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Evaluation of Drumstick Meat Quality Attributes in Different Chicken Genotypes Under On-station condition

[1*]*Atsbaha Hailemariam Gebreslassie,* [1]*Chala Edea Muleta*
[1]*Ethiopian Institute of Agricultural Research, Debrezeit Agricultural Research Center, Bishoftu, Ethiopia*
[1*]*Corresponding Author; Email:* **** atsbaba@yahoo.com***

ABSTRACT
The study was conducted to evaluate the drumstick meat quality attributes of different chicken genotypes under On-station condition. The drumstick meat quality attributes of Cosmopolitan (**C**), Improved Horro (**H**), ♂Improved Horro*Cosmopolitan♀ (**HC**), ♂Cosmopolitan*Improved Horro♀ (**CH**), Indigenous (**L**), and Koekoek (**KK**) genotypes were evaluated in On-station condition over a 24-week period. The study utilized a completely randomized design (**CRD**), and the data were analyzed using the General Linear Model (**GLM**) in SAS software. A total of 144 chickens from the six genotypes were used. For each genotype, around 24 chickens were slaughtered, with each drumstick cut samples replicated six times. The shear force (WBSF) was significantly highest in the KK genotype, followed by C and CH, while the L genotype exhibited the lowest WBSF. Drumstick meats from the L and HC genotypes demonstrated the highest water-holding capacity (WHC), with C and HC also showing elevated values. In contrast, the KK genotype had the lowest WHC. The pH45 value was lowest in KK, with slightly higher values in C and HC, while the H genotype recorded a higher pH45 value. The L genotype exhibited the highest pH45 value significantly. The pH24 value was significantly higher in the L drumstick compared to H and HC, with the lowest values in C, CH, and KK. Cooking loss (CL) was significantly greater in the KK, CH, and C genotypes than in H, HC, and L. Drip loss (DL) values were highest in KK and CH, followed by C and HC, while L had the lowest DL. Lightness (L*) values were significantly higher in KK, CH, and C than in HC and H, with L showing the lowest score. Additionally, the redness (a*) score was significantly lower in KK, CH, and HC compared to H, C, and KK, whereas the yellowness (b*) score was significantly higher in KK, CH, and C than in HC, H, and L. The chroma (C*) and hue angle (h*) scores were also significantly higher in KK, CH, and C compared to HC, H, and L. **In conclusion**, these findings underscore the substantial influence of genetic variations on drumstick meat quality attributes of different chicken genotypes. This study could serve as a valuable reference for future research on the quality characteristics of drumstick meat in various chicken genotypes, supporting efforts in poultry selection and breeding to enhance meat quality.
Keywords: Genotype, Drumstick, Meat Quality,Attribute, Chicken, On-station
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1. Introduction

Ethiopian chickens are raised in diverse management and production systems, ranging from family-based poultry farming to medium and large-scale intensive systems [1]. The quality of chicken meat is becoming an increasingly important concern for both consumers and the poultry industry [2]. Study demonstrated that chicken meat is in highly demand due to its high protein content, low fat and cholesterol levels, and affordability implication [3]. Similarly, chicken meat consumption is free from cultural or religious restrictions [4]. Numerous studies have shown that factors such as breed, strain, age, sex, and diet can affect meat quality [5]. Meat quality is determined by factors such as color, pH, water-holding capacity, drip loss, cooking loss, and shear force [6, 8]. Reports have highlighted that chicken meat color serves as a crucial indicator of its quality and plays a significant role in shaping consumer preferences during purchase decisions [7, 38]. Meat color is primarily influenced by myoglobin, with hemoglobin and cytochrome C also playing a contributing role [29, 38]. According to some studies, the CIE L*a*b* and Munsell C*h* systems can be used to measure the color of meat [9,10], as well as utilizing human senses [11]. Some scholars have reported that meat pH is largely determined by the level of glycogen stored in the muscle at the time of slaughter [12, 38]. Study has confirmed that meat pH levels at 45 minutes and 24 hours post-slaughter are critical indicators for assessing chicken meat quality [13]. According to previous findings, the normal pH values of meat are 6.01–6.70 at 45 minutes and 5.50–6.01 at 24 hours post-mortem, respectively [14]. A pH reading of less than 5.70 at 45 minutes after death is indicative of

pale, soft, exudative meat [15], while meat that has a pH value of more than 6.20 24 hours after death is considered dark, firm, and dry and affect the meat standard or grade levels [16, 38]. Meat tenderness is reported to be one of the primary attributes consumers consider when purchasing meat and meat products [17], and it can be measured using the Warner-Bratzler or Kramer shear force methods [18, 19]. The water-holding capacity of meat refers to its ability to retain its natural moisture or absorb added water when subjected to external forces [10]. According to some reports, the water-holding capacity of meat plays a crucial role in both whole meat and processed meat products [13, 20]. The results indicated that a lower pH is linked to reduced water-holding capacity (WHC), leading to higher cooking and drip loss [21].

The genetically improved Horro genotype of Ethiopia (H) has been shown to enhance growth and egg production [22]. The Cosmopolitan chicken (C), an imported breed, is recognized as a representative of global chicken diversity [23]. Additionally, the Koekoek (KK) dual-purpose chicken was imported from South Africa [24]. The indigenous chicken (L) served as a reference for selection and breeding [25]. Given that the Cosmopolitan genotype is newly introduced to Ethiopia, it is clear that initial research and documentation are needed before its broader dissemination, providing valuable insights for future studies. The Cosmopolitan (C) and Improved Horro (H) breeds were crossed both directly and reciprocally—Cosmopolitan♂*Improved Horro♀ (CH) and Improved Horro♂*Cosmopolitan♀ (HC)—with the hypothesis that there would be variations in drumstick meat quality characteristics among the experimental chickens. These drumstick meat traits were compared with those from the indigenous (L) and Koekoek (KK) genotypes.

General Objective

The objective of study was to compare the drumstick meat quality traits under on-station condition.

Specific Objectives

The specific objectives are indicated below as:

a) To compare the instrumental tenderness of drumstick meat of different chicken genotypes.

b) To compare the drip loss of drumstick meat of different chicken genotypes.

c) To compare the cooking loss of drumstick meat of different chicken genotypes.

d) To compare the waterholding capacity of drumstick meat of different chicken genotypes.

e) To compare the pH ofdrumstick meat of different chicken genotypes.

2. Materials and Methods

2.1. Description of the Study Areas

The experiment was carried out at the Werer Agricultural Research Centre (WARC) in Ethiopia, located 280 km from the capital, Addis Ababa. The center sits at an altitude of 820 meters above sea level, with coordinates of 55′ N latitude and 40° 40′ E longitude. The annual rainfall at WARC ranges from 400 mm to 600 mm, and the average minimum and maximum temperatures are 19.3 °C and 45 °C, respectively.

2.2. Ethical Approval, Experimental Animals, Managements, and Sampling Procedures

2.2.1. Ethical Approval and Experimental Animals

This experiment was conducted in accordance with the guidelines approved by the Institutional Animal Care and Use Committee (IACUC) and was carried out in collaboration with the study reported in [23]. A total of 144 chickens, equally distributed across the six genotypes, were sampled for slaughter. The experimental genotypes included: I = Improved Horro (H), II = Cosmopolitan (C), III = Koekoek (KK), IV = Indigenous (L), V = Cosmopolitan♂*Improved Horro♀ (CH), and VI = Improved Horro♂*Cosmopolitan♀ (HC).

2.2.2. ManagementsandSampling Procedures

Before the experiment began, the watering and feeding troughs, as well as the laying nests, were cleaned, disinfected, and treated for external parasites. The floor of each pen was lined with disinfected grass hay, which was replaced as needed. All hens, both indigenous and imported, were hatched on the same day. They were fed the same commercial starter, grower, and layer rations according to their age phases (Alema Koudjis; Feed Co., Ltd., Debrezeit, Ethiopia). The hens were vaccinated against Newcastle disease, Gumboro (Infectious Bursal Disease-IBD), and Fowl Typhoid with the appropriate vaccines following the manufacturer's recommendations (NVI-Ethiopia). The experimental chickens were managed under consistent on-station conditions throughout the study, with their health monitored during the trial. Feed from Alema Koudjis; Feed Co., Ltd., Debrezeit, Ethiopia was used throughout the trial, and supplements, including vitamin-mineral premixes and amino acids, were provided according to the poultry feed manufacturer's guidelines. The pens were also equipped with laying nests to meet all necessary requirements.

2.3. Quality of Drumstick Meats of Different Chickens

2.3.1. Meat Color and PH

The meat color parameters (CIE L*, a*, and b* values) were determined using a HunterLab MiniScan EZ (MSEZ-4500L, Serial No. MsEZ1547) with a 45/0° illumination/viewing system, D65 light source, and 10° observer angle. The L* value indicates lightness, a* measures the red-green range, and b* measures the blue-yellow range. A digital colorimeter (Hunter Lab MiniScan EZ, Washington, DC, USA) calibrated with black and white standardized plates was used, with three readings taken at different locations on each sample and averaged. Meat pH was measured using a portable pH meter (Meat pH meter-HI99163, HANAN Instruments) equipped with an InLaB Solids Pro puncture-type sharp blade electrode, following the manufacturer's instructions. The probe was cleaned with distilled water and calibrated with pH 4.01, 7.01, and 10.01 standard buffer solutions between sample measurements. Meat pH was recorded at 45 minutes and 24 hours post-mortem, with three readings taken at different locations per sample and averaged. For color measurement, the internal face of the cranial position of the filleted drumstick meat samples was exposed on a flat white background in the measurement room and allowed to bloom for about 45 minutes at ambient temperature (24°C ± 1.2°C). This study included 144 genotypes, with 24 per genotype and 6 samples per cut. The six drumstick meat samples per cut were averaged to determine meat pH and color measurements for each genotype. Hue and Chroma were calculated using the following formula:Hue(h)=Arctangent(b/a),Chroma(C)=$(a^2+b^2)^{1/2}$

2.3.2.Water Holding Capacity (WHC%)

The water holding capacity of meat was determined 24 h postmortem using the method suggested in [27]. Two Whatman number-1 filter papers were weighed and a 0.5 g of meat sample was placed between two filter papers, this in turn was placed between two glass sheets. Over it, a weight of 2.015 kg weight was placed while the glass sheet weighed 0.8278 kg sheet, giving a total compression weight of 2.8428 kg load for 5 min. Then the weight was removed, and the meat was separated from the filter papers and weighed. In the end, the filter paper was dried and the weight was recorded. After that, the amount of protein attached to the filter paper and the actual weight of meat after pressure treatment was determined. The water holding capacity (WHC%) was calculated as: WHC(%) = (ASWBPT-ASWAPT/ASWBPT)*100, where; ASWBPT = Actual Sample Weight Before Pressure Treatment, ASWAPT = Actual Sample Weight After Pressure Treatment

Furthermore, a total of 144 genotypes, 24/genotype, and 6 samples/cut were considered in this study. The six-sample drumstick meat cut was averaged to determine the water holding capacity (%) of each genotype of the current study.

2.3.3. InstrumentalTenderness Determination

The Warner-Bratzler shear force (WBSF) method was used to determine instrumental tenderness. The steak which was cooked for 70 °C was allowed to cool down to room temperature (24–25 °C) for about an hour to evaluate instrumental tenderness using WBSF. After cooling, the steak was cut across the long axis putting the knife tip on the heavy connective tissue side and the handle of the knife on the ventral side to expose the fiber direction. The six cores (1.27 cm diameter) were removed parallel with the muscle fibers. It was critical that the muscle fibers run parallel with the core so that the shear was across the grain. The WBSF device was used to shear each core. The shear was across the middle (center) on each core. The peak values of WBSF were recorded in N (Newton) for each core. The average values for the six cores were taken for the determination of the value for each steak. The samples of meat were classified in to very tender, tender, intermediate and tough based on the range of value of WBSF which classified WBSF value in to very tender = WBS <31.4 N, tender = 31.4 N < WBS <38.3 N, intermediate = 38.3 N < WBS <45.1 N and tough = WBS >45.1 [30]. In a total of 144 genotypes with equal replica of each chicken, the cuts were measured six times and were averaged to determine the instrumental meat tenderness of each genotype of the current study.

2.3.4. DripLoss (%)

The drip loss of the drumstick meat sample from the reared chickens was measured using a plastic drip method according to the procedure [26]. From 30 g of meat, the sample was excised and cut perpendicular to the fiber direction in the widest part of the sampled muscle. The samples were hung in an inflated plastic bag and stored in the refrigerator at 4 °C for 24 h and reweighed. The six genotypes were measured and equally replicated for the drumstick meat considered in the current study. A total of 144 genotypes were used and 12 drumstick cuts/genotype, and the data collected were averaged to determine the drip loss percentage of each genotype of the current study. The drip loss (DL%) was calculated as: DL (%) = (ISWT-FSWT/ISWT)*100, Where; ISWT= Initial Sample Weight, FSWT=Final Sample Weight

2.3.5. CookingLoss (%)

The cooking loss of the thigh meat sample from the experimental chickens was measured using a plastic drip method according to the procedure [26]. From 30 g of meat, the sample was excised and cut perpendicular to the fiber direction in the widest part of the sampled muscle. The samples were hung in an inflated plastic bag and stored in the refrigerator at 4 °C for 24 h and reweighed. A total of 144 genotypes,

24/genotype, and 6 samples/cut were considered in this study. The six-sample drumstick meat cut was averaged to determine the cooking loss measurements of each genotype. The cooking loss (CL%) was calculated as: CL (%) = (WRS-WCS/WRS)*100, Where; WRS=Weight of Raw Sample, WCS=Weight of Cooked Sample

2.4. Statistical Analysis

The drumstick meat data was recorded according to the prepared sheet and entered into Excel on a regular basis. The collected data was then summarized and analyzed using the GLM model in SAS software (SAS, 2004). When the GLM revealed a significant difference at $P<0.05$, Duncan's multiple range tests were applied to separate the means.

The model used for the analysis: $Y_{ij}=\mu+G_i+e_{ij}$

Where,

Y_{ij}=the response variables

μ=the overall Mean

G_i=the effect of genotype (I =1,2,3,4,5,6)

e_{ij}=Randomerror

3.Results and Discussion

3.1. Genotype Effect on Drumstick Meat Quality of Different Chickens

3.1.1. Genotype Effect on Instrumental Tenderness of Drumstick Meat of Different Chickens

The result of the effect of genotypes on Instrumental tenderness of drumstick meat (**WBSF**) of different chickens is indicated in **Figure 1**. The shear force (WBSF) of the KK drumstick was significantly the highest (41.52 N), followed by higher values in CH (38.71 N) and C (38.49 N). The WBSF values were also elevated in HC (36.38 N) and H (35.79 N), while the L genotype had the lowest WBSF (33.65 N). These findings are consistent with the idea that variations in meat shear (WBSF) values are due to breed differences that affect tenderness as measured by instruments [28, 29, 38].

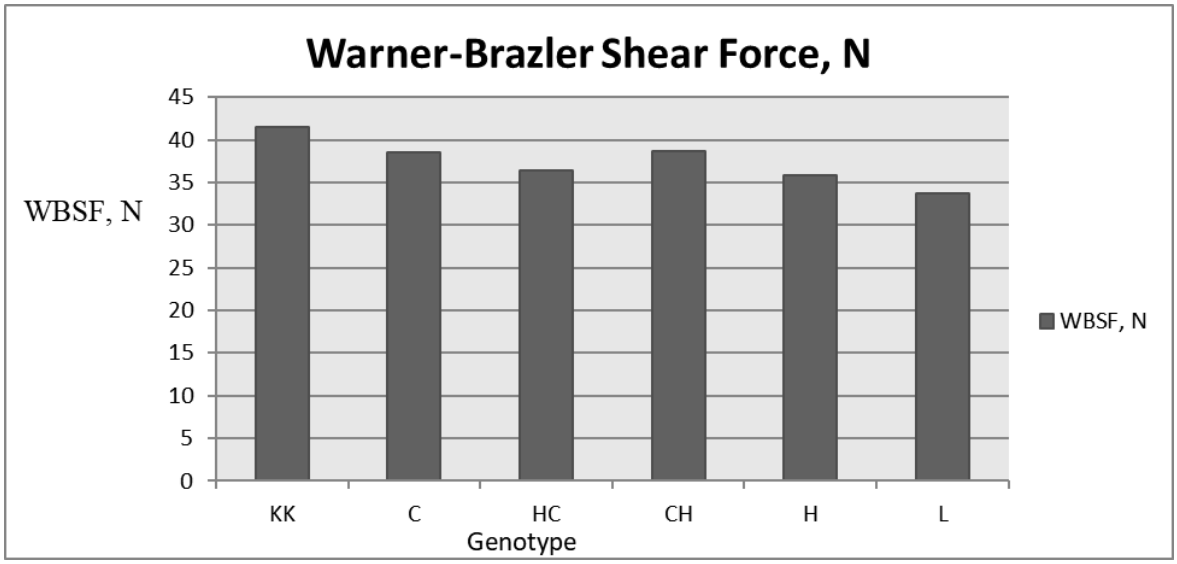

Figure (1). Effect of genotype on Instrumental tenderness (WBSF) of drumstick meat of different chickens

3.1.2. Effect of Genotype on Waterhoding Capacity of Drumstick Meat of Different Chickens at 24 Hours

The result of the effect of genotype on waterhoding capacity of drumstick meat of different chickens at 24 hours is indicated in **Figure 2**. The drumstick meats from the L (83.69) and H (82.26) genotypes exhibited significantly the highest water holding capacity (WHC) values, followed by HC (80.09) and C (82.63), which also showed high WHC values. The CH genotype had a lower WHC (79.74), while the KK drumstick meat had the significantly lowest WHC value (77.36). Differences in the water-holding capacity (WHC) of chicken meat are associated with breed variations in water retention, which can be attributed to differences in composition and quality [10, 38].

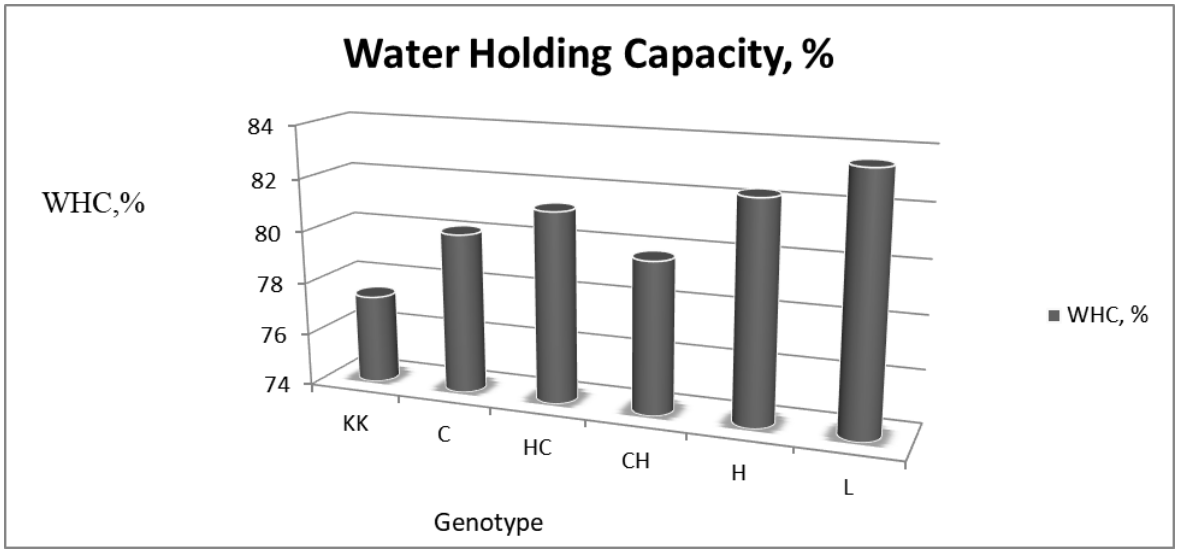

Figure (2). Effect of genotype on Waterholding capacity (WHC) of drumstick meat of different chickens

3.1.3. Effect of Genotype on pH of Drumstick Meat of Different Chickens at 45 Minutes and 24 Hours

The result of the effect of genotype on pH of drumstick meat at 45 minites (**min**) and 24 hours (**hr**) is presented in **Figure 3.** The CH drumstick had the lowest pH45 value (6.57), with slightly higher values observed in KK (6.59) and C (6.62), and a lower value in HC (6.64). In contrast, the H genotype had a higher pH45 value (6.65), while the L drumstick meat had the highest pH45 value (6.68), which was significantly greater. The L drumstick also showed a significantly higher pH24 value (5.95) compared to the H (5.92) and HC (5.91) genotypes. On the other hand, the lowest pH24 values were found in the drumstick meat from the C (5.89), CH (5.88), and KK (5.88) genotypes. The variation in meat pH is linked to the level of acidification in the meat [30, 35, 37]. These results suggest that the differences in pH are due to the amounts of glycogen stored in the muscle at the time of slaughter [31, 36].

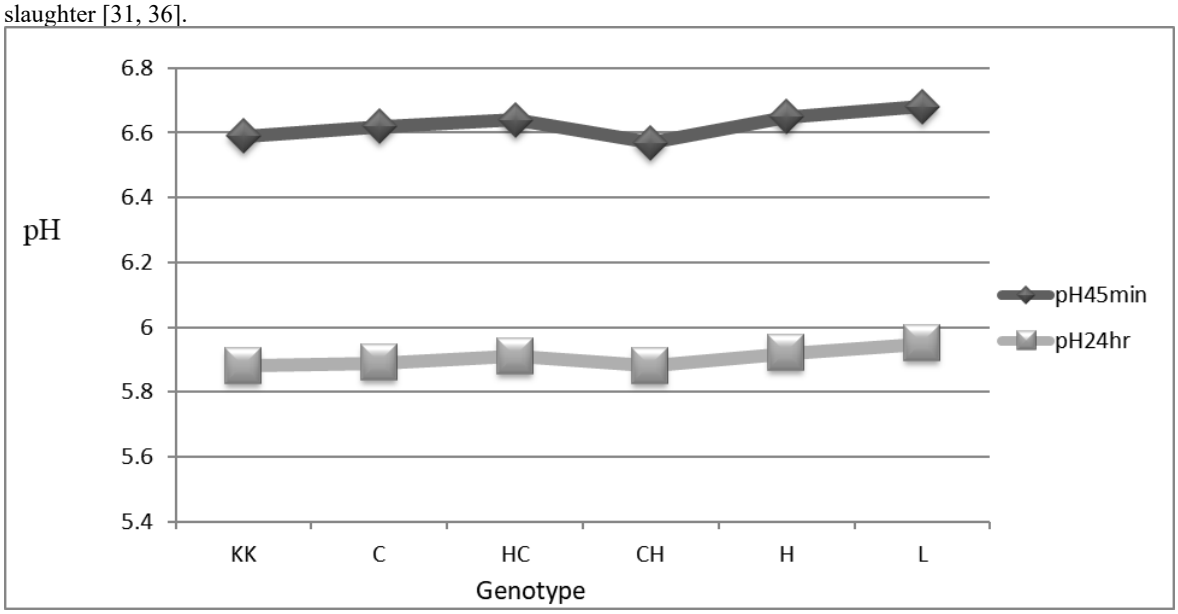

Figure (3). Effect of genotype on pH of drumstick meat of different chickens at 45 minutes and 24 hours

3.1.4. Effect of Genotype on Cooking Loss (Cl) of Drumstick Meat of Different Chicken

The result of the effect of genotype on cooking loss (CL) of drumstick meat of different chicken is presented in **Figure 4.** Cooking loss (CL) was significantly higher in the KK (25.51), CH (24.82), and C (24.64) genotypes compared to the HC (22.50), H (22.56), and L (22.34) genotypes. The variations in cooking loss (CL) among the chicken breeds are associated with differences in glycogenolysis [32, 33, 38].

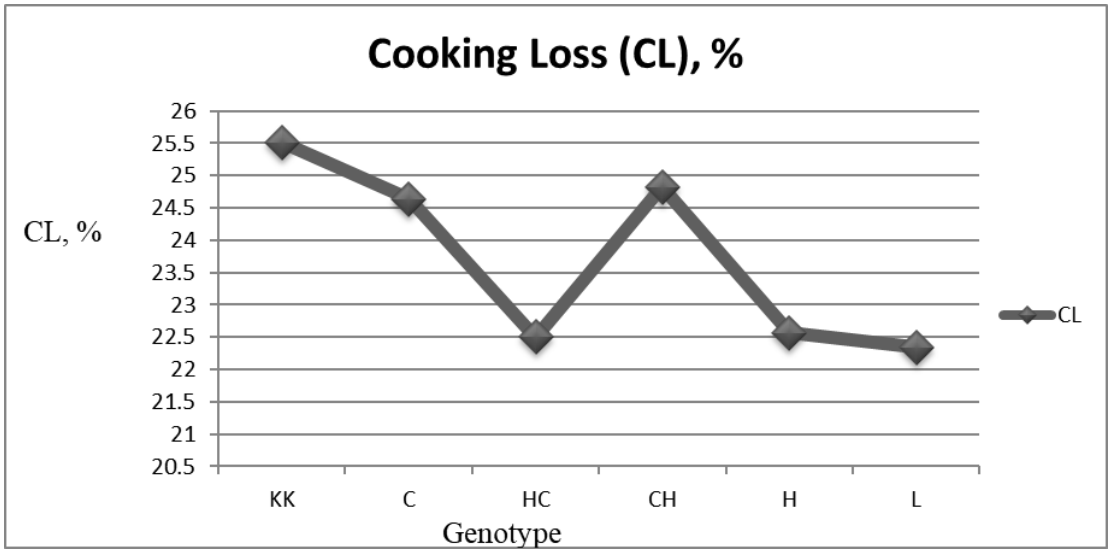

Figure (4). Effect of genotype on cooking loss (CL) of drumstick meat of different chicken

3.1.5.Effect of Genotype on Drip Loss of Drumstick Meat of Different Chicken Genotypes

Figure 5 shows the drumstick meat drip loss (DL) of different chicken genotypes. Drumstick meat from the KK (2.43) and CH (2.37) genotypes exhibited the highest drip loss values, followed by C (2.31) and HC (2.29), which also had relatively high values. The H genotype showed a lower drip loss (2.21), while the L genotype had the lowest and significantly reduced value (2.16). Similarly, variations in drip loss (DL) across genotypes were observed, attributed to differences in the connective tissues and their interconnections [34, 37].

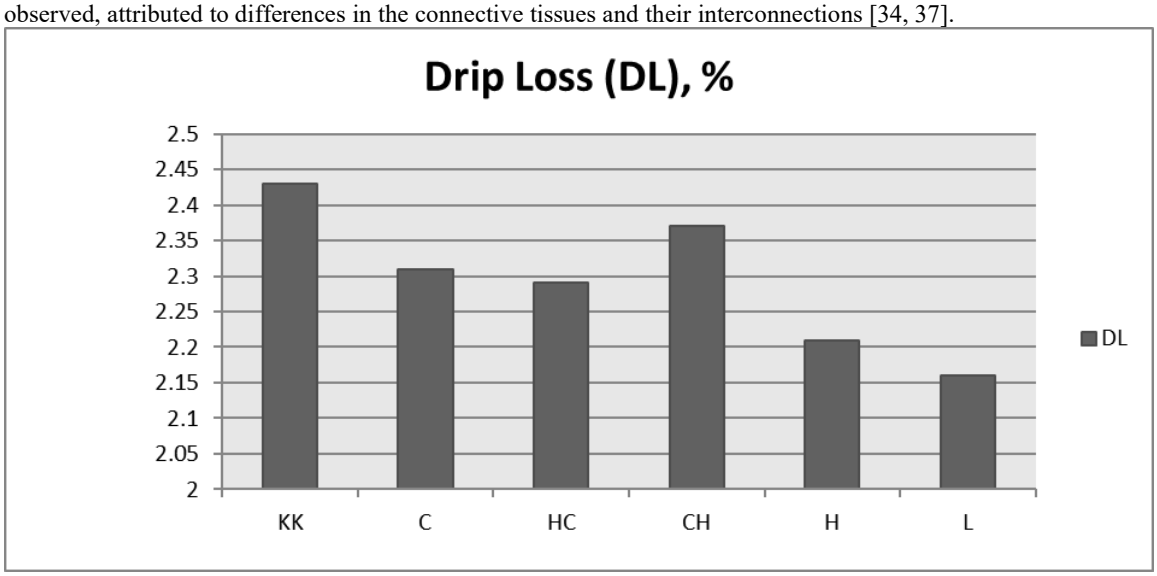

Figure (5). Effect of genotype drip loss (DL) of drumstick meat of different chicken genotypes

3.2.Genotype Effect on Drumstick Meat Color Traits of Different Chickens

The result of the effect of genotype on drumstick meat color traits of different chickens is presented in **Table 1.** The drumstick meat from the KK (56.42±0.44), CH (55.81±0.41), and C (55.54±0.43) genotypes had significantly higher lightness (L*) values compared to the HC (51.35±0.40) and H (51.09±0.38) genotypes. The L genotype, on the other hand, showed the lowest lightness score (50.39±0.37). Reports indicated that lightness scores (L*) can be influenced by genotype differences. The redness (a*) score of drumstick meat was notably lower in the HC (5.48±0.18), CH (5.55±0.19), and KK (5.61±0.17) genotypes, compared to the C (6.40±0.23), H (6.29±0.25), and L (6.26±0.29) genotypes. The reference suggested that redness scores (a*) in meat can vary among different genotypes [30]. The yellowness (b*) score for drumstick meat was significantly higher in the KK (15.75±1.29), CH (14.99±1.69), and C (14.78±1.26) genotypes compared to the HC (11.28±1.34), H (10.90±0.85), and L (10.65±0.89) genotypes. It was reported that the yellowness score (b*) of chicken meat varies due to genetic differences [10]. The chroma (C*) score for drumstick meat was significantly higher in the

KK (16.71±0.39), C (16.11±0.37), and CH (15.98±0.27) genotypes compared to HC (12.54±0.36), H (12.58±0.15), and L (12.35±0.19) genotypes. Higher chroma (C*) scores were observed in Naked-Neck and Hybrid breeds than in New-Hampshire, Koekoek, and Australorp breeds [10, 22]. The drumstick meat hue angle (h*) score was significantly higher in the KK (70.41±1.19), CH (69.68±1.16), and C (66.59±0.73) genotypes compared to HC (64.28±0.92), H (59.97±0.75), and L (59.53±0.68). Breast meat hue angle (h*) scores were also higher in Hybrid and Koekoek breeds compared to Broilers [32]. These results indicated that differences in meat color are due to factors such as variations in myoglobin content, heme structure, cytochrome C, ante- and postmortem stress, and meat pH [10, 32, 38]. Variations in chicken meat color may also stem from differences in the proportion of glycolytic type IIB fibers versus oxidative type IIA fibers [33, 34].

Table 1.Effect of Genotype on Drumstick Meat Color Traits

Category	Genotype						P-value
	KK	C	HC	CH	H	L	
Color	Mean ± SE						
L*	56.42±0.44^{a}	55.54±0.43^{a}	51.35±0.40^{b}	55.81±0.41^{a}	51.09±0.38^{b}	50.39±0.37^{c}	***
a*	5.61±0.17^{b}	6.40±0.23^{a}	5.48±0.18^{b}	5.55±0.19^{b}	6.29±0.25^{a}	6.26±0.29^{a}	**
b*	15.75±1.29^{a}	14.78±1.26^{a}	11.28±1.34^{b}	14.99±1.69^{a}	10.90±0.85^{b}	10.65±0.89^{b}	**
C*	16.71±0.39^{a}	16.11±0.37^{a}	12.54±0.36^{b}	15.98±0.27^{a}	12.58±0.15^{b}	12.35±0.19^{b}	**
h*	70.41±1.19^{a}	66.59±0.73^{a}	64.28±0.92^{b}	69.68±1.16^{a}	59.97±0.75^{b}	59.53±0.68^{b}	**

Mean under the same category bear different superscript letters are significantly different, *** = P ≤ 0.001, *** = P ≤ 0.01 SE = Standard error

4. ConclusionandRecommendation

The KK genotype exhibited the highest shear force (WBSF), followed by C and CH, while the L genotype had the lowest WBSF. Drumstick meat from L and HC genotypes showed the greatest water-holding capacity (WHC), with C and HC also displaying elevated WHC values; in contrast, KK had the lowest WHC. The pH45 was lowest in KK, slightly higher in C and HC, higher in H, and significantly highest in L. For pH24, the L genotype had the highest value, while H and HC were intermediate, and C, CH, and KK recorded the lowest values. Cooking loss (CL) was more pronounced in KK, CH, and C compared to H, HC, and L. Drip loss (DL) was greatest in KK and CH, followed by C and HC, with L having the lowest DL. Lightness (L*) was significantly higher in KK, CH, and C compared to HC and H, with L scoring the lowest. Redness (a*) was lower in KK, CH, and HC relative to H and C, while yellowness (b*) was higher in KK, CH, and C than in HC, H, and L. Chroma (C*) and hue angle (h*) were also elevated in KK, CH, and C compared to HC, H, and L. **In conclusion**, these findings underscore the substantial influence of genetic variations on drumstick meat quality attributes of different chicken genotypes. This study might also be recommendable to serve as a reference for future research into the quality characteristics of drumstick meat across diverse chicken genotypes, aiding in the selection and breeding of poultry for improved meat quality.

Abbreviations

WBSF	Warner Bratzler Shear Force
CL	Cooking Loss
DL	Drip Loss
WHC	Waterholding Capacity
L*	Lightness
a*	Redness
b*	Yellowness
C*	Chroma
h*	Hue angle
KK	Koekoek
C	Cosmopolitan
H	Improved Horro
L	Indigenous

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Author Contributions

Atsbaha Hailemariam Gebreslassie: Conceptualization, Data curation, Formal Analysis, Writing– original draft, Writing – review & editing

Chala Edea Muleta: Conceptualization, Data curation, Formal Analysis, Writing– original draft, Writing – review & editing

Conflicts of Interest
The authors declare no conflicts of interests

Data Availability
Data will be made available on request.

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