EFFECT OF INCREMENTAL LEVELS OF AVOCADO POMACE ON PERFORMANCE AND CARCASS PARAMETERS OF BROILER CHICKENS

MSc. THESIS

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DEDICATION

I dedicate this thesis to my beloved grandmother **Titiru Tiro Gota,** unfortunately, who passed away before I start master's program.

STATEMENT OF THE AUTHOR

I declare that this thesis is my own original work and all sources of materials used for this study is duly acknowledged. I declare that this thesis is not submitted to any other institution anywhere for the award of academic degree, diploma or certificate.

Name: ________________________________ signature________________

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BIOGRAPHICAL SKETCH

The author was born in Yirgalem on February 28, 1995 from his father Ato Sintayehu Birhanu and his mother W/ro Almaz Adamo. He obtained his elementary education from Bookasso and Ras Desta elementary and junior school in Yirgalem and did his high school education at Yirgalem higher secondary School. He completed his preparatory education at Yirgalem preparatory School. Then, he joined Debre Tabor University from November 2013 to June 25, 2015, and graduated with Bachelor of Science in Animal Science. In September 2016, he joined Yirgalem Agricultural office as expert and from June 2018 he joined Southern Agricultural Research Institute and served as Researcher. Subsequently, in September 2023 he joined School of Animal and Range sciences, College of Agriculture, Hawassa University, ,to pursue MSc in Animal Production.

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LIST OF ABRIVATIONS

ANF	Anti- nutritional Factor
AOAC	Association of Official Analytical Chemist
APM	Avocado pomace meal
CBMG	Cobb Broiler Management Guide
CF	Crude Fiber
CFR	Conventional feed resource
CP	Crude Protein
CSA	Central Statistical Authority
DM	Dry Matter
EDTA	Ethylene di amine tetra-acetic acid tube
EE	Ether Extract
FAO	Food and Agriculture Organization
FL	Femtoliters
Hb	Haemoglobin
ILRI	International Livestock Research Institution
ME	Metabolisable Energy
NCFR	Non-Conventional Feed Resources
MCV	Mean cell volume

MCHC	Mean corpuscular haemoglobin concentration
PCV	Packed Cell Volume
PG	Pictogram
RBC	Red Blood Cell
SCT	Sodium citrate tubes
SEM	Standard Error of Means
SPSS	Statistical Package for Social Science
UNIDO	United Nations Industrial Development Organization
WBC	White blood cell

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EFFECT OF INCREMENTAL LEVELS OF DIETARY AVOCADO POMACE ON PERFORMANCE AND CARCASS PARAMETERS OF BROILER CHICKENS

By: Sidirak Sintayehu

Advisor: Professor Ajebu Nurfeta

ABSTRACT

The utilization of fruit and vegetable by-products can contribute to the supply of animal feeds, improve feed deficiency, decrease the costs of livestock feeding, and also mitigate environmental problems by converting these wastes into useful human food. This study investigated the effect of different levels of dried avocado pomace meal (APM) in broiler diets on feed intake, growth performance, carcass parameters, mortality and hematology of broiler chickens. A total of 144 day-old coob-500 commercial broilers were assigned to 4 treatments, each replicated into 3 pens with 12 chicks per replicate. Isocaloric and isonitrogenous treatment diet were formulated. The treatments were a control diet without APM (T_1), 5% (T_2), 10% (T_3), and 15% (T_4) Avocado pomace meal (APM) inclusion in the total diet. The actual experiment lasted 42 days. Data on feed intake, live weight changes, growth rate, feed conversion ratio, and mortality were taken. At the end of the experiment, two chickens randomly taken from each pen were slaughtered for carcass evaluation. The APM contains 9.07%, 25.61%, 9.23%, 19.07%, 30.55%, and 3070.24kcal/kg DM of ash, ether extract, crude protein, crude fiber, nitrogen-free extract, and metabolisable energy, respectively. The feed intake of broilers decreased ($P < 0.05$) with increasing levels of APM in the diet. The highest ($P<0.05$) feed intake and average daily gain was observed for T1 compared with T4 during the entire experimental period. The highest ($P<0.05$) feed conversion ratio was recorded for T4 and lowest ($P<0.05$) for T1. In almost all carcass characteristics and non-edible offal the highest ($P<0.05$) values were obtained in T1 than T2, T3 and T4. The hematological and biochemical profile were similar ($P>0.05$) among treatment except platelets. The platelets for T3 and T4 were higher ($P<0.05$) than that of T1. The water holding capacity was similar ($P > 0.05$) among treatments. The average cooking loss for T4 was greater ($P<0.05$) than T1. In conclusion poor performance by the birds was observed in APM fed treatments indicating that avocado pomace meal is not a suitable feed for commercial broilers. Further studies are required to establish the causes of the poor performance of broilers consuming APM whether it can be rectified.

Key words: *Anti-nutritional factor. Avocado pomace meal; Blood chemistry, Carcass cuts; Feed conversion ratio*

1. INTRODUCTION

In Ethiopia, the total chicken population is estimated at about 57.1 million (CSA, 2023). The majority of the chicken population is almost entirely composed of indigenous breeds, which constitute 78.85%, 12.04%, and 9.11% indigenous, hybrid, and exotic, respectively (Tamiru and Lensa, 2023). In terms of breed, 34.26% correspond to laying hens and 32.86% to broilers, which produce around 77,000 metric tons of meat annually (Aman, 2024). Poultry production contributes to poverty alleviation and socio-economic inclusion of vulnerable groups such as the urban poor, women, the disabled, orphans, and the unemployed to provide them with a decent livelihood (Gororo and Mabel, 2016). Besides, poultry is a staple of many diets around the world because many consumers believe eggs to be an economical source of calories and animal protein (Alig et al., 2023).

In Ethiopia, trends in meat production are moderately rising, with some fluctuations (CSA, 2018; FAO, 2018; Birhanu, 2019). According to the Ethiopian livestock master plan, chicken meat production is projected to increase from 48,900 tons in 2015 to 164,000 tons in 2020, which is a 247% increase (Shapiro et al., 2015). However, consumption of poultry meat and eggs in the country is very low compared to other African countries. On the other hand, the demand for poultry products is generally increasing rapidly (Dana et al., 2006; FAO, 2018). Generally, the demand for animal-sourced foods is not yet met in Ethiopia (FAO, 2018). Regardless of the farming system implemented in developing countries, the supply, quality, and price of feed components greatly restrict the broiler industry's ability to produce animal proteins (Shapiro et al., 2015; Ugwuowo et al., 2019). Poultry producers are constantly complaining about the high cost and quality of poultry feed. The quality of the mixed feed used is generally poor, and most formulations available do not have vitamin or mineral premixes (EIAR, 2016). The cost of raw materials varies by region and the availability of resources. Prices of mixed feed remain excessively high even at times when the price of the major component of mixed rations falls by more than 50% (Tadelle et al., 2001). Therefore, using freely accessible and reasonably priced local feed sources could increase poultry productivity (Lukuyu et al., 2011).

To solve the feed problem for many years now, formulating inexpensive, high-quality feeds requires highly nutritious ingredients that are easily accessible, and their market prices are low (Masenya et al., 2021). Consequently, many researchers all over the world have investigated various alternative feed ingredients that can partially or completely replace conventional meal parts, with more recent attention directed to the use of agricultural by-products (Iqbal et al., 2021). Such alternatives should have comparable nutritional value but be cheaper than conventional energy and protein sources. Even though conventional feedstuff components are becoming progressively costly, indication shows unconventional resources can sustain efficiency and productivity in poultry. Several wastes, such as peels and seeds of fruits and vegetables (Ismail et al., 2004), raw fruit extracts (Ganhao et al., 2010), and other food waste sources, which are considered industrial wastes, can also be used alone or as supplements to improve the productivity of animals (Leontopoulos et al., 2021). Another important incentive is to find ways of utilizing agricultural waste products and residues, such as avocado pomace.

The utilization of fruits and vegetable by-products can contribute to the supply of animal feeds, improve feed deficiency, decrease the costs of livestock feeding, and also mitigate environmental problems by converting these wastes into useful human food (Wadhwa et al., 2015; Wadhwa et al., 2013). The avocado industry uses the pulp for human consumption and discards the skin and seed as waste. According to Ejiofor et al. (2018), 100 grams of dried avocado seed contain about 49.03 grams of carbohydrate, 17.90 grams of lipid, 15.55 grams of protein, 2.26 grams of ash, and 15.10 grams of moisture. Papetti (2019) pointed out that avocado by-products, peels and seeds, contain relatively significant amounts of carbohydrates, proteins, lipids, fibers, and high amounts of bioactive compounds like tannins and phytates. According to George et al., (2020) dietary inclusion of avocado seed meal (*Persea americana*) did not significantly affect the carcass yield and hematological profile of broiler chickens. Van Ryssen (2013) pointed out that substitution of avocado meal at 0%, 10%, 20%, 30%, and 40% level of the maize decreased feed intake, average daily gain, and feed conversion efficiency linearly as the level of Avocado meal in the diet increased. Therefore, the aim of the present experiment was to investigate the effect of avocado pomace meal on feed intake, feed conversion ratio, body weight gain, carcass characteristics and hematology of broiler chickens.

1.1. Statement of the Problem

In Ethiopia, avocado is grown on a total of 20,908.00 hectares, with a production of 104,492 metric tons. Its output ranged from 13,888 metric tons in 2001 to 104,492 metric tons in 2019 (FAOSTAT, 2020). Approximately 36% of the nation's annual avocado production comes from the Sidama region (Tibebu et al., 2023). Sunvado Agro-industry at Yirgalem Agro-Industrial Park processes 40–50 tons of avocados per day, with the capacity to process 80 tons. Such factories are being established in different parts of Ethiopia. The factory extracts oil for export, which is 5% of the total processed avocado, suggesting that 95% of the avocado by-product is available to be used as animal feed (UNIDO, 2023). This huge amount can be used to solve the prevailing feed shortage in the area by surrounding farmers if a proper method of utilization is devised. By using such by-products, feed costs and feed scarcity could be reduced. However, to date, no information is available on the effects of incremental levels of avocado pomace in poultry diets. The effect of feeding avocado waste to broilers on feed intake, growth performance, and carcass characteristics has not been fully investigated, and pertinent data for poultry is lacking in Ethiopia.

1.2. Significance of study

Different factors, including high feed costs, which constitute more than 70% of total production costs, affect chicken production. Functional feed ingredients such as avocado pomace can be incorporated into poultry diets as natural sources of nutrients and biologically active substances to deliver sustainable production. Pomaces are agro-industrial waste by-products that have no direct food value for humans. Their utilization as feed ingredients would reduce feed-food competitions, optimize poultry production systems, and promote environmental, economic, and social sustainability. Large quantities of fruit pomace are generated and disposed of in landfills or through incineration with little regard to the environment. Thus, their inclusion in poultry feeds could offer a long-term strategy to protect the environment. Valorizing fruit pomaces to enhance poultry production would also contribute toward sustainable development goals and food security through the provision of affordable, high-quality protein to the rapidly growing human population. Moreover, the use of fruit pomace complements food production systems by ensuring that food animals are reared on human-inedible feedstuffs.

1.3 Objectives

1.3.1 General objective

- To investigate the effect of the incremental level of processed avocado pomace meal on broiler chicken performance and hematological parameters.

1.3.2 Specific objective

- To investigate the effect of processed avocado pomace meal on feed intake, feed conversion ratio, body weight, body weight gain, and carcass characteristics of broiler chicken.
- To investigate the hematological and biochemical parameters of broiler chickens fed with avocado pomace meal.

2. LITERATURE REVIEW

2.1 Patterns of Broiler Chicken Production and Meat Consumption in Ethiopia

Poultry production is affected by factors such as breeds of chicken used, environmental conditions, feeding practices, and the husbandry system (Tamiru et al., 2023). Since poultry meat is relatively cheap and provides more affordable protein than other animal products such as beef, most consumers are choosing it (World Bank, 2014; ILRI, 2016).

Consumption of poultry products, especially poultry meat, has globally increased over the years and this trend is expected to continue (Ravindran, 2013). The production of poultry is a highly growing agribusiness (Teshome et al., 2019). The growth of the broiler industry has been phenomenal in many countries (Gietema, 2005). Broiler chickens are meat-type chicken breeds and raised for meat production and supplies the populations with animal proteins (FAD, 2013; Ugwuowo et al., 2019). They are produced from special chicken breeds, and nowadays they are usually hybrid birds (Gietema, 2005). Ethiopia had a huge number of livestock population, but meat production is still low and contributes to about 0.2 percent of the world's total meat production (Birhanu, 2019). In Ethiopia, levels of sales and consumption of both Chicken meat and eggs could vary from year to year, which may contribute to varied per capita consumption figures of chicken products, and the variation is also common in incomes generated from it too (Abadi, 2017). Over the past several decades, the consumption of poultry meat in Ethiopia was very low and remains far below African and global averages. The prospects for the future growth of commercial poultry in Ethiopia are high, with an average poultry meat consumption of about 0.66 kg per capita compared with about 1.64 kg in East Africa, and around 6.73 kg in Africa (FAO, 2019). The trends in Consumption and the per capita intake of energy and protein derived from poultry meat have not changed much from 2003 to 2013 (FAO, 2019). Forecasts indicate that the Ethiopian poultry sector is expected to grow annually by between 6–10 percent until 2025 (FAO, 2020).

According to the report of (Thomas, 2013), broiler production systems can be classified into two different categories, such as commercial broiler production systems, which involve an average of 10,000 broilers, kept under indoor conditions in one batch with a medium biosecurity level, and small-scale broiler production systems. Their flock sizes usually range from 2000 to 5000 broiler chicks kept for operation, and most of these farms obtain their feed and day-old chickens from large-scale commercial broiler farms and are involved in the supply of broiler meat to various supermarkets and hotels through middlemen. However, since the margin of profit per chicken is usually small, broiler production is often a large-scale enterprise. Thousands of chickens have to be reared by a single producer in order to make a reasonable income (Meseret, 2010).

2.2 Chicken Feed Resources in Ethiopia

Feed is the most important input for poultry production, and it is one of the factors that determine the success of the poultry business (Ravindran, 2013). In Ethiopia, extensive poultry production systems are entirely dependent on scavenging feed resources within the local environment, such as household waste and food leftovers, field crops, worms, and insects (FAO, 2018). As reported by different authors (Tadesse, 2013; Abera and Geta, 2014), scavenging is the main feed resource for rural poultry, with rare supplementary feed for their chickens (Moges et al., 2010). Similarly, chicken owners commonly supplement feeds for their chickens, such as wheat, barley, maize, sorghum, and household wastes (Tadele et al., 2013; Ahmed 2018; Edmew et al., 2018). The most common poultry feed ingredients in Ethiopia are cereal grains, milling by products (e.g., wheat shorts and middling), and oil seed cakes (e.g., noug seed cake, cotton seed cake, sunflower seedcake, sesame seedcake, groundnut cake, and linseed cake) (FAO, 2020).

In intensive systems, poultry is fed compound rations (FAO, 2019). The diets are formulated from a mixture of ingredients, including cereal grains, cereal by-products, fats, plant protein sources, animal byproducts, vitamin and mineral supplements, amino acids, and feed additives (Ravindran, 2013). In Ethiopia, seasonality, shortages, and prices of feed ingredients are key challenges for sustainable and affordable delivery of compound feeds (Moges 2010). Maize and soybeans are the major raw materials used in poultry rations. However, there are still substantial gaps in the supply of major raw materials used in poultry feeding, particularly maize and soybean (FAO, 2018). Instance, the price trends of soybean meal taken from 2010–11 to 2016 increased up to 60 percent across five years (Ahmed, 2018*)*. In addition, various inputs, including premixes, minerals, and vitamins, are currently imported from abroad using hard currency, and their prices are very high (Aman et al., 2012). Hence, price and quality of feeds are the most important factors limiting commercial poultry production in the country (FAO, 2019). Research in promoting the commercial feed sector (use of alternative chick feeds for compound feeds; innovative approaches to import substitution via local production of feed supplements; and on-farm testing) is also very weak (Ahmed, 2018). So to overcome the shortage of raw materials for feed ingredients, there are wide opportunities to produce maize and soybeans for feed production in Ethiopia. Additionally, huge amounts of land are available for the commercial production of these commodities. As the demand for poultry products increases in developing countries, it has a profound effect on the demand for feed and raw materials (Ravindran, 2013).

2.3 Feed Quality

Yami and Dessie (1997) reported that the quality of mixed feed for commercial boiler chicken production is generally poor in Ethiopia. Most formulations available do not have vitamin/mineral premixes Fixings and prepared feeds change in nutritive value and there is no standard quality control mechanism in the country (ILRI, 2016). Essential, inaccessibility of feed quality depiction and research facility offices for chemical analysis too contribute considerably the poor quality of prepared feeds. Currently, understanding the problem the Ethiopian Quality and standards authority is working with the Ethiopian society of animal production on feed quality standards and legislation (Demeke 2004; Mazengia et al., 2012 Dessie et al., 2013).

2.4 Feed Cost

The cost of raw materials fluctuates based on the supplier and geographical area. There is often minimal focus on creating the most cost-effective rations. It is thought that there is significant potential to lower feed costs in certain regions without compromising its nutritional quality. Transport costs add significantly to the cost of feed in areas far from the source of supply. The lack of bulk shipments and storage options has raised the costs of feed. In certain instances, significant waste results from weevil infestations. The limited availability of animal-based protein supplements has driven up the prices of abattoir by-products considerably. In many instances, the cost of mixed feed does not seem to follow reductions in ingredient costs. Prices of mixed feed remain unduly high even at times when the price of the major component of mixed rations (e.g., corn) falls by more than fifty percent (Demeke, 2004; Dessie et al., 2013). Several factors contribute to the high cost of chicken feed, including rising prices of feed ingredients like maize and soybean meal, increased energy costs, geopolitical tensions, and logistical challenges that lead to trade disruptions and higher transportation costs (Janberg. 2025). Maize and soybean meal are major components of poultry feed, and their prices fluctuate significantly, impacting overall feed costs. Other Ingredients like Vitamins, minerals, and amino acid supplements also contribute to the overall cost of feed (Mengesha 2012). Droughts and crop failures are another factor for feed cost. Unfavorable weather conditions can lead to reduced harvests and higher prices for feed ingredients (Janberg. 2025). Growing demand for poultry and eggs, coupled with the fact that many feed ingredients are also used for human consumption, contributes to increased competition and higher prices (Mengesha 2012).

2.5 Feed Resource of Chicken in Ethiopia

2.5.1 Conventional feed resource

Conventional feed resources are facing a problem of competition with human foods. Gura (2008) stated that the recent feed price increment may upset many of the plans for further development of industrial poultry productions. Concerns about the utilization of locally available feed sources are very likely to improve poultry feed price increments. As a result, (FAO, 2009) indicated that smallholder farmers, if left unprotected, could be among those most adversely affected by rising prices of local feed supplies. According to a report from sudan, the primary expense for various size and type of poultry farm is feed (Emam and Hassan, 2010). While replacing alternative ingredients, the equivalency of nutritional values, costs, and side effects on birds should be assessed and considered. Moreover, the trend of poultry production and the poultry feed source situation analysis are required for a country. Chad (2007) reported that elevated levels of poultry feed availability will be required to meet the feed demands of poultry production.

In Ethiopia, scavenging feed resources are the common source of diet for those chickens under village conditions. Although chicken owners offer a supplement to feed their chickens, the scavenging system is becoming so popular (Moges et al., 2010; Mengesha et al., 2011). The reason why the scavenging system is so popular may be the effective utilization of locally available feed resources (Moges et al., 2010). It plays an important role in converting leftovers, waste, and insects into valuable and quality protein (ILRI, 2016). In addition, the scavenging feed resource base contains different feeding materials, which include crop seeds, plant material, worms, insects, and undefined materials for improving chicken performance (CSA, 2017).

However numerous countries, including Ethiopia have reported feed supplementation as a common practice (Moges et al., 2010; Ahmed, 2018; Mengesha et al., 2021). According to (Habtamu et al., 2015), the supplementary feeds used in Amaro district were mainly combinations of maize, wheat and sorghum. However, the majority of chicken owners supply feed to chickens on the ground (Getachew et al., 2015; Ahmed, 2018). Wondu et al. (2013)

reported that in North Gondar, 58% of respondents supply feed to chickens on the ground. Nebiyu (2013) also reported that about 81.8% of the farmers provided supplemental feeds for different age groups together in Alaba district. The majority of households offer supplements twice a day. Emebet (2015) reported about 44.6% and (Meseret, 2010) found that 48.3% of farmers offered supplemental feeds twice a day. Furthermore, about 96% of farmers provided water to their chickens with free access (Desalew, 2012). Therefore, the scavenging system may seem better, as feeding with supplements needs some improvement in the husbandry system. To improve growth and reproductive rate and survival at the village level, provision of shelter, regular supply of drinking water, and some supplementary feeds are important factors (Wilson, 2010). Based on their nutritional needs, broilers feeding periods are classified in to three categories: starter (0–14 days), grower (15–28 days), and finisher (29–42 days). The recommended feed structure during the starter phase is crumb, while pelleted feed is provided during the grower and finisher phases. The CP requirement of the broiler ranges from 21-22%, 19-20%, and 18-19%, while the ME requirement is 2800, 3000, and 3200 kcal/kg during the starter, grower, and finisher, respectively (CBMG, 2015).

Corn, wheat bran, and soybean meal are some of the traditional feed sources for poultry in Ethiopia (Jurgens 2002) and they are often the most abundant sources of energy and protein. Meals including fish, meat, and bones are also excellent sources of protein and amino acids. Bone is a wonderful supply of calcium and phosphorus. Depending on their costs, they can be added up to 2-5% to the diet. Calcium and phosphorus are major minerals and found in plants either organic form or inorganic sources should be added, or the availability should be increased in some way. Salt are added from 0.2 to 0.5% most poultry diets. Yellow pigmentation - as much yellow corn as possible plus good sources of xanthophyll, such as alfalfa meal or corn gluten meal or vegetables leaf, for the yellow coloration of the shanks, feet, skin, and egg yolks (Jurgens 2002).

2.5.2 Non-conventional feed resource (NCFR)

The NCFR generally refer to all those feedstuffs that have not been conventionally used for feeding poultry and are not commercially used in the production of poultry ration. Potentially available NCFR include plant materials, such as the leaves and seeds of Moringa, Taro, Mango, Cassava, Pigeon pea, agro-industrial by-products rice bran and filter sugar cake. Most of these feed materials are low in energy, protein, minerals and contain high amounts of anti-nutritional components (Salem, 2014). The majority of research in the field of animal nutrition has been redirected to examine all potential solutions to the nutritional crisis due to the scarcity of feed resources for poultry (Abadi, 2018). Exploiting the usage of NCFR in poultry production systems is one method of reducing a significant gap that arises between the supply and demand of conventional feed resources for feeding poultry. Animals are also fed non-traditional foods including weeds and brewer's grains, a byproduct of the tella (beer) production (Feyissa et al., 2014).

2.6 Origin, Botanical classification and Nutritional value of Avocado

The avocado (*Persea americana*) is a tree native to Mesoamerica, whose origin is in the central part of Mexico and some parts of northern Guatemala (Sagarpa,2011). It belongs to family Lauraceae which is one of the oldest among the flowering plants; particularly, avocado is the most important and only edible fruit of this family and has a high commercial value (Ding et al., 2007; Ranade et al., 2015). According to Botany, avocado are classified as

‘*’Persea americana’’* mill. This species include three ecological races: Guatemalan, Mexican, and west Indian. This races are named after the fruit’s characteristics and place of origin (Ranade et al., 2015). Currently it is grown all over the world, although production areas were primarily in Central America and South America. Consumption of Avocado is rising globally, which has led to significant investments in avocado production in many nations. Globally, about 8.06 million tonnes of avocado are produced annually (Clinton, 2023). The avocado fruit can be grown in more than 60 countries worldwide because it is suited to the different tropical ecological zones (Araújo et al., 2018). The Dominican Republic, Indonesia, Mexico, Colombia, Peru, Kenya, Brazil, Ethiopia, United States of America, Haiti, and Chile are the top eleven avocado-producing nations in the world (FAOSTAT, 2020). The leading producers of avocado fruits in Africa include Kenya, Ethiopia, Malawi, South Africa, Cameroon and Morocco, (FAOSTAT, 2020). Avocado farming occupies a total areas of 20,908 hectares in Ethiopia, producing 104,492 tonnes. FAOSTAT data from 2020 reveals that the output of avocados in Ethiopia has seen ahistorical range from 13,888 tonnes in 2001 to 104,492 tonnes in 2019.

Approximately 36% of the nation's annual avocado production comes from the Sidama region (Tibebu, 2023). Avocado is rich in unsaturated lipids, improves and maintains healthy heart and circulatory system and it is valuable source of energy. In addition to dietary fiber, essential nutrients and phytochemicals is high in calorie 15–30% oil, B6, B12, C,K, E, Folacin and Niacin, minerals, high caloric value 123–387 kcal/kg Shamil, 2023; Huth et al., 2013), Low sugar content, vitamins A, vitamin E, ascorbic acid, vitamin B6 and B- and carotene

(Mooz et al., 2012). Avocado has nutritional benefits such as potassium, unsaturated fatty acids, proteins, and fat-soluble vitamins that are uncommon in other fruits (Shamil, 2023).

2.6.1. Avocado Pomace (AP)

Pomace is the solid remains of Avocado, Grapes, Olives, or other fruits after pressing for juice or oil extraction. It contains the fruit's skins, pulp, seeds, and stems. These solid wastes, referred to as, “pomace” contain high moisture content (70–75%) and biodegradable organic load values so their management is an important concern.

Colombo (2019) reported that avocado by-products (peels and seeds) contain significant amounts of carbohydrates, proteins, lipids, fibers, and high amounts of bioactive compounds. Moreover, studies have showen that avocado peels have antibacterial, anti-inflammatory, and anti-biotic effects (Morais et al., 2015). Given this importance, leftover avocado material shows promise for use in the manufacturing of pharmaceuticals and functional foods. Hence, there is a need to utilize avocado by-products to mitigate the negative impacts brought about by their release into the environment. The seeds are rich in nutrients such as carbohydrates, protein, lipids and ash (Ejiofor et al., 2018; Talabi et al., 2016). However, avocado seeds have been of main concern in recent years because it is believed they contain anti-nutrients such as tannins that are a potential threat to proximate analysis and mineral contents of different avocado variety presented in table 1 below.

Avocado pulp also contains the polyhydroxylated alcohols avocadyne and avocadene. In vitro, avocadyne was shown to be a potential inhibitor of fatty acid oxidation. Together, these molecules may antagonize each other’s actions. Additionally, avocado was shown to spare normal hematopoietic cells while suppressing primary acute myeloid leukemia cell growth and reducing cell engraftment in vivo (Tcheng et al. 2019). Phenolic acid in avocado pulp out of 100g are 1mg Succinic acid, 26.9mg Fumaric acid, 20.6mg Quinic acid, 119.2mg Malic acid, 216mg Citric acid, 0.11mg Benzoic acid and 0.267mg Abscisic acid (López-Cobo et al 2016). The remaining ingredients of avocado seed are water, protein, fat, sugar and starch. However, the phytochemical compounds in avocado seed include saponins (0.00052%), flavonoids (0.0203%), tannins (0.00076%), alkaloids (0.0054%), phytates (0.00044%), and oxalates (0.0044%)BahruT.etal.,(2019).

Table 1: Proximate composition and minerals contents of different varieties of avocado fruit

Avocado varieties	Moisture	DM	ME kcal	carbohydrate (g)	CP	CF(g)	fat	Ash	SFA	MUFA	PUFA	Na(mg)	K(mg)	Ca(mg)	Mg(mg)	Reference
Hass	27.7	72.3	167	8.64	1.96	6.8	15.4	2.21	12.21	72.9	14.8	5.5	514	13.4	19.5	Mark et al.,2013
Ettinger	27.8	72.2		3.36	2.04	3.36	17.8	1.16	17.91	72.5	9.5	8.3	550.5	13.1	29.2	Galil Rozan et al., 2021
Fuerte	29.87	70.1		3.24	1.87	3.03	20.4	1.31	10.91	75.7	13.4	8.4	405.0	10.6	28.5	Galil Rozan et al., 2021
Pinkerto	29.62	70.38		3.22	2.16	1.72	20.8	1.73	18.63	69.3	12.1	14.6	378.	11.8	27.3	Galil Rozan et al., 2021
Maluma	31.31	68.69		3.42	2.33	2.54	21.49	1.49	13.12	72.3	14.5	11.0	492.3	13.2	21.6	Galil Rozan et al., 2021
Reed	28.95	71.0		3.68	1.98	4.25	17.6	1.38	14.19	70.9	14.8	11.4	385.5	12.7	27.0	Galil Rozan et al., 2021
Proximate composition of peel, flesh, and seed																
Seed %	13.09	86.9	334.1	80.1	2.64	2.87	0.33	3.8				1.41	4.16	0.82		Egbuonu et al., 2018; Ifesan & Olorunsola, 2015
peel	1.96	98.14		76.21	6.46	9.19	3.04	5.1				0.45	1.25	0.06	0.11	Ozdemir, 2004;
Flesh	67.9	32.1		4.9	2.8	4.7	18.7	1.1				51.5	28.0	27.1	40.8	Nwaokobia., 2018

Mg: milligram; %: percentage; g: gram

2.7 Nutritional requirements of broilers

Through selection and genetic improvement, broilers reached an efficient feed conversion, fastest growth rate and better ability to grow well on cheaper, low-density feeds. Birds are unable to synthesize nine of these amino acids due to a lack of specific enzymes: Histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine. For these nine amino acids, termed as essential amino acid. Histidine, glysine, and proline can be produced by the chicken but their rate is usually insufficient to meet is to meet their metabolic need for good production**.** The minerals required for poultry in the diet in large amounts (mg or g per day) are called the macro minerals, and these include calcium, phosphorus, sodium, potassium, manganese, chlorine, and sulfur. The most essential nutrient and is required in greater amounts than any other nutrient is water. Under thermo neutral conditions, a general guideline is that birds will drink adlibtum. Since chickens are unable to synthesize vitamins, they are an unrelated class of compounds involved in metabolism that must be consumed in very small amounts. Vitamins A,D,E and K are typically categorized as fat soluble while (thiamin (B_1), riboflavin (B_2), niacin (B_3), pantothenic acid (B_5), pyridoxine (B_6), biotin (B_7), folic acid (B_9), cobalamin (vitamin B_{12}), and choline are typically categorized as water-soluble. Because there are several form of form of vitamin A, D, and E and their potencies vary, requirement are expressed in IUs. Nevertheless, young chicks are lesws effective than older birds at using beta-carotene . Cobb-500 is more productivity than other breeds and less during fattening phase. According to (Vantress, 2018), average weight is 1.9 kg in 35 days, and 2.4 kg in 42 days.

Broiler diets are formulated to provide a balanced array of nutrients that are essential for health and efficient production (Vantress, 2018). Nutrients required by birds vary according to species age and the purpose of production (Ravindran, 2013). Most of the feed is formulated by poultry. Nutritionists are designed to attain maximum profitability for live birds or to Optimize yields of certain carcass components, such as breast muscle (FAD, 2013). The basic nutritional components required by the birds are water, amino acids, energy, vitamins, and minerals (Vantress, 2018). To satisfy the requirements of broilers, feeds are often supplemented with synthetic amino acids, such as methionine, lysine, and threonine, which are the limiting amino acids in broiler feed (FAD, 2013). To meet the nutritional requirements of commercial Broilers with high protein and energy levels are needed. To attain the desired body weight gain of broilers, at starter, grower, and finisher phases, feed should contain metabolic energy (kcal/kg) 3035.37, 3107.07, and 3178.78, with crude protein (%) of21–22, 19-20 and 18-19, respectively (Vantress, 2018).

2.8 Feed intake and efficiency

Successful broiler development is dependent on optimal feed intake throughout the growing period (Jafarnejad et al., 2010). Feed intake is the major factor that influences body weight gain and feed efficiency (Peter et al, 2006). Optimal feed intake and growth are dependent on a number of factors, such as dietary nutrient composition, feed formulation, and feedstuffs inclusion levels, and feed pellet quality) and managerial (feed and water availability to the birds, environmental management, stocking density, and disease control) (Peter et al, 2006; Jafarnejad et al., 2010). Moreover, there are many other factors that affect feed intake and level of nutrient intake in chicken production (Ahmed, 2018). A deficiency or excess of although feed intake will be adversely affected by dietary nutrients most nutrients have a limited impact on feed intake when their levels fall within commercially accepted ranges (Peter R. et al, 2006). Modern commercial broilers will not grow to their full genetic potential unless they consume their full nutritional requirement each and every day (Peter R. et al, 2006). So, the growth rate and efficiency are linked to the ability to consume, digest, absorb, and metabolize dietary nutrients (Peter R. et al, 2006). When feed intake is increased, a greater proportion of nutrients is used for growth, and feed conversion ratio (FCR) is improved. The FCR is a measure of how well a flock converts feed intake (feed usage) into live weight, and it is the most commonly used parameter to determine broiler nutritional requirements. (Rostagno et al., 2007). Feed efficiency is not only a change in the efficiency of muscle deposition, but also a reduction in the time taken to reach market weight and decreased maintenance costs (Scott, 2005).

2.9 Carcass and non-edible offal characterization

Broiler chicken carcass characteristics are important factors that are considered in the poultry industry for assessing meat quality, yield, and market value (Benjamin Oyewole, 2019). Carcass characteristics of broiler chickens include weight, composition, and meat quality. Non-edible offal parts of broiler chicken meat are the parts of the chicken that are not typically consumed as part of the regular diet but may have other uses or be considered waste in the food processing industry. Some common carcass and non-edible offal parts of broiler chickens include: Live weight which is measured of the chicken before fasting. Carcass weight is weight of the chicken after removing the head, neck, feathers, and some viscera

Dressing Percentage is measured dressing percentage is the ratio of the carcass weight to the live weight of the bird, expressed as a percentage. It indicates the proportion of the live weight that translates into carcass weight after processing. Internal Organs are some parts of the internal organs of chickens, such as the liver and gizzard, are consumed as delicacies or utilized in cooking; other parts like the intestines and lungs are not typically eaten and may be discarded.

2.10 Hematological and biochemical parameters of broiler chickens

Since hematological parameters are crucial in determining the health and physiological state of birds, hematological characteristics in birds are receiving more and more attention these day. (Etim et al., 2014). Hematological parameters are important indicators of their overall health and can provide valuable information about their immune status, nutritional status, and disease status and it refer to measurements such as red blood cell count, white blood cell count, hemoglobin concentration, hematocrit level, and platelet count (Onunkwo, 2022). These values can provide valuable information about the overall health and physiological status of the birds. Changes in hematological parameters may indicate issues such as anemia, infection, inflammation or stress. The value of hematological parameters is influenced by a number of factors, including age, breed, sex, management systems and season (Addass et al., 2012; Irivboje et al., 2020). Although normal hematological values of some chickens have been determined based on different factors, there is little information about the reference values of hematology for broilers (Nanbol et al., 2016; Al-Nedawi, 2018). Biochemical parameters, on the other hand, include measurements such as serum protein levels, enzyme activities, glucose concentration, lipid profiles, and electrolyte balance. These parameters help evaluate the metabolic functions, organ health, and nutrient utilization of the birds (Wayas et al., 2018). Abnormalities in biochemical parameters may reflect disturbances in organ function, nutrient imbalances, or metabolic disorders (Irivboje et al., 2020).

Some common hematological parameters that are measured in broiler chickens include: Hemoglobin concentration it refers the oxygen carrying protein in the RBC and it a direct reflection of the amount of oxygen in the blood. Increased Hb is seen in dehydration, chronic obstructive pulmonary disease etc. while a decrease results in anaemia, blood loss, liver disease etc. The normal range in broilers is around 7-13g/dL (Bounous and Stedman, 2000). Red blood cell count is ability of oxygen carrying animal tissues for the oxidation process to release energy and transport carbon-dioxide out of the tissues (Omiyale, C. A., 2012) and the manufacture of haemoglobin. White blood cell count are a critical part of the immune system and help the chicken defends the body against invasion by foreign organisms and to supply antibodies for immune response. The increase in WBC could also be attributed to the presence of some phytochemicals in bitter leaf which induces the animal to respond as if it had an infection (Areghore et al., 1997) or due to the presence of residual anti-nutrients which induces production of more antibodies that stimulate more WBC production to fight the infection being a defense system. Birds with low WBC are exposed to high risk of disease infection while an increase can produce antibodies in the process of phagocytosis and have a higher degree of disease resistance (Soetan, 2009). The increase in WBC indicates a superior disease fighting ability (Eroschenko, 2000). An elevated white blood cell count can indicate an active infection, while a low count may indicate immune suppression. Platelet count are an important component of the blood clotting system in chickens, including broilers. Platelets play a crucial role in blood clotting, helping to stop bleeding and prevent excessive blood loss. They do this by aggregating and forming a platelet plug at the site of injury. In broilers, the normal range for platelet count is between 500,000 and 1,500,000 platelets per microliter (μL) of blood. The average platelet size in broilers is around 5-7 μm (Areghore et al., 1997). Mean corpuscular volume (MCV), high MCV may indicate anaemia due to nutritional deficiencies, bone marrow abnormalities, liver disease, alcoholism, chronic lung disease, or therapy with certain medications (Jaime and Howlette, 2008). Hematocrit (packed cell volume) is refers to transport of oxygen and absorbed nutrients round the body delivering it to target cells or tissues. Too high PCV is an indicator of toxic factors that could have an adverse effect on the formation of blood (Ma et al., 2011). Serum Protein Levels are synthesized in the liver to maintain blood volume through the colloidal osmotic effect, buffer blood pH, transport hormones and drugs, cell coagulation, catalyze enzymatic reactions, regulate hormones, and defend body against foreign materials. (Mmereole., 2008). Serum cholesterol (triglycerides) is synthesized in the intestinal mucosa and in the liver from the digestion of dietary components and the absorption of fatty acids.

3. MATERIALS AND METHODS

3.1 Description of the study area

The avocado pomace was obtained from SUNVADO (Yirgalem Agro-industrial Park), transported to College of Agriculture fresh, sun dried, and meal was produced at the School of Animal and Range Sciences. The feeding experiment was conducted at Poultry Research Station, College of Agriculture, Hawassa University; Ethiopia.The farm is located at $7^{o}15'$ N latitude and $38^{o}45'$ E longitude. The altitude of the area is 1708 masl, annual rainfall is 955 mm and the mean temperature ranges from 9-29 ºC (Oluwasinaayomi et al., 2018).

3.2 Experimental broilers management

The experimental house was thoroughly cleaned, washed with sodium hypochlorite (10%), and disinfected with copper sulfate. The floor was bedded with wood shavings at a thickness of 5–10 cm and disinfected before the placement of the experimental birds in the pens. Circular plastic feeders and waterers were also placed in the pens. A total of 144-day-old Cobb-500 broiler chickens were purchased from Alema Private Farms PLC, Bishoftu, and transported to College of Agriculture poultry farm, Hawassa University. Chickens were kept in the brooder house for eight days before the commencement of the experiment to provide an optimum environmental adaptation for birds in the early part of their lives through the application of an external heat source for first week of age. This is usually from day one until the chicks were able to regulate their body temperature efficiently (Fairchild, 2012). Two infrared lamps with 250 watts were used to provide heat for chicken in the brooder room. After the arrival of the chicks, a sugar solution which is prepared by mixing one spoon of sugar with one litre of warm water was provided to reduce transportation stress (McNaughton, 2024).

Chickens were vaccinated against Newcastle disease (Lasota) on day 10^{th}, Gumboro-I on day 14^{th}, and Newcastle (HB1) on day 21^{st}, and Gumboro-II on day 28^{th} through eye drop. Besides vaccines, antibiotics like vita chicken, amprolium and oxytetracycline were provided 12^{nd} 23^{rd} and 29^{th} date. Feed was offered *ad libitum* (10% refusal). The daily offer was presented in two portions at 08:00 and 16:00 h. Water was available at all times.

Preparation of Avocado pomace meal

Rejected Avocado pulp after oil extraction was purchased from Yirgalem Agro-industrial Park and transported to the College of Agriculture. Then dry the pulp completely by using sun light for 4-6 consecutive days until it get dried completely and then grind it into a fine powder, and mix it with the chickens' regular feed ingredients. Drying was done by spreading the pomace thinly in a well-ventilated area to dry completely, ensuring it's free of moisture to prevent mold growth. Grinding was done using a grinder or mill. Grounded pomace meal was storing in a cool, dry place to maintain its quality.

3.3 Design of the experiment and ingredients

The ingredients used for experimental ration preparation were maize, wheat bran, avocado pomace meal (APM), soyabean meal (SBM), salt, bone meal, lysine, methionine, vitamin premix, and limestone. The SBM, salt, bone meal, lysine, methionine, vitamin premix, and limestone were purchased from Dararo Feed Processing and Trading PLC, Hawassa. Maize and wheat bran were purchased from the local market in Hawassa town. Avocado pomace was taken from SUNVADO (Yirgalem Agro-Industrial Park). Treatment rations were formulated to be isocaloric and isonitrogenous using Win Feed 2.8 software to meet the nutrient requirement standards for broilers (NRC, 1994). Accordingly, each of the starter treatment rations contained about 2800 kcal/kg DM of metabolisable energy and 23% of crude protein, whereas the grower ration contained 3000 kcal/kg DM of metabolisable energy and 20% crude protein. Finally, the finisher ration had 3200 kcal/kg DM of metabolisable energy and 18% crude protein (CBMG, 2015). The treatment rations designated as T1, T2, T3 and T4 were formulated with the inclusion of 0%, 5%, 10%, and 15% of avocado pomace meal, respectively. The four treatment rations were assigned to the pens with three replicates consisting of 12 chicks per replicate. The design of the experiment was a completely randomized design (CRD). The experiment lasted for 49 days.

Table 2: **Ingredients proportion of starter, grower and finisher broiler chickens ration**

Phases	Feed (Kg)	Treatments			
		T_1 (Control)	T_2 (APM 5)	T_3 (APM 10)	T_4 (APM 15)
Starter phase	Maize	43.5	41.20	40.37	36.85
	APM	0.00	5.00	10.00	15.00
	Wheat bran	24.23	20.8	17.5	15
	Soybean meal	28.77	29.5	29.8	30.5
	Limestone	1.0	1.0	1.0	1.0
	Lysine	0.50	0.50	0.50	0.50
	Methionine	0.50	0.50	0.50	0.50
	Premix	0.50	0.50	0.50	0.50
	Bone meal	0.50	0.50	0.50	0.50
	Salt	0.50	0.50	0.50	0.50
	Total, Kg	100.00	100.00	100.00	100.00
	Crude protein, %	23.00	23.00	22.96	22.97
	ME, Kcal/Kg DM	2800	2800	2800	2800
Grower phase	Maize	56.8	53.25	48.6	45.1
	APM	0	5.00	10.00	15.00
	Wheat bran	17.15	15.2	14.6	12.6
	Soybean meal	22.35	22.85	23.1	23.6
	Limestone	1.20	1.20	1.20	1.20
	Lysine	0.50	0.50	0.50	0.50
	Methionine	0.50	0.50	0.50	0.50
	Premix	0.50	0.50	0.50	0.50
	Bone meal	0.50	0.50	0.50	0.50
	Salt	0.50	0.50	0.50	0.50
	Total, Kg	100.00	100.00	100.00	100.00
	Crude protein, %	20.00	20.00	20.00	20.00
	ME, Kcal/Kg DM	3166.98	3156.18	3139.25	3128.70
Finisher phase	Maize	63.00	58.10	55.50	52.50
	APM	0.00	5.00	10.00	15.00
	Wheat bran	16.00	14.50	11.00	9.60
	Soybean meal	17.50	18.60	19.01	19.40
	Limestone	1.00	1.00	1.00	1.00
	Lysine	0.50	0.50	0.50	0.50
	Methionine	0.50	0.50	0.50	0.50
	Premix	0.50	0.50	0.50	0.50
	Bone meal	0.50	0.50	0.50	0.50
	Salt	0.50	0.50	0.50	0.50
	Total, Kg	100.00	100.00	100.00	100.00
	Crude protein, %	18.00	18.00	18.00	18.00
	ME, Kcal/Kg DM	3299.99	3300	334000	3304.0

APM = Avocado pomace meal; T1= control group without APM; T2= diets with 5% of APM; T3= diets with 10% of APM and T4=diets with 15% of APM; ME= metabolizable energy; Kcal/Kg=kilocalorie per kilogram; DM=dry matter

3.4 Data collection and analysis

3.4.1 Measurements of growth performance of broilers

Broilers were fed on a replicate basis, and each day a measured amount of feed was offered in the 8:00 AM and late 16:00Am. The refusals were collected and weighed the next morning. Feed intake on a group basis was then computed by subtracting the feed refusal from the feed offered as follows:

Feed intake /chick/day= Total feed offered –Total refusal

Body weight was taken at the beginning of the experiment, day 8 (considered the initial weight), and then on days 15, 36, and 49 before feed was offered. The body weight taken at the end of the experiment was considered the final body weight for each phase. The total body weight gain was then computed by subtracting the initial body weight from the final. The feed conversion ratio was calculated by dividing the total feed intake by the total weight gain. Any ill health signs and mortality rates were recorded throughout the experiment and expressed in percentage.

3.4.2 Carcass parts yield and visceral organ measurements

At the end of the experiment a total of 24 birds, 6 per treatment and 2 per replication were randomly taken for carcass evaluation. These birds were humanly slaughtered. After bleeding, birds were placed in a scalding tank. And then, the dressed weight (after shank with claw, head, and feather removed) weighted. Then, the eviscerated weights were weighed after removal of the visceral organs. The carcass parts including the breast cut, drumstick, thighs were cut up and weighed.

The visceral organ weights (heart, liver, Proventrculus and gizzard, pancreas, small and large intestine) were weighed. Dressed carcass weight was measured after the removal of blood, shank with claw, head and feather and the dressing percentage calculated as the proportion of dressed carcass weight to slaughter weight multiplied by 100. Eviscerated carcass weight was determined after removing blood, feather, lower leg, head and visceral organs. The eviscerated carcass percentage was determined as the proportion of the eviscerated weight to slaughter weight multiplied by 100 (Ulla and Gjedrem ,1985).

$$\text{Carcass dressing percentage} = \frac{\text{Total edible carcass weight}}{\text{Slaughter weight}} * 100$$

3.4.3 Chemical analysis

Representative samples of dried feed ingredients were milled to pass through 1 mm sieve screen. Samples of feed ingredients were analyzed for dry matter, ether extract, crude fiber and ash following the proximate analysis method (AOAC, 2000). Nitrogen content was determined by Kjeldahl method (AOAC, 2000) and crude protein was calculated as N x 6.25. Metabolisable energy (Kcal/kg) content of the experimental diets was calculated by indirect method from the equation.

$$\text{ME}\left(\frac{\text{Kcal}}{\text{kg}}\,\text{DM}\right) = 3951 + 54.4\ \text{EE} + 88.7\text{CF} + 40.8\text{ash}$$

Where: - ME = metabolisable energy, EE = ether extract, CF = crude fiber

3.4.4 Quantitative estimation of tannin, total phenolic, flavonoids and alkaloids of avocado pomace meal

Estimation of Tannins

The tannins were determined by the vanillin method at Arba Minch University Food Science laboratory.Five grams of avocado pomace were ground to produce an extract, which was then extracted using methanol and centrifuged to separate the liquid extract from the solid residue (Price m., et al., 1978). About 0.05 ml of the sample extract was added to a volumetric flask (10 ml) containing 7.5 ml of distilled water and 5 ml of vanillin (4-hydroxy-3-methoxybenzaldehyde) reagent, and diluted with 10 ml distilled water. The mixture was shaken well and kept at room temperature for 30 minutes. A set of reference standard solutions of tannic acid was prepared in the same manner, and two drops of HCl were added. Absorbance for test and standard solutions was measured against the blank at 500 nm with an UV/visible spectrophotometer. The quantity was determined using a Perkin Elmer Spectrum 400 FT-IR instrument. The estimation of the tannin content was carried out in triplicate. The tannin content was determined from the extrapolation of the calibration curve and expressed in terms of mg of tannic acid equivalents per gram of dried sample.

Estimation of Total Phenolic Content

The total phenolic content of dry extracts was determined using the Folin-Ciocaltaeu assay method (Pérez M. and Dominguez-López I, 2023). 100 µg/mL of sample (0.1 mg/ml) was mixed with 3.5 ml of Folin Ciocalteu's phenol reagent. After 5 minutes, 10 ml of 7% sodium carbonate solution was added to the mixture, followed by the addition of 13 ml of deionized distilled water and mixed thoroughly. The mixture was kept in the dark room for 40 minutes at

23 °C, after which the absorbance was measured at 760 nm. The total phenolic content was determined from the extrapolation of the calibration curve, which was made by preparing Gallic acid solution. The estimation of the phenolic compounds was carried out in triplicate. The TPC was expressed as milligrams of gallic acid equivalents (GAE)/g of dried sample.

Estimation of Total Flavonoid Content

The total flavonoid content was determined by the calorimetric assay method (Chang Chia-Chi, et al., 2002). 10 mg of extract was weighed and made up to 10 ml with methanol in a 10 ml volumetric flask. From the stock solution, solutions of concentrations 5, 10, 25, 50, 100, and 200 µg/ml were prepared. 4 ml of water was added to each, followed by 0.3 ml of 5% sodium nitrite. After 5 minutes, 0.3 mL of a 10% aluminum chloride solution was added and at the 6^{th} minute, 2 mL of 1M sodium hydroxide was added. The total volume was made up to 10 ml with distilled water. A blank was prepared without the addition of an aluminum chloride solution. The solutions were mixed well, and the absorbance was measured against the blank at 510nm using a UV-visible spectrophotometer. A standard graph was plotted using various concentrations of APM and their corresponding absorbance.

Estimation of alkaloids

Alkaloids were determined by the high-pressure liquid chromatography (HPLC) method (Edward R. Adlard, 2011) at Arba Minch University, Abaya Campus. 10 g of the APM powder was introduced into a beaker and then moistened with ammonia (NH4OH 5 %) while homogenizing. The moistened powder is then transferred to a filter paper cartridge and fed into the intermediate part of the Soxhlet. Enough dichloromethane (CH2Cl2) is introduced into the flask. Extraction is conducted for three hours with a temperature of 40°. The organic extract of alkaloids (bases) is obtained at the end. The resulting organic extract is introduced into a decanting ampoule, and then extraction is carried out by sulfuric acid (H_2SO_4 0.5 N); 15 mL for each extraction, the operation is repeated until the Hager's reagent test is negative (testifying to the absence of alkaloids). It consists of passing the extractive solutions, in an acid medium or a basic medium to eliminate water-soluble impurities and fat-soluble impurities (Elyebdri., 2024). The aqueous phases of extractions are collected and the resulting solution (containing alkaloids as salts) is alkalized by NH_4OH 5 % until the pH is between 10-12.method Chromatographic analysis using high-performance liquid chromatography, was performed for: Extraction residues from avocado pomace meal. A uHPLC with automatic injection, connected to a UV-visible detector (190-600nm), was used. It consists of a Perkin-Elmer- pump, a binary gradient Chrom 7100, an automatic injection valve, and a Perkin-Elmer-USA LCI-100 integrator. The analysis was done in an isocratic mode. The flow rate was 1 mL/min, and the column used is of type C18 of 25 mm length and 4 mm diameter. The injection volume was 20 μL and the detection wavelength λ=210 nm.

3.4.5 Hematological Parameters of Broilers Fed the Experimental Diets

On the 49th day, six birds were randomly chosen from each treatment, individually weighed on a digital scale, isolated, tagged, and starved overnight. They were bled via the wing vein and blood samples were collected by using disposable syringes, 10-ml disposable needles (27-gauge to 23-gauge bent), EDTA (ethylene diamine tetra-acetic acid tube), and SCT (sodium citrate tubes) heparin pediatric 0.5-ml to 1-ml blood tubes. The set of samples was taken in labeled sterile universal bottles containing ethylene diamine tetra-acetic acid (EDTA) and others in heparin bottles without anti-coagulant. Blood samples in EDTA-containing bottles were used to analyze the full blood count (white blood cells, red blood cells, hemoglobin, packed cell volume, and platelets) with the help of an automatic hematology analyzer at Hawassa University comprehensive Specialized Hospital. Serum was obtained from blood samples in heparin bottles by centrifugation (4000 rpm for 5 min at 20°C). Commercially available kits were used to analyze the serum parameters on a biochemical auto-analyzer. The concentration of the biochemical constituents was calculated according to the manufacturer's instructions. In the blood serum, the content of total protein, glucose, creatinine, and total cholesterol was determined with an Epoll 20 photometer using the original Alpha Diagnostics kits.

3.4.6 Water holding capacity, pH, and cooking loss of carcasses

Water holding capacity

Salt-induced water gain indicates the maximal potential for muscle to gain water in the presence of salt. Salt-induced water gain was measured by a swelling and centrifugation method. The minced samples of meat (5 g) and 15 ml of 0.6 M sodium chloride were added to a 50 mL centrifuge tube and mixed with a vortex for 1 minute. Before being centrifuged at 3000 x g for 15 minutes, the tubes were refrigerated at 40 °C for 15 minutes. After centrifugation, the excess liquid was decanted and the samples were reweighed at Hawassa university Food Sciences laboratory. Salt-induced water gain was expressed as the percentage of weight gained by the pellet (100 x final initial weight/initial weight (Soeparno, 2009).

Meat pH

Meat pH is the level or degree of acidity of meat after a postmortem. 5 gm of fresh meat was taken from back cut and packed in plastic bag until reaching laboratory for pH analysis. The principle of measuring pH knows the acidic and basic conditions. It was determined by a microelectrode and a pH-ion meter (model 301, Hanna Instruments, Vila do Conde, Portugal). The tip of the pH meter was inserted into a 10 g sample of broiler meat (Septinova, 2016).

Cooking loss

Cooking loss was calculated using the method by (Pang et al. 2020). Meat samples from broilers were taken from the boneless breast immediately after slaughter; 10 g was weighed, put in a plastic bag, and vacuumed. Then the meat was brought to the laboratory to calculate the cooking loss value. The average weight of a breast fillet was 10 g.

The fillet samples were boiled to a temperature of 600 °C for 1 hour. Samples were removed from the boiler and cooled down at 5 and 10 minutes for estimating cook loss. A total of 24 single fillets were used in this experiment, and the entire experiment was repeated twice at the same time. The cooking loss was calculated using the following formula:

% cook loss = (W1-W2)/W2 x 100,

Where: W1 is the weight of raw meat samples before cooking.

W2 is the post-cooking weight of the samples cooled at room temperature.

3.4.7 Data management and analysis

All the collected data was arranged in Microsoft Excel 2010 before the actual data analysis was conducted. Descriptive statistics and one-way ANOVA were used to test the values of parameters such as feed intake, body weight change and food conversion ratio for all three phases, as shown in the model. A general linear model (GLM) was used to analyze the main effects of the treatments on feed intake, body weight change and food conversion ratio, carcass yield, cut parts, and visceral organ by using SAS (V 9.4) software. The significant mean values, at $p < 0.05$, were separated by DMRT**.**

The following model was used: $Y_{ij} = \mu + Ti + e_{ij}$

Where:

$Y_{ij=}$ is the observed j variable in the i^{th} treatment;

μ = the overall mean of the response variable;

T_i = the effect due to the i^{th} APM inclusion level (i = 0%, 5%, 10%, and 15%) at the starter, grower, and finisher phases.

e_{ij} = random residual error.

4. RESULTS

4.1 Chemical composition of feed ingredients

The avocado pomace meal CP content (9.23%) was lower compared to maize (10.5%) and wheat bran (17%). Avocado pomace meal ME (3070 Kcal/kg DM) content was low as compared to maize (3454Kcal/kg DM). APM (9.07) had high ash contents compared with maize (2.84%), wheat bran (5.6%) and soybean meal (7.56%).

Table 3: Chemical composition of feed ingredients

Ingredients	DM %	Ash %	EE %	CP %	CF %	NFE %	ME Kcal/kg	Tan g/100g	Phen g/100g	Alka g/100g	Flav g/100g
Maize	93.8	2.84	4.14	10.5	4.26	72.06	3454				
WB	92.81	5.60	3.57	17.00	8.42	58.22	2942				
SBM	92.51	7.56	6.09	49.75	6.73	22.68	3134				
APM	93.53	9.07	25.61	9.23	19.07	30.55	3070	6.2	46.6	5.7	40.9

*APM = Avocado pomace meal; DM = Dry matter; CP = Crude protein; EE = Ether extract; CF = Crude fiber; ANF=Anti nutritional factor; ME = Metabolisable energy; NFE = Nitrogen free extract = DM - (CP + EE + CF + Ash); Tan=tannin; Phen=phenolic compounds; Alka=alkaloid; Flav= flavonoids; WB=wheat bran; SBM=soybean meal. **ME = Metabolizable energy.*

4.2 The effect of inclusion of different levels of avocado pomace meal on feed intake, body weight, body weight gain, and feed conversion ratio in broilers during different phases

The effect of inclusion of different levels of avocado pomace meal on feed intake, body weight, body weight gain, and feed conversion ratio in broilers were presented in Table 3. Daily feed intake for T1 during the starter phase was higher ($P<0.05$) than T3 and T4. T1 and T2 had similar feed intake. There was no mortality during the starter. During grower phase the highest average daily gain was recorded in T_1. The highest ($P<0.05$) feed conversion ratio was recorded for T4 and lowest ($P<0.05$) for T1.

Daily feed intake was the highest ($P<0.05$) for T1 during finisher phase. Feed conversion ratio was similar ($P >0.05$) in finisher phase among treatments. Moreover, body weight gain, average daily gain, and final body weight were increased ($P < 0.05$) with increasing levels of avocado pomace meal. The highest number of mortality was recorded at the finisher phase on T4The highest ($P<0.05$) average daily gain during the finisher phase was observed in T1. Feed conversion ratio was similar ($P>0.05$) among treatments during finisher phase. Additional health problems are observed like lack of strength, difficulty exercising, thin or frail body, neck twisting, and abnormal movement of the head in T4. At slaughter, an enlarged bile duct is observed in one chicken from T_4.

Table 4: The effect of inclusion of different levels of avocado pomace meal on feed intake, body weight, body weight gain, and feed conversion ratio in broilers during different phases

Parameters	Treatments				SEM	P-Value
	Control	APM 5%	APM 10%	APM15%		
Starter phase (8-14 days)	T_1	T_2	T_3	T_4		T_1
Daily feed intake(g/bird)	40.9[a]	40.5[ab]	37.2[c]	38.9[b]	0.39	0.000
Initial body weight(g/bird)	124.3	120.2	126.3	129.6	3.84	0.421
Final body weight(g/bird)	250.0	238.33	219.40	200.0	13.3	0.115
Body weight gain(g/bird)	125.6	118.13	93.13	70.36	14.24	0.088
Average daily gain(g/bird)	17.9	16.8	13.3	10.0	2.03	0.087
Feed conversion ratio	2.5	2.4	2.81	4.19	0.49	0.111
Mortality, %	0	0	0	0	0.0	0.00
Grower phase (15-35 days)						
Daily feed intake(g/bird)	116.4[a]	91.3[b]	91.4[b]	84.9[b]	1.46	0.000
Initial body weight(g/bird)	250.0	238.3	219.4	200.0	13.13	0.115
Final body weight(g/bird)	1302.7[a]	728.6[b]	800.0[b]	501.9[c]	45.49	0.000
Body weight gain(g/bird)	1052.7[a]	490.3[bc]	580.5[b]	301.9[c]	48.93	0.000
Average daily gain(g/bird)	50.1[a]	23.3[bc]	27.6[b]	14.3[c]	2.32	0.000
Feed conversion ratio	2.3[b]	3.9[ab]	3.3[ab]	6.4[a]	0.71	0.018
Mortality, %	0.0	1.0	0.0	0.0	0.28	0.095
Finisher phase (36-49 days)						
Daily feed intake(g/bird)	176.8[a]	89.5[b]	88.8[b]	68.4[c]	2.99	0.000
Initial body weight(g/bird)	1302.7[a]	728.6[b]	800.0[b]	501.9[c]	45.45	0.000
Final body weight(g/bird)	2047.2[a]	1143.9[b]	1082.0[b]	661.2[c]	51.90	0.000
Body weight gain(g/bird)	744.4[a]	415.3[b]	282.0[bc]	159.2[c]	30.05	0.000

Average daily gain(g/bird)	53.1[a]	29.6[b]	20.1[bc]	11.3[c]	2.14	0.000
Feed conversion ratio	3.33	3.05	4.53	7.08	1.10	0.111
Mortality, %	0	2.00[ab]	1.00[b]	3.67[a]	0.72	0.037
Entire period (8-49 days)						
Daily feed intake(g/bird)	125.5[a]	81.6[b]	81.3[b]	71.4[c]	1.64	0.000
Initial body weight(g/bird)	124.4	120.2	126.3	129.6	3.84	0.421
Final body weight(g/bird)	2047.2[a]	1143.9[b]	1082.1[b]	661.3[c]	51.9	0.000
Body weight gain(g/bird)	1922.9[a]	1023.8[b]	955.8[b]	531.6[c]	52.5	0.000
Average daily gain(g/bird)	45.8[a]	24.4[b]	22.8[b]	12.7[c]	1.25	0.000
Feed conversion ratio	2.7[b]	3.6[b]	3.61[b]	5.7[a]	0.27	0.000
Mortality, %	0.0	2.00[ab]	1.00[b]	3.67[a]	0.73	0.037

[a,b,c,] Means in the same row without common letter are statically different at $P<0.05$; APM=Avocado Pomace meal, T_1 = Control diet without APM; T_2 = APM included at 5%; T_3 = APM included at 10%; T_4 = APM included at 15%; SEM = Polled standard error of mean.

4.3 The effect of inclusion of different levels of avocado pomace meal on the carcass characteristics of broilers

The carcass characteristics of broilers fed on diets containing different levels of APM are presented in Table 4. In almost all carcass characteristics the highest ($P<0.05$) carcass characteristics were obtained in T1 than T2, T3 and T4.

Table 5: The effect of inclusion of different levels of avocado pomace meal on the carcass characteristics of broilers

Parameters	Treatments				SEM	P-Value
	T_1	T_2	T_3	T_4		
Slaughter weight (g)	2214.0^{a}	1369.0^{b}	1142.6^{b}	723.3^{c}	143.22	<0.000
Unevicerated carcass (g)	1714.3^{a}	1064.6^{b}	882.0^{b}	583.6^{b}	109.48	<0.000
Drumsticks (g)	194.3^{a}	128.6^{ab}	117.0^{b}	64.0^{b}	17.03	<0.004
Thighs (g)	245.0^{a}	137.6^{b}	112.6^{b}	70.3^{c}	19.90	<0.001
Breast cut (g)	546.0^{a}	268.3^{b}	215.0^{b}	115.0^{b}	37.23	<0.002
Neck (g)	72.0^{a}	50.0^{ab}	44.0^{b}	29.6^{b}	5.56	<0.004
Wings (g)	132.3^{a}	85.4^{b}	68.3^{b}	46.2^{b}	10.18	<0.002
Back cut (g)	155.6^{a}	86.3^{b}	80.3^{b}	54.3^{b}	12.76	<0.002
Skin (g)	102.2^{a}	58.2^{b}	48.4^{b}	33.7^{b}	8.05	<0.001
Gizzard (g)	67.6^{a}	45.3^{ab}	49.0^{ab}	29.8^{b}	7.84	<0.005
Whole leg (g)	440.0^{a}	265.6^{b}	230.0^{b}	134.3^{b}	34.09	<0.000
Breast muscle (g)	335.6^{a}	145.3^{b}	115.6^{b}	58.3^{b}	19.62	<0.001
Breast bone (g)	210.0^{a}	122.3^{b}	100.6^{b}	55.6^{b}	17.41	<0.000
TEO (g)	230.7^{a}	151.9^{b}	136.7^{b}	89.0^{b}	16.4	<0.014
Total edible carcass (g)	1579.0^{a}	948.9^{b}	769.3^{bc}	436.1^{c}	130.54	<0.002
Dressing (%)	71.3	69.3	67.6	61.6	3.49	<0.3096

^{a,b,c} *Means in the same row without common letter are statically different at $P<0.05$; T_1 = Control diet without APM; T_2 = APM included at 5%; T_3 = APM included at 10%; T_4 = APM included at 15%; SEM = Polled standard error of mean; TEO = total edible offal's; g=gram*

4.4 Effect of inclusion of different levels of avocado pomace on Non edible offal parameter of broiler chickens

The non-edible offal components of broilers fed different proportions of APM are presented in Table 5. The weights of most non-edible offals were higher ($P<0.05$) in T1 compared to other treatments except lung, intestine, proventrculus, esophagus and crop.. The weight of lungs, intestine proventrculus and esophagus were similar ($P> 0.05$) among treatments. The heart weight in T_1 and T_2 are higher ($P < 0.05$) than T_3 and T_4.

Table 6: Effect of inclusion of different levels of avocado pomace on Non edible offal parameter of broiler chickens

Parameters	Treatments				SEM	P-value
	T_1	T_2	T_3	T_4		
Head (g)	72.2^a	43.3^b	37.6^b	25.0^b	5.91	<0.002
Blood (g)	71.0^a	12.6^b	10.0^b	9.6^b	3.60	<0.000
Shank with claw(g)	90.3^a	65.6^{ab}	60.0^{ab}	35.3^b	6.71	<0.003
Feather (g)	155.9^a	89.0^b	73.9^b	51.5^b	12.30	<0.001
Lungs (g)	7.0	5.0	3.6	3.3	0.84	<0.057
Kidney (g)	2.0^a	1.1^b	1.0^b	1.0^b	0. 08	<0.000
Heart (g)	11.6^a	11.3^a	7.6^{ab}	5.6^b	0.97	<0.006
Liver (g)	49.3^a	37.0^{ab}	31.66^{ab}	20.0^b	3.85	<0.004
Spleen (g)	2.00^a	1.00^b	1.00^b	1.00^b	0. 41	<0.000
Pancrease (g)	2.0^a	1.1^b	1.0^b	1.0^b	0. 08	<0.000
Intestines(g)	105.6	76.3	93.3	56.3	15.94	<0.224
Proventrculus(g)	12.0	9.3	7.3	8.0	2.22	<0.501
Crop with esophagus(g)	16.3	8.6	13.3	8.3	2.90	<0.231
Cloaca (g)	16.0^a	8.6^b	7.0^b	4.33^b	1.43	<0.002
Abdominal fat(g)	51.3^a	25.3^b	14.0^b	15.3^b	8.72	<0.0053
TNEO(g)	603.8^a	347.5^b	323.2^b	220.2^b	44.05	<0.001

[a,b,c] Means in the same row without common letter are statically different at $P<0.05$; T_1 = Control diet without APM; T_2 = APM included at 5%; T_3 = APM included at 10%; T_4 = APM included at 15%; SEM = Polled standard error of mean; TNEO = Total non-edible offal's; g=gram

4.5 Effect of inclusion of different levels of avocado pomace on Haematological and biochemical profile of broiler chickens

The effect of the feed APM on the hematological parameters of the experimental birds is presented in Table 6. The heamatological and biochemical profile were similar ($P>0.05$) among treatment except platelets. The value of platelets for T3 and T4 were higher ($P<0.05$) than that of T1.

Table 7: Effect of inclusion of different levels of avocado pomace on Haematological and biochemical profile of broiler

Parameters	Treatments				SEM	P-Value
	T1	T2	T3	T4		
PCV (%)	30.36	26.23	28.03	25.20	1.71	0.234
Hb (g/dl)	15.63	14.06	14.46	13.26	0.79	0.279
MCV(FL)	119.10	128.10	116.51	112.46	0.70	0.451
MCHC (pg)	51.53	53.60	51.73	52.70	0.83	0.343
RBC(10^6/ µl)	2.55	2.27	2.40	2.24	0.12	0.329
Platelets (10^{3}/µl)	7.66^b	12.00^{ab}	15.33^a	14.66^a	1.52	0.027
WBC(10^{3}/ µl)	90.67	70.19	74.15	64.38	7.45	0.155
Neutrophils (%)	24.03	16.10	4.73	9.63	6.35	0.238
Lymphocyte (%)	74.10	82.30	94.26	88.63	6.55	0.234
Monocytes (%)	0.13	0.03	0.16	0.23	0.05	0.133
Eosinophil (%)	1.14	0.73	0.23	0.22	0.35	0.186
Basophils (%)	0.46	0.31	0.41	17.37	0.11	0.800
TP(mg/dl)/	2.63	3.06	3.02	4.19	0.485	0.207
Cholestrol (mg/dl)	135.6	152.9	137.8	173.8	10.49	0.107
Glucose (mg/dl)	175.4	139.9	246.8	282.9	37.09	0.808
Creatinine (mg/dl)	0.49	0.48	0.45	0.47	0.03	0.839

T_1=*control,* ***T_2***=*5%APM,* ***T_3***=*10%APM,* ***T_4***=*15% APM, ab= means on the same row with different superscript differs significantly among treatments, PCV= Packed Cell Volume, MCV=Mean cell volume, MCHC= Mean corpuscular haemoglobin concentration, WBC=White Blood Cell, RBC= Red Blood Cell, SEM= Standard Error of Means, Hb= Haemoglobin; FL=femtoliters; PG=pictogram; mg/dl=milligram per deciliter,* ***TP***=*Total protein,*

4.7 Effect of inclusion of different levels of avocado pomace on Water holding capacity, p^H and cooking loss of broiler chicken carcass

Water holding capacity, pH, and cooking loss of broilers carcass are presented in Table 7. The water holding capacity was similar ($P > 0.05$) among treatments. The average cooking loss forT3 and T4 was greater ($P<0.05$) than T1. .

Table 8: Effect of inclusion of different levels of avocado pomace on Water holding capacity, p^H and cooking loss of carcass Effect of by feeding APM

	Treatments				SEM	P-Value
Parameter	T_1	T_2	T_3	T_4		
p^H	6.4	6.3	6.5	6.6	0.19	0.052
WHC (%)	83.6	80.6	88.0	81.34	5.74	0.43
Cooking loss	9.52^c	27.0^b	30.3^a	29.2^{ab}	12.8	0.021

***T_1*=control, *T_2*=5%APM, *T_3*=10%APM, *T_4*=15% APM; abc= means on the same row with different superscript differs significantly among treatments; SEM= Standard Error of Means, WHC=water holding capacity.*

5. DISCUSSION

5.1 Chemical composition

The crude protein, ash, ether extract, crude fiber value of avocado pomace meal was higher than the value reported for avocado seed powder and peel (Clinton, 2023). The CP content (9.23%) of avocado pomace meal whereas crude fiber (19.07 %) content of avocado pomace was higher than the maximum tolerable crude fiber in broiler ration which is 5% (BIS, 2007). According to Ginindza et al., (2022) tolerable amount of crude fiber in broiler feed should range from 2-8%. The tannin content in avocado pomace meal in the current study is higher than that of maximum tolerable amount in broilers chicken feed; broilers could not tolerate tannin a doses of 0.375 mg/g and above (Huiping Xu et al., 2025). Higher tannin content in broilers chicken feed can consequences in potentially reducing their digestibility and absorption, cellular damage, poor growth performance and impaired immune system (Huiping Xu et al., 2025). Phenolic compounds in present study was higher than maximum tolerable amount in broiler ration; 1.5mg/g (Mahfuz, 2021). Excessive phenolic compound may negatively impact gastrointestinal health, nutrient absorption, and overall poultry performance. The recommended amount of alkaloids in broilers chicken ration is 0.0057mg/g (Dänicke, 2017). Higher amounts of alkaloids in poultry feed can lead to several negative effects, including reduced feed intake and growth performance, liver damage, and metabolic disturbances (Kovatsis. et al., 2003). Recommended amount of flavonoids in the chicken ration was 0.049–1 g/kg (Nath and Kumar, 2021).

The content of anti-nutritional factors observed in the current study was higher than the recommended level. These could be one of the reason why the performance of chickens decreased with increasing levels of avocado pomace meal.

5.2 The effect of inclusion of different levels of avocado pomace meal on feed intake, body weight, body weight gain, and feed conversion ratio in broilers during different phases.

In present experiment avocado pomace meal inclusion negatively influenced the body weight gain and feed conversion ratio than those on control treatment group. Similarly, Aghili et al. (2019) reported decreased growth performance and carcass characteristics and internal organs of broilers with increasing levels of apple pomace in broilers. Feed intake in the entire period was higher in control group and similarly reported by (Mikail et al., 2022) with different level of apple pomace. The birds that fed on the control diet were superior in average daily gain and feed efficiency which is consistent with the report of standard weight of broilers Coob companyBCMG (2015). In addition to growth performance, leg muscle paralysis, twisting their heads up, weakness to stand and abnormal movement were observed at 15% of APM inclusion in the current experiment probably because of high content of phenolic compounds and tannin as reported by Santos et al. (2013). The daily feed intake, average daily gain and feed conversion ratio were lower in the avocado pomace meal supplemented group during the grower and finisher phase which is consistent with the findings of Van Ryssen et al. (2013) who reported that inclusion of 7.3 to 29.3 % avocado meal in the diet of broilers reduced feed intake and weight gain. probably due to avocado lipids oxidation and rancidity causing off flavor and reduced palatability.

In other fruit pomace different authors reported contrasting effect on feed intake and ADG. The study of Sosnówka et al. (2023) reported no effect of feeding dried fruit pomace (apple and cherries) up to 30 g/kg of the feed on body weight gain. Similarly, it was reported (Hu et al., 2023) reported similarity in the growth performance of broiler chickens with the addition of dried blueberry or pineapple pomace during starter which was consistent with the current finding in broilers fed avocado pomace. On the contrary, Colombino et al. (2020) showed no significant differences with control group on growth performance, gut morphometry, or histopathology by using apple pomace, blackcurrant pomace, or strawberry fruit pomace. Moreover, it was reported that addition of dried pomace from strawberries reduced ADG of the experimental birds (Sosnówka et al., 2023).

One of the reason for the decrease in performance of broilers in the current study might relate to high level of tannin and crude fiber content in avocado pomace . High levels of dietary tannins negatively affected the average daily gain and average daily feed intake of broiler chickens, decreased carcass and organ development like drumstick and liver weights (Hidayat et al., 2021) which might be the case in the current experiment.   In general as the level of APM increased from 0 to 15% in diets, feed efficiency was reduced and body weight gain was retarded. The depressed performance observed in broiler chicks suggests that younger birds are more susceptible to the effects of anti-nutritional factors (Perez-Maldonado et al., 2003).

5.3 The effect of inclusion of different levels of avocado pomace meal on the carcass characteristics and non-edible offal of broilers

The majority of carcass characteristics and offals were lower in avocado pomace fed broilers in the current experiment compared with the control. Similarly, Van Ryssen et al. (2013) observed decreased breast weight and thigh yield by inclusion of different levels (7.3%, 14.7%, 22.0% and 29.3%) of AP compared with the control for broilers. The slaughter weight, eviscerated weights, and weight of carcass cuts, including drumsticks, thighs, and breasts, of birds decreased with incremental levels of avocado pomace meal in the diets in the current experiment which is consistent with Van Ryssen et al. (2013). A similar finding was also observed by Eugenes et al. (2019) which reported lower proportion of giblets in the carcass when birds were fed with strawberry pomace compared to chickens from the control group. .

The weight of visceral organs such as the crop with esophagus, lungs, intestine, and Proventrculus were similar among the AP fed group. In contrast (Colombino et al. 2020), reported weight of visceral organs were significant different among the dietary treatments of conventional feed with apple, blackcurrant or strawberry pomace. The similar weight of spleen, kidney and pancreases weight observed on APM fed groups were consistent with Yaodong, et al. (2023), who reported similar internal organ weight with increased levels of dried apple pomace meal. Farran et al., (2005) and Mushtaq et al. (2014) found that internal organ size is impacted by the presence of anti-nutritional substances in the diet.

5.4 Effect of inclusion of different levels of avocado pomace on Haematological and biochemical profile of broiler chickens

The PCV of all group in the current study is within the normal values (25.2-30.36) reported by Onunkwo, (2022). For healthy birds, PCV ranged from 24.90–45.20%, as reported by Mitruka and Rawnsley. (1997). Too high PCV is an indicator of toxic factors that could have an adverse effect on the formation of blood (Bounous and Stedman, 2000). The hemoglobin content in the current study ranged from 15.63 to 13.26 g/dl, which is out of the normal range (7–13 g/dl) for chicken hemoglobin (Bounous and Stedman, 2000) which may be due to higher content of ant nutritional factors (Onunkwo et al., 2022) in AP. The MCV range in the current experiment (128.10 to 112.46 fl) is within the normal range (90–140 FL) for healthy chickens (Bounous and Stedman, 2000).

Packed cell volume (PCV), hemoglobin, and mean corpuscular hemoglobin (MCHC) are major indices for evaluating circulatory erythrocytes and are significant in the diagnosis of anemia (Peters et al., 2011). RBC transports oxygen to animal tissues for the oxidation process to release energy and transport carbon-dioxide out of the tissues (Omiyale, 2012) and the manufacture of haemoglobin. The observed hemoglobin values range between 2.24 – 2.55 $*10^6/mm^3$ in the current study where only T1 is within the normal range for healthy broiler chicken (Onunkwo, , 2018) where other treatments (T2, T3, and T4) are lower than normal range. This shows that the APM disabled proper functioning of the RBC in respiration, expiration, supply of nutrients and manufacture of haemoglobin. APM resulted in and depress RBC value which could be due to the occurrence of ant-nutrient factors in pomace. The number of erythrocytes (RBC) in chickens influences the overall conditions of the birds

(Ikpitanyi., et al 2020). In the current study the range of platelet values ($7.6\text{-}14.7*10^3$) only T1 was out of normal range (Onunkwo., 2022). The average platelet size in broilers is around 5-7. Therefore, the numerical decreases in PCV, hemoglobin, and RBC counts of the birds fed the test ingredients are an indication that the oxygen-carrying capacity of the blood is lowered. Hemoglobin, mean corpuscular hemoglobin, and mean corpuscular hemoglobin concentration are important blood parameters whose values are used to determine the presence and severity of anemia (Huff et al., 2008).

The range ($64.38\%–90.6710^{3/\ \mu l}$) of white blood cell in the current study was higher than the referenced ranges of 12-30 ($10^{3/\mu l}$) (Wayas et al., 2018). An elevated white blood cell count can indicate an active infection (Ganomg, 1991). The increase in WBC could also be attributed to the presence of some phytochemicals in bitter APM which induces the animal to respond as if it had an infection (Areghore et al., 1997) or due to the presence of residual anti-nutrients which induces production of more antibodies that stimulate more WBC production to fight the infection being a defense system. Total protein in the current study ranged from 4.19 to 2.63 mg/dl which is in the normal range TP (2.5-4.6 gmg/dl) in the broilers as reported by Wayas et al. (2018). A total cholesterol level of less than 200 mg/dL is normal, and the present finding falls in the range of normal conditions for both the control and experimental groups. Typically, broiler glucose levels are higher than in mammals and ranges from 180 to 250 mg/dl (Hernawan et al., 2012). But higher glucose concentrations was observed in T_4 (282.93 mg/dl) which is higher than normal range probably due to antagonistic reaction of antinutritional factor (Ji et al., 2020).

The creatinine concentration in the present study ranged from 0.45 to 0.49 mg/dl, is below the normal range (0.6 to 1.2 mg/dl) (Agida, 2020). Lower levels of creatinine usually indicate that the kidneys are functioning well and are effectively filtering waste from the blood (Ma et al., 2011). The mean value of creatinine implies that APM has a similar effect on the kidneys of the birds across the dietary treatments, with the creatinine value also being total muscle catabolism displayer (Ladokun et al., 2008). This low creatinine level is responsible for low muscle mass, a lack of strength, difficult to stand and a thin or frail body.

5.5 Effect of inclusion of different levels of avocado pomace on Water holding capacity, pH and cooking loss of broiler chicken carcass

The ranges of water content (81.34–88%) in the current study are outside the normal water content of chicken meat, (Soeparno, 2009) which ranges from 65–80% (Forrest, 1975). As a comparison, an earlier study found that broiler meat had a much higher average water-holding capacity (**13.50 ± 0.05%)** than layer meat 11.82 ± 0.19%; (Saleem et al., 2017). High water content in meat causes meat to rot quickly after postmortem due to fast microbial growth in meat that has moisture content above 80% (Soeparno, 2009).

A pH value can be used to indicate the level of acidity and alkalinity of a meat, whose value when the animal is still alive is around 7.0–7.2. After the postmortem, the pH value in the muscles will decrease due to the accumulation of lactic acid. A decrease in the pH value of animal muscles properly handled prior to postmortem will progress gradually from 7.0 to 5.6–5.7 within 6–8 hours postmortem and will reach a final pH value of about 5.5–5.6 (Septinova, 2016). The pH of the broiler breast in the current study is within the normal pH range of meat in postmortem conditions (5.3-6.5). Cooking loss is an indicator of the value of meat nutrition related to levels of meat juice, which is the amount of water bound in and between muscle fibers. Meat juice is a component of meat that determines the tenderness of meat (Soetan. and Oyewol, 2009). The value of cooking loss in the current study (28.13 and 42.31%) is within the normal range (Soetan . and Oyewol 2009) indicated that the cooking loss value of meat varies between 1.5 and 54.5% with a range of 15 to 40%.

6. Conclusion

In this study, daily feed intake, and body weight gain decreased with incremental levels of avocado pomace meal during entire period of experiment. Growth performances of broilers were highly affected at 15% inclusion level of avocado pomace, and mortality percentages were high in this group, particularly during the grower and finisher phases. Treatment without avocado pomace was high in most carcass characters. Most hematological and biochemical parameters were within the normal range for all treatments. The presence of anti-nutritional factors and low palatability has contributed to the poor performance of the birds. Therefore, based on the present evidence, avocado pomace meal is not recommended for inclusion in broiler diets.

7. RECOMMENDATION

- Further studies are required to establish the cause of the poor performance of broilers consuming APM and whether it can be rectified

- Application of appropriate antinutrional factor treating mechanism: Fermentation, Enzymes, and heat treatments can is recommended for proper utilization of avocado pomae.
- Inclusion of low levels of avocado pomace meal below 5%, is worth investigating.

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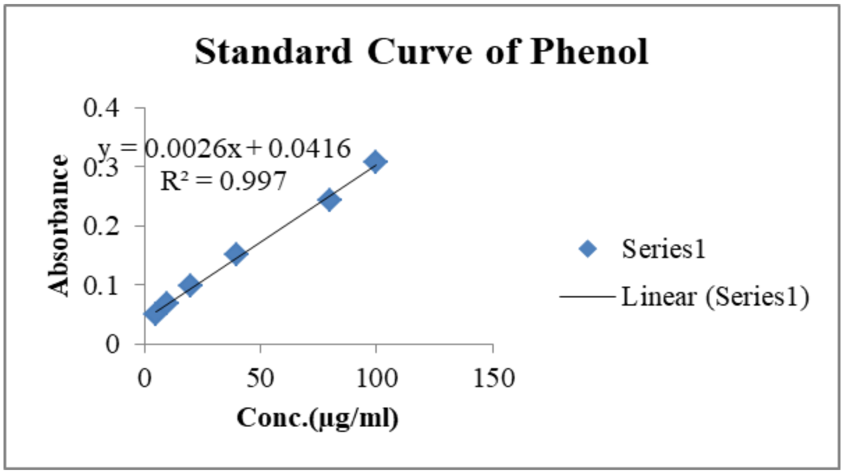
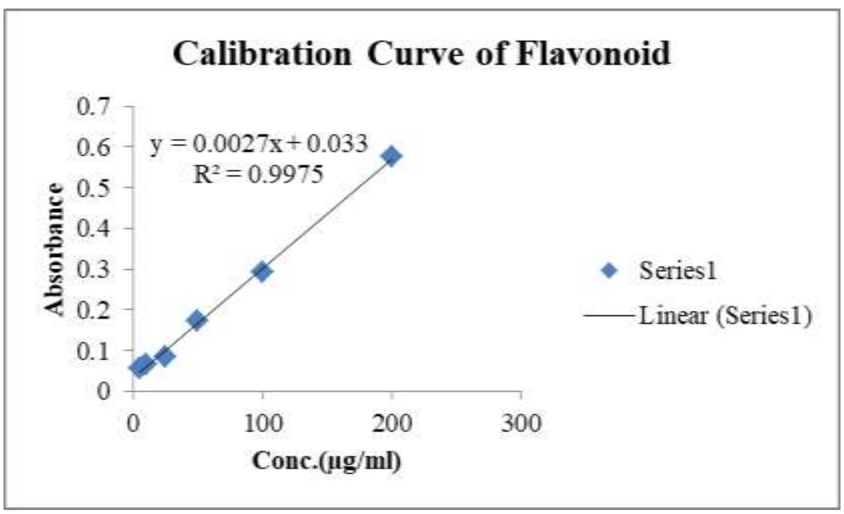
APPENDIX

Figure 1: Antinutritional factors standard curves.



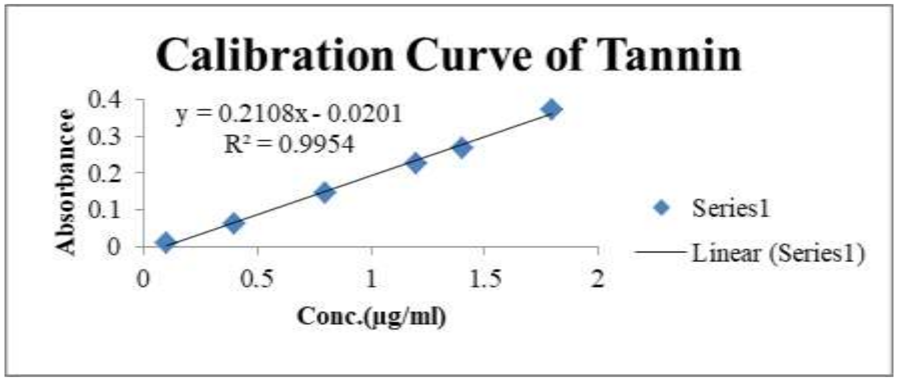
S1	0.3807	S1	130.4231
S2	0.3872	S2	132.9231
S3	0.383	S3	131.3077



Catchen standars Flavonoid

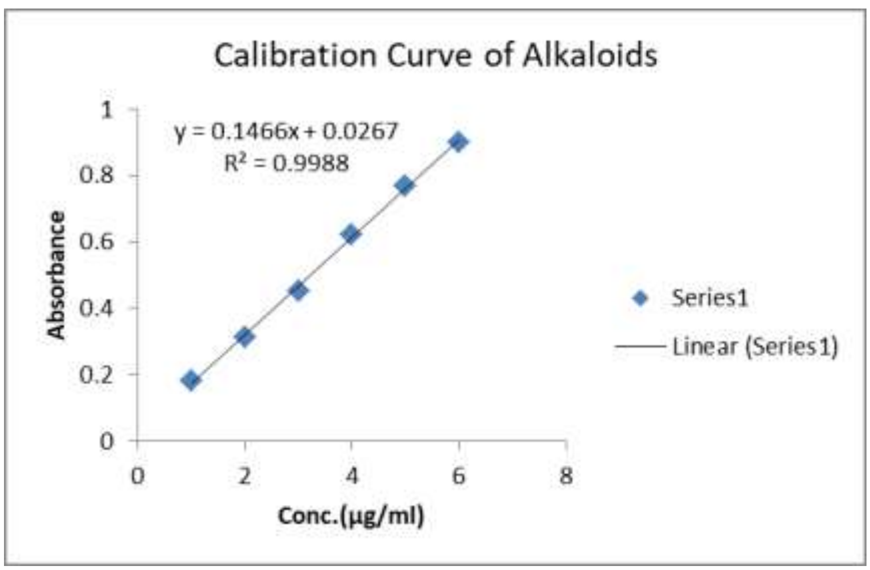
S1	1.1023	396.037
S2	1.1386	409.4815
S3	1.148	412.963

Tannin standard



	Conc.		
S1		0.0979	0.559772
S2		0.1052	0.594402
S3		0.1112	0.622865

Alkaloid Standard



Concentration		
S1	0.8647	5.716235
S2	0.8588	5.675989
S3	0.8607	5.68895

Phytochemical of Bioactive Substance Screening of Sample for the determination

Parameters	Sample
Alkaloides	Positive
Flavonids	Positive
Aminoacids and Protiens	Positive
Phenols	Positive
Tannins	Positive
Terphenoids	Positive
Quinones	Negative
Saponins	Positive

Figure 2: Pictures of broilers during brooder room, grower and finisher phases

Figure 3: Different parts of commercial cuts

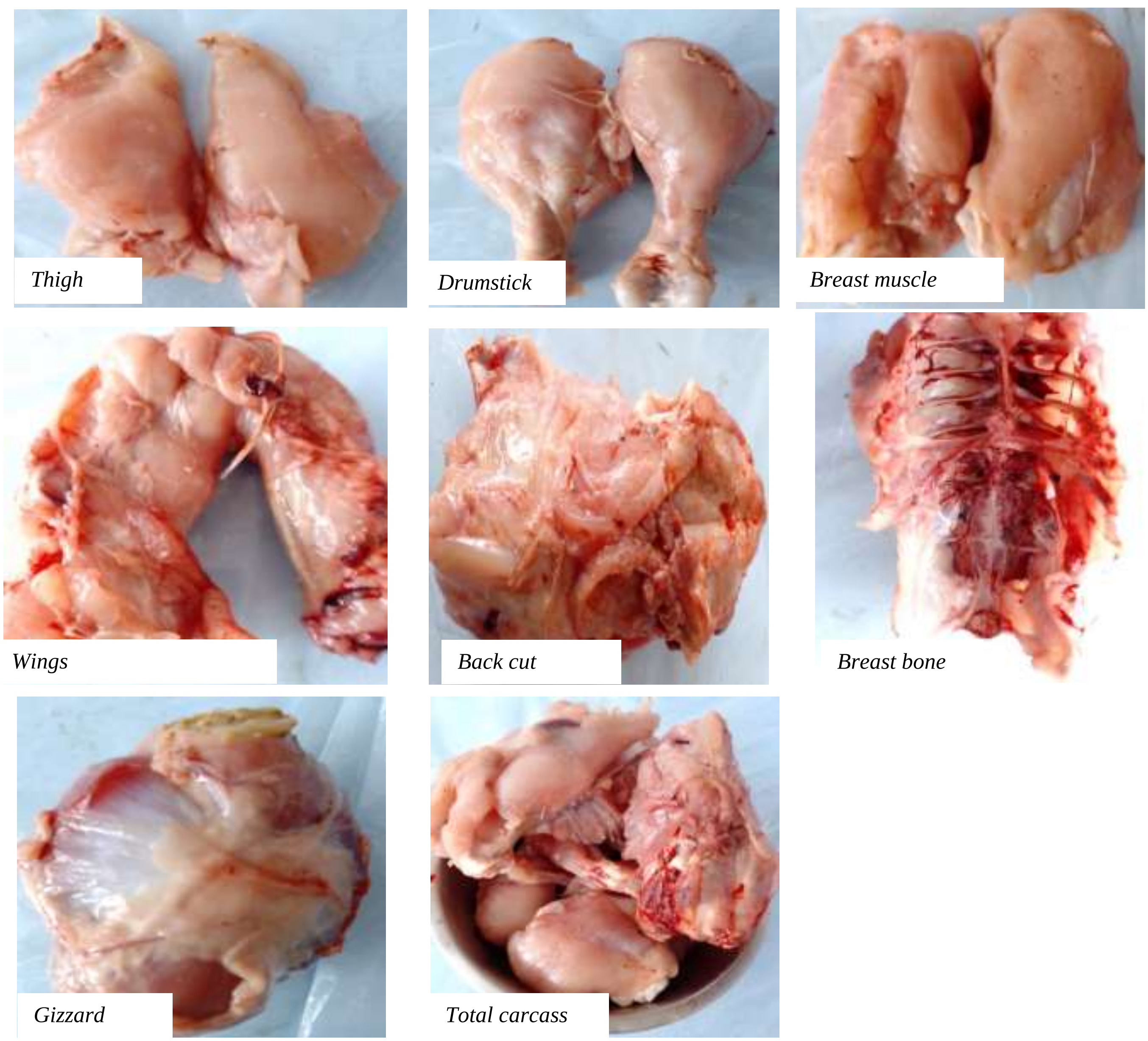
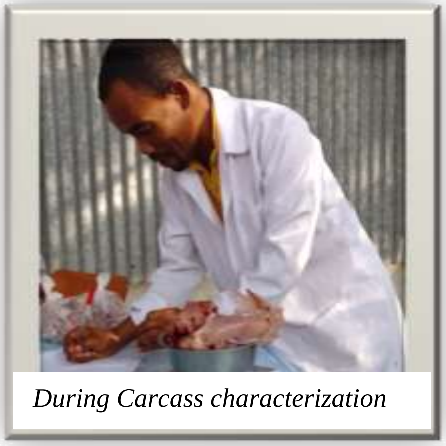


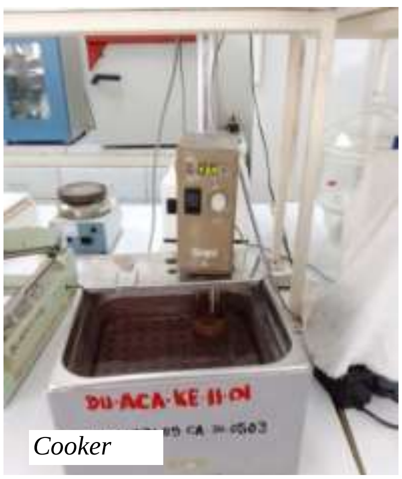
Figure 4: pictures during lab work



During Carcass characterization

During lab work

Figure 5: materials used during meat quality analysis



Cooker

PH meter

Centrifuge