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The Effects Of Different Amino Acid Concentrations, With Or Without Chromium Supplementation, On The Performance And Yield Of Commercial Broiler Chickens Fed Two Different Feeding Programs.

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By

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Abstract

The objective of this study was to evaluate performance parameters and meat yield of commercial broiler chickens fed diets with different amino acid concentrations, with or without chromium supplementation, and delivered through two different feeding programs over 54 days. The experimental study was completed as a randomized-block design with 4,800, Ross 708 X Ross 708 commercial broiler chickens, picked at random, and evenly divided into six treatment groups (800 birds per group). Treatments 1 and 4 where placed under feeding program (FP1). Treatments 2, 3, 5, and 6 where placed under a different feeding program (FP2). Three different feed formulations were used, treatments 1 and 4 received formulation (A), treatments 2 and 5 received formulation (B), and treatments 3 and 6 received formulation (C). The treatments 1, 2, and 3 did not receive chromium (NC), while treatments 4, 5, and 6 did receive chromium (C). These birds were reared in 96, 5’X10’ (50 ft^2) floor pens, at a stocking density of 1.00 ft^2/bird (50 birds per pen). Throughout the duration of the trial bird performance was measured. Average body weight, feed conversion ratio, feed consumed, and percent mortality was collected at the change of each feed phase. From the results of this study there was no significant effect on broiler performance from the supplementation of chromium, feed formulation, and feeding program. Although, the results on Table 14 from the yield study shows that treatment 2 was significantly different from treatments 1, 3, and 4 in front half carcass weight, however, was not significantly different from treatments 5 and 6. Table 14 results also show treatment 2 having significant differences from treatments 1 and 4 in

breast meat yield, however was not significantly different from treatments 3, 5, and 6. However, there is a possibility that these areas of significance in the yield study could be false positives found in the data of this single trial. Additional studies should be conducted to further the assumption if there is an actual significant difference between the treatments.

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CHAPTER I

Introduction

Increased consumer demand for poultry meat over several decades has consequently increased the production of broiler chickens. Broiler production has well exceeded those of swine and cattle, projecting to produce approximately forty billion pounds of poultry meat (Westcott, 2010). Based on this high demand, the poultry industry is consistently trying to achieve the goal of producing the maximum amount of meat yield from broilers, for the least amount of cost. When analyzing the costs of production for broiler chickens, the main input of expenses is feed, being around 70% of all production costs (Willems, et al., 2013). Broiler nutrition is an important concern in regard to the high costs of production. For instance, broilers have nutritional requirements that must be fulfilled in order to efficiently put on flesh. The industries nutritionists are attempting to meet those nutrient requirements at the lowest cost. That can vary based on the available commodities for feed production and also the different nutritional requirements of broiler strains that are being produced. Additionally, feed additives have been used for improving bird growth and the utilization of feed, resulting in an increase on production return (Peric, et al., 2009). As consumers continue to increase in demand the poultry industry must continue to find ways to strategically increase production, broiler nutrition being of emphasis. During this study we evaluated the influence of different feed formulations at varied amino acid concentrations with and without the addition of chromium under two different feeding programs on performance and yield.

Research Objective

The objective for this study was to evaluate performance parameters and meat yield of commercial broiler chickens fed diets with different amino acid concentrations, with or without chromium supplementation, and delivered through two different feeding programs over 56 days. Performance parameters were evaluated by comparing average body weights of all six treatments per pen. Data collection included the calculation of feed conversion ratio (FCR), feed consumption, and mortality. At the conclusion of the rearing period a yield study was conducted to determine the collection of meat yield, based on the retail cuts of meat from the front and lower halves of the bird's carcass including other elements of the carcass. This study attempted to identify the significance of amino acid concentration, the addition of chromium in the diet, and feeding programs administered to the bird.

CHAPTER II

Literature Review

Broiler Nutrition

Through technological advancements and scientific research, broiler nutrition has greatly improved over decades of production. Beginning with determining the nutritional needs of the bird. There are six basic nutrients in the bird's diet, those nutrients being: carbohydrates, fats, proteins, vitamins, minerals, and water. (Coon, 2001) These nutrients are key components in the formulating of the bird's diet. When nutritionists are formulating a diet, their goal is to create a "balanced" or "complete" diet meaning that every nutritive requirement has been met. The lack of meeting these requirements results in poor growth performance and low meat yield (Griffin & Goddard, 1994).

Over the past 80 years the industry has made many changes in nutrition, including those of amino acid levels. There was a lower amount of lysine and methionine in the diets of broiler chickens in previous years. Amino acid levels aren't the only change from previous years. Mash was the only form of feed as compared to present day feed forms such as crumbles and pellets (Havenstein, et al., 2003). The justification of applying the practice of pelletizing the feed is converting smaller particles of feed into a larger particles, a pellet, which can enhance the intake of feed by allowing a more palatable form for the bird, as well as increasing the economic impact of the production of feed (Abdollahi, et al., 2013). This area of research has been performed to improve the efficiency of production in the poultry industry. Innovation and advancements in technology has allowed us to make adjustments to areas in broiler production that before were not possible.

Amino Acids

Out of the twenty-two total amino acids all but ten are able to be naturally synthesized by the bird. These ten amino acids are classified as “essential amino acids.” Out of these ten essential amino acids, only five have been considered to be critical. These five are methionine, cystine, lysine, tryptophan, and arginine (North & Bell, 1990). Essential amino acids need to be added into the diet at an adequate level in order for the bird to utilize them (Leeson & Summers, Nutrition of the Chicken, 2001). From previous formulations of diets methionine has been deemed to be the most lacking essential amino acid, reason being the level of vegetable protein being used in the diet, such as soybean meal, is deficient in having a high amount of methionine. Other major ingredients like corn also have a deficiency in amino acids, such as lysine. During formulation of a diet the value of the protein percentage within the diet is determined by the limiting amino acid (North & Bell, 1990). Nutritionists in the poultry industry must use this information and apply it to the ingredient commodities that are available. For instance, if there isn’t a high percentage of amino acids within standard ingredients an alternative synthetic form is used. A study conducted by Sibbald & Wolynetz (1985), examined a comparison between using synthetic lysine (L-lysine HCl) and conventional feed ingredients. Their results conveyed that cockerels that were used had metabolized 93% of the bioavailability in the synthetic lysine as compared to 88% of lysine in its natural form. Research has shown that applying certain levels of essential amino acids properly balance the bird's diet. This can be reflected by significant effect on feed intake, that influences the bird's carcass composition and weight gain (Summers et. al., 1992). From this study the industry can formulate their diets that meet the needs of the bird, promote carcass composition, and also have a beneficial component in weight gain.

The bird's ability to digest and metabolize amino acids and other ingredients are essential to the production and performance of the bird. The classification of digestion refers to the changes that occur in the alimentary canal that makes it possible for feed to be absorbed through the intestinal wall and enter the bloodstream. Whereas metabolism is defined by the chemical changes in feed components that occurs during digestion and nutrient absorption (North & Bell, 1990). The difference between these two terms is critical when using certain ingredients, because one ingredient might be digestible but lacking in being able to be properly metabolized.

Further understanding the digestion of proteins and amino acids in the bird, can be aided through its anatomy. Once feed is consumed by the bird there is no digestion of protein in the mouth or crop. It is when the feed has entered the proventriculus that protein digestion begins. The proventriculus is the organ before the ventriculus or gizzard and is known as the "glandular or true stomach". The proventriculus secretes hydrochloric acid and the enzyme pepsinogen. As the pH level in the proventriculus decreases pepsinogen then becomes the active enzyme known as pepsin. This secretion of fluids was possible by the reflex stimulation of the vagus nerves from the gastric mucosa, where gastric fluids are secreted into the proventriculus. It is important to note that proteins have to be broken down, through digestion, to become an amino acid. This makes it possible for it to enter the intestinal wall (North & Bell, 1990). Amino acids are the so-called "building blocks" in the broiler's body that influences the growth of muscle, bone, and connective tissues. These protein derivatives constitute the bird's ability to have a high yield in muscle content.

According to Hickling, Guenter, and Jackson (1990), a study was conducted to test the effects of increasing supplemental methionine and lysine in the broiler's diet. Their results showed that there was an increase in weight gain, feed efficiency, and breast meat yield with increased supplementation of methionine. Increased lysine supplementation only conveyed an increased breast meat yield. This can be of economic importance to the producer to see the benefits of having these amino acids in the diet.

Since feed costs accounts for the majority of expenses in broiler production. The costs a major ingredient such as corn and soybean meal, that consists of amino acids like lysine and methionine, has increased substantially in recent years. This has forced some producers to lower concentrations of amino acids in the diet in order to lower feed costs. Although, it might consequently increase feed conversion and lower breast meat yield that results in profit loss (Zhai, et al., 2016). However, increased amino acid concentrations in the diet have shown to have an effect in enhancing live performance and meat yield, but it might not always be cost effective (Zhai, et al., 2013).

Chromium

The application of chromium into the bird's diet is being tested to see if it has any beneficial effects on the bird's performance and meat yield. Nutritionally, chromium has been considered to be an essential mineral element for animals (NRC, 1980). Chromium has also been determined to enhance amino acid uptake (Steele & Rosebrough, 1979). A study was conclusive that trivalent chromium being added, from days seven to twenty-one, to a corn-soybean meal diet at 20 ppm significantly improved the growth rate in turkey poults.

The function of chromium is to optimize the activation of insulin receptors, by binding with circulating insulin within the bloodstream. The chromium molecules bind with the insulin recpetors allowing for an eight-fold insulin receptor activational difference. The benefit from this reaction is the glucose transporter activation is enhanced allowing for a greater amount of glucose to enter the cell. Chromium has also been test on its possible influences on blood gluvose levels of the bird. While the concentration of blood glucose is much higher in birds while exhibiting a lower insulin levels and reduced sensitivity to insulin. Although, it was concluded that with the supplementation of chromium proprionate insulin sensitivity was enhanced in broilers, but no other performance characteristics were noted (Brooks, et al., 2016). Other studies conducted on the influence of chromium propionate has identified an increase in breast meat yield with the supplementation of chromium propionate at an increased dosage (Rajalekshmi, et al., 2014). Although, no significance found in weight gain, feed consumption, and feed conversion. A study on the effects of chromium-histidinate supplementation on broilers during heat stress conditions has been proven to have a beneifcial effect on the feed conversion (Sahin, et al., 2017). This is conveys that chromium takes the role of regulation of metabolism under chronic heat stress conditions. Where chromium improves the insulin sensitivity to improve the metabolism of carbohydrates, proteins, and lipids by decreasing the uptake of glucose for lipogenesis in the liver. Resulting in a decrease of heat generation from high cellular energy glucose during metabolization.

Strategic Feeding Programs

Various feeding strategies have been used in the poultry industry to aid in production performance and meat yield. Since today's broiler chickens are growing at such a rapid pace they receive both a high protein and high energy level diet. Intaking a higher protein diet at the beginning of production and then receiving a reduced protein diet with higher energy levels as growth continues. The reasoning for this can be displayed through an economical standpoint. Feed costs tend to be more expensive when containing a higher protein percentage, therefore the broiler producers change over to a different feeding phase (Saleh, et al., 1996). These feeding phases include starter, grower, and finisher/withdrawal diets. For this experimental study, the diets will have two different feeding programs within the feeding phases. Where one feeding program will receive two pounds of starter compared to the other only receiving one pound. The diets only receiving one pound of starter will be intaking approximately one pound more of grower and the two withdrawal phases.

Feeding programs previously researched saw the effects in the variation between energy and protein concentrations when manipulating the feeding program. When analyzing the effects of increaseing the energy and amino acid concentration that birds conveyed and increase in overall performance. However, when only increasing the amino acid concentration carcass yield and abdominal fat content was reduced (Basurco, et al., 2015). In addition, feeding programs can also have an effect on the immune response. When broilers are under feed restriction they will consequently undergo a lower growth rate, although it will improve the IgY anti-BSA reponse. In comparison to broilers who were provided feed *ab libitum* both of these broiler groups on day 42 had no significant difference in weights. Using feeding programs like this can provide information that can be applied to economic costs and returns.

CHAPTER III

Materials and Methods

Animals and Housing

This study began on August 30th, 2019 and was completed on September 23rd, 2019. This study was conducted using 4,800 one day old, male Ross 708 X Ross 708 commercial broiler chickens, sourced from a local hatchery in Nacogdoches, Texas. Prior to placement the birds were divided into six treatment groups in a randomized-block design at the SFASU Poultry Research Center (See Table l.). Birds were randomly divided amongst the pens at a stocking density of 1.00 ft^2/bird (50 birds/pen). Birds will be reared for a 54-day growth period on used built-up litter (pine shavings). Water was provided at *ad libitum* throughout the study via Lubing FeatherSoft® nipple drinkers at a ratio of 5 birds per 1 water nipple. Feed was provided at *ad libitum* throughout the study via two Chore-time hanging tube feeders. The 4,800 broilers were housed in a tunnel-ventilated facility, with ventilation and heat provided and adjusted to maintain bird comfort based on bird age. The house is divided into two identical sides with 48 pens to each side. The pens were then split up amongst sixteen different blocks where each block contained one pen for each of the six treatment groups. The experimental reasoning for this arrangement as to minimize the environmental variation from the bird's location in the house.

Table 1. Randomized Block Design with Treatment (TX) Assignments

PEN	TX	Block	TX	PEN
1	1	1	5	48
2	4		2	47
3	3		6	46
4	2	2	4	45
5	5		3	44
6	6		1	43
7	3	3	6	42
8	2		4	41
9	1		5	40
10	3	4	5	39
11	6		2	38
12	1		4	37
13	5	5	3	36
14	4		1	35
15	2		6	34
16	1	6	2	33
17	5		4	32
18	6		3	31
19	2	7	6	30
20	3		4	29
21	5		1	28
22	4	8	3	27
23	5		1	26
24	6		2	25

PEN	TX	Block	TX	PEN
49	2	9	6	96
50	1		5	95
51	3		4	94
52	1	10	5	93
53	4		3	92
54	6		2	91
55	3	11	6	90
56	4		5	89
57	2		1	88
58	6	12	2	87
59	1		4	86
60	3		5	85
61	4	13	1	84
62	2		6	83
63	5		3	82
64	5	14	1	81
65	4		2	80
66	6		3	79
67	1	15	6	78
68	3		5	77
69	4		2	76
70	6	16	3	75
71	2		4	74
72	5		1	73

Notes: Pens highlighted in light blue will have different feeding program and weigh days compared to pens highlighted in pink.

Experimental Treatment and Groups

This experimental study was comprised of six different treatment groups (800 birds with 16 replications/TX). The treatments were manipulated by three various feed formulations, with or without the inclusion of KemTRACE Chromium, and two different feeding programs (See Table 2.).

Treatments 1 & 4:

The starter diet was given *ab libitum* at 1 pound of feed per bird for 14 days. (See Table 2.) The grower diet was delivered *ab libitum* at 4 pounds of feed per bird from day 15 to day 30. The withdrawal I diet (WD1) was given *ab libitium* at 7 pounds of feed per bird from day 31 to day 46. The withdrawal II diet (WD2) was given *ab libitum* at 5.65 pounds of feed per bird from day 47 to day 54, the end of the trial.

Treatments 2, 3, 5, & 6:

The starter diet was delivered *ab libitum* at 2.1 pounds of feed per bird for 20 days. (See Table 2.) The grower diet was fed *ab libitum* at a rate of 5 pounds of feed per bird from day 21 to day 35. The withdrawal I diet (WD1) was given *ab libitium* at 6.35 pounds of feed per bird from day 36 to day 49. Withdrawal II diet (WD2) was fed *ab libitum* at 4.2 pounds of feed per bird from day 50 to day 54, the end of the trial.

Table 2. Treatment groups (6 treatment groups (800 birds/TX) with 16 replications/TX)

Treatment #			
	Feed Formulation	Feeding Program	KemTRACE Chromium
1	A Formulation (see appendix)	Starter – 1.00 lb./bird (800 lbs.) Grower – 4.00 lbs./bird (3,200 lbs.) WD1 – 7.00 lbs./bird (5,600 lbs.) WD2 – 5.65 lbs./bird (4,520 lbs.)	0.0 lb./ton in All Diets (Starter, Grower, WD1 & WD2)
2	B Formulation (see appendix)	Starter – 2.10 lbs./bird (1,680 lbs.) Grower – 5.00 lbs./bird (4,000 lbs.) WD1 – 6.35 lbs./bird (5,080 lbs.) WD2 – 4.20 lbs./bird (3,360 lbs.)	0.0 lb./ton in All Diets (Starter, Grower, WD1 & WD2)
3	C Formulation (see appendix)	Starter – 2.10 lbs./bird (1,680 lbs.) Grower – 5.00 lbs./bird (4,000 lbs.) WD1 – 6.35 lbs./bird (5,080 lbs.) WD2 – 4.20 lbs./bird (3,360 lbs.)	0.0 lb./ton in All Diets (Starter, Grower, WD1 & WD2)
4	A Formulation (see appendix)	Starter – 1.0 lb./bird (800 lbs.) Grower – 4.0 lbs./bird (3,200 lbs.) WD1 – 7.0 lbs./bird (5,600 lbs.) WD2 – 5.65 lbs./bird (4,520 lbs.)	1.0 lb./ton in All Diets (Starter, Grower, WD1 & WD2)
5	B Formulation (see appendix)	Starter – 2.10 lbs./bird (1,680 lbs.) Grower – 5.00 lbs./bird (4,000 lbs.) WD1 – 6.35 lbs./bird (5,080 lbs.) WD2 – 4.20 lbs./bird (3,360 lbs.)	1.0 lb./ton in All Diets (Starter, Grower, WD1 & WD2)
6	C Formulation (see appendix)	Starter – 2.10 lbs./bird (1,680 lbs.) Grower – 5.00 lbs./bird (4,000 lbs.) WD1 – 6.35 lbs./bird (5,080 lbs.) WD2 – 4.20 lbs./bird (3,360 lbs.)	1.0 lb./ton in All Diets (Starter, Grower, WD1 & WD2)

Feed

The diets were formulated according to the treatments listed above, mixed, crumbled/pelletized, weighed and recorded at the SFASU Research Feed Mill. Feed formulations mimicked standard corn-soybean meal-based US commercial broiler chicken diets (see appendix) Feed Samples were retained for analysis. The treatments received starter (S), grower (G), and two withdrawal diets (WD1 & WD2), with and without inclusion of KemTRACE chromium. Only treatments 4, 5, and 6 diets will consist of 1 pound of chromium per ton of feed within all the diets. Starter diets were crumbled after being pelletized to a size for chicks to eat efficiently. Grower and both withdrawal diets were fed as pellets.

Three feed formulations were used among the treatment groups that differed in amino acid concentrations, such as lysine, methionine, and threonine (see appendix). Although, the feed formulations varied in the amino acid concentrations they still had the same nutritional value. The importance of this is to compare the formulations on a cost-effective standpoint.

Performance Data

All birds were observed twice daily (AM & PM) and any abnormalities were recorded. Observation of the bird's feathering, leg disorders, and litter condition was conducted throughout trial. Any signs of toxicity, including mortality, was visually observed daily. Mortality was collected and recorded by weight of the bird and probable cause of death. Bird weights were recorded and analyzed in order to calculate the average body weight for each treatment group.

The average body weights were recorded for Treatments 1 and 4 per pen on days (d) d14, d30, d47. Average body weights were recorded for Treatments 2, 3, 5, and 6 per pen on days (d) d20, d35, and d49. On day 54 average body weights were recorded among all treatment groups.

The significance of these days is represented by feed change; d14 & d20 was the end of the starter phase, d30 & d35 was the end of the grower phase, d47 & d49 was the end of the withdrawal one phase, and d54 was the end of withdrawal two phase. The process of recording the average body weight was by collecting every bird by hand from each pen and weighing them on a Doron 8000 XL cage scale. The birds in each pen were counted to ensure an accurate calculation of average body weight. All feed weighed in the SFASU Research Feed Mill was recorded before being distributed into the pens. The remaining feed not consumed was recorded and labeled as feed weigh back. This was used to determine the total feed consumption and feed conversion ratio.

Feed consumed is the amount of feed that is left in the feed pan from the feed that was administered to the pen and calculated by the following equation:

Feed Consumed = Feed Received – Feed Leftover

Feed Conversion is the average body weight divided the amount of feed consumed and calculated by the following equation:

Feed Conversion = Average Body Weight / Pounds of Feed Consumed

Yield Study

At the completion of the study, four randomly selected birds/pen, for a total of 384 birds were individually weighed, recorded, and wing tagged. A numbered wing tag was placed in the wing web of each bird for further individual identification throughout the yield process. Birds from each treatment group remained together and were placed in individual isolation pens until time of processing. Birds were provided feed and water until 10 hours prior to processing, when the feed only was removed for gut passage time.

At time of processing the birds are collected from the isolation pens and transported to the SFASU Poultry Processing Building. Upon arrive the birds are individually weighed, where recording the bird's live weight and tag number were recorded. After recording the bird's tag and weight the bird is transferred over to the euthanasia cones. The bird is electrically stunned before the carotid artery and jugular vein in the neck was severed. After exsanguination the bird is move into the 140°F scalder, where the bird rotates on a moving plate causing the feather follicles to open and the feathers loosen from the skin. Once 90 seconds has past the rotating plate will halt, the bird is then taken to the plucker. Inside the plucker there are rubber rods that run along the sides and bottom of the plucker. Water is added as the machine rotates for 90 seconds removing the feathers from the bird's skin by rubbing against the rubber rods located throughout. Upon completion of the 90 seconds the bird's paws and hocks are removed by cutting through the hock joint and discarded into inedible barrels for disposal. The bird is then hung breast side out on a rotating shackle line for the neck and tail to be removed. Once removed the bird is eviscerated, removing the organs, intestines, and lungs. From there the front-half and lower-half are detached from another. Leaving the front half completely attached, and the lower-half is quartered into drums, thighs, back, and fat pad. The contents of the carcass are placed into a colander where the lower-half parts are recorded on a Doran 8000XL digital scale connected to a computer, after recording the weight the contents of the lower-half are placed into a chiller. Each part weight is collected into a specialized software that separates the weights by part into an excel spreadsheet. The front-half is butchered into wings, tenders, breast, frame, and skin. The contents were also placed into a colander to be recorded on a scale connected to a computer, then placed in a separate chiller.

Birds were processed for yield analysis and the following weights were recorded: Live weight, carcass weight-without-giblets (WOG), front-half carcass, lower-half carcass, breast, tenders, wings, drums, thighs, frame, back, abdominal fat pad, and skin. The birds that remained in the house were collected by Pilgrim's for commercial distribution.

Data Analysis and Interpretation

The data was statistically analyzed using SAS 9.4. The data was interpreted using a three by two factorial, analysis of variance (ANOVA) using the PROC GLM procedure. When significance was observed between the treatments at alpha level $P < 0.05$, means were then separated using Duncan's Multiple Range Test

CHAPTER IV

Results and Discussion

The objective for this study was to evaluate performance parameters and meat yield of commercial broiler chickens fed diets with different amino acid concentrations, with or without chromium supplementation, and delivered through two different feeding programs over 54 days. Performance parameters were evaluated by comparing average body weights of all six treatments per pen. Data collection included the calculation of feed conversion ratio (FCR), feed consumption, and mortality. At the conclusion of the rearing period a yield study was conducted to determine the collection of meat yield, based on the retail cuts of meat from the front and lower halves of the bird's carcass including other elements of the carcass. This study attempted to identify the significance of amino acid concentration, the addition of chromium in the diet, and feeding programs administered to the bird. Once the study was completed, the recorded performance parameters and yield data was evaluated. The data results to follow determined the findings of the trial. The data results convey the comparison of the treatments according to the feed formulation, with or without addition of chromium, and the differences in feeding program.

Analysis of Chromium Supplementation for Feed Program 1 (TX 1 and 4) from Days 1-47

Treatments 1 and 4 were under the same feeding program (FP1) and received the same feed formulation (A). The comparison to be made from these two treatments with Treatment 1 being the control group with no chromium (NC) and Treatment 4 receiving chromium (C). Table 3 conveys the means for average body weight and feed conversion while Table 4. shows the amount of feed consumed and percent of mortality on days 14, 30, and 47. No significant differences were shown in the results of any of the recorded performance variables on these days.

Table 3. Average Body Weight and Feed Conversion Ratio for Treatments 1 & 4, Day 1-47

TX	Formulation	Chromium	Day 14		Day 30		Day 47	
			Avg. Body Weight (lbs.)	Feed Conversion (lb:lb)	Avg. Body Weight (lbs.)	Feed Conversion (lb:lb)	Avg. Body Weight (lbs.)	Feed Conversion (lb:lb)
1	A	NC	0.903[a]	0.933[a]	3.272[a]	1.36[a]	6.733[a]	1.70[a]
4	A	C	0.900[a]	0.935[a]	3.282[a]	1.37[a]	6.836[a]	1.67[a]
		P Value	0.5047	0.9351	0.4571	0.3357	0.5903	0.411

*Means with the same letter are not significantly different ($p<0.05$).

Table 4. Feed Consumed and Percent Mortality for Treatments 1 and 4, Day 1-47

TX	Formulation	Chromium	Day 14		Day 30		Day 47	
			Feed Consumed (lbs.)	Percent Mortality %	Feed Consumed (lbs.)	Percent Mortality %	Feed Consumed (lbs.)	Percent Mortality %
1	A	NC	40.687[a]	1.500[a]	215.211[a]	1.857[a]	543.397[a]	2.571[a]
4	A	C	40.601[a]	1.714[a]	216.169[a]	1.929[a]	544.470[a]	2.286[a]
		P Value	0.8895	0.3243	0.6523	0.709	0.8937	0.9161

*Means with the same letter are not significantly different ($p<0.05$).

Analysis of Chromium Supplementation for Feed Program 2 (TX 2, 3, 5, and 6) from Days 1-49

Treatments 2 and 5 were under the same feeding program (FP2) and received the same feed formulation (B). However, treatment 2 did not receive chromium supplementation (NC) while treatment 5 did receive chromium supplementation (C). The results shown in Table 5 and 6 does not show any significance in performance from chromium supplementation.

Table 5. Average Body Weight & Feed Conversion Ratio for Chromium (C & NC) in Treatments 2 and 5, Day 1-49

TX	Formulation	Chromium	Day 20		Day 35		Day 49	
			Avg. Body Weight (lbs.)	Feed Conversion (lb:lb)	Avg. Body Weight (lbs.)	Feed Conversion (lb:lb)	Avg. Body Weight (lbs.)	Feed Conversion (lb:lb)
2	B	NC	1.562[a]	1.17[a]	4.324[a]	1.41[a]	7.107[a]	1.71[a]
5	B	C	1.600[a]	1.15[a]	4.386[a]	1.43[a]	7.325[a]	1.75[a]
		P Value	0.1834	0.2700	0.3960	0.2731	0.1277	0.0618

*Means with the same letter are not significantly different ($p<0.05$).

Table 6. Feed Consumed & Percent Mortality for Chromium (C & NC) in Treatments 2 and 5, Day 1-49

TX	Formulation	Chromium	Day 20		Day 35		Day 49	
			Feed Consumed (lbs.)	Percent Mortality %	Feed Consumed (lbs.)	Percent Mortality %	Feed Consumed (lbs.)	Percent Mortality %
2	B	NC	88.819[a]	2.556[a]	293.290[a]	2.900[a]	583.290[a]	2.636[a]
5	B	C	86.141[a]	3.286[a]	294.417[a]	3.500[a]	588.900[a]	3.533[a]
		P Value	0.0512	0.2495	0.9031	0.4344	0.5724	0.2192

*Means with the same letter are not significantly different ($p<0.05$).

Treatments 3 and 6 were under the same feeding program (FP2) and receiving the same feed formulation (C). However, treatment 3 did not receive chromium supplementation (NC) while treatment 6 did receive chromium supplementation (C). The results shown in Table 7 and 8 does not show any significance in performance from chromium supplementation.

Table 7. Average Body Weight & Feed Conversion Ratio for Chromium (C & NC) in Treatments 3 and 6, Day 1-49

TX	Formulation	Chromium	Day 20		Day 35		Day 49	
			Avg. Body Weight (lbs.)	Feed Conversion (lb:lb)	Avg. Body Weight (lbs.)	Feed Conversion (lb:lb)	Avg. Body Weight (lbs.)	Feed Conversion (lb:lb)
3	C	NC	1.529[a]	1.21[a]	4.320[a]	1.49[a]	7.055[a]	1.77[a]
6	C	C	1.542[a]	1.20[a]	4.352[a]	1.47[a]	7.091[a]	1.75[a]
		P Value	0.6532	0.2824	0.5529	0.1151	0.7118	0.4162

*Means with the same letter are not significantly different ($p<0.05$).

Table 8. Feed Consumed & Percent Mortality for Chromium (C & NC) in Treatments 3 and 6, Day 1-49

TX	Formulation	Chromium	Day 20		Day 35		Day 49	
			Feed Consumed (lbs.)	Percent Mortality %	Feed Consumed (lbs.)	Percent Mortality %	Feed Consumed (lbs.)	Percent Mortality %
3	C	NC	88.828[a]	2.385[a]	307.031[a]	2.429[a]	591.820[a]	2.929[a]
6	C	C	88.863[a]	2.154[a]	302.936[a]	2.467[a]	584.620[a]	2.688[a]
		P Value	0.7477	0.2789	0.5791	0.6213	0.5728	0.1563

*Means with the same letter are not significantly different ($p<0.05$).

Analysis of Treatments (TX 2, 3, 5, and 6) from Days 1-49

The following tables of results conveys the comparison of Treatments 2, 3, 5, and 6. The data comparison of these treatments was specific to the formulation and whether or not chromium was added to the diet. The results from Tables 9-11 show there were no significant differences found within any performance parameters between the treatments on days 20, 35, and 49.

Table 9. Average Body Weight, Feed Conversion Ratio, Feed Consumed, and Percent Mortality in Treatments 2, 3, 5, and 6, Days 1-20

TX	Formulation	Chromium	Day 20		Day 20	
			Avg. Body Weight (lbs.)	Feed Conversion (lb:lb)	Feed Consumed (lbs.)	Percent Mortality %
2	B	NC	1.562[a]	1.174[a]	88.819[a]	2.556[a]
3	C	NC	1.529[a]	1.214[a]	88.828[a]	2.385[a]
5	B	C	1.600[a]	1.150[a]	86.141[a]	3.286[a]
6	C	C	1.542[a]	1.198[a]	88.863[a]	2.154[a]
		P Value	0.5576	0.7726	0.0772	0.2766

*Means with the same letter are not significantly different (p<0.05)

Table 10. Average Body Weight, Feed Conversion Ratio, Feed Consumed, and Percent Mortality in Treatments 2, 3, 5, and 6, Days 1-35

TX	Formulation	Chromium	Day 35		Day 35	
			Avg. Body Weight (lbs.)	Feed Conversion (lb:lb)	Feed Consumed (lbs.)	Percent Mortality %
2	B	NC	4.324[a]	1.409[a]	293.290[a]	2.900[a]
3	C	NC	4.320[a]	1.490[a]	307.031[a]	2.429[a]
5	B	C	4.386[a]	1.435[a]	294.417[a]	3.500[a]
6	C	C	4.352[a]	1.467[a]	302.936[a]	2.467[a]
		P Value	0.7507	0.0771	0.5508	0.5277

*Means with the same letter are not significantly different ($p<0.05$).

Table 11. Average Body Weight, Feed Conversion Ratio, Feed Consumed, and Percent Mortality in Treatments 2, 3, 5, and 6, Days 1-49

TX	Formulation	Chromium	Day 49		Day 49	
			Avg. Body Weight (lbs.)	Feed Conversion (lb:lb)	Feed Consumed (lbs.)	Percent Mortality %
2	B	NC	7.107[a]	1.708[a]	583.286[a]	2.636[a]
3	C	NC	7.055[a]	1.775[a]	591.817[a]	2.929[a]
5	B	C	7.325[a]	1.753[a]	588.901[a]	3.533[a]
6	C	C	7.091[a]	1.752[a]	584.616[a]	2.688[a]
		P Value	0.4498	0.0915	0.4031	0.2181

*Means with the same letter are not significantly different ($p<0.05$).

Analysis of Treatments 1-6 on Day 54

At the conclusion (Day 54) of the trial performance parameters were recorded for Treatments 1-6. The following results include the comparison of all treatment groups in regard to the specified diet the treatment received. Tables 16 and 17 show the results from the recorded data.

Table 12. Average Body Weight and Feed Conversion in Treatments 1-6, Day 54

TX	Formulation	Chromium	Feed Program	Day 54	
				Avg. Body Weight (lbs.)	Feed Conversion (lb:lb)
1	A	NC	FP1	8.027[a]	1.83[a]
2	B	NC	FP2	8.218[a]	1.80[a]
3	C	NC	FP2	8.089[a]	1.85[a]
4	A	C	FP1	8.264[a]	1.82[a]
5	B	C	FP2	8.188[a]	1.84[a]
6	C	C	FP2	8.166[a]	1.83[a]
			P Value	0.7601	0.5619

*Means with the same letter are not significantly different (p<0.05

Table 13. Feed Consumed and Percent Mortality in Treatments 1-6, Day 54

TX	Formulation	Chromium	Feed Program	Day 54	
				Feed Consumed (lbs.)	Percent Mortality %
1	A	NC	FP1	687.57[a]	3.214[a]
2	B	NC	FP2	689.60[a]	3.333[a]
3	C	NC	FP2	692.41[a]	3.667[a]
4	A	C	FP1	700.42[a]	3.429[a]
5	B	C	FP2	691.82[a]	4.000[a]
6	C	C	FP2	688.20[a]	3.938[a]
			P Value	0.9736	0.8744

*Means with the same letter are not significantly different ($p<0.05$).

The results from Tables 12 and 13 showed that there were no significant differences between Treatments 1-6

Yield Study

At the conclusion the study a yield study was conducted to record the meat yield from Treatments 1-6. Four birds were randomly selected from each pen within each treatment from every block as a representative sample. From the results shown on Table 20 conclude that treatment 2 was significantly different from treatments 1 and 3 in front half carcass weight. Recording a weight of 4.26 lbs. Results also show treatment 2 having significant differences from treatments 1 and 4 in breast meat yield. Recording a weight of 1.91 lbs. There was no significance found with the inclusion from supplementation of chromium into the diet. As compared to study conducted by Rajalekshmi, Sugumar, Chirakkal, & Ramarao (2014) where breast meat yield was increased by the supplementation of chrromium proprionate, this trial did not show similar results.

Table 14. Yield Study Data Results of Treatments 1-6, Day 54

Day 54							
Weight of Parts (lbs.)	Treatment						
	1	2	3	4	5	6	P Value
Average Live Weight	8.38[a]	8.67[a]	8.39[a]	8.55[a]	8.61[a]	8.64[a]	0.1592
WOG	6.69[a]	6.94[a]	6.72[a]	6.79[a]	6.89[a]	6.91[a]	0.1291
Carcass – Front Half	4.03[c]	4.26[a]	4.04[c]	4.06[bc]	4.23[ab]	4.16[abc]	0.0129
Carcass – Lower Half	2.54[a]	2.62[a]	2.57[a]	2.61[a]	2.59[a]	2.63[a]	0.3505
Breast	1.77[b]	1.91[a]	1.80[ab]	1.77[b]	1.87[ab]	1.86[ab]	0.0224
Tenders	0.39[a]	0.40[a]	0.39[a]	0.40[a]	0.41[a]	0.40[a]	0.4831
Wings	0.67[a]	0.69[a]	0.68[a]	0.70[a]	0.69[a]	0.72[a]	0.1031
Drums	0.88[a]	0.92[a]	0.88[a]	0.91[a]	0.93[a]	0.91[a]	0.2238
Thighs	1.05[a]	1.04[a]	1.01[a]	1.05[a]	1.02[a]	1.05[a]	0.7087
Skin	0.26[a]	0.27[a]	0.26[a]	0.26[a]	0.27[a]	0.28[a]	0.8247
Fat Pad	0.12[a]	0.12[a]	0.11[a]	0.13[a]	0.12[a]	0.11[a]	0.1474
Frame	1.05[a]	1.06[a]	1.04[a]	1.07[a]	1.09[a]	1.08[a]	0.4519
Back	0.65[a]	0.66[a]	0.67[a]	0.68[a]	0.68[a]	0.67[a]	0.5103

*Means with the same letter are not significantly different ($p<0.05$).

CHAPTER V

Summary and Conclusion

From the results of this study there was no significant effect on broiler performance from the supplementation of chromium, feed formulation, and feeding program. Although, the results on Table 14 from the yield study shows that treatment 2 was significantly different from treatments 1, 3, and 4 in front half carcass weight, however was not significantly different from treatments 5 and 6. Table 14 results also show treatment 2 having significant differences from treatments 1 and 4 in breast meat yield, however was not significantly different from treatments 3, 5, and 6. However, there is a possibility that these areas of significance in the yield study could be false positives found in the data of this single trial. Additional studies should be conducted to further the assumption if there is an actual significant difference between the treatments. Additionally, increasing the sample size of the yield study can improve the statistical values and determine if the results are accurate for future trials.

Based on the results that were collected from this trial we assume that there is no effect on the performance on feeding an extra pound of starter in feeding program 2 (FP2), where the protein percentage is the highest among all feeding phases and being the most expensive ingredient in the formulation. We assume it would not be economically beneficial for the producer to use this feeding program.

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Appendix – A

Broiler Starter						
Formulation	**A (NC)**	**B (NC)**	**C (NC)**	**A (C)**	**B (C)**	**C (C)**
Corn	1,084.47	1,109.35	1,119.96	1,084.47	1,109.35	1,119.95
SBM	724.36	683.04	701.4	724.36	683.04	701.4
Distiller's Dried Grains	80	80	80	80	80	80
Corn Oil	42.36	58.36	29.74	42.36	58.36	29.74
Limestone	20.37	20.37	20.37	20.37	20.37	20.37
Defl. Phosphate	18.97	19.29	19.07	18.97	19.29	19.07
MHA	6.83	6.75	7.49	6.83	6.75	7.49
Salt	7.32	7.32	7.32	7.32	7.32	7.32
Biolys	6.27	6.38	5.81	6.27	6.38	5.81
Adisodium	0.5	0.5	0.5	0.5	0.5	0.5
Bio-Avail Trace Minerals	1.5	1.5	1.5	1.5	1.5	1.5
Threonine	2.21	2.15	1.96	2.21	2.15	1.96
TBCC	0.4	0.4	0.4	0.4	0.4	0.4
Broiler Vitamins	0.5	0.5	0.5	0.5	0.5	0.5
Optiphos	0.5	0.5	0.5	0.5	0.5	0.5
SBF Butyrate	1.5	1.5	1.5	1.5	1.5	1.5
Magni Phi	0.5	0.5	0.5	0.5	0.5	0.5
Choline	1.23	1.39	1.29	1.23	1.39	1.29
Hostazym X	0.2	0.2	0.2	0.2	0.2	0.2
Chromium	0	0	0	1	1	1
	2,000.00	**2,000.00**	**2,000.00**	**2,001.00**	**2,001.00**	**2,001.00**

Appendix – B

Broiler Grower

Formulation	A (NC)	B (NC)	C (NC)	A (C)	B (C)	C (C)
Corn	1,231.46	1,203.91	1,266.08	1,231.46	1,203.91	1,266.08
SBM	562.65	569.23	560.41	562.65	569.23	560.41
Distiller's Dried Grains	81.04	89.8	73.39	81.04	89.8	73.39
Corn Oil	57.7	69.9	35.85	57.7	69.9	35.85
Limestone	20.44	20.57	20.06	20.44	20.57	20.06
Defl. Phosphate	17.84	17.62	15.22	17.84	17.62	15.22
MHA	5.92	6.25	6.13	5.92	6.25	6.13
Salt	7.36	7.36	7.36	7.36	7.36	7.36
Biolys	6.4	6.4	6.44	6.4	6.4	6.44
Adisodium	0.77	0.77	1.16	0.77	0.77	1.16
Bio-Avail Trace Minerals	1.5	1.5	1.5	1.5	1.5	1.5
Threonine	1.58	1.38	1.8	1.58	1.38	1.8
TBCC	0.4	0.4	0.4	0.4	0.4	0.4
Broiler Vitamins	0.5	0.5	0.5	0.5	0.5	0.5
Optiphos	0.5	0.5	0.5	0.5	0.5	0.5
SBF Butyrate	1.5	1.5	1.5	1.5	1.5	1.5
Magni Phi	0.5	0.5	0.5	0.5	0.5	0.5
Choline	1.75	1.72	1	1.75	1.72	1
Hostazym X	0.2	0.2	0.2	0.2	0.2	0.2
Chromium	0	0	0	1	1	1
	2,000.00	**2,000.00**	**2,001.00**	**2,001.00**	**2,001.00**	**2,001.00**

Appendix – C

Broiler Withdrawal 1						
Formulation	**A (NC)**	**B (NC)**	**C (NC)**	**A (C)**	**B (C)**	**C (C)**
Corn	1,361.95	1,396.59	1,332.28	1,361.95	1,396.59	1,332.28
SBM	496.96	441.96	461.95	496.96	441.96	461.95
Distiller's Dried Grains	26.43	40.17	95.05	26.43	40.17	95.05
Corn Oil	53.31	60.41	48.22	53.31	60.41	48.22
Limestone	19.3	19.75	20.79	19.3	19.75	20.79
Defl. Phosphate	16.31	16.88	14.74	16.31	16.88	14.74
MHA	5.37	4.46	5.21	5.37	4.46	5.21
Salt	7.27	7.13	8.44	7.27	7.13	8.44
Biolys	6.14	5.63	6.06	6.14	5.63	6.06
Adisodium	0.76	0.8	1.12	0.76	0.8	1.12
Bio-Avail Trace Minerals	1	1	1	1	1	1
Threonine	1.21	0.88	1.18	1.21	0.88	1.18
TBCC	0.4	0.4	0.4	0.4	0.4	0.4
Broiler Vitamins	0.25	0.25	0.25	0.25	0.25	0.25
Optiphos	0.5	0.5	0.5	0.5	0.5	0.5
SBF Butyrate	1	1	1	1	1	1
Magni Phi	0.5	0.5	0.5	0.5	0.5	0.5
Choline	1.15	1.51	1.09	1.15	1.51	1.09
Hostazym X	0.2	0.2	0.2	0.2	0.2	0.2
Chromium	0	0	0	1	1	1
	2,000.02	**1,999.98**	**2,001.01**	**2,001.02**	**2,000.98**	**2,001.00**

Appendix – D

Broiler Withdrawal 2						
Formulation	**A (NC)**	**B (NC)**	**C (NC)**	**A (C)**	**B (C)**	**C (C)**
Corn	1,477.65	1,454.90	1,475.41	1,477.65	1,454.90	1,475.41
SBM	420.72	421.81	426.61	420.72	421.81	426.61
Distiller's Dried Grains	12.06	16.78	16.28	12.06	16.78	16.28
Corn Oil	37.49	54.48	29.01	37.49	54.48	29.01
Limestone	18.26	18.31	18.36	18.26	18.31	18.36
Defl. Phosphate	8.34	8.27	8.16	8.34	8.27	8.16
MHA	4.21	4.22	4.68	4.21	4.22	4.68
Salt	8.4	8.4	8.4	8.4	8.4	8.4
Biolys	5.63	5.59	5.66	5.63	5.59	5.66
Adisodium	2.75	2.75	2.75	2.75	2.75	2.75
Bio-Avail Trace Minerals	1	1	1	1	1	1
Threonine	0.84	0.84	1.03	0.84	0.84	1.03
TBCC	0.4	0.4	0.4	0.4	0.4	0.4
Broiler Vitamins	0.25	0.25	0.25	0.25	0.25	0.25
Optiphos	0.5	0.5	0.5	0.5	0.5	0.5
SBF Butyrate	0	0	0	0	0	0
Magni Phi	0	0	0	0	0	0
Choline	1.3	1.3	1.3	1.3	1.3	1.3
Hostazym X	0.2	0.2	0.2	0.2	0.2	0.2
Chromium	0	0	0	1	1	1
	2,000.00	**2,000.00**	**2,001.00**	**2,001.00**	**2,001.00**	**2,001.00**

VITA

The author, Ian Andrew, graduated from L.D. Bell Highschool of Hurst, Texas in May of 2015 and was accepted into Stephen F. Austin State University of Nacogdoches, Texas to begin classes in the Fall of 2015, where he pursued a Bachelors of Agribusiness degree and a minor in General Business. After graduating and receiving his degree in December 2018, Ian decided to continue his education at Stephen F. Austin State University for a Master of Science in General Agriculture. Ian plans to graduate with his Master of Science in General Agriculture in May 2020 and pursue a career in the agricultural industry.

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