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Effects of Graded Amounts of Pre-Starter Ration on The Performance and Carcass Characteristics of Broiler Chickens

تأثير الكميات المتدرجة من عليقة ما قبل البادئ على اداء وخصائص الذبح للدجاج اللاحم

A dissertation submitted in partial fulfillment of the requirements for the degree of M. Sc. in Tropical Animal Production

by

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Dedication

This work is

dedicated to

my family

my friends

and colleges

To you…….

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First of all, praise is due to Allah (the lord of the universe) for giving me the inner strength and ability to accomplish this study.

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Abstract

This study aimed to decrease the total cost of broilers feeding by testing the effect of different amounts of pre- starter diet less than the recommended amount (100 g/chick) on the performance and carcass quality. The experiment was conducted at the Albosairry farm for broiler production, (private farm) in Khartoum State – Sudan. Five dietary groups of pre-starter were formed. Which contained (100, 75, 50, 25, and 0 g/chick). A total of 225-day old chicks (Ross 308) were allocated into five treatment groups, each group was replicated three times, fifteen birds for each replicate (5×3×15). Complete randomized design was used. Similar starter diet was provided to each group after the total consumption of the tested amount of pre-starter until 22 days of age and finisher diets from 23 up to the end of the experiment (42 days). The starter and finisher diets were formulated according to the recommendations of (NRC, 1994). Feed and water were provided *ad libtum.* The studded broiler performance parameters were: feed intake (g/bird), live body weight (g/bird), weight gain (g/bird), feed conversion ratio (g feed/g gain). For carcass characteristics, carcass weight. Weight of carcass cuts (breast, leg and wing) and edible organs weights (heart, liver, gizzard, spleen and abdominal fat). Results showed no significant difference ($P>0.05$) in feed intake (g/bird) and feed conversion ratio among the tested groups, however, body weight gain by the groups fed 75 and 0 g pre- starter was significantly lower compared to other groups. The edible organs heart, liver, gizzard and carcass cuts were not significantly different between treatments, however, carcass yield (dressing %), spleen and abdominal fat were significantly ($P<0.05$) higher by the group fed 100 g pre-starter. From the results of this study it can be concluded that, the commonly used amount of pre-starter (100 g) can be reduced to only 25 g/ bird and then followed by starter diet without affecting the performance and carcass characteristics of broiler chickens.

مستخلص الدراسة

اجريت هذه الدراسة في مزرعة البصيري لانتاج الدواجن (مزرعة خاصة) بولاية الخرطوم – السودان, وذلك لمعرفة أثر استخدام كميات مختلفة من عليقة ما قبل البادئ على الاداء الانتاجي لدجاج اللحم و بعض خصائص الذبيحة. تم تقسيم عليقة ما قبل البادئ الى 5 كميات مختلفة (100, 75, 50, 25, و 0) جرام/ كتكوت, واستخدم عدد 225 كتكوت عمر يوم من سلالة روص 308 تم توزيعها عشوائيا (باستخدام التصميم كامل العشوائية) الي خمسة مجموعات كل مجموعة تحتوي علي ثلاثة مكررات بكل منها خمسة عشر كتكوت (5*3*15). بعد انتهاء الكمية المختبرة من علف ما قبل البادي تم تغذيةا لكتاكيت علي علف بادئ حتى اليوم 22. تم استخدام نفس العلف البادي لكل المجموعات يليه العلف الناهي جتي نهاية مدة التجربة (42 يوم). عليقتي البادي والناهي تم تركيبهما حسب توصيات المجلس الوطني للبحوث 1994. العلف والماء كانت متوفرة دون انقطاع للكتاكيت طوال فترة التجربة.

المعايير التي قيست لتقييم ومقارنة الأداء الانتاجي للدجاج اللاحم بين المجموعات المختلفة هي : كمية العلف المستهلك ,الوزن الحي للكتكوت, الوزن المكتسب للطائر و معدل التحويل الغذائي (جرام علف/وزن مكتسب) , المعايير التي استخدمت لتقييم صفات الذبيحة هي وزن الذبيحة , نسبة التصافي ,متوسط اجزاء الذبيحة (الصدر , الارجل و الاجنحة) واوزان الاحشاء الماكولة (القلب , الكبد , القانصة) اضافة لوزن الطحال و دهن البطن . اظهرت نتائج هذه الدراسة عدم وجود فروق معنوية ($P>0.05$) في متوسط العلف المستهلك (جرام/طائر) و متوسط معدل التحويل الغذائي (جرام علف/وزن مكتسب) بين المجموعات المختلفة بينما كان الوزن المكتسب للمجموعة التي غذيت علي75 و 0 جرام علف ما قبل البادئ اقل معنويا مقارنة بقية المجموعات. واظهرت الدراسة كذلك عدم وجود فروق معنوية ($P>0.05$) في اجزاء الذبيحة (الصدر , الارجل و الاجنحة) ومتوسط اوزان الاحشاء الماكولة (القلب, الكبد و القانصة) بين المجموعات, بينما كانت نسبة التصافي للمجموعة التي غذيت علي العلف البادي اقل معنويا مقارنة بالمجموات الاخري ($P>0.05$) وهنالك فرق معنوي ($P<0.05$) في الطحال و دهن البطن بين المجموعات التي غذيت علي نسب اقلة من 100 جرام من (كنترول) علف ما قبل البادي.. عليه يمكن تلخليص هذه الدرارسه في انه يمكن استبدال 100 جرام التي تسخدم للعلف ماقبل البادي بكميات اقل يمكن ان تصل الي 25 جرام فقط منه ثم تقديم العاف البادي دون تاثير علي الاداء الانتاجي وصفات الذبيحة للدجاج اللاحم.

TABLE CONTENTS

Tables List

Tables Abbreviations

ANOVA	Analysis of Variance
BW	Body Weight
BWG	Body Weight Gain
CRD	Complete Randomized Design
FAO	Food and Agriculture Organization
FCR	Feed Conversion Ratio
FT	Feed Intake
GIT	Gastro Intestinal Tract
IB	Infectious Bronchitis
IBD	Infectious Bursa Disease
LBW	Live Body Weight
LSD	Last Significant Difference
ND	Newcastle Disease
NRC	National Research Council
NS	No Significant
SPSS	Statistical Package of Social Science

Chapter one

1.0 Introduction

Current broiler feeding programs provide a pre-starter feed from chick placement to 7 days of age, however, the chicks' requirements change quickly during their early days of life, and this should be taken into account when composing starter diets, Therefore, the composition of the pre-starter diet can influence the subsequent growth and development of broiler chickens (Swennen et al. 2009). Suitable feed composition and optimal feed formulations, specifically for the first-day post-hatch, may be of great importance for broiler chickens to manifest their genetic potential growth rate. The use of an appropriate pre-starter diet consisting of simple sources of protein and energy supplements would meet the specific needs of the newly hatched chicks more efficiently. Lilburn (1998); Ebling et al. (2015) pointed that the uses of more expensive ingredients to provide a higher plain of nutrition could improve performance during the first two weeks and should be seen as an investment rather than a cost.

The common method applied for the use of pre starter by the Sudanese poultry producers is provide chicks with amount of 100 g pre-starter per chicks in the first days of life, then followed by starter diet *ad libitum*. The prices of pre-starter are becoming very high and consequently, increase the cost of broiler production. In addition, the impact of the amount of pre-starter diet provided to chicks on broiler performance is less investigated. For these two reasons, the objective of this study is to investigate the effects of graded amounts of the pre-starter diet on the performance and carcass characteristics of broiler chickens. In order to find an economically optimum amount of pre-starter diet feeding.

1-1 Research problem:-

1. There is a noticeable increase in the price of pre-starter diet.
2. Use of high-cost feedstuffs in the pre-starter diet.

1-2 Research importance:-

1. Reducing the quantities used from the pre-starter diet.
2. Using the diet as the lowest-cost feed in substitute for the pre-starter diet.

1-3 Research Justifications:-

1. High price of the per-starter diet in poultry feed.
2. Poultry feed industry from material with a lower cost.
3. The great need for white meat in the world and countries.

1-4 Research Hypothesis:-

These is a very high price of the pre-starter diet in feed for poultry and consequently the cost increase in feeding.

Chapter two

2.0 Literature review

2.1 World poultry industry:

World Poultry production has been gradually growing at a level of 4% annually. The productivity of poultry has almost tripled in the last 100 years because of genetic selection, improved feeding methods, application of recent knowledge, technology, developed housing, better disease control and excellent management in addition to processing and improved storage of poultry products (Elamin et al., 2008). There are many species of poultry used by man. The domestic hen (Gallus domestic) is the most important one. Its products are rich in protein, minerals, and vitamins. It accounts for more than 90% of the world's poultry flocks, ducks account for 5% and turkey for about 2%. The rest of the poultry species accounts for about 3%, which includes geese, dove, pigeons…etc (Suad, 1998).

Poultry production is currently expanding in developing countries through the usage of small-scale production facilities and increased poultry husbandry skills. (Suad, 1998).

Egg production is a highly economical business that involves a substantial investment of capital and considerable risk. Demand for eggs is inelastic so that relatively small changes in total egg production can cause a sharp decline in the egg price. (Laura, 1996).

Poultry meat is the fastest-growing component of world-wide meat production, utilization, and trade, with developing and transition economies playing an important role in the development. In addition to offering chances to increase poultry trades (Regmi, 2001). The broiler industry has been spectacular and followed by improvement in breeding, disease control and marketing practices (Laura, 1996).

World poultry meat output increased nearly eight-times between1961-2001. The biggest global poultry meat producers are the United States, the European Union, China, Brazil, Mexico, Canada, and Japan. Among middle-income countries, China was the major producer in 2001, followed by Brazil, Mexico, Argentina, Iran, Russia, Egypt, and Poland. In 1961. Middle-income countries produced 34 percent of world poultry meat, high-income countries 61 percent, and low-income countries the remaining 5 percent. By the mid-1990s, middle-income country production had reached a level of 47 percent of the output of high-income countries. By 2001, middle-income countries accounted for the major share of world poultry production (52 percent) compared with 42 percent in high-income countries and less than 6 percent in low-income countries (Regmi, 2001).

2.2 Poultry industry in Sudan:

Poultry production has become one of the most common and noticeable enterprises in Sudan. The Sudanese poultry industry revolves mainly around the chicken. The commercial poultry breeds are always characterized by rapid body weight gain and high egg production with less consumption of feed (Paul et al, 2004). According to the records in the Ministry of Animal Resources and Fisheries (2008) Poultry production was estimated to 45.6 million. Salih (2002) reported that the commercial poultry industry in Sudan was started by the establishment of the Sudanese Kuwaiti Company 1979 and the Arab Sudanese Poultry Company in 1982 both were centered in Khartoum. These two pioneering projects started with closed systems and modern feed mills. Then the poultry industry started to grow rapidly around Khartoum city and other cities in Sudan due to the increasing demand for poultry products and the concurrent progress of the animal feed industry and the activity of veterinary services. Broilers are the main type of poultry produced by modern integrated poultry raising facilities due to their high feed conversion ratio Food and Agriculture Organization (FAO, 2010). The poultry industry in Sudan showed a significant

development in the last decade, with production rising from 5 million broilers in 2006 to close to 90 million in 2017 (Chamber of Poultry, 2018).

2.3 Poultry Nutrition:

Nutrition plays a major role in the success of poultry production (Mahmood et al., 2012). The main objective of poultry nutrition is to maximize the economic production performance of poultry. Diets are usually compounded from cereals, such as wheat, sorghum and maize, as the principal source of energy and protein-rich ingredients such as oilseed meals, pulses and animal proteins (Waldroup et al., 2005). Fats or oils are added as additional sources of energy and diets are routinely supplemented with a range of additives, including minerals, vitamins, amino acids, growth promoters, enzymes and medications (Mahmood et al., 2012).

The feed components are provided usually to poultry in the farm of either, mash, crumble or pellets after they have been mixed. Birds can discriminate between food sources and when offered a choice between feeds can select a mixture of the major nutrients, such as energy and protein that is broadly appropriate for their individual needs (Mahmood et al., 2012).

Improvement nutrition during the first weeks, with practical neglect for cost, could progress gut health and guarantee birds improve to their extreme genetic potential. Ferket (2015) suggested that, under nutrition in the perinatal and immediate post-hatch nutrition is constraining development to support subsequent growth.

In newly hatched chicks, the remaining yolk (yolk sac) – which comprises approximately 14% of the chick's body weight at the time of hatching provides the so-called internal feed for survival in the first days of life. Yolk sac contents are absorbed and utilized for the growth of the small intestine and to supply energy (Noy and Sklan 1998) and nutrient reserves for several days (Uni et al. 2003) until the introduction of external feed intake (Sklan, 2001). Consequently, one of the major

changes occurring immediately after the hatch is a shift in the source of available nutrients for the neonatal chick; the hatchling has to make the transition from metabolic dependence on the endogenous lipid-rich yolk to the utilization of exogenous carbohydrate and protein-rich feed (Noy and Sklan 1995). Newly hatched chicks have an immature digestive system and the digestive tract has to undergo major morphological and physiological changes in the first week of age to allow proper digestion and utilization of ingested nutrients (Willemsen et al. 2010). As young chicks are less efficient in utilizing nutrients from complex nutritive components, they could benefit from diets having simply digested components.

2.4 Broilers feeding phases:

The recent systems for broilers feeding are based on the concept that the birds should be fed diets with decreasing protein and increasing energy content as they approach market age (Skinner et al, 2001). Broiler chicks are commonly fed four type of diets (pre-starter, starter, grower, and finisher). If broilers are fed a single diet theoretically the protein level would be lower than recommended when the birds are young and higher than recommended as the birds get older. Similarly, energy levels would be higher than recommended as the birds are young and lower than recommended as the birds get older (Skinner et al., 2001).

2.5 Broiler feeding at first week:

The broiler hybrids in the last decades have been selected for fast growth in order to reach slaughter weight at a younger age. Consequently, the embryonic developmental period as well as the first week after hatching represents a larger proportion of the whole life span (Bigot et al. 2003). The first week of life makes up 17% of a typical broiler's life, slaughtered at 49 days, but only accounts for about 4.5% of total feed consumption (Lilburn 1998; Havenstein et al. 2003).

Leeson (2012) pointed out that each gram of extra bodyweight at day 7 converts to 5 gram gain on day 45.

The increasing interest using more specific diets for young birds may be related to the positive correlation between body weight in the first week and that achieved at the age of the market (Willemsen et al. 2008).

During the first week of life, broiler chickens undergo various developmental changes that are already initiated during incubation. Ongoing 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 that may provide nutritional support during the first days after hatch, the growth performance may be affected by the nutritional composition of the pre-starter diet, as well as feed availability directly after hatch has an effect on physiological development directly after hatch, but also at later age (Koedijk et al., 2016).

From the first week of incubation onwards, broiler chicken embryos mainly rely on lipid oxidation for their growth and development, as the yolk primarily contains fatty acids that may function as an energy source (De Oliveira et al., 2008). At hatch, the residual yolk still consists mainly of fatty acids (Yadgary et al., 2010). Nevertheless, chickens are provided a diet rich in complex carbohydrates at placement on a broiler farm (Sklan, 2001). The switch from fats towards carbohydrates as the primary energy supply for young broiler chickens may be perceived as contradictive, given their reliance on lipid metabolism during most of the incubation process. This requires a better understanding of the digestive status of chickens during the first week of life (Sklan, 2001). The fulfillment of the nutritional requirements of broiler chickens during the first week of the life requires a proper understanding of ingredient digestibility and metabolizability, as this ultimately affects the nutrient availability for utilization. Because the gastro intestinal tract GIT is not fully mature

yet at the moment of the hatch, it appears to be logical to suggest that the digestibility and metabolizability of various nutrients are also not optimal (Green et al., 1987).

2.6 Pre-starter diet:

At the pre-starter phase, the gastrointestinal tract undergoes morphological and physiological alterations until it reaches maturation. Adaptation period is necessary for the chicks to achieve the maximum capacity of digestion and absorption of nutrients. Feed consumption stimulates the development of the gastrointestinal tract and, consequently, digestion and absorption capacity (Noy and Sklan. 1997). Thus, ingredients of high nutrient availability may benefit newly hatched chicks, which have immature gastrointestinal tracts (Noy and Sklan. 1997). Pre-starter diets of high digestibility and high protein content can be used to meet the requirements of chicks in the first days of life and are considered as investment, not a cost, in poultry production (Lilburn, 1998). It is well known that the ratio of macronutrients (protein, lipids, and carbohydrates) in the pre-starter diet of broiler chicks has a great impact on their performance and body composition (Buyse et al., 1992; Swennen et al., 2007).

There are two options for formulating pre-starter diets; the first is to use higher than normal concentrations of nutrients, whereas the second approach is to include more highly digestible ingredients to accommodate deficiencies in digestibility or immaturity of digestive functions (Leeson 2008).

There is considerable interest in the precision of formulating a diet for poultry with the prospect of decreasing initial mortality and improving lot uniformity. Besides the knowledge of the metabolic and physiological peculiarities in the post-hatching period gives subsidies for the optimization of food management, allowing the birds to express their full genetic potential. Selection for rapid growth in broiler chickens resulted in increased appetite, live weight and cut yields and improved feed

conversion, thus reducing the number of days for slaughter (Joseph, and Moran, 2005).

2.7 Effect of pre-starter diet on broiler performance:

The first week of the life of a broiler chicken has a large impact on its health, welfare, and growth performance as it matures (Lemot, 2017). By supplying a pre-starter diet with a high concentration of nutrients with special attention to the quality of energy and protein sources, it is believed to have a positive effect on the production performance of the broiler chicks (Leeson and Zubair, 2004). Leeson (2012) pointed out that each gram of additional bodyweight at Day 7 translates to 5 g extra gain at day 45, insured further highlighting the importance of optimal feeding of young broilers. The increasing interest using more specialized diets for young birds may be related to the positive correlation between body weight in the first week and that obtained at the market age (Willemsen et al. 2008). Several investigations have shown that chicken weight in six and seven-week-old had a linear relationship with their weight in the first week of rearing. This was not due to the breeder age and day-old chicken weight (Pezeshkian, 2002). Post–hatch feeding could affect broiler performance during the rearing period. (Nobakht, 2001) noted that using a period as a pre-starter before starter feeding for helping to chicken growth rate is very necessary. Early diet manipulation in chickens can modify their growth and fat accumulation (Akiba, and Murakami 1995).

Chapter three

3.0 Materials and Methods

3.1 Experimental sites and duration:

The experiment was conducted at the Albosairry farm for broilers production, (private farm) in Khartoum state - Sudan. The experiment was conducted during the period from 19 November 2018 to 31 December 2018.

3.2 Experimental birds:

A total of two hundred and twenty-five (225) unsexed one-day-old commercial broiler chicks (Hybrid-Ross308) were used in this study. They were divided randomly into 5 groups (A, B, C, D and E) with 3 replicate for each group and 15 chicks per replicate, using complete randomized design (CRD).

3.3 Experimental House:

The experiment was conducted in a closed system house, hence, temperature cooling and ventilation were automatically controlled. A part of this house was divided into fifteen experimental cages of equal size 1m square for each. The experimental house and equipment were cleaned and disinfected before the arrival of the birds and then fresh wood shaving litter was spread on the floor of the experimental cages, moreover, each cage was provided with one metal feeder and plastic drinker. Lighting program used was 24 hours' light.

3.4 Experimental diets:

In this experiment pre-starter was provided to the broiler groups at different amounts: 100 g (T1, control) 75g (T2), 50g (T3), 25g (T4), or 0 g/bird (T5, only starter feed). Similar conventional starter diet was then provided to each group after the total consumption of the tested amount of pre-starter and continued until twenty-two days of age. After that finisher diet was provided until the end of mast. The Pre-starter (named NaPo) was used in this study manufactured by Champrix Company in Netherlands. The chemical composition of the Pre-starter is presented in (table 1).

The starter and finisher diets were formulated to be approximately iso-caloric and iso-nitrogenous to meet the nutrient requirement for broiler chicks as outlined by the National Research Council (NRC. 1994). The composition and chemical analysis of the used starter and finisher diets are presented in (Table 2). Birds were offered feed and water ad libitum throughout the experimental period.

Table (1): Pre-starter chemical composition

Item	**%**
Crude protein	23
Crude fat	6.5
Crude ash	3
Crude fiber	0.5
Lysine	1.4
Methionine + Cystine	0.99
Calcium	1
Available phosphorous	0.62
Metabolizable energy (kcal/kg)	3.100

*NaPo Pre Starter Feed, Champrix Company, (Netherlands)

Table(2): Composition and calculated chemical analysis of the starter and finisher diets:

Ingredients	Starter	Finisher
Sorghum	65	72
Ground nut cake	27.3	19
Concentrate*	5	5
Vegetable oil	1.6	3.2
Dicalcium phosphate	1	0.6
Mycotoxin	0.1	0.2
Total	100	100
Calculated chemical analysis:		
Metabolizable energy	3073.659	3206.643
Crude protein	22	18.79
Crude fiber	6.3	5.8
Methionine	0.34	0.28
Lysine	1.2	0.96
Available phosphorus	0.43	0.37
Calcium	0.68	0.55

* Concentrate(starter): Contained: Crude protein 35%, Crude fat 2.8%, Crude fiber 4.8%, Calcium 6.8% available phosphorus 5%, Lysine 12%, Methionine 3.71% and Metabolizable energy 1897.77 kcal/kg

* Concentrate(finisher): Contained: Crude protein 35%, Crude fat 2.7%, Crude fiber 4.6%, Calcium 6.56% available phosphorus 5.14%, Lysine 10%, Methionine 3% and Metabolizable energy 1904.45 kcal/kg

3.5 Vaccination program:

One day old chicks were vaccinated against Infectious Bronchitis and Newcastle disease (IB -ND) by spray. On the 4th day, each chick was vaccinated against Newcastle disease (ND) by injection by the Veterinary Doctor. On day 11 chicks were revaccinated against Newcastle (ND) through drinking water and repeated on day 16 with Infectious Bronchitis (IB). On day 13 chicks were vaccinated against Infectious Bursa Disease (IBD) through drinking water and repeated on day 22. A multivitamin was added in the drinking water before and after each vaccination, while antibiotics were also given as prophylactic doses during the first week.

3.6 Broiler performance parameters:

3.6.1 Feed intake (FI):

Feed intake for the birds of each replicate was recorded daily by subtracting the amount of feed that remained from the amount of the offered feed for each replicate.

3.6.2 Bodyweight (BW) and body weight gain (BWG):

Bodyweight for the birds of each replicate was recorded weekly. Weight gain was calculated weekly by subtracting the bodyweight of the previous week from the present body weight.

3.6.3 Feed conversion ratio (FCR):

Feed conversion ratio (FCR) was calculated by dividing the amount of feed intake by body weight gain (g feed/g gain).

3.7 Carcass characteristics:

By the end of the experiment (42 days of age) two birds from each replicate were randomly selected and individually weighed, slaughtered according to the Islamic way, scalded and defeathered. Heads and shanks and the intestine were removed. The empty carcasses were weighed. The dressing percentage for each bird was calculated as a percentage of carcass weight over the live body weight. The organs abdominal fat, liver, heart, spleen, and gizzard these organs were isolated from the

viceroy and separately weighed for each bird. The abdominal fat was softly collected and weighted. The carcass cuts breast, leg and wing were weighed and calculated as percentage of live weight.

3.8 Statistical analysis:

In this experiment the complete randomized design (CRD) was used. The data was subjected to analysis of variance (one-way-ANOVA) and the means were tested for significance by least significant difference (LSD) using the Statistical Package of Social Science (SPSS) version 23.

Chapter four

4.0 Results

4.0 Effect of graded amounts of pre-starter diets on broiler performance:

4.1 Feed intake:

Table (3) shows the effect the provided amounts of pre starter diet on the feed intake of broiler chicks in different experimental weeks. Results show that, there is a significant difference ($p<0.01$) in feed intake between birds during week 1, 2 and 3. However, no significant differences ($p<0.01$) were found, when birds became older during the last weeks (week 4, 5 and 6). The group fed 25 g prestater showed the highest feed intake.in week 1. Feed intake was the highest by the group fed the control (100 g perstarter) and the lowest by group 5 that fed (0 prestarter) in week 2 and 3.

4.2 live body weight:

The effect of the pre- starter amount by week 1 of the feeding trials live body weight (LBW) of bird in (T2, and T3) were similar but significantly different ($p<0.01$) from the others. Birds on diets (T2, and T3) showed the best and birds on (T5) recorded the lowest live body weight.

During week 2, chickens on dietary treatment (T1, T2 and T3) recorded the highest (LBW) and they were significantly different ($p<0.01$) from those on diet (T4, and T5). Chickens in treatment (T5) had the least live body weight during the week-2 (Table 4).

Live body weight during week 3, chickens on diet (T1 and T2) recorded the highest (LBW) and those were significantly different ($p<0.01$) from the birds in diet (T3, T4, and T5) birds on (T5) recorded the lowest (LBW) during week-3.

By week 4, the live body weight (LBW) in the diet (T1, T2, T3, and T4) was highest and was significantly different ($p<0.01$) from the birds on (T5) which had the lowest live body weight. (Table 4).

During week 5, chickens on dietary treatment (T1, T3, and T4) were similar but were significantly different ($p<0.01$) from those on diet (T2, and T5). Birds on diet (T1, T3, and T4) recorded high (LBW) and those on diet (T5) had the lowest (LBW). Week 6 flowed the same direction of week 5.

4.3 Body weight gain:

During week body weight gains of chicks on (T2, and T3) were not significantly different ($p>0.05$) on the other hand, those on (T1, T4 and T5) were significantly different ($p<0.01$) from the chicks on diets (T2, and T3). The highest body weight gain recorded by the birds on diets (T2 and T3) while those on (T5) had the least body weight gain.

Mean body weight gain for week 2 showed a significant difference ($p>0.01$) between the control (T1) and other treatment groups. Chicks fed diet no per starter (T5) had the least body weight gain while treatment (T1) had the highest (Table 3).

During week3, body weight gains of chicks on (T1, T2, and T4) were not significantly different ($p>0.05$). The highest body weight gain recorded by the birds on diets (T1, T2 and T4) while those fed starter (T5) had the least body weight gain.

During week 5, dietary treatment (T1, T3 and T4) gave the best performance in body weight gain. Those on diets (T2, and T5) were significantly different ($p<0.01$) from birds on diets (T1, T3 and T4). Chickens on diet (T2) had the worst performance.

On week 4, and 6 there were no significant differences ($p<0.05$) noticed between all treatments (Table 5).

4.4 Feed conversion ratio (FCR):

During week 1, broiler chicks on dietary treatments (T1, T2, and T3) showed significant differences ($p<0.01$). Chickens on diets (T1, T2, and T3) had the best (FCR) compared to other groups.

In week 2, 3, 4, 5, and 6 There were no significant differences ($p<0.05$) in (FCR) across all the five dietary treatments. (Table 6).

4.5 The overall performance of chicks (1-6 week):

The initial live body weights of the 7-day old chicks were similar. The total feed intake (FI) showed that there was no significant difference ($p>0.05$) in the mean weight across the various treatments at the start of the trial (Table 7).

Final live body weight, chickens on dietary treatment (T1, and T4) were similar but were significantly different ($p<0.01$) from those on diet (T2, T3, and T5) birds on diet (T1 and T4) recorded high live body weight and those on diet (T5) had the lowest live body weight (Table 7).

The total body weight gains of birds on diets (T1, and T4) were similar while there were significant differences ($p<0.05$) between them and those chicks on diet (T2, T3, and T5) The highest body weight gain observed on chicks on diet (T1, and T4) while the lowest body weight gain was in chicks on diet (T5).

The final (FCR) showed there was no significant difference ($p>0.05$) in the mean weight across the various treatments at the start of the trial (Table 7). There was no significant difference ($p>0.05$) in mortality recorded during 6 weeks of this experiment across the various dietary treatments (Table 7).

4.6 Carcass characteristics and internal organs weights:

The results on (Table 8) was no significantly different in dressing percentage (hot or cold base) between all groups fed pre starter. (T1-T4) showed the group fed only starter diet (no pre starter T5) was significant lowest carcass %.

The results of spleen weight showed that chicks on diets (T4, and T5) were similar, there were significant differences ($p<0.01$) from birds on diets (T1, T2 and T3) chicks on (T4, and T5) had the highest spleen weight while chicks on diet (T1, T2, and T3) recorded the lowest.

Abdominal fat weight of chickens on dietary treatment (T1, T4 and T5) was the highest and was significantly different ($p<0.05$) from those on diet (T2, and T3), birds on diet (T2) had the lowest abdominal fat weight (Table 8).

The results of liver%, gizzard%, heart%, leg %, wing%, total breast%, showed that there were no significant differences ($p<0.05$) among all treatment groups of this experiment.

Table (3): The effect of graded amounts of pre-starter diets on weekly broiler Feed Intake:

Treatment / Week	(T1) m±sd	(T2) m±sd	(T3) m±sd	(T4) m±sd	(T5) m±sd	sig
Week 1	1OO.00±00^{d}	104.33±1.13^{c}	109.68±1.54^{b}	118.53±2.05^{a}	97.83±3.38^{d}	**
Week 2	332.04±4.11^{a}	307.23±3.04^{b}	303.55±12.35^{b}	289.46±4.90^{c}	253.70±7.41^{d}	**
Week 3	584.42±24.39^{a}	576.84±11.89^{a}	544.44±15.88^{b}	545.88±5.20^{b}	485.92±3.07^{c}	**
Week 4	581.96±20.17	580.67±48.09	589.62±37.97	588.22±63.47	521.77±42.38	**NS**
Week 5	840.57±54.60	800.02±48.47	802.60±64.36	847.60±60.00	781.87±42.84	**NS**
Week 6	843.64±71.09	852.93±86.50	855.09±18.21	895.26±41.01	873.38±37.04	**NS**

NS: no significant different at ($p>0.05$)
**: significant different at ($p\leq0.01$)
*: significant different at ($p\leq0.05$)
a,b,c : mean within the same row followed by different superscripts are significantly ($p<0.05$) different

Table (4): The effect of graded amounts of pre-starter diets on weekly broiler live body weight:

Treatment / week	(T1) m±sd	(T2) m±sd	(T3) m±sd	(T4) m±sd	(T5) m±sd	sig
Week 1	126.75±1.95^{bc}	134.40±5.26^{a}	133.46±4.54^{ab}	122.62±3.67^{c}	112.66±3.49^{d}	**
Week 2	376.84±1.82^{a}	361.51±5.34^{a}	362.97±14.97^{a}	337.91±5.41^{b}	305.50±12.44^{c}	**
Week 3	737.88±9.70^{a}	723.15±8.43^{ab}	701.95±7.08^{b}	690.31±26.41^{c}	614.02±3.30^{d}	**
Week 4	1106.37±23.65^{a}	1059.92±24.76^{a}	1049.58±48.65^{a}	1067.57±42.58^{a}	937.78±50.03^{b}	**
Week 5	1701.00±70.00^{a}	1502.29±39.05^{bc}	1600.36±96.07^{ab}	1605.77±74.31^{ab}	1428.94±64.64^{c}	**
Week 6	2134.19±53.28^{a}	1944.37±20.28^{b}	2039.95±77.19^{ab}	2048.43±41.12^{a}	1848.07±55.32^{c}	**

**: significant different at ($p \leq 0.01$)

*: significant different at ($p \leq 0.05$)

a,b,c : mean within the same row followed by different superscripts are significantly ($p<0.05$) different

Table (5): The effect of graded amounts of pre-starter diets on weekly broiler weight gain:

Treatment / Week	(T1) m±sd	(T2) m±sd	(T3) m±sd	(T4) m±sd	(T5) m±sd	sig
Week 1	88.71±1.89^{bc}	96.35±5.26^{a}	95.42±4.49^{ab}	84.62±3.67^{c}	74.54±3.49^{d}	**
Week 2	250.08±1.42^{a}	227.11±0.20^{b}	229.51±10.49^{b}	215.28±1.74^{c}	192.84±9.20^{d}	**
Week 3	361.04±8.00^{ab}	361.64±3.55^{a}	338.97±7.97^{b}	352.40±21.11^{ab}	308.51±13.64^{c}	**
Week 4	368.48±13.97	336.77±30.43	347.62±42.43	377.26±65.82	323.76±50.98	NS
Week 5	594.63±93.63^{a}	442.37±16.33^{c}	550.77±49.34^{ab}	538.20±36.87^{ab}	491.15±24.78^{bc}	*
Week 6	433.18±26.33	442.07±18.79	439.59±26.13	442.65±42.82	419.12±63.49	NS

NS: no significant different at ($p>0.05$)
**: significant different at ($p\leq0.01$)
*: significant different at ($p\leq0.05$)
a,b,c : mean within the same row followed by different superscripts are significantly ($p<0.05$) different

Table (6): The effect of graded amounts of pre-starter diets on weekly broiler Feed Conversion Ratio (FCR):

Treatment / Week	(T1) m±sd	(T2) m±sd	(T3) m±sd	(T4) m±sd	(T5) m±sd	sig
Week 1	1.12±0.02^{b}	1.08±0.07^{b}	1.15±0.05^{b}	1.40±0.07^{a}	1.31±0.05^{a}	**
Week 2	1.32±0.00	1.35±0.01	1.32±0.02	1.34±0.01	1.32±0.01	NS
Week 3	1.61±0.03	1.59±0.04	1.60±0.08	1.55±0.09	1.57±0.06	NS
Week 4	1.57±0.00	1.72±0.03	1.70±0.10	1.57±0.09	1.62±0.15	NS
Week 5	1.44±0.32	1.80±0.07	1.45±0.07	1.57±0.03	1.59±0.13	NS
Week 6	1.94±0.11	1.93±0.19	1.95±0.13	2.03±0.28	2.10±0.26	NS

NS: no significant different at ($p>0.05$)
**: significant different at ($p\leq0.01$)
a,b,c : mean within the same row followed by different superscripts are significantly ($p<0.05$) different

Table (7): The effect of graded amounts of pre-starter diets on overall broiler chick performance:

Treatment / Parameters	(T1) m±sd	(T2) m±sd	(T3) m±sd	(T4) m±sd	(T5) m±sd	Sig
Initial weight(g)	38.18±0.02	38.04±0.08	38.04±0.08	38.00±0.00	38.22±0.15	NS
Live body weight (g)	2134.19 ± 53.29^{a}	1944.37 ± 20.28^{c}	2039.95 ± 77.19^{b}	2048.43 ± 41.12^{ab}	1826.79 ± 36.86^{d}	**
Feed intake (g/bird)	3282.65±136.70	3232.73±138.34	3210.39±125.25	3285.02±156.78	3034.85±101.01	NS
Weight gain (g)	2096.01 ± 53.17^{a}	1906.33 ± 20.31^{c}	2001.91 ± 77.17^{b}	2010.43 ± 41.12^{ab}	1788.57 ± 36.74^{d}	**
Feed conversion ratio (g FI/ g WG)	1.57±0.09	1.70±0.06	1.60±0.00	1.63±0.05	1.70±0.02	NS
Mortality %	13.33±6.67	13.33±11.55	6.67±0.00	13.33±6.67	15.57±3.85	NS

NS: no significant different at ($p>0.05$)
**: significant different at ($p\leq0.01$)
a,b,c : mean within the same row followed by different superscripts are significantly ($p<0.05$) different

Table (8): The effect of graded amounts of pre-starter diets on broiler chicks' carcass characteristics and internal organs weights

Treatment / Parameters	(T1) m±sd	(T2) m±sd	(T3) m±sd	(T4) m±sd	(T5) m±sd	Sig
Hot dressing %	74.31±1.71^{a}	75.02±1.55^{a}	74.41±1.77^{a}	74.10±1.93^{a}	71.46±1.08^{b}	**
Cold dressing %	74.71±1.86^{a}	75.42±1.47^{a}	74.97±1.77^{a}	74.57±1.96^{a}	71.82±1.10^{b}	**
Gizzard %	2.53±0.19	2.44±0.19	2.45±0.09	2.45±0.13	2.53±0.28	NS
Liver %	2.23±0.12	2.28±0.24	2.23±0.09	2.23±0.08	2.30±0.08	NS
Spleen %	0.57±0.03^{c}	0.58±0.03^{bc}	0.57±0.04^{c}	0.63±0.05^{ab}	0.64±0.02^{a}	**
Heart %	0.67±0.03	0.69±0.07	0.73±0.04	0.74±0.05	0.70±0.08	NS
Abdominal fats %	0.73±0.02^{a}	0.64±0.03^{b}	0.65±0.03^{b}	0.69±0.03^{ab}	0.68±0.07^{ab}	*
Leg %	29.12±3.28	26.83±1.10	26.78±1.61	26.12±2.12	28.45±1.50	NS
Wing %	11.09±1.21	10.00±0.50	10.16±0.62	9.76±0.65	10.67±0.29	NS
Breast %	30.94±2.56	29.32±1.66	29.50±1.35	28.62±2.20	31.71±1.76	NS

NS: no significant different at ($p>0.05$)
**: significant different at ($p\leq0.01$)
*: significant different at ($p\leq0.05$)
a,b,c : mean within the same row followed by different superscripts are significantly ($p<0.05$) different

Chapter five

5.0 DISCUSSION

The results of the present study showed a highly significant difference ($P<0.01$) between means of live body weight (g/bird), weight gain (g/bird), and carcass yield (%) for birds fed the different graded levels of pre-starter diets.

The results of live body weight in this study was highly significant ($P<0.01$), This result agrees with those of Biclar and Rezaei (2007) they reported that there were significant differences ($p<0.05$) between birds fed pre-starter diet during three periods (4, 7, and 14 days), while disagree with those of Mohammad (2006) and Reza Mahdavi et al., (2017), whom noticed that there were no significant differences ($p>0.05$) among birds fed pre-starter diet during four periods (4, 6, 8, and 10 days). The birds fed (100g) of pre-starter in this study recorded the highest live body weight, while the birds fed directly starter diet after hatching (0g pre-starter) recorded the lowest live body Wight. This finding is in line with those of Saki (2005) and Deaton (1995) who reported that there was a depression of the live bodyweight of the birds fed starter diet immediately after hatching. The live body weight tends to increase with the pre-starter fed by the birds, this might be due to that the pre-starter diets contain great value, highly digestible ingredients and high concentration of nutrients, (Garcia et al., 2006), that may improve live body weight. The good feeding in pre-starter phase has benefit that would carry forward in the subsequent starter, grower and finisher phases, (Rutz *et al*., 2007).

The results of the feed intake of broilers fed the different amounts of pre-starter diets were not significantly affected. This result agrees with those reported by Mohammad (2006).

The results of body weight gains in this study flows in the same direction of the live body weight. The body weight gains increased by increasing the amount of pre-starter diet fed. This result is an agreement with Biclar and Rezaei (2007) who reported that there were significant differences ($p<0.05$) in body weight gain between the birds fed pre-starter diet during three periods (4, 7, and 14 days). The positive effect of feeding high amount of pre-starter diet on body weight gain might be due to its highly digestive ingredient content and its highly nutritive value that permit the young birds to get their requirement and that may have a great impact on their performance and body weight gain Buyse et al., (1992); Swennen et al., (2007)
The result of the feed conversion ratio of broilers fed the different amounts of pre-starter diets showed no significant difference ($p>0.05$). This result agrees with those reported by Mohammad (2006).

The result of dressing % of the broilers fed by the different amounts of pre-starter diets showed a highly significant difference ($P<0.01$). The results of this study showed that the birds fed (100g, 75g, 50, and 25g) of pre-starter diet recorded the best in carcass yield (%), while the birds fed directly starter diet after hatching (0g pre-starter) recorded the worst. The aim of feeding a pre-starter diet is therefore to provide more digestible ingredients and a higher concentration of nutrients, (Garcia et al., 2006) that improve and increase carcass weight. The parts of the carcass (%) of the broilers fed the different amounts of pre-starter diets (100g, 75g, 50g, 25g, and 0g) showed no significant differences ($p>0.05$).

The results showed there was no significant difference ($p>0.05$) on broiler organs weight (%) except spleen which showed a higher significant different ($p<0.01$). The high spleen weight was observed on diet (0g) while the lowest spleen weight recorded on diets (100g and 50g) a non-reason. The abdominal fat weight was significantly ($p<0.05$) increased on birds fed the diets (100g, 25g, and 0g) and decreased on the birds fed the diets (75g and 50g). These results agreed with the

findings of Samapika et al., (2017), Reid and White, (1978) and Hargis and Cregar, (1980).

Chapter six

6.0 Conclusions and Recommendations

6.1 Conclusions:

Since the overall goal of current study was to determine the effect of amount of pre-starter diets during the first week of age on broiler performance and carcass traits. Information of this study strongly confirms the beneficial effect of the pre-starter diet especially on body weight of broiler chicks during their growing phases.

6.2 Recommendations

- More economic and technical studies to reduce cost and increase profitability using modern production and feeding techniques.
- Usage inexpensive material of feed staff to formulation of pre-starter diets to make more nutrient available for young birds.

Reference:

Akiba, Y., and H. Murakami (1995) Partitioning of energy and protein during early growth of broiler chicks and contribution of vitteline residues. Pages 46–52 in Proc. World Poult. Sci. Conf., Antalia, Turkey. World's Poult. Sci. Assoc., Wallingford, Oxfordshire, UK.

Biclar. N, Rezaei. M 2007, Effect of Feeding Periods and Sodium Levels of Pre-starter Diet on Broiler Performance and Serum Electrolytes, Joumal of Animal and Veterinary Advances 6 (8): 959-963, 2007 ISSN: 1680 5593.

Bigot K, Mignon GS, Picard M, Tesseraud S. (2003) Effects of delayed feed intake on body, intestine and muscle development in neonate broilers. Poult. Sci. 82:781–788.

Buyse, J., Decuypere, E., Berghman, L., Kuhn, E.R. & Vandesande, F. (1992) "Effect of dietary protein content on episodic growth hormone secretion and on heat production of male broiler chickens", British poultry science, vol. 33, no. 5, pp. 1101-1109.

Chamber of Poultry (2018) Union of Chamber of Agricultural and Animal Production, in Khartoum–Sudan.

De Oliveira, J. E., Z. Uni, and P. R. Ferket. (2008) Important metabolic pathways in poultry embryos prior to hatch. World's Poult. Sci. J. 64:488-499.

Deaton, J. W., (1995). The effect of early feed restriction on broiler performance. Poult. Sci., 74: 1280-1286.

Ebling, P.D., A.M. Kessler, A.P. Villanueva, G.C. Pontalti, G. Farina and A.M.L. Ribeiro, (2015) Rice and soy protein isolate in pre-starter diets for broilers. Poult. Sci., 94: 2744-2752.

Elamin, A.A, Omer, M.I. and H.A. Wagge Alla (2008) Poultry Industry in Sudan and prospects for Future Development. The proceeding of the first scientific conference, Animal Production Research Center (APRC). Sudan.

Ferket, P., (2015) Nutrient requirements of poultry: Nutrition and health feedstuffs. Reference Issue and Buyers Guide No. 87, Sarah Muirhead, Bloomington, MN.

Food and Agriculture Organization of the United Nations (FAO) investment center, (2010) Agribusiness hand book (poultry meat& egg), Vial delle Terme dicaracalla, 00153 Rome, Italy

Garcia, A.R., Batal, A.B. & Dale, N.M. 2006, "Biological Availability of Phosphorus Sources in Prestarter and Starter Diets for Broiler Chicks", The Journal of Applied Poultry Research, vol. 15, no. 4, pp. 518-524.

Green, J., T. Kellogg, R. Keirs, and R. Cooper. (1987) Determination of bile acid pool size, turnover time, and distribution of male broiler chicks during the first: 6 weeks posthatch using sehcat, a gamma ray-emitting bile acid analogue. Poult. Sci. 66:1853-1858.

Hargis P.H. and Creger, C.R. (1980). Effects of varying dietary protein and energy levels on growth rate and body fat in broilers. Poult. Sci., 59:1499–1504.

Havenstein GB, Ferket PR, Qureshi MA. (2003) Growth, liveability and feed conversion of 1957 versus 2001 broilers when fed representative 1957 and 2001 broiler diets. Poult Sci. 82:1500–1508.

Joseph, N.S. and Moran, J.R.E.T. (2005) Effect of flock age and postemergent holding in the hatcher on broiler live performance and further-processing yield, J. Appl. Poult. Res., vol. 14, pp. 512–520.

Koedijk R.M., van de Linde I.B., Lamot D.M., Hilbert M., and H. Enting (2016) The effect of hatch moment and moment of feed access after hatch on broiler development. magazine of the Animal Feed Manufacturers Association of South Africa. Pages 50-52.

Laura L. Farrelly. (1996) Economics of Poultry Industry. Department of Agriculture and the Department of Economics, Michigan State University (MSU).

Leeson S (2008) Predictions for commercial poultry nutrition. Journal of Applied Poultry Research 17, 315–322.

Leeson S (2012) Future considerations in poultry nutrition. Poultry Science 91, 1281–1285.

Leeson, S. & Zubair, A.K. (2004) "Digestion in poultry I: proteins and fats", Department of animal and Poultry Science, University of Guelph.Guelph, Ontario, Canadá.

Lemot D (2017) First week nutrition for broiler chickens Effects on growth, etabolic status, organ development, and carcass composition. PhD Thesis (where)

Lilburn M (1998) Practical aspects of early nutrition for poultry. Journal of Applied Poultry Research 7, 420–424.

Mahmood, S., Hossien, J., Saman, L., Mortaza, D. Torkamani, A.G. (2012) Evaluation of protein quality in hydrolyzed protein meals by biological assay

methods in broiler chickens, International Journal of Agriculture: Research and Review. 2 (4): 352- 356.

Mohammad Hooshmand., 2006. Effect of Early Feeding Programs on Broiler Performance, International Journal of Poultry Science 5 (12): 1140-1143, 2006 ISSN 1682-8356.

Nobakht, A., (2001) Primary nutrition of broiler, Poult. Jahan , vol.17, 18, p: 25-45.

Noy Y, Sklan D (1995) Digestion and absorption in the young chick. Poultry Science 74, 366–373.

Noy Y, Sklan D. (1998) Yolk utilization in the newly hatched poult. Br. Poult. Sci. 39:446–451.

Noy, Y., and D. Sklan. (1997) Posthatch development in poultry. J. Appl. Poult. Res. 6:344–354.

Paul, B.K, S.C. Das, M.R. Budhy, K.M. Amin, R. Amin and S.C. Banik (2004) Effect of existing and imposed vaccination against Gambaro on body weight in broiler under farm condition. Int. J. Poult Sci., 3:655-657.

Pezeshkian, S., (2002) Utilization of standard-prestarter feed formulation flour corn, calcium propionate in primary nutrition of chicken. Jahan Poult, 9:13-15.

Regmi, A. (Ed). (2001) Changing Structure of Global Food Consumption and Trade [Online]. Washington DC [USA]. Economic Research Service/USDA. pp103-107.

Reid J.T. and White, O.D. (1978). Tests show energy, protein, amino acids as fat factors. Feedstuffs., 16: 16.

Reza Mahdavia, O. A. Karlovicha, and V. I. Ficininb 2017, Effects of Supplying Time of Prestarter on Subsequent Broiler Performance, Carcass Yield and Intestinal Morphometry1, Russian Agricultural Sciences, Vol. 43, No. 4, pp. 326–331.

Rutz, F., Xavier, E.G., Anciuti, M.A., Roll, V.F.B., Rossi, P., Lyons, T.P., Jacques, K.A. & Hower, J.M. 2007, "The role of nucleotides in improving broiler pre-starter diets: The Brazilian experience." Book chapter; Conference paper, Nutritional biotechnology in the feed and food industries: Proceedings of Alltech's 23rd Annual Symposium. The new energy crisis: food, feed or fuel? 2007 pp. 175-181.

Saki, A.A. 2005, "Effect of post-hatch feeding on broiler performance", International Journal of Poultry Science, vol. 4, no. 1, pp. 4-6.

Salih, G.E. (2002) Development, Communication and Implementation of Poultry Farming Technologies in the Gezira State, Ph.D. Thesis, University of Gezira, Sudan.

Samapika Mahapatra*, G. Srinivasan, Asha R. Rajini and A. Mangala Gowri 2017. Effect of early post-hatch nutrition on production performance of commercial broiler chicken, Indian J. Anim. Res., 51 (2) 2017 : 291-295.

Skinner, D. O., noble, Berry J.G and Teeter R.G. (2001) Use of a single diet feeding program for female broilers. Animal Science Research Report. 47 46.

Sklan, D. (2001) Development of the digestive tract of poultry. World's Poult. Sci. J. 57:425- 428.

Suad. (1998) Critical Studies of Thesis's on Poultry Science in Universities from 1973 to 1997. M.Sc. Thesis. Faculty of Agriculture. University of Khartoum.

Swennen Q, Everaert N, Debonne M, Verbaeys I, Careghi C, Tona K, Janssens GPJ, Decuypere E, Bruggeman V, Buyse J. (2009). Effect of macronutrient ratio of the pre-starter diet on broiler performance and intermediary metabolism. J Anim Physiol Anim Nutr. 94:375–384.

Swennen, Q., Decuypere, E. & Buyse, J. (2007) "Implications of dietary macronutrients for growth and metabolism in broiler chickens", World's poultry science journal, vol. 63, No. 04, pp. 541-556.

Uni Z, Tako E, Gal-Garber O, Sklan D. (2003) Morphological, molecular, and functional changes in the chicken small intestine of the late-term embryo. Poultry Sci. 82:1747–1754.

Waldroup, P.W., Jiang, Q. and Fritts, C.A. (2005) Effects of supplementing broiler diets low in crude protein with essential and nonessential amino acids. International Journal of Poultry Science, 4 (6): 425-431.

Willemsen H, Everaert N, Witters A, De Smit L, Debonne M, Verschuere F, Garain P, Berckmans D, Decuypere E, Bruggeman V (2008) Critical assessment of chick quality measurements as an indicator of posthatch performance. Poultry Science 87, 2358–2366.

Willemsen H, Debonne M, Swennen Q, Everaert N, Careghi C, Han H, Bruggeman V, Tona K, Decuypere E (2010) Delay in feed access and spread of hatch: importance of early nutrition. World's Poultry Science Journal 66, 177–188.

Yadgary, L., A. Cahaner, O. Kedar, and Z. Uni. (2010) Yolk sac nutrient composition and fat uptake in late-term embryos in eggs from young and old broiler breeder hens. Poult. Sci. 89:2441-2452.