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Evaluation of different stocking densities on fattening performance, slaughter, carcass, meat quality characteristics, and fatty acid composition in New Zealand rabbits

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Abstract: The aim of the research was to investigate the effects of different stocking densities on fattening performance, slaughter, carcass, meat quality characteristics, and fatty acid composition in New Zealand rabbits raised in cage conditions and also determine the ideal housing frequency so that yields were not adversely affected. In the study, 36 New Zealand rabbits were used. After weaning, the fattening was started and rabbits were put into cages at different stocking densities as 1 rabbit/cage, 2 rabbits/cage, and 3 rabbits/cage. The live weight of rabbits and feed consumption data were taken every week. At the end of 8 weeks of fattening, slaughtering was carried out and slaughter weights of the rabbits were recorded. The internal organ weights and hot carcass weights were determined. After 24 h, chilled carcass weight and reference carcass weight were defined. As quality parameters of meat; pH, color, cooking loss, water holding capacity, drip loss, and fatty acid composition were determined. In the results of the study, 3 rabbits/cage group had the lowest final live weight (2353.60 g) and daily live weight gain (25.62 g) but 1 rabbit/cage group had the lowest feed conservation ratio (3.56) ($p < 0.05$). There were no significant differences in dressing out percentage, hot, chilled, and reference carcass weight. Head and hind part percentages were higher for 2 rabbits/cage and 3 rabbits/cage groups ($p < 0.05$). Stocking density had no relationship between meat quality and fatty acid composition data except b* value for the longissimus dorsi muscle measured at the 24th h and for the biceps femoris muscle measured at the 0th h ($p < 0.05$). In conclusion, 1 rabbit/cage and 2 rabbits/cage groups had better fattening performance values comparing the 3 rabbits/cage group because of movement area, social and hierarchical behavior between rabbits and advised for laboratory and commercial rabbit breeding for uniformity and profitability.

Key words: Cage, fatty acid composition, meat quality, rabbit, stocking density

1. Introduction

Rabbit is an important laboratory animal that is frequently used in experimental studies and also a farm animal that is recommended to breed widely due to its superior nutritional components such as high omega 3 fatty acids, polyunsaturated fatty acids, and essential amino acids [1–3].

In order to achieve desired results in laboratory animal breeding, it is necessary to have an efficient genotype, meet the physiological requirements of animals, improve welfare standards, and protect them against stress. Standardizing the environmental conditions is very important for decreasing the individual differences between animal groups for reliability and uniformity of results obtained in the experiments [1,2].

The stocking density of rabbits refers to the number of animals per unit area. Stocking density is an important factor affecting the labor force, costs, profitability, and performance of animals. Increasing the number of animals in the cages greatly reduces the production costs, but also reduces the performance of the animals to the same extent. In this regard, stocking density is one of the important stress factors for rabbits. Animals that do not have enough space, become aggressive and stressed so cannot show their species' specific normal behaviors [3,4].

Rabbits are kept in cages or live within groups in pens. In group breeding, because of showing more locomotor activity, they need more energy. At the same time, aggressive behaviors and injuries could frequently be seen in these groups depending on high stocking density. This is a significant disadvantage in terms of animal welfare and production. With the increase in the number of animals kept in the group, infectious diseases and enteritis can cause serious deaths [5–7].

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The ideal cage size for rabbits should be wide enough to allow the animal to stretch its full body and to be high enough to allow the animal to stand straight. In addition, it should be taken into account that young rabbits need more space due to their rapid movements and higher activity [8]. According to the European Food and Safety Authority (EFSA) data, the minimum floor area that should be allocated for 1 rabbit should be 625 cm^2 and the maximum body weight per m^2 could be 40 kg in order not to observe abnormal behavior [9].

The number of animals raised per unit area without any decrease in yields and vital activities is important in terms of profitability for commercial enterprises. However, higher stocking density causes stress-related fattening performance, a decrease in meat quality, and serious economic losses. On the other hand for producing uniform laboratory animals it is crucial for providing the optimal area. The aim of this research is to investigate the effects of stocking density on fattening performance, slaughter, carcass, meat quality and fatty acid composition in New Zealand rabbits raised in cage conditions and to determine the ideal housing frequency that yields are not adversely affected.

2. Materials and methods

This study was carried out within the scope of the permission of Balıkesir University Animal Experiments Local Ethics Committee dated 25/06/2020 and numbered 2020/4-19.

2.1. Experimental design and animals

In the study, 36 New Zealand rabbits were used as animal material. After the weaning (30 days old), the rabbits were taken into the experimental cages, divided into the stocking density groups and the fattening was started. Rabbits were housed in Techniplast R-suite brand and X-type model standard cages within Balıkesir University Experimental Animals Research Center. The dimension of the cages was 71.3 × 71.6 × 47,6 cm (width × depth × height).

Stocking density groups were 1 rabbit/cage with 1 rabbit in the cage (n = 12), 2 rabbits/cage with 2 rabbits in the cage (n = 12) and 3 rabbits/cage with 3 rabbits in the cage (n = 12). The surface area per rabbit for each stocking density group was calculated as 0.43 m^2, 0.21 m^2,and 0.14 m^2, respectively. Rabbits were fed with the most suitable ration mixtures for their metabolic energy and protein requirements. Ingrediants and chemical composition of the diet are shown in Table 1. At the end of the 8 weeks of fattening, slaughtering was carried out.

2.2. Evaluation of fattening performance

Rabbits were weighed every week for determining the body weights and daily weight gain from the beginning to the end of the experiment. The feed consumption of each cage was determined and the feed conversion ratio was calculated by dividing feed intake by weight gain.

2.3. Determine of slaughter and carcass characteristics

While obtaining the rabbit carcasses, the method reported by Blasco and Quhayoun [10] was used. After bleeding, skin, distal part of the legs, gastrointestinal and urogenital tract were removed and the hot carcass weight was determined. After resting the carcasses at 4 °C for 24 h, they were weighed again, the chilled carcass weight was determined and the dressing out percentage was calculated by proportioning the chilled carcass weight to the slaughter weight. Head, kidney, liver, spleen and LH (thymus, trachea, esophagus, heart and lung) weights were determined and percentage values were calculated by proportioning to the slaughter weight. Head, dissectible fat (kidney, inguinal and scapular fat) and internal organ weights were diminished from the chilled carcass weight and the reference carcass weight was calculated.

Carcasses were cut between the 7^{th} and 8^{th} thoracic vertebrae and the 6^{th} and 7^{th} lumbar vertebrae. They divided into 3 parts as fore, mid, and hind. The ratios of the parts were calculated according to the reference carcass weight. Percentage values of the dissectible fat on the carcass, hind and fore legs were calculated by proportioning the weights of the parts to the weight of the reference carcass.

Longissimus dorsi muscle (MLD) was removed from both sides of the carcass and meat samples were taken. Water holding capacity, cooking loss and drip loss analyzes were made in fresh samples. For determining fatty acid composition, samples were kept at –18 °C until analysis by placing each sample in plastic bags [10–13].

2.4. Evaluation of meat quality parameters

2.4.1. pH

The pH was determined by a pH meter with a portable glass electrode (Mettler Toledo) from the longissimus dorsi and biceps femoris muscles. pH data were taken three times as immediately after slaughtering then 45 min and 24 h postslaughtering.

2.4.2. Colour

For analysis, L* (brightness), a* (redness), and b* (yellowness) values were determined with a colorimeter (Konica Minolta CR-400) by making incisions from the middle parts of the longissimus dorsi and biceps femoris muscles for three times as immediately after slaughtering then 45 min and 24 h postslaughtering.

2.4.3. Water holding capacity

Meat samples were stored at –18 °C, rested at 4 °C for 24 h weighed 5 g and divided into 5 separate pieces, placed between filter papers whose weight was determined before, and 2250 g weight was applied on it for 5 min. At the end of 5 min, the meat samples were removed and filter papers were weighed again. The water holding capacity was determined as % by proportioning the difference between the initial and final weight of the filter papers to the initial

Table 1. Ingredients and chemical composition of the diet.

Ingredients	**%**
Barley	20.75
Corn	18.00
Wheat bran	14.00
Soybean meal	18.50
Yeast	0.20
Alfalfa flour	25.00
Methionine	0.15
Phytase	0.10
L-lysine	0.20
By-pass fat	1.50
Vitamin and mineral mixture	1.60
Chemical composition	**%**
Dry matter	94.20
Crude protein	19.35
NDF	31.45
ADF	14.55
ADL	1.02
Ether extract	4.45
Starch	19.50
Ash	9.68
Digestible energy (kcal/kg)	2850

NDF: Neutral Detergent Fiber
ADF: Acid Detergent Fiber
ADL: Acid Detergent Lignin.

weight of the samples for Beriain et al. [14] according to the Grau and Hamm [15] method explained.

2.4.4. Cooking loss

For determining the cooking loss, meat samples were weighed as 50 g and cooked at 80 °C for 45 min [16] allowing the internal temperature of the meat sample to reach 70 °C. Afterwards, the samples were weighed again and the cooking loss was determined as % by dividing the difference between the initial and the final weight of the sample to the initial weight.

2.4.5. Drip loss

Meat samples for drip loss were weighed and their initial weight was determined. After that, samples were taken out of the plastic bags, dried and weighed again after 24 and 48 h for determining 48th and 72nd h of drip loss. The difference between the two weights determined as drip loss (%) according to Honikel [16].

2.4.6. Fatty acid composition

Meat samples for determining the fatty acid composition were extracted according to the method of Blight and Dyer [17] and placed in GC-MS vials in which the fatty acid methyl esters were exposed. HP Agilent 6890/5972 branded gas chromatography-mass spectrophotometer device was carried out. HP-88 brand (100 m length, 0.25 mm i.d. × 0.20 μm) capillary column was used. The injector temperature was set to 250 °C, the detector temperature to 270 °C, the injection split ratio was 1:50 and the total injection volume was 1 μL.

2.5. Statistical analysis

Statistics analyses were performed using the IBM SPSS software version 25 (SPSS Inc., Chicago, IL, USA). One-way analysis of variance (ANOVA) was used to determine the effects of different stocking density groups on the fattening performance, slaughter, carcass, meat quality and fatty acid composition characteristics. Comparisons among groups were made by the Tukey test.

3. Results

Growth and fattening performance data determined at different stocking densities are presented in Table 2. While there was no significant difference between 1 rabbit/cage group and 2 rabbits/cage group in terms of final live weight and daily weight gain; 3 rabbits/cage group had lower data ($p < 0.05$). The highest amount of daily feed intake per animal per day was determined for 2 rabbits/cage and 3 rabbits/cage; while the group that consumed the least feed was 3 rabbits/cage ($p < 0.01$). While the group with the lowest feed conversion ratio was 1 rabbit/cage and no significant difference was found between 2 rabbits/cage and 3 rabbits/cage groups ($p < 0.05$).

Daily live weight gain and daily feed intake data on a weekly basis during the experiment are shown in Figure 1 and Figure 2. It was observed that the live weight gain and feed intake were less in the 3 rabbit/cage group at the 7th and 8th weeks of the fattening.

Slaughter and carcass characteristics determined at different stocking density groups are presented in Table 3. There was no significant difference between the stocking density groups in terms of carcass weights (hot, chilled and reference) and dressing out percentage values obtained after 8 weeks of fattening. While the head percentage of the carcass was the lowest for the 1 rabbit/cage group and there was no significant difference between the 2 rabbits/cage and 3 rabbits/cage groups ($p < 0.05$). When the parts of carcass were evaluated, it was found that the hind part ratio was at the lowest level for the 1 rabbit/cage group and it was determined that there was no significant difference between 2 rabbits/cage and 3 rabbits/cage groups ($p < 0.05$). Considering the dissectible fat from the carcass, it was found that the 3 rabbit/cage group had the lowest value although it was not statistically significant.

The data obtained in terms of meat quality characteristics examined in the study are presented in Table 4. The b* value measured from the longissimus dorsi muscle at 24th hwas the lowest for the 3 rabbits/cage group ($p < 0.05$) and the b* value measured immediately after slaughtering from the biceps femoris muscle was found to be higher in the 2 rabbit/cage group than for the 1 rabbit/cage group ($p < 0.05$). There were no significant differences between stocking density groups in terms of pH, water holding capacity, cooking loss, and drip loss values ($p > 0.05$).

There were no statistically significant differences between stocking density groups in terms of fatty acid composition analysis presented in Table 5 and the calculated fatty acid rates are presented in Table 6 ($p > 0.05$).

4. Discussion

Rabbit is used as laboratory animal in many experimental studies due to the short duration of generation and multiple birthing. In order to make a commercially profitable breeding, higher rates of offspring that belong to higher growth rate is desired. The number of animals raised per unit area should be ideal and optimized [2,3,18,19]. In terms of experimental studies, it is indispensable to ensure uniformity due the welfare of the animals and the optimal conditions specific to the species. In this study, the fattening performance, slaughter, carcass, meat quality and fatty acid composition characteristics obtained at different stocking densities in New Zealand rabbits were evaluated and the differences between groups were revealed.

Considering the final live weights, although the 3 rabbits/cage group had the lowest weight; the fact that 1 rabbit/cage and 2 rabbits/cage groups had higher weights were similar to many studies on this subject in the literature [2,3,20,21]. As the number of animals in the cage increased, they consumed less feed due to fighting behavior with each other, restriction of the movement area and hierarchical stress [13,22–24]. The study group that consumed the least feed was the 3 rabbits/cage that supported this information. Daily live weight gain was directly related to the amount of feed consumed by the animal. In this respect, the 3 rabbits/cage groups had also the lowest value for this parameter. In terms of feed conversion ratio, the

Table 2. Growth and fattening performance of rabbits housed at different stocking densities.

Rabbits, n	**1 rabbit/cage (n = 12)**	**2 rabbits/cage (n = 12)**	**3 rabbits/cage (n = 12)**	**SEM**	**P**
Initial live weight (30th day) (g)	865.05	945.39	895.33	26.48	0.470
Final live weight (86th day) (g)	2543.25^{a}	2589.17^{a}	2353.60^{b}	38.97	0.028
Daily weight gain (g/day)	29.65^{a}	29.09^{a}	25.62^{b}	0.65	0.019
Daily feed intake (g/day)	95.78^{ab}	102.82^{a}	90.80^{b}	1.63	0.007
Feed conversion ratio (feed/gain)	3.25^{a}	3.58^{b}	3.56^{b}	0.07	0.038

SEM: Standart error of mean.
a, b: means within a row with different superscript differ significantly

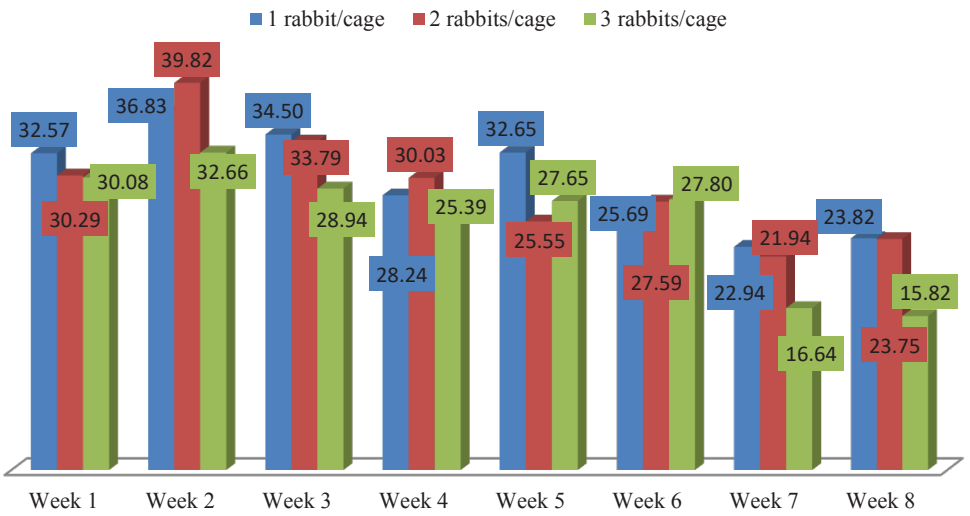

Figure 1: Daily weight gain (g) at different stocking density among weeks of fattening

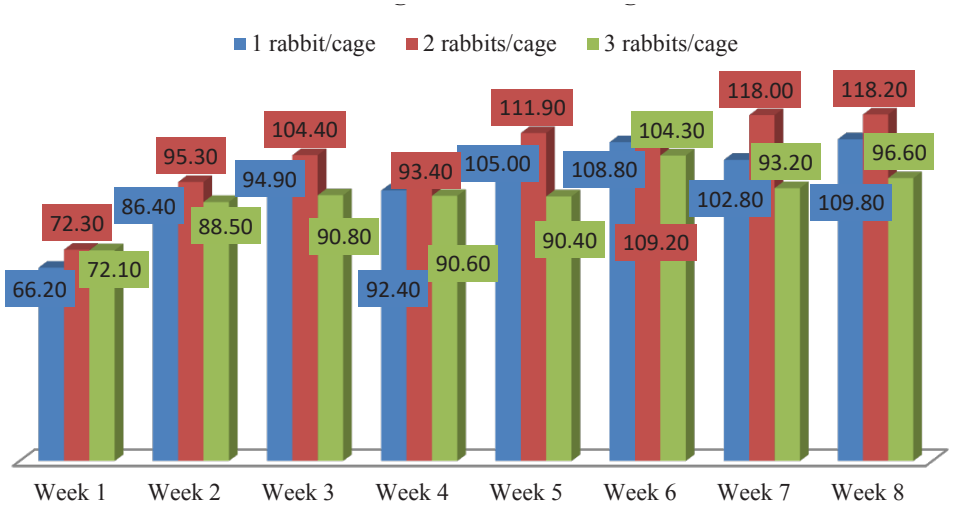

Figure 2: Daily feed intake (g) at different stocking density groups among weeks of fattening

1 rabbit/cage group had the lowest value compared to other groups. When daily live weight gain and daily feed intake data were examined, it was found that the fattening performance values of the 3 rabbit/cage groups were lower than the other experimental groups for the last two weeks of the fattening. This suggested that 1 rabbit/cage and 2 rabbits/cage groups were more suitable for all times of fattening. In other studies conducted in parallel with the results of the research, when the area per animal in rabbit cages increased, the locomotor activities observed in animals also increased so decreased values were seen in final body weight, growth rate, daily live weight gain, feed consumption, carcass weight and carcass fat content. The feed conservation ratio was reported to be increased [3,8,12,13,19–21,24–27]. Unlike the study findings, there were also literature reports stating that housing frequency had no effect on the final live weight, daily weight gain, feed consumption and feed conversion ratio [7,9,11,28].

Considering the hot, cold and reference carcass weights determined in the groups, it was observed that the data determined for the 3 rabbits/cage groups were lower than the values obtained from the 1 rabbit/cage and 2 rabbits/

Table 3. Slaughter characteristics of rabbits housed at different stocking densities.

Rabbits, n	**1 rabbit/cage (n = 12)**	**2 rabbit/cage (n = 12)**	**3 rabbit/cage (n = 12)**	**SEM**	**P**
Hot carcass (HC), g	1652.37	1644.66	1542.00	23.61	0.101
Chilled carcass (CC), g	1581.37	1566.50	1489.20	22.08	0.191
Reference carcass (RC), g	1264.41	1265.54	1194.17	17.53	0.165
Dressing out percentage (DoP), %	62.20	60.65	63.29	0.37	0.055
SW%					
Head	5.04[a]	5.45[b]	5.42[b]	0.07	0.042
Kidney	0.58	0.56	0.56	0.00	0.544
Liver	2.47	2.42	2.33	0.06	0.675
Spleen	0.05	0.04	0.04	0.00	0.486
LH	0.94	0.97	0.87	0.02	0.124
RCW%					
Dissectible fat	5.57	5.58	4.93	0.29	0.588
Hind leg	30.67	30.87	31.13	0.17	0.597
Fore leg	13.87	13.25	13.88	0.18	0.291
Fore part	28.89	27.94	28.80	0.23	0.202
Mid part	34.98	34.66	34.84	0.23	0.856
Hind part	36.04[a]	37.30[b]	37.28[b]	0.20	0.013

SEM: Standart error of mean.
a, b: means within a row with different superscript differ significantly
SW: Slaughter weight
RCW: Reference carcass weight
LH: Set of organs consisting of thymus, trachea, esophagus, heart, and lung

cage groups, although it was not statistically significant. This is an expected situation in terms of the natural state for 3 rabbits/cage group that reached at the lowest final live weight. Similar to research findings as the final live weight decreased, the carcass weight also decreased [2,3,20,21].

Different from the study findings, it was determined that carcass yield, carcass weight, and hind part weight were higher in groups with more area allocated per animal and the rate of dissectible fat in the carcass was lower in other studies [11,13,23–29]. In the study, the carcass hind part ratio was the lowest in the 1 rabbit/cage group that had the highest area per animal. The locomotor movements of the animals were higher for 2 rabbits/cage and 3 rabbits/cage groups due to the socialization of the animals with each other, fighting and hierarchical behaviors; whereas the low level of moving behavior in the 1 rabbit/cage group may be the reason for the lower carcass hind part ratio. Observing injured and hairless parts on the back and loin of animals in some of the 2 rabbits/cage and 3 rabbits/cage groups strengthened the possibility of struggle and fighting behaviors. According to Villabolos et al. [9] as the frequency of stocking density in cages increased, the level of aggression in animals increased and wounds were observed in the ear and tail regions.

When the carcass yield and the dissectible fat ratio in the carcasses were examined, no significant difference was found between the stocking density groups. According to Villabolos et al. [9], Dorra et al. [7], Trocino et al. [30], Abdel-Hamid [19], and Krunt et al. [22] reported the similar findings to research.

The head ratio per carcass was higher in the 3 rabbits/cage and 2 rabbits/cage groups than in the 1 rabbit/cage group. It is thought that this situation may have occurred due to the overdevelopment of the nervous system organs.

Table 4. Meat quality characteristics of rabbits housed at different stocking densities.

Meat samples, n	**1 rabbit/cage (n = 12)**	**2 rabbits/cage (n = 12)**	**3 rabbits/cage (n = 12)**	**SEM**	**P**
Longissimus Dorsi					
pH 0. h	6.47	6.48	6.46	0.03	0.949
pH 45 min	6.11	6.21	6.24	0.03	0.318
pH 24. h	5.78	5.87	5.85	0.01	0.092
L* 0. h	42.88	42.12	39.52	1.03	0.390
a* 0. h	2.69	2.85	3.24	0.22	0.603
b* 0. h	1.60	2.64	1.85	0.17	0.059
L* 45 min	52.46	42.53	40.02	9.72	0.326
a* 45 min	3.15	3.16	3.39	0.24	0.909
b* 45 min	2.39	2.81	2.11	0.14	0.134
L* 24. h	48.40	47.75	48.85	0.61	0.770
a* 24. h	3.94	3.96	3.72	0.20	0.873
b* 24. h	4.05^{a}	4.43^{a}	3.01^{b}	0.21	0.013
Biceps Femoris Muscle					
pH 0. h	6.41	6.43	6.47	0.03	0.829
pH 45 min	6.12	6.20	6.27	0.03	0.314
pH 24. h	5.84	5.86	5.94	0.01	0.101
L* 0. h	49.09	49.99	47.14	0.67	0.216
a* 0. h	2.75	3.47	2.92	0.19	0.308
b* 0. h	0.76^{a}	3.27^{b}	2.18^{ab}	0.35	0.010
L* 45 min	48.87	47.84	48.28	0.39	0.577
a* 45 min	2.83	3.27	3.20	0.22	0.692
b* 45 min	2.72	3.32	2.86	0.14	0.232
L* 24. h	51.51	52.53	52.30	0.47	0.676
a* 24. h	3.82	3.81	3.27	0.19	0.455
b* 24. h	3.85	3.61	3.21	0.22	0.516
Water holding capacity (%)	6.61	6.81	5.94	0.35	0.584
Cooking loss (%)	31.33	32.03	32.08	0.30	0.555
Drip loss 48. h (%)	1.83	1.35	1.42	0.18	0.535
Drip loss 72. h (%)	2.96	2.58	2.56	0.29	0.833

SEM: Standard error of mean.
a, b: means within a row with different superscript differ significantly

It is supported by other studies that due to the higher number of animals in the cages, food access struggle, hierarchical fighting behavior observed among animals, and social interactions, locomotor activity was higher and the brain weight may be proportionally higher in these animals [22,31]. El-Bayoumi et al. [20] reported parallel results with the research findings that the head ratio increased as the area allocated per animal decreased.

Since the rabbits were slaughtered at the same age, the absence of a significant difference in visceral organ weights indicated that the animals had similar developmental rates. Unlike the findings of the study, Metzeger et al. [25], Zotte et al. [4], Dorra et al. [7], and Omar et al. [18] found that the liver ratio was higher in groups with a higher area allocated per animal. Bayoumi et al. [20] found that the kidney ratio was higher in the group with less space per animal.

Table 5. Fatty acid composition of rabbits housed at different stocking densities.

Meat samples, n	1 rabbit/cage (n = 12)	2 rabbit/cage (n = 12)	3 rabbit/cage (n = 12)	SEM	P
C10	0.339	0.288	0.238	0.020	0.119
C12	0.331	0.288	0.259	0.018	0.284
C13	0.142	0.093	0.192	0.034	0.516
C14	3.814	3.638	3.800	0.125	0.825
C14.1	0.449	0.445	0.525	0.032	0.533
C15	0.984	0.961	1.055	0.064	0.833
C15.1	0.632	0.539	0.425	0.049	0.230
C16	34.291	34.06	34.227	0.322	0.961
C16.1	6.029	5.149	6.694	0.347	0.194
C17	0.926	0.695	0.679	0.051	0,090
C17.1	0.373	0.379	0.379	0.027	0.995
C18	6.143	6.727	6.232	0.259	0.627
C18.1	24.297	23.726	24.274	0.275	0.646
C18.2 ω6	17.253	19.185	17.562	0.393	0.096
C18.3 ω3	0.924	1.257	1.032	0.073	0.171
C18.3 ω6	0.160	0.138	0.069	0.032	0.496
C20	0.046	0.076	0.047	0.005	0.069
C20.1	0.121	0.043	0.020	0.034	0.460
C20.2	0.102	0.115	0.100	0.007	0.697
C20.3 ω3	0.015	0.023	0.019	0.002	0.448
C20.3 ω6	0.162	0.156	0.154	0.012	0.968
C20.4 ω6	1.746	1.389	1.474	0.111	0.406
C20.5 ω3	0.258	0.210	0.203	0.015	0.289
C21	0.048	0.119	0.054	0.017	0.172
C22	0.099	0.083	0.094	0.007	0.689
C22.1 ω9	0.021	0.021	0.007	0.006	0.582
C22.2	0.008	0.005	0.011	0.002	0.598
C22.6 ω3	0.080	0.017	0.017	0.020	0.356
C23	0.019	0.018	0.019	0.003	0.997
C24	0.057	0.045	0.042	0.003	0.231
C24.1	0.115	0.087	0.086	0.006	0.144

SEM: Standard error of mean.

When meat quality characteristics were examined, the effect of stocking density was not found to be significant in most of the investigated parameters. Only the b* value of the measured meat color parameters differed between the groups at 24th h for the longissimus dorsi muscle and immediately after slaughtering for the biceps femoris muscle. The color parameter in meat samples was affected by the feed consumed, pH changes, and individual differences. Since all animals consumed the same ratio in the study, the difference may be due to individual differences. Similar to the research results, Volek et al. [11] found no significant difference between the stocking density groups in terms of meat quality characteristics.

Unlike research findings, as the stocking density increased, Paci et al. [32] determined that L* value increased, a* value decreased, Krunt et al. [13] found that b* value increased, a* value decreased and Lazzaroni

Table 6. Calculated fatty acid ratios of rabbits housed at different stocking densities.

Meat samples, n	1 rabbit/cage (n = 12)	2 rabbit/cage (n = 12)	3 rabbit/cage (n = 12)	SEM	P
Saturated fatty acids (SFA), %	47.246	47.106	46.943	0.430	0.962
Monounsaturated fatty acids (MUFA), %	32.040	30.393	32.413	0.556	0.297
Polyunsaturated fatty acids (PUFA), %	20.529	22.367	20.525	0.447	0.154
Total unsaturated fatty acids (TUFA), %	52.570	52.760	52.938	0.431	0.944
Desired fatty acids (DFA), %	58.714	59.488	59.171	0.313	0.612
Nutritive value (NV), %	0.891	0.896	0.892	0.010	0.981
PUFA/SFA	0.437	0.476	0.437	0.010	0.246
MUFA/SFA	0.683	0.648	0.694	0.016	0.507
TUFA/SFA	1.121	1.125	1.132	0.019	0.973
Σω6/Σω3	18.419	17.538	22.203	3.236	0.831
Atherogenic index (AI), %	0.952	0.929	0.940	0.015	0.930
Thrombogenic index (TI), %	16.362	17.998	16.278	0.365	0.093

SEM: Standard error of mean.
Desired fatty acids: C18:0 + TUFA
Nutritive value (NV): (C18:0 + C18:1) / C16:0.
Atherogenic index (AI): (C12:0 + 4 × C14:0 + C16:0)/(MUFA + Σω3 + Σω6)
Thrombogenic index (TI): (C14:0 + C16:0 + C18:0)/(0.5 × MUFA) + (0.5 × Σω6) + (3 × Σω3) + (Σω3 / Σω6)

et al. [26] reported that a* and b* values increased as the stocking density decreased. As the movement area of animals increased, the rate of oxidative metabolism increased and also the ratio of red muscle cells increased compared to white muscle cells. In this respect, as the area allocated per animal increased, the a* value determined in meat increased [13]. In the study, it was determined that the stocking density was ineffective on meat pH. Unlike research findings, when the amount of individual space allocated per animal was increased, Zotte et al. [4] found that the pH value of meat was decreased but Lazzaroni et al. [26], Trocino et al. [30], and Krunt et al. [22] reported that the pH value was increased.

In the study, no significant differences were found between the stocking density groups in terms of cooking loss, water holding capacity, drip loss, and fatty acid composition. According to Zotte et al. [12] and Paci et al. [32] different stocking densities of housing did not change the cooking loss. Zotte et al. [4] revealed no significant differences between stocking density groups for drip loss. Cavani et al. [29] found that the rabbit group, which was allocated 0.17 m^2 per animal and raised in the open air, had a higher MUFA, PUFA, and arachidonic acid (C:20) ratio and a lower SFA ratio compared to the group allocated 0.07 m^2 per animal in closed conventional cages. MUFA and omega 6 fatty acid ratios were determined higher by Pla [33], Chodova et al. [23], Zotte et al. [12], and Loponte et al. [24] at lower stocking density.

5. Conclusions

The stocking density of housing rabbits is very important both in order to ensure uniformity for laboratory animal breeding and to produce more animals per unit area for commercial enterprises. In this respect, it is crucial to determine the appropriate cage frequency by considering the physiological needs and welfare conditions of the rabbits.

In the study 3 rabbits/cage group reached the minimum final live weight and daily live weight gain. 1 rabbit/cage group had the lowest feed conservation ratio. As the number of rabbits increased and the movement space decreased, the fattening performance was influenced. Animals got stressed, struggle with each other and eat lower. The head ratio and hind part of the carcass was the lowest for 1 rabbit/cage group because of establishing a hierarchy, social and fighting behaviors. Stocking density had no relationship between meat quality and fatty acid composition except b* value of meat color parameters. In conclusion, for standard laboratory cages, it is recommended that 1 rabbit/cage and 2 rabbit/cage frequency were optimal for growth and fattening performance so that yields were not adversely affected.

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Informed consent
All procedures used in the present study were approved by the Ethic Committee of the Balıkesir University (2020-4-19).

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