EFFECT OF BOVINE COLOSTRUM FEEDING PERIOD AFTER HATCHING ON PERFORMANCE AND CARCASS CHARACTERISTICS OF ROSS 308 BROILER CHICKENS

by

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DECLARATION

I declare that this mini-dissertation hereby submitted to the University of Limpopo for the degree of Master of Science in Agriculture (Animal Production) has not been submitted by me for a degree at this or any other university, this is my own work in design and execution, and that all materials contained herein has been duly acknowledged.

Signature…….. Date……

Ms Naum Nyanese Makhubela

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ABSTRACT

An experiment was conducted to determine the effect of bovine colostrum feeding period after hatching on performance and carcass characteristics of male Ross 308 broiler chickens. The experiment was based on 0, 12, 24, 36, 48 and 72 hours of liquid bovine colostrum feeding after hatching of broiler chickens. The experiment commenced with 180 male Ross 308 broiler chicks with an initial live weight of 42 ± 2g per bird and was carried out for six weeks. The chicks were randomly assigned to six treatments with three replications, resulting in 18-floor pens with 10 chicks per replicate. A complete randomized design was used in this experiment. Data was analysed using the General Linear Model (GLM) procedures of the Statistical Analysis of system, Version 9.3.1 software program. Where there were significant differences, mean separation was done using the Turkey test at the 5% level of significance. A quadratic regression model was used to determine the optimum productivity of the experiment while a linear model was used to determine the relationships between bovine colostrum feeding period and responses in the variables measured.

Feed intake during Week 1, growth rate during Week 3 and feed conversion ratio (FCR) during Weeks 2 and 3 of the growing period of male Ross 308 broiler chickens were not affected ($p>0.05$) by bovine colostrum feeding periods after hatching. Similarly, bovine colostrum feeding had no effect ($p>0.05$) on diet dry matter (DM), neutral detergent fibre (NDF), acid detergent fibre (ADF) and ash digestibilities in male Ross 308 broiler chickens aged 14 to 21 days. Bovine colostrum feeding period after hatching had no effect ($p>0.05$) on nitrogen retention (N-retention) in male broiler chickens aged one to 21 days. Similarly, gut organ digesta pH, length and weight of male Ross 308 broiler chickens aged 21 days were not improved ($p>0.05$) by bovine colostrum feeding after hatching. However, bovine colostrum feeding improved ($p<0.05$) feed intake during Weeks 2 and 3 of the growing period of male Ross 308 broiler chickens. Similarly, bovine colostrum feeding after hatching improved ($p<0.05$) crude protein (CP) digestibility in male broiler chickens aged 14 to 21 days. Metabolisable energy (ME) intake of male Ross 308 broiler chickens aged one to 21 days was improved ($p<0.05$) by bovine colostrum feeding period after hatching. Similarly, growth rate of male broiler

chickens during Weeks 1 and 2 was improved ($p<0.05$) by colostrum feeding after hatching. Feed conversion ratio of male broiler chickens during Week 1 was improved ($p<0.05$) by bovine colostrum feeding period after hatching. Bovine colostrum feeding after hatching improved ($p<0.05$) live weight of male Ross 308 broiler chickens at the ages of 7, 14 and 21 days.

Nitrogen retention and FCR of male Ross 308 broiler chickens aged 22 to 42 days were not affected ($p>0.05$) by bovine colostrum feeding after hatching. In addition, live weights of male Ross 308 broiler chickens aged 35 and 42 days were not affected ($p>0.05$) by bovine colostrum feeding period after hatching. Similarly, bovine colostrum feeding had no effect ($p>0.05$) on gut organ digesta pH, large intestine lengths, breast and drumstick weights and breast meat juiciness of male Ross 308 broiler chickens aged 42 days. However, bovine colostrum feeding improved ($p<0.05$) feed intake and growth rate of male Ross 308 broiler chickens aged 22 to 42 days. Live weights of male Ross 308 broiler chickens aged 28 days were improved ($p<0.05$) by bovine colostrum feeding period after hatching. Similarly, bovine colostrum feeding after hatching did not affect ($p<0.05$) diet DM, CP, NDF, ADF and ash digestibilities in male Ross 308 broiler chickens aged 35 to 42 days. Metabolisable energy intake of male broiler chickens aged 22 to 42 days was improved ($p<0.05$) by bovine colostrum feeding period after hatching. Similarly, GIT, small intestine and caecum lengths and crop, proventriculus, gizzard, small intestine, caecum, large intestine, carcass and thigh weights of male Ross 308 broiler chickens aged 42 days were improved ($p<0.05$) by bovine colostrum feeding after hatching. Bovine colostrum feeding after hatching improved ($p<0.05$) breast meat tenderness, flavour and shear force of male Ross 308 broiler chickens aged 42 days.

It is concluded that reasons for differing responses to bovine colostrum feeding periods of up to 72 hours after hatching are not clear. Therefore, further studies in which longer bovine colostrum feeding periods are used after hatching are recommended.

Keywords: Feed intake, Growth rate, Feed conversion ratio, Live weight.

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LIST OF ABBREVIATIONS

ADF	Acid detergent fibre.
AOAC	Association of Analytical Chemists.
α-la	alpha-lactalbumin
β-lg	beta-lactoglobulin
Ca	Calcium.
^{o}C	Degree centigrade.
Cm	Centimetre.
Cu	Copper.
CP	Crude protein.
DM	Dry matter.
DMI	Dry matter intake.
DTI	Department of Trade and Industry.
d	Day.
EGF	Epidermal Growth Factor.
FCR	Feed conversion ratio.
Fe	Iron.
G	Gram.
GIT	Gastrointestinal tract.
GLM	General Linear Model.
$g.mL^{-1}$	Grams per millilitre.
H	Hour.
Igs	Immuno-globulins.
IGF	Insulin-like growth factor.
KDa	Kilodalton.
N	Nitrogen.
Na	Sodium.
m^2	Meter squared.
$mg.mL^{-1}$	Milligram per millilitre.
Min	Minute.
P	Phosphorus.
%	Percent.
r	Correlation.

RTNTN	Retention.
SAPA	South African Poultry Association.
SAS	Statistical Analysis System.
TGF	Transforming growth factor.
USA	United State of America.
USDA	United State Department of Agriculture.
WBSF	Warmer Bratzler Shear Force.
Wk	Week.
Zn	Zinc.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

Poultry meat is an important source of protein in the world (Boer *et al.*, 2001). Thus, there has been a lot of improvement in poultry productivity through efficient breeding and nutrition (Tallentire *et al.*, 2016). However, matching nutrition with the development and growth of broiler chickens after hatching is a challenge. The first week after hatching is a critical period for the development and survival of newly hatched chickens (Khoa, 2007). Thus, according to Khoa (2007), the changes from the yolk (the endogenous diet) to a solid (exogenous diet) diet causes large metabolic and physiological changes. This, normally, results in lower growth rates of the chick (Khoa, 2007).

During the first week of life, broiler chickens undergo various development changes that are already initiated during incubation. On-going development of organs such as the gastrointestinal tract and the immune system may affect the nutritional requirements during this age period. Despite the residual yolk that is available at hatch and may provide nutritional support during the first days after hatch, the growth performance may be affected by the time in between hatch and first feed intake. Furthermore, it remains largely unknown to what extent the nutritional composition of a pre-starter diet, as well as feed availability directly after hatch, has an effect on physiological development directly after hatch, but also at a later stage (Khoa, 2017). It is better to have proper nutritional support for broiler chickens.

Colostrum plays an important nutritional role for neonatal growth and the development of body tissues, while also containing growth factors for digestive development and metabolic requirements in mammals (Blum *et al*., 2002). According to Blum and Hammon (2000); Uruakpa *et al.* (2002), ingestion of colostrum by various new-borns exhibits important morphological and functional improvements in the gastrointestinal tract, tissue and organ developments and repairments. The intake of colostrum modifies gastrointestinal tract development and digestive and absorptive capacities in mammals (Blum and Hammon, 2000). However, the effect of colostrum feeding on the performance of broiler chicks for a period of 72 hours after hatching is not clear. This requires some investigation.

1.2 PROBLEM STATEMENT

Chickens tend to lose weight immediately after hatching and this has adverse effects on subsequent growth (Willemsen *et al.*, 2010). This may be related to nutritional limitations immediately after hatching, such as the adaptation of the gut to solid feed (Sklan *et al.*, 2000). Thus, utilization of feeds like liquid bovine colostrum that can be absorbed without being digested may be helpful. There is very little information on such feeds for chickens. However, colostrum is very much utilized by young mammals, like calves, immediately after birth. In such animals, colostrum is absorbed and utilized without being digested (Georgiev, 2008). Colostrum, also, provides nutrients and immunity to the young animals. However, it is not known if colostrum would be useful to chicks after hatching.

1.3 RATIONALE

After giving birth, mammals produce colostrum for their young ones. The gut of the young mammal is permeable to colostrum, provided it is fed within 48 hours after birth (Lin *et al.*, 2009). Colostrum provides nutrients and immunity to the young ones before they get adapted to solid feeds (Georgiev, 2008). Thus, animals like calves attain rapid growth rates immediately after birth. Chickens do not produce colostrum. Thus, immediately after hatching chicks start eating solid feeds while, also, depending on the remaining yolk on their body (Sklan, 2003). The result of this is that chicks lose weight immediately after hatching (Willemsen *et al.*, 2010). This has adverse effects on subsequent growth rates (Willemsen *et al.*, 2010). However, when chicks are given liquid feeds, such as glucose, they tend to maintain weight and subsequently attain higher growth rates than those not offered glucose (McWhorter *et al.*, 2006). However, it is not clear if the gut of chicks is permeable to colostrum. Additionally, the response of chicks to colostrum feeding is not known.

1.4 AIM

The aim of the study was to determine the effect of bovine colostrum feeding periods of up to 72 hours after hatching on performance and carcass characteristics of Ross 308 broiler chickens aged one to 42 days.

1.5 OBJECTIVES

The objectives of the study were to:

i. determine the effect of liquid bovine colostrum feeding periods of 0, 12, 24, 36, 48 and 72 hours after hatching on diet intake, digestibility and growth of Ross 308 broiler chickens aged one to 42 days.
ii. determine the effect of liquid bovine colostrum feeding periods of 0, 12, 24, 36, 48 and 72 hours after hatching on gut morphology of Ross 308 broiler chickens aged 21 and 42 days.
iii. determine the effect of liquid bovine colostrum feeding periods of 0, 12, 24, 36, 48 and 72 hours after hatching on carcass characteristics of Ross 308 broiler chickens aged 42 days.

1.6 HYPOTHESES

The following were the null hypotheses tested:

i. Liquid bovine colostrum feeding periods of 0, 12, 24, 36, 48 and 72 hours after hatching have no effect on diet intake, digestibility and growth of Ross 308 broiler chickens aged one to 42 days.
ii. Liquid bovine colostrum feeding periods of 0, 12, 24, 36, 48 and 72 hours after hatching have no effect on gut morphology of Ross 308 broiler chickens aged 21 and 42 days.
iii. Liquid bovine colostrum feeding periods of 0, 12, 24, 36, 48 and 72 hours after hatching have no effect on carcass characteristics of Ross 308 broiler chickens aged 42 days.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The broiler chicken industry is an important source of protein in the world compared to other livestock (Boer *et al.*, 2001). The majority of people in Southern Africa, generally, rely on chicken meat to meet their dietary protein requirements (Mwale and Masika, 2009). Chicken meat is considered better than red meat because of low levels of fat and cholesterol and high levels of iron (Jaturasitha *et al.*, 2008).

Development of broiler chickens in terms of nutrition is an on-going challenge in poultry production. This is particularly important in post-hatch chicks. Chicks need feeds that will give them the necessary nutrients for body functioning, growth and meat production. The nutrient supply to chicks after hatching can increase the intestinal mechanical activity, fasten intestinal development, increase assimilation of feed, help in the development of immunity and thereby improve overall growth performance (Yadav *et al.*, 2010).

Colostrum can be supplemented to poultry diets as a feed additive due to its nutritious and performance-enhancing properties. Growth factors and hormones present in colostrum, effectively stimulate cellular growth and DNA synthesis in neonatal calves (Kuhne *et al.*, 2000) and improve feed intake and growth rate in pigs (Dunshea *et al.*, 2002). King *et al.* (2001) stated that spray-dried colostrum added to pig starter diets improved the performance of the animals. Additionally, in other previous studies (Qureshi *et al.*, 2004; King *et al.*, 2005) it was reported that spray-dried or colostrum concentrate supplementation to feed broiler chickens for a 14-day period improved chicken performance parameters such as body weight gain, feed intake and feed conversion ratio. However, information on liquid colostrum feeding to chicks after hatching is limited and inconclusive.

2.2 Broiler chicken production

Chickens are most widely kept livestock species in the world (Moreki *et al.*, 2010). Dieye *et al.* (2010) stated that poultry production is the widest spread of all livestock enterprises and contributes to food security improvement, socio-cultural and economic developments in most countries. Poultry production creates employment and promotes economic development in any society (SAPA, 2012). According to King'ori *et al.* (2010), chicken production has an advantage of having quick returns

on investment and relatively simple management practices with numerous market outlets for products.

Globally, broiler production was predicted by the Food and Agriculture Organisation to increase by 1.1% in 2016 (SAPA, 2016). Trade in poultry products was expected to increase by 3.5% in 2016 (SAPA, 2016). Brazil, United States of America (USA) and Thailand were expected to increase growth in trade volumes in 2016, making low global feed prices and increasing demand in the markets (SAPA, 2016). The United States Department of Agriculture (USDA) estimated that USA broiler production would increase by 1.63% in 2016 and by 2.1% in 2017 (SAPA, 2016). The USDA predicted 3.9% growth in USA broiler exports in 2017 (SAPA, 2016). The contribution of the broiler industry to the nutrition and economic status of South African consumers is well recognized (SAPA, 2012). However, broiler industry was classified by the South African Department of Trade and Industry (DTI) as an industry in distress as a result of an increase in relatively cheaper imports as well as an increase in feed prices (SAPA, 2013).

Broiler chicken industry in the developing countries like South Africa is facing challenges which include high feed to gain ratio and increase in the cost of feed due to high prices of protein and energy sources (Abbas, 2013). Researchers are looking for affordable and available alternative sources of protein and energy (Abbas, 2013). The nutritional constraints immediately after hatching may be overcome by adding feed additives in poultry diets, such as colostrum.

2.3 Nutritional requirements of chickens

Chickens require adequate amounts of all the nutrients for them to be healthy and productive. According to Richard (2005), nutritional deficiencies lead to poor productivity and increased susceptibility to infections while nutritional excesses lead to nitrogen build-up and nutritional disorder. Thus, formulating balanced rations for optimal productivity is essential. Proper management including nutrition and health in chickens is an essential factor in poultry production. According to McDonald *et al*. (2011), nutrition plays a vital role in influencing growth in livestock. Carbohydrates, fats and proteins that the chicken utilizes as sources of energy are essential requirements for growth. Mbajiogu (2010) reported that chickens can adjust their

feed intake over a considerable range of feed energy levels to meet their daily energy requirements. Thus, dietary energy levels are used to set the levels of other nutrients including protein and amino acids.

In order for productivity to be improved and maximized, the nutritional needs of the chickens must be met optimally in terms of energy and protein requirements. Alabi (2013) stated that changes in dietary energy concentration affect feed conversion efficiency in various ways, firstly, increasing dietary energy improves feed conversion ratio as less feed is taken in to satisfy the energy needs. Secondly, the growth rate is increased by increasing levels of dietary energy (Alabi, 2013). The amino acids obtained from dietary protein are used by chickens to fulfil a diversity of functions such as growth, meat or egg production. Therefore, bovine colostrum can be practically added to poultry diets for optimum growth performance due to high nutrients.

2.4 Chemical constituents of bovine colostrum

The concentration of lactose is low in colostrum and changes in an inverse manner to other constituents such as fat, protein and ash (Kehoe *et al.,* 2007). A low level of lactose in early post-partum milkings, followed by an increase until a normal level is reached, has been stated by several authors (Kehoe *et al.,* 2007; Tsioulpas *et al.,* 2007; Georgiev, 2008; Morrill *et al.,* 2012). Kehoe *et al.* (2007) and Morrill *et al.* (2012) reported that lactose concentration in colostrum is as low as 1.2%. Lactose concentration reaches a normal concentration within 7 days post-partum. A low level of lactose results in the production of milk that is extremely viscous and contains little water due to the absence of the osmoregulator lactose (Bleck *et al.,* 2009).

Bovine milk contains glucose, fructose, glucosamine, galactosamine, N-acetylneuraminic acid and oligosaccharides, defined as carbohydrates. Oligosaccharides are divided into two broad classes, that is, neutral and acidic. Neutral oligosaccharides contain no charged carbohydrate residues, whereas acidic oligosaccharides contain one or more negatively charged residues of N-acetylneuraminic acid (Gopal and Gill, 2000). The concentration of oligosaccharides in bovine colostrum is approximately 0.7 to 1.2 g.mL^{-}1 (Nakamura *et al.,* 2003), the

majority of which are acidic; whereas mature milk contains only trace amounts (Gopal and Gill, 2000).

Bovine colostrum has 40 oligosaccharides (Tao *et al.,* 2008; Barile *et al.,* 2010). However, it varies between individual cows due to unique genetic variability (Ninonuevo *et al.,* 2006). The types of oligosaccharides that are predominant in bovine colostrum includes 3′ Sialylactose (3′SL), 6′ sialylactose (6′SL), 6′ sialylactosamine (6′SLN) and disialyllactose (DSL), with 3′SL accounting for 70% of the total oligosaccharide content (Nakamura *et al.,* 2003; McJarrow and van Amelsfort-Schoonbeek, 2004; Tao *et al.,* 2009; Urashima *et al.,* 2009). Nakamura *et al.* (2003) reported that levels of 3′SL, 6′SL and 6′SLN in bovine colostrum were highest immediately following parturition and decreased rapidly by 48 hours post-partum, whereas levels of neutral oligosaccharides increased after parturition.

The concentration of casein is higher in bovine colostrum than in milk (Madsen *et al.,* 2004) and decreases at each milking post-partum. According to Sobczuk-Szul *et al.* (2013), early post-partum milk contained reduced proportions of αs-casein, which increased with time post-partum, and elevated proportions of κ-casein, which decreased with time post-partum, while the proportion of β-casein remained constant throughout. Colostrum contains elevated levels of immunoglobulin-G, -A and -M (Smolenski *et al.,* 2007) and immunoglobulins make up 70 – 80% of the total protein in colostrum, which is of particular importance to the neonate, as transfer of passive immunity to the young one occurs through colostrum and not via the placenta (Zhang *et al.,* 2011). Changes in the level and relative proportions of the immunoglobulins in colostrum compared with milk have been reported by several authors (Korhonen *et al.,* 2000; Elfstrand *et al.,* 2002; Zhao *et al.,* 2010). The concentrations of beta-lactoglobulin (β-lg) and alpha-lactalbumin (α-la) are higher in colostrum than in mature milk (Marnila and Korhonen 2002; Georgiev, 2008). Marnila and Korhonen (2002) reported that the initial concentration of β-lg in colostrum ranges from 7.9 to 30 mg.mL^{-}1, the average being 14 mg.mL^{-}1 in the first milking and falling sharply thereafter to 8 mg.mL^{-}1 in the second to fourth milkings; the decrease is more gradual until the 16th milking, when the average is 5 mg.mL^{-}1. The concentration of bovine serum albumin in colostrum is higher than in milk (Zhang *et al.*, 2011).

Lactoferrin is a cationic iron-binding glycoprotein of mammary origin that plays a key role in the defence of the mammary gland (Farrell *et al.,* 2004). Several authors have reported an increased concentration of lactoferrin in colostrum (Zhang *et al.,* 2011; Sobczuk-Szul *et al.,* 2013). Yamada *et al.* (2002) observed a total of 29 minor proteins were identified in colostrum and milk using immunoabsorption, of which several were observed only in colostrum, i.e. fibrinogen β-chain, chitinase 3-like 1, α-antitrypsin, complement C3 α-chain, gelsolin and apolipoprotein H.

Table 2.1 Components of bovine colostrum and regular milk

Component	Bovine colostrum/litre	Bovine milk/litre	References
DM	153-245g	122g	Blum and Hammon, 2000
Crude protein	41-140g	34g	Gopal and Gill, 2000
Lactose	27-46g	46g	Gopal and Gill, 2000
Crude fat	39-44g	37g	Gopal and Gill, 2000
Crude Ash	5-20g	7g	Gopal and Gill, 2000
IgG1	50-90	0.30-0.40g	Elfstrand *et al*., 2002
IgG2	1.5-2g	0.03-0.08g	Elfstrand *et al*., 2002
IgA	3.0-6.5g	0.04-0.06g	Elfstrand *et al*., 2002
IgM	3.8-6g	0.03-0.06g	Elfstrand *et al*., 2002
Lactoferrin	1.5-5g	0.1-0.3g	Elfstrand *et al*., 2002
Lactoperoxydase	30mg	20mg	Elfstrand *et al*., 2002
Lysozyme	0.14-0.7mg	0.07-0.6mg	Elfstrand *et al*., 2002
IL-IB	840µg	3µg	Hagiwara *et al*., 2000
IL-Ira	5.2mg	21µg	Hagiwara *et al*., 2000
IL-6	77µg	0.15µg	Hagiwara *et al*., 2000
TNF-α	926µg	3.3µg	Hagiwara *et al*., 2000
IFN-γ	260µg	0.21µg	Hagiwara *et al*., 2000
IGF-1	100-2000µg	<25µg	Elfstrand *et al*., 2002
IGF-2	200-600µg	<10µg	Pakkanen and Aalto, 1997
GH	<1µg	0.03µg	Scammell, 2001
EGF	4-8mg	2µg	Scammell, 2001
TGF	100-300µg	1-2µg	Elfstrand *et al*., 2002

DM = dry matter, Ig = immunoglobulin, IL = interleukin, TNF = tumor necrosis factor, INF = interferon, IGF = insulin-like growth factor, GH = growth hormone, EGF = epidermal growth factor, TGF = transforming growth factor

2.5 Antimicrobial and growth factors in bovine colostrum

2.5.1 Introduction

Antimicrobial and growth factors are the most essential biochemical components found in colostrum. Antimicrobial factors found in colostrum include lactoferrin and lysozyme while growth factors include insulin-like growth factors (IGF-1 and IGF-2), insulin and transforming growth factor beta (TGF-β1 and TGF-β2). Growth factors are required for stimulating the growth and development of a living cell while antimicrobial factors provide passive immunity and protect against infections during the first weeks of life. (Pakkanen and Alto, 1997; Gauthiet *et al*., 2006).

2.5.2 Antimicrobial factors

Lactoferrin found in colostrum is an 80 kDa iron-binding glycoprotein and it is also found in milk and other exocrine fluids (Tsuji *et al.,* 1990). Lactoferrin plays an important role in iron uptake in the intestine and activation of phagocytes and immune responses. The concentration of lactoferrin in bovine colostrum and mature milk is about 1.5 - 5mg mL^{-1} and 0.1mg mL^{-1}, respectively (Tsuji *et al.,* 1990). Lactoferrin stimulates cell growth and acts as a growth factor or iron carrier molecule (Hagiwara *et al.,* 1995). Receptors for lactoferrin are found in intestinal tissues, monocytes, macrophages, neutrophils, lymphocytes, platelets and on some bacteria (Viljoen, 1995). As a binding free iron, lactoferrin may act as an antioxidant, protecting the immune cells against free radicals produced by themselves in areas of inflammation or infection (Britigan *et al.,* 1994).

Lysozyme is a lytic enzyme of 14.3 kDa. The natural substrate of this enzyme is the peptidoglycan layer of the bacterial cell wall and its degradation results in lysis of the bacteria (Ibrahim *et al.,* 1994). Due to the difference of the outer membrane structure between gram-negative and gram-positive bacteria, the lysozyme action is more intensive on gram-positive bacteria, leading to the death of the bacteria, while it does not adversely affect the viability of gram-negative bacteria (Ibrahim *et al.,* 1994).

A particularity of the lysozyme is its interaction with other factors present in the colostrum. It partly activates lactoperoxidase by forming a complex with it (Hulea *et al.,* 1989). In the presence of lactoferrin, the antimicrobial activity of lysozyme

against *E. coli* is also enhanced as lactoferrin damages the outer membrane of gram-negative bacteria and the organism becomes susceptible to lysozyme (Yamauchi *et al.,* 1993).

Immunoglobulins are glycoproteins constituted by four amino acid chains; two identical light chains (23 kDa) and two identical heavy chains (50 - 70 kDa) (Elfstrand *et al.,* 2002). According to the structure of their heavy chains, they can be divided into five classes: IgG, IgA, IgM, IgE and IgD. Igs are present in very high concentrations in colostrum. They represent 70 - 80% of the total protein contents in colostrum (up to 100 g.l^{-1} in bovine colostrum) (Elfstrand *et al.,* 2002), whereas in mature milk Igs account for only 1 - 2% of the protein.

Three classes of Igs are present in bovine colostrum: IgG, IgA and IgM. The major Igs present in bovine colostrum is IgG, among which 95% belong to the subclass IgG1 and 5% to the IgG2. In the neonates, the colostral Igs are transferred from the lumen of the intestine into the circulation through a non-selective macromolecular transport system across the small intestinal epithelium (Pakkanen and Alto, 1997). This non-selective absorption occurs only within about 24 - 36 hours after birth and provides the transmission of passive immunity from the dam to its young one (Pakkanen and Alto, 1997). However, it has been shown that older animals can absorb Igs, but larger quantities of these antibodies are required for effective transport (Maher, 2000). All Igs exhibit one or more effector function in addition to antigen binding (Maher, 2000). Whereas one part of an antibody binds to an antigen, other parts interact with other elements. The immunological function mediated by the Igs depends on the Ig class. The most important action of IgG antibodies is the activation of complement-mediated bacteriolytic reactions (Korhonen *et al*., 2000). Another vital function is their ability to increase the recognition and phagocytosis of bacteria by leucocytes. Immunoglobulin-M antibodies are considerably more efficient than IgG in regards to the above activities, especially complement-mediated lysis (Korhonen *et al*., 2000). Immunoglobulins present in bovine colostrum under a secretory form make them resistant to the activities of proteolytic digestive enzymes (Korhonen *et al*., 2000). The effect of antimicrobial factors on the productivity of hatchlings is not clear. It is, therefore, important to determine such effects in broiler chickens.

2.5.3 Growth factors

The most abundant growth factors of bovine colostrum are insulin-like growth factors-I and –II (IGF-I and –II). Both IGF-I and -II are single chain polypeptides with 70 and 67 amino acid residues and molecular weights of about 7.6 and 7.5 kDa, respectively (Xu *et al.,* 2000). The primary structures of IGF-I and -II are highly conserved across species and have identical sequences in pigs, humans and cattle (Xu *et al.,* 2000). They stimulate cell growth and differentiation and are proposed to act both as endocrine hormones through the blood and, locally, as paracrine and autocrine growth factors. Insulin-like growth factor-I is biologically more potent than IGF-II (Jones *et al.,* 1994).

The detectable level and rank of specific IGFBP in bovine mammary secretions are IGFBP-3 > IGFBP-2 ≈ IGFBP-4 > IGFBP-5 (Blum *et al.,* 2002). These binding proteins are involved in the regulation and the coordination of biological activities of the IGF-I and -II (Hwa *et al.,* 1999).

In biological fluids, IGF-I is usually bound to its binding proteins (IGFBP), which have also been detected in bovine milk. Insulin-like growth factor-I appears in mature milk mainly in the bound form (85-90%), but in the first milkings postpartum the free form of IGF-I predominates (73%). The slightly acidic pH (6.3) of the colostral secretion is correlated with an increased proportion of the free IGF-I (Einspanier and Schams, 1991).

The polypeptides of this family have the common property of binding to the epidermal growth factor (EGF) receptor (a 175 kDa cell surface glycoprotein with tyrosine kinase activity). The most important members of this family are EGF and transforming growth factor alpha (TGF-α) (Barnard *et al.,* 1995).

Epidermal growth factor (EGF) is a 6 kDa peptide, composed of 53 amino acids. The peptide is highly homologous among species and elicits similar effects across species (Schweiger *et al.,* 2003). Colostral EGF plays an important role in the prevention of bacterial translocation and also in the stimulation of gut growth in suckling neonates by playing an important role in cell differentiation rather than cell proliferation and in stimulating mucus secretion (Schweiger *et al.,* 2003). Transforming growth factor-α is a 6 kDa peptide, composed of 50 amino acids and

shares about 30% sequence identity with EGF. It may play a complementary role to that of TGF-β in controlling the balance between cell proliferation and differentiation in the intestinal epithelium (Playford *et al.,* 2000).

Three isoforms of transforming growth factor beta (TGF-β1, β2 and β3) are known. Transforming growth factor-β1 and β2 have been isolated from bovine colostrum, with a predominance of the β2 form (85-95%) (Elfstrand *et al.,* 2002). Transforming growth factor-β stimulates proliferation of some cells, especially in connective tissue, whereas it acts as a growth inhibitor of some other cells, such as lymphocytes and epithelial cells (Elfstrand *et al.,* 2002). Transforming growth factor-β plays an important role in embryogenesis, tissue repair, the formation of bone cartilage, and in the control of the immune system (Tripathi *et al.,* 2006). During injury or disease, it acts in concert with EGF to stimulate cell proliferation (Tripathi *et al.,* 2006).

2.6 Bovine colostrum as feed additives in broiler chicken production

Colostrum is known as a nutrient-dense liquid secreted by female mammals during the first few days following parturition (Akdemir *et al.*, 2016). Its primary importance is derived from the number of immono-globulins (Igs) it contains, which play a role in the immune system (Godhia and Patel, 2013). Previous studies have shown that colostrum is important for the growth of developing cells and tissues during the early phase of life because it contains immune-regulating components, nutritional substances, transferrin, essential and non-essential amino acids, fatty acids and anti-microbial and larger amounts of protein, fats, vitamins and minerals (Blum and Hammon, 2000; Godhia and Patel, 2013).

Uruakpa *et al.* (2002) stated that colostrum is responsible for important morphological and functional improvements in the gastrointestinal tract, tissue and organ development, metabolic and endocrine changes in the newborn calves, lambs and pigs. Colostrum has been evaluated for use in a powdered feed additive that includes essential and non-essential amino acids, fatty acids, proteins, fats, vitamins and minerals (Xu, 1996). Furthermore, it has been stated in other studies that colostrum powder supplementation improves palatability and enhancement of beneficial microflora population in the digestive system associated with better digestion and absorption of nutrients in neonates (Cheeke, 2005; Chiba, 2014).

Bovine colostrum is extremely nutritious and is essential for the development and immune status of neonates (Przybylska *et al.*, 2007; Godhia and Patel, 2013). Dried colostrum powder supplement contains larger quantities of nutrients such as carbohydrates, fats, amino acids, globulins and probiotics (Blum and Hammon, 2000). Akdemir *et al.* (2016) reported that colostrum powder supplementation increased body weight gain and improved feed efficiency in Japanese quails. Spray-dried colostrum supplemented to broiler ration, for 14 days improved growth performance parameters such as body weight gain, feed intake and feed conversion ratio (Quresh *et al.*, 2004; King *et al.*, 2005).

King *et al.* (2005) indicated that dietary spray-dried colostrum improved feed conversion ratio at Day 14 while Qureshi *et al.* (2004) observed that protein concentrate having similar ingredients to colostrum increased body weight gain at Day 13 in the growing period of broiler chickens. The effect of colostrum powder on the performance parameters of growing Japanese quails increased the final body weight, live weight gain, feed intake, carcass weight, carcass yield and improved feed efficiency as the inclusion levels of colostrum powder increased from 0 to 5% (Akdemir *et al.*, 2016). Akdemir *et al.* (2016) reported that high doses of colostrum powder caused 6.8, 11.0, 5.6, 11.4 and 10.1% increases in final body weight, live weight gain, feed intake, carcass weight and carcass yield, respectively and 4.9% improvement in feed efficiency. However, there is a lack of information on the effect of liquid colostrum as a dietary supplement for broiler chickens. There was, therefore, need to determine the response of broiler chickens to liquid colostrum feeding.

2.7 Bovine colostrum feeding in broiler chickens

Bovine colostrum is used in chickens due to its nutritional value and performance-enhancing properties. Immune and growth factors are two important components contained in bovine colostrum (Kelly, 2003). According to Gauthier *et al*. (2006), immune factors are substances that reduce the effects of microorganisms causing diseases. Therefore, Uruakpa *et al*. (2002) stated that growth factors contain components that increase healing effects by building and aiding recovery of bones, muscles, fibres and cartilage, stimulating fat metabolism, sustaining blood glucose level balance and helping to regulate brain chemicals. In addition, bovine colostrum

contains an array of antibacterial and antiviral factors which are responsible for performing specific and non-specific passive immunological defence functions in the intestinal lumen (King *et al*., 2005).

Spray-dried bovine colostrum is commonly used as sources of highly digestible and palatable protein in the pig industry, where their inclusion on the weaner-starter diets improves pig performance (Coffey and Cromwell, 2001; van Dijk *et al*., 2001). The inclusion of spray-dried colostrum in the diet of birds after hatching reduce the density of crypt goblet cells compared with those not fed colostrum (King *et al.*, 2005). King *et al*. (2001) stated that dietary spray-dried bovine colostrum is more effective at stimulating voluntary feed intake of calves. According to Pluske *et al*. (1999a), spray-dried bovine colostrum improves growth rate, feed intake and feed conversion ratio in the first 10 days after weaning of calves. However, the effect of feeding colostrum effect on the performance of broiler chickens is not clear. Therefore, there is a need to do more research on the effect of bovine colostrum feeding on the performance of broiler chickens.

It has been reported in the literature that powdered and liquid colostrum efficiently improves the performance of Japanese quails (Akdemir *et al*., 2016; Baran *et al*., 2017). Colostrum powder supplementation increases the palatability of feed and enhances the beneficial effects of microflora population in the digestive system associated with better digestion and absorption of nutrients in animals (Cheeke, 2005; Chiba, 2014). Baran *et al*. (2017) stated that liquid bovine colostrum supplementation increased body weight gain and decreased feed efficiency in quails with increasing dietary bovine liquid colostrum supplementation. It has been reported that animal protein by-products must be added to poultry diets because of deficiency in some nutrients, especially amino acids (Beski *et al*., 2015). Thus, in studies made on humans, it has been reported that cow colostrum increases muscle growth, accelerates muscle-skeleton regeneration and enhances strength (Buckley *et al.*, 2002). However, more research has been on colostrum’s effects on performance of ruminants than in poultry. Not much is known on the effect of feeding bovine colostrum on the productivity of broiler chickens.

2.8 Effect of early feeding on the performance and gut health in broiler chickens

2.8.1 Gastrointestinal development in chicks

Yadav *et al.* (2010) reported that post-hatch nutrition of chicks in the first week helps in the utilization of yolk sac, thus improving immunity development and gut function enhancement. At hatching, the digestive system of a chick is anatomically immature and its functional capacity is not fully developed (Yadav *et al.*, 2010). The gastrointestinal tract of the newly hatched chick is immature and undergoes morphological changes (increase in intestinal length, villus height and density) and physiological changes (increased production of pancreatic and digestive enzymes) including the increased surface area of digestion and absorption during the post-hatch period (Yadav *et al.*, 2010). During the post-hatch period, the small intestine weight increases at a faster rate than the body (Sklan, 2001) because of rapid enterocyte proliferation and differentiation (Geyra *et al.*, 2001).

According to Noy and Sklan (1998), feeding immediately after hatching accelerates the morphology development of the small intestines while delayed access to external feed slows down the development of the small mucosal layer (Geyra *et al.*, 2001; Uni *et al.*, 2003). Geyra *et al.* (2001) reported that delayed access of feed to day-old chicks for 24 - 48 hours resulted in a decrease in villi length and enterocytes migration rate. Previous studies have also shown that delayed access to feed for 48 hours post-hatch resulted in changes in mucin dynamics which affect the absorptive and protective functions of the small intestines (Uni *et al.*, 2003). Early feeding has a positive effect in triggering the development of the gut in broiler hatchlings.

According to Aptekmann *et al.* (2001), a healthy chick, as the physiological development of birds is directly related to digestion and nutrient absorption in the small intestines (Aptekmann *et al.*, 2001). Dramatic developmental changes occurring in the avian gut 2 to 3 days post-hatch is due to change in nutrient sources from yolk to an exogenous feed ration rich in carbohydrates and other nutrients (Henderson *et al.*, 2008). Nutritional supplements immediately after hatching helps in the development of the digestive system which evokes the nutrient utilization, growth and overall performance of chicks (Henderson *et al.*, 2008).

During incubation, the swallowing of amniotic fluid helps initiate and support the development of the gastrointestinal tract (Bohorquez *et al.*, 2011). Amniotic fluid is rich proteins, amino acids, growth factors and hormones which play a role in the stimulation of the division and proliferation of the intestinal epithelium and the consumption initiates the rapid growth and development of the gastrointestinal tract (Bohorquez *et al.*, 2011). Gastrointestinal tract (GIT) becomes functionally mature and effective at digestion and nutrient absorption by Day 12 of age in poultry (Bohorquez *et al.*, 2011).

Diet structure and composition are causative factors to explain the variation in the functioning of the gastrointestinal tract (Gabriel *et al.,* 2003). A good functioning of the gut with regard to the diet can be defined as a diet that is designed to match the intrinsic characteristics of the gastrointestinal tract of the bird. The changes from the yolk (endogenous diet) to a solid (exogenous diet) will cause large metabolic and physiological transitions (Khoa, 2007). The exogenous solid diets offered to chicks during early feeding can vary due to differences in both nutrients (carbohydrates, protein, fats and their functionality) and also in feed form due to technological modification (Plavnik, 2003). This variation determines feed intake in the first days and this will have a major impact on the development of the gastrointestinal tract and of the other digestive organs. In general, GIT development in newly hatched chicks is influenced by access to feed and water. Delayed feeding may cause poor viability and reduction in growth (Madsen *et al.*, 2004). Bovine colostrum added to poultry diets may have positive effects on the GIT of newly hatched chicks. However, the role of colostrum feeding in the poultry diet has not been fully defined.

2.8.2 Influence of early feeding on growth performance in broiler chickens

The importance of early feeding has been extensively researched in recent years. Hence, early feeding has a great effect in triggering the right momentum of growth in broiler chicken hatchlings (El-Husseiny *et al.*, 2008; Panda *et al.*, 2010). Noy and Sklan (1999) reported that the residual yolk is usually utilized within 4 days of post-hatching while Juul-Madsen *et al.* (2004) indicated that the residual yolk is utilized more quickly in chickens that have access to feed immediately after hatch than in those that are fasted for 48 hours. Noy and Uni (2010) reported that the delayed consumption of water and nutrients could lead to reduced growth and weight in

chicks. In addition, early access to feed and water not only improved the weight gain of chicks but also reduced mortality (Yi *et al.*, 2005). It should be noted that early nutritional strategies offer the promise of sustaining progress in production efficiency and welfare of commercial broiler chicks (Noy and Uni, 2010).

According to Pourreza *et al.* (2012), the nutrient intake of chicks after hatching can influence their subsequent performance characteristics. It has been determined that early access to feed and/or protein supplementation results in the more rapid development of the gastrointestinal and muscular system (Noy and Sklan, 2001), immune system (Brink and Rhee, 2007) and faster utilization of yolk (Noy *et al.*, 1996). The gastrointestinal tract grows more rapidly than body weight during the first few days following hatch and plays a critical role in the early stages of chick growth (Alhotan, 2011). Early feeding, that is, access to feed and water in newly hatched birds has been demonstrated to be beneficial (Kornasio *et al.*, 2011).

Delayed access to feed is normally due to the time chicks spend in the hatchery as well as time spent travelling from the hatchery to the farm (Paul, 2015). Newly hatched chicks rely on the yolk sac, which can provide chicks with temporary sustenance for several days. Despite the yolk sacs in chicks, delayed feeding can have negative consequences on the growth and development of broiler chicks. Some of the consequences include slow gastrointestinal and muscular development, reduced growth performance and immunosuppression (Ao *et al.*, 2012; Juul-Madsen *et al.*, 2004). However, early feeding strategies have suggested and developed to diminish or possibly reverse the negative effects of delayed feeding.

Delayed access to feed can be detrimental to the development and performance of broiler chicks, which result in negative consequences for producers (Paul, 2015). The physiological consequence of delayed access to feed is chick body weight loss. Hence, in the time between placements (24 – 48 hours), chicks may lose an average initial body weight of 8% (Noy and Sklan, 1999). According to El-Husseiny *et al.* (2008), prolonged delayed access to feed, larger than 72 hours, often results in significant increases in chick mortality.

When chicks are subjected to delayed access to the feeding of 24 – 72 hours, gastrointestinal growth is decreased and the morphology of the intestinal tract is

altered by increasing villus surface area and reducing villus height in the small intestines (Mikec *et al.*, 2006). Bar Shira *et al.* (2005) reported that gastrointestinal development associated with lymphoid tissue, especially in the hindgut, may be susceptible to infectious pathogens during the first two weeks of life when chicks are delayed access to feed. According to Bhanja *et al*. (2010), 48 hours of delayed feeding caused reduced body weight in broiler chickens. Most studies in the literature examined the long-term effects of delayed feeding on the performance of chicks, particularly reduced feed intake, were observed in chicks that were denied access to feed post-hatch. According to Juul-Madsen *et al.* (2004), post-hatch delayed feeding of 48 hours lowered immune capacity of broilers up to 42 days of age due to reduced humoral and cellular immune capacity.

In response to the negative effects of delayed feeding on broiler chicken production, early feeding strategies with different nutritional approaches have been developed which include hatchery feeding or feeding during transportation, nutrient injection into the egg during incubation and feeding pre-starter diets (Paul, 2015). According to Paul (2015), the nutritional approaches for early feeding strategies have been based on yolk nutrient composition, embryo energy and nutrient metabolism, nutrient in gastrointestinal development, early post-hatch digestibility of simplified and complex diets or various combinations. Information on the effect of liquid colostrum feeding post-hatch on the performance and carcass characteristics of newly hatched chicks is lacking. It is, therefore, important to determine the response of broiler chicks to colostrum feeding. Such information will result in better economic, the nutritional and social status of the farmers.

2.9 Conclusion (Summary)

Bovine colostrum can play an important role in chicken diets due to its performance-enhancing properties and high nutrients. Information on the use of bovine colostrum post-hatch is not extensive and inconclusive. There is, also, a lack of information on the effect of bovine colostrum feeding on optimal productivity of broiler chickens. Thus, there is a need to determine the effect of bovine colostrum feeding period on feed intake, digestibility, growth rate, feed conversion ratio, live weight, gut morphology and carcass characteristics of Ross 308 broiler chickens. Such

information will be valuable to farmers in South Africa and elsewhere with regard to improving the productivity of their chickens.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study site

The study was conducted at the University of Limpopo Livestock Unit (latitude 27.55°S and 24.77°E), Limpopo province, South Africa. The ambient temperatures around the study area range between 20 and 36°C during the summer and between -5 and 28°C during winter (Shiringani, 2007).

3.2 Preparation of the house

The poultry house was thoroughly cleaned with water and then disinfected using Vet GL 20 disinfectant (NTK, Polokwane). Drinkers and feeders were cleaned and disinfected with Vet GL 20 before use. The house was left empty for 7 days prior to the start of the experiment in order to eliminate the population of infectious microorganisms. The experimental house was divided into 18-floor pens of $2m^2$ per pen. Fresh sawdust was spread in each pen to a thickness of 8cm high. The heating of the house was done using 250 watt-infrared lights.

3.3 Acquisition of materials and chickens

Ross 308 broiler chicks were acquired from Lufafa Hatchery, Tzaneen, South Africa. Commercial grower mash was acquired from Voorslagvoere Milling Company at Mokopane, South Africa. Bovine colostrum was obtained from the Limpopo Dairy, situated in Louis Trichardt, South Africa. Vet GL 20 disinfectant, 250 watts infrared lights, feeders and drinkers were acquired from NTK, Polokwane, South Africa.

3.4 Experimental procedures, diets and design

Ross 308 broiler chickens were sexed at hatching, only males were used in the study because of lack of facilities at the farm, and also because males grow faster than females (Kaminski and Wong, 2017). A total of 180 male Ross 308 broiler chicks were used in this study. The chicks were randomly assigned to six treatment groups (Table 3.3) of bovine colostrum feeding periods of 0 or no bovine colostrum given ($MCOL_0$), 12 ($MCOL_{12}$), 24 ($MCOL_{24}$), 36 ($MCOL_{36}$), 48 ($MCOL_{48}$) and 72 ($MCOL_{72}$) hours after hatching in a completely randomised design with three replicates of 10 chicks in each. After 72 hours of liquid bovine colostrum feeding plus grower mash, all the chicks continued feeding grower mash until the end of the

experiment. Data collection was done from day-old up to 42 days of age. The experiment was terminated when chickens were 42 days of age. The chicks were vaccinated at the hatchery against New Castle and Infectious Bronchitis (Gumboro) with Vitabron (produced at Ceva Animal Health Company, South Africa) before being delivered to the experimental site. The initial live weights of the chicks were taken using an electronic weighing balance and their initial mean live weight was 42 ± 2g. The experimental chicks were fed a grower mash formulated by Voorslagvoere Milling Company at Mokopane, South Africa. The diets were isonitrogenous and isocaloric. The ingredients of the experimental diets are presented in Table 3.1. The nutrient contents of bovine colostrum are indicated in Table 3.2. Bovine colostrum was given *ad libitum* depending on the treatment as specified in Table 3.3. Feed intake was measured every day. Feed and water were offered *ad libitum* throughout the experiment. The light was provided for 24 hours per day throughout the experiment and mortality was observed every day throughout the study period.

3.5 Data collection

3.5.1 Growth parameters

The initial live weight of the chicks were measured at the commencement of the experiment, thereafter, average live weight per bird was measured at weekly intervals. These live weights were used to calculate the growth rate of the chickens. Daily feed intake was measured by calculating the difference between the weight of feed offered and weight of feed leftover and the difference was divided by the total number of chickens in the pen. Feed conversion ratio per pen was calculated as total feed consumed divided by the weight gain of the birds in that pen (McDonald *et al.*, 2010).

3.5.2 Nutrient digestibility

Apparent digestibility was determined when the chickens were aged 14 to 21 days and 35 to 42 days. Apparent digestibility trials were conducted in specially designed metabolic cages equipped with separate feed and water troughs. One bird was randomly selected from each replicate and transferred to the metabolic cage for the measurement of apparent digestibility. A three-day acclimatization period was allowed prior to a four-day total faecal collection period. Droppings voided by each

bird were collected daily at 8:00 hours. Apparent digestibility (AD) was calculated using the following formula:

$$\text{AD (\%)} = \frac{(\text{Amount of nutrient ingested} - \text{Amount of nutrient excreted})}{\text{Amount of nutrient ingested}} \times 100$$

3.5.3 Carcass characteristics

Chickens were slaughtered at the ages of 21 and 42 days in accordance with the guidelines of the University of Limpopo Animal Research Ethics Committee to determine gut organ weights and lengths and gut organ digesta pH. Before the slaughtering, each chicken was weighed using an electronic weighing balance. The carcasses were then put inside a bucket containing hot water for a few seconds and they were then taken out. The carcasses were then put on a table for defeathering with hands. The carcasses were cut open at the abdominal site and the digestive tracts were removed from the abdominal cavities of the chickens. After slaughter, the carcass weight of each chicken was measured only at the age of 42 days. Gastrointestinal tract, small intestine, caeca and large intestine lengths were determined using a tape measure. The pH of gut contents (crop, proventriculus, gizzard, ileum, caecum, and colon) were measured using a digital pH meter (Crison, Basic 20 pH meter). Breast, drumstick, thigh, crop, proventriculus, gizzard, small intestine, caeca and large intestine weights were measured using an electronic weighing balance.

3.6 Chemical analysis

Dry matter of feeds, bovine colostrum, feed refusals, faeces and meat were determined by drying the samples in the oven for 24 hours at a temperature of 105ºC (AOAC, 2012). Neutral and acid detergent fibre contents of feed and faeces were determined according to Van Soest *et al*. (1991). Ash contents of feeds, bovine colostrum, faeces and meat samples were determined by ashing the sample at 600ºC in a muffle furnace overnight. Ash was analysed for calcium, magnesium, phosphorus, potassium, sodium, zinc, iron, copper and manganese (AOAC, 2012). Nitrogen contents of feed, colostrum and meat samples were determined by the Kjeldahl method (AOAC, 2012). Gross energy values of feeds, bovine colostrum, faeces and meat were determined using a bomb calorimeter (AOAC, 2012). Fatty

acid and amino acid contents of the diets and meat were analysed by ion – exchange chromatography (HPLC, University of Limpopo). A full analysis for faeces and feeds was performed at the Pietermaritzburg laboratory, Kwa-Zulu Natal, South Africa according to AOAC (2012). Metabolisable Energy (ME) content of the diets was calculated according to AOAC (2000). Crude fat of the diet was determined following the methods of AOAC (2000).

3.7 Sensory evaluation

Meat samples which were previously frozen at -40°C for 4 days were thawed for 7 hours at room temperature prior to cooking. The breast meat was prepared and the skin was left on the meat samples. The method adopted by Pavelková *et al.* (2013) was used for sensory evaluation of the meat. The following sensory attributes were evaluated by the sensory panel: tenderness, juiciness and flavour of meat samples. The sensory panel consisted of 20 trained panellists. Each panellist was offered to drink lemon juice after tasting meat from each treatment before proceeding to the next treatment as to wash out the previous treatment to avoid confusion of tastes. The five-point ranking scale scores used are as indicated in Table 3.4. Nothing was added to the meat samples so as not to affect taste. An oven set at 105ºC was allowed to preheat prior to cooking. The meat samples were put in trays and they were covered with aluminium foil to prevent water loss. Thereafter, the trays with meat were put in an oven for approximately 60 minutes and the meat samples were turned after every 10 minutes. Samples were cut into small 5cm cubic pieces and served immediately after cooking. The individual breast meat was selected for sensory evaluation because of ease of handling.

Table 3.1 Feed ingredients and nutrient composition of the diets

	Treatment *					
	$MCOL_0$	$MCOL_{12}$	$MCOL_{24}$	$MCOL_{36}$	$MCOL_{48}$	$MCOL_{72}$
Feed Ingredient (%)						
Yellow maize	39.82	39.83	39.83	39.83	39.83	39.83
Soybean full fat	17.73	17.73	17.73	17.73	17.73	17.73
Wheat	15.00	15.00	15.00	15.00	15.00	15.00
Sunflower	12.39	12.39	12.39	12.39	12.39	12.39
Fishmeal	5.66	5.66	5.66	5.66	5.66	5.66
Vitamin + minerals premix	3.00	3.00	3.00	3.00	3.00	3.00
Oil sunflower	2.50	2.50	2.50	2.50	2.50	2.50
Na bicarbonate	1.50	1.50	1.50	1.50	1.50	1.50
Limestone	1.50	1.50	1.50	1.50	1.50	1.50
Salt	1.30	1.30	1.30	1.30	1.30	1.30
Monocalcium Phosphate	0.20	0.20	0.20	0.20	0.20	0.20
DL methionine	0.15	0.15	0.15	0.15	0.15	0.15
L threonine	0.15	0.15	0.15	0.15	0.15	0.15
L lysine	0.10	0.10	0.10	0.10	0.10	0.10
Colostrum (hours)*	0	12	24	36	48	72
Total	100	100	100	100	100	100
Nutrients						
Crude Protein (%)	20	20	20	20	20	20
Energy (MJ/kg DM)	16.1	16.0	16.1	16.1	16.1	16.0
Lysine (%)	1.08	1.08	1.08	1.08	1.08	1.08
Methionine (%)	0.53	0.53	0.53	0.53	0.53	0.53
Threonine (%)	0.89	0.89	0.89	0.89	0.89	0.89
Fat	2.27	2.27	2.27	2.27	2.27	2.27
Ash	10.28	10.28	10.28	10.28	10.28	10.28
Ca	1.07	1.07	1.07	1.07	1.07	1.07

*Liquid bovine colostrum fed *ad libitum* for a period of 0 “no bovine colostrum”, 12, 24, 36, 48 and 72 hours after hatching

Table 3.2 Nutrient contents (g/kg) of bovine colostrum

Component	Bovine colostrum
Dry matter	939
Crude protein (N×6.25)	766
Crude fat	8.9
Gross energy, MJ/kg	20.6
Amino acids	
Alanine	28
Arginine	29
Aspartic acid	59
Cystine	8
Glutamic acid	144
Glycine	18
Histidine	20
Isoleucine	34
Leucine	68
Lysine	58
Methionine	19
Phenylalanine	33
Proline	65
Serine	47
Threonine	39
Tyrosine	39
Valine	49
Minerals	
Calcium	12.9
Phosphorus	9.1
Sodium	1.1
Potassium	4.6

Table 3.3 Dietary treatments for the study

Diet code	Diet description
$MCOL_0$	Male Ross 308 broiler chickens fed a 20% CP grower mash without liquid bovine colostrum.
$MCOL_{12}$	Male Ross 308 broiler chickens fed a 20% CP grower mash plus *ad libitum* liquid bovine colostrum for 12 hours after hatching.
$MCOL_{24}$	Male Ross 308 broiler chickens fed a 20% CP grower mash plus *ad libitum* liquid bovine colostrum for 24 hours after hatching.
$MCOL_{36}$	Male Ross 308 broiler chickens fed a 20% CP grower mash plus *ad libitum* liquid bovine colostrum for 36 hours after hatching.
$MCOL_{48}$	Male Ross 308 broiler chickens fed a 20% CP grower mash plus *ad libitum* liquid bovine colostrum for 48 hours after hatching.
$MCOL_{72}$	Male Ross 308 broiler chickens fed a 20% CP grower mash plus *ad libitum* liquid bovine colostrum for 72 hours after hatching.

Table 3.4 Evaluation scores used by the sensory panel

	Sensory attribute		
Score	Tenderness	Juiciness	Flavour
1	Too tough	Too dry	Very bad flavour
2	Tough	Dry	Poor flavour
3	Neither tough nor tender	Neither dry nor juicy	Neither bad nor good flavour
4	Tender	Juicy	Good flavour
5	Too tender	Too juicy	Very good flavour

Source: Pavelková *et al.* (2013)

3.8 Shear force

Shear force assessment was done according to Warner-Bratzler Shear Force determination procedures (Dawson *et al.*, 1991). Frozen samples of chicken breast meat were thawed for 24h at 2°C. The samples were removed, tagged and used for cooked Warner Bratzler Shear Force (WBSF) measurements. Cooked meat was prepared by boiling breast cuts in a cylindrical pot using an electric stove. An electric Astove was set on for 25 min prior to preparation. The cuts were boiled to an internal temperature of 35°C, then turned and finished at 70°C. Cooked cuts were cooled down to room temperature (18°C) for at least 2 hours before WBSF measurements. Three cylindrical samples (12.5 mm core diameter) of each cut were cored parallel to the grain of the meat and sheared perpendicular to the fibre direction using a Warner-Bratzler shear device mounted on a Universal Instron Apparatus (cross head speed = 200 mm / min, one shear in the centre of each core). The reported value in kg represents the average of three peak force measurements of each sample.

3.9 Statistical analysis

Data on feed intake, live weight, growth rate, digestibility, feed conversion ratio, metabolisable energy, gastrointestinal morphology, shear force, sensory evaluation and carcass characteristics of male Ross 308 broiler chickens was analysed using General Linear Model (GLM) procedures of the statistical analysis of variance Version 9.3.1 software program (SAS, 2008) to detect dietary treatment effects. Where significant differences were observed, the mean separation was done using the Turkey test at the 5% level of significance (SAS, 2008). The statistical model Y_{ij} =

$\mu + T_i + e_{ij}$, was applied, where Y_{ij} = feed intake, digestibility, feed conversion ratio, growth rate, live weight, gastro-intestinal morphology, carcass characteristics, sensory evaluation and shear force; μ= the overall mean; T_i = treatments of liquid bovine colostrum feeding periods (0, 12, 24, 36, 48 and 72 hours) and e_{ij}= random error.

The responses in optimal feed intake, crop and gizzard weight, tenderness and shear force to bovine colostrum feeding periods were modelled using the quadratic equation (SAS, 2008) below:

$$Y = a + b_1x + b_2x^2 + e$$

Where Y = optimal feed intake, crop and gizzard weight, tenderness and shear force; a = intercept; b = coefficients of the quadratic equation; x = bovine colostrum feeding period and $-b_1/2b_2$ = x value for optimal response, e is the error.

The relationships between optimal responses in growth rate, live weight, caecum length, small intestine, carcass and thigh weight and bovine colostrum feeding periods was modelled using a linear regression equation (SAS, 2008) in the form of:

$$Y= a+ bx$$

Where Y = growth rate, live weight, caecum length, small intestine, carcass and thigh weights, a = intercept, b = coefficient of the linear equation and x = bovine colostrum feeding periods.

CHAPTER FOUR

RESULTS

4.1 Nutrient composition of the diets

Results of the nutrient composition of the experimental diets are presented in Table 4.1. The diets had similar protein and energy contents of 20% and 16.92MJ/kg DM, respectively. However, the diets had different *ad libitum* bovine colostrum feeding periods of 0 or no bovine colostrum given ($MCOL_0$), 12 ($MCOL_{12}$), 24 ($MCOL_{24}$), 36 ($MCOL_{36}$), 48 ($MCOL_{48}$) or 72 ($MCOL_{72}$) hours after hatching.

Table 4.1 Diet composition (% except MJ/kg DM for energy and mg/kg DM for Zn, Cu, Mn and Fe)

	Treatment #					
Nutrient	$MCOL_0$	$MCOL_{12}$	$MCOL_{24}$	$MCOL_{36}$	$MCOL_{48}$	$MCOL_{72}$
DM	90.93	90.93	90.93	90.93	90.93	90.93
CP	20.00	20.00	20.00	20.00	20.00	20.00
Energy	16.92	16.92	16.92	16.92	16.92	16.92
ADF	9.26	9.26	9.26	9.26	9.26	9.26
NDF	12.54	12.54	12.54	12.54	12.54	12.54
Fat	2.27	2.27	2.27	2.27	2.27	2.27
Ash	10.28	10.28	10.28	10.28	10.28	10.28
Ca	1.57	1.57	1.57	1.57	1.57	1.57
Mg	0.22	0.22	0.22	0.22	0.22	0.22
K	1.24	1.24	1.24	1.24	1.24	1.24
Na	0.38	0.38	0.38	0.38	0.38	0.38
K/Ca+Mg	0.33	0.33	0.33	0.33	0.33	0.33
P	0.75	0.75	0.75	0.75	0.75	0.75
Zn	288	288	288	288	288	288
Cu	23	23	23	23	23	23
Mn	263	263	263	263	263	263
Fe	609	609	609	609	609	609
Bovine colostrum*	0	12	24	36	48	72

* : Bovine colostrum fed for a period of 0, 12, 24, 36, 48 and 72 hours after hatching

\# : Treatment codes are explained in Chapter 3, Table 3.3 (The treatments were feeding *ad libitum* bovine colostrum to chicks for 0, 12, 24, 36, 48 or 72 hours after hatching)

4.2 Growth performance and nutrient digestibility of broiler chickens aged one to 21 days

Results of the effects of bovine colostrum feeding period after hatching on feed intake, digestibility, growth rate, live weight and feed conversion ratio (FCR) of male Ross 308 broiler chickens aged one to 21 days are presented in Table 4.2. Bovine colostrum feeding had no effect ($p>0.05$) on feed intake during Week 1. However, bovine colostrum feeding period after hatching affected feed intake of the chickens during Week 2 (Table 4.2). Male Ross 308 broiler chickens fed bovine colostrum for 72 hours after hatching had higher ($p<0.05$) dry matter intakes than those fed no bovine colostrum or those fed bovine colostrum for 12 or 36 hours after hatching during Week 2. Similarly, male broiler chickens on bovine colostrum feeding for 48 hours after hatching had higher ($p<0.05$) feed intakes than those on no bovine colostrum feeding or on bovine colostrum feeding for 12 hours after hatching during Week 2. However, male broiler chickens on bovine colostrum feeding for 24, 48 or 72 hours after hatching had similar ($p>0.05$) dry matter intakes (DMI) during Week 2. Similarly, male Ross 308 broiler chickens on bovine colostrum feeding for 24, 36 or 48 hours after hatching had similar ($p>0.05$) dry matter intakes during Week 2. Male Ross 308 broiler chickens on no bovine colostrum feeding or on bovine colostrum feeding for 12 or 36 hours after hatching had similar ($p>0.05$) dry matter intakes during Week 2.

Feed intake of male Ross 308 broiler chickens was affected ($p<0.05$) by bovine colostrum feeding period after hatching during Week 3 (Table 4.2). Male Ross 308 broiler chickens fed bovine colostrum for 48 or 72 hours after hatching had higher ($p<0.05$) dry matter intakes than those on bovine colostrum feeding for 12 hours after hatching during Week 3. However, male broiler chickens on no bovine colostrum feeding or on bovine colostrum feeding for 24, 36, 48 and 72 hours after hatching had similar ($p>0.05$) dry matter intakes during Week 3. Similarly, male Ross 308 broiler chickens on no bovine colostrum feeding or on bovine colostrum feeding for 12, 24 or 36 hours after hatching had similar ($p>0.05$) dry matter intakes during Week 3.

Bovine colostrum feeding period after hatching had no effect ($p>0.05$) on diet DM, NDF, ADF and ash digestibilities (Table 4.2). However, male Ross 308 broiler

chickens fed bovine colostrum for 36 or 72 hours after hatching had higher ($p<0.05$) diet crude protein (CP) digestibility values than those on no bovine colostrum feeding or on bovine colostrum feeding for 12 hours after hatching (Table 4.2). However, male broiler chickens on bovine colostrum feeding for 24, 36, 48 or 72 hours after hatching had the same ($p>0.05$) crude protein digestibility values. Similarly, male broiler chickens on no bovine colostrum feeding or on bovine colostrum feeding for 12, 24 or 48 hours after hatching had the same ($p>0.05$) diet crude protein digestibility values.

Bovine colostrum feeding period after hatching had no effect ($p>0.05$) on N-retention of male Ross 308 broiler chickens aged one to 21 days (Table 4.2). However, bovine colostrum feeding period after hatching affected ($p<0.05$) metabolisable energy (ME) intake of male Ross 308 broiler chickens. Male broiler chickens on bovine colostrum feeding for 36 or 72 hours after hatching had higher ($p<0.05$) ME intakes than those on no bovine colostrum feeding or on bovine colostrum feeding for 12, 24 or 48 hours after hatching. Similarly, male Ross 308 broiler chickens on bovine colostrum feeding for 24 hours after hatching had higher ($p<0.05$) ME intakes than those on no bovine colostrum feeding or on bovine colostrum feeding for 12 or 48 hours after hatching. However, male broiler chickens on bovine colostrum feeding for 36 or 72 hours after hatching had similar ($p>0.05$) ME intakes. Similarly, male Ross 308 broiler chickens on no bovine colostrum feeding or on bovine colostrum feeding for 12 or 48 hours after hatching had the same ($p>0.05$) ME intakes.

Growth rates of male Ross 308 broiler chickens were affected ($p<0.05$) by bovine colostrum feeding period after hatching during Week 1 (Table 4.2). Male chickens fed bovine colostrum for 72 hours after hatching had higher ($p<0.05$) growth rates than those on no bovine colostrum feeding or on bovine colostrum feeding for 12, 24 or 36 hours after hatching. Similarly, male broiler chickens on bovine colostrum feeding for 48 hours after hatching had better ($p<0.05$) growth rates than those on no bovine colostrum feeding after hatching. However, male broiler chickens on bovine colostrum feeding for 48 or 72 hours after hatching had similar ($p>0.05$) growth rates during Week 1. Similarly, broiler chickens on bovine colostrum feeding for 12, 24, 36 or 48 hours after hatching had similar ($p>0.05$) growth rates during Week 1. Male

Ross 308 broiler chickens on no bovine colostrum feeding or on bovine colostrum feeding for 12, 24 or 36 hours after hatching had similar (*p>0.05*) growth rates.

Bovine colostrum feeding period after hatching had an effect (*p<0.05*) on growth rates of the chickens during Week 2 (Table 4.2). Male Ross 308 broiler chickens fed bovine colostrum for 72 hours after hatching had higher (*p<0.05*) growth rates than those on no bovine colostrum feeding or on bovine colostrum feeding for 12 hours after hatching. However, male chickens on bovine colostrum feeding for 24, 36, 48 or 72 hours after hatching had similar (*p>0.05*) growth rates. Similarly, broiler chickens on no bovine colostrum feeding or on bovine colostrum feeding for 12, 24, 36 or 48 hours after hatching had the same (*p>0.05*) growth rates. Growth rates of male Ross 308 broiler chickens were not affected (P>0.05) by bovine colostrum feeding during Week 3 (Table 4.2).

Bovine colostrum feeding had no effect (*p>0.05*) on feed conversion ratio (FCR) during Weeks 2 and 3 (Table 4.2). However, male broiler chickens on bovine colostrum feeding for 12, 24, 36, 48 or 72 hours after hatching had better (*p<0.05*) FCR values than those on no bovine colostrum feeding after hatching. Male chickens on bovine colostrum feeding for 12, 24, 36, 48 or 72 hours after hatching had similar (*p>0.05*) FCR values.

Live weights of male Ross 308 broiler chickens aged 7 days were affected (*p<0.05*) by bovine colostrum feeding (Table 4.2). Male broiler chickens fed bovine colostrum for 72 hours after hatching had higher (*p<0.05*) live weights than those on no bovine colostrum feeding or on bovine colostrum feeding for 12, 24 or 36 hours after hatching. Similarly, broiler chickens on bovine colostrum feeding for 48 hours after hatching were heavier (*p<0.05*) than those on no bovine colostrum feeding after hatching. However, male broiler chickens on bovine colostrum feeding for 48 or 72 hours after hatching had similar (*p>0.05*) live weights. Similarly, broiler chickens on bovine colostrum feeding for 12, 24, 36 or 48 hours after hatching had the same (*p>0.05*) live weights at age of 7 days. Male broiler chickens on no bovine colostrum feeding or on bovine colostrum feeding for 12, 24 or 36 hours after hatching had similar (*p>0.05*) live weights.

Bovine colostrum feeding affected ($p<0.05$) live weights of male Ross 308 broiler chickens aged 14 days (Table 4.2). Male broiler chickens on bovine colostrum feeding for 72 hours after hatching had heavier ($p<0.05$) live weights than those on no bovine colostrum feeding or on bovine colostrum feeding for 12, 24 or 36 hours after hatching. However, broiler chickens on bovine colostrum feeding for 48 or 72 hours after hatching had similar ($p>0.05$) live weights. Similarly, Ross 308 male broiler chickens on no bovine colostrum feeding or on bovine colostrum feeding for 12, 24, 36 or 48 hours after hatching had the same ($p>0.05$) live weights. At the age of 21 days, male broiler chickens fed bovine colostrum for 72 hours after hatching had higher ($p<0.05$) live weights than those on no bovine colostrum feeding or on bovine colostrum feeding for 12 hours after hatching. However, broiler chickens on bovine colostrum feeding for 24, 36, 48 or 72 hours after hatching had similar ($p>0.05$) live weights. Similarly, male broiler chickens on no bovine colostrum feeding or on bovine colostrum feeding for 12, 24, 36 or 48 hours after hatching had similar ($p>0.05$) live weights.

Dry matter intake of male Ross 308 broiler chickens during Week 3 was optimized ($r = 0.902$) at a bovine colostrum feeding period of 64 hours after hatching (Figure 4.1). Positive relationships ($r = 0.907$ and 0.882, respectively) were observed between feeding period of bovine colostrum and growth rates in Weeks 1 and 2 (Figures 4.2 and 4.3, respectively, and Table 4.3). Similarly, positive relationships ($r = 0.957$, 0.957 and 0.967, respectively) were observed between bovine colostrum feeding period and live weights at Days 7, 14 and 21 of male Ross 308 broiler chickens (Figures 4.4, 4.5 and 4.6, respectively, and Table 4.3).

Table 4.2 Effect of bovine colostrum feeding on diet intake, digestibility, metabolisable energy (ME) intake, nitrogen retention (N-retention), growth rate, feed conversion ratio and live weight of male Ross 308 broiler chickens aged one to 21 days*

	Treatment #					
Variable	$MCOL_0$	$MCOL_{12}$	$MCOL_{24}$	$MCOL_{36}$	$MCOL_{48}$	$MCOL_{72}$
Intake (g DM/chicken/d)						
Week 1	14^{a}±0.4	14^{a}±1.6	15^{a}±1.1	14^{a}±0.5	16^{a}±0.6	15^{a}±0.8
Week 2	44^{c}±1.8	43^{c}±3.5	51^{abc}±1.3	49^{bc}±1.8	53^{ab}±1.7	59^{a}±0.6
Week 3	86^{ab}±0.8	83^{b}±4.3	92^{ab}±2.0	94^{ab}±3.6	98^{a}±2.1	97^{a}±1.0
Digestibility (%), Week 3						
DM	62^{a}±9.3	60^{a}±2.9	65^{a}±5.8	70^{a}±3.4	61^{a}±2.2	67^{a}±4.7
CP	50^{b}±11.2	50^{b}±5.7	55^{ab}±4.8	64^{a}±3.0	55^{ab}±0.9	65^{a}±4.9
NDF	48^{a}±9.6	52^{a}±2.6	46^{a}±2.5	57^{a}±3.9	58^{a}±4.4	50^{a}±5.8
ADF	52^{a}±5.3	50^{a}±2.2	55^{a}±4.6	60^{a}±2.6	50^{a}±3.5	56^{a}±3.8
Ash	31^{a}±13.6	37^{a}±3.0	37^{a}±9.6	40^{a}±7.0	36^{a}±3.3	39^{a}±8.2
ME intake (MJ/kg DM),W3	10.5^{c}±0.05	10.3^{c}±0.03	11.0^{b}±0.06	11.3^{a}±0.02	10.3^{c}±0.01	11.3^{a}±0.02
N-retn. (g N/bird/d),W3	1.3^{a}±0.17	1.2^{a}±0.34	1.5^{a}±0.18	1.6^{a}±0.02	1.5^{a}±0.04	1.9^{a}±0.19
Growth rate (g/chicken/day)						
Week 1	8^{c}±0.2	11^{bc}±0.4	9^{bc}±0.5	11^{bc}±0.5	12^{ab}±1.0	15^{a}±1.2
Week 2	16^{b}±1.2	16^{b}±1.9	20^{ab}±0.7	17^{ab}±1.0	19^{ab}±1.0	23^{a}±1.3
Week 3	25^{a}±1.5	28^{a}±1.6	30^{a}±0.7	29^{a}±3.4	30^{a}±1.2	30^{a}±1.9
FCR (g DM feed intake/g weight gain)						
Week 1	1.7^{a}±0.01	1.3^{b}±0.10	1.4^{b}±0.06	1.3^{b}±0.05	1.3^{b}±0.09	1.2^{b}±0.05
Week 2	2.8^{a}±0.10	2.8^{a}±0.15	2.5^{a}±0.02	2.8^{a}±0.09	2.8^{a}±0.07	2.5^{a}±0.12
Week 3	3.5^{a}±0.21	3.0^{a}±0.23	3.1^{a}±0.05	3.4^{a}±0.42	3.2^{a}±0.06	3.2^{a}±0.18
Live weight (g/chicken)						
Age 7 days	111^{c}±3.8	126^{bc}±3.9	120^{bc}±5.0	129^{bc}±1.7	139^{ab}±3.7	155^{a}±4.8
Age 14 days	221^{b}±11.0	235^{b}±17.1	262^{b}±3.5	251^{b}±5.3	271^{ab}±7.1	318^{a}±13.5
Age 21 days	396^{b}±12.0	430^{b}±23.7	470^{ab}±5.1	452^{ab}±28.2	484^{ab}±15.1	530^{a}±26.9

* : Values presented as a mean ± standard error (SE)

^{a,b,c,d} : Means with different superscripts in the same row indicate significant differences between treatments ($p<0.05$)

\# : Treatment codes are explained in Chapter 3, Table 3.3 (The treatments were feeding bovine colostrum to chicks for 0, 12, 24, 36, 48 or 72 hours after hatching)

N-retn. : Nitrogen retention

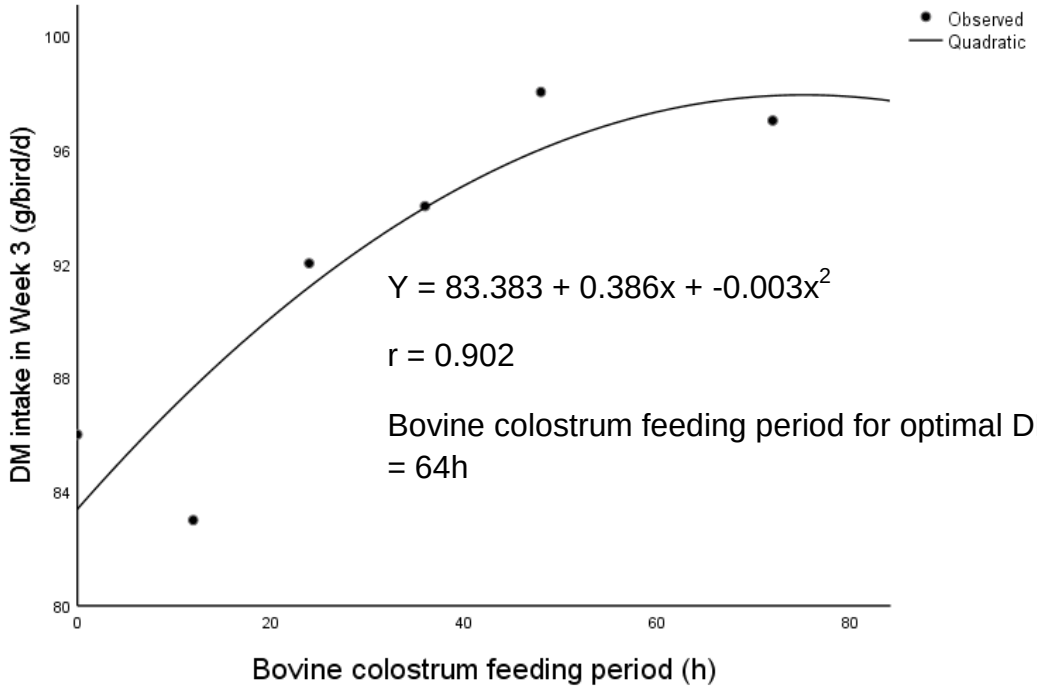

Figure 4.1 Effect of bovine colostrum feeding period after hatching on DM intake of male Ross 308 broiler chickens during Week 3

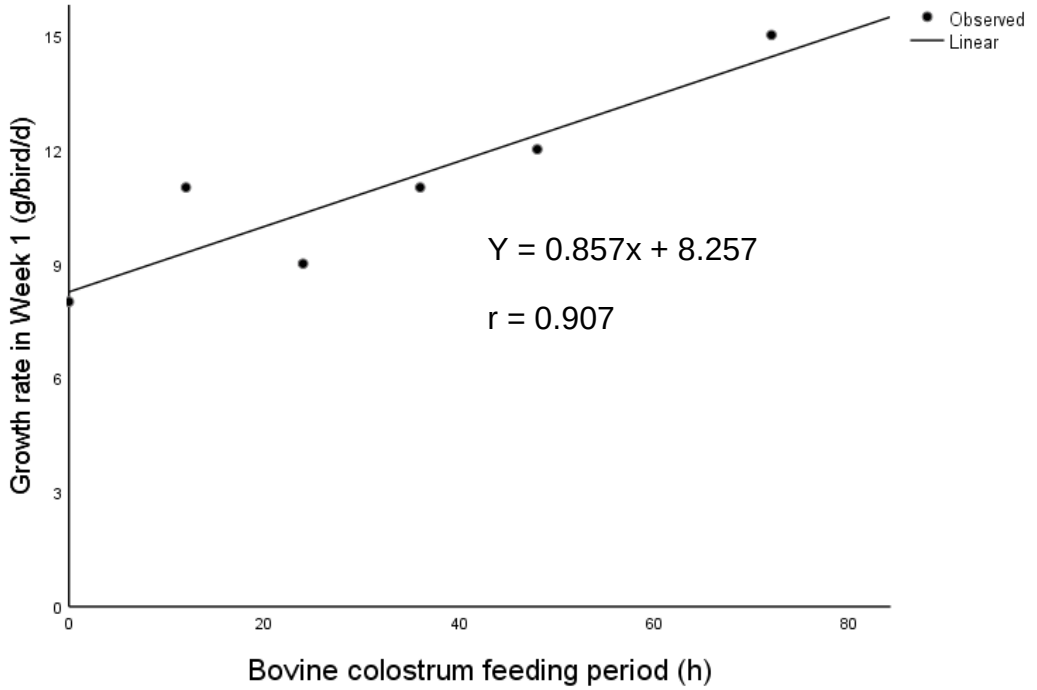

Figure 4.2 Relationship between bovine colostrum feeding period after hatching and growth rates of male Ross 308 broiler chickens during Week 1

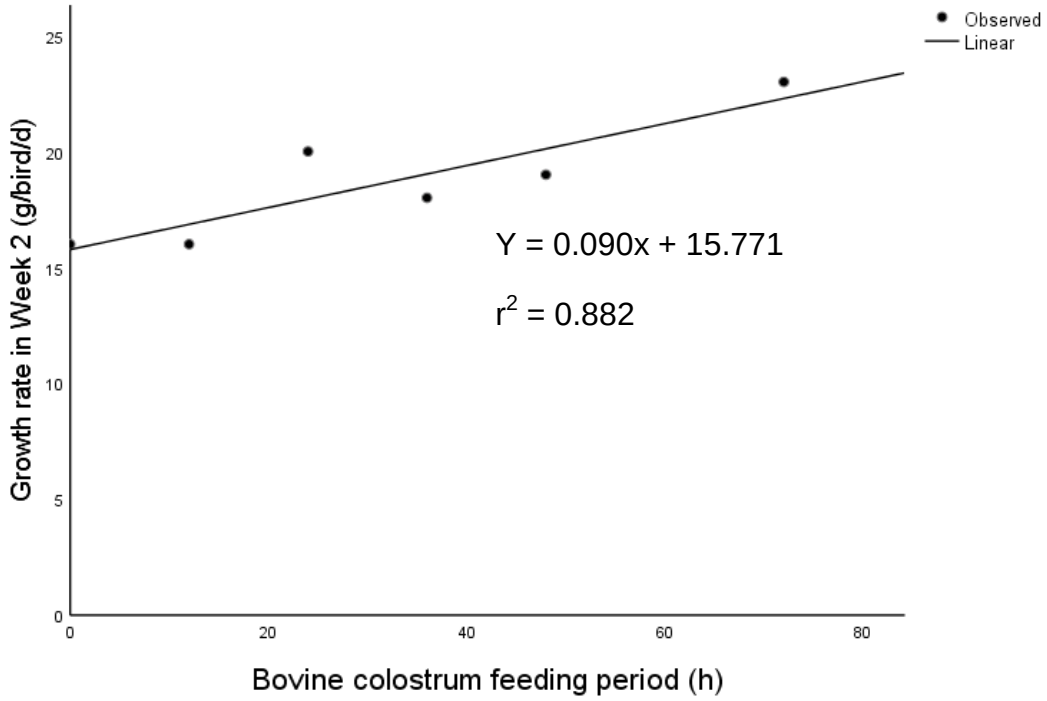

Figure 4.3 Relationship between bovine colostrum feeding period after hatching and growth rates of male Ross 308 broiler chickens during Week 2

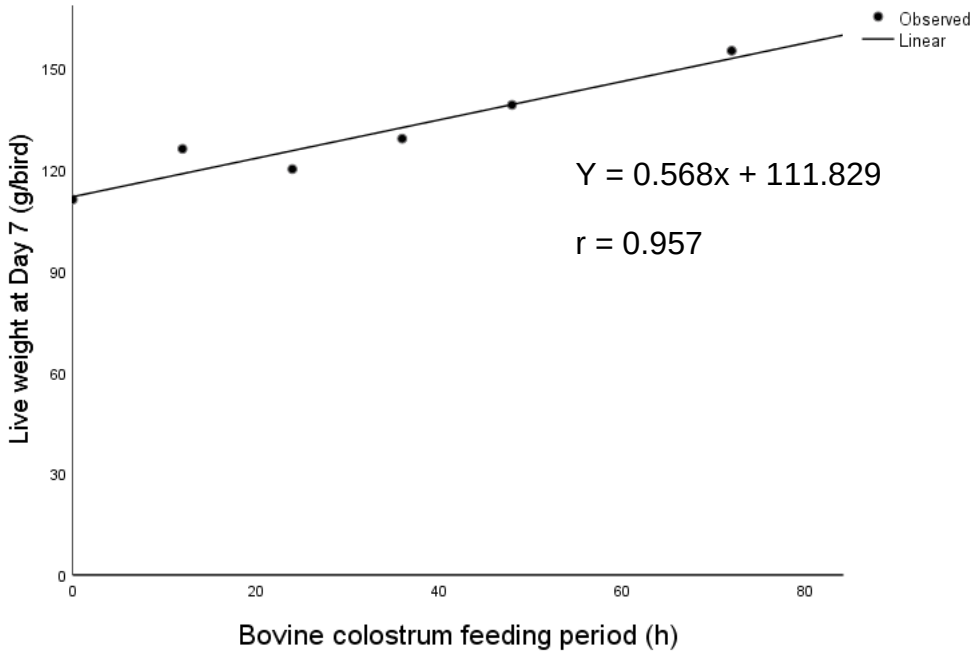

Figure 4.4 Relationship between bovine colostrum feeding period after hatching and live weights of male Ross 308 broiler chickens aged 7 days

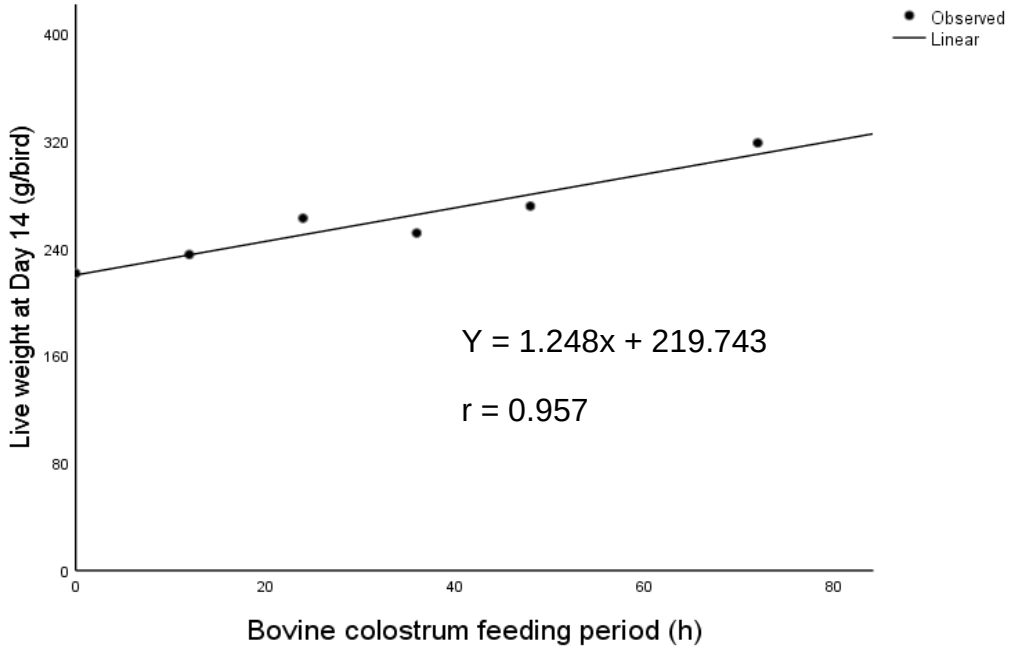

Figure 4.5 Relationship between bovine colostrum feeding period after hatching and live weights of male Ross 308 broiler chickens aged 14 days

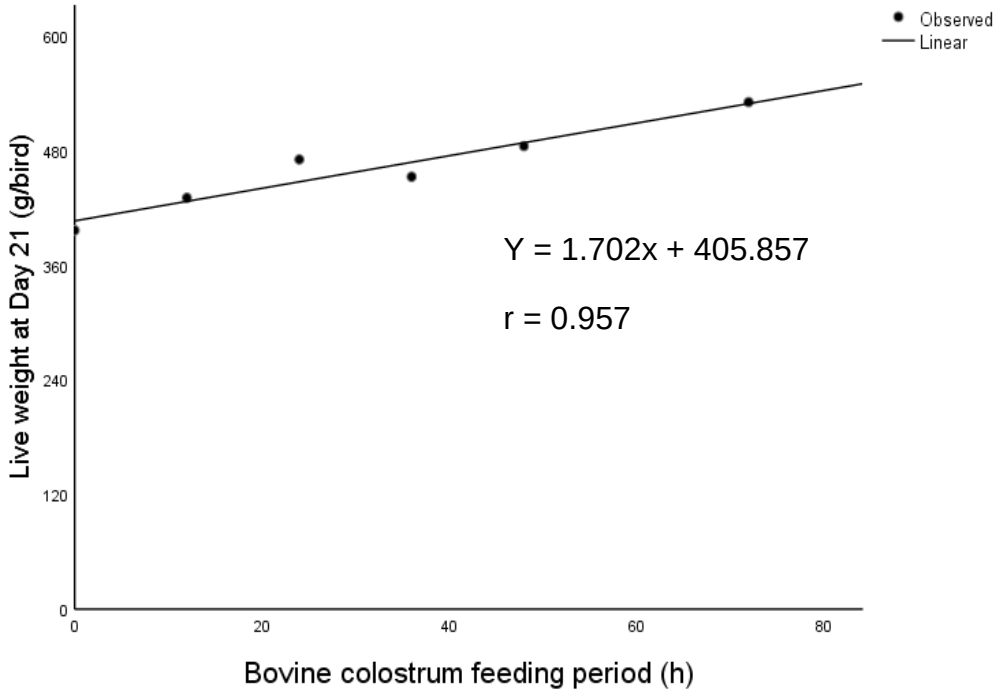

Figure 4.6 Relationship between bovine colostrum feeding period after hatching and live weights of male Ross 308 broiler chickens aged 21 days

Table 4.3 Relationships between bovine colostrum feeding periods and growth rates in Weeks 1 and 2 and live weights at Day 7, 14 and 21 of male Ross 308 broiler chickens

Variable	Formula	r	Probability
Growth rate in Week 1	Y = 0.857x + 8.257	0.907	0.013
Growth rate in Week 2	Y = 0.090x + 15.771	0.882	0.020
Live weight at Day 7	Y = 0.568x + 111.829	0.957	0.003
Live weight at Day 14	Y = 1.248x + 219.748	0.957	0.003
Live weight at Day 21	Y = 1.702x + 405.857	0.957	0.003

r^2 : Coefficient of determination

4.3 Gut morphology of broiler chickens aged 21 days

Results of the effects of bovine colostrum feeding on gut organ digesta pH, gut organ lengths and weights of male Ross 308 broiler chickens aged 21 days are presented in Table 4.4. Bovine colostrum feeding had no effect (*p>0.05*) on gut organ digesta pH, length and weight of male Ross 308 broiler chickens.

Table 4.4 Effect of bovine colostrum feeding period after hatching on gut organ digesta pH, length and weight of male Ross 308 broiler chickens aged 21 days*

	Treatment #					
Variable	$MCOL_0$	$MCOL_{12}$	$MCOL_{24}$	$MCOL_{36}$	$MCOL_{48}$	$MCOL_{72}$
Gut organ digesta Ph						
Crop	5^a±0.5	4^a±0.4	4^a±0.4	6^a±0.4	5^a±0.2	5^a±0.6
Proventriculus	4^a±0.3	4^a±0.2	5^a±0.2	4^a±0.1	5^a±0.1	4^a±0.2
Gizzard	2^a±0.2	2^a±0.1	3^a±0.2	2^a±0.2	3^a±0.1	2^a±0.1
Small intestines	6^a±0.2	6^a±0.2	6^a±0.3	6^a±0.2	6^a±0.2	6^a±0.1
Caecum	7^a±0.1	7^a±0.3	7^a±0.4	6^a±0.2	7^a±0.1	6^a±0.1
Large intestines	6^a±0.6	7^a±0.6	7^a±0.2	7^a±0.2	6^a±0.1	6^a±0.2
Gut organ length (cm)						
GIT	140^a±9.9	139^a±1.6	142^a±3.1	139^a±8.2	138^a±4.9	141^a±2.8
Small intestines	129^a±9.5	122^a±1.2	125^a±4.8	139^a±8.0	125^a±4.8	138^a±5.5
Caecum	12^a±1.5	10^a±0.2	13^a±1.3	11^a±1.3	12^a±0.9	12^a±0.6
Large intestines	7^a±0.3	7^a±0.3	8^a±0.1	7^a±0.5	8^a±0.5	8^a±0.9
Gut organ weight (g)						
Crop	3^a±1.3	3^a±0.5	2^a±0.3	2^a±0.2	2^a±0.2	3^a±0.7
Proventriculus	3^a±0.3	3^a±0.7	4^a±0.8	2^a±0.4	2^a±0.2	3^a±0.3
Gizzard	22^a±0.9	21^a±0.9	21^a±0.6	21^a±2.0	21^a±0.6	23^a±1.8
Small intestines	36^a±4.4	37^a±1.1	35^a±1.3	36^a±1.7	35^a±5.9	36^a±1.7
Caecum	2^a±0.2	2^a±0.2	3^a±1.0	2^a±0.7	2^a±0.5	2^a±0.4
Large intestines	2^a±0.9	2^a±2.0	3^a±0.6	3^a±0.8	2^a±0.8	2^a±0.7

* : Values presented as a mean ± standard error (SE)

^{a,b,c} : Means with similar superscripts in the same row indicate non-significant differences between treatments (*p>0.05*)

\# : Treatment codes are explained in Chapter 3, Table 3.3 (The treatments were feeding bovine colostrum to chicks for 0, 12, 24, 36, 48 or 72 hours after hatching

4.4 Growth performance and nutrient digestibility of broiler chickens aged 22 to 42 days

Results on the effects of bovine colostrum feeding period on feed intake, digestibility, growth rate, live weight and feed conversion ratio (FCR) of male Ross 308 broiler chickens aged 22 to 42 days are presented in Table 4.5. Dry matter (DM) intake of male Ross 308 broiler chickens was affected (*p<0.05*) by bovine colostrum feeding period after hatching during Week 4. Male chickens fed bovine colostrum for 36 hours after hatching had higher (*p<0.05*) DM intakes than those on no bovine colostrum feeding after hatching. However, male broiler chickens fed bovine colostrum for 12, 24, 36, 48 or 72 hours after hatching had similar (*p>0.05*) DM

intakes. Similarly, Ross 308 male broiler chickens on no bovine colostrum feeding or on bovine colostrum feeding for 12, 24, 48 or 72 hours after hatching had the same ($p>0.05$) DM intakes.

Bovine colostrum feeding had an effect ($p<0.05$) on DM intake of male Ross 308 broiler chickens during Week 5 (Table 4.5). Male broiler chickens on no bovine colostrum feeding or on bovine colostrum feeding for 12 or 36 hours after hatching had higher ($p<0.05$) DM intakes than those fed bovine colostrum for 24 hours after hatching. However, broiler chickens on no bovine colostrum feeding or on bovine colostrum feeding for 12, 36, 48 or 72 hours after hatching had similar ($p>0.05$) DM intakes. Similarly, male chickens fed bovine colostrum for 24, 48 or 72 hours after hatching had the same ($p>0.05$) DM intakes.

Dry matter intakes of male Ross 308 broiler chickens was affected ($p<0.05$) by bovine colostrum feeding period after hatching during Week 6 (Table 4.5). Male Ross 308 broiler chickens on bovine colostrum feeding for 36 hours after hatching had higher ($p<0.05$) DM intakes than those on no bovine colostrum feeding or on bovine colostrum feeding for 12, 24, 48 or 72 hours after hatching. Similarly, male broiler chickens on no bovine colostrum feeding after hatching had higher ($p<0.05$) DM intakes than those on bovine colostrum feeding for 12, 24, 48 or 72 hours after hatching. Male chickens fed bovine colostrum for 12 or 72 hours after hatching had higher ($p<0.05$) DM intakes than those on bovine colostrum feeding for 24 or 48 hours after hatching. However, male Ross 308 broiler chickens fed bovine colostrum for 12 or 72 hours after hatching had similar ($p>0.05$) DM intakes.

Bovine colostrum feeding period after hatching affected ($p<0.05$) diet DM digestibility (Table 4.5). Male Ross 308 broiler chickens on no bovine colostrum feeding after hatching had higher ($p<0.05$) diet DM digestibility values than those fed bovine colostrum for 36 hours after hatching. However, male broiler chickens on no bovine colostrum feeding or on bovine colostrum feeding for 12, 24, 48 or 72 hours after hatching had similar ($p>0.05$) diet DM digestibility values. Similarly, broiler chickens on bovine colostrum feeding for 12, 24, 36, 48 or 72 hours after hatching had the same ($p>0.05$) diet DM digestibility values. Male Ross 308 broiler chickens on no bovine colostrum feeding or on bovine colostrum feeding for 12 hours after hatching had higher ($p<0.05$) diet CP digestibility values than those on bovine colostrum

feeding for 24, 36, 48 or 72 hours after hatching. Similarly, male broiler chickens on bovine colostrum feeding for 24, 48 or 72 hours after hatching had higher ($p<0.05$) diet CP digestibility values than those on bovine colostrum feeding for 36 hours after hatching. Male Ross 308 broiler chickens on no bovine colostrum feeding or bovine colostrum feeding for 12 hours after hatching had the same ($p>0.05$) diet CP digestibility values. Similarly, male broiler chickens on bovine colostrum feeding for 24, 48 or 72 hours after hatching had the same ($p>0.05$) diet CP digestibility values.

Results of the present study indicate that bovine colostrum feeding period after hatching affected ($p<0.05$) diet NDF and ADF digestibilities, respectively (Table 4.5). Male Ross 308 broiler chickens on no bovine colostrum feeding after hatching had higher ($p<0.05$) diet NDF and ADF digestibility values than those on bovine colostrum feeding for 36 hours after hatching. However, male chickens on no bovine colostrum feeding or on bovine colostrum feeding for 12, 24, 48 or 72 hours after hatching had similar ($p>0.05$) diet NDF and ADF digestibility values. Similarly, male broiler chickens on bovine colostrum feeding for 12, 24, 36, 48 or 72 hours after hatching had the same ($p>0.05$) diet NDF and ADF digestibility values.

Bovine colostrum feeding period after hatching had an effect ($p<0.05$) on diet ash digestibility (Table 4.5). Male broiler chickens on no bovine colostrum feeding after hatching had higher ($p<0.05$) diet ash digestibility than those on bovine colostrum feeding for 24, 36, 48 or 72 hours after hatching. Similarly, broiler chickens on bovine colostrum feeding for 48 or 72 hours after hatching had higher ($p<0.05$) diet ash digestibility values than those on bovine colostrum feeding for 24 or 36 hours after hatching. Male Ross 308 broiler chickens on no bovine colostrum feeding or on bovine colostrum feeding for 12 hours after hatching had similar ($p>0.05$) diet ash digestibility values. Similarly, male broiler chickens on bovine colostrum feeding for 12, 48 or 72 hours after hatching had the same ($p>0.05$) diet ash digestibility values. Broiler chickens on bovine colostrum feeding for 24 or 36 hours after hatching had similar ($p>0.05$) diet ash digestibility values.

Bovine colostrum feeding period after hatching had no effect ($p>0.05$) on N-retention of male Ross 308 broiler chickens aged 22 to 42 days (Table 4.5). However, bovine colostrum feeding period after hatching had an effect ($p<0.05$) on ME intake of male broiler chickens. Male Ross 308 broiler chickens on no bovine colostrum feeding had

higher ($p<0.05$) ME intakes than those on bovine colostrum feeding for 12, 24, 36, 48 or 72 hours after hatching. Similarly, male broiler chickens on bovine colostrum feeding for 12 hours after hatching had higher ($p<0.05$) ME intakes than those on bovine colostrum feeding for 24, 36, 48 or 72 hours after hatching. Broiler chickens on bovine colostrum feeding for 48 hours after hatching had higher ($p<0.05$) ME intakes than those on bovine colostrum feeding for 24, 36 or 72 hours after hatching. Similarly, male Ross 308 broiler chickens on bovine colostrum feeding for 24 or 72 hours after hatching had higher ($p<0.05$) ME intakes than those on bovine colostrum feeding for 36 hours after hatching. However, male broiler chickens on bovine colostrum feeding for 24 or 72 hours after hatching had similar ($p>0.05$) ME intakes.

The growth rate of male Ross 308 broiler chickens was affected ($p<0.05$) by bovine colostrum feeding period after hatching during Week 4 (Table 4.5). Male Ross 308 broiler chickens fed bovine colostrum for 72 hours after hatching had higher ($p<0.05$) growth rates than those on no bovine colostrum feeding or on bovine colostrum feeding for 12, 24 or 36 hours after hatching. Similarly, male broiler chickens on bovine colostrum feeding for 12, 24 or 48 hours after hatching had higher ($p<0.05$) growth rates than those on no bovine colostrum feeding or on bovine colostrum feeding for 36 hours after hatching. However, broiler chickens on bovine colostrum feeding for 48 or 72 hours after hatching had similar ($p>0.05$) growth rates. Similarly, male broiler chickens on bovine colostrum feeding for 12, 24 or 48 hours after hatching had the same ($p>0.05$) growth rates. Male Ross 308 broiler chickens on no bovine colostrum feeding or on bovine colostrum feeding for 36 hours after hatching had similar ($p>0.05$) growth rates.

Bovine colostrum feeding period after hatching had an effect ($p<0.05$) on the growth rate of male Ross 308 broiler chickens during Week 5 (Table 4.5). Male broiler chickens on no bovine colostrum feeding or on bovine colostrum feeding for 12 hours after hatching had higher ($p<0.05$) growth rates than those on bovine colostrum feeding for 24, 36, 48 or 72 hours after hatching. Similarly, Ross 308 broiler chickens fed bovine colostrum for 48 or 72 hours after hatching had higher ($p<0.05$) growth rates than those on bovine colostrum feeding for 24 or 36 hours after hatching. However, male broiler chickens on no bovine colostrum feeding or on bovine colostrum feeding for 12 hours after hatching had similar ($p>0.05$) growth

rates. Similarly, broiler chickens on bovine colostrum feeding for 48 or 72 hours after hatching had the same (*p>0.05*) growth rates. Male Ross 308 broiler chickens on bovine colostrum feeding for 24 or 36 hours after hatching had similar (*p>0.05*) growth rates.

The growth rates of male Ross 308 broiler chickens were affected (*p<0.05*) by bovine colostrum feeding period after hatching during Week 6 (Table 4.5). Male Ross 308 broiler chickens fed bovine colostrum for 12 or 48 hours after hatching had higher (*p<0.05)* growth rates than those on no bovine colostrum feeding or on bovine colostrum feeding for 24, 36 or 72 hours after hatching. However, male broiler chickens on bovine colostrum feeding for 12 or 48 hours after hatching had similar (*p>0.05*) growth rates. Similarly, male Ross 308 broiler chickens on no bovine colostrum feeding or on bovine colostrum feeding for 24, 36 or 72 hours after hatching had similar (*p>0.05*) growth rates.

Feed conversion ratio of male Ross 308 broiler chickens aged 22 to 42 days and live weights of male Ross 308 broiler chickens aged 35 or 42 days were not affected (*p>0.05*) by bovine colostrum feeding period after hatching (Table 4.5). However, bovine colostrum feeding period after hatching affected (*p<0.05*) live weights of male Ross 308 broiler chickens aged 28 days (Table 4.5). Male broiler chickens on bovine colostrum feeding for 36 or 72 hours after hatching had higher (*p<0.05*) live weights than those on bovine colostrum feeding for 12 hours after hatching. However, male Ross 308 broiler chickens on no bovine colostrum feeding or on bovine colostrum feeding for 12, 24, 36, 48 or 72 hours after hatching had similar (*p>0.05*) live weights. Similarly, male broiler chickens on no bovine colostrum feeding or on bovine colostrum feeding for 12, 24 or 48 hours after hatching had the same (*p>0.05*) live weights.

Table 4.5 Effect of bovine colostrum feeding period after hatching on diet dry matter intake, digestibility, metabolisable energy (ME) intake, nitrogen retention (N-retention), growth rate, live weight and feed conversion ratio of male Ross 308 broiler chickens aged 22 to 42 days*

	Treatment #					
Variable	$MCOL_0$	$MCOL_{12}$	$MCOL_{24}$	$MCOL_{36}$	$MCOL_{48}$	$MCOL_{72}$
Intake (g DM/chicken/day)						
Week 4	96^{b}±3.8	103^{ab}±4.6	99^{ab}±2.8	111^{a}±8.4	105^{ab}±3.5	106^{ab}±1.1
Week 5	154^{a}±3.9	152^{a}±2.0	137^{b}±5.8	154^{a}±2.1	147^{ab}±2.0	150^{ab}±2.4
Week 6	183^{b}±1.0	166^{c}±1.1	160^{d}±1.1	189^{a}±1.4	148^{e}±0.2	167^{c}±0.3
Digestibility (%), Week 6						
DM	77^{a}±3.4	76^{ab}±2.2	72^{ab}±1.4	70^{b}±2.1	74^{ab}±2.3	72^{ab}±0.9
CP	75^{a}±3.4	75^{a}±2.1	70^{b}±1.6	67^{c}±0.8	71^{b}±3.8	72^{b}±0.9
NDF	48^{a}±7.2	44^{ab}±5.0	37^{ab}±6.5	27^{b}±4.0	39^{ab}±4.1	36^{ab}±3.8
ADF	59^{a}±6.3	52^{ab}±3.7	50^{ab}±4.5	43^{b}±2.5	48^{ab}±3.0	53^{ab}±1.4
Ash	76^{a}±4.0	74^{ab}±2.4	69^{c}±1.9	67^{c}±1.8	71^{b}±2.7	71^{b}±0.8
ME intake(MJ/kg DM),W6	13.0^{a}±0.02	12.9^{b}±0.04	12.2^{d}±0.05	11.8^{e}±0.03	12.5^{c}±0.01	12.2^{d}±0.05
N-retn.(g N/bird/d),W6	4.8^{a}±0.78	4.6^{a}±0.45	3.9^{a}±0.08	3.8^{a}±0.17	4.3^{a}±0.17	4.0^{a}±0.5
Growth rate (g/chicken/day)						
Week 4	41^{c}±1.1	45^{b}±2.0	48^{b}±0.7	44^{c}±2.1	49^{ab}±3.4	54^{a}±0.3
Week 5	128^{a}±3.6	114^{a}±6.8	87^{c}±1.4	78^{c}±0.1	91^{b}±5.2	99^{b}±2.0
Week 6	64^{b}±5.1	88^{a}±3.0	64^{b}±3.6	64^{b}±1.5	79^{a}±1.8	61^{b}±2.6
FCR (g DM feed intake/g weight gain)						
Week 4	2.3^{a}±0.40	2.9^{a}±0.56	2.4^{a}±0.57	2.2^{a}±0.36	2.3^{a}±0.23	2.2^{a}±0.13
Week 5	1.6^{a}±0.25	1.5^{a}±0.16	1.5^{a}±0.08	1.8^{a}±0.16	1.6^{a}±0.12	1.6^{a}±0.11
Week 6	3.1^{a}±0.11	2.2^{a}±0.29	2.6^{a}±0.08	2.5^{a}±0.20	2.5^{a}±0.43	2.4^{a}±0.42
Live weight (g/chicken)						
Age 28 days	814^{ab}±61.1	697^{b}±48.7	809^{ab}±2.8	883^{a}±39.1	804^{ab}±17.0	909^{a}±27.9
Age 35 days	1482^{a}±184.4	1430^{a}±38.3	1466^{a}±48.9	1416^{a}±42.3	1440^{a}±20.0	1565^{a}±47.9
Age 42 days	1825^{a}±190.3	1978^{a}±104.0	1914^{a}±72.4	1926^{a}±38.8	1910^{a}±83.6	2071^{a}±61.5

* : Values presented as a mean ± standard error (SE)

a,b,c,d,e : Means with different superscripts in the same row indicate significant differences between treatments ($p<0.05$)

: Treatment codes are explained in Chapter 3, Table 3.3 (The treatments were feeding bovine colostrum to chicks for 0, 12, 24, 36, 48 or 72 hours after hatching)

N-retn : Nitrogen retention

Dry matter intake of male Ross 308 broiler chickens during Week 4 was optimized (r = 0.766) at bovine colostrum feeding period of 51 hours after hatching (Figure 4.7). A positive relationship (r = 0.892) was observed between bovine colostrum feeding

period after hatching and growth rates of male Ross 308 broiler chickens during Week 4 (Figure 4.8).

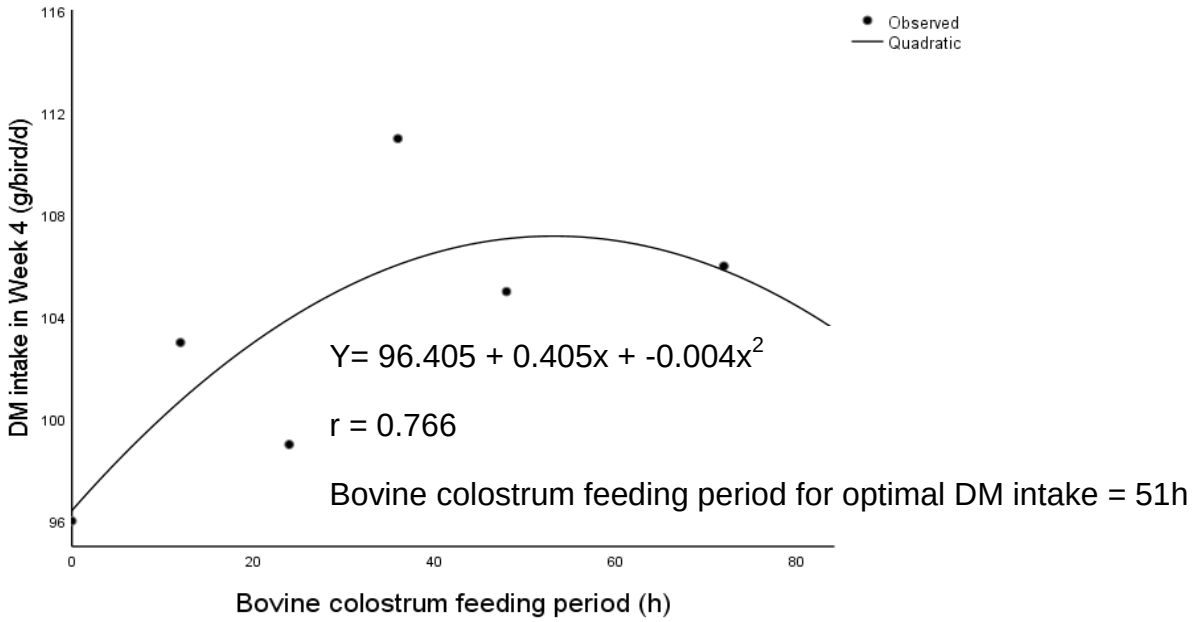

Figure 4.7 Effect of bovine colostrum feeding period after hatching on DM intake of male Ross 308 broiler chickens during Week 4

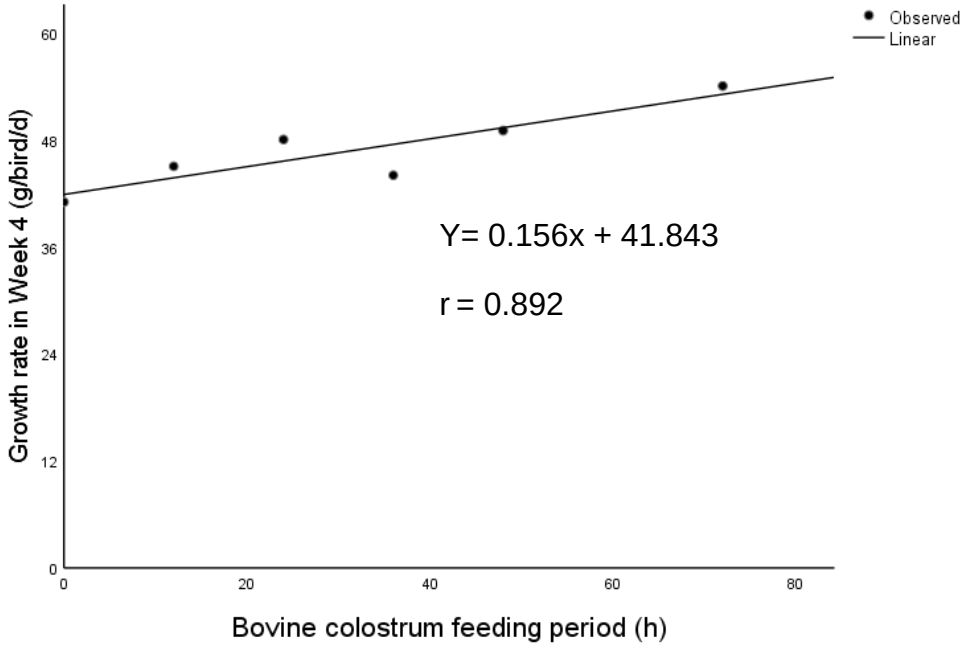

Figure 4.8 Relationship between bovine colostrum feeding period after hatching and growth rates of male Ross 308 broiler chickens during Week 4

4.5 Gut morphology of broiler chickens aged 42 days

Results on the effects of bovine colostrum feeding period on gut organ digesta pH values, gut organ lengths and weights of male Ross 308 broiler chickens aged 42 days are presented in Table 4.6. Bovine colostrum feeding had no effect ($p>0.05$) on gut organ digesta pH values of male Ross 308 broiler chickens. Similarly, bovine colostrum feeding had no effect ($p>0.05$) on large intestine lengths of male Ross 308 broiler chickens aged 42 days. However, bovine colostrum feeding had an effect ($p<0.05$) on gastrointestinal tract (GIT) lengths of male Ross 308 broiler chickens. Male broiler chickens on bovine colostrum feeding for 12 hours after hatching had longer ($p<0.05$) GIT than those on bovine colostrum feeding for 72 hours after hatching. However, male broiler chickens on no bovine colostrum feeding or on bovine colostrum feeding for 12, 24, 36 or 48 hours after hatching had similar ($p>0.05$) GIT lengths. Similarly, broiler chickens on no bovine colostrum feeding or on bovine colostrum feeding for 24, 36, 48 or 72 hours after hatching had similar ($p>0.05$) GIT lengths.

Bovine colostrum feeding period after hatching affected ($p<0.05$) lengths of small intestines of male Ross 308 broiler chickens aged 42 days (Table 4.6). Male Ross 308 broiler chickens on no bovine colostrum feeding or on bovine colostrum feeding for 24, 48 or 72 hours after hatching had longer ($p<0.05$) small intestines than those on bovine colostrum feeding for 12 or 36 hours after hatching. Male chickens on no bovine colostrum feeding or on bovine colostrum feeding for 24, 48 or 72 hours after hatching had similar ($p>0.05$) small intestine lengths. Similarly, male broiler chickens on bovine colostrum feeding for 12 or 36 hours after hatching had the same ($p>0.05$) small intestine lengths.

Results of bovine colostrum feeding period after hatching indicated that caecum lengths of male Ross 308 broiler chickens aged 42 days were affected ($p<0.05$) (Table 4.6). Male broiler chickens on bovine colostrum feeding for 12, 48 or 72 hours after hatching had longer ($p<0.05$) caeca than those on no bovine colostrum feeding after hatching. However, male Ross 308 broiler chickens on bovine colostrum feeding for 12, 24, 36, 48 or 72 hours after hatching had similar ($p>0.05$) caecum lengths. Similarly, male broiler chickens on no bovine colostrum feeding or on bovine

colostrum feeding for 24 or 36 hours after hatching had the same (*p>0.05*) caecum lengths.

Results of the present study indicate that bovine colostrum feeding period after hatching had an effect (*p<0.05*) on crop, proventriculus, gizzard, small intestine, caecum and large intestine weights of male Ross 308 broiler chickens aged 42 days (Table 4.6). Male Ross 308 broiler chickens fed bovine colostrum for 24, 36 or 48 hours after hatching had heavier (*p<0.05*) crops than those on no bovine colostrum feeding or on bovine colostrum feeding for 12 or 72 hours after hatching. However, male broiler chickens fed bovine colostrum for 24, 36 or 48 hours after hatching had similar (*p>0.05*) crop weights. Similarly, broiler chickens on no bovine colostrum feeding or on bovine colostrum feeding for 12 or 72 hours after hatching had the same (*p>0.05*) crop weights.

Bovine colostrum feeding period after hatching affected (*p<0.05*) proventriculus weights of male Ross 308 broiler chickens aged 42 days (Table 4.6). Male Ross 308 broiler chickens on bovine colostrum feeding for 24 hours after hatching had heavier (*p<0.05*) proventricula than those on no bovine colostrum feeding or on bovine colostrum feeding for 36 hours after hatching. However, male broiler chickens on bovine colostrum feeding for 12, 24, 48 or 72 hours after hatching had similar (*p>0.05*) proventriculus weights. Similarly, broiler chickens on no bovine colostrum feeding or on bovine colostrum feeding for 12, 36, 48 or 72 hours after hatching had similar (*p>0.05*) proventriculus weights.

Gizzard weights of male Ross 308 broiler chickens aged 42 days were affected (*p<0.05*) by bovine colostrum feeding period after hatching (Table 4.6). Male broiler chickens on bovine colostrum feeding for 36 or 48 hours after hatching had heavier (*p<0.05*) gizzards than those on no bovine colostrum feeding after hatching. However, male Ross 308 broiler chickens on bovine colostrum feeding for 12, 24, 36, 48 or 72 hours after hatching had similar (*p>0.05*) gizzard weights. Similarly, male broiler chickens on no bovine colostrum feeding or on bovine colostrum feeding for 12, 24 or 72 hours after hatching had the same (*p>0.05*) gizzard weights.

The present results indicate that bovine colostrum feeding period after hatching had an effect (*p<0.05*) on small intestine weights of male Ross 308 broiler chickens aged

42 days (Table 4.6). Male broiler chickens on no bovine colostrum feeding or on bovine colostrum feeding for 12 hours after hatching had heavier ($p<0.05$) small intestines than those on bovine colostrum feeding for 24, 36, 48 or 72 hours after hatching. Similarly, broiler chickens on bovine colostrum feeding for 24, 36 or 48 hours after hatching had heavier ($p<0.05$) small intestines than those on bovine colostrum feeding for 72 hours after hatching. However, male broiler chickens on no bovine colostrum feeding or on bovine colostrum feeding for 12 hours after hatching had similar ($p>0.05$) small intestine weights. Similarly, male Ross 308 broiler chickens on bovine colostrum feeding for 24, 36 or 48 hours after hatching had the same ($p>0.05$) small intestine weights.

Bovine colostrum feeding period after hatching affected ($p<0.05$) caecum weights of male Ross 308 broiler chickens aged 42 days (Table 4.6). Male broiler chickens on bovine colostrum feeding for 36 hours after hatching had heavier ($p<0.05$) caeca than those on no bovine colostrum feeding or on bovine colostrum feeding for 24 hours after hatching. However, male Ross 308 broiler chickens on bovine colostrum feeding for 12, 36, 48 or 72 hours after hatching had similar ($p>0.05$) caecum weights. Similarly, male broiler chickens on no bovine colostrum feeding or on bovine colostrum feeding for 12, 24, 48 or 72 hours after hatching had the same ($p>0.05$) caecum weights.

Results on bovine colostrum feeding period after hatching indicate that large intestine weights of male Ross 308 broiler chickens aged 42 days were affected ($p<0.05$) (Table 4.6). Male broiler chickens on bovine colostrum feeding for 36 hours after hatching had heavier ($p<0.05$) large intestines than those on no bovine colostrum feeding or on bovine colostrum feeding for 12 or 48 hours after hatching. Similarly, male Ross 308 broiler chickens on bovine colostrum feeding for 24 or 72 hours after hatching had heavier ($p<0.05$) large intestines than those on no bovine colostrum feeding or on bovine colostrum feeding for 48 hours after hatching. Male broiler chickens on bovine colostrum feeding for 24, 36 or 72 hours after hatching had similar ($p>0.05$) large intestine weights. Similarly, broiler chickens on bovine colostrum feeding for 12, 24 or 72 hours after hatching had the same ($p>0.05$) large intestine weights. Male Ross 308 broiler chickens on no bovine colostrum feeding or

on bovine colostrum feeding for 12 or 48 hours after hatching had similar (*p>0.05*) large intestine weights.

Table 4.6 Effect of bovine colostrum feeding after hatching on gut organ digesta pH, length and weight of male Ross 308 broiler chickens aged 42 days*

	Treatment #					
Variable	$MCOL_0$	$MCOL_{12}$	$MCOL_{24}$	$MCOL_{36}$	$MCOL_{48}$	$MCOL_{72}$
Gut organ digesta pH						
Crop	5^{a}±0.2	5^{a}±0.1	5^{a}±0.4	5^{a}±0.3	5^{a}±0.3	5^{a}±0.3
Proventriculus	4^{a}±0.3	3^{a}±0.3	4^{a}±0.4	4^{a}±0.3	3^{a}±0.1	4^{a}±0.1
Gizzard	4^{a}±1.6	3^{a}±0.3	3^{a}±0.4	3^{a}±0.3	3^{a}±0.5	3^{a}±0.6
Small intestines	7^{a}±0.2	6^{a}±0.1	6^{a}±0.2	7^{a}±0.3	6^{a}±0.5	6^{a}±0.3
Caeca	7^{a}±02	7^{a}±0.2	7^{a}±0.2	6^{a}±0.3	7^{a}±0.1	7^{a}±0.1
Large intestine	7^{a}±0.2	6^{a}±0.2	7^{a}±0.4	6^{a}±0.2	7^{a}±0.1	6^{a}±0.2
Gut organ length (cm)						
GIT	225^{ab}±2.8	242^{a}±17.2	230^{ab}±6.4	220^{ab}±1.3	232^{ab}±10.6	209^{b}±14.8
Small intestines	195^{a}±4.8	191^{b}±1.9	197^{a}±5.5	192^{b}±1.9	197^{a}±6.5	195^{a}±4.9
Caecum	15^{b}±1.0	19^{a}±1.6	18^{ab}±1.4	18^{ab}±0.6	19^{a}±1.3	21^{a}±0.8
Large intestines	13^{a}±1.1	15^{a}±1.7	15^{a}±0.2	14^{a}±1.1	15^{a}±1.0	15^{a}±1.4
Gut organ weight (g)						
Crop	11^{b}±0.4	11^{b}±0.5	13^{a}±1.2	14^{a}±1.3	14^{a}±2.8	11^{b}±0.6
Proventriculus	9^{b} ±0.4	10^{ab}±1.1	11^{a}±0.6	9^{b}±0.7	10^{ab}±0.3	10^{ab}±0.1
Gizzard	39^{b}±3.7	40^{ab}±2.3	41^{ab}±1.5	45^{a}±1.6	45^{a}±2.0	44^{ab}±0.3
Small intestines	111^{a}±14.2	111^{a}±12.3	103^{b}±9.0	107^{b}±5.6	103^{b}±10.5	86^{c}±6.8
Caecum	6^{b}±0.3	7^{ab}±0.9	6^{b}±0.8	9^{a}±0.4	8^{ab}±1.0	7^{ab}±0.8
Large intestines	8^{c}±1.2	10^{bc}±0.7	12^{ab}±0.4	13^{a}±1.1	9^{c}±0.5	12^{ab}±0.7

* : Values presented as a mean ± standard error (SE)

a,b,c : Means with different superscripts in the same row indicate significant differences between treatments (*p<0.05*)

\# : Treatment codes are explained in Chapter 3, Table 3.3 (The treatments were feeding bovine colostrum to chicks for 0, 12, 24, 36, 48 or 72 hours after hatching)

A positive relationship (r = 0.832) was observed between bovine colostrum feeding period after hatching and caecum lengths of male Ross 308 broiler chickens aged 42 days (Figure 4.9 and Table 4.7). Crop and gizzard weights of male Ross 308 broiler chickens aged 42 days were optimized (r = 0.904 and 0.926, respectively) at bovine colostrum feeding periods of 44 and 55 hours after hatching, respectively (Figures 4.10 and 4.11, respectively). There was a negative relationship (r = 0.897) between

bovine colostrum feeding period after hatching and small intestine weights of male Ross 308 broiler chickens aged 42 days (Figure 4.12 and Table 4.7).

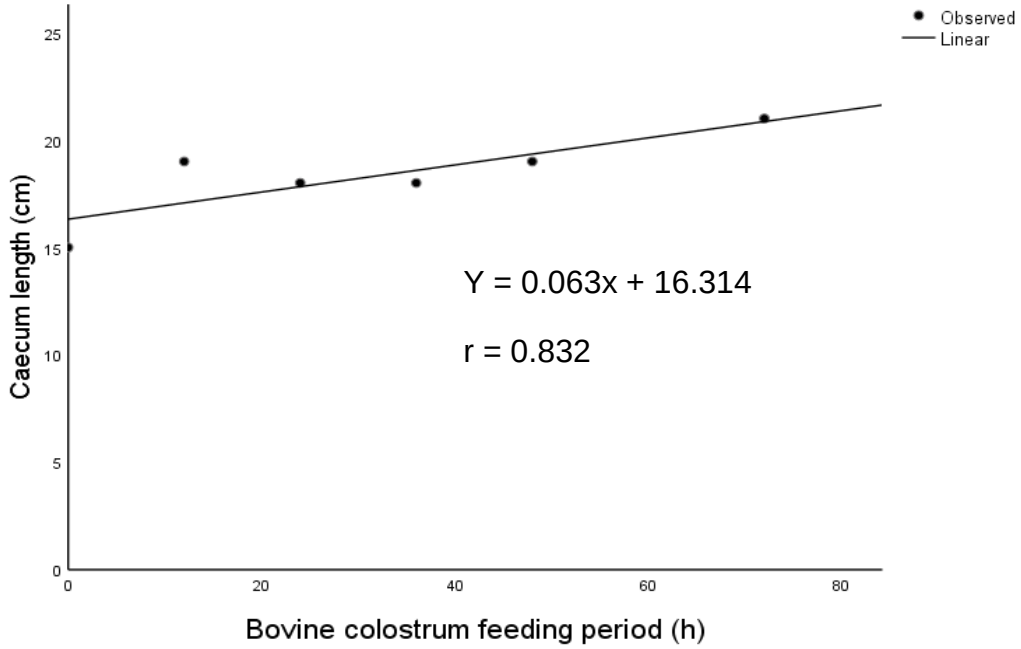

Figure 4.9 Relationship between bovine colostrum feeding period after hatching and caecum lengths of male Ross 308 broiler chickens aged 42 days

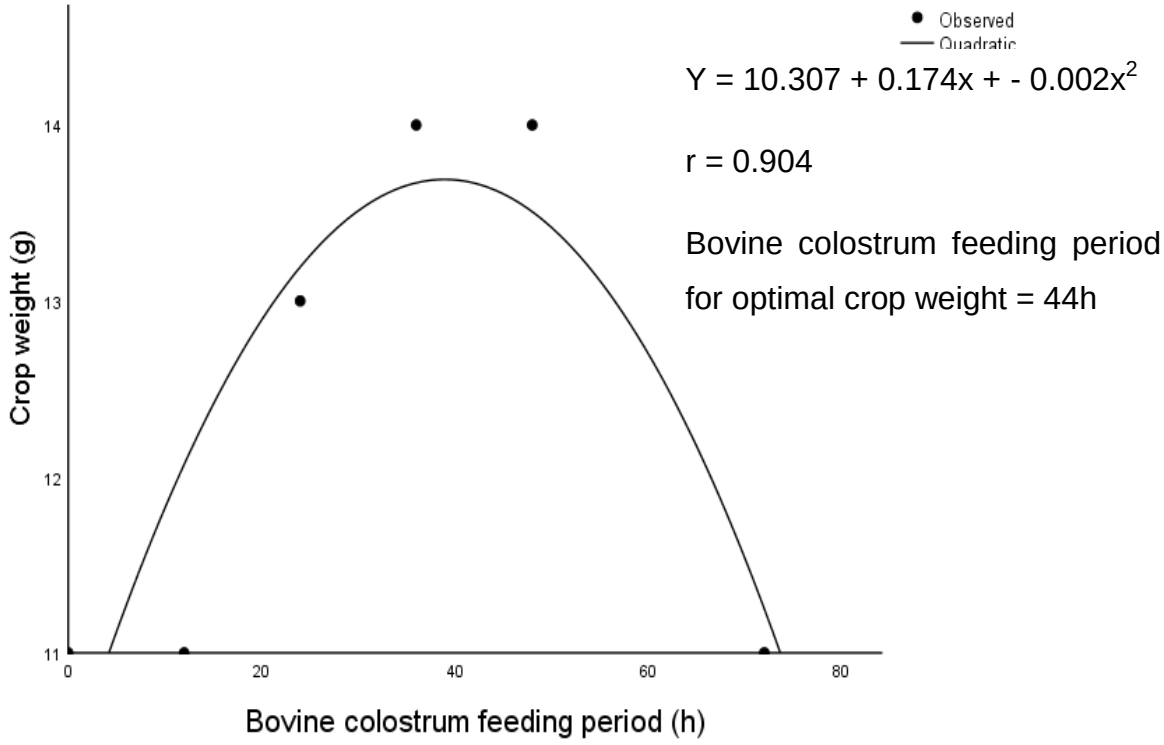

Figure 4.10 Effect of bovine colostrum feeding period after hatching on crop weight of male Ross 308 broiler chickens aged 42 days

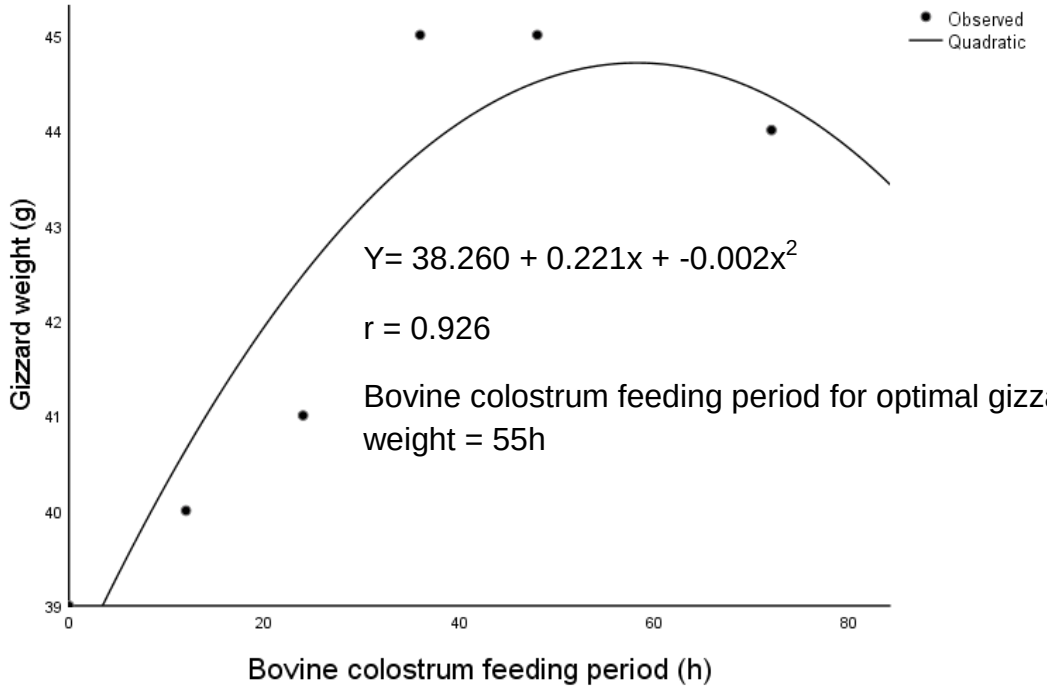

Figure 4.11 Effect of bovine colostrum feeding period after hatching on gizzard weights of male Ross 308 broiler chickens aged 42 days

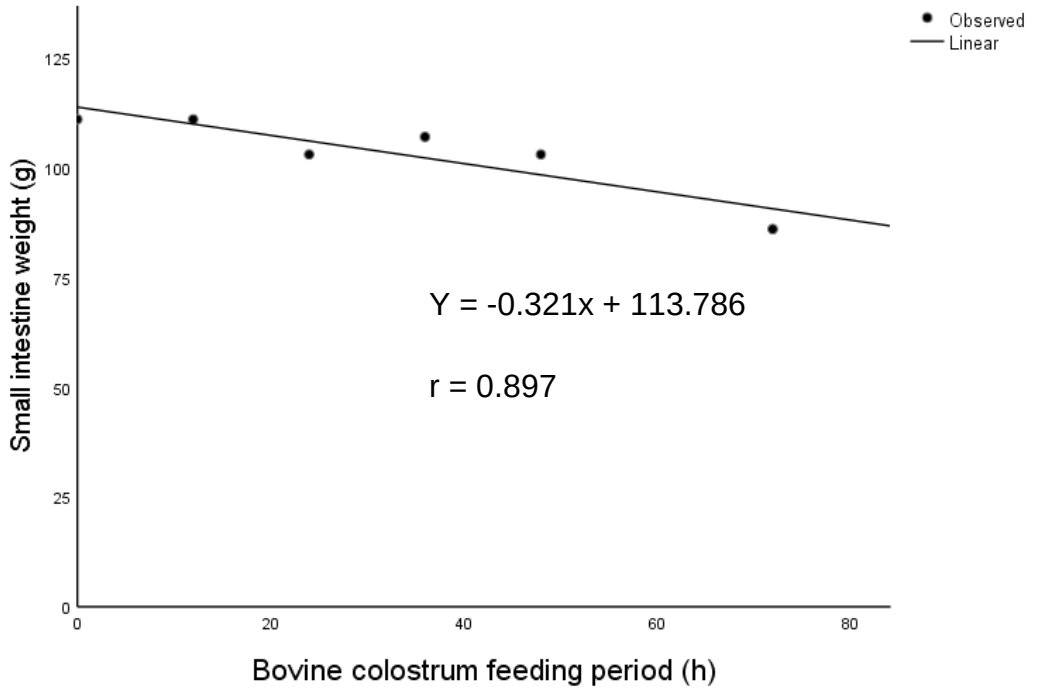

Figure 4.12 Relationship between bovine colostrum feeding period after hatching and small intestine weight of male Ross 308 broiler chickens aged 42 days

Table 4.7 Relationships between bovine colostrum feeding periods after hatching and caecum length and small intestine weights of male Ross 308 broiler chickens aged 42 days

Variable	Formula	r	Probability
Caecum length	Y = 0.063x + 16.314	0.832	0.040
Small intestine weight	Y = -0.321x + 113.786	0.897	0.015

r^2 : Coefficient of determination

4.6 Carcass characteristics

Results on the effects of bovine colostrum feeding period after hatching on carcass weights of male Ross 308 broiler chickens aged 42 days are presented in Table 4.8. Bovine colostrum feeding had no effect (*p>0.05*) on breast and drumstick weights of male Ross 308 broiler chickens. However, male Ross 308 broiler chickens on bovine colostrum feeding for 72 hours after hatching had heavier (*p<0.05*) carcass and thigh weights than those on no bovine colostrum feeding after hatching. Male broiler chickens on bovine colostrum feeding for 12, 24, 36, 48 or 72 hours after hatching had similar (*p>0.05*) carcass and thigh weights. Similarly, broiler chickens on no bovine colostrum feeding or on bovine colostrum feeding for 12, 24, 36 or 48 hours after hatching had the same (*p>0.05*) carcass and thigh weights.

Table 4.8 Effect of bovine colostrum feeding period after hatching on carcass weights (g) of male Ross 308 broiler chickens*

	Treatment #					
Variable	$MCOL_0$	$MCOL_{12}$	$MCOL_{24}$	$MCOL_{36}$	$MCOL_{48}$	$MCOL_{72}$
Carcass	1250^{b}±159.4	1342^{ab}±125.6	1358^{ab}±59.2	1387^{ab}±49.8	1350^{ab}±80.2	1495^{a}±59.5
Breast	215^{a}±21.5	196^{a}±29.4	207^{a}±6.7	209^{a}±17.0	210^{a}±19.2	217^{a}±22.1
Drumstick	86^{a}±7.8	86^{a}±7.6	91^{a}±3.8	99^{a}±4.7	89^{a}±5.7	97^{a}±5.2
Thigh	111^{b}±2.6	123^{ab}±10.3	121^{ab}±6.5	121^{ab}±6.5	128^{ab}±7.5	139^{a}±6.4

* : Values presented as a mean ± standard error (SE)

a,b : Means with different superscripts in the same row indicate significant differences between treatments (*p<0.05*)

: Treatment codes are explained in Chapter 3, Table 3.3 (The treatments were feeding bovine colostrum to chicks for 0, 12, 24, 36, 48 or 72 hours after hatching)

Positive relationships (r = 0.900 and 0.926, respectively) were observed between bovine colostrum feeding period after hatching and carcass and thigh weights, respectively (Figures 4.13 and 4.14, respectively and Table 4.9).

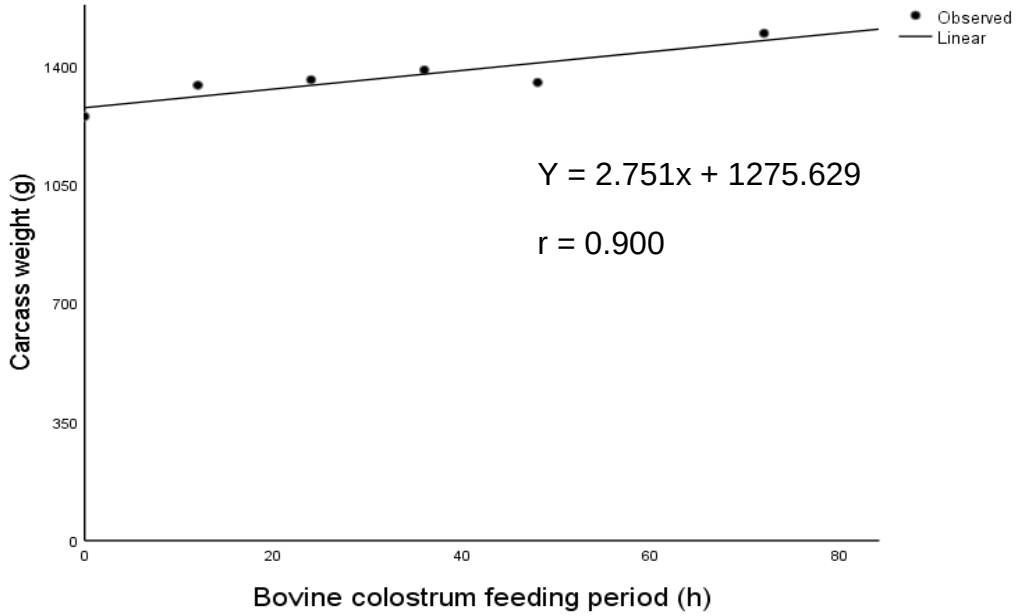

Figure 4.13 Relationship between bovine colostrum feeding period after hatching and carcass weights of male Ross 308 broiler chickens aged 42 days

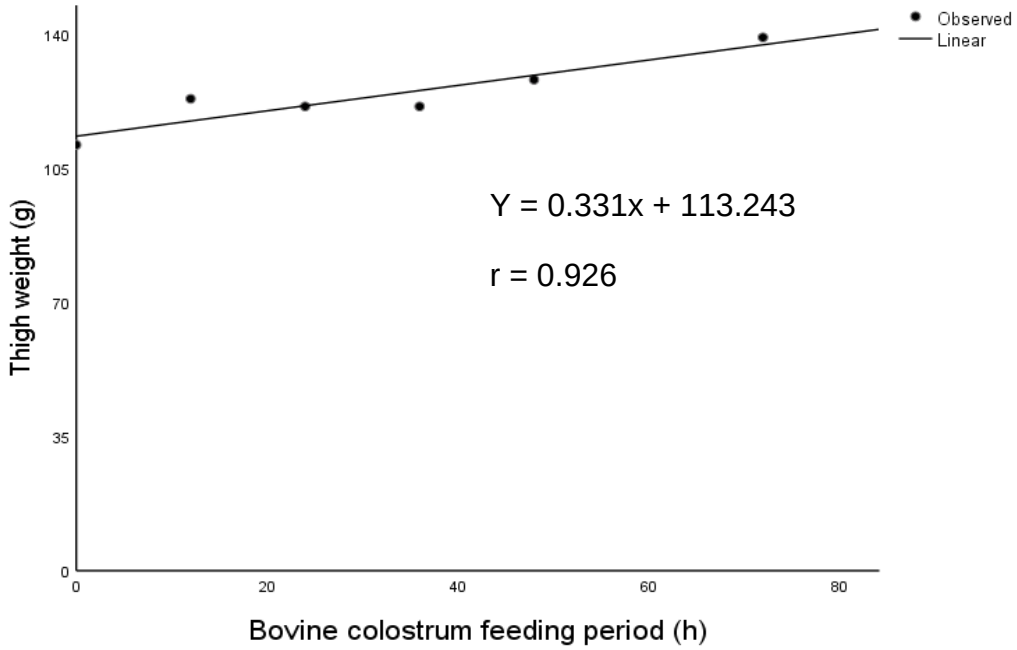

Figure 4.14 Relationship between bovine colostrum feeding period after hatching and thigh weights of male Ross 308 broiler chickens aged 42 day

Table 4.9 Relationships between bovine colostrum feeding period after hatching and carcass and thigh weights of male Ross 308 broiler chickens aged 42 days

Variable	Formula	R	Probability
Carcass weight	Y = 2.751x + 1275.629	0.900	0.015
Thigh weight	Y = 0.331x + 113.243	0.926	0.008

r^2 : Coefficient of determination

4.7 Sensory evaluation

Results on the effects of bovine colostrum feeding period after hatching on tenderness, juiciness, flavour and shear force of male Ross 308 broiler chicken meat are presented in Table 4.10. Bovine colostrum feeding period after hatching had no effect (*p>0.05*) on the juiciness of male Ross 308 broiler chicken meat. However, bovine colostrum feeding period after hatching affected (*p<0.05*) the tenderness of broiler chicken meat. Male broiler chickens fed bovine colostrum for 36 hours after hatching had better (*p<0.05*) meat tenderness values than those on no bovine colostrum feeding after hatching. However, broiler chickens on bovine colostrum feeding for 12, 24, 36, 48 or 72 hours after hatching had similar (*p>0.05*) meat tenderness values. Similarly, male broiler chickens on no bovine colostrum feeding or on bovine colostrum feeding for 12, 24, 48 or 72 hours after hatching had similar (*p>0.05*) meat tenderness values.

Bovine colostrum feeding period after hatching affected (*p<0.05*) meat flavour of male broiler chickens aged 42 days (Table 4.10). Male Ross 308 broiler chickens on bovine colostrum feeding for 72 hours after hatching had better (*p<0.05*) meat flavour values than those on no bovine colostrum feeding after hatching. However, male broiler chickens on bovine colostrum feeding for 12, 24, 36, 48 or 72 hours after hatching had similar (*p>0.05*) meat flavour values. Similarly, broiler chickens on no bovine colostrum feeding or on bovine colostrum feeding for 12, 24, 36 or 48 hours after hatching had the same (*p>0.05*) meat flavour values.

4.8 Shear force

Meat shear force values of broiler chickens aged 42 days were affected (*p<0.05*) by bovine colostrum feeding period after hatching (Table 4.10). Male Ross 308 broiler chickens on no bovine colostrum feeding had higher (*p<0.05*) meat shear force

values than those on bovine colostrum feeding for 36 hours after hatching. However, male broiler chickens on no bovine colostrum feeding or on bovine colostrum feeding for 12, 24, 48 or 72 hours after hatching had similar (*p>0.05*) meat shear force values. Similarly, male broiler chickens on bovine colostrum feeding for 12, 24, 36, 48 or 72 hours after hatching had the same (*p>0.05*) meat shear force values.

Table 4.10 Effect of bovine colostrum feeding period after hatching on tenderness, juiciness, flavour and shear force value (kg) of breast meat of male Ross 308 broiler chickens aged 42 days*

	Treatment #					
Variable	$MCOL_0$	$MCOL_{12}$	$MCOL_{24}$	$MCOL_{36}$	$MCOL_{48}$	$MCOL_{72}$
Tenderness	2.7^{b}±0.18	3.2^{ab}±0.17	2.9^{ab}±0.26	3.7^{a}±0.03	3.3^{ab}±0.18	3.3^{ab}±0.09
Juiciness	2.6^{a}±0.24	3.2^{a}±0.43	2.8^{a}±0.09	3.3^{a}±0.20	3.3^{a}±0.48	2.9^{a}±0.12
Flavour	3.2^{b}±0.08	3.3^{ab}±0.06	3.4^{ab}±0.03	3.5^{ab}±0.15	3.5^{ab}±0.06	3.6^{a}±0.88
Shear force	20^{a}±1.6	15^{ab}±1.4	14^{ab}±0.7	11^{b}±1.5	12^{ab}±1.2	13^{ab}±2.1

* : Values presented as a mean ± standard error (SE)

^{a,b} : Means with different superscripts in the same row indicate significant differences between treatments (P<0.05)

\# : Treatment codes are explained in Chapter 3, Table 3.3 (The treatments were feeding bovine colostrum to chicks for 0, 12, 24, 36, 48 or 72 hours after hatching)

Breast meat tenderness and shear force values of male Ross 308 broiler chickens aged 42 days were optimized (r = 0.992 and 0.973, respectively) at bovine colostrum feeding periods after hatching of 47 and 43 hours, respectively (Figures 4.15 and 4.16, respectively).

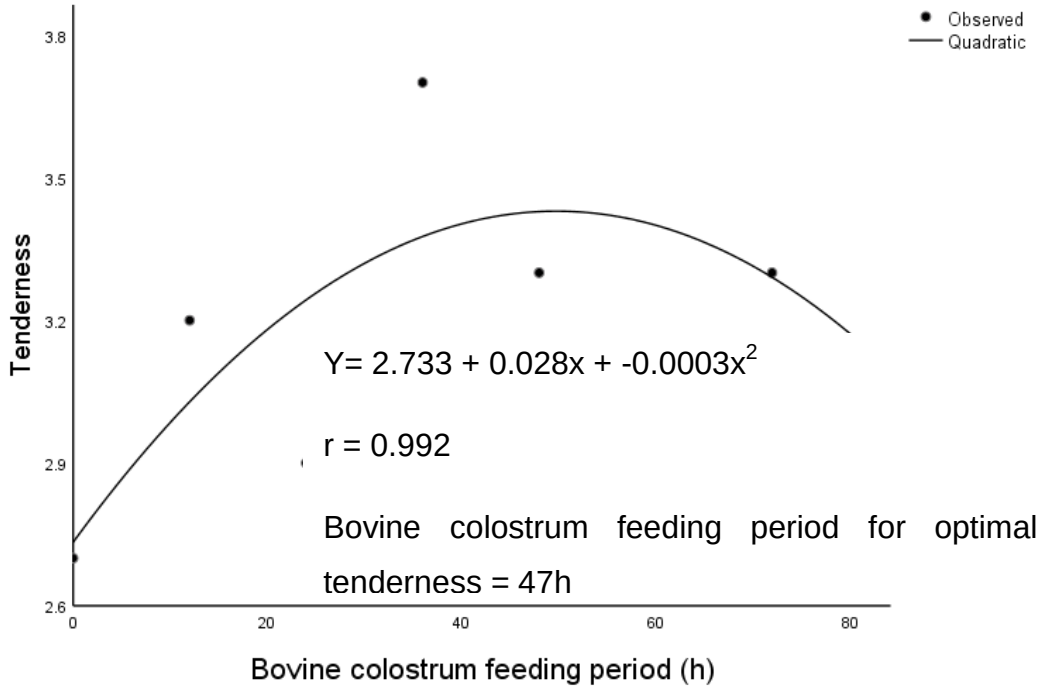

Figure 4.15 Effect of bovine colostrum feeding period after hatching on the breast meat tenderness of male Ross 308 broiler chicken aged 42 days

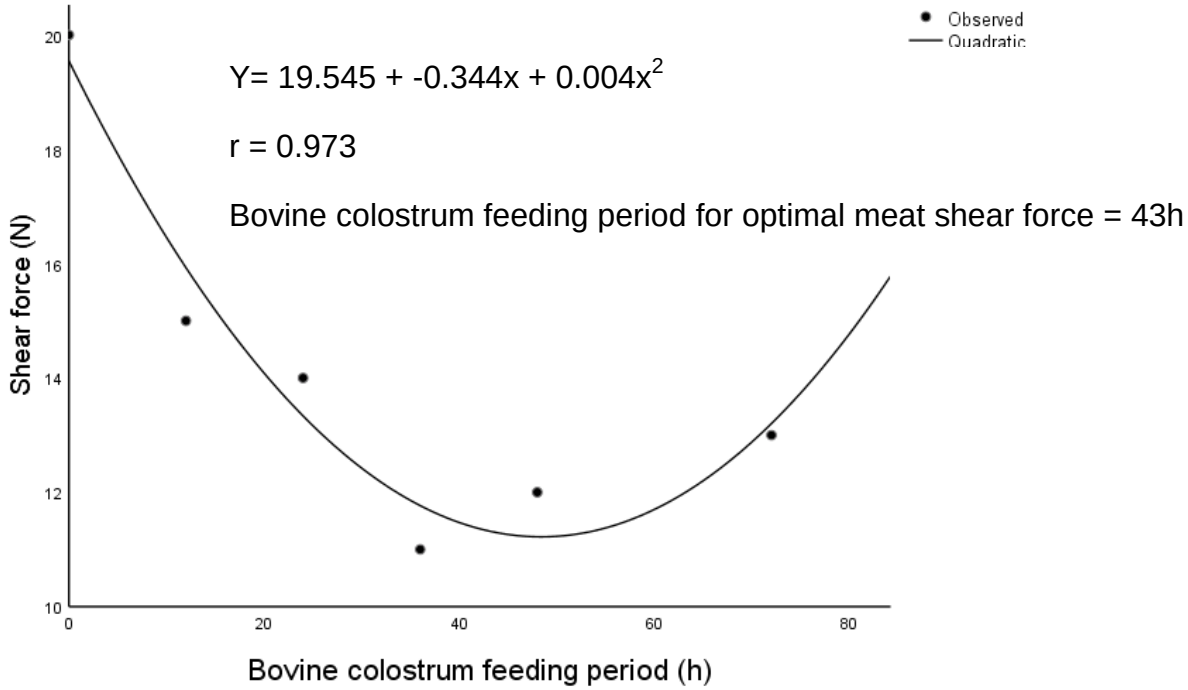

Figure 4.16 Effect of bovine colostrum feeding period after hatching on shear force value of meat of male Ross 308 broiler chickens aged 42 days

CHAPTER 5

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.1 Discussion

5.1.1 Growth performance and nutrient digestibility of broiler chickens aged one to 21 days

The diets used in this study had crude protein and energy levels of 20% and 12 MJ/kg dry matter, respectively. The diets also contained similar levels of other nutrients. *Ad libitum* bovine colostrum feeding periods of up to 72 hours after hatching did not significantly change the nutrient composition of the diets. All the diets met the nutrient requirements for broiler chickens as specified by McDonald *et al*. (2010). Thus, any differences in responses by the chickens must be due to colostrum feeding.

Bovine colostrum feeding periods after hatching did not improve voluntary feed intake of male Ross 308 broiler chickens aged one to 7 days. However, bovine colostrum feeding periods of 48 and 72 hours after hatching improved feed intake of male Ross 308 broiler chickens aged 8 to 14 days. The differences in feed intake between treatments disappeared during the third week of growth of the chickens. Qureshi *et al*. (2004) observed that spray-dried bovine colostrum inclusion in the diet improved feed intake of broiler chickens aged one to 14 days. The authors attributed the improved feed intake to additional nutrients found in colostrum. However, King *et al*. (2005) observed that the inclusion of spray-dried bovine colostrum, spray-dried bovine colostrum plasma and spray-dried porcine colostrum plasma had no effect on feed intake of broiler chickens aged one to 14 days.

Colostrum feeding periods of up to 72 hours after hatching did not improve diet DM, NDF, ADF and ash digestibilities of male Ross 308 broiler chickens aged 15 to 21 days. However, bovine colostrum feeding periods of 36 and 72 hours after hatching improved crude protein digestibility in male Ross 308 broiler chickens aged 15 to 21 days. Improved protein digestibility may have been due to the presence of growth factors in colostrum which allows better nutrient digestion absorption (King *et al*., 2005). No studies on the effect of bovine colostrum feeding after hatching on diet digestibility by broiler chickens were found.

Bovine colostrum feeding periods of 24, 36 and 72 hours after hatching improved metabolisable energy intake of male Ross 308 broiler chickens aged 15 to 21 days.

However, bovine colostrum feeding after hatching did not affect nitrogen retention of male Ross 308 broiler chickens aged 15 to 21 days. No studies were found on the effect of bovine colostrum feeding after hatching on metabolisable energy intake and nitrogen retention of broiler chickens.

Bovine colostrum feeding period of 72 hours after hatching improved growth rates of male Ross 308 broiler chickens aged one to 7 days. Similarly, colostrum feeding period of 72 hours after hatching improved growth rates of male Ross 308 broiler chickens aged 8 to 14 days. However, colostrum feeding after hatching did not affect the growth rates of male Ross 308 broiler chickens aged 15 to 21 days. Improved growth rates after colostrum feeding may have been due to the presence of growth promoting proteins (insulin-like growth factors 1 and 2), transforming growth factors-β and platelet-derived growth factors which allow better nutrient absorption and utilization (King *et al*., 2005; Qureshi *et al*., 2004). Qureshi *et al*. (2004) reported that immunmilk given via drinking water for a 7-day period after hatching improved growth rates of broiler chickens.

Colostrum feeding periods of up to 72 hours after hatching improved feed conversion ratio of male Ross 308 broiler chickens aged one to 7 days. However, colostrum feeding periods of up to 72 hours after hatching did not improve feed conversion of male Ross 308 broiler chickens aged 8 to 21 days. Yi *et al*. (2001a) observed that dietary inclusion of spray-dried colostrum plasma had no effect on feed conversion ratio of broiler chickens aged one to 21 days. However, King *et al*. (2005) observed that the inclusion of spray-dried bovine colostrum, spray-dried bovine colostrum plasma or spray-dried porcine colostrum plasma improved feed conversion ratio of broiler chickens aged one to 21 days. Similarly, Campell *et al*. (2003) observed that the inclusion of spray-dried bovine colostrum serum through drinking water improved feed conversion ratio of broiler chickens aged one to 14 days. Improvements in feed conversion ratio have also been observed in turkeys when offered spray-dried bovine colostrum serum through drinking water (Campell *et al*., 2004).

Colostrum feeding period of 72 hours after hatching improved live weights of male Ross 308 broiler chickens aged 7 days. The improvement in live weight of the chickens might have been because of improved growth rates and feed conversion ratios due to colostrum feeding. Bovine colostrum feeding period of 72 hours after

hatching improved live weights of male Ross 308 broiler chickens aged 14 days. Improved live weights of the chickens might have been because of improved feed intake and growth rates due to colostrum feeding. Colostrum feeding period of 72 hours after hatching, also, improved the live weight of male Ross 308 broiler chickens aged 21 days. This improvement in live weight of the chickens might have been because of improved metabolisable energy intake and crude protein digestibility due to colostrum feeding. Results of the present study are contrary to those of King *et al*. (2005) who observed that the inclusion in the diet of spray-dried bovine colostrum, spray-dried bovine colostrum plasma or spray-dried porcine colostrum plasma did not affect live weights of broiler chickens aged 14 days. Similarly, Yi *et al*. (2001b) observed no effect of dietary inclusion of spray-dried colostrum plasma on live weights of turkeys aged 21 days.

5.1.2 Gut morphology of broiler chickens aged one to 21 days

Results of the present study indicate that bovine colostrum feeding periods of up to 72 hours after hatching had no effect on gut organ digesta pH values, gut organ lengths and gut organ weights of male Ross 308 broiler chickens aged 21 days. No studies on the effect of colostrum feeding after hatching on gut morphology of broiler chickens were found.

5.1.3 Growth performance and nutrient digestibility of broiler chickens aged 22 to 42 days

Colostrum feeding periods of up to 72 hours after hatching did not improve diet DM intake of male Ross 308 broiler chickens during Week 5. However, a colostrum feeding period of 36 hours after hatching improved diet DM intake of male broiler chickens during Week 4 and 6. Reasons for differing DM intake responses to colostrum feeding after hatching are not clear. Akdemir *et al.* (2016) reported that powdered colostrum feeding after hatching increased diet intake of broiler chickens. Qureshi *et al*. (2004) reported that colostrum feeding after hatching improved growth and integrity of the intestinal tract thereby allowing better digestion, resulting in higher diet intakes of the chickens.

Results of the present study indicate that colostrum feeding periods of up to 72 hours after hatching did not improve diet dry matter, crude protein, NDF, ADF and ash

digestibilities in male Ross 308 broiler chickens aged 22 to 42 days. This is contrary to the findings of Qureshi *et al*. (2004). These authors reported that colostrum feeding after hatching improved growth and integrity of the intestinal tract thereby allowing better nutrient digestibility, absorption and utilization in poultry. However, in their studies, they used longer colostrum feeding periods.

Colostrum feeding periods of up to 72 hours after hatching did not improve metabolisable energy (ME) intake of male broiler chickens aged 36 to 42 days. In fact, those on colostrum feeding tended to have low ME intakes. Nitrogen retention values were, also, not improved by colostrum feeding periods of up to 72 hours after hatching. No studies were found on the effect of bovine colostrum feeding after hatching on ME intake and nitrogen retention in broiler chickens.

Colostrum feeding period of 72 hours after hatching improved growth rates of male Ross 308 broiler chickens during Week 4. However, colostrum feeding periods of up to 72 hours after hatching did not improve growth rates of male Ross 308 broiler chickens during Week 5. However, colostrum feeding periods of 12 and 48 hours after hatching improved growth rates of the chickens during Week 6. Colostrum feeding improves growth and integrity of the intestinal tract thereby allowing better nutrient digestibility, absorption and utilization, resulting in higher growth rates of the chickens (Qureshi *et al*., 2004). A number of authors observed that feeding spray-dried bovine colostrum plasma (Campell *et al*., 2003) and spray-dried porcine colostrum plasma (Campell *et al*., 2004) exerted higher growth rates in broiler chickens and turkeys, respectively.

The present results indicate that bovine colostrum feeding periods of up to 72 hours after hatching did not improve feed conversion ratio of male Ross 308 broiler chickens aged 22 to 42 days. Similarly, colostrum feeding after hatching did not improve live weights of male broiler chickens aged 22 to 42 days. These results are contrary to those of Akdemir *et al*. (2016) who reported that the addition of colostrum powder to the diets of chickens increased final body weights. Similarly, Baran *et al*. (2017) reported that liquid colostrum supplementation period of up to 42 days after hatching increased body weight of chickens. These authors attributed the good response to high protein levels in colostrum and, also, to longer colostrum supplementation periods.

5.1.4 Gut morphology of broiler chickens aged 42 days

Results indicate that bovine colostrum feeding periods of up to 72 hours after hatching had no effect on gut organ digesta pH values of male Ross 308 broiler chickens aged 42 days. Similarly, colostrum feeding periods after hatching did not improve GIT, small intestine and large intestine lengths of male broiler chickens. However, colostrum feeding periods of 12, 48 and 72 hours after hatching improved caecum lengths. Improved caecum lengths may have been due to the fact that colostrum improves organ development in the neonates (Uruakpa *et al*., 2002). However, no studies on the effect of bovine colostrum feeding after hatching on gut morphology of broiler chickens were found.

Colostrum feeding periods after hatching affected gut organ weights of male broiler chickens aged 42 days. Colostrum feeding periods of 24, 36 and 48 hours after hatching improved crop weights of the chickens. However, only colostrum feeding periods of 24 and 36 hours after hatching increased proventriculus and caecum weights of the chickens, respectively, compared to the chickens on no colostrum feeding. Similarly, colostrum feeding periods of 36 and 48 hours; 24, 36 and 48 hours and 24, 36 and 72 hours improved gizzard, small intestine and large intestine weights of the chickens, respectively. Crop and gizzard weights of male broiler chickens were optimized at different colostrum feeding periods of 44 and 55 hours after hatching, respectively. Increased gut organ weights may have been due to the fact that colostrum feeding improves development in neonates (Uruakpa *et al*., 2002). However, no studies on the effect of bovine colostrum feeding after hatching on gut morphology of chickens were found.

5.1.5 Carcass characteristics

Colostrum feeding periods of up to 72 hours after hatching did not improve the drumstick and breast weights of male Ross 308 broiler chickens aged 42 days. However, colostrum feeding period of 72 hours after hatching improved carcass and thigh weights of the chickens. Colostrum feeding improves growth and integrity of the intestinal tract thereby allowing better nutrient absorption and utilization, resulting in higher growth rates of the chickens (Qureshi *et al*., 2004). No studies on the effect

of bovine colostrum feeding periods after hatching on broiler chicken carcass weights were found.

5.1.6 Sensory evaluation

Results of the present study indicate that colostrum feeding periods of up to 72 hours after hatching did not improve male broiler chicken meat juiciness. However, colostrum feeding for 36 hours after hatching improved chicken meat tenderness. Optimal meat tenderness was achieved at a calculated colostrum feeding period of 47 hours after hatching. It is possible that the high amounts of amino acids in colostrum were essential for chicken meat tenderness (Ojano-Diranin and Waldroup, 2002).

5.1.7 Shear force

Feeding bovine colostrum for 36 hours after hatching reduced male broiler chicken meat shear force values. A value of 43 hours of feeding colostrum after hatching was calculated to be for optimal (lowest) meat shear force value. Colostrum feeding for 72 hours after hatching improved male chicken meat flavour. Thus, different colostrum feeding periods of 47, 43 and 72 hours after hatching optimized chicken meat tenderness, shear force value and flavour. No studies on the effect of bovine colostrum feeding after hatching on broiler chicken meat sensory attributes and shear force values were found.

5.2 Conclusions and recommendations

5.2.1 Growth performance, nutrient digestibility and gut morphology of broiler chickens aged one to 21 days

Colostrum feeding periods of up to 72 hours after hatching improved voluntary feed intake during the first two weeks of growth of male Ross 308 broiler chickens. This improvement in voluntary feed intake disappeared by the third week of growth of the chickens. Similarly, colostrum feeding periods of up to 72 hours after hatching improved FCR values during the first week of growth of male chickens; but this positive effect on FCR disappeared by the third week of growth of the chickens.

Bovine colostrum feeding periods of up to 72 hours after hatching did not improve DM, ADF, NDF and ash digestibilities. However, colostrum feeding periods of 36 and 72 hours after hatching improved CP digestibility in male Ross 308 broiler chickens aged one to 21 days. Reasons for different responses to colostrum feeding periods of up to 72 hours after hatching are not clear. However, it is established that growth factors present in colostrum allow faster gut cell growth and better nutrient absorption (King *et al*., 2005). However, results of the present study indicate that colostrum feeding periods of up to 72 hours after hatching had no effect on gut digesta pH, gut organ lengths and weights of male broiler chickens aged 21 days.

Colostrum feeding periods of 24, 36 and 72 hours after hatching improved metabolisable energy intake but not nitrogen retention of male broiler chickens aged one to 21 days. Only a colostrum feeding period of 72 hours after hatching improved live weights of the chickens aged 21 days. Reasons for differing responses to colostrum feeding periods of up to 72 hours after hatching are not clear. This requires further studies.

5.2.2 Growth performance, nutrient digestibility and gut morphology of broiler chickens aged 22 to 42 days

Colostrum periods of up to 72 hours after hatching did not improve diet DM intake of male Ross 308 broiler chickens aged 28 to 35 days. However, a colostrum feeding period of 36 hours after hatching improved diet DM intake of the chickens aged 22 to 42 days. Reasons for differing diet DM intake responses to colostrum feeding periods after hatching are not clear. Bovine colostrum feeding of up to 72 hours after hatching did not have an effect on diet dry matter, CP, NDF, ADF and ash digestibilities in male Ross 308 broiler chickens aged 22 to 42 days.

Results of the present study indicate that colostrum feeding periods of up to 72 hours after hatching did not improve ME intake, FCR and live weight of Ross 308 broiler chickens aged 22 to 42 days. Colostrum feeding periods of up to 72 hours after hatching had no effect on gut organ digesta pH values, and GIT, small intestine and large intestine lengths of male broiler chickens aged 42 days.

5.2.3 Carcass characteristics

Results of colostrum feeding periods of up to 72 hours after hatching indicate that colostrum feeding did not improve drumstick and breast meat weights of male Ross 308 broiler chickens aged 42 days. However, a colostrum feeding period of 72 hours after hatching improved carcass and thigh weights of the chickens. Further studies in which longer colostrum feeding periods are used after hatching are recommended.

5.2.4 Sensory evaluation

Colostrum feeding periods of up to 72 hours after hatching did not improve male broiler chicken meat juiciness. However, a colostrum feeding period of 36 hours after hatching improved chicken meat tenderness, with a calculated colostrum feeding period of 47 hours after hatching for optimal meat tenderness.

5.2.5 Shear force

Feeding bovine colostrum for 36 hours after hatching reduced male broiler chicken meat shear force values. A period of 43 hours of feeding colostrum after hatching was calculated for optimal (lowest) meat shear force value. Thus, different colostrum feeding periods of 47, 43 and 72 hours after hatching optimized chicken meat tenderness, shear force value and flavour, respectively. Further studies are recommended to ascertain these results.

CHAPTER 6

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