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Original Paper

Physical Attributes and Nutritional Composition of Meat From Dual Purpose (Sasso C431 and TR51) Broiler Breeds in Ntabazinduna, Zimbabwe

Nomagugu Ndlovu[1], Mabel S Ndebele[2], Tecklah Usai[2], Ruth Nyoka[2], Patience Marume[2]*

1) *Cardiometabolic Research Niche, Walter Sisulu University, P Bag X1, Nelson Mandela Drive, UNITRA, Mthatha, South Africa.*
2) *Department of Food Science and Nutrition, Faculty of Science and Technology, Midlands State University, P Bag 9055, Gweru, Zimbabwe*

*) *Corresponding Author: nondlovu@wsu.ac.za*

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***Abstract*— The growing animal welfare concerns regarding poultry production have led to the rearing of slow-growing meat type chickens also known as free-range chickens. In Zimbabwe these slow-growing chickens are gaining popularity as an alternative to the commercial broiler chickens owing to their preferred sensory attributes comparatively. Little is known regarding the quality of the meat versus that of the conventional broilers. We evaluated the physical characteristics and nutritional composition of meat from dual purpose slow-growing hybrids, Sasso C431 and TR51 in comparison with the commercial broiler breed Ross 308, under intensive feeding conditions. Birds were fed the standard commercial chicken feed produced by Hamara, a local chicken and chicken feed producing company. Birds were slaughtered on days 42, 56 and 70 of life where carcass and breast yield were measured. The pH, drip loss and cooking losses were determined for all carcasses. Proximate composition (dry matter, ash, protein, fat, carbohydrate) and mineral composition (iron, zinc and phosphorus) were determined for all the meat samples. The fast-growing broiler breed had a higher breast yield; than the slower-growing breeds, Sasso C431 and TR51 breeds (P<0.05). The highest cooking and drip loss were observed in the faster growing breed Ross 308 and the lowest ones for Sasso C431 and TR51 breeds (P<0.05). Shear texture values were higher in the Sasso C431 and TR51 than the Ross 308 breed (P<0.05). The Sasso C431 and TR51 breeds can produce more meat with a lower fat and a higher protein compared to the Ross breeds.**

Keywords*— *Carcass traits, Chicken, Fast growing breeds, Meat quality, Slow growing breeds

I. Introduction

Meat and meat products play an important role in the human diet among meat species and chicken represents the most consumed meat type worldwide [1]. This is possibly because of several factors which include, the lack of cultural prejudice related to its consumption, favourable textural attributes, mild taste, low fat content and the overall nutritional profile [2]. Meat quality is a term used to describe the characteristics of meat such as its biochemical, physical, chemical, morphological, microbial, sensory, hygienic, nutritional, technological, and culinary properties [3]. Poultry meat is of high-quality animal protein and is an important source for sustaining health and nutrition of human beings [2].

The broiler chicken sector has grown massively over the years, to be one of the most intensive production systems in the world characterised by indoor rearing, high stocking densities, fast growing hybrids that have been achieved through genetic selection, [4]. Chicken meat quality is influenced by genetics and genetic selection has been considered as one of the best tools for improvement of broiler meat quality, [3]. Apart from genetics husbandry management practices such as production system, lighting period and light intensity, feed type and feed access, and environmental temperature, also affect chicken meat quality [5]. In the last few decades poultry primary breeders have constantly developed new lines through selection and improvements in the performance of carcass traits with aim to improve growth rates and technical efficiency performance along with increased breast meat yield to cater for the rising demand of white meat, [3].

However, the 21st century has seen a development in the interest of slower growing meat type chickens, [5]. Consumers have become more health consciousness, and aware of the nutritional value of the foods they consume which has led to food processors paying special attention on the quality of food they produce [6]. Even though the relative global market share for the slow growing meat type is small, slow growing chickens are an important component within the niche markets [5]. Some of the consumers have shown an increased interest in chicken meat characterized by different attributes, such as the overall nutritional characteristics, product safety, animal welfare and environmental sustainability but also most importantly fresh chicken meat obtained from unconventional production systems [7]. The main factors that influence a consumer's choice of poultry meat were mostly price, genetic modification status, health and safety, accessibility, production methods, taste, appearance, tenderness, product labelling, country of origin, packaging, and branding [4].

This growing awareness of broiler rearing welfare issues associated with high stocking densities and broiler leg health problems, has led to the increasing development of new markets which offer unconventional meat and meat products [4]. The slow growing breeds can adapt to environmental changes and diverse diets without being dependant on strict nutritional diets like the fast-growing broiler hybrids [8]. The commercial production of slow growing chicken breeds has been achieved in different countries which include, Netherlands, the UK, France, and Germany [9]. Slow growing chickens are considered rustic and have a slower muscle and organ growth [4]. The skeletal muscles of a chicken are the main edible parts, which is the major and minor pectoralis despite the sex, genetics or production system of the chicken. However, the important components of the edible muscles are mostly concerned with the nutritional profiles, size, chemical and histological properties [5]. Slow growing chickens have been reported to have potential to be used as an alternative to the commercial broiler as they have been reported to have special meat quality attributes [10,11]. In Zimbabwe the slow growing Sasso hybrid chickens have shown positive consumer and market response, however there is scanty data in literature on the meat quality and sensory attributes. This study was aimed at characterizing the meat physical quality traits, the proximate composition and characterize the sensory profile of the Sasso C431 and TR51 slow growing meat breeds to that of the fast-growing Ross 308 broiler in Zimbabwe.

II. Materials And Methods

A. Ethical Approval

Permission to carry out the study was granted by the local leadership (the chief) and the study was cleared by the Research ethics Committee at Midlands State University, ethics number 2021/05/02. Handling of birds complied with the internationally accepted Helsinki principles and guidelines in the use of animals in experimentation as well as the guidelines of European Convention for the Protection of Vertebrate Animals used for Experimental and Other Scientific Purposes.In northern Botswana, winter is milder, and the maximum temperature is around 24/26 °C and the minimum temperature is around 8/10 °C. The hottest period in the north occurs from September to November while in the summer, the temperature slightly decreases because of the prevalence of more humid air masses of tropical origin. In the northernmost area, which is the rainiest of the country, rainfall exceeds 600 mm per year, though the rains are concentrated, as usual, in the summer. In this area, the sun regularly shines in the long dry season, while in the rainy period, the sunshine hours decrease as compared to in the rest of the country.

B. Study Site

The study was conducted in Ntabazinduna (20.0167° S, 28.8500° E) located in Umguza District, Matabeleland North, Zimbabwe.Sample Preparation

C. Study Design

A completely randomized design was used in the sampling and selection of farmers that were placed with the broiler breeds for the study in three villages of Ntabazinduna which are Nana, Mafanisa and Dibha. A total of 90 male broilers (30 Sasso C431; 56 days of age + 30 SassoTR51; 70 days of age + 30 Ross; 42 days of age) were used in this study, and the Ross broiler was used as a control. Nine (9) famers were selected, 3 farmers per village to participate in the study.

Animal handling

One day old broiler chicks for the 3 breeds were placed on the same day to 3 randomly selected commercial contract farmers at 1100 chicks' per/farmer. This was done for uniform brooding conditions, up to 21 days of age. Carmino (vitamins) and Bedgen 40 (liver protector) was administered in drinking water at 2ml/litre and 1ml/litre respectively for the first 5 days to manage transportation and placement stress. The birds were vaccinated for Newcastle, IBD and Mareks's at the hatchery. Floor feeding was done for the first 4 days at 80% house coverage to maximize feed uptake in the first week with 1 hour of darkness. Lighting period was gradually increased by an hour every week and until the 6th week, where it was maintained at 6 hours of darkness for all breeds until slaughter. At 28 days of age, 100 birds were transferred to each of the 9 randomly selected small-scale farmers respectively for the Ross, C431 and TR51 breeds. In each village 3 farmers received Ross, C431 and TR51 respectively. One field officer was allocated to these farmers for daily technical management visits. Grass haybales were used for bedding and it was managed daily with turning and topping where there was need. The birds ate feed and drank water at adlib until slaughter. The Ross broilers were fed with three -phase broiler feed 500g Starter crumbles, 1 kg Grower pellets and 3.5kgs finisher pellets. The Sasso breed was fed using the 3phase Sasso feed, 500g Starter crumbles, 1kg Grower pellets and 5 kg finisher pellets per bird. From each village, 30 male broiler samples for analysis (10 Sasso C431 + 10 Sasso TR51 + 10 Ross) were to be obtained for slaughter at maturity age for each breed respectively. Male bids were selected to standardize the weight variations within breeds, as the female and males have different target weights for each age.

Terminatin procedures

The chickens were fasted for 8hrs before slaughter. Mechanical stunning was used to terminate the birds, and then there was bleeding (the external jugular vein and carotid artery were cut) close to the occipital bone and the atlas. After bleeding, birds were scalded for a maximum of two minutes in a tank that was typically 60 to 70°C before being promptly defeathered with an automatic turning machine. Carcasses were hung on the rollers on hook joints and eviscerated, their giblets and abdominal fat was collected. Carcasses were chilled in a spin chiller at 5° C for 15 minutes to retard bacterial growth and preserve meat quality. After this period, carcasses were weighed and cut up into commercial parts and blast frozen at -25°C to -30°C for 12hr and then packed and stored in a holding freezer (-20°C).

Carccass characteristics: carccass and breast yields

Carcass weight (CW) considered whole slaughtered birds, with neck and feet, and no head, abdominal fat, or giblets. Carcass yield (CY) corresponded to the ratio between carcass weight after chilling (CW) and body weight at slaughter (BWs), and was calculated according to the following formula:

$$CY (\%) = CW/BWs \times 100. \quad (1)$$

Breast yield was determined by carefully removing the breast on each left side of the carcass and weighing on a scale. Breast yield (BY) was calculated using the equation below:

$$BY (\%) = (\text{Mass of Breast/ Carcass mass}) * 100 \quad (2)$$

D. *Physical Properties*

Determination of pH

pH was determined on breast meat sample using a digital pH meter (Cyber-14L pH meter).

Drip loss

Drip loss was determined by the standard bag method [12]. The breast meat was cut into slices with 2.5 cm thickness. In the bag method (DL), the slices were placed into bags. The drip loss was measured as the weight loss during suspension of a standardized (40–50 g and approximately 30 × 60 × 25 mm) breast meat sample (in an airtight container over 24 h at 4°C). Drip loss was expressed as a percentage relative to the initial weight.

Cook loss

The meat sample were cut into slices into 2.5cm. The sliced chicken meat samples were weighed before and after cooking, and the cooking loss was calculated as weight difference between fresh and cooked samples relative to the weight of fresh meat samples in percentage.

$$\% \text{ Cooking Loss} = [(W_0 - W_1)/W_0] \times 100 \quad (3)$$

Where: W_0 and W_1 are the weights before and after cooking, respectively.

Shear value

Using a texture analyser (TA-XT plus, Stable Micro Systems, Surrey, England), fresh chicken meat samples were subjected to Meullenet-Owens razor shear blade and 5-kg load cell studies to determine the texture of the meat (MORS). Blade penetration depth was 20 mm, and crosshead speed was 10 mm/s. The samples of chicken were sliced. The texture analyser program was used to calculate the shear force (maximum force, N).

E. *Proximate Analysis*

Moisture content

The meat samples' moisture content was analysed by AOAC methods with slight modifications [13]. 5g of the sample was added to a dry, clean dish that had been weighed. The dish was then dried in desiccators, chilled in the hot air oven at 105°C to maintain weight, and reweighed. Then, the moisture content was estimated by the formula:

$$Moisture\ content\ (\%\, w.b) = \frac{W2-W3}{W1} * 100 \quad (4)$$

Where:
W1= weight of sample (2g)
W2= weight of fresh sample and crucible (g)
W3= weight of dry sample and crucible (g)
(%) w.b = percentage wet basis

Protein

The protein content was determined using the Standards Association of Zimbabwe Test Method -Nitrogen Carbon Sulphur (NCS) [14]. The sample was weighed into 1.5 and 3.5 mg into silver capsule. The sample was placed in the NCS Analyzer cells (2–31, respectively). Back flashing was performed by ensuring that the pressure in the He and O2 cylinders was greater than 2000 kPa and that the cylinders were replaced once the pressure was less than 2000 kPa. The calculations were performed with auto-set, and the results were automatically communicated in a digital result spread sheet using pre-determined conversion factors (Nitrogen Factor – 6.25)

$$\% \text{ Protein} = 1.4 \times 6.25 \times \text{nitrogen per g sample} \quad (5)$$

Fat

The fat content percentage was determined using the Soxhlet method as described by AOAC methods [13]. Briefly, a solvent (petroleum spirit) was used to extract fat from the sample. The weight of the fat that was recovered was measured. A porous thimble was used to contain the finely ground meat sample (5g) and allow for the sample to be covered in the solvent through the continuous extraction process which took 6 hours. Before the fat extraction process moisture analysis was conducted on the meat samples. The fat content was calculated by the following formula:

Weight of empty flask (g) = W1
Weight of flask and extracted fat (g) = W2 Weight of sample = S

$$\%\ Crude\ fat\ = (W2 - W1) * \frac{100}{S} \quad (6)$$

Ash

Ash was determined by a gravimetric method [13]. Briefly, fresh minced chicken sample (5g) was transferred to a muffle furnace at (550oC) for 4–5 hours in a pre-weighed crucible. The sample of ash was then placed in a desiccator with silica gel acting as the desiccant. The dish was weighed after one hour. The ash content was calculated by the following formula:

$$Ash\ (\%) = \frac{Wt\ of\ ashed\ sample}{Wt\ of\ sample\ taken} x\ 100 \quad (7)$$

Mineral Analysis

The mineral content was determined using Inductively coupled plasma-optical emission spectroscopy [13]. Briefly, the meat samples were mixed with 1mL of HNO3 and 1mL of H202 and digested in a SINEO microwave digester (JUPITER-B, T625210049, China). The filtrate was then analysed using Inductively Coupled Plasma–Optical Emission Spectrometer (ICP-OES) (ICAP 6500 Radial, ICP – 20104501, England, United Kingdom).

Sensory Evaluation

The acceptance test was used for three of the different breeds to assess which meat type was more accepted by consumers using the 9-point hedonic scale. The meat was boiled and served without salt. The samples were numbered using a random 3-digit code for each sample. There was a total of 60 untrained panelist. The 60 untrained panelist were briefly trained for 30 minutes on the process of the sampling methods and response parameters on the questionnaire to avoid confusion. The sampling was done in two rounds. The first sample was served, and the panelist scored anonymously on the score sheets they had been given. They had to rinse their mouth with water before the next sample was served. Each evaluation was done in 3 batches until it was complete. Each sampling method took roughly 10-15 minutes to complete.

F. Data Analysis

All assays were done in triplicate to reduce bias and ensure consistency. One way ANOVA (SPSS 22nd Edition) followed by LSD test was used to establish significant difference between means at 5% for difference of all meat properties. For sensory evaluation the chi-square distribution was used to evaluate results from triangle tests.

III. Results And Discussion

A. Carcass and Breast Yield

Results of the carcass yield and breast yield are shown in Table 1. Sasso C431 and TR51 had a significantly lower carcass and breast yield compared to Ross 308 (P<0.05).

TABLE 1. CARCASS AND BREAST YIELD

Parameter (%)	Ross 308	C431	TR51	P value
Carcass	71.62±0.41[a]	66.31±0.02[b]	65.72±0.06[b]	0.031
Breast	22.13±0.01[a]	20.11±0.03[b]	19.42±0.02[b]	0.042

Mean ± standard deviations are reported. Means with different superscripts (a, b) in a row are significantly different at p < 0.05; n=10 for all groups.

B. pH, Drip Loss, Cooking Loss, and Shear Value

Results for breast meat pH, cooking loss, drip loss and shear value are shown in Table 2. There were no significant differences in the Ph and drip loss of all chicken breeds (P>0.05). TR51 had the lowest cooking loss followed by C431 then Ross 308 (P=0.041). Ross 308 had a significantly lower shear value compared to Sasso C431and TR51 (P =0.023).

TABLE 2. PH, COOKING LOSS, DRIP LOSS AND SHEAR VALUE OF THE BROILER BREEDS

Parameter	Ross 308	C431	TR51	P-value
pH	6.45±0.15	6.32±0.90	6.21±0.02	0.053
Cooking loss, %	24.98±0.17[a]	22.32±0.12[b]	19.98±0.08[c]	0.041
Drip loss, %	0.28±0.01	0.23±0.02	0.20±0.01	0.082
Shear value, N	11.22±0.02[b]	16.58±0.03[a]	17.01±0.03[a]	0.023

Mean ± standard deviations are reported. Means with different superscripts (a, b, c) in a row are significantly different at p < 0.05; n=10 for all groups.

C. Proximate and Mineral Composition of the Three Broiler Breeds

Table 3 shows the results of proximate and mineral content of the three broiler breeds. Sasso C431 and TR51 had the highest dry matter, protein and lowest fat (P<0.05). The ash content did not significantly differ among the three breeds (P>0.05). There were no significant differences in the phosphorus and potassium content of all the breeds (P>0.05). Sasso C431 and TR51 had a significantly higher iron content compared to Ross 308 (P =0.0369). Sasso C431 had a significantly lower zinc content compared to Ross 308 and SassoTR51 (P =0.0211).

D. Sensory Evaluation

Figure 1 represents the variability of different six parameters among the three breeds. We stacked the three breeds on each of the used parameter to show the differences per parameter. The Sasso TR51 breed is consistently higher than the rest for Aroma, Taste, and Overall acceptability.

E. Discussion

The carcass and breast yield of the Sasso broiler breeds in our study was significantly lower than that of the Ross 308 broilers (Table 1). Carcass and parts yield depend on the age, strain and sex of the bird. Consumers prefer chickens with high yield of noble parts, such as breast, drumsticks, and thighs [15]. Earlier studies reported that fast growing broiler had better carcass yield than slow-growing broilers [16, 17, 18], our findings are consistent with these previous reports. They established that because of fast growth carcass weight and breast weight

TABLE 3. PROXIMATE AND MINERAL COMPOSITION OF THE BROILER BREEDS

Proximate Composition	Ross 308	Sasso C431	Sasso TR51	P-value
Dry Matter, %	25.6 ±0.10[b]	33.2 ±0.26[a]	35.6 ±0.11[a]	0.0617
Protein %	17.6 ±0.20[b]	20.21 ±0.90[a]	20.15 ±0.02[a]	0.0297
Fat %	5.26 ± 0.03[a]	3.33 ±0.04[b]	3.30 ±0.01[b]	0.0193
Ash %	1.18 ±0.01	1.17 ±0.01	1.17±0.01	0.0632
Iron (mg/kg)	7.01 ±0.08[b]	8.05 ±0.01[a]	8.99 ±0.04[a]	0.0369
Phosphorus, G/KG	2.8 ±0.07	3.17 ±0.01	3.2 ±0.02	0.0939
Potassium, mg/kg	3200 ±0.02	3260 ±0.02	3110 ±0.03	0.0745
Zinc, mg/kg	11.11 ±0.15[a]	8.77 ±0.06[b]	11.34 ±0.02[a]	0.0211

Mean ± standard deviations are reported. Means with different superscripts (a, b, c) in a row are significantly different at p < 0.05.

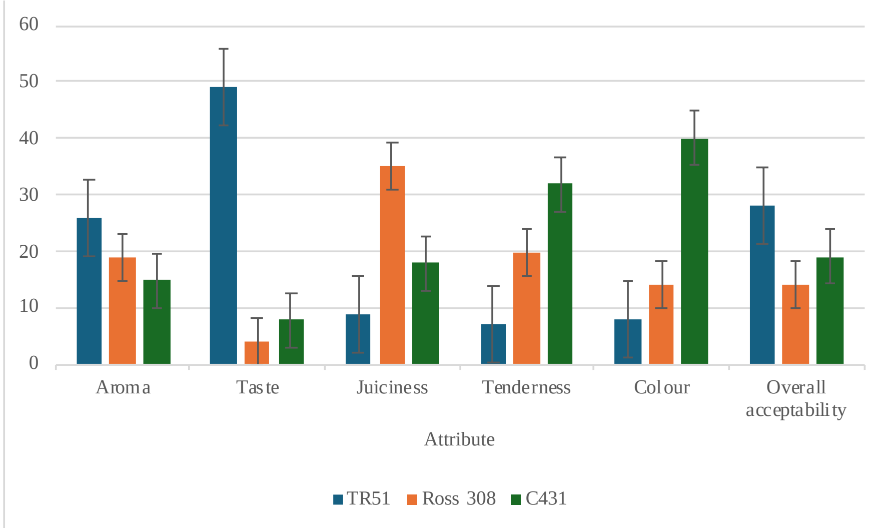

Fig. 1. Image of *Guibourtia coleosperma* seeds collected from Shakawe, Botswana

percentage increased because of selection. Slower growing broilers had lower breast weight and higher leg, back and wing percentage compared with fast-growing broilers. Carcass and parts yield is largely a function of feed conversion efficiency. Slow growing broilers have been reported to be poor feed convertors compared to the fast-growing broilers [17], hence the findings of this study and others reported earlier.

The pH decline post-mortem is important in the conversion of muscle to meat as it impacts the texture, color and water holding capacity of the meat, because it is dependent on the glycolytic enzymes after death which are also dependent on glycogen reserves in the muscles after death [19].

The pH of the three broiler breeds did not differ significantly among the broiler breeds, however the values of pH in the slower growing breeds were numerically lower compared with the fast-growing breed. The process of turning muscle into meat is extremely important since it influences the meat's ability to retain water as well as its texture and color [19]. Findings in other studies [20, 18] have shown that slow growing genotypes have a lower ultimate pH in comparison to faster growing genotypes which concluded that increased growth rate of faster growing hybrids leads to reduced post-mortem glycolysis thus reducing the level of pyruvic acid releases and thus resulting in a higher pH for fast growing breeds. Slow-growing broiler breast muscle rate of pH decline was founder to be greater, the meat was darker, yellow, redder, and had greater drip loss compared with birds from two faster growing broiler strains [21]. Although, we did not in our study measure meat color to compare with the pH, we noted a faster decline in pH and if we had measured pH later (24hrs), we could have possibly observed a statistically significant decline in the slow growing breeds. We only measured the pH, 30mins postmortem and that could explain the similarities we report on the breast meat of both fast and slow growing breeds.

In this study we found that faster growing broiler hybrid had a slightly higher drip loss post-mortem than slower growing broiler hybrids, though not significantly different. A study showed that slow growing chicken breeds had a better water holding capacity and lower drip loss as compared to fast growing when both birds were slaughtered under conditions which minimized struggle and stress pre-slaughter [16]. The conclusion was that fast-growing broilers were predisposed to poor processing ability. An increase in breast weight results in an increase in thaw and cook loss, which was also observed in this study. In contrast to the findings in this study, other studies found that breast muscle of slow-growing broilers had a higher drip loss due to a lower water-holding capacity than the fast-growing breed thus a higher drip loss [22, 7]. They concluded that it was supposedly linked to the fact that fillets from slow growing birds are thinner and smaller which gives them more surface area and thus a higher drip loss [16]. Another study reported that there was a decrease in drip loss with increasing age at slaughter, which could possibly be explained by the decrease of water content in slow growing broilers in this study [24].

In this study we found that cook loss was higher for the fast-growing Ross 308 broiler than the slow growing broiler hybrids. Cook loss refers to the loss of weight that occurs when meat is cooked, typically due to moisture evaporation. Similar to our findings, another study reported that faster growing hybrids lost more water during cooking which they concluded could be related to higher fat content in fast growing broilers [25]. Faster-growing broilers may have higher fat content, which could contribute to greater moisture loss during cooking. This finding suggests a correlation between growth rate, fat content, and cook loss in broiler chickens

The meat shear value was highest for slow-growing breeds, with Sasso TR51 being the highest and lowest for the fast-growing broiler Ross 308. Shear value measured the meat toughness. Meat toughness is related to endogenous proteolytic activity as the birds age [16]. Fast growing birds tend have large muscle to secrete protein through reduced catabolism of protein. This gives them lower proteolytic potential thus reducing tenderisation in meat post-mortem.

In this study the higher protein and lower lipid content observed in the Sasso C431 and TR51 as compared to the Ross

308 is possibly attributed to the higher levels of locomotory activity associated with slow growing breeds as compared to fast growing broiler breed strains [24]. Another study reported similar findings as ours, they observed a higher lipid and lower protein content in slow growing hybrids as compared to the fast-growing breeds [26]. As animals grow in ages muscle and body composition changes, increasing protein and decrease in moisture [19].

Sensory results supported the shear value observations that were done for tenderness/ toughness and texture, and they positively correlated to shear force. Toughness and texture for slow growing birds was found to be higher than faster growing birds [7].

IV. Conclusions

The higher protein content and lower lipid content found in Sasso C431 and TR51 imply that Sasso breeds are potentially a healthy meat option as they produce meat with a low fat and high protein content. The lower cook loss observed in the Sasso breeds can result in juicier and more tender meat, better retention of nutrients as well as more meta for consumers. Therefore, both consumers and producers can benefit economically from the Sasso breeds considering the superior quality of the meat produced by Sasso breeds. Importantly, consumers benefit value for money from Sasso meat's superior sensory characteristics and higher nutritional value.

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