for BWG ($P<0.05$) and linear tendency for F:G ($P<0.001$) with the increasing of SB level; comparing with control treatment, SB supplementation improved BWG ($P<0.001$) and FI ($P<0.01$), and F:G ($P<0.001$) were lower in birds receiving 4.0% SB.

2.21 Effect of sodium bicarbonate on feed conversion ratio (FCR)

Pasha *et al.*, (2008), reported that dietary inclusion of different levels of $NaHCO_3$ has depicted a significant increase in the digestibility of crude fibers in layers when compared to that fed diet without its addition. The increase in the digestibility of crude fibers of the treated groups may probably be due to the availability of more sodium and bicarbonate ions concentration in rations containing sodium bicarbonate. Dietary inclusion of $NaHCO_3$ has also shown to improve electrolyte balance in poultry diets by creating physiological conditions favorable for improvement in digestibility of nutrients. By using different levels of sodium bentonite in broiler rations and found an improvement in nutrient digestibility as compared to the control group (without sodium bentonite).

Salari *et al.,* (2006), have also observed improvement in nutrient digestibility because of the addition of sodium bentonite in broiler diets. Digestibility of ether extract was found to be significantly better in the birds using diets containing $NaHCO_3$ as compared to those of untreated group. Hyperthermia seems to be the most possible contributing factor for decreased digestibility and absorption of ether extract in the birds fed diet without sodium bicarbonate as have been observed by Koh & Macleod, (1999). Leeson & Summer, (2001), while discussing the factors affecting digestibility of fats, have also stated that fat digestibility is negatively affected in the birds exposed to heat stress. These findings are compatible with those observed in birds maintained under heat stress conditions.

2.22 Effect of sodium bicarbonate on mortality and survivability

Peng, *et al.,* (2013), observed that there were both linear and quadratic effects of increasing SB for diarrhea incidence, mortality and AS related mortality (Table 3). Broilers fed with 4.0% SB showed the highest diarrhea ($P < 0.001$), mortality ($P < 0.001$) and AS mortality ($P < 0.001$). Moreover, all died chickens in the 4.0% SB treatment exhibited AS syndrome, such as drooping, expiratory dyspnea, comb cyanosis, hypertrophy and dilation of the heart, and fluid accumulation in pericardium and peritoneal cavity.

2.23 Effect of sodium bicarbonate on carcass traits

Peng, *et al.,* (2013), observed that a linear effect is seen for heart ($P < 0.001$) and bursa indices ($P < 0.05$) on day 21. Sodium bicarbonate (SB) higher than 1.0% significantly increased heart index ($P < 0.001$), and addition of 4.0% SB gave a higher bursa index (P

< 0.05) compared with the control treatment. On day 42, there is a linear tendency of SB on spleen ($P < 0.01$) and bursa indices ($P < 0.05$), and a quadratic trend on heart ($P < 0.001$) and liver ($P < 0.001$) indices with the increasing SB level. Heart and liver indices are the lowest in broilers fed with diet supplemented 0.5% SB.

2.24 Antimicrobial effect of sodium bicarbonate

Rakib *et al.,* (2016) reported that dietary inclusion of different levels of $NaHCO_3$ depicted a significant increase in antibody titer against Newcastle disease in layers when compared to those fed diet without its addition. Environmental stressors have been known to affect immunity and innate resistance of the host directly or indirectly. Therefore, increase in antibody titer against Newcastle disease virus in birds fed diets containing different levels of $NaHCO_3$ may probably be due either to less heat stress upon these birds because of reduction in their body temperature or lower cortisol concentration as compared to those of control group, or both.

Borges *et al.,* (2003), have observed that an increase in dietary electrolyte balance may cause a decrease in heterophil to lymphocyte ratio in blood, leading to an increase in antibody titer. Similarly, Santin *et al.,* (2003) have reported a significant linear increase in Newcastle disease virus antibody titers with increasing DEB (40, 140, 240, 340mEq/kg), using NaCl, $NaHCO_3$ and NH_4Cl as supplements, Therefore, it may safely be concluded that the dietary addition of $NaHCO_3$ may improve antibody titter against Newcastle disease virus in layers.

CHAPTER 3

MATERIALS AND METHODS

3.1 Statement of the experiment

The study was carried out from August, 16 to September 12, 2023 (28 days) at the Central Poultry farm of Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh, to compare the effects on growth performance, feed conversion ratio (FCR), livability, mortality, and carcass traits in commercial broilers providing of drinking water containing Acetic acid and Sodium bicarbonate. The steps listed below were taken in order to finish the research project.

3.2 Site of the experiment

The study was carried out at the Central Poultry Farm, which is part of the Veterinary and Animal Sciences faculty of Hajee Mohammad Danesh Science and Technology University (HSTU), located in Dinajpur, Bangladesh.

3.3 Preparation of research shed

The birds were kept in an open-sided house with a concrete floor. First, the experimental house was thoroughly cleaned and scrubbed with forceful water using a hose-pipe. All of the equipment and liter were removed, and dry washing was done. After a thorough cleaning, the floor, walls, and ceiling were disinfected using detergent and bleach. In addition, all feeders, drinkers, and other required equipment received thorough cleaning, washing, and disinfection using detergent powder at the same time. Following that, the room was locked for a week. Then, Timsen Poultry (n-Alkyl Dimethyl Benzyl Ammonium Chloride (active ingredient): 40% Urea (inert ingredient): 60%) @1gm/liter water was sprayed all over the home once again to disinfect it. The home was utilized for raising the birds when it had dried properly. Experiment shed was constructed with compartment of housing for 10 birds. The house was divided into 21 separate pens of equal size (4ft x 3ft) with plastics net, plain sheet and wooden materials. Dry rice husk was used as litter materials on the floor at a depth of 2 cm to maintain a comfortable environment. Then the house was prepared for brooding before the setting of chicks. Before chick arrival, feeders and drinkers were placed and electric supply was checked.

3.4 Collection of the experimental birds

A total of 210, day old broiler chicks (Efficiency Plus-Hubbard) were collected from Aftab Agro Company Limited, Dinajpur Sadar, Bangladesh. Experiment birds were healthy, disease free and physiologically sound.

3.5 Layout of the experiment

A total of 210, day old broiler chicks (Efficiency Plus-Hubbard) were randomly and equally distributed to 7 groups having 3 replicates of 10 birds in each under Completely Randomized Design (CRD). The birds were grouped as T_0, T_1, T_2, $T_{3,}$ $T_{4,}$ T_5 and T_6 group of which T0 was with normal water (control group). In group T_1, T_2 and T_3 drinking water was treated with 0.25ml/L, 0.33ml/L and 0.50ml/L Acetic Acid respectively. $T_{4,}$ T_5 and T_6 group was treated with Sodium Bicarbonate Powder at the rate of 0.50gm/L, 1.00gm/L and 1.50gm/L drinking water. Chicks were housed in open-sided pens from day old to 28 days. No antibiotics were used during the experimental period.

Table 3.1 Layout showing the distribution of chicks to treatment and replication

Treatment Group	**Birds/replication**			**Total**
	R_1	**R_2**	**R_3**	
$T_{0\,=}$ control (Without any treatment)	10	10	10	30
$T_{1=}$ 0.25 ml Acetic Acid/L drinking water	10	10	10	30
$T_{2=}$ 0.33 ml Acetic Acid/L drinking water	10	10	10	30
$T_{3=}$ 0.50 ml Acetic Acid/L drinking water	10	10	10	30
T_4= 0.50 gm Sodium Bicarbonate/L drinking water	10	10	10	30
T_5= 1.00 gm Sodium Bicarbonate/L drinking water	10	10	10	30
T_6= 1.50 gm Sodium Bicarbonate/L drinking water	10	10	10	30
Grand total				210

3.6 Procurement of feed ingredients

Required amount of feed ingredients for making the experimental diet was procured from local market of Dinajpur town.

3.7 Sample collection

The Acetic Acid was purchased from Rahman Scientific Store, Dinajpur Sadar and Sodium Bicarbonate was purchased from local grocery shop of Dinajpur town.

Figure 3.1: Acetic Acid

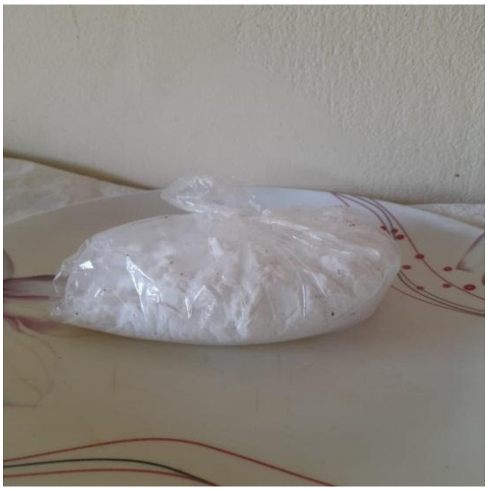


Figure 3.2: Sodium Bicarbonate

3.8 Management procedure

3.8.1 Transportation of DOC to shed

The day old chicks were received from Aftab Agro Farm Ltd. The DOC were hatched in Mymensingh at their own facility and sent to HSTU Dinajpur by a cargo van.

3.8.2 First day care of DOC after arrival

The brooder house was prepared 3 days prior to chick arrival and kept the light on from the day before arrival to maintain 95^0F (35^0C) to give the chicks a comfortable environment. As the DOC could not differentiate between litter and food, we used paper to cover the litter. On arrival of the DOC, inspected them manually and gently put them in the brooder house. In order to give instant energy and reduce stress we supplied Glucovet (Glucose and Vitamin-C) @ 50gm/liter.

3.8.3 Brooding

Brooding denotes the crucial phase immediately following hatching, where meticulous care and attention are devoted to chicks to ensure their health and survival. The brooder house underwent a comprehensive cleaning regimen, initiated at least one week before the chicks' arrival. The existing litter in the brooder house was systematically removed, and all essential equipment underwent a thorough cleaning and disinfection process utilizing a Timsen Poultry solution (1gm/liter). Following the cleaning procedure, the house was allowed to thoroughly dry. Fresh and dry rice husk was employed as the litter material, meticulously spread to a depth of 3-4 cm to enhance insulation. To prevent chicks from ingesting litter materials, feeds were presented on clean, simple paper or newspaper at three-hour intervals during the first day. This practice proved effective in promoting a conducive environment for the chicks. Subsequently, the paper used for feeding was taken away, and both feeders and drinkers were evenly positioned throughout the brooder area. The electric brooder underwent adjustments 24 hours prior to the chicks' arrival, setting the temperature at 95°F (35°C) on the first day. Gradual temperature reduction occurred daily, decreasing by 1°C until reaching the ambient environmental temperature. An optimal temperature of 21°C was deemed suitable for the growing period. Rigorous monitoring ensured that this ideal temperature was maintained, recognizing that excessively low or high temperatures could result in subpar growth rates and ultimately compromise the overall performance of the birds.

Figure 3.3: Brooding management

3.8.4 Distribution of chicks in pen

After brooding chicks were randomly distributed to pens. Each pen consists of 10 birds according to the design of experiment. Care and management for each treatment and replication was maintained uniformity.

3.8.5 Space requirement

The space for each pen was 12 (4 feet x 3 feet) square feet. Therefore, the space allowed for each bird was 1.2 square feet.

3.8.6 Litter management

Fresh and dry rice husk served as the litter material, with a consistent depth of 3 cm. The damp section of the litter, inclusive of droppings, was regularly eliminated and appropriately disposed of. Subsequently, new litter was introduced as needed to uphold the standard depth and prevent any moisture-related issues. Stirring the litter occurred twice daily as a routine practice, effectively breaking up its compactness and ensuring the maintenance of proper moisture levels. This systematic approach aimed to create a conducive environment for the well-being of the chicks.

3.8.7 Lighting management

Throughout the experimental period, the birds experienced a continuous lighting period of 23 hours, with a daily 1-hour dark period. This practice was implemented to adopt the broilers to potential darkness resulting from electricity failure. To ensure sufficient lighting during the dark period, supplementary light at night was supplied through electric bulbs. This approach aimed to familiarize the broilers with varying lighting conditions and maintain an optimal environment for their well-being.

3.8.8 Temperature and humidity

Throughout the experimental period, the environmental temperature remained elevated, reaching a peak of 36.7°C with 96% humidity. Despite the challenging conditions, an ideal temperature of 21°C was targeted for the growing phase. The humidity levels during the experiment were consistently high, ranging from 80% to 97%. The recommended range for relative humidity in a broiler house is typically 55%-65%. To monitor these conditions, a digital thermometer cum hygrometer was regularly employed to check and ensure that the temperature and humidity levels remained within acceptable parameters.

3.8.9 Ventilation

Thorough monitoring of standard ventilation practices was conducted to guarantee a continuous supply of fresh air within the house, as it is crucial for the well-being and overall health of the chicks. Inadequate ventilation can lead to the buildup of harmful substances such as carbon monoxide, ammonia, and create a damp litter condition in the brooder house. To address this, fans were employed to effectively expel these detrimental gases from the house, ensuring a conducive and healthy environment for the chicks.

3.8.10 Feeder and drinker space

An area of 12 sq. feet was allocated for 10 birds in each pen. One round feeder and one round drinker were provided in each pen for 10 birds. Required feeding and drinking space were provided according to the number of birds in each replication.

Figure 3.4: Feeding of birds

Figure 3.5: Drinking of birds

3.8.11 Feed and water management

3.8.11.1 Source of feed

Ready feed was used for the experimental study. At first required amount of ready feed ingredients were weights by digital weighing balance. The experimental period were divided into three phases (broiler pre-starter, broiler-starter and broiler-grower). The broiler chicks were fed broiler pre-starter from 0-5 days, broiler starter from 6 to 14 days and broiler grower from 15 to 28 days of age). The commercial feed was collected from local market of Dinajpur town. The feeds were produced by “Nourish Poultry and Hatchery Ltd”.

Table 3.2 Nutrient concentration of supplied feed

Nutrients	Pre- Starter (01-05 days)	Starter (06-14 days)	Grower (16-28 days)
ME (Kcal/kg)	2950	**3000**	3050
Crude protein (%)	21	20	19
Crude fibre (%)	5	5	5
Calcium (%)	1	0.95	0.95
Phosphorus (%)	0.45	0.45	0.45
Lysine (%)	1.15	1.05	1.05
Methionine (%)	0.48	0.45	0.45
Vitamin & mineral (%)	*Ad-libitum*	*Ad-libitum*	*Ad-libitum*

3.8.11.2 Feed and feeder management

For the first day, feed was given to the birds on clean newspaper then trough feeder was provided. The feeders were set properly so that bird were able to eat conveniently. Feeds were weighted with electric measuring balance and supplied twice daily (once at morning and at evening). Linear feeders and tray feeder were used during brooding period. After that it was replaced by round plastic trough feeders.

Table 3.3 Feed supplied to the birds during the experimental period

Type of diet	Age of birds
Pre-starter	1-5 days
Starter	6-14 days
Grower	15-28 days

3.8.11.3 Water management

Fresh, clear and cold drinking water was made available all the times during the experimental period. T_0 was with normal water (control group). T_1, T_2 and T_3 drinking water was treated with 0.25ml/L, 0.33ml/L and 0.50ml/L Acetic Acid respectively. $T_{4,}$ T_5

and T_6 group was treated with Sodium Bicarbonate Powder at the rate of 0.50gm/L, 1.00gm/L and 1.50gm/L drinking water. Drinking water was supplied twice daily (once at morning and at evening). Drinkers were thoroughly cleaned and washed every day.

Table 3.4 pH of the drinking water treated with acetic acid and sodium bicarbonate as a source of acid and alkali

Treatment	Dose of Acetic Acid /L drinking water	PH	Treatment	Dose of Sodium Bicarbonate /L drinking water	PH
T_1	0.25 ml	4.9	T_4	0.50 gm	8.0
T_2	0.33 ml	4.4	T_5	1.00 gm	8.2
T_3	0.50 ml	4.1	T_6	1.50 gm	8.3

Where, T_0 contains normal water of PH 7.00.

Figure 3.6: PH reading of drinking water treated with acid

3.8.12 Vaccination

All broilers were vaccinated against New Castle (Ranikhet) Disease and Infectious Bursal (Gumboro) Disease. The birds were vaccinated according to the following schedule.

Table 3.5 Vaccination program maintained for the experimental birds

SL. No	Age of the birds (days)	vaccine	Route
1	4	BCRDV	Eye drop
2	11	Gumboro disease vaccine	Eye drop
3	18	Gumboro disease vaccine (booster)	Drinking Water
4	22	RDV	Drinking Water

3.8.13 Medication

Immediately after unloading from the chick boxes, the chicks were given Glucose solution and Vitamin C to prevent the stress occurring during transport. In order to give instant energy and reduce stress we supplied Glucovet (Glucose and Vitamin-C) 5% solution (@50gm/liter).

3.8.14 Bio-security measures

Rigorous bio-security measures were implemented throughout the experiment to uphold the health and safety standards for broiler production. Regular cleaning and disinfection of equipment were conducted prior to use. Access to the facility was restricted for individuals, and before entering, hands were washed with soap, and separate footwear was dedicated for farm use. Disinfectant was consistently sprayed in and around the house to minimize potential contamination. In the case of bird mortality, deceased birds were buried away from the farm premises, and any sick birds were promptly isolated to a separate area distinct from the experimental house. Adherence to these bio-security protocols was strictly maintained, recognizing their paramount importance in ensuring the standard production of broilers.

3.9 The performance trial

During 28 days of experimental period, growth performance was evaluated. Before treatment, body weight was taken for each group of birds. Then body weight and feed consumption were recorded daily and body weight gain and feed conversion were then calculated. Mortality was recorded throughout the study period.

3.10 Record keeping

The following records were kept during 28 days of rearing period:

i. Feed consumption
ii. Live weight
iii. Feed conversion ratio (FCR).
iv. Mortality
v. Survivability
vi. Temperature: Five times daily during the experimental period.
vii. Dressing yield: At the end of the experiment one broiler was slaughtered from each replication to estimate dressing yield.

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

3.10.1 Feed intake

Feed consumption of each replication was recorded daily on a cumulative basis. Feed intake was calculated as the total feed consumption in a replication divided by number of birds in each replication.

$$\text{Feedintake}\left(\frac{\text{g}}{\text{bird}}\right) = \frac{\text{Feed intake per replication}}{\text{No of birds per replication}}$$

3.10.2 Body weight and body weight gain

The birds were weighed just prior feeding in the morning. The birds were weighed in a group at the beginning of the experiment and then every week at the age of 7, 14, 21, 28 days. The weight was done using digital balance. All birds in a pen were weighed and body weight of each bird was recorded.

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

Body weight gain= Final weight (gm)- Initial weight (gm)

3.10.3 FCR

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

$$\text{FCR} = \frac{\text{Total amount of feed consumed (gm)}}{\text{Live weight gain (gm)}}$$

3.10.4 Mortality

The mortality of birds from every individual treatment was recorded until the end of the experiment. It was calculated as

$$\text{Mortality} = \frac{\text{Total dead birds}}{\text{Total birds housed}} \times 100$$

3.10.5 Survivability

The survivability of birds from every individual treatment was recorded until the end of the experiment. It was calculated as

$$\text{Survivability} = \frac{\text{Total survived birds}}{\text{Total birds housed}} \times 100$$

3.11 Processing of chicken

At the conclusion of the experiment, one broiler bird was randomly selected from each replication, totaling three birds per treatment group. These selected birds were weighed and then slaughtered for further processing. To ensure proper bleeding, feed withdrawal was initiated, and water was supplied ad libitum during a 12-hour fasting period prior to slaughtering. The slaughtering process adhered to the halal method. After complete bleeding, the skin and viscera were removed from the slaughtered birds and weighed again. The breast meat, thigh meat, drumette, and drumstick meat were carefully separated from the carcass. The final processing steps involved the removal of the head, shank, viscera, oil gland, kidneys, and lungs from the carcasses. Upon removal of the gall bladder from the liver, the pericardial sac and arteries were excised from the heart. The gizzard was separated by cutting it loose in front of the proventriculus, and both incoming and outgoing tracts were then cut. The gizzard was subsequently split open with a knife, emptied, washed, and the lining was removed by hand.

3.11.1 Dressing yield

Dressing yield is based on the relationship between the dressed carcass weight and live bird weight after things like the and internal organs have been removed. Dressing yield can be calculated by taking weight of the carcass divided by weight of live bird.

Dressing yield=Weight of the carcass ÷ weight of the live bird

Figure 3.7: Weighing of carcasses and different internal & external organs

3.12 Cost benefit analysis

The cost of broiler production for each treatment group was calculated based on the market price of feed ingredients, cost of chicks, Acetic Acid, Sodium Bicarbonate and management cost (labor cost, vaccine, electricity, litter depreciation cost and miscellaneous) to produce per kg of live broiler at the time of trial. The income from per kg of live broiler in different treatment groups were calculated by selling price of per kg live broiler.

3.13 Data analysis

Data on different variables were subjected to analysis of variance (ANOVA) in a Complete Randomized Design (CRD) (Steel and Torrie, 1980). The significant differences between the treatment means were calculated from analysis of variance (ANOVA) table All analyses were performed by using "IBM SPSS statistics 22" Program.

CHAPTER 4

RESULTS AND DISCUSSION

The present investigation was carried out to find out the comparative effects of drinking water containing Acetic Acid and Sodium Bicarbonate on growth performance, feed conversion ratio (FCR), livability, mortality and carcass traits in commercial broilers. The birds were fed diets for a period of 28 days. The findings of the present study are presented and discussed in this chapter under the following major heads.

4.1 Effect of acetic acid and sodium bicarbonate on feed intake

The effect of Acetic Acid and Sodium Bicarbonate on feed intake of broiler is shown in Table 4.1. The present study revealed that the feed intake was significantly ($P<0.05$) varied among the treatment groups during 21^{st}, 28^{th} days of age and total feed intake. At 21^{st} day the highest feed intake was found in T_5 (766.33±15.04) and the lowest in T_4 (687.33±13.27). At 28^{th} day the highest feed intake was found in T_1 (1058.33±6.42) and the lowest in T_6 (963.00±14.1) among the dietary treatment groups. Total feed intake in T_0, T_1, T_2, $T_{3,}$ $T_{4,}$ T_5 and T_6 is 2327.33±70.05, 2362.33±14.64, 2330.66±30.08, 2323.00±18.08, 2235.33±12.74, 2412.00±27.71 and 2293.33±36.29 respectively. Finally the highest feed intake was found in T_5 (2412.00±27.71) and the lowest in T_4 (2235.33±12.74) shown in Table 4.1.

Table 4.1 Comparative feed intake (gm) pattern of various treatment

Days	Dietary Treatment Group							Level of significance
	T_0	T_1	T_2	T_3	T_4	T_5	T_6	
7	180.66±3.21	180.66±3.21	178.66±5.50	181.66±5.03	179.00±4.00	179.33±1.52	181.33±0.57	NS
14	401.00±14.17	405.66±22.03	409.66±14.18	415.33±17.78	403.66±17.00	426.66±9.23	425.00±10.44	NS
21	716.00 ± 42.79^{b}	717.66 ± 8.14^{b}	722.66 ± 18.61^{b}	711.33 ± 8.38^{b}	687.33 ± 13.27^{b}	766.33 ± 15.04^{a}	723.66 ± 18.61^{b}	*
28	1029.66 ± 13.05^{bc}	1058.33 ± 6.42^{a}	1020.00 ± 9.16^{bc}	1014.66 ± 12.09^{c}	965.66 ± 14.15^{d}	1039.66 ± 9.81^{ab}	963.00 ± 14.1^{d}	**
Total feed intake	2327.33 ± 70.05^{bc}	2362.33 ± 14.64^{ab}	2330.66 ± 30.08^{bc}	2323.00 ± 18.08^{bc}	2235.33 ± 12.74^{d}	2412.00 ± 27.71^{a}	2293.33 ± 36.29^{cd}	**

All the result shown in Mean ± Standard deviation
NS = Non Significant
* Indicated significance at 5% level (P <0.05)
** Indicated significance at 1% level (P <0.01)
T_0= Control diet
T_1= Control diet + 0.25 ml Acetic Acid/L drinking water
T_2= Control diet + 0.33 ml Acetic Acid/L drinking water
T_3= Control diet + 0.50 ml Acetic Acid/L drinking water
T_4= Control diet + 0.50 gm Sodium Bicarbonate/L drinking water
T_5= Control diet + 1.00 gm Sodium Bicarbonate/L drinking water
T_6= Control diet + 1.50 gm Sodium Bicarbonate/L drinking water
^{abcde} means having different superscript in the same row differed significantly (P<0.05)

4.2 Effect of acetic acid and sodium bicarbonate on body weight

The average live weight patterns of the experimental birds from day 7 to 28 days of age under various treatments shown in Table 4.2. Results indicated that production performance in terms of body weight was affected by the dietary treatments. There were significant ($P < 0.05$) differences among the dietary groups to 21st days (3rd week) and in 28th days (4th week) of age but at 7th days and 14th days of age, no significant differences were found among the treatment groups. From day 7 to 28 days of age under various treatments the recorded average body weight (gm) for T_0, T_1, T_2, T_3, T_4, T_5 and T_6 was (1609±31.19), (1772±20.07), (1741.33±12.09), (1698±11), (1653.33±15.17), (1727±16.46) and (1629.33±6.65) respectively shown in (Table 4.2). At 21st day the highest body weight was found in T_2 (1081.00±29.81) and the lowest in T_0 (987.33±6.11). At 28th day the highest body weight was found in T_1 (1772.00±20.07) and the lowest in T_0 (1609.00±31.19) among the dietary treatment groups.

Table 4.2 Body weight (gm) of experimental birds under various treatments

Days	Dietary Treatment Group							Level of significance
	T_0	T_1	T_2	T_3	T_4	T_5	T_6	
7	186.00±3.00	192.33±11.01	190.33±11.37	193.33±4.93	197.00±6.55	195.00±7.21	189.33±6.80	NS
14	511.33±22.14	541.00±18.68	537.00±26.00	536.33±17.09	536.00±15.87	543.00±25.51	519.33±24.54	NS
21	987.33 ± 6.11^{c}	1090.00 ± 9.53^{a}	1081.00 ± 29.81^{ab}	1060.33 ± 52.00^{ab}	1039.00 ± 54.58^{abc}	1063.66 ± 30.27^{ab}	1011.33 ± 46.00^{bc}	*
28	1609.00 ± 31.19^{e}	1772.00 ± 20.07^{bc}	1741.33 ± 12.09^{ab}	1698.00 ± 11.00^{c}	1653.33 ± 15.17^{d}	1727.00 ± 16.46^{a}	1629.33 ± 6.65^{de}	**

All the result shown in Mean ± Standard deviation
NS = Non Significant
* Indicated significance at 5% level (P <0.05)
** Indicated significance at 1% level (P <0.01)
T_0= Control diet
T_1= Control diet + 0.25 ml Acetic Acid/L drinking water
T_2= Control diet + 0.33 ml Acetic Acid/L drinking water
T_3= Control diet + 0.50 ml Acetic Acid/L drinking water
T_4= Control diet + 0.50 gm Sodium Bicarbonate/L drinking water
T_5= Control diet + 1.00 gm Sodium Bicarbonate/L drinking water
T_6= Control diet + 1.50 gm Sodium Bicarbonate/L drinking water
^{abcde} means having different superscript in the same row differed significantly (P<0.05)

4.3 Effect of acetic acid and sodium bicarbonate on body weight gain

The effect of lemon juice and vitamin-c in on body weight gain of broiler is presented in Table 4.4. It was observed that there were no significant differences among the treatment groups. From day 7 to 28 days of age under various treatments the recorded average body weight for T_0, T_1, T_2, T_3, T_4, T_5 and T_6 was 621.33±29.14, 682±29.51, 660.33±35.85, 637.33±52.65, 614.33±59.21, 663.33±20.42 and 618±47.28 respectively at 28 days of age is shown in Table 4.3.

Table 4.3 Body weight gain (gm) of experimental birds under various treatments

Days	Dietary Treatment Group							Level of significance
	T_0	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	
7	143.00±3.00	149.33±11.01	147.33±11.37	150.33±4.93	154.00±6.55	152.00±7.21	146.33±6.80	NS
14	325.33±19.39	348.66±7.76	346.66±19.73	343.00±12.16	339.00±10.44	348.00±21.37	330.00±18.33	NS
21	476.33±28.72	549.00±12.16	544.00±46.22	524.00±63.15	503.33±46.31	520.66±46.92	492.00±24.26	NS
28	621.33±29.14	682.00±29.51	660.33±35.85	637.33±52.65	614.33±59.21	663.33±20.42	618.00±47.28	NS
Total gain	1565.99 ± 111.44^{e}	1729.00 ± 60.44^{bc}	1698.32 ± 113.17^{ab}	1654.99 ± 132.89^{c}	1610.33 ± 122.51^{d}	1784.00 ± 95.92^{a}	1586.33 ± 96.67^{de}	**

All the result shown in Mean ± Standard deviation
NS = Non Significant
T_0= Control diet
T_1= Control diet + 0.25 ml Acetic Acid/L drinking water
T_2= Control diet + 0.33 ml Acetic Acid/L drinking water
T_3= Control diet + 0.50 ml Acetic Acid/L drinking water
T_4= Control diet + 0.50 gm Sodium Bicarbonate/L drinking water
T_5= Control diet + 1.00 gm Sodium Bicarbonate/L drinking water
T_6= Control diet + 1.50 gm Sodium Bicarbonate/L drinking water

4.4 Effect of acetic acid and sodium bicarbonate feed conversion ratio (FCR)

The feed conversion ratio (FCR) of the experimental birds is shown in Table 4.4. The feed conversion ratio (FCR) in T_0, T_1, T_2, $T_{3,}$ $T_{4,}$ T_5 and T_6 was 1.44±0.01, 1.33±0.00, 1.34±0.01, 1.36±0.00, 1.35±0.00, 1.39±0.01 and 1.4±0.02 respectively. The feed conversion ratio (FCR) was lowest in T_1 (1.33±0.00) and highest in T_0 (1.44±0.01). Result indicated that there were significant ($P < 0.01$) differences at 28 days of age and significant ($P < 0.05$) differences at 21 days of age among the treatment groups. The superior FCR in this study was exhibited in T_1 group treated with 0.25 ml Acetic Acid/L drinking water. On the other hand, the worst FCR in this study was recorded for control (T_0) group. It was shown from the study that Acetic Acid supplied with water significantly influenced the obtained FCR of the experimental birds.

Table 4.4 FCR of experimental birds under various treatments

Days	Dietary Treatment Group							Level of significance
	T_0	T_1	T_2	T_3	T_4	T_5	T_6	
7	0.97±0.01	0.94±0.03	0.94±0.04	0.94±0.03	0.90±0.05	0.92±0.04	0.95±0.03	NS
14	1.13±0.06	1.08±0.05	1.09±0.03	1.11±0.05	1.08±0.00	1.11±0.04	1.16±0.03	NS
21	$1.31±0.05^{a}$	$1.19±0.02^{c}$	$1.21±0.05^{bc}$	$1.23±0.03^{abc}$	$1.22±0.07^{bc}$	$1.29±0.02^{ab}$	$1.31±0.03^{a}$	*
28	$1.44±0.01^{a}$	$1.33±0.00^{c}$	$1.34±0.01^{c}$	$1.36±0.00^{b}$	$1.35±0.00^{ab}$	$1.39±0.01^{ab}$	$1.40±0.02^{ab}$	**
Total FCR	$1.44±0.01^{a}$	$1.33±0.00^{c}$	$1.34±0.01^{c}$	$1.36±0.00^{b}$	$1.35±0.00^{ab}$	$1.39±0.01^{ab}$	$1.40±0.02^{ab}$	**

All the result shown in Mean ± Standard deviation
NS = Non Significant
* Indicated significance at 5% level (P <0.05)
** Indicated significance at 1% level (P <0.01)
T_0= Control diet
T_1= Control diet + 0.25 ml Acetic Acid/L drinking water
T_2= Control diet + 0.33 ml Acetic Acid/L drinking water
T_3= Control diet + 0.50 ml Acetic Acid/L drinking water
T_4= Control diet + 0.50 gm Sodium Bicarbonate/L drinking water
T_5= Control diet + 1.00 gm Sodium Bicarbonate/L drinking water
T_6= Control diet + 1.50 gm Sodium Bicarbonate/L drinking water
^{abcde} means having different superscript in the same row differed significantly (P<0.05)

4.5 Effect of acetic acid and sodium bicarbonate on mortality and survivability

The mortality and survivability of the experimental birds under different treatments was recorded from the beginning to the end of the experiment and was expressed in terms of percentage for each group. The mortality and survivability from day 1 to 28 days of age of the experimental birds is demonstrated in Table 4.5. There were no significant ($p<0.05$) differences among the dietary treatment groups. Results indicated that percent of mortality was lowest in T_1 and T_3 0.00% and highest was recorded in T_0 and T_6 group 6.67% and the percent of survivability was lowest in T_0 and T_6 93.33%. On the other hand, the highest survivability was recorded in T_1 and T_3 group 0.00%.

Table 4.5 Mortality (%) of experimental birds under various treatments

Dietary Treatment Group							Level of significance
T_0	T_1	T_2	T_3	T_4	T_5	T_6	
6.67±5.77%	0%	3.33±5.77%	0%	3.33±5.77%	3.33±5.77%	6.67±5.77%	NS

All the result shown in Mean ± Standard deviation
NS = Non-significant
T_0= Control diet
T_1= Control diet + 0.25 ml Acetic Acid/L drinking water
T_2= Control diet + 0.33 ml Acetic Acid/L drinking water
T_3= Control diet + 0.50 ml Acetic Acid/L drinking water
T_4= Control diet + 0.50 gm Sodium Bicarbonate/L drinking water
T_5= Control diet + 1.00 gm Sodium Bicarbonate/L drinking water
T_6= Control diet + 1.50 gm Sodium Bicarbonate/L drinking water

4.6 Effect of acetic acid and sodium bicarbonate on carcass yield

The effect of Acetic acid and Sodium Bicarbonate with drinking water on carcass yield of experimental birds is presented in Table 4.6. It shows that live weight (g), carcass weight (g), thigh weight and breast weight were significantly ($p<0.05$) differed among the dietary treatment groups. The highest live weight found in treatment group T_1 was (1746.66±27.3) whereas the lowest live weight found in treatment group T_0 (1630±69.65).

The highest carcass yield was obtained under T_1 (1051.33±18.58) followed by T_2 (1041.33±21.93), T_5 (1036±36.16^c), T_3 (1022±34), T_6 (1002±60.89), T_4 (995.33±20.81) respectively and the lowest carcass yield T_0 (986±39.39) was recorded for birds under the T_0 group in the results of the current study which are significantly ($p<0.05$) varied.

Table 4.6 Carcass yield (gm) of experimental birds under various treatments

Ctg	Dietary Treatment Group							Level of significance
	T_0	T_1	T_2	T_3	T_4	T_5	T_6	
Carcass	986±39.39^{d}	1051.33±18.58^{a}	1041.33±21.93^{ab}	1022±34.00^{bc}	995.33±20.81^{cd}	1036±36.16^{b}	1002±60.89^{c}	*
Dressing%	58.49±4.22	60.19±3.69	65.47±4.45	61.76±4.41	60.51±3.66	62.04±4.47	61.02±4.02	NS
Thigh	156.66±8.08^{cd}	164.66±4.16^{a}	163.33±5.03^{ab}	160.66±8.08^{b}	154.66±8.32^{d}	159.33±6.11^{bc}	155.33±10.26^{d}	*
Drumstick	146.00±7.21	152.66±5.03	151.33±4.16	150.66±10.06	144.00±6.00	152.66±5.03	144.66±10.06	NS
Drumette	59.33±5.03	61.33±3.05	62.00±4.00	61.33±7.02	58.00±2.00	62.00±6.00	60.66±6.11	NS
Breast	403.33±6.11^{d}	436.66±7.02^{a}	428.66±8.32^{b}	422±19.07^{ab}	405.33±19.21^{ab}	429.33±20.13^{b}	417.33±22.3^{c}	*
Liver	48.00±2.00	48.66±4.16	46.66±4.16	48.66±3.05	45.33±3.05	47.33±5.03	48.00±4.00	NS
Heart	7.33±1.15	8.66±1.15	8.00±0.00	8.66±1.15	6.66±1.15	8.66±1.15	7.33±1.15	NS
Gizzard	52.00±6.00	56.00±2.00	54.66±3.05	55.33±5.03	51.33±3.05	55.33±3.05	51.33±5.03	NS
Intestine	126.66±6.11	132.66±5.03	132.00±5.29	129.33±7.02	127.33±4.16	132.00±6.00	128.00±7.21	NS
Feet	57.33±3.05	58.00±4.00	60.00±2.00	58.00±4.00	55.33±3.05	57.33±5.03	56.66±3.05	NS

All the result shown in Mean ± Standard deviation

NS = Non Significant, * Indicated significance at 5% level (P <0.05)

T_0= Control diet

T_1= Control diet + 0.25 ml Acetic Acid/L drinking water

T_2= Control diet + 0.33 ml Acetic Acid/L drinking water

T_3= Control diet + 0.50 ml Acetic Acid/L drinking water

T_4= Control diet + 0.50 gm Sodium Bicarbonate/L drinking water

T_5= Control diet + 1.00 gm Sodium Bicarbonate/L drinking water

T_6= Control diet + 1.50 gm Sodium Bicarbonate/L drinking water

^{abcde} means having different superscript in the same row differed significantly (P<0.05)

4.7 Effect of acetic acid and sodium bicarbonate on thigh meat yield

The effect of Acetic acid and Sodium Bicarbonate on thigh meat yield of various treatment groups is presented in Table 4.6. It was observed that thigh meat yield was significant ($P < 0.05$) differences among different dietary groups. The highest thigh meat yield was found in T_1 (164.66±4.16) group and the lowest in T_4 was (154.66±8.32).

4.8 Effect acetic acid and sodium bicarbonate on breast meat yield

Data presented in Table 4.6 showed that there were significant ($P < 0.05$) differences in breast meat yield among different treatment groups. T_1 group showed higher value (436.66±7.02) and control group T_0 showed lower value (403.33±6.11) among the supplementary groups.

4.9 Economics of production

Costs of different groups of birds is presented in (Table 4.7). Table 4.7 revealed that the average rearing costs of broiler kept under different treatment groups T_0, T_1, T_2, $T_{3,}$ $T_{4,}$ T_5 and T_6 was 224.49 tk, 230.63 tk, 229.58tk, 230.35 tk, 222.98 tk, 237.42 tk and 231.23 tk respectively.

Miscellaneous cost summed up 5 Tk per broiler, which included the estimated cost of electricity cost of labor, disinfectant etc. The average live weight/broiler in group T_0, T_1, T_2, $T_{3,}$ $T_{4,}$ T_5 and T_6 was 1.61 kg, 1.77 kg, 1.74 kg, 1.70 kg, 1.65 kg, 1.73 kg and 1.63 kg respectively. The broiler was sold in live weight basis at the rate of Tk. 160/kg. The net profit/Kg live weight in the T_0, T_1, T_2, $T_{3,}$ $T_{4,}$ T_5 and T_6 group was found to be 20.56 tk, 29.70 tk, 28.06 tk, 24.50 tk, 24.86 tk, 22.76 tk and 18.14 tk respectively. The level of Acetic acid combination used in the drinking water exhibited its effect on the profit margin of the broiler rather than Sodium Bicarbonate compared to the controlled group.

Table 4.7 Economics of broiler production kept under different treatment groups from day old chick to 28 days of age

Parameters (Tk.)	T_0	T_1	T_2	T_3	T_4	T_5	T_6
Chick cost	47	47	47	47	47	47	47
Litter cost / bird	8.5	8.5	8.5	8.5	8.5	8.5	8.5
Vaccine + medicine	8	8	8	8	8	8	8
Feed price/kg	67	67	67	67	67	67	67
Dietary treatment cost / broiler production	0	4	5	6	5	7	9
Feed cost /Broiler production	155.99	158.13	156.08	155.85	149.48	161.92	153.73
Feed cost /kg production	96.89	89.34	89.70	91.67	90.60	93.60	94.32
Miscellaneous cost	5	5	5	5	5	5	5
Total cost/broiler	224.49	230.63	229.58	230.35	222.98	237.42	231.23
Average live weight(kg)/broiler	1.61	1.77	1.74	1.7	1.65	1.73	1.63
Sale price Tk./kg	160	160	160	160	160	160	160
Sale price / broiler	257.60	283.20	278.40	272.00	264.00	276.80	260.80
Net profit Tk./ broiler	33.11	52.57	48.82	41.65	41.02	39.38	29.57
Profit Tk./kg live weight	20.56	29.70	28.06	24.50	24.86	22.76	18.14

T_0= Control diet
T_1= Control diet + 0.25 ml Acetic Acid/L drinking water
T_2= Control diet + 0.33 ml Acetic Acid/L drinking water
T_3= Control diet + 0.50 ml Acetic Acid/L drinking water
T_4= Control diet + 0.50 gm Sodium Bicarbonate/L drinking water
T_5= Control diet + 1.00 gm Sodium Bicarbonate/L drinking water
T_6= Control diet + 1.50 gm Sodium Bicarbonate/L drinking water

CHAPTER 5

SUMMARY AND CONCLUSION

This study was conducted to determine the comparative effects of drinking water containing Acetic acid and Sodium Bicarbonate on growth performance, feed conversion ratio (FCR), livability, mortality and carcass traits in commercial broilers. The study was conducted at the Central Poultry farm of Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh during the period from 16 August to 12 September (28 days), 2023. A total of 210, day old broiler chicks (Efficiency Plus-Hubbard) were randomly and equally distributed to 7 groups having 3 replicates of 10 birds in each. The birds were grouped as T_0, T_1, T_2, T_3, T_4, T_5 and T_6 group of which T_0 was with normal water (control group) and T_1, T_2 and T_3 drinking water was treated with 0.25ml/L, 0.33ml/L and 0.5ml/L Acetic Acid respectively. T_4, T_5 and T_6 group was treated with Sodium Bicarbonate Powder at the rate of 0.5gm/L, 1gm/L and 1.5gm/L drinking water. No antibiotics were used during the experimental period.

At the end of experiment, a total of 21 broilers were selected from seven dietary treatment groups from each replication for determining and comparing meat yield characteristics. Further, the cost benefit ratio was also estimated. The present study revealed that the feed intake was significantly varied among the treatment groups. At the end of the experiment the feed intake (gm/broiler) at the age of 28 days in T_0, T_1, T_2, T_3, T_4, T_5 and T_6 was 2327.33±70.05, 2362.33±14.64, 2330.66±30.08, 2323.00±18.08, 2235.33±12.74, 2412.00±27.71 and 2293.33±36.29 respectively. Finally The highest feed intake was found in T_5 (2412.00±27.71) and the lowest in T_4 (2235.33±12.74) among the treatment groups. Significant difference was found in body weights among the dietary treatment groups. The live body weight in T_0, T_1, T_2, T_3, T_4, T_5 and T_6 was (1609.00±31.19), (1772.00±20.07), (1741.33±12.09), (1698.00±11.00), (1653.33±15.17), (1727.00±16.46) and (1629.33±6.65) respectively. Live body weight was highest body weight was found in T_1 (1772.00±20.07) and the lowest in T_0 (1609.00±31.19) among the dietary treatment groups. The body weight-gain of the treatment groups were non-significant. Feed conversion ratio (FCR) of different treatments were statistically significant compare to the groups. The feed conversion ratio (FCR) in T_0, T_1, T_2, T_3, T_4, T_5 and T_6 was 1.44±0.01, 1.33±0.00, 1.34±0.01, 1.36±0.00, 1.35±0.00, 1.39±0.01 and 1.4±0.02 respectively. The feed conversion ratio (FCR) was lowest in T_1 (1.33±0.00) and highest in T_0 (1.44±0.01). It was shown from the study that Acetic Acid supplied with water significantly influenced the obtained FCR of the experimental birds. There were no significant differences in Mortality and Survivability among different dietary groups. In T_0, T_1, T_2, T_3, T_4, T_5 and T_6 livability was 93.33%, 100.00%, 96.67%, 100.00%, 96.67%, 96.67% and 93.33% respectively and mortality was 6.67%, 0.00%, 3.33%, 0.00%, 3.33%, 3.33% and 6.67% respectively. Results indicated that percent of mortality was lowest in T_1 and T_3 0.00% and highest was recorded in T_0 and T_6 group 6.67% and the percent of survivability was lowest in T_0 and T_6 93.33%. On the other hand, the highest survivability was recorded in T_1 and T_3 group 0.00%. The highest carcass yield was obtained under T_1 (1051.33±18.58) followed by T_2 (1041.33±21.93), T_5 (1036±36.16^c), T_3 (1022±34), T_6 (1002±60.89), T_4 (995.33±20.81) respectively and the lowest carcass yield T_0 (986±39.39) was recorded for birds under the T_0 group in the results of the current study which are significantly ($p<0.05$) varied.

The current study reported that higher cost-benefit analysis by supplying Acetic Acid with drinking water. The overall findings revealed promising effects of Acetic Acid supplementation on profitable broiler production without any antibiotics rather than Sodium Bicarbonate which is available in local market. It is suggested that Acetic Acid supplements up to 0.25 ml/L drinking water increase performance and reduce the mortality rates of broiler chickens with maximum economic benefit are recommended.

Taking into account the aforementioned information, these results could indicate and motivate farmers to opt for antibiotic-free green broiler production through the use of 0.25 ml Acetic Acid/L in drinking water. This approach may help address the country's need for safe meat and boost the economy of Bangladesh.

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