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Effects on Growth Performance Parameters, Carcass Traits, Meat Nutrimental Quality and Intramuscular Fatty Acid Profile of Rabbits Fed with Diets with Avocado Waste (*Persea americana* Mill)

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Abstract: The objective of this paper was to evaluate the effect of four levels (0%, 4.32%, 8.39% or 12.25%) of avocado waste (AW) included in the diets on productive performance, carcass characteristics and meat nutritional quality of fattening rabbits. For that, one hundred and twenty male rabbits (New Zealand × California; 945 ± 47 g initial body weight) were fed over 28 days, randomly distributed to one of the four treatments (T) (T1 = 0, T2 = 4.32, T3 = 8.39 and T4 = 12.25% AW as fed). The chemical and fatty acids profiles were evaluated in the *Longissimus thoracis et lumborum* (LTL) muscle. The rabbits fed with 8.39% of AW reported the best productive parameters ($p < 0.05$), the greater ($p < 0.05$) dissectible adipose tissue and higher polyunsaturated fatty acids (PUFAs) n-3 content ($p < 0.05$) than control meat. It is concluded that the inclusion of AW in the growing–finishing rabbit's diet can modify the nutritional quality of the meat, reducing the n-6/n-3 ratio and the thrombogenic index.

Keywords: rabbits; avocado waste; growth performance; carcass; meat quality; fatty acids

1. Introduction

Avocado is a native fruit in Mexico, it is a source of energy because it has a large amount of vegetable fat, mainly with monounsaturated fatty acids (MUFAs) or sterols of biological interest due to the presence of phenolic compounds and pigments with antioxidant activity [1]. The international production of avocado in 2017 was 5,924,398 tons; Mexico corresponds to the largest production in the world, with 34.21% [2], allowing it to supply the internal demand and to export it. Grageola et al. [3] reported that the packing companies that export avocado discard part of the product due to smaller size or physical damage. These imperfections of the fruit do not affect the nutritional and chemical composition, so at the same time, they can be used for animal feeding. Thus, this is an alternative to take advantage of this agro-industrial waste which can allow for reducing environmental pollution and lowering animal production costs. Whole avocado waste paste (pulp, peel and seed) contains Crude Protein (5.50%), Lysine (0.23%), Crude fiber (17.94%), Ether extract (46.95%), unsaturated fatty acids (67.5%) and saturated fatty acids (32.25%) [4,5], and is a good alternative to modify the lipid profile of animal meat. The omega 3 and 6 polyunsaturated fatty acids (ω-3 and ω-6), are of great interest because they

are related to a decrease in the risk and incidence of cardiovascular diseases, compared to the consumption of diets rich in saturated fatty acids [6].

There is a demand for products of animal origin that provide human health benefits and meet the health recommendations to increase the PUFA n-3 and decrease the n-6/n-3 ratio in the human diet [7]. In addition, there is an increasing interest to modify the fatty acid profile (FA) and extend the shelf life of rabbit meat [8]. This modification is a viable method to give added value to rabbit meat, in order to provide benefits to the consumer. Dalle Zotte and Szendro [6] mentioned that rabbit meat contains excellent nutrients (low MUFA and high PUFA levels, low sodium and high phosphorus content), which are able to further strengthen bioactive compounds; therefore, they consider rabbit meat a functional food.

The composition of fatty acids in the meat of some species such as rabbits, pork and poultry can be modified by supplementation with different sources of lipids [6]. Rabbits are able to directly incorporate dietary fatty acids into adipose and muscle tissue lipids, making it possible to modify the fatty acid profile of rabbits through the strategic use of unsaturated dietary fat sources [9].

Previous research on the inclusion of AW for animal feeding has only been reported by Hernández et al. [10], who evaluated the carcass conformation, nutritional quality and oxidative stability in pork. However, in rabbit, these diets have not been evaluated. The objective of the present study was to evaluate the effect of the level of inclusion of AW in diets for growing–finishing rabbits on its productive performance, carcass characteristics and meat nutritional quality.

2. Materials and Methods

2.1. Animals and Diets

This research project (4536/2018/CI) was approved in October, 2019 at the Bioethics and Animal Welfare Committee of Facultad de Medicina Veterinaria y Zootecnia of the Universidad Autónoma del Estado de México. One hundred and twenty male rabbits (New Zealand × California) with average initial body weight 945 ± 47 g (35 days old), were divided and assigned randomly to four treatments that contained T1 = 0%, T2 = 4.32%, T3 = 8.39% and T4 = 12.25% of avocado waste (AW), thirty rabbits per treatment were fed over 28 days. Rabbits were housed in individual cages equipped with feeders and drinkers, feed and water were available ad libitum. The composition of diets (treatments: T) are shown in Table 1. The diets were formulated to satisfy the requirements of growing–finishing rabbits according to NRC [11] and Lebas [12] (Table 1). The AW was a byproduct of the Hass avocado variety, packed by a company located (this company exports avocado to the USA and other countries) in Xalisco Nayarit, Mexico as described by Lemus et al. [5].

Table 1. Composition and chemical analysis of experimental diets.

Ingredients/Nutrients	Avocado Waste (% as Fed)			
	0	**4.32**	**8.39**	**12.25**
Avocado waste	0.00	4.32	8.39	12.25
Soybean meal	0.00	4.89	4.75	4.62
Canola meal	20.82	11.91	11.19	10.32
Wheat bran	22.55	21.87	21.24	20.67
Sorghum	22.96	19.76	17.18	16.46
Alfalfa hay	4.87	6.61	6.42	6.25
Oats hay	27.14	29.03	29.26	27.90
Premix [1]	0.76	0.74	0.72	0.70
$CaCO_3$	0.90	0.87	0.84	0.82

Table 1. *Cont.*

Ingredients/Nutrients	Avocado Waste (% as Fed)			
	0	**4.32**	**8.39**	**12.25**
Chemical composition				
Dry matter (%)	82.71	85.42	84.93	80.12
Digestible energy (MJ/kg^{-1} DM)	10.75	10.79	10.81	10.86
Crude protein (%)	16.25	16.61	16.29	16.52
Ether extract (%)	1.39	1.47	1.57	2.23
Crude fiber (%)	14.00	15.00	15.83	15.49
Ash	6.61	6.44	6.36	6.51
Ca (%)	0.80	0.79	0.79	0.78
P (%)	0.64	0.59	0.59	0.60
Total of fatty acids (%)				
C14:0	0.24	0.21	0.23	0.26
C16:0	16.37	19.36	22.45	22.83
C16:1	1.91	2.25	2.34	2.14
C18:0	1.84	1.79	2.38	2.59
C18:1n9c	35.74	35.42	37.50	38.13
C18:2n6c	38.38	35.65	30.52	29.50
C18:3n3	5.18	4.94	4.38	4.41
C22:0	0.35	0.38	0.21	0.14

[1] Premix: *Sacaromyces cereviciae* 50 g, Mynasel 100 g, Compactor 300 g, Antibiotics 60 g, Coccidiostat 33 g, Calcium carbonate 1100 g, Betaine 100 g, Phytase 10 g, Calcium 14.28%, Phosphorus 0.026%, ash 46.34%.

2.2. Growth Performance

The live weight of rabbits was recorded every week and the feed intake was recorded daily during all of the experimental period; feed conversion was calculated. At the end of the experimental period (28 days), rabbits were weighed and slaughtered according the Mexican Official Norm procedure [13].

2.3. Carcass Measurements and Sample Collection

Immediately after slaughter, the rabbits were eviscerated according to the procedure described by Blasco and Ouhayoun [14]. The weight of the hot carcass was obtained after 45 min, then they were refrigerated at 4 °C for 24 h and then weighed again to record the cold carcass weight. The yield of the carcass was calculated using values of final live weight divided by the cold carcass weight; in the present study the carcass was considered without the head. The carcass was deboned to obtain the values of dissectible adipose tissue, and bone and meat content. The *Longissimus thoracis et lumborum* (LTL) muscle was removed from the carcass for instrumental and chemical nutritional analysis.

2.4. Meat Quality

After slaughtering the rabbits, at 45 min and 24 h, pH was measured in the LTL muscle (Hanna Instruments, HI) at the level of the first lumbar vertebra. The pH meter is designed to be calibrated automatically by the effect of temperature compensation, and was calibrated using standard buffers of pH 4.0 and 7.0 and the maintenance of calibration was monitored between samples. The color of meat was measured using a Chromameter (Minolta Chroma Meter CR-400) using the CIELAB scale as recommended by the International Meat Commission, with a 10 mm diameter measurement area at room temperature (approximately 20 °C) with illuminant D65 and a viewing angle of 0°. Before each measuring session the chromameter was calibrated on the CIE color space [15] system using a white tile. One measurement consisted of three consecutive flashes of illumination to obtain a mean value. The L^*, a^*, b^*, C* and H° values were recorded to obtain the values of lightness, redness, yellowness, chroma and hue angle, respectively.

2.5. Chemical Analysis

The chemical composition of meat was analyzed in the LTL muscle following the procedures described by the AOAC (Association of Official Analytical Chemists International) [16]. Dry matter (DM) (2001.12) was determined by weight loss of sample after drying in an oven at 102 °C, crude protein (CP) using the Kjeldahl method (968.06), ether extract (EE) with the Soxlet method (920.39) and ash by incineration in a muffle furnace at 550 °C (935.12).

The content of fatty acids was determined by gas chromatography according to the method described by Rodriguez-Maya et al. [17], where 1 µL of each sample was injected into the gas chromatograph (Perkin Elmer, Clarus 500 model) and the fatty acids were separated in a capillary column 100 m × 0.25 mm inner diameter × 0.2 µm of film thickness (SUPELCO TM-2560). The separation was obtained a temperature ramp (140 °C for 5 min with increments of 4 °C per min up to 240 °C), using nitrogen as the carrier gas. The retention times were compared with known standards (SUPELCO37, SIGMA USA analytical FAME MIX). Saturation (S/P), atherogenic (AI) and thrombogenic (TI) indexes were calculated as proposed by Ulbricht and Southgate [18]:

$$S/P = (C14{:}0 + C16{:}0 + C18{:}0)/\sum SFA + \sum PUFA$$

$$AI = (C12{:}0 + 4 \times C14{:}0 + C16{:}0)/\sum SFA + \sum PUFA$$

$$TI = (C14{:}0 + C16{:}0 + C18{:}0)/[0.5 \times \sum SFA + 0.5 \times \sum (n-6) + 3 \times \sum (n-3)/\sum (n-3)/\sum (n-6)]$$

where SFA is the total saturated fatty acids and PUFA is the total polyunsaturated fatty acids.

2.6. Statistical Analysis

A completely randomized experimental design was used. Growth performance was evaluated with PROC MIXED, considering treatments as fixed effects and rabbits as random effects within the measurement periods using an ante-dependent covariance structure ANTE (1). The comparison of treatment means was performed with the pdmix800.sas program with Tukey's test adjustment for LSM. The color and pH values, boneless weight and nutritional composition of the meat were processed with the analysis of variance using the GLM procedure [19]. Comparison of means was performed using Tukey's test, considering significant differences between means if $p < 0.05$ [20].

3. Results

3.1. Growth Performance and Carcass Characteristics

The growth performance and carcass characteristics are shown in Table 2. The initial weight at 40 days of age was similar between treatments ($p > 0.05$). At 68 days of age the final weight was different between treatments ($p < 0.05$), rabbits fed with the control diet (0% AW) were the lightest (1976.9 g) and rabbits fed with the diet with 8.39% AW, were the heaviest (2102.37 g). Significant differences were observed in daily weight gain (DWG) ($p < 0.05$), with the highest gain in the treatment of 8.39% AW (43.71 g/d), intermediate gain in the diet at the level of 12.25% AW (40.21 g/d) and the lowest gain in the control diet (36.66 g/d). The daily feed intake (DFI) was higher ($p < 0.05$) in rabbits with a diet of 8.39% AW (149.49 g/d), similar between the 4.32% and 12.25% AW diets (148.49 and 145.16 g/d) and there was a lower DFI in the control diet (142.62 g/d). The feed conversion (FC) and feed efficiency (FE) were different ($p < 0.05$) between treatments, with lower FC in diets with 8.39% and 12.25% AW (3.48 and 3.56 kg) and higher FE (0.30 and 0.28%). Diet * time interaction was detected for all of these parameters ($p < 0.05$).

There were differences ($p < 0.05$) in hot carcass weight (HCW), cold carcass weight (CCW) and Dressing (DS), where the HCW was higher in rabbits that consumed diets with 4.32 and 8.39% AW (1038.61 and 1081.11 g), medium values in diets with 12.25% AW

(1031.60 g) and less with the control diet (978.75 g). Regarding the CCW, the control diet obtained lower values (916.26 g), they were higher in the diet with 8.39% AW (997.85 g) and medium for the diets with 4.32 and 12.25% AW (964.53 g y 953.65 g). The DS was lower ($p < 0.05$) for rabbits that consumed the control diet compared with rabbits that received diets with 8.39% of AW, and they were medium for diets with 4.32 and 12.25% AW.

Table 3 shows the weight of the dissectible carcass; no differences ($p > 0.05$) were observed in the total bone and meat. Regarding to the total dissectible fat, differences ($p < 0.05$) were found between treatments, where the control diet had less fat deposition (54.98 g), compared to the diet with 8.39% AW (73.53 g), and the diets with 4.32 and 12.25% AW had medium values (69.93 g and 62.28 g).

Table 2. Growth performances and carcass traits of fattening rabbits fed diets with different levels of avocado waste.

Item	Avocado Waste (% as Fed)				SEM [1]	*p*-Value
	0	4.32	8.39	12.25		
Initial body weight, g	939.52	953.16	937.11	950.00	10.96	0.67
Final body weight, g	1976.9 [b]	2032.63 [ab]	2102.37 [a]	2040.36 [ab]	25.46	0.008
Average daily gain, g [Tr, Ti]	36.66 [c]	37.90 [bc]	43.71 [a]	40.21 [b]	0.96	0.002
Feed intake daily, g [Tr, Ti]	142.62 [b]	148.49 [ab]	149.49 [a]	145.16 [ab]	3.03	0.01
Feed conversión, kg [Tr, Ti]	4.07 [a]	4.25 [a]	3.48 [b]	3.56 [b]	0.10	0.0001
Hot carcass weight, g	978.75 [b]	1038.61 [a]	1081.11 [a]	1031.60 [ab]	16.034	0.001
Cold carcass weight, g	916.26 [b]	964.53 [ab]	997.85 [a]	953.65 [ab]	17.354	0.012
Dressing, %	49.67 [b]	50.92 [ab]	51.54 [a]	50.53 [ab]	0.452	0.028

[1] Standard error of the mean. [a, b, c] Means in the same row with different superscripts are different ($p < 0.05$). [Tr] Effect of treatment ($p < 0.05$). [Ti] Effect of aging time (0 vs. 28 days of measurement) ($p < 0.05$).

Table 3. Dissectible components of the carcass of fattening rabbits fed diets with different levels of avocado waste.

Item	Avocado Waste (% as Feed)				SEM [1]	*p*-Value
	0	4.32	8.39	12.25		
Bone, g	151.01	153.83	154.51	148.90	4.317	0.779
Meat, g	674.47	700.29	717.61	724.44	17.478	0.169
Adipose tissue, g	54.98 [b]	69.93 [ab]	73.53 [a]	62.28 [ab]	4.404	0.015

[1] Standard error of the mean. [a, b] Means in the same row with different superscripts are significantly different ($p < 0.05$).

3.2. Meat Quality

The color indices and pH values are shown in Table 4. No differences ($p > 0.05$) were observed between treatments.

Table 4. Color and pH values of the *Longissimus thoracis et lumborum* muscle of fattening rabbits fed diets with different levels of avocado waste.

Item	Avocado Waste (% as Feed)				EEM [1]	*p*-Value
	0	4.32	8.39	12.25		
Color 24 h						
L^* [2]	59.23	57.87	58.52	58.57	1.089	0.844
a^* [3]	4.09	3.63	3.65	4.05	0.277	0.481
b^* [4]	2.86	3.15	2.80	3.33	0.240	0.358
C* [5]	5.09	7.63	7.17	7.94	2.230	0.783
H* [6]	35.49	40.74	38.55	39.29	2.406	0.444
pH 45 min	6.48	6.49	6.46	6.52	0.063	0.946
pH 24 h	5.18	5.12	5.14	5.23	0.039	0.176

[1] Standard error of the mean. [2] *L* Lightness from black (0) to white (100), [3] a^*: from green (−) to red (+) chromacity coordinates, [4] b^*: from blue (−) to yellow (+) chromacity coordinates, [5] Chroma, [6] Metric hue. No differences were found due to the effect of the applied treatments ($p > 0.05$).

3.3. Chemical Analysis

The chemical analysis composition and fatty acids content in the LTL muscle are shown in Table 5. The addition of AW did not influence ($p < 0.05$) the content of dry matter, ash, crude protein or ether extract.

Table 5. Chemical composition (%) and fatty acid content (expressed as g/100 g of fatty acids) of *Longissimus thoracis et lumborum* muscle of fattening rabbits fed diets with different levels of avocado waste.

Item	Avocado Waste (% as Feed)				SEM [1]	*p*-Value
	0	4.32	8.39	12.25		
Dry matter, %	26.06	26.18	26.31	25.93	0.239	0.693
Ash, %	1.36	1.35	1.35	1.35	0.023	0.970
Crude protein, %	22.21	22.65	22.63	22.58	0.361	0.811
Ether extract, %	3.03	3.24	3.45	3.58	0.148	0.063
Fatty acids (g/100 g of fatty acids)						
C12:0 (Lauric)	0.12	0.14	0.10	0.17	0.026	0.385
C14:0 (Myristic)	1.89	2.18	2.04	2.23	0.098	0.073
C15:0 (Pentadecanoic)	0.34	0.34	0.33	0.31	0.031	0.833
C16:0 (Palmitic)	30.81	30.57	30.39	29.63	0.512	0.356
C16:1 (Palmitoleic)	3.15 ^{b}	4.63 ^{ab}	4.14 ^{ab}	4.91 ^{a}	0.397	0.020
C17:0 (Heptadecanoic)	0.54	1.26	0.78	0.70	0.195	0.058
C18:0 (Estearic)	8.28	7.76	7.76	7.46	0.234	0.107
C18:1n9c (Oleic)	30.87	30.96	32.51	32.32	0.637	0.163
C18:2n6c (Linoleic)	19.05	17.82	17.30	17.08	0.699	0.219
C18:3n3 (Linolenic)	0.71 ^{b}	0.85 ^{ab}	1.02 ^{a}	1.06 ^{a}	0.072	0.008
C20:4n6 (Eicosatetraenoic)	2.73	2.15	2.25	2.35	0.258	0.404
Other fatty acids	1.72	1.62	1.46	1.96	0.142	0.140
SFA [2]	42.86 ^{a}	42.79 ^{a}	42.10 ^{ab}	41.21 ^{b}	0.391	0.013
MUFA [3]	34.41 ^{b}	36.02 ^{ab}	36.93 ^{ab}	37.90 ^{a}	0.745	0.017
PUFA [4]	22.83	21.30	21.07	21.05	0.873	0.430
PUFA n-3 [5]	0.73 ^{b}	0.90 ^{ab}	1.05 ^{a}	1.11 ^{a}	0.078	0.009
PUFA n-6 [6]	19.25	18.03	17.56	17.35	0.961	0.238
n-6/n-3 [7]	32.24 ^{a}	22.80 ^{b}	19.52 ^{b}	18.08 ^{b}	2.123	0.001
S/P [8]	0.73	0.72	0.70	0.68	0.013	0.055
Atherogenic index	0.68	0.70	0.67	0.67	0.017	0.573
Thrombogenic index	1.36 ^{a}	1.33 ^{ab}	1.28 ^{ab}	1.23 ^{b}	0.026	0.009

[1] Standard error of the mean. $^{a, b}$ Means in the same row with different superscripts are significantly different ($p < 0.05$). C14:1, C18:1n9t, C18:3n6, C20:1, C21:0, C20:2, C22:0, C20:3n6, C22:1n9, C20:3n3, C24:0, C20:5n3, C24:1, C22:6n3, were detected but not listed in the table. All the mentioned fatty acids have been utilized for calculating the sums of the fatty acid fractions. [2] SFA: saturated fatty acid, [3] MUFA: monounsaturated fatty acid, [4] PUFA: polyunsaturated fatty acid, [5] PUFA n-3: polyunsaturated fatty acid series n-3, [6] PUFA n-6: polyunsaturated fatty acid series n-6, [7] n-6/n-3: PUFA n-6/PUFA n-3 ratio, [8] S/P: saturated fatty acid/unsaturated fatty acid.

With respect to fatty acids contents, the acids C12:0, C14:0, C15:0, C16:0, C17:0; C18:0, C18:2 and C20:4 were similar between treatments ($p > 0.05$). There was a significant increase ($p < 0.05$) observed in palmitoleic acid (C16:1) and linoleic acid (C18:3) content with the inclusion of AW. The total short fatty acids (SFAs) was higher ($p < 0.05$) in the meat of rabbits that consumed diets with 0 and 4.32% AW, and less in the diet with 12.25% AW. The content of MUFAs was higher ($p < 0.05$) in meat of the treatment with 12.25% AW and less in the control treatment. Differences were found ($p < 0.05$) in the total content of PUFA n-3, which was higher in the meat of rabbits fed with 8.39 and 12.25% AW. The n6/n3 ratio was less ($p < 0.05$) in meat of rabbits fed with AW diets. The thrombogenic index was different ($p < 0.05$) between treatments; it was lower in the LTL muscle of rabbits fed with 12.25% AW, medium for diets with 4.32 and 8.39% of AW and higher from the control diet rabbits.

4. Discussion

4.1. Growth Performance and Carcass Characteristics

Avocado is a good source of energy; Xiccato and Trocino [21] found that the amount of energy ingested by rabbits is regulated by a chemostatic mechanism, where the release of nutrients from food, their absorption and arrival via portal to the liver, as well as their presence in the blood, produces signaling that reaches the hypothalamus, causing satiety in the animal using a peptide hormone (cholecystokinin) to regulate food intake [22]. However, avocado seed contains antinutritional factors (tannins, phytic acid, alkaloids and persin), which is considered a limiting factor in animal and human nutrition [23]. Persin is a natural toxin, mainly present in avocado leaves and seed and derived from the biosynthesis of long chain fatty acids [24]; it has been reported that ingesting high doses of avocado leaves causes cardiotoxicity (fibrosis and myocardial necrosis) in mice [25] and cardiomyopathy in sheep and ostriches [26,27]. The lesions caused by persin in mice were caused when they consumed 100 mg/kg of avocado leaves and lethal effects were presented when they consumed 200 mg/kg [25]. The addition of AW in this study did not cause harmful effects to rabbits in the final stage of growth at doses of 4.32 and 8.32%; however, a decrease in the fed intake was observed in rabbits which consumed the diet with 12.25%, this could be attributed to the content of persin in the diet.

The dressing is one of the most important criteria of animal production according to Renouf and Offner [28], in some slaughterhouses this criterion is used for the payment of rabbit carcass. The average DSs of treatments including AW are within the range indicated by the Spanish Association of Cuniculture, which ranges from 50 to 65% [29]. García et al. [30] reported rabbit dressing of 53.67%. Traoré [31] highlights that the relationship of intramuscular fat, high-energy diets and older rabbits is reflected in the characteristics of the carcass, mainly due to the fat accumulation. The differences found in the performance of the carcass are influenced by the final live weight of the animals and the amount of adipose tissue deposited; in this study, rabbits fed with 8.39% AW obtained a higher performance and greater adipose tissue in the carcass.

In terms of food processing and consumer's preferences, the carcasses should have a desired conformation, proportion of meat, optimal distribution of fat tissues and appropriate color [32]. Cinti [33] indicated that in rabbits the main regions of fat deposits are the pelvic, thoracic and visceral areas. In the present study, treatments with AW were higher in CDA and dissimilar fat content, whereas these factors were lower in control treatment. AW is a highly energetic ingredient, since it contains around 46.95% of ether extract. The liver is the main site of fatty acid synthesis in growing rabbits, contributing 70% of the lipogenesis [34]; as a consequence, when the animal consumed fatty acids and these are absorbed at cellular level, they are synthesized, forming fat reserves which can later be used by metabolic processes such as lipolysis and β-oxidation for energy production [35].

4.2. Meat Quality

Simonová et al. [36] mentioned that pH is related to the color parameters, influencing the texture of the meat and oxidation of the heme pigment groups; the handling of the meat post-mortem, and processes of oxygenation and myoglobin oxidation affect the color of the carcass [37]. Koziol et al. [38] evaluated changes in color and pH in rabbit meat fed with diets containing 16.5% CP, 14% CF and 10.2 MJ of Metabolizable Energy (ME); they found that pH was similar at 45 min (6.64), and at 24 h (5.90), and the color values were *L**55.43; *a**5.16; *b**3.48; C*6.36 and H°0.58, with the H° value being lower than that obtained in the present work (35.49–40.74), indicating that the difference was a lighter color than the work reported by Koziol et al. [38]. Simonova et al. [36] found values of *L**52.07; *a**1.79; *b**8.90 and a 24 h pH of 5.73 in rabbits fed with extract of Salvia spp., a plant rich in PUFA (linoleic acid α-linolenic acid). Virag et al. [39] evaluated the effect of vegetable oil (flaxseed and sunflower, combined with Vit E) on the pH and color of rabbit meat, reporting values of *L**51.17, *a**0.06, *b**3.32, H*90.5, C*3.54 and a 24 h pH of 5.95 in male rabbits. The values obtained for *L** confirm the classification of the rabbit meat as

white but not exudative, as it is considered a pale meat with a luminosity greater than 52 ($L^* > 52$) [40]. In the a^* values (chromatic coordinates from (−) green to (+) red), there was observed a positive relationship between pH and a^* of the meat; with a greater pH, there was a greater dark red color, a product of the conversion of oxyglobin in myoglobin [41]. Regarding the b^* values (chromatic coordinates from blue (−) to yellow (+)) obtained in the meat, Münch [42] relates them to the free radicals generated during the storage of the meat.

4.3. Chemical Analysis

Kouba et al. [43], Corino et al. [44] and Dal Bosco et al. [45] evaluated different diets (vitamin E, linseed and CLA, and alfa-linoleic) in growing–finishing rabbits, and they found values of CP (21.7–23.29%), EE (1.0–2.63%), ash (1.11–1.26%) and DM (24.45–24.95%) in the LTL muscle. These values are similar to this investigation; nevertheless, the EE content found in the present study was higher due to highly digestible energy content in the diets used (10.75–13.97 MJ/kg DM). The AW increased the energy content in the diets, influencing their content of EE in the muscle and dissectible fat of the rabbit carcasses. Peiretti et al. [46] reported values of 2.91 and 3.40% of EE in meat of rabbits fed with false flax seed (*Camelina sativa*, L.), where rabbits consumed diets with digestible energy of 12.1 and 12.5 MJ/kg DM; these values are similar to the results of present study with the inclusion of 4.32 and 8.39% AW.

It is taken into account that rabbits are able to directly incorporate dietary fatty acids into adipose and muscle tissue lipids [9]. A high proportion of the fatty acids from the diet are absorbed in the small intestine, before that any biohydrogenation process can be carried out in the cecum [47]. Each fatty acid provided by the diet has a different metabolic pathway. Xiccato et al. [48] and Gondret et al. [35] mentioned that short and medium chain fatty acids are catabolized and used mainly as an energy source, and long chain fatty acids are more likely to be deposited directly into adipose tissue.

According to various studies [44,46,49], the ability of rabbits in biosynthesize PUFA n-3 from linolenic acids (C18:3ω3) using Δ6 and Δ5 desaturase and elongase enzymes has been observed. In the present study, despite the increase in linolenic acid content (C18:3ω3) in LTL muscle, there was not an increase in the content of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) in the meat, which demonstrated limited efficiency of linolenic acid conversion to PUFA n-3. Although the content of linolenic acid in the experimental diets was reduced with the inclusion of AW, possibly due to the reduction of canola meal which is rich in linolenic acid [5,50], the content of this acid increased slightly in the meat of rabbits fed with AW. The fatty acid with the highest content in rabbit meat is oleic acid (C18:1ω-9) [51], which is of importance in human health since replacing SFAs with oleic acid and PUFAs reduces the concentrations of lipids in the blood, producing cardiovascular benefits [52]. Similarly, palmitoleic acid (C16:1) improves the lipid profile since it prevents apoptosis of beta cells induced by SFAs or glucose [53,54].

The differences found in the total MUFAs in the LTL muscle were due to the amounts obtained from palmitoleic acid. The content of SFAs was lower in the meat of rabbits fed with 12.25% AW, this reduction is favorable for human health since it reduces coronary heart disease, due to the hypercholesterolemic properties present in these fatty acids [55]. The total increase in PUFA n-3 induced a decrease in the n-6/n-3 ratio and in the composition of fatty acids of the LTL muscle. The levels of n-3 observed in the present investigation are similar with other studies [43,51,56], in which the profile of PUFAs was increased in rabbit meat by adding energy sources high in essential fatty acids. Simonova et al. [36] reported a high n-6/n-3 ratio in rabbit meat, from 22.26 to 24.33 in the LTL muscle. We found a superior result in our control treatment (32.24); these high n-6/n-3 ratios are due to the linoleic acid content present in rabbit meat. A decrease in the thrombogenic index (TI) was observed in the meat of rabbits fed with AW diets. Dal Bosco et al. [57] reported a TI value of 0.67 in rabbits fed with a flax diet; Peiretti and Meineri [8] added 15% chia seed in diets for rabbits, reporting a TI value of 0.28; and Peiretti et al. [46] reported a TI value of 0.35 in meat of rabbits fed with 15% false flax seeds. These values are lower than our

results mainly due to the different amounts of PUFAs and MUFAs that prevented a lower TI. Lower TI values are healthier and prevent cardiovascular diseases [58].

5. Conclusions

Avocado waste is an interesting strategy to feed rabbits without any adverse effects on growth performance. The rabbits fed with 8.39% avocado waste had the best parameters of productive performance, dressing and a higher deposition of dissectible adipose tissue. The addition of AW in the diets increased the content of palmitoleic (C16:1) and linolenic (C18:3n3) fatty acids. The addition of 12.25% AW increased the content of palmitoleic and linolenic acids and reduced the thrombogenic index of the rabbit meat, with consistent benefits for consumers. However, the impact of the tissue fatty acid modification on the sensory traits of meat still needs to be evaluated.

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Conflicts of Interest: By this conduct, the authors of the article entitled "Effects on growth performance parameters, carcass traits, meat nutrimental quality and intramuscular fatty acid profile of rabbits fed with diets with avocado waste (*Persea americana* Mill)", declare that we do not have conflict of interest of any kind with anybody.

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