

Relationship between body weight, body condition score and body fat distribution in rabbits of different physiological state

Arbez-Abnal, Tomás A.^{1,2}; Piñeiro-Vázquez, Angel T.¹; Aguilar-Urquiza, Edgar¹; Hernández-Melchor, Gloria I.²; Chay-Canul, Alfonso J.^{3*}

¹ Tecnológico Nacional de México/ Instituto Tecnológico de Conkal. Avenida Tecnológico s/n, C.P. 97345, Conkal, Yucatán, México.

² Universidad Autónoma de Chiapas, Facultad Maya de Estudios Agropecuarios. Carretera Catazajá-Palenque Km 4, C.P. 29980, Catazajá, Chiapas, México.

³ Universidad Juárez Autónoma de Tabasco. División Académica de Ciencias Agropecuarias, Carr. Villahermosa-Teapa, km 25, C.P. 86280, Villahermosa, Tabasco, México.

* Correspondence: alfonso.chay@ujat.mx

ABSTRACT

Objective: Understanding the body characteristics of rabbits raised under tropical conditions is crucial for informed decision-making in rabbit husbandry. This study examined the relationships among body weight (BW), body condition score (BCS), total body fat (TBF), and fat distribution across abdominal regions (perirenal and gastrointestinal) and subcutaneous areas (dorsal-scapular and inguinal-hypodermal) in both juvenile and adult New Zealand White rabbits.

Design/Methodology/Approach: A total of 33 rabbits (16 juveniles and 17 adults, both female and male) were randomly selected, bred, and humanely sacrificed for data collection. The data were analyzed using descriptive statistics and Pearson's correlation coefficients.

Results: From the juvenile to the adult stage, BW and BCS increased by 31% and 36%, respectively. TBF was also higher in adults (5.1%) compared to juveniles (3.6%). Fat distribution varied notably across regions and physiological stages. Significant correlations ($p < 0.05$) were observed between BW, BCS, and TBF with the distribution of fat in both age groups. The strongest correlations for BW and TBF were found with abdominal fat ($r = 0.66-0.78$ and $0.93-0.96$, respectively), whereas BCS was more closely associated with subcutaneous fat ($r = 0.73-0.77$).

Study Limitations/Implications: The insights gained from this study may contribute to the development of predictive mathematical models for rabbit body composition.

Findings/Conclusions: Abdominal and subcutaneous fat showed low to moderate correlations with BW and BCS. Notably, only TBF demonstrated strong correlations across both juvenile and adult New Zealand White rabbits.

Keywords: Correlation, adipose tissue, New Zealand White breed, young and adult, tropical climate.

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INTRODUCTION

Rabbit farming in many tropical countries serves primarily as a source of meat, while also contributing secondarily to fur production, biomedical research, and companionship.



As such, information related to the productive and reproductive performance of rabbits is of significant interest (El-Raffa, 2004). In traditional livestock systems, body weight (BW) has long been a key indicator for assessing animal morphology and composition, particularly in the context of meat production. However, in situations where precise weighing tools are unavailable, alternative methods for estimating body mass are required. One such alternative is the body condition score (BCS), a subjective yet practical tool that has gained popularity in recent decades due to its strong predictive value in assessing anatomical features through palpation and tissue evaluation (Cardinali *et al.*, 2008). Studies have shown a high correlation between BW and BCS in adult rabbits (Prebble *et al.*, 2014; Sweet *et al.*, 2013); however, research exploring this relationship across different physiological stages in this species remains limited. In Mexico, rabbit meat is commonly marketed as whole carcasses, with an emphasis on high nutritional quality. To meet this market demand, production systems often slaughter animals of varying ages, sexes, and genetic backgrounds, resulting in considerable variability in carcass characteristics (Kumar, 2023). These rabbits undergo rapid development of bone, muscle, and adipose tissues (Arbez-Abnal *et al.*, 2022), though excessive fat is generally discouraged by consumers due to its perceived health risks (Petracci & Cavani, 2013). Despite its negative perception, adipose tissue is a key energy reserve and a precursor of steroid hormones (De la Fuente & Rosell, 2012; Onuoha, 2020). It is also highly responsive to changes in diet quality (ASESCU, 1981; Pascual *et al.*, 1999; Prebble *et al.*, 2014), physical activity (Ferrian *et al.*, 2013; Grace & Olorunju, 2005; Marelli *et al.*, 2012), environmental temperature, health status (Huerta *et al.*, 2015; Silva *et al.*, 2021), and reproductive activity (Bonanno *et al.*, 2008; Savietto *et al.*, 2016). Given this variability, understanding how fat accumulates and distributes throughout the body is essential for selecting animals that align with consumer preferences. In this context, the present study aimed to evaluate the relationship between live weight, body condition, and fat distribution in New Zealand White rabbits at two physiological stages, raised under tropical climatic conditions.

MATERIALS AND METHODS

The study was conducted in the experimental facilities of the Instituto Tecnológico de Conkal, located northeast of Mérida, Yucatán, Mexico. The region is characterized by a tropical sub-humid climate, with average maximum temperatures reaching 36 °C in the summer and 30 °C in the winter. A total of 33 male and female New Zealand White (NZW) rabbits, with an average age of 35 ± 7 days and an average body weight of 380 ± 96 g, were used. The animals were housed individually in cages and received Coccittrak[®] 5% as a preventive treatment against coccidiosis. Water and a commercial feed were provided ad libitum, with the feed composition comprising 88% dry matter, 17% crude protein, 11% crude fiber, 2% fat, and 11% ash. According to Onuoha (2020), rabbits at 119 and 196 days of age correspond to the juvenile and adult stages, respectively. Therefore, two groups (male and female) were euthanized at each of these stages for evaluation. The experimental protocol was approved by the Committee for the Use and Welfare of Experimental Animals at the Instituto Tecnológico de Conkal (Project ID: MX-ITC-002522) and adhered to

ethical guidelines and procedures for animal care and welfare outlined in Meat and Milk Production (Parada-Hernández, 2016).

Before slaughter, rabbits were fasted for 12 hours. Body weight (BW) was recorded using a digital scale with a 10 kg capacity and 1 g precision. Body condition score (BCS) was assessed using the method described by Cardinali *et al.* (2008), which evaluates the prominence of muscle and bone in the loin, rump, and hind legs through visual inspection and palpation. The scale ranges from 0 to 4: scores 0 and 1 indicate cachexia, with prominent bones and minimal muscle; scores 2 and 3 represent optimal condition, with slight bone visibility and adequate muscle; and score 4 reflects full muscularity with no visible bone structures.

Slaughter was performed in accordance with NOM-033-SAG/ZOO-2014, “Methods of Humane Killing of Domestic and Wild Animals.” The animals were exsanguinated via the jugular and carotid veins, and the skin, ears, tail, limbs, and thoracic and abdominal organs were removed to access and collect fat from both the cavity and the carcass. The carcass was then dissected to extract subcutaneous fat, which was categorized into dorsoscapular (DSF) and inguinal hypodermal (GIH) fat. Visceral fat was categorized as perirenal (GP) and gastrointestinal (GGI). Each fat deposit was weighed (in grams), and the total body fat (TBF) was estimated by summing all fat deposits. Carcass dissection procedures followed the guidelines established by the World Rabbit Science Association (WRSA), as described by Blasco *et al.* (1993).

Statistical analysis

Descriptive statistics were performed using PROC MEANS for the juvenile and adult slaughter data, and together with Pearson’s correlation coefficients (r) using PROC CORR, the association of BW, BCS and TBF with DSF, GIH, GP and GGI was determined, both using the statistical package (SAS, ver 9.0, 2010).

RESULTS AND DISCUSSION

Body weight and body condition

Table 1 presents the mean values of body weight (BW), body condition score (BCS), and fat accumulation in New Zealand White (NZW) rabbits. Adult rabbits exhibited an average BW increase of 696 g compared to their younger counterparts, indicating that juvenile rabbits represented approximately 76% of the adult BW. The BCS also increased by 0.7 units in adults relative to juveniles, a trend consistent with findings reported by De la Fuente and Rosell (2012) and Grace and Olorunju (2005). In contrast, Marelli *et al.* (2012) reported higher BCS values (ranging from 3 to 4) in adult pet rabbits fed a high-energy, high-protein diet. It is worth noting that BCS tends to decline when animals are exposed to prolonged periods of high ambient temperatures (Pascual *et al.*, 2013). Studies by Prebble *et al.* (2014) and Sweet *et al.* (2013) evaluating the nutritional health of adult companion rabbits suggest that an intermediate BCS is most appropriate. In the present study, the BCS values observed across physiological stages fall within the optimal range for maintaining adequate body condition, supporting the health and welfare of the animals.

Table 1. Descriptive statistics of NZB rabbits in young and adult stages.

Characteristics	Mean±SD	Min	Max	CV (%)
Body weight (g)				
Young	2243±152	2003	2572	6.77
Adult	2939±366	2334	3494	12.45
Body condition				
Young	1.94±0.44	1	3	22.68
Adult	2.64±0.70	2	4	26.51
Dorsoscapular fat (g)				
Young	10.4±3.7	5	18	35.58
Adult	18.8±10.7	8	48	56.91
Inguinal hypodermal fat (g)				
Young	12.4±4.8	4	21	38.71
Adult	20.8±12.9	6	50	62.02
Perirenal fat (g)				
Young	23.5±6.2	12.5	35.5	26.38
Adult	48.6±20.1	21.3	89.6	41.36
Gastrointestinal fat (g)				
Young	33.9±9.9	14	53	29.20
Adult	61.5±20.7	23	91	33.66
Total body fat weight (g)				
Young	80.1±18.9	44.5	110.4	23.60
Adult	149.6±57.6	61.4	256.3	38.50

SD: standard deviation. CV: coefficient of variation.

Adipose tissue

In adult rabbits, fat accumulation doubled in the dorsoscapular (DSF), inguinal hypodermal (GIH), perirenal (GP), and gastrointestinal (GGI) regions. These findings are consistent with those reported by Silva *et al.* (2021) in adult NZW×California crossbreeds, as well as by Fernandez and Fraga (1996) in California×NZW rabbits raised for meat production. As illustrated in Figure 1, both juvenile and adult rabbits stored approximately 26-28% of their total body fat in subcutaneous regions and 72-74% in abdominal areas.

It is important to highlight that market preferences often prioritize whole carcasses or meat cuts with lower fat content, which plays a significant role in shaping consumer demand (Petracci & Cavani, 2013). Consequently, the identification and genetic selection of individuals with reduced tendencies for fat deposition represents a strategic approach for producers aiming to enhance the marketability of rabbit meat.

The average total body fat in juvenile rabbits was approximately 80 g, which increased significantly by 86% in adult rabbits. This pattern aligns with previous findings in growing animals (Arbez-Abnal *et al.*, 2022; ASESCU, 1981; Kumar *et al.*, 2023; Shahin, 2001), although it remains slightly lower than the 8% total body fat reported by Petracci and Cavani (2013) and Silva *et al.* (2021). Excessive fat accumulation can adversely affect both

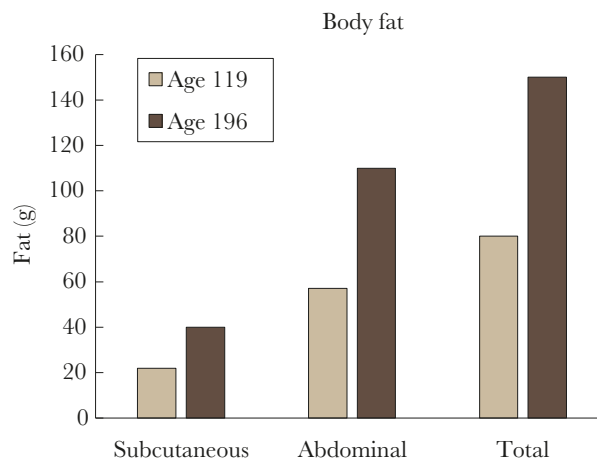


Figure 1. Regional fat tissue accumulation in New Zealand White rabbits at juvenile (119 days) and adult (196 days) stages.

the health and reproductive performance of animals (Bonanno *et al.*, 2008; Huerta *et al.*, 2015). From a commercial perspective, carcasses with higher fat content are often directed toward processed meat products such as sausages, where fat contributes to texture and flavor (Kumar *et al.*, 2023; Petracci & Cavani, 2013).

Correlations

Table 2 presents the Pearson correlation coefficients between body weight (BW), body condition score (BCS), total body fat (TBF), and adipose tissue distribution in New Zealand White (NZW) rabbits. Among the adipose tissue regions, the gastrointestinal (GGI) and perirenal (GP) fat showed the strongest correlations with BW, with coefficients of $r=0.78$ and $r=0.66$, respectively. These findings are consistent with previous studies conducted on juvenile males (Huerta *et al.*, 2015) and adult females (Silva *et al.*, 2021). Similarly, other researchers have reported that increases in abdominal fat deposition are closely linked to gains in live weight (Brecchia *et al.*, 2008; Fernández & Fraga, 1996).

Table 2. Pearson correlation between body weight (BW), body condition score (BCS), and fat tissue in juvenile and adult NZW rabbits (n=33).

	BW	BCS	DSF	GIH	GP	GGI	TBF
BW	1						
BCS	0.66***	1					
DSF	0.57**	0.73***	1				
GIH	0.51*	0.77***	0.85***	1			
GP	0.66***	0.59**	0.77***	0.61**	1		
GGI	0.78***	0.71***	0.81***	0.68***	0.87***	1	
TBF	0.72***	0.75***	0.91***	0.81***	0.93***	0.96***	1

BW: body weight; BCS: body condition score; DSF: dorsoscapular fat; GIH: inguinal hypodermal; GP: perirenal; GGI: gastrointestinal fat; TBF: total body fat. The values shown in the cells with superscripts are as follows: *** equal ($p<0.0001$); ** ($p\leq 0.001$); and * ($p\leq 0.01$).

Moderate correlations were observed between body condition score (BCS) and subcutaneous fat deposits, specifically in the inguinal hypodermal (GIH) region ($r=0.77$) and the dorsoscapular (DSF) region ($r=0.73$). These results are consistent with those reported in adult males (De la Fuente & Rosell, 2012). In adult females, Silva *et al.* (2021) documented a correlation of $r=0.53$ between BCS and DSF, while Cardinali *et al.* (2008) found a stronger relationship ($r=0.76$) between BCS and both GP and DSF in multiparous rabbits. The DSF and GIH fat deposits, located near muscle surfaces and close to the anatomical regions evaluated during BCS assessment, likely influence score perception due to their visibility and palpability.

In contrast, studies in adult females of synthetic lines with a BCS of 2 revealed reduced mobilization of perirenal fat reserves (Ferrián *et al.*, 2013). This suggests a functional alignment between increases in BCS and the accumulation of more metabolically active adipose tissue, such as GP (Brecchia *et al.*, 2008; Savietto *et al.*, 2016). However, the present study did not find significant differences in BCS values (ranging from 1.94 to 2.64), which may explain the observed variation in correlation strength. Strong correlations were also identified between total body fat (TBF) and regional adipose tissue deposits, with coefficients ranging from $r=0.81$ to 0.96 ($p<0.05$). These findings are consistent with previous studies showing a correlation of $r=0.93$ between TBF and perirenal fat thickness (Pascual *et al.*, 1999), and $r=0.90$ between TBF and abdominal fat content (Cardinali *et al.*, 2008). This reinforces the value of GP as a reliable predictor of overall body fat (Fernández & Fraga, 1996). Practically speaking, in cases where direct measurements of abdominal fat are unavailable, DSF and GIH can be used as alternative indicators for estimating TBF (Shahin, 2001).

CONCLUSIONS

In this study, correlations between body weight (BW) and body condition score (BCS) with fat distribution across the dorsoscapular (DSF), inguinal hypodermal (GIH), perirenal (GP), and gastrointestinal (GGI) regions at two physiological stages (juvenile and adult) in New Zealand White (NZW) rabbits were found to be low to moderate. In contrast, total body fat (TBF) exhibited consistently strong correlations with regional fat deposits. These relationships hold potential value for applications in genetic selection, health assessment, reproductive management, and carcass quality evaluation of NZW rabbits raised under tropical conditions.

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