



EFFECTS OF REPLACING MAIZE WITH BOILED MANGO (*Mangifera indica* Linn) SEED KERNEL ON THE GROWTH PERFORMANCES AND CARCASS CHARACTERISTICS OF BROILER CHICKENS

MSc Thesis

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**June, 2020
Bishoftu, Ethiopia**

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A Thesis submitted to College of Veterinary Medicine and Agriculture of Addis Ababa University

In Partial Fulfillment of the Requirements for the Degree of Master of Science in Animal Production

**By
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**June, 2020
Bishoftu, Ethiopia**

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As MSc research advisors, we hereby certify that we have read and evaluated this Thesis prepared under our guidance by Yasin Beriso Ulo, title: **Effects of replacing maize with boiled mango (*Mangifera indica*) seed kernel on the growth performance and carcass characteristics of broiler chickens**, we recommend that it can be submitted as fulfilling the MSc Thesis requirement.

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DEDICATION

This thesis manuscript is dedicated to my father Beriso Ulo and my mother Fatima Dido, who was always immersed in fantasy about my success though death come ahead of their revels a bit before my success in joining of the Ethiopian Institute of Agricultural Research in 2016.

STATEMENT OF AUTHOR

First, I declare that this thesis is my bonafide work and that all sources of material used for this thesis have been duly acknowledged. This thesis has been submitted in partial fulfillment of the requirements for MSc degree at Addis Ababa University, College of Veterinary Medicine and Agriculture and is deposited at the University/College library to be made available to borrowers under rules of the Library. I solemnly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate.

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BIOGRAPHICAL SKETCH

The author Yasin Beriso Ulo was born on October 1991 in Dodola town, West Arsi Zone of Oromia Regional State. He attended his elementary and junior education in Dodola Junior and Elementary School from 2000 to 2007. He also attended his Senior Secondary and preparatory education at Dodola Preparatory and Senior Secondary School from 2008 to 2011. He joined then Hawassa University and was awarded a BSc Degree in July 2014 in Animal and Range Sciences. Soon after graduation, he was employed by Addis Ababa City Administration in urban agriculture as Animal and Animal Products Development Officer in 2015 and served for one year. Soon after he was employed by Ethiopian Institute of Agricultural Research as Junior Researcher in Livestock Research Directorate in 2016 and till he joined the School of Graduate Studies of Addis Ababa University to pursue Master of Science Degree in Animal Production in September 2019.

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LIST OF ABBREVIATIONS

ADG	Average Daily Gain
ANOVA	Analysis of Variance
AOAC	Association of Official Analytical Chemist
BMSK	Boiled Mango Seed Kernel
BW	Body Weight
CF	Crude Fiber
CP	Crude Protein
CRD	Completely Randomized Design
CSA	Central Statistical Agency
DM	Dry Matter
EIAR	Ethiopian Institute of Agricultural Research
EE	Ether Extract
FAO	Food and Agricultural Organization
FAOSTAT	Food and Agricultural Organization Statistics
FCR	Feed Conversion Ratio
ME	Metabolizable Energy
MFW	Mango Fruit Waste
MSK	Mango Seed Kernel
NFE	Nitrogen Free Extract
PLC	Private Limited Company

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SEED KERNEL ON THE GROWTH PERFORMANCES AND CARCASS
CHARACTERISTICS OF BROILER CHICKENS**

Yasin Beriso

MSc Thesis

ABSTRACT

An investigation was undertaken to study the effects of replacing maize with boiled mango seed kernel (BMSK) on the growth performance parameters and carcass yield characteristics of Hubbard broiler chicks. The experiment was arranged in a completely randomized design with four treatments, each replicated three times with 13 birds each. One-hundred fifty six day-old chicks with similar body weight (BW) were used for this trial and were randomly distributed to the four treatment diets. The four treatments were control (T_1) (100% maize + 0% BMSK), T_2 (95% maize + 5% BMSK), T_3 (90% maize + 10% BMSK) and T_4 (85% maize + 15% BMSK). The chicks were weighed at the start for initial BW for which the experiment was lasted for 7 weeks during which daily feed intake and weekly BW were measured. At the end of the experimental period, 2 chicks from each replication were randomly selected and slaughtered to evaluate the effect of BMSK on carcass yields. The results on average daily feed intake per bird for T_1 and T_2 was 71.38 and 70.82 g, respectively and this difference was not significant ($p>0.05$) between them but it was significantly ($p<0.05$) higher than that of T_3 and T_4 which was 68.13 and 68.23 g. At the end of 7 weeks, the final BW of chicks fed on T_1 and T_2 , was 2657 and 2644 and this difference was not significant ($p>0.05$) between them but it was significantly ($p<0.05$) higher than that of T_3 and T_4 which was 2610 and 2603 g per bird, respectively. The Average daily BW gain (ADG) for the respective T_1 and T_2 was 53.4, 53.15 and was significantly ($p<0.05$) higher than that of T_3 and T_4 which was 52.44 and 52.31 g per bird. The feed conversion ratio (g feed/g gain) for T_1 and T_2 was 1.36, 1.36 and was significantly higher than that of T_3 and T_4 which was 1.33 and 1.33 g per bird, respectively. The dressing percentage of T_1 , T_2 , T_3 and T_4 was 80.85, 80.80, 80.33 and 82.24, respectively. Except for breast meat and heart weight, no significance differences were observed in all carcass traits and visceral organs between chickens fed on control diet and treatment diets. Chickens fed on control diet had significantly higher breast meat, heart and abdominal fat weight than those of treatment diets. Mortality was not ($p>0.05$) significant across all treatment and control groups and it was 2.5% in T_1 , 5% in T_2 , 2.5% in T_4 and no mortalities were observed in those chickens fed on T_3 diets. The partial budget analysis indicated that replacement of maize up to 15% with BMSK gave reduced feed cost per BW gain and a similar net return. Therefore, BMSK up to 15% can replace maize in broilers ration without affecting nutrient intake, growth and net return.

Keywords: Boiled Mango Seed Kernel; Broiler chicken; Carcass traits; Growth performance; Partial budgeting

1. INTRODUCTION

1.1. Background of the Study

Ethiopia has the largest livestock in Africa and ranked tenth in the world. It was reported that the country own about 60.39 million cattle, 31.30 million sheep, 32.74 million goats, 2.01 million horses, 8.85 million donkeys, 0.46 million mules, 1.42 million camels and 56.06 millions of poultry (chicken in Ethiopian condition) (CSA, 2018). Poultry production plays an important role in Ethiopia's economy (Fekade *et al.*, 2019). It renders a significant contribution to household income and food security particularly in providing animal protein to the people (Gondwe, 2004). However, the productivity per unit of bird and the contribution of this sector to the national economy is relatively low in Ethiopia (Fekade *et al.*, 2019). Feed scarcity and consequent high price of conventional energy and protein sources are factors that limit the productivity of poultry in Ethiopia (Aberra *et al.*, 2011). Unfortunately, there is also an increasing competition between man and livestock especially poultry for available feed stuff, for food, feed and industrial raw materials. Bamgbose *et al.* (2004) reported that maize (*Zea mays*) as a major energy source in chicken feeds accounting for 50 and 55% of most chicken feeds. It is equally used in human nutrition thus creating a stiff competition between man and chickens. The resulting effect is high feed cost and unaffordable chicken products therefore, any effort to substitute maize in poultry feed will significantly reduce the cost of production Bamgbose *et al* (2014).

For economic efficiency of broiler farming, the feed ingredients of broiler diets should have lesser agronomic demand, high in energy, limited processing method and more importantly have a low competitive demand for human consumption (Odunsi and Farinu, 1997). Mango seed kernel (MSK), an agricultural waste, appears to satisfy most of these requirements. Many workers (El-Alaily *et al.*, 1976; Dhingra and Kapoor, 1985; Das *et al.*, 1988) have elucidated potential of MSK in animal nutrition. These workers further revealed that as it contains protein (5-8%); fat (6-12%); carbohydrate (75-80%); ash (1.5-3.0%); fibre (1.8-4.01%); calcium (0.21%) and phosphorus (0.21%). Though it is a poor source of protein, is an excellent source of energy containing about 13% ether extract (El Alaily *et al.*, 1976) ;

77% NFE (Patel *et al.*, 1971). Diarra and Usman (2008) reported 20% of maize replacement with BMSK in broiler diet without adverse effects on growth and blood parameters. The presence of antioxidant vitamins such as vitamin C, E and A suggests that mango seed could be used as an alternative source of these vitamins also (El Alaily *et al.*, 1976). Antioxidant vitamins have been reported to reduce oxidative processes which are known to be vital in the initiation. However, most of these feeds contain anti-nutrients and toxic components such as saponins, lectins, tannins, trypsin inhibitors and cyanogenic glycosides which make them unsafe as protein and carbohydrate sources in livestock production (Aregheore, 1992). Drying, soaking, leaching and fermentation have been reported to be simple means of detoxifying these feed sources to reduce the presence of anti-nutrients and toxic components (Aregheore, 1998). Several researchers reported that the treated (de-oiled, soaked or boiled) mango seed kernel has been successfully used to replace maize in levels up to 15-20% in poultry diets (Ravindran and Sivakanesar, 1996) and Odunsi (2005).

Boiling has been reported to be effective in reducing the tannin content of MSK (Diarra and Usman, 2008). Similarly, boiling reduced the tannin content of the kernel from 9.89 to 1.26%, representing about 87.26% reduction (Diarra *et al.*, 2011). Diarra *et al.* (2010) reported no adverse effect of boiling on the crude protein (CP), crude fibre (CF), ether extract (EE) and nitrogen free-extract (NFE) of the kernel. Mango consists of between 33-85% edible pulp, with 9-40% inedible kernel and 7-24% inedible peel. Because of this, a huge amount of waste is generated during industrial processing which are serious disposal problems (Berardini *et al.* 2005).

In case of Ethiopia, the country is producing huge amount of mango fruit and feeding the needs of the communities in high land and low land irrigated parts. However, there is huge by-product of mango including seed kernel that are disposed in towns and cities and spoiling the area without mobilizing and using of it for any use. So the general objective of the current study was to determine the level of BMSK replacement of maize in broilers diets through evaluation of their growth performances, carcass characteristics and partial budgeting while the specific objectives were;

- To determine optimum level of BMSK inclusion in the broiler diets,

- To evaluate the growth performance and carcass characteristics of broiler chicks fed on BMSK; and,
- To analyze the partial budgeting due to inclusion of BMSK in the broilers diet.

2. LITERATURE REVIEW

2.1. Origin, Distribution and Nutritive Value of Mango Fruit

The mango (*Mangifera indica*) tree is originated from South-East Asia and now widespread in tropical and subtropical areas between 30°N and 25°S, from sea level up to 1200 m (Orwa *et al.*, 2009). Optimal growth conditions are average day temperature ranging from 24-30°C, annual rainfall between 750-2500 mm with a marked dry period for fruit induction, full-sun exposition on deep, well-drained and poor soils with pH ranging from 5.5 to 7.5. Mango trees are tolerant of drought or flooding conditions. In the subtropics, it can survive frost but young shoots and flowers are killed at temperatures ranging from 4°-12°C. Fruit production will be hampered if the frost comes too late in the season. Mango will not stand acidic or saline soils (Sukonthasing *et al.*, 1991). Mango production in 2010 was 39 million metric tons (including mango steens and guava). The 80% of the world production came from India (40%), China (11%), Thailand, Pakistan, Mexico, Indonesia, Brazil, the Philippines, Bangladesh and Nigeria (Orwa *et al.*, 2009).

Most mangoes are consumed locally and only 3% of the production is exported, the main exporters being India and Mexico. Due to the increasing popularity of the fruit in Europe and North America, mango production doubled between 1990 and 2009 and exports saw an eight-fold increase during that period (FAO, 2011; Jedele *et al.*, 2003). Mango is the most important tropical fruit crop after bananas and plantains (FAO, 2011). The mango fruit is a large fleshy drupe, highly variable in size, shape, color and taste and weighing up to 1 kg in some cultivars. Green when unripe, the fruit turns orange-reddish as it ripens after 3 to 6 months. The fruit consists of a woody endocarp (pit), a resinous edible mesocarp (flesh) and a thick exocarp (peel). The majority of mango production is consumed fresh and about 1-2% of the production is processed to make products such as juices, nectars, concentrates, jams, jelly powders, fruit bars, flakes and dried fruits (Berardini *et al.*, 2005; Jedele *et al.*, 2003). Mango varieties too fibrous or too soft for fresh consumption can be used for juice making (Hui, 2007). Mango processing yields about 40-50% of by-products which can be used to feed livestock (Medina *et al.*, 2002; Sruamsiri *et al.*, 2009) and these by-products are also potential sources of pectins and phenolic compounds (antioxydants) (Berardini *et al.*, 2005).

The mango kernel contains 7-12% of an oil rich in stearic (24-57%) and oleic (34-56%) acids that can be fractionated to give an olein with excellent emollient properties and a stearin that is one of the few fats that can replace cocoa butter in chocolate in certain countries (including the European Union) (Gunstone, 2006). Mango seed kernels (mango kernels) is the kernel inside the seed represents from 45% to 75% of the whole seed (Maisuthisakul *et al.*, 2009). Mango seed kernels (MSK) contained carbohydrate (69.2 - 80%), protein (7.5 – 13%), fibre (2.0–4.6%), ash (2.2–2.6%), calcium (0.21%) and phosphorus (0.22%), which is comparable to that of maize, depending on the variety (Kiftewahid *et al.*, 1982). The kernel is also balanced in amino acids (Anon, 1967).

2.2. Mango Seed Kernel Definition and Concepts

Mango seed kernels are by-products of mangos (*Mangifera indica* Linn) used for both human and animal consumption after several treatment options. It comprises the seeds and kernels and possibly also the skins. In countries such as in India, Pakistan and Bangladesh where mangoes are abundant, these by-products are also available in quite large quantities. India alone produces an estimated 1.0 - 1.5 million tons of the by-products (Devendra, 1985). But the feed is dispersed throughout the country and collection presents problems. Recent work has reported that a 10% level of inclusion is optimum for dairy cattle which produced a daily milk yield of 8 kg/day (annual report, 1983).

Table 1: Proximate analysis values of mango seed kernel

Characteristic	Reported values (mean)			
	Znikou <i>et al.</i> , 2010	Dhingra and Kapoor, 1985	Dhingra and Kapoor, 1985	Changso, 2008
Moisture content%	45.2	38.55	50.98	40.5
Crude protein%	6.36	5.34	5.25	1.43
Fats (oil)%	13.0	7.82	6.98	4.92
Crude fiber%	2.02	1.75	1.65	3.96
Ash content%	3.2	2.75	2.47	0.83
Total carbohydrate%	32.24	Nr	Nr	48.19

Early work by Kehar and Chandra (1945) indicated that mango seed kernel had a digestible crude protein (DCP) content of 6.1% and a total digestible nutrient (TDN) content of 50.0%. Feeding trials with Kankrej calves and Surti buffalo calves for 12 weeks indicated that the optimum level of incorporation in concentrate diets was 20% (Patel *et al.*, 1971). With working bullocks, Patel *et al.* (1972) found a 40% level to be satisfactory. A concentrate mixture made up of tomato waste, MSK and *Cassia tora* seed in the ratio 4:3:2 yielded live weight gains at reduced feed costs (Patel and Patel, 1971). One limiting factor in this feed is the presence of about 5 - 10% of tannins.

2.3. Nutritional Composition of Mango Seed Kernel

Mango seed is a single flat oblong seed that can be fibrous or hairy on the surface, depending on the cultivar. Inside the seed coat 1 - 2 mm thick is a thin lining covering a single embryo, 4 - 7 cm long, 3 - 4 cm wide, and 1 cm thick. Mango seed consists of a tenacious coat enclosing the kernel. The seed content of different varieties of mangoes ranges from 9% to 23% of the fruit weight (Palaniswamy *et al.*, 1974) and the kernel content of the seed ranges from 45.7% to 72.8% (Hemavathy *et al.*, 1988). Variation in characteristic yield may be due to the differences in variety of plant, cultivation climate, ripening stage, the harvesting time of the seeds kernels and the extraction method used.

Table 2: Mineral elemental composition of mango seed kernel (mg/100g)

	Znikou <i>et al.</i> , 2010	Fowomola, 2010
Calcium, Ca	10.21	111.3
Magnesium, Mg	22.34	94.8
Potassium, K	158.0	22.3
Sodium, Na	2.70	21.0
Phosphorus, P	20.0	Nr
Iron, Fe	Nr	11.9
Zinc, Zn	Nr	1.10
Manganese, Mn	Nr	0.04

Mango seed kernel is high in potassium, magnesium, phosphorus, calcium and sodium (Table 2). Potassium is an essential nutrient and has an important role in the synthesis of amino acids and proteins (Malik and Srivastava, 1982). Calcium and magnesium plays a significant role in photosynthesis, carbohydrate metabolism, nucleic acids and binding agents of cell walls (Scalbert, 1991). Calcium assists in teeth development (Brody, 1994). Magnesium is essential mineral for enzyme activity, like calcium and chloride; magnesium also plays a role in regulating the acid-alkaline balance in the body. Phosphorus is needed for bone growth, kidney function and cell growth. It also plays a role in maintaining the body's acid-alkaline balance (Fallon and Enig, 2001).

Table 3: Amino acids contained in mango seed kernel based on dry weight

Amino acid	Quantity (mg/100g)			
	Fowomola, 2010	Om El-Saad El-Gammal, 2011	Arogba, 1999	World Health Organization, 1985
Essential amino acids				
Isoleucine	3.23	2.68	4.4	4.2
Lysine	3.13	3.94	6.9	4.2
Methionine	1.04	0.38	1.2	2.2
Phenylalanine	4.46	2.75	3.4	2.8
Threonine	2.04	3.46	3.4	4.00
Tyrosine	3.17	2.74	2.7	2.8
Valine	3.80	6.07	5.8	4.2
Non-essential amino acids				
Arginine	1.17	14.27	7.3	
Alanine	6.40	4.86	4.2	
Aspartate	6.33	8.66	6.5	
Cysteine	2.30			
Glutamate	13.00	15.66	18.2	
Glycine	3.5	2.81	4.0	
Histidine	2.31	2.19	5.5	
Leucine	8.40			
Proline	3.00	4.5	3.5	
Serine	2.93	3.94	3.3	

The amino acids content of mango seed kernel are demonstrated in Table 3. Data in this Table showed that valine and phenylalanine achieved higher values compared to the

FAO/WHO reference (WHO, 1985) followed by threonine, lysine and tyrosine which were somewhat equaled to the reference. On the other hand, arginine and glutamic acids revealed the highest values of all non-essential amino acids in mango seed kernel content. Fowomola (2010) reported that mango seed is richer in different vitamins (Table 4). The presence of antioxidant vitamins such as vitamin C, E and A suggests that mango seed could be used as an alternative source of these vitamins.

Table 4: Vitamins contents of mango seed kernel

Vitamin	Amount (mg/100g)
A	15.27
E	1.30
K	0.59
B1	0.08
B2	0.03
B6	0.19
B12	0.12
C	0.56

2.4. Challenges and Limitation of Using Mango Seed-Kernel

2.4.1 Environmental Problem

Mango processing industries utilize up to 25% of the mangoes produced, equivalent to about 10 million metric tons per year worldwide and during its processing, huge amounts of peels and seeds are generated as by-products, which are oftentimes regarded as wastes. It can be estimated that during mango processing in different products it yields between 150,000 and 400,000 metric tons of wastes as by products worldwide, which may cause environmental problems in the vicinity of the processing plants as well as increasing labor requirements in the city and town (Beyene, 2015). Its disposal is a major problem among many fruit processing industries because such wastes are easily spoiled, degraded, and is a potential hazard to both people and the environment. The waste peels and seeds of mango amount to 35- 60% of the total fruit weight, of which mango peels form about 15-20% of whole mango fruit and the remaining 20-40% may be composed of the mango seeds. On the other hand, the

kernel inside the mango seed represents from 45-75% of the seed and about 20% of the whole fruit. This invention attempts to exploit such fruit wastes in order to recover more valuable compositions or products from such seemingly worthless by-products in fruit processing (Evelyn *et al.*, 2013). The use of mango wastes in livestock feeding is a way of reducing environmental concerns (Jedele *et al.* 2003; El-Kholy *et al.*, 2008).

2.4.2. Anti-nutritional factors of mango seed kernel

There are few reports on the use of MSK in livestock feeding, but the level of inclusion in poultry diets has been low because of the presence of anti-nutritional which reduces chicken growth (Odunsi, 2005; Tegua, 1995). Mango seed kernels are fairly rich in tannins, which progressively lead to reduced growth rates and less efficient feed utilization when included as a major component in diets for pigs and poultry (Moore, 2004). They also contain cyanogenic glucosides, (64 mg/kg DM), oxalates (42 mg/kg DM) and trypsin inhibitors (20 TIU/g DM) (Ravindran *et al.*, 1996). These anti-nutrients chelate divalent ions like Ca^{2+} , Mg^{2+} , Fe^{2+} , and Zn^{2+} and also react with the charged groups of protein and polysaccharides thereby forming indigestible complexes while the toxic substances interfere with nutrient bioavailability and utilization (Ravindran *et al.*, 1996).

2.4.3. Processing and Handling of Mango Seed Kernel for Feeding Purpose

Several treatments (soaking, boiling, HCl or NaOH treatment, autoclaving or HCl followed by $\text{Ca}(\text{OH})_2$) may remove tannins and HCN but the more effective proved to be is soaking as it removed 61% of the tannins and 84% of HCN (El Boushy *et al.*, 2000). The nutritive value of mango kernels was improved by boiling, which restored growth depressed with untreated kernels (Diarra *et al.*, 2008; Joseph *et al.* 1997). Boiling or autoclaving reduced anti-nutritional factors as tannins of trypsin inhibitors (Farag, 2001). Soaking without boiling could also reduce anti-nutritional factors to some extent but was not efficient enough to restore growth up to the level of the control diet (without mango kernels) (Ravindran *et al.*, 1996). Generally treatment of soaked and boiled MSK with $\text{Ca}(\text{OH})_2$ was found to effectively enhance the reduction of anti-nutritional factors to barest minimum, if not

complete removal. This implies that this processing method had greatly detoxified the MSK, thereby enhancing better utilization of the MSK in livestock and poultry nutrition.

2.5. Opportunities of Using Mango Seed Kernel for Animal Feeds

The world's top ten mango producers with their main varieties were identified and provided in Table 5. In the context of Ethiopia, mango is produced in the southern and western parts of the country. The total production of mango in Ethiopia is 72,187 tons in 2013/14 (CSA, 2014). This accounts for 7219 tons of mango seed kernel, annually. The production of mango at Arba Minch and Zuria Woreda is 126,800 qt with total area coverage of 634 hectares. Mango farmsteads in Asossa produce an average of 13,500 mangoes per farmstead (James *et al.*, 2008).

Table 5: World's top ten mango producers, 2015

No.	Country	Variety	Production (tons/year)
1	India	Alphonso, Badami, Chaunsa, Dasherri, Kesar, Jauhari, Lucknowi, Fazli, Totapuri, Banganapalli, Sindhuri, Kalmi, Neelam, Langra	16337400
2	China	Zillate, Mallika, Deshehari, Edward, Saigon, R2E2, Spooner, Bambaroo	4351593
3	Thailand	Brahm Kai Meu	2550600
4	Pakistan	Anwar Ratol, Langra, Sindhri, Chaunsa, Fajri, Samar Bahist, Dasehri, Saroli	1784300
5	Mexico	Ataulfo, Haden, Tommy Atkins, Kent, Keitt	1632650
6	Indonesia	Arumanis, Gedong	1313540
7	Brazil	Espada, Rosa, Bourbon, Uba	1188910
8	Bangladesh	Gopalbhog, Himsagar, Khirsapat, Langra, Fasli, Ashwina, Amropali	1047850
9	Philippine	Champagne mangoes	823,576
10	Nigeria	Kerosene, Sherri	790,200

The production of mango fruits for the past six years in Ethiopia was found from CSA (2009), and is summarized and presented below in Table 6. With an increase in Ethiopian mango crop production and considering the current postharvest loss of mango fruits is at 26.3%. There is not only a need but also a potential for the fruit to be processed into various product types, consequently increasing the market potential of the mango fruit (Kader and Truneh, 2009). Industrial processing opportunities, to increase the market value of the initial fruit, may lead to the potential development of the following products: - Food (mango juice and fizzy drinks, canned fruits and pulp, fruit leather, dried pieces, jam and chutney), domestic (mango detergent and cleaning agents), beauty (as an applied product in skin creams products), animal feed (Mango seed kernel, mango Peel, Saponin)

Table 6: Estimate of area, production and yield of Mango fruits, Meher season

Year	Number of holders	Area in hectare	Production quintal	in Yield (qt/ha)
2003/04 (1996) E.C	350,067	4,964.00	292,283.00	58.88
2004/05 (1997) E.C	414,574	5,814.00	301,715.00	51.89
2005/06 (1998) E.C	463,868	5,400.31	547,291.24	104.06
2006/07 (1999) E.C	558,976	6,796.10	626,111.83	94.08
2007/08 (2000) E.C	695,030	6,730.83	484,360.97	71.96
2008/09 (2001) E.C	716,447	6,051.00	441,582.00	72.97

2.5.1. Mango seed kernel application in ruminants and poultry nutrition

The overall chemical composition of mango seed kernels make it suitable for poultry feeding, despite the presence of anti-nutritional factors. The metabolizable energy value is low in dried raw kernels (7.9 MJ/kg DM) but increased after boiling up to 10.3 MJ/kg DM (Ravindran *et al.*, 1996). In broiler chicks, the inclusion of raw mango seed kernel meal generally results in degraded performance. Raw mango seed kernel meal included at 5–10 percent in the diet depressed feed intake and growth in broiler chicks (El-Alaily *et al.*, 1976). The incorporation of 5 percent raw mango seed kernel meal in layer chickens decreased laying rate and increased the weight losses in layers (Odunsi, 2005).

Inclusion rates as low as 5 to 10% depressed growth and feed intake in some experiments (ElAlaily *et al.*, 1976; Diarra *et al.*, 2008; Tegua, 1995) while performance was maintained at 10% inclusion rate in another trial (Odunsi, 2005). The recommendation for optimum growth is to use boiled mango seed kernels <5 percent in broiler chicks during the starter phase (0–28 days) and 10–20 percent in the diets of broilers during the finisher phase (28–63 days) on DM basis (Joseph and Abolaji, 1997; Diarra and Usman, 2008). Daily feed intake and feed conversion ratio (FCR) were significantly ($P<0.05$) improved on the 60% mango kernel diet inclusion in broilers compared to the control diets (Diarra *et al.*, 2010). The author also reported that there were no significant ($P>0.05$) treatment differences in final BW and ADG on the 60% mango kernel diet inclusion compared to the control diets. Diarra *et al.* (2010) were concluded also that up to 60% of the maize in broiler finisher diets can be replaced with boiled mango seed kernel meal (BMSKM) without adverse effects on the growth, health and carcass parameters. Hence, Diarra *et al.* (2011) was concluded that boiled mango kernel meal can replace 50% of maize in the diets of broiler chicks and up to 75% in the finisher diets.

Similarly, Faniyi (1997) reported that broiler birds can utilize up to 30% level of mango seed kernel meal as an energy source during starter and finisher phases but that appropriate protein and metabolizable energy (ME) requirements of the birds should be taken care of in the diets. In large ruminant animals, raw kernel meal seems to be better consumed and performance can be maintained (Diarra *et al.*, 2008; Odunsi *et al.*, 1997). Mango seed kernels can be incorporated in the large ruminant concentrate mixture up to 50 percent without any adverse effects (Göhl, 1982). In sheep, DM digestibility of dried seed kernels was 70 percent but intake was low (1.2 percent of BW), mainly due to the tannin content.

3. MATERIALS AND METHODS

3.1. Description of the Study Area

The feeding trial was conducted at Modjo town on private poultry farm which is located about 72 km South-East of Addis Ababa. The area has a latitude and longitude of [8°39'N 39°5'E / 8.650°N 39.083°E](#), respectively with an elevation of 1781 meters above sea level. The Modjo climate is mild, and generally warm and temperate with the average annual temperature of 20.1°C and rainfall around 863 mm per year and relative humidity of 59.9% (CSA, 2009).

3.2. Source and Processing of Mango Seed Kernel

The mango fruit waste (MFW) was collected from local fruit processing and juice houses in Addis Ababa and Hawassa cities. For the sake of minimizing contamination with other materials in fruit processing houses, wastes of mango were collected in clean plastic materials immediately after squeezing the juice. The MFW was then spread evenly on plastic sheets and allowed to sundry. After the waste was completely dried in the sun, the seed kernel was obtained by mechanically hammering it with sharp knife and removing the hard seed coat.

The kernel was soaked in cold water and boiled in tap water at 100⁰C for 20 minutes and again washed with cold water then sun-dried until it was become completely dry in order to prevent the growth of molds (Dakare *et al.*, 2012; Tegua and Beynen, 2005; Mbajunwa, 1995). Then the dried kernel was kept and tied in clean plastic bag labeled as boiled MSK (BMSK) to differentiate it from other feeds. Samples of both raw and boiled MSK were analyzed for proximate composition (AOAC, 1990) to use it in the formulation of the experimental diets. Finally the dried BMSK was mixed with other ingredients and grounded by machine (mill) until it has the same size as others conventional poultry feed ingredients with correct sieve size for easily consumption for the chicks.



Figure 1: Processing steps followed for preparing BMSK for broiler meal
 A=fresh MFW; B=breaking and collecting MSK; C= raw MSK; D=soaked MSK boiling; E=boiled and dried MSK

3.3. Experimental Diet

Four diets, in which BMSK replaced maize at 0, 5, 10, and 15%, respectively were formulated for the experimental birds. Kernel and diet proximate composition were analyzed by method of AOAC (1990). All the four diets were nearly made to contain isonitrogenous with CP of 21-19% and isocaloric with ME of 2.818-2.918 MJ/kg DM both for starter and finisher broiler feeds.



Figure 2: Preparation steps of experimental diets for broiler feeding

A=milling machine; B=milled BMSK; C=unmixed ration; D=mixing of ration; E=prepared experimental ration

Table 7: Experimental design of the feeding trial with Hubbard broiler chickens

Treatment diets	Proportions of diets	Replication	Birds per rep.	Total birds
T ₁	100% maize + 0% BMSK	3	13	39
T ₂	95% maize + 5% BMSK	3	13	39
T ₃	90% maize + 10% BMSK	3	13	39
T ₄	85% maize + 15% BMSK	3	13	39

T₁: control diet; T₂: diet with 5% BMSK; T₃: diets with 10% BMSK; T₄: diets with 15% BMSK; rep.: replication

3.4. Experimental Design and Ration Formulations

For this study the experiment was organized in a completely randomized design (CRD) with four treatments each with three replications. One hundred fifty six Hubbard broiler chicks were randomly assigned to the four treatment diets consisting of three replications (Table 7). Accordingly, maize of the control diet (T₁) was replaced by BMSK at levels of 5%, 10% and 15% for treatment 2 (T₂), treatment 3 (T₃) and treatment 4 (T₄), respectively.

Table 8: Proportion of feed ingredients of starter and finisher rations of Hubbard broiler chicks

Feed ingredients	Starter ration				Finisher ration			
	T ₁	T ₂	T ₃	T ₄	T ₁	T ₂	T ₃	T ₄
White maize	58.00	55.10	52.20	49.30	68.00	64.60	61.20	57.80
Soybean meal	19.50	19.50	20.00	20.00	18.00	18.00	18.00	18.00
Meat and bone meal	6.36	6.36	6.00	6.00	6.00	6.00	6.00	6.00
Nougseed cake	9.91	9.91	9.57	9.57	3.77	3.77	3.77	3.77
Wheat middling	4.00	4.00	4.20	4.20	2.00	2.00	2.00	2.00
Mango seed kernel	0.00	2.90	5.80	8.70	0.00	3.40	6.80	10.20
Salt	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Limestone	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09
Premix	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
DL-lysine	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
DL-methionine	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Total	100	100	100	100	100	100	100	100

Proportion of feed ingredients that were used to formulate control and treatment starter and finisher rations of the chicks is presented in Table 8. The broiler starter and finisher feed ingredients that was used for the experiment were purchased from Debre Zeit local market and food oil producing factory around and then formulated by taking the proximate composition of major ingredients (maize, soybean meal, nougseed cake, wheat middling and BMSK) and balancing with the nutrient requirement of broiler chicks.

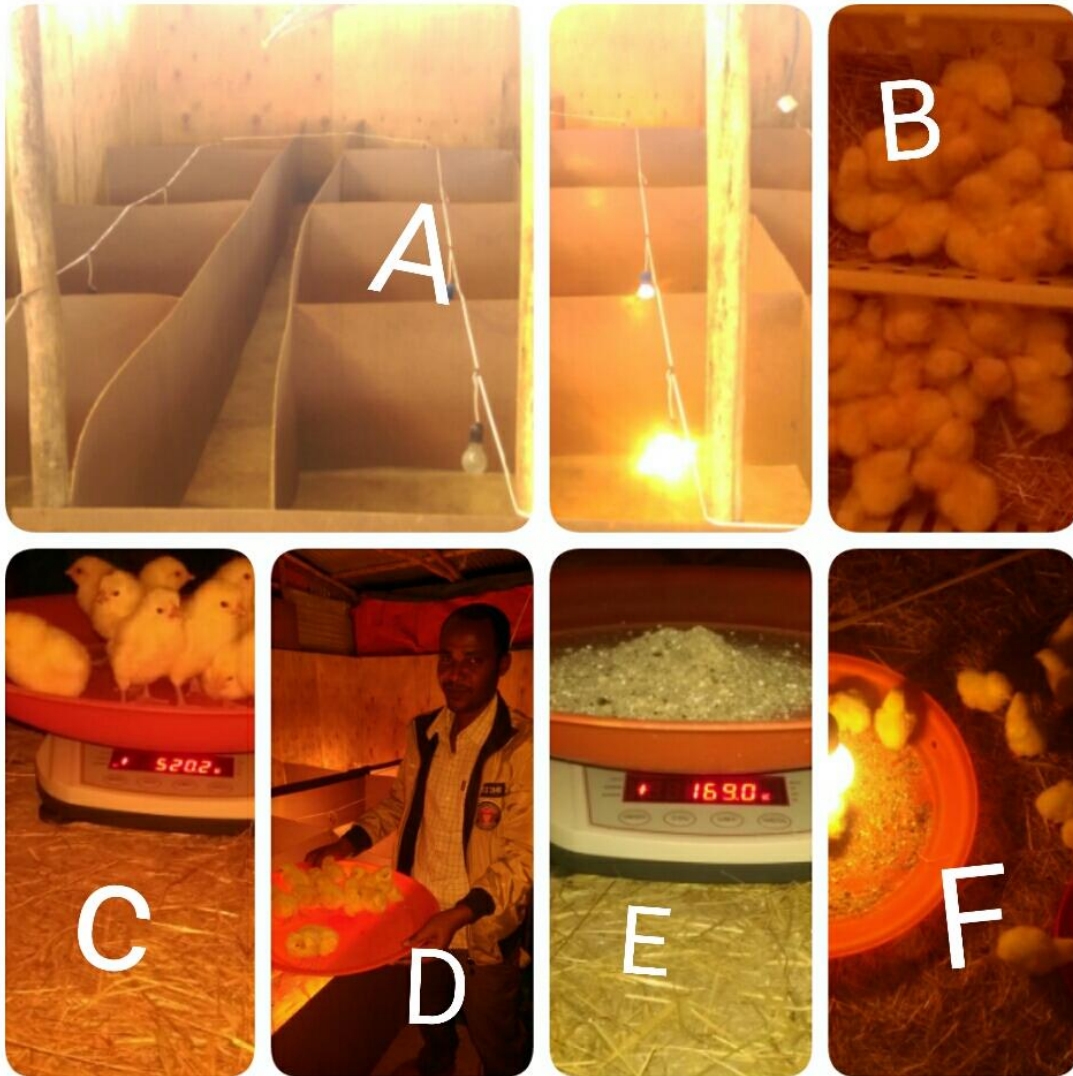


Figure 3. Design of experimental pen and delivering of experimental chicks and distributing
 A=3X4 experimental pen; B=unloaded chicks; C&D=weighing and distributing of chicks;
 E&F=weighing and supplying experimental diets to chicks within their pen

3.5. Chemical Analysis of Experimental Feeds

The nutrient compositions of feed ingredients and BMSK were analyzed at Ethiopian Institute of Agricultural Research head office (EIAR) laboratory, Addis Ababa, Ethiopia. Dry matter EE, CF and ash were determined according to AOAC (1990). Nitrogen was determined by Kjeldhal procedure and CP was calculated by multiplying N content by 6.25. The NFE was calculated indirectly by subtracting all other chemical compositions from 100 and the metabolizable energy (ME) values were also calculated indirectly from the CP, CF

and NFE adopting the equation proposed by Wiseman (1987). All samples were analyzed in duplicates.

3.6. Management of Experimental Animals

For the purpose of decreasing errors and balancing within and between all treatments, pens were properly cleaned, disinfected, well ventilated, and electrically heated before the arrival of the chicks. One-hundred fifty six Hubbard unsexed day-old broiler chicks were purchased from Passion Farm P.L.C at Denkaka Modjo. All the chicks were vaccinated against Gomboroo, Lasota and HB1 on days 5, 21 and 28, respectively by the health professionals and all other management practices such as removing dead chicks and monitoring their status, ventilating by removing the outer covering of the house during increased temperature and the reverse during decreased temperature, addition of fresh litter material and others were followed. Mortality was recorded as it occurred and expressed as percent mortality per treatment.

They were kept in 1 m x 1.5 m veneer partitioned deep litter floor housing, which was covered with *teff* straw litter material at 7 cm depth. The chicks were weighed in a group containing 13 chicks per replication to determine the initial BW. The thirteen chicks were randomly distributed to each of the 12 replications making a total of 156 chicks and fed with the treatment diets. They were fed twice a day at 8:00am and 1:00pm hours throughout the experimental period. The daily feed offer was given to the birds irrespective to the treatment diets at 30.7g during the starter phase average and 106.3g during the finisher phase average. Water was available at all times. Feed was offered in plastic plate and round feeders, whereas water was provided in plastic fountains. Vitamin premix was given through drinking water according to the recommendations given by the health professionals. The birds were fed on starter diet until the age of 3 weeks (21 days) and on finisher diet up to the end of the experiment (at age of 7 weeks).

3.7. Measurements

The experiment stayed for 7 weeks during which the daily feed intake and weekly BW measurements were considered. The refusals were collected, weighed and recorded every

day. The feed refused was weighed after removal of the external contaminants. The daily as well as total feed consumption of the birds were calculated as the difference between the amount of feed offered and refused. Body weight was measured at the start as initial BW and weekly per pen according to their pen identification numbers to calculate the BW changes and at the end of the experiment for final BW. Average daily BW gain (ADG) calculated by dividing the weight difference between 2 consecutive weighing by number of days in the week. Feed conversion ratio (g feed consumed/g BW gain) was also calculated. At the end of the experiment, 2 randomly selected chicks from each replicate were starved overnight (but provide clean and fresh drinking water *ad libitum*) and weighed immediately before slaughter (slaughter weight).

After then the weighed birds were bleed and the body was scaled in hot water for a minute and de-feathered manually, eviscerated and carcass cuts, the edibles (breast meat, thigh, drumstick, wing, back and neck) as well as the non-edibles (spleen, kidney and other) offal were weighed and recorded following to the procedure described by Kekeocha (1985) and Kubena *et al.* (1974). While cutting the total carcass, the breasts, thighs, drumsticks, wings, back, neck, giblet (gizzard, heart and liver) were separated as most important edible parts and their yield were categorized as carcass weight. Dressing percentage was then calculated as the proportion of carcass weight to the slaughter weight multiplied by 100. Abdominal fat was determined to assess the effects of BMSK substitution on fat deposition. Fat around the abdominal wall, cloacae, proventriculus and gizzard was collected and weighed. For all the measurements, sensitive balance of 0.1g precision was used.

3.8. Partial Budget Analysis

Partial budget analysis to estimate the economic benefit of each treatment ration was done according to Upton (1979). To estimate the net gain or lose as a result of replacing BMSK for maize, the feed expenses were considered as a variable cost and sale of live chicks was considered as a return. Market price of each feed ingredients were registered at the time of purchase in Birr per kg and average feed consumed by bird per kg were calculated and then multiplied by the cost of the ingredient to get the cost of feed per head in Birr for each treatment.

The calculation was done by using the formulae; Total Return (TR) was calculated as live weight in kg per chick and multiplied by price of one kg live weight of a chick at Bishoftu during the experimental period. Net return (NR) = TR-TVC (Total Variable Cost, in this case feed cost). Change in total variable cost (Δ TVC) was calculated as total feed cost of treatments containing BMSK (termed as experimental ration) minus total feed cost of treatments without BMSK (the control diet). The change in TR (Δ TR) was calculated as the difference between total incomes from the respective experimental treatments minus total income of the control. Change in NR (Δ NR) was calculated as NR of the respective experimental treatments minus NR of the control experiment. The marginal rate of return (MRR) was calculated as: $MRR = \Delta NR / \Delta TVC$ (Fekade *et al.*, 2019).

3.9. Data Analysis

The collected data were subjected to analysis of variance (ANOVA) for CRD consisting of four treatments and replicated 3 times using the General Linear Models (GLM) in R software versions R3.40.7034.0. Since significant differences were observed in some of the parameters, these differences between treatment means were separated using Tukey's Honest Significant Difference test. All statements of statistical differences or not were based on $p < 0.05$ or $p > 0.05$ unless noted otherwise. The following model was used for data analysis.

$$Y_{ij} = \mu + T_i + e_{ij},$$

Where, Y_{ij} = represents the j^{th} observation in the i^{th} treatment level,

μ = over all mean,

T_i = treatment effect and

e_{ij} = random error.

4. RESULTS

4.1. Effect of Processing Methods on Nutrient Contents of Raw and Boiled MSK

The nutrient contents of raw and processed MSK after applying the different processing methods (soaking, boiling, washing and sun drying) in comparison with white maize are presented below (Table 9) and the results were 8.74% CP, 92% DM, 69.57% NFE and 3275 kcal ME per kg DM and 10.02% CP, 90.84% DM, 53.57% NFE and 3047 kcal ME/kg DM for boiled and raw MSK, respectively and for white maize was also 8.4% CP, 88.90% DM, 71.17% NFE and 3258 kcal ME per kg DM .

Table 9: Proximate composition of maize, raw and boiled mango seed kernel

Constituent%	RMSK	BMSK	Maize
Dry matter (DM) (%)	90.84	92	88.90
Crude protein (CP) (%DM)	10.02	8.74	8.4
Crude fiber (CF) (%DM)	4.26	3.93	3.22
Ether extracts (EE) (%DM)	9.62	7.01	4.4
Total ash (%DM)	6.74	2.75	1.45
Nitrogen free extracts (NFE) (%DM)	53.2	69.57	71.17
Metabolizable energy (ME kcal/kg)	3047	3275	3258
Starch (%DM)	60.29	65.34	64.15
Moisture (%)	9.16	8	11.10

RMSK=Raw mango seed kernel, BMSK=Boiled mango seed Kernel

4.2. Chemical Composition of the Experimental Diets

Chemical composition of the starter and finisher ration used in the experiments, were summarized below in Tables 10. The CP (% DM), ME (kcal/kg DM) and all others were formulated for both starter and finisher broiler diets depending on the nutrients requirement of broiler chicken referring to the already documented references.

Table 10: Chemical composition of treatment diets used in the starter (1-21 days of age) and finisher (22-49 days of age) rations

Nutrient composition (%)	Starter ration (0-21 days)				Finisher Ration(22-49 days)			
	T ₁	T ₂	T ₃	T ₄	T ₁	T ₂	T ₃	T ₄
Dry Matter (%)	88.83	88.92	88.99	89.08	89.08	89.19	89.29	89.39
Crude protein (%DM)	20.63	21.00	21.00	21.00	18.2	18.2	18.2	18.2
Crude fiber (%DM)	4.60	5.00	5.00	5.00	3.49	3.55	3.60	3.66
Ether extract (%DM)	4.68	5.00	5.00	5.00	4.53	4.62	4.70	4.79
NFE (%DM)	48.68	47.37	47.28	47.28	56.56	56.46	56.32	56.20
ME(kcal/kg DM)	2817	2818	2815	2815	2913.4	2914	2914.5	2915.1
Ca (%DM)	1.19	1.00	1.00	1.17	1.13	1.14	1.14	1.15
P (%DM)	0.79	1.00	0.80	0.66	0.72	0.72	0.72	0.72

NFE= Nitrogen free extract; ME= Metabolizable energy; T₁: control diet; T₂: diet with 5% MSK; T₃: diets with 10% MSK; T₄: diets with 15% MSK

4.3. Effect of Boiled Mango Seed Kernel replacement for Maize on Feed Intake, Body Weight and Feed Utilization of Hubbard Broiler Chicks

As indicated below (Table 11) there was a decreasing trend of feed consumption observed as the BMSK was increased in replacing maize in the ration. Maximum ($p < 0.05$) feed intake was recorded in group assigned T_1 and T_2 diet. As indicated above from analyzed composition of the diet (Table 9), diet with 15% BMSK inclusion had the highest metabolizable energy. The significantly lower ($p < 0.05$) feed intake in birds fed with 15% BMSK (Table 12) was also observed; however, the differences in the present study were non-significant ($p > 0.05$) among the treatments.

The average initial BW of all groups are similar as planned and there was no significant ($P > 0.05$) difference among treatments. The average final BW of chickens fed with control and 5% BMSK included diet was significantly ($p < 0.05$) higher than those fed on 10% (T_3) and 15% (T_4) BMSK included diets but no ($p > 0.05$) significant differences between those fed on 10% (T_3) and 15% (T_4) BMSK included diets. As indicated in Table 11 chickens fed on the control and 5% BMSK (T_2) included diets had significantly ($p < 0.05$) higher daily weight gain (ADG) than the those fed on 10% (T_3) and 15% (T_4) BMSK included diets. Among treatment groups, chickens fed on 10% (T_3) and 15% (T_4) BMSK included diets had lower ADG, but higher daily feed to gain ratio than those of control and 5% BMSK (T_2) included diet group ($p < 0.05$).

The average FCR (g feed/g gain) of the chicken decreased as the BMSK levels were increased in the ration (Table 11). Best feed efficiency among different groups was noted in broiler fed on T_3 and (T_4) diets. Therefore, difference in FCR of treatment groups that fed on 10% BMSK and 15% BMSK inclusion levels were found statistically non-significant ($p > 0.05$). Regarding mortality, the number of died chicks was very few in some of the treatments even zero in the other and this was 2.5%, 5%, and 2.5% in T_1 , T_2 and T_4 , respectively. However, no mortality was observed in those chickens fed on T_3 diets.

Table 11: Growth performances of broilers fed different levels of boiled mango seed kernel meal

Performance parameters	T ₁	T ₂	T ₃	T ₄	SEM	sign
Mean initial BW (g/bird)	40.43	40	39.72	39.4	0.33	non
Average final BW (g/bird)	2657 ^a	2644 ^{ab}	2610 ^{bc}	2603 ^c	7.67	**
Average daily feed intake (g/bird)	71.38 ^a	70.82 ^a	68.13 ^b	68.23 ^b	0.46	***
ADG (g/bird)	53.4 ^a	53.15 ^{ab}	52.44 ^{bc}	52.31 ^c	0.16	**
Daily FCR (g feed/g weight gain)	1.33 ^b	1.28 ^d	1.30 ^c	1.36 ^a	0.01	***
Average feed intake(g/bird)	3569 ^a	3541 ^a	3406 ^b	3411 ^b	23.01	***
Average weight gain (g/bird)	2616 ^a	2604 ^{ab}	2570 ^{bc}	2563 ^c	7.69	**
Feed conversion ratio	1.36 ^a	1.36 ^a	1.33 ^b	1.33 ^b	0.01	*
Mortality (%)	2.5	5%	0.00	2.5%	1.09	non

^{a-d} = means within the same row bearing different superscripts differ significantly ($p < 0.05$); non-significant SEM: standard error of the mean; T₁: control diet; T₂: diet with 5% MSK; T₃: diets with 10% MSK; T₄: diets with 15% MSK

4.4. Effect of Mango Seed Kernel on Carcass Yield Parameters of the Chickens

The mean and the standard error of mean for carcass traits of the experimental chicken fed the four treatment diets were presented below (Table 12). Mean slaughter weight of chicken fed on control diet (T₁) was significantly ($p < 0.05$) higher than those fed on treatment T₄ (15% BMSK replaced maize) but there were no significant difference in slaughter weight ($p > 0.05$) between chickens fed on T₁, T₂ and T₃ diets. The dressed weight and dressing percentage of chicks fed on control diet (T₁) were not statistically significant ($p > 0.05$) than the other treatment groups. There were also no significant differences ($p > 0.05$) in dressing weights and dressing percentages between chickens fed on the treatment groups. Except for breast weight, the weights of prime cuts such as thighs, drumsticks, back, wing and neck had not significantly ($p > 0.05$) differ between both chickens fed on the treatment and control diets. The breast weight of chicken fed on control diet was significantly ($p < 0.05$) higher than those fed on 15% BMSK replaced maize (T₄) but there was no significant ($p > 0.05$) differences between the control fed group and those fed on 5% and 10% BMSK included diet group in breast weight. There was also no significant ($p > 0.05$) differences between the three treatment (treatment with BMSK included) groups in breast weight. Except for heart weight,

the inclusion of different levels of BMSK had no significant ($p>0.05$) effect on weight of all other visceral organs such as liver, gizzard and spleen compared to the control diet fed group. Among treatment diet fed and control diet fed groups, chickens fed on control group weighed significantly ($p<0.05$) higher heart weight than those fed on 15% BMSK included diets (T_4) but it had similar heart weight ($p>0.05$) with those fed on diets containing 5 and 10% BMSK included while those fed on diet (T_4) had lower heart weight than these two treatment group.

Table 12: Carcass yield traits of broiler birds fed different levels of mango seed kernel

Carcass traits	T₁	T₂	T₃	T₄	SEM	Sig.
Slaughter weight (kg)	2.606 ^a	2.604 ^{ab}	2.595 ^{ab}	2.588 ^b	2.68	*
Dressed weight (kg)	2.107	2.104	2.085	2.103	8.98	NS
Dressing percentage (%)	80.85	80.8	80.33	81.24	0.31	NS
Thighs (g)	184	180.8	179.2	177.3	1.27	NS
Drumsticks (g)	132.3	131.6	130.7	131.2	0.96	NS
Breast (g)	636 ^a	591.3 ^{ab}	580.9 ^b	583.3 ^b	8.20	*
Back (g)	302.6	312.3	300.2	300.7	2.19	NS
Wing (g)	119.7	117.7	119	117.7	0.67	NS
Neck (g)	70.33	70	69.67	69.67	0.40	NS
Skin (g)	107.3	102.7	105.7	102.3	1.91	NS
Spleen(g)	10	10	10	10	0.00	NS
Abdominal fat (g)	38.33 ^a	33.33 ^{ab}	31.67 ^{ab}	27 ^b	1.40	**
Gizzard weight (g)	55	55.67	55.3	52	0.79	NS
Liver weight (g)	55	56.33	56	57.33	0.50	NS
Heart weight (g)	26.93 ^a	25.33 ^{ab}	25.23 ^{ab}	24.33 ^b	0.35	*

^{a,b}: means within the row bearing different superscripts differ significantly ($p<0.05$); non- significant ($p>0.05$) otherwise; SEM: standard error of the mean; Sig.: significant level; T₁: control diet; T₂: diet with 5% MSK; T₃: diets with 10% MSK; T₄: diets with 15% MSK, NS: non-significant

Chickens fed on diets without BMSK (control) had significantly ($p<0.05$) higher abdominal fat weight than those fed on diets with 15% BMSK (T_4) but, birds fed on 5 and 10% BMSK included diets had similar ($p>0.05$) abdominal fat weights.

4.5. Partial Budget Analysis

Table 13: Cost of feeding as influenced by the feeding of MSK to broilers

Cost parameters	Treatment				SEM	sign
	T ₁	T ₂	T ₃	T ₄		
Total feed consumed/ head (kg)	3.57 ^a	3.54 ^a	3.41 ^b	3.41 ^b	23.01	***
Total feed cost/head (Birr)	48.06 ^a	47.05 ^b	46.26 ^c	45.25 ^d	0.31	***
Feed cost (Birr) /BW gain (g)/head	18.37 ^a	18.07 ^b	18 ^c	17.66 ^d	0.10	***
Total Variable Cost (feed cost in Birr)	48.06	47.05	46.26	45.25	NA	NA
ΔTVC (Birr)	-	-1.01	-1.804	-2.81	NA	NA
Total revenue						
Chick sale (gross return)(TR)(birr)	164.73	163.93	161.82	161.39	NA	NA
ΔTR (Birr)	-	-0.8	-2.91	-3.34	NA	NA
Net Return (NR)/chick(birr)	116.7 ^b	116.9 ^a	115.6 ^d	116.1 ^c	0.15	***
ΔNR (Birr)	-	0.21	-1.11	-0.53	NA	NA
MRR (%)	-	-0.21	0.62	0.19	NA	NA

ΔTVC: Change in Total Variable Cost; ΔTR: Change in Total Return; ΔNR: Change in Net Return; MRR: Marginal Rate of Return; Birr: Ethiopian unit of currency: chick sale= 62 Birr/kg live weight; T₁= 0% MSK; T₂= 5% MSK; T₃= 10% MSK; T₄= 15% MSK as replacement to maize, NA=not analyzed

The cost benefit analysis in terms of partial budget from Hubbard broiler chicks fed ration containing increasing level of BMSK replacing maize are presented in Table 13 above. There was a significant ($p < 0.05$) decrease in the cost of feed (Birr/kg) from the control to the treatment group. There was also a significant ($p < 0.05$) decrease in the feed cost per weight gain from control diet to treatment diets. Regarding net return, 116.9, 116.9, 115.6 and 116.1 Birr per bird was obtained from sale of chick on control and 5%, 10% and 15% BMSK diets, respectively, for the 7 weeks of experimental period. Marginal rate of return of -0.21 for T₂, 0.62 and 0.19 for T₃ and T₄, respectively was also calculated.

5. DISCUSSION

Unlike to the present results of the proximate composition both for boiled as well as raw MSK (8.74% and 10.02%, respectively) different authors (El Alaily *et al.*, 1976; Odunsi, 2005; Naveen *et al.*, 2006; Emeshaw *et al.*, 2012) reported to some extent a lower value in CP content ranged 3.8% - 6.74%. The value of processed CP is lowered than that of the raw MSK. This might be as a result of soaking and boiling which is in line with the observation of earlier report by Diarra *et al.* (2010) who obtained 8.7% CP value for RMSK and 8.63% value for processed MSK. Similarly, the same authors reported a higher range of values for the nitrogen free extractive (NFE) content of 68.10% - 79.00% while the present findings were 53.20% and 69.57%, respectively for raw and boiled MSK. The ME values for the present study for both raw as well as boiled MSK, respectively were 3047 kcal/kg DM and 3275 kcal/kg DM whereas authors (El Alaily *et al.*, 1976; Emeshaw *et al.*, 2012) reported 3154 kcal ME per kg DM and 3160 kcal ME per kg DM, respectively.

The NFE of the processed MSK is higher than the raw MSK but still within the range reported by Odunsi (2005) who found 61.6 g CP, 136.2 g EE, 22.3 g Ash, 46.4 g CF, 673.5 g NFE value used for poultry diet. The NFE content reported by El Alaily *et al.* (1976) (77.5%) and Naveen *et al.* (2006) (79.0%) was higher than the current result (69.57%); however, the NFE results of the current analysis for BMSK was higher (69.7) than the results of Emeshaw *et al.* (2012) (68.1%) for MFW and Odunsi (2005) (67.4%) for MSK. As we can see from the result, maize contained lower CP (8.4 %), DM (88.90%) and ME (3258 kcal/kg) than BMSK which contain CP (8.74 %), DM (92.0%) and ME (3275 kcal/kg). On the other hand, BMSK had lower NFE (69.57.1%) contents than Maize NFE (71.17%); however with contradiction with these results, Emeshaw *et al.* (2012) reported maize containing higher CP (8.8 %) and ME (3417 kcal/kg) than MFW. But with agreement to this result Emeshaw *et al.* (2012) found that maize contained higher NFE (79.1%) than MFW. The ash and CF contents obtained for the raw MSK was higher than that obtained for the processed MSK and this is in agreement with the report of Dakare *et al.* (2012) who obtained 2.19 and 1.67% ash, 2.82 and 2.47% CF for raw and BMSK, respectively.

Although boiling was taken as alternative solution for anti-nutritional factors reduction for this experiment, it has also attributed to the leaching of nutrients due to boiling. For example

the reason for the reduced protein content in the boiled kernel compared with raw MSK might be due to some denaturing of protein by heat as reported by Parsons *et al.* (1992) and the leaching of soluble proteins in the processing water. Mbajunwa (1995) also reported the leaching of soluble minerals in water. This might be used to explain the lower ash content of the boiled kernel as compared to the raw MSK in this experiment. Even if the percent contents of tannin was not analyzed in both raw and boiled MSK for this study due to the delayed laboratory results delivery from the laboratory directorate of EIAR and corona virus pandemic, there might be a maximum reduction of tannin in the soaked and boiled one which is supported by the findings of Mbajunwa (1995) who observed maximum reduction of tannin in the boiled kernel and Tegua and Beynen (2005) who suggests cooking of MSK for 20-30minutes in tap water is an efficient method of reducing the tannin content of feeds.

As tried to see from the results, the requirement for both protein (CP 21% for starter, CP 18.2% for finisher) and energy levels (ME 2816 kcal/kg DM for starter, ME 2915kcal/kg DM for finisher) of the four diets were found within the recommended levels for broiler chicks. This agrees with the results of Olomu and Offiong (1978) that recommended the ME requirement of the chicks as 2800-3000 kcal/kg for optimal performance of broilers. Oluyemi and Robert (1988) also recommended protein requirement for broilers raised in the tropics as 23-24% for starter and 19-20% for finisher broiler chickens. Pfizer (1996) also formulated the protein requirement of the starter broiler as 23% and that of finisher as 21% in the tropics. However, ME level of 2900 kcal/kg for both starter and finisher rations under local conditions was also recommended (Pfizer, 1996).

In the present study, there was a decreasing trend of feed consumption observed as the BMSK replacement for maize was increased in the ration. In agreement with the current report, Augustin and Ling (1987) reported a significant decrease of feed intake in chickens as the level of MSK increased. As indicated in results of this study of analyzed composition of the diet, diet with 15% BMSK inclusion had the highest metabolizable energy which may be responsible for the lowest feed intake in birds placed on T₃ and T₄ diet and in congruent with this report, Jansman *et al.* (1989) observed feed intake increased with decreased contents of ME of the feed and poultry consume feed to meet their energy requirement and *vice versa*.

The significantly lower ($p < 0.05$) feed intake in birds fed with 15% BMSK were the reasons for the significantly ($p < 0.05$) lower in FCR value on the 15% inclusion diet and this agrees with the findings of ME El-Alaily *et al.* (1976) who observed increased feed intake in lower ME content diets containing MSK in comparison to maize and the tendency of chicks to balance their energy intake from diets containing different levels of MSK. Feed intake observations of the present study are in good agreement with earlier observations of Patil *et al.* (1982) and Patle (1980) who found no significant differences in feed intake of birds fed MSK at the levels of 141, 282 and 428g per kg but this declined as the levels increased.

The average BW of chickens fed with control and 5% BMSK included diet was significantly ($p < 0.05$) higher than those fed on 10% (T_3) and 15% (T_4) BMSK included diets but no ($p > 0.05$) significant differences between those fed on 10% (T_3) and 15% (T_4) BMSK included diets. Congruent with this findings Emshaw *et al.* (2012) found the average BW of chickens fed with control and 5% MFW included diets was not different but decreased as the level of MFW increased. In this study, chickens fed on the control and 5% BMSK (T_2) included diets had a higher ADG than those fed on 10% (T_3) and 15% (T_4) BMSK included diets. Among treatment groups, chickens fed on 10% (T_3) and 15% (T_4) BMSK included diets had lower ADG, but higher daily feed to gain ratio than those of control and 5% BMSK (T_2) included diet group. This agrees with the results of Emshaw *et al.* (2012), who reports that, chickens fed on increased MFW diet had the lowest ADG but higher feed to gain ratio than those of control diet.

The reason for this lower ADG might be due to the effect created during their starter phase by the presence of tannin in increased level of BMSK that might not be completely removed through the processing methods used than maize that was replaced in the feed ingredients. These results also agrees with the observations of earlier workers Odunsi (2005) and Tegua (1995), who reported that, a significant increase of BW and ADG in broiler chickens fed up to 10% MSK and then declined as the level of MSK inclusion increased at the expense of maize in the ration. The average FCR (g feed/g gain) of the chicken decreased as the BMSK levels were increased in the ration which is the sign of good performance quality of the chicks although Emshaw *et al.* (2012) reported FCR increased as the levels of MFW substitution increased. In contrast to the current result, Hussain *et al.* (1976) and El-Alaily *et*

al. (1976) also reported that, the feed efficiency of chickens reduced as MSK inclusion increases in the feed factored by the presence of tannin in MSK. Best feed efficiency among different groups was noted in broiler fed on T₃ and (T₄) diets which has the lowest FCR that indicates best performance quality of the chicks fed on increased BMSK feed. The present findings are in good agreement with those of El Alaily (1976), who reported that, using the processed MSK has improved chick performance. Therefore, difference in FCR of treatment groups that fed on 10% BMSK and 15% BMSK inclusion levels of MSK were found statistically non-significant ($p>0.05$). Thus increasing BMSK to 15% level in broiler diet decreased the quantity of feed needed for each unit of weight gain and decreased FCR of the chickens.

There was the decline in slaughter weight of chicks across the treatment groups following the increase in level of MSK from 5%-15% in small amount. The reason for decline in slaughter weight as the level of MSK increases might be due to the presence of some anti-nutritional factors like tannin in MSK although some of them may be reduced through boiling as processing method (Dakare *et al.*, 2012). The current findings are in good agreement with the findings of Emshaw *et al.*(2012), who reported that chickens fed on increased levels of MFW had similar ($p>0.05$) slaughter weight while those fed on diet without MFW (control) had significantly ($p<0.05$) higher slaughter weight than those fed on diets with lower MFW inclusion. There was also similar ($p>0.05$) dressing percentage across all control and treatment group. In congruent with the current result, Odunsi (2005) and Emshaw *et al.* (2012) also found dressing percentages of chickens fed on increased MFW level and control diets did not differ significantly ($p>0.05$). Previously, Odunsi and Farinu (1997) also reported dressing percentages of the birds fed 0, 10, 20% MSK and were 71.04, 73.3 and 71.8, respectively which is in agreement with the current findings. Similarly, Scanes *et al.* (2004) and Maigualema and Gernat (2003) also observed 70% dressing percentage for broiler chickens that is also in good agreement with the present study. Besides, a comparable dressing percentage of 67% for Rhode Island Red unsexed chickens fed on fishmeal up to 12 weeks of age was also reported by Tegene and Asrat (2010). On the other hand, dressing percentage of 63% for Rhode Island Red chickens kept on choice feeding of energy or protein feeds under intensive and semi intensive management conditions was also observed by Negussie (1999).

In agreement with these results, Emshaw *et al.* (2012) and Odunsi (2005) also observed as there was no differences between chickens fed on MFW included and control diets in thighs and drumsticks weights. In agreement with this finding Diarra *et al.* (2010) observed as there were no differences among the treatments (those fed on graded levels of MSK) and the control group which is the indication of nutritional adequacy of all the diets. The significant differences observed in breast weight between the control diet and the 15% BMSK included diet fed group might be due to the decrease in live weight observed in increased level of BMSK diet in the treatment assigned (T₄). In line with this present report, Sign *et al.* (2015) obtained no differences in all visceral organ weights between groups fed on control and MSK included diets. Among treatment diet fed and control diet fed groups, chickens fed on control group weighed higher heart weight than those fed on 15%BMSK included diets (T₄) but it not different heart weight with those fed on diets containing 5 and 10% BMSK included while those fed on diet (T₄) had lower heart weight than these two treatment group which are in line with the findings of Odunsi (2005).

From this result, it can be clearly pointed out that feeding BMSK up to the level of 15% in the broiler ration had no adverse effect on vital organs of the broilers. Chickens fed on diets without BMSK (control) had higher abdominal fat weight than those fed on diets with 15% BMSK (T₄) but birds fed on 5 and 10% BMSK included diets had the same abdominal fat weights which agrees with similar reports of Emshaw *et al.* (2012) that chickens fed on diets without MFW had higher abdominal fat weight than those fed on diets with different levels of MFW; however, the author also observed a the same abdominal fat weights on birds that fed the 10, 20 and 30% MFW.

The mortality observed was very low and even zero in some of the treatment. This low mortality of chicks in all treatment and control groups was due to effective management and routine husbandry practice followed from the preparation; spacing, disinfecting, and other technical aspects happened in the house and finally timed vaccination and effective feed and water provided. The other reason might also be due to the kernel of the mango fruit that has no any deleterious health effects on the chicks and this also proves that there was an effective processing to properly remove its anti-nutritional factors. According to Berardini *et al.* (2005) MSK was also used widely in Ayurvedic medicines for treatment of different ailments

and this also helped prevent chick death throughout the experimental period. The presence of antioxidant vitamins such as vitamin C, E and A suggests that mango seed could be used as an alternative source of these vitamins also which may help reduce the risk of diseases (El Alaily *et al.*, 1976).

There was a decrease in the cost of feed (Birr/kg) from the control to the treatment group. This reduction in the total cost of the feed with the increase in the level of MSK was the result of the price difference between MSK and maize at the time of the experiment and this current findings agreed with findings of Diarra *et al.* (2010) who observed that there was a reduction in the feed cost (N/kg) with the increase in the level of mango kernel as a result of the price difference between mango kernel and maize. There was also a decrease in the feed cost per weight gain from control diet to treatment diets and this was favored by the decline in the feed cost per kg of chick BW from the control group to the treatment group. In line with the current results, Diarra *et al.* (2010) found the significant decrease in the feed cost per weight gain from control group to the treatment group with increased MSK inclusion. As it was already discussed above the weight gain of the treatment group was decreased as the level of MSK inclusion increased which was the result of the suspected tannin contents in the MSK that may affect the digestibility of feed at the starter phase of the chicks.

In the present study, the net return from chicks fed on control diet was higher than that of the treatment groups and there were also a decrease in the net return from T₂ fed chicks to T₄ fed chicks as the level of BMSK inclusion increased from 5% through 10% to 15%. Accordingly, broiler chicks fed on treatment (ration containing 0% MSK and 5% BMSK included) diets returned a higher profit than those fed on ration containing 10% and 15% BMSK diets. The highest net return for T₁ (0% BMSK) in the current study might be due to higher live BW of the chicks than the treatment groups. In addition, T₁ feed was free from anti-nutritional factors like tannin with compared to the treatment groups which might have suspected anti-nutritional factors including tannin even though not caused a deleterious health effect on the chicks performance. From the MRR results we can see also minimal difference between the treatment groups. Therefore, under the condition of the current experiment, BMSK can replace maize economically up to 15% without affecting both Net Return and MRR from replacing BMSK by Maize in broiler feed.

6. CONCLUSION AND RECOMMENDATIONS

6.1. Conclusion

To conclude from this study, compared to raw MSK, the combination of soaking in cold water plus boiling for 20 minutes, then washing and drying in the sun, changed the nutrient composition of BMSK and improved subsequently its fiber content, DM, NFE, ME but decreased the CP. For this reason this method is effective in processing MSK to be used as broiler feed. Nevertheless, compared to the control diet, chickens fed diets including BMSK did not achieve similar performance and showed lower average daily weight gain. Therefore, this feed stuff needs further research to completely make free from the anti-nutritional factors for effective utilization of it for livestock feed in general and the chickens in particular.

The replacement of maize with BMSK in different level resulted in a difference in feed intake, ADG, FCR, live weight gain, abdominal fat, breast weight and in some visceral organs like heart weight whereas dressed weight, dressing percentage, drumstick, thigh, back, neck, wing, liver, spleen, gizzard and skin weight were not different between the birds that fed the control diet and the treatments. The profitability of replacing maize with BMSK revealed that the control diet was the profitable one than the treatment diets regarding NR. The mortality recorded from the starting to the end of the experiment among the treatments was nil to count. With all, it is concluded from this study that replacing maize with BMSK up to the level of 15% were not had an adverse effect on the performance of broiler chicken and can be recommended.

Moreover, since price of MSK is cheaper than the price of maize and even other feed ingredients, which can also reduce the competition between human and chicken for cereals in general and for maize in particular, its utilization as chicken feed would be beneficial to the poultry industry to minimize production expenses associated with high conventional feed costs. In addition, in line to solving a problem of competition between poultries and humans for cereal grains especially maize, inclusion of MSK in the diets of chicken's can contribute in reducing the disposal problems of such wastes in the town and cities. Thus, further study

on feeding of MSK as both proteins and as energy source for layers and other species of livestock like ruminant animal may be warranted.

6.2. Recommendations

- Since there was slight differences in some parameters between the control and the treatment group which might come from the tannin content in BMSK which was not completely removed by the boiling without chopping, chopping prior to boiling may be a more efficient way of reducing tannin through increased surface area of contact with the boiling water which was not done in this work and may need further investigation in this regard.
- For effective waste disposal and better utilization from the waste of the mango fruit in general and MSK in particular, there must be the policy update regarding the recycling and use of wastes from these horticultural trees in such a way that it will minimize its threat to both human being and the environment.
- There must also be emphasis from all the concerned bodies on solving the crisis on poverty issues through increasing the output from the livestock sector in general and poultry industry in particular by using such alternative non-conventional feed resources mobilization and feeding the livestock and decreasing the competition between man and animal for the same products.
- As a value addition to the horticultural products in general and mango fruit in particular, there must be a technology that ease the processing these by products with minimum labor and cost to different products including as animal feed specially poultry so that the income from both mango and livestock sector will increase.
- From job creating points of view in collecting and processing of these wastes to use it in such important sector, there are huge participating jobless peoples to fed themselves and improve their life too through contributing in availing the crisis on food and feed between man and animal.

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8. APPENDICES

Appendix I:

Daily feed Intake Data Record Sheet

Experiment type: Boiled Mango seed kernel

Breed type: Hubbard classic

Treatment No: _____ **Pen No:** _____ **Replication No:** _____

Day	Date	Week	No of birds	feed offer (g)			Total feed refused (gm/total)	Feed offered (gm/bird)	Feed refused (gm/bird)	Mortality	Remark
				am	pm	total					
								-			

Appendix II:

Weekly Body Weight Change data Record Sheet

Experiment type: Boiled Mango seed kernel

Breed type: Hubbard Classic Broiler Chicken

Treatment No: _____ Pen No: _____ Replication No: _____

TR	Date	Age (days)	Age Week	No of birds weighed	Total wt (gm)	Average wt (gm)		Date	Age (days)	Week	No of birds weighed	Total wt (gm)	Average wt (gm)

Appendix III: Analysis of Variance Tables

Appendix Table 1: Analysis of Variance of Feed Intake (g/chick)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	65117	21706	36.53	5.12e-05 ***
Error	8	4753	594.1322		
Corrected Total	11	69870	6351.818		

CV= 93%

Appendix Table 2: Analysis of Variance of average Daily feed intake (g/chick)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	26.047	8.682	36.53	5.12e-05 ***
Error	8	1.901	0.238		
Corrected Total	11	27.948	2.54		

CV=93%

Appendix Table 3: Analysis of Variance of average Daily FCR (g/chick)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	0.0114765	0.0038255	77.923	2.911e-06 ***
Error	8	0.0003927	0.0000491		
Corrected Total	11	0.0118691	0.001079		

CV=97%

Appendix Table 4: Analysis of Variance of average FCR (g/chick)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	0.0034613	0.00115376	6.0044	0.0191 *
Error	8	0.0015372	0.00019215		
Corrected Total	11	0.0049985	0.0004544		

CV=69%

Appendix Table 5: Analysis of Variance of average Initial weight (g/chick)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	1.7218	0.57393	0.3719	0.7757
Error	8	12.3457	1.54321		
Corrected Total	11	14.0675	1.278		

CV=12%

Appendix Table 6: Analysis of Variance of average Final weight (g/chick)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	6201	2066.9	10.54	0.00374 **
Error	8	1569	196.1		
Corrected Total	11	7770	706.36		

CV=80%

Appendix Table 7: Analysis of Variance of average weight gain (g/chick)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	6062.8	2020.93	9.2674	0.005558 **
Error	8	1744.5	218.07		
Corrected Total	11	7807.3	709.7545		

CV=78%

Appendix Table 8: Analysis of Variance of average Slaughter weight (g)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	607.86	202.621	4.8103	0.03363 *
Error	8	336.98	42.122		
Corrected Total	11	944.84	85.895		

CV=64%

Appendix Table 9: Analysis of Variance of average Dress weight (g)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	916.3	305.44	0.251	0.8585
Error	8	9736.3	1217.04		
Corrected Total	11	10652.6	968.41		

CV= 8.6%

Appendix Table 10: Analysis of Variance of average Dressing percentage

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	1.2692	0.42307	0.2939	0.8289
Error	8	11.5159	1.43949		
Corrected Total	11	12.7851	1.16228		

CV= 9.93%

Appendix Table 11: Analysis of Variance of average Thigh weight (g)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	73.172	24.391	1.3964	0.3128
Error	8	139.737	17.467		
Corrected Total	11	212.909	19.355		

CV=34.37%

Appendix Table 12: Analysis of Variance of average Drumstick weight (g)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	4.041	1.347	0.0914	0.9627
Error	8	117.916	14.739		
Corrected Total	11	121.957	11.087		

CV=3.3%

Appendix Table 13: Analysis of Variance of average Breast weight (g)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	6133.0	2044.32	5.9475	0.01959 *
Error	8	2749.8	343.73		
Corrected Total	11	8882.8	807.53		

CV=69%

Appendix Table 14: Analysis of Variance of average Back weight (g)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	286.76	95.585	2.2146	0.164
Error	8	345.29	43.161		
Corrected Total	11	632.05	57.46		

CV=45.37%

Appendix Table 15: Analysis of Variance of average Wing weight (g)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	9	3	0.48	0.7051
Error	8	50	6.25		
Corrected Total	11	59	5.36		

CV=15.25%

Appendix Table 16: Analysis of Variance of average Neck weight (g)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	0.9167	0.30556	0.1222	0.9444
Error	8	20.0000	2.50000		
Corrected Total	11	20.9167	1.9015		

CV=4.4 %

Appendix Table 17: Analysis of Variance of average Skin weight (g)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	52.33	17.444	0.324	0.8082
Error	8	430.67	53.833		
Corrected Total	11	483	43.909		

CV=10.84%

Appendix Table 18: Analysis of Variance of average Heart weight (g)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	10.4636	3.4879	4.9019	0.03211 *
Error	8	5.6923	0.7115		
Corrected Total	11	16.1559	1.4687		

CV=64.77%

Appendix Table 19: Analysis of Variance of average gizzard weight (g)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	25.503	8.5008	1.216	0.3649
Error	8	55.927	6.9908		
Corrected Total	11	81.43	7.4027		

CV=31.32%

Appendix Table 20: Analysis of Variance of average liver weight (g)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	8.3333	2.7778	1.0417	0.4251
Error	8	21.3333	2.6667		
Corrected Total	11	29.6666	2.6969		

CV=28.1%

Appendix Table 21: Analysis of Variance of average abdominal fat weight (g)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	196.92	65.639	8.7519	0.006599 **
Error	8	60.00	7.500		
Corrected Total	11	256.92	23.356		

CV=76.7%