

Research Article



Predicting Meat Yield and Quality of Simmental X Ongole Grade Crossbred Bulls using Body Measurements

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Abstract | Currently, an easy and cheap method is needed to predict meat production and meat quality of Simmental x Ongole Grade crossbred (SOG) bulls to help butchers or traders without slaughtering. This study was conducted to estimate carcass weight, meat weight, bone weight, meat colour, and meat tenderness using body measurements of SOG bulls. One hundred and fifty SOG bulls aged 12 – 18 months were used to measure correlations between body measurements and carcass, meat, bone weight. Then, 30 meat samples of those bulls were taken to observe the correlations between body measurements and meat colour and tenderness. The parameters observed were body height, body length, heart girth, chest width, chest depth, body weight, hot carcass weight, meat weight, bone weight, meat colour, and meat tenderness. The data obtained were analysed by correlation and regression models. The results showed that body measurements (heart girth, body length, chest depth, and body height at withers) had positive and strong correlations with carcass weight ($r = 0.6 - 0.9$; $P < 0.01$), meat weight ($r = 0.6 - 0.9$; $P < 0.01$), and bone weight ($r = 0.6 - 0.9$; $P < 0.01$). The body measurements had positive and medium correlation with meat tenderness ($r = 0.4 - 0.6$; $P < 0.01$). On the other hand, body measurements had low and negative correlation with the lightness ($r = -0.12$ to 0.22 ; $P < 0.05$) and the redness ($r = -0.02$ to -0.15 ; $P < 0.05$), and had low and positive correlation with the yellowness of meat ($r = 0.09 - 0.25$; $P < 0.05$). It was concluded that body measurements could be used to predict the meat yield and tenderness of SOG bull meat.

Keywords | Beef, Body measurements, Meat bone yield, Meat colour, Tenderness

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INTRODUCTION

In general, body weight of cattle is widely used to determine the purchase price of the animals for traders and butchers (Arifin *et al.*, 2016; Wangchuk *et al.*, 2018). Body weight determines the amount of money obtained by breeders, traders, and butchers, because it determines the production of meat (Arifin *et al.*, 2016; Azwanda *et al.*, 2017) and meat quality profile (Camacho *et al.*, 2017;

Luthfi *et al.*, 2022; Luthfi *et al.*, 2024). Consumers also pay attention to meat quality according to the needs of the menu to be served. Some studies suggested that body weight was associated with fat deposition, while the level of fatness greatly influences the meat quality (Joo *et al.*, 2013; Tomasevic *et al.*, 2021; Warner *et al.*, 2022). The qualitative characteristics of fresh meat that affected by fatness are level of tenderness and colour (Bolumar *et al.*, 2013; Mancini and Ramanathan, 2019; Beno *et al.*, 2023).

Therefore, body weight can be used as a consideration in estimating meat quality, especially tenderness and meat colour. However, at many cattle yards in Indonesia, animal scales are not provided; so that farmers, traders and butchers use their experience to predict body weight and meat production based on body appearance. This causes inaccuracy in estimating the profit that can be expected from the purchased animal (Setiyono *et al.*, 2015; Luthfi *et al.*, 2024).

Several studies showed that body measurements such as shoulder height, heart girth and body length can be used to predict body and carcass weight of cattle (Gruber *et al.*, 2018; Prihandini *et al.*, 2020; Nurfitriani *et al.*, 2022; Luthfi *et al.*, 2024). A high carcass weight linearly resulted in high meat weight (Setiyono *et al.*, 2015; Luthfi *et al.*, 2022; Luthfi *et al.*, 2024). Those indicated that body measurements may associated with meat yield and its quality, indirectly. Currently, there were limited studies that examine the relationship between body measurements and the amount of meat weight and meat quality (meat colour and level of tenderness) of beef cattle.

In Central Java Province, Indonesia, the dominating breed of beef cattle raised by the farmers are Ongole Grade. This breed is the result of cross breeding between Javanese local breed and Ongole breed that was imported from India about 150 years ago. The physical appearance of this breed is more like Ongole breed cattle. In the last decade, Ongole Grade cows are widely inseminated by Simmental semen, producing Simmental x Ongole Grade crossbred (SOG).

Based on the description above, it is necessary to have an appropriate and inexpensive method to estimate the meat yield and meat quality of SOG bulls, while the animal scale is not available. The objective of this study was to examine the correlation between body measurements and body weight, carcass weight, meat weight and meat quality of SOG bulls. Using this correlation, the regression was established to find out the equation to predict the carcass weight, meat weight and meat quality.

MATERIALS AND METHODS

The rearing and the slaughtering method of the animals used in this study were approved by ethical committee with approval number: No. 117/A.II/IV/2023. The study was conducted in 5 months (March-July 2023) in the Slaughter House of Semarang Regency, Central Java, Indonesia. The study was conducted by a survey method on SOG bulls. The samples of bulls were taken purposively. The materials used in this study were 150 SOG bulls aged 12 – 18 months. The data observed were body measurements (i.e. shoulder height, heart girth and body length), body weight, carcass weight, meat weight and bone weight. Among the

150 bulls slaughtered, 30 of them were taken as samples for the correlations between body measurements and meat colour and tenderness. Equipment used were an animal weighing scale with 1000 kg capacity with 0.5 kg accuracy for weighing the bulls, a digital hanging scale of 500 kg capacity and 0.02 kg accuracy for weighing carcass and meat, a measuring stick with 150 cm length 1 cm accuracy for measuring body height at withers (WH), and the body length (BL), and measuring tape of 150 cm long with and 0.1 cm accuracy for measuring heart girth (HG), chest width (CW) and chest depth (CD).

BODY MEASUREMENTS

All measurements of body size were carried out 3 times to avoid measurement errors and the final result was the average of these measurements (Figure 1).

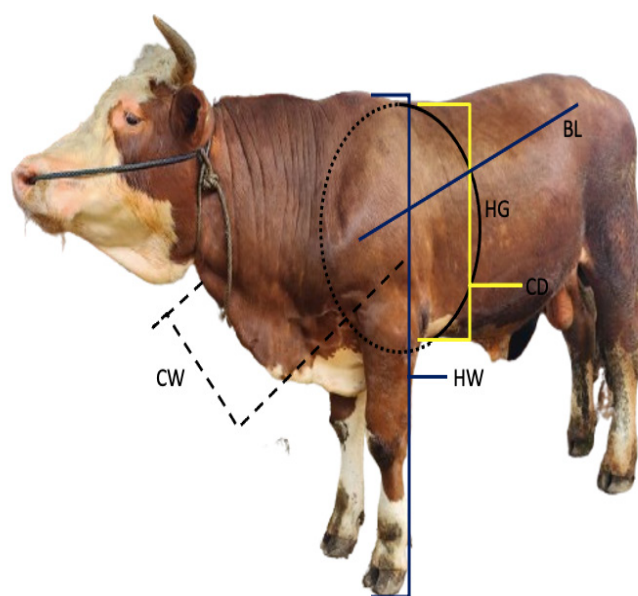


Figure 1: Body measurements of Simmental x Ongole grade crossbred bulls.

Measurement of body size was carried out according to the method described by Pikan *et al.* (2018):

- Body weight (BW) was obtained by the weighing the bulls.
- Body height at withers (HW) was measured using a measuring stick, from the highest point of the shoulder past the back of the scapula, perpendicular to the ground.
- Heart girth (HG) was measured using a measuring tape, circular just behind the scapula.
- Body length (BL) was measured with a measuring tape from the side end of the shoulder bone to the end of the sitting bone.
- Chest width (CW) was measured the distance between the left and right shoulder
- Chest depth (CD) was measured the distance from the highest point of the shoulder to the sternum, measured just behind the elbow.

The bulls were fasted for 12 hours before being slaughtered to minimize the contents of the digestive tract. The drinking water was provided *ad libitum*. The bulls were then slaughtered in a halal manner and animal welfare procedures. The bulls were cut at the joints of the atlas bone, jugular vein, oesophagus and trachea. The head was separated by cutting the occipitoatlantic joint. The forelegs were cut at the carpo-metacarpal joints and the hind legs were cut at the carpo-metatarsal joints suspended from the Achilles tendon, then they were skinned. The viscera (consisting of the heart, liver, lungs, trachea, spleen, digestive tract, tail and reproductive tract) were taken. The formed hot carcass and all non-carcass components were weighed (Colomer-Rocher *et al.*, 1987). The hot carcass weight was recorded and then the carcass was split at the vertebrae, starting from the sacral end and ending at the neck, into two equal parts, namely the left and right.

MEAT WEIGHT

The right and left parts of carcass were divided into 4 sections, namely shoulder-neck-brisket, rib-back-chest, loin-belly, rump-leg-hindshanks (Macit, 2002) to facilitate the process of separating the meat and bones. Meat and bones were separated to determine the proportion of meat and bone (Lima *et al.*, 2017). Meat samples were taken from the Longissimus dorsi (LD) muscle.

MEAT QUALITY ANALYSIS

The LD meat samples were analysed for tenderness and fatty acid profile (saturated and unsaturated). Each sample was around 100 g from each bull. The meat samples were put in aluminium foil, put in a plastic bag and labelled. The degree of tenderness of the meat was analysed using the Texture Profile Analysis (TPA) method. The meat texture profile was measured according to the procedure described by Mudalal *et al.* (2015). A scale or number in TPA was defined as hardness, springiness and gumminess. Hardness (g) was the maximum force needed to compress the meat sample. The level of hardness was affected by springiness (mm), namely the ability of the sample to return to its original shape after the pressure was eliminate (Schreuders *et al.*, 2021). The meat colour was measured a Chromameter. The sample was placed in a container on the instrument, read in the form L, a* and b*. Colour was measured with a colorimeter working on the CIE 1976 L, a*,b* principle (also known as CIELAB; Hui *et al.*, 2023).

DATA ANALYSIS

The data obtained were analysed using correlation and regression methods. The correlation between body measurements and body weight, carcass, meat and bone yield, meat colour, meat tenderness, and income were calculated then a regression equation was made. The coefficient

of determination (R^2) was used to achieve the accuracy of the prediction equation between variables on linear body measurements.

Table 1: The body measurements, productivity and meat quality of Simmental-ongole cross beef.

Parameters	sample	average	min	max	SD
Body Measurements					
Heart Girth (cm)	150	187.1	172.0	207.0	8.0
Body length (cm)	150	137.9	118.0	155.0	5.7
Chest depth (cm)	150	69.4	53.0	87.0	6.0
Body height (cm)	150	139.2	126.0	200.0	9.0
Chest width (cm)	150	58.3	46.0	83.0	6.8
Production					
Body weight (kg)	150	525.4	322.7	614.1	49.6
Carcass weight (kg)	150	270.8	182.0	389.0	39.4
Carcass percentage (%)	150	51.54	39.53	62.16	14.8
Meat weight (kg)	150	216.1	141.0	309.0	33.9
Bonen weight (kg)	150	55.0	40.0	80.0	5.9
Skin weight (kg)	150	48.5	30.0	67.0	5.3
Head weight (kg)	150	18.9	13.7	24.6	2.0
Viscera weight (kg)	150	33.3	24.5	49.1	3.8
Legs weight (kg)	150	6.7	4.8	9.2	0.7
Tail weight (kg)	150	1.8	1.3	2.5	0.2
Meat Quality					
Colour					
L*	30	36.3	15.9	65.5	14.9
a	30	27.3	20.4	35.9	4.7
b	30	8.7	-5.4	16.1	5.4
Hardness (g)	30	729.2	417.0	1055.5	175.3
Springiness (mm)	30	9.2	5.4	14.7	3.1
Gumminess (g)	30	423.2	156.8	790.3	180.3

L*: lightness ranges from 0 (black) to 100 (white); a*: redness ranges from green (-60%) to red (+60%); b*: yellowness ranges from blue (-60%) to yellow (+60%), Poveda-Arteaga *et al.* (2023).

RESULTS AND DISCUSSION

BODY MEASUREMENTS AND PRODUCTIVITY

The data of body measurements, productivity, colour and tenderness of meat are presented in Table 1. The results showed that the average of heart girth, body length, chest depth, body height and chest width were 187.1 cm; 137.9 cm; 69.4 cm; 139.2 cm; and 58.3 cm, respectively. Several studies found that the body size was highly affected by age, sex, nutrient intake and growth rate of animal (Vanvanhosou *et al.*, 2018; Firdaus *et al.*, 2023). A review by Firdaus *et al.* (2023) showed that the older the beef cattle, the higher the body size and body weight. From under 1 year to above

Table 2: The correlation (R-square) between body measurements and meat production and quality in simmental X ongole grade crossbred bulls.

Body Measurements	Carcass weight	Meat weight	Bone weight	L*	a*	b*	hardness	springiness	gumminess
Heart girth	0.83	0.82	0.63	0.02	0.00	0.02	0.28	0.22	0.28
Body length	0.38	0.35	0.36	0.02	0.02	0.08	0.08	0.33	0.23
Chest depth	0.71	0.64	0.54	0.03	0.00	0.01	0.31	0.22	0.26
Body height at withers	0.37	0.31	0.55	0.05	0.02	0.02	0.24	0.22	0.17
Chest width	0.88	0.87	0.66	0.02	0.00	0.06	0.34	0.30	0.31
Body weight	0.86	0.83	0.70	0.03	0.00	0.06	0.41	0.36	0.37

2 years, the body size and body weight increased significantly. [Shoimah et al. \(2021\)](#) found that heart girth, body length and body height of Simmental bull were 215.72 cm; 170.13 cm and 142.79 cm, This difference occurred was due to differences in the age of the cattle used. [Shoimah et al. \(2021\)](#) used Simmental bulls aged 1 – 12 years.

The body weight of SOG bulls in this study varied from 343.25 to 714.10 kg; producing 182.00 – 389.00 kg carcass; 141.00 – 309.00 kg meat; and 40.00 – 80.00 kg bone. The carcass percentage varied from 39.53 to 62.16%, indicating that there was a big variation in the fatness of the bulls. This was supported by the fact that the meat-bone ratio varied from 2.47 (thin) to 4.79 (fat). The lowest and the highest percentage of meat weight to carcass were 71.21% and 82.74%, respectively. [Luthfi et al. \(2022\)](#) found that meat production of animal was highly affected by the amount of nutrient intake. The study by [Carvalho et al. \(2010\)](#) showed that the hot carcass production and meat-bone ratio SOG was generally 51.18% and 4.57, respectively. It can be caused by the high productivity of those animal and the fasting before slaughtering. [Hafid et al. \(2019\)](#) found that lower feed and water in digestive tract induced higher carcass percentage.

The value of L*, a and b of meat of Simmental-Ongole Crossbred bulls in this study were 36.3, 27.3 and 8.7 respectively. This study indicated that the meat was able to maintain its attractive red colour 24 hours after the animal being slaughtered. It was because the value of lightness, redness and yellowness did not lean towards dark red and bluish or pale. [Nuraini et al. \(2019\)](#) stated that meat colour was greatly influenced by the myoglobin levels in the meat. The myoglobin content in meat depends on breed, age, feed, muscle movement, and slaughtering technique. Meat colour is also determined by the reactions that occur in myoglobin. The purplish red colour of meat is due to a lack of oxygen levels in the meat, but if there is oxidation within a few minutes the colour will become bright red. The bright red colour can change to red or brown if oxidation occurs or if the meat is stored for a long time, or reddish green if spoilage has occurred.

The hardness, springiness and gumminess in this study were 792.2 g; 9.2 mm; and 423.2 g, respectively. The higher value of those parameters indicated that the meat was tough, conversely the lower the value of hardness, springiness and gumminess the more tender the value of the meat. [Nuraini et al. \(2019\)](#) stated that the tenderness of meat indicated a quality and a value of the structural properties of muscle protein. All factors that influence the level of meat tenderness are growth and development of livestock, nutrition, before and after aging, processing and cooking.

CORRELATIONS

The correlation between body measurements and the carcass weight, meat yield, meat colour, tenderness and income is presented on [Table 2](#). The results showed that heart girth, body length, chest depth, chest width and body weight had positive and strong relationship ($P < 0.01$) with hot carcass weight, meat and bone weight. The highest correlation to carcass and meat weight were heart girth, chest depth and chest width ($r = 0.81 - 0.94$; $P < 0.01$). This finding showed that body measurements the bulls was like a “tube”; the larger the body size, the higher the body volume of the beef; so that, the higher body volume and the higher carcass and meat weight of the bulls. This finding was in line with previous study by [Gruber et al. \(2018\)](#) and [Nurfitrani et al. \(2022\)](#) that body measurements such as heart girth, body length, chest depth, body height, and chest width can be used to estimate the carcass production. [Ruangwittayanusorn et al. \(2019\)](#) found that carcass weight was highly affected by hearth girth ($r = 0.80$), body height ($r = 0.71$) and body length ($r = 0.84$).

On the other hand, the body measurements had no significant correlation with meat colour ($P > 0.05$). This indicated that body size did not influence the colour of meat, so that it could not be used to predict the meat colour L, and a*. However, this study showed that all body measurements had positive and low correlation with colour b* ($P < 0.05$). It was due to muscles in different locations in animals had their own specific functions and differed greatly in the metabolism of the energy. The value of L* and a were strongly influenced by the metabolism process in muscle fibres and the nutrient of feed ([Ijaz et al., 2020](#)).

The results of this study showed that there was a positive and moderate correlation between all body measurements with meat tenderness i.e hardness, springiness, and gumminess ($P < 0.01$). This might due to body weight and body size were linear with age. The more mature the animal, the body measurements will increase until reached a certain size, and the more mature the animal, the more insoluble collagen content of the meat. the older the animal the higher the body size, and this made the meat to be tougher. A study by [Luthfi et al. \(2022\)](#) found that the older the animal, the tougher the meat because the older animal had more insoluble collagen in the meat.

Table 3: Regression models of body measurements with carcass, meat production, and meat quality of simmental-ongole crossbred.

Variable	Regression Models	R ²	p value
BM to BW	$y = -396.87 + 3.40X_1 + 0.42X_2 + 3.06X_3$	0.91	0.00
BM to hot carcass	$y = -367.72 + 2.44X_1 + 0.10X_2 + 3.00X_3$	0.96	0.00
BM to meat yield	$y = -345.40 + 2.25X_1 - 0.11X_2 + 2.55X_3$	0.95	0.00
BM to bone	$y = -13.70 + 0.12X_1 + 0.28X_2 + 0.42X_3$	0.74	0.00
BM to L colour	$y = 29.77 + 0.27X_1 - 0.46X_2 - 0.20X_3$	0.04	0.00
BM to a colour	$y = 15.27 + 0.11X_1 - 0.08X_2 + 0.07X_3$	0.01	0.00
BM to b colour	$y = 0.69 + 0.04X_1 - 0.15X_2 + 0.19X_3$	0.07	0.00
BM to Hardness	$y = 63.92 - 1.57X_1 + 7.39X_2 + 7.64X_3$	0.38	0.00
BM to Springiness	$y = 1.72 - 0.02X_1 + 0.05X_2 + 0.09X_3$	0.32	0.00
BM to Gumminess	$y = -77.56 + 0.54X_1 + 1.01X_2 + 2.07X_3$	0.34	0.00

BM: Body Measurements; **BW:** Body weight; **X1:** Heart girth, **X2:** Chest depth; **X3:** Chest width.

REGRESSIONS

The regression models of body measurements of SOG bulls, production, and meat quality are presented in [Table 3](#). Based on partial regression, the dependent variables chosen were those that had r square higher than 0.7 to make an easy equation and easy to be used ([Table 2](#)). The best regression model formula to predict carcass weight was $y = -367.72 + 2.44X_1 + 0.10X_2 + 3.00X_3$; for predicting meat weight was $y = -345.40 + 2.25X_1 - 0.11X_2 + 2.55X_3$; and to predict bone weight was $y = -13.70 + 0.12X_1 + 0.28X_2 + 0.42X_3$ (X_1 = Heart girth, X_2 = Chest depth; X_3 = Chest width). It was due to the value of the determination was very strong ($P < 0.01$) and the correlations of body measurements were positive and high. Based on the correlation, the most body measurements that had a strong influence in predicting carcass,

meat and bone weight were heart girth, chest depth and chest width. This study showed that the higher the volume of animals, the higher the body weight, carcass weight, meat weight and bone weight of the animal. Therefore, it should be combined all body measurements to predict the carcass and meat weight of Simmental x Ongole Grade Crossbred bulls. The equation can be used to estimate body weight, carcass weight and meat weight of Simmental x Ongole Grade Crossbred bulls. However, there was a low confession of determination between body measurements and meat colour ($P > 0.05$), so that the equations could not be used to predict the meat colour.

The regressions indicated that the equations can be used as an easy and cheap method to predict the production and meat quality of SOG bulls, and might be used in helping management system to predict and evaluate the production of SOG bulls. This finding was parallel with the study by [Seo et al. \(2021\)](#) that body size can be used to estimate carcass fat and carcass weight more accurately. There was a high correlation between body size and carcass main cuts. The relationship between carcass conformation and body size with carcass characteristics can be used to determine the price of carcass and meat in Hanwoo cattle. A study by [Setiyono et al. \(2015\)](#) showed that slaughter weight, carcass weight, bone weight, and non-carcass weight of SOG cattle was positive and strong with meat weight. [Ru-angwittayanusorn et al. \(2019\)](#) claimed that the equation from the regression models by body measurements is very helpful for traders and butchers to estimate without using expensive equipment and methods such as an ultrasound machine so that it can reduce the cost and risk of collection estimates of carcass composition in cattle.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results it can be concluded that body measurements can be used to predict carcass weight, meat weight, bone weight and meat tenderness of SOG bulls. The formula that could be used for estimating carcass weight is $y = -367.72 + 2.44X_1 + 0.10X_2 + 3.00X_3$ and for estimating meat weight is $y = -345.40 + 2.25X_1 - 0.11X_2 + 2.55X_3$.

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NOVELTY STATEMENTS

The authors declared that there have been very limited

AUTHOR'S CONTRIBUTIONS

All of author have been done this study with their each own contribution. Nadlirotun Luthfi as a concepthor, validator, writer of manuscript, and reviewer/ revision; Ismiarti as data analyst and methodology, and corrector of manuscripts formats; Alex Setyo Mulyo and Danang Yusuf Setiawan as data analyst and methodology; and Edy Rianto as concepthor, validator, writer and reviewer.

ETHICS APPROVAL

All experiment were performed in accordance with relevant regulations, proven with Ethical Clearance No. 117/A.II/IV/2023.

CONFLICT OF INTEREST

We declare that there are no conflicts of interest of this article.

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