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Effects of housing condition, feeding style, and age on fattening performances, comfort, and some slaughterhouse characteristics in Eastern Anatolian Red bulls

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Abstract: It is crucial to bring domestic animal breeds to production and to produce meat based on sectoral structure. The objective of this study was to determine the effects of age, housing condition, and feeding style on fattening performance, comfort, and carcass characteristics of the Eastern Anatolian Red (EAR) bulls, a native breed which is suitable for adverse environmental conditions and marginal land as well as resistant to diseases. Twenty-five purebred EAR bulls (15 head of 2-year-olds and 10 head of 1-year-olds) were assigned randomly to 1 of 5 finishing programs after allocating by the age, feeding protocol, and environmental conditions. The groups were housed either individually in pens inside the barn or in paddocks outside the barn during the experimental period. The floor of the roofed paddock was cleaned and kept dry. The results indicated that there were statistically significant differences in daily live weight gain, total live weight gain ($P < 0.05$), and feed efficiency ($P < 0.01$) among the groups. The differences among the groups were also significant in terms of hot carcass, dressing, and pelvic fat ($P < 0.01$), as well as weights of noncarcass components (except head) ($P < 0.01$). The different values of the Wind Chill Index did not affect animal comfort adversely. It was clearly concluded that the EAR cattle can be a good fattening material if housing conditions and feeding style are appropriately designed.

Key words: Age, housing condition, feeding style, fattening, Eastern Anatolian Red cattle, animal comfort

1. Introduction

In Turkey, beef cattle production is a traditional husbandry activity and an important support to agricultural economic growth of the country. This activity became one of the agricultural sector's significant production areas in the past, and today it meets the beef demand in the national market. Nowadays, beef production faces challenges, however, due to a number of social, environmental, and human factors. In order to overcome this challenge, the politicians, researchers, and beef producers must all work together on increasing the sustainability of beef production to meet a growing demand. Therefore, it is of great importance to investigate and implement new production and rearing models. Developing different production models and transferring them into practice is important for people and the country's future.

Beef production systems are related to climatic and environmental conditions, animal phenotypes, and management practices of the region [1]. Efficient introduction of domestic cattle breeds into production is one of the methods used in the region for beef production. One of these native breeds is the Eastern Anatolian Red (EAR) cattle that are common in the eastern part of Turkey. These animals are known to have genetically contributed to some cattle breeds in Europe [2], and are suitable material for new breeding studies because they are grown without any rearing models and are more profitable.

Similar to many highland regions, in eastern Turkey beef production is done according to traditional methods which disregard age, housing form, and feeding method effects on performance. This results in poor production efficiency and unfeasible utilization of resources.

This research was conducted to determine the fattening performance and some slaughterhouse data of the EAR bulls that were of different ages, fed using different feeding models, and housed under different conditions.

2. Material and methods

2.1. Animals and housing conditions

The study was carried out at the Eastern Anatolian Agricultural Research Institute, Erzurum, Turkey (39°55′15.49″N, 41°17′12.90 E, and at an altitude of 1850 m). The experimental protocol was approved by the Local and Institutional Committee on Animal Ethics and Research. A total of 25 purebred EAR bulls (15 head of 2-year-olds and 10 head of 1-year-olds) were assigned

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randomly to 1 of 5 finishing programs after allocating by the age, feeding protocol, and environmental conditions.

The groups were housed either individually in pens (2 × 2.20 m) inside the barn or in paddocks (8 × 21 m for 2-year-old bulls and 8 × 15 m for 1-year-old bulls) outside the barn during the experimental period. The floor of the roofed paddock was cleaned and kept dry. The climatic features effective in the study are given in Table 1.

2.2. Feedings, experimental groups, and management

The nutritive values of the diets are presented in Table 2. During the 2-week adaptation period, animals started to consume ad libitum the fodder and limited compound feed. The experiment lasted for 130 days. The following groups were set: Group 1 (G1, in the individual pens inside) consisted of 2-year-old bulls (n = 5) fed once daily at 7:30 AM. Group 2 (G2, in the individual pens inside) consisted of 2-year-old bulls (n = 5) fed twice daily at 7:30 AM and 3:30 PM. Group 3 (G3, in the paddocks outside) consisted of 2-year-old bulls (n = 5) fed once daily at 7:30 AM. Group 4 (G4, in the individual pens inside) consisted of 1-year-old bulls (n = 5) fed once daily at 7:30 AM. Group 5 (G5, in the paddocks outside) consisted of 1-year-old bulls fed once daily at 7:30 AM. All groups fed ad libitum consumption of the rations with 40% roughage (40% alfalfa hay, 45% meadow hay, and 15% wheat straw) and 60% concentrate (20% barley, 20% wheat bran, 10% ground corn, 10% wheat, 8% cotton seed meal, 8% sunflower seed meal, 10% corn bran, 10% molasses, 2.5% ground limestone, and 1.5% salt on a dry matter basis) and clean water. Orts were collected prior to next feeding.

2.3. Data collection and laboratory analyses

The bulls were weighed every other week. Feed consumption, initial and final weights, daily live weight gain (total body weight gain / feed time), total live weight gain (final weight–initial weight) and growth rate ([fattening weight gain / final weight] × 100) were measured and calculated. Haircoat structure and general behaviors of animals were followed and recorded at 2-h intervals. The Wind Chill Index (WCI) was calculated with the method (WCI = 35.74 + 0.6215 × temperature - 35.75 × wind speed$^{0.16}$ + 0.4275 × temperature × wind speed$^{0.16}$) developed by Tew et al. [3]. Feeds were withdrawn 12 h prior to slaughtering. The head, hide, 4 feet, kidney, pelvis fat, and heart were removed and weighed. Hot carcass weights, hot dressing, and carcass measurements (length, length of round, width of round from medial side) were also obtained [4].

2.4. Statistical analysis

The data were subjected to the GLM procedure, including the effects of animal age, housing condition, and feeding style [5]. The Duncan method was applied for comparison of subclass means when F-tests for main effects were significant. The mathematical model in data analysis:

$Y_{ij} = \mu + A_i + e_{ij}$, where μ: population mean, A_i: effect of treatment groups (i: G1, G2, G3, G4, G5), Y_{ij}: weight gains, slaughter, carcass traits or carcass measurements, e_{ij}: random error.

3. Results

3.1. Fattening performance

The daily live weight gain, total live weight gain, growth rate, feed efficiency, and feed consumption values according to the bull age, housing condition, and feeding style are shown in Table 3. Daily and total weight gains of the G1 were greater than those of the other groups ($P < 0.05$). Growth rate of the G4 was similar to that of the G5, and both were higher than those of the other groups ($P < 0.01$). The feed consumption was the highest for the G3, which consumed the highest amount of feed ($P < 0.01$).

3.2. Slaughterhouse characteristics

Table 4 summarizes the carcass characteristics. The initial weights varied from 231 to 233 kg for 2-year-old bulls and from 153 to 154 kg for 1-year-old bulls ($P < 0.01$). The trend was similar for final body weight, hot carcass weight, and hot carcass dressing. The wastage enhancive factors were not allowed during transport and slaughter. The dressing percentage was calculated as a ratio of hot carcass weight to the live weight. The amount of pelvic fat differed by the bulls' age, housing condition, and feeding style ($P < 0.01$); the G1 group was similar to the G2 and the G4 was similar to the G5. The differences in pelvic fat/hot carcass (PF/HC) ratio among the groups were significant

Table 1. The climatic features effective in the study.

Events	January	February	March	April	May
Day temperature (°C)	−2.2	3.9	9.1	14.0	15.8
Night temperature (°C)	−17.0	−14.8	−7.0	−3.1	3.2
Rainy days	0	0	1	2	11
Snowy days	11	5	14	2	1
Wind speed (mps)	0.44	0.71	1.08	1.25	0.71

Table 2. Chemical composition of feeds used (DM basis).

Feed	DM	CP	ME	CA	ADF	NDF
	%	%	Mcal/kg	%	%	%
Alfalfa hay	90.56	19.13	2.13	9.53	31.06	41.1
Meadow hay	92.26	10.13	2.10	8.9	39.55	62.4
Wheat straw	91.23	3.53	1.48	8.43	50.10	67.75
Concentrate	90.25	16.45	2.50	7.4	-	-

DM: Dry matter; CP: crude protein; ME: metabolizable energy; CA: crude ash; ADF: acid detergent fiber; NDF: neutral detergent fiber

Table 3. The fattening performance of bulls of different ages and of those subjected to different housing conditions and feeding programs.

	Groups[1]						
Dependent variable	G1	G2	G3	G4	G5	SEM	P-value
Daily weight gain, g	0.788^{a}	0.641^{bc}	0.750^{ab}	0.708^{abc}	0.609^{c}	0.037	<0.014
Total weight gain, kg	102.40^{a}	83.40^{bc}	97.50^{ab}	92.00^{abc}	79.20^{c}	4.835	<0.014
Growth rate, %	30.55^{bc}	26.51^{c}	29.61^{bc}	37.53^{a}	34.28^{ab}	1.684	<0.001
Feed efficiency[2,*]	10.25^{ab}	11.29^{a}	11.03^{a}	8.29^{b}	9.13^{b}	0.379	<0.000
Feed intake, DM-kg/130 day							
Concentrate*	668.3^{ab}	611.1^{ab}	682.2^{a}	489.2^{b}	474.7^{b}	3.86	<0.000
Roughage*	372.2^{b}	320.1^{c}	465.2^{a}	272.7^{d}	292.6^{cd}	1.95	<0.000
Total*	1040.6^{ab}	931.2^{b}	1147.5^{a}	762.0^{c}	767.3^{c}	5.35	<0.000

[1]Group 1 (G1, in the individual pens inside) consisted of 2-year-old bulls (n = 5) fed once daily at 07:30 AM. Group 2 (G2, in the individual pens inside) consisted of 2-year-old bulls (n = 5) fed twice daily at 7:30 AM and 3:30 PM. Group 3 (G3, in the paddocks outside) consisted of 2-yearr-old bulls (n = 5) fed once daily at 07:30 AM. Group 4 (G4, in the individual pens inside) consisted of 1-year-old bulls (n = 5) fed once daily at 7:30 AM. Group 5 (G5, in the paddocks outside) consisted of 1-year-old bulls fed once daily at 7:30 AM.
A–C: Different letters on the same line are statistically different.

(P < 0.01); this ratio was the highest for the G1 and lowest for the G5. The weights of noncarcass components were different among groups (P < 0.05; P < 0.01).

3.3. Animal comfort

The relationship between different temperatures and animal comfort were evaluated. Evaluations based on observations about haircoat and general behavior are given in Table 5; groups based on impact factors of the WCI are given in Table 6. The G1, G2, and G4 groups have bright horizontal structure in the study. The G3 showed matt raise structure in January, February, March, and April. When the temperature rose, it became bright horizontal feature. The G5 group had a similar appearance with the G3. The G1 group, from the groups having similar physiological characteristics, consumed the same amount of feed with the G3 group for January, but the G1 made 13.1% more weight gain. In the same period, the consumed feed ratio and the weight gain of the G4 and the G5 groups were detected to be close to each other. The WCI values were 17.84–5.03 in May. In this period, the G3 and G5's variation in feed consumption and in live weight were 17.7% and 23.3%, and 9.4% and 42.8%, respectively. These values were higher than those of the G1 and the G4 groups.

4. Discussion

The results of this study are important in terms of the preservation of domestic animal breeds, their earnings in the meat production sector, and literature knowledge. The outcome of this study may benefit breeders and producers, since this breed is contented and highly adaptable, and suitable material for breeding studies. The G1 bulls were

Table 4. The carcass characteristics of bulls of different ages and subjected to different housing conditions and feeding programs.

	Groups[1]						
Dependent variable	G1	G2	G3	G4	G5	SEM	P-value
Initial weight, kg	232.20^{a}	231.00^{a}	233.16^{a}	153.40^{b}	154.20^{b}	10.31	<0.000
Final weight, kg	334.60^{a}	314.40^{a}	330.66^{a}	245.40^{b}	233.40^{b}	11.44	<0.000
Hot carcass weight, kg	190.00^{a}	179.16^{a}	187.50^{a}	130.08^{b}	125.88^{b}	7.37	<0.000
Dressing, %	56.81^{a}	56.89^{a}	56.66^{a}	52.90^{b}	53.92^{b}	0.69	<0.001
Pelvic fat, kg	6.63^{a}	5.69^{ab}	4.93^{b}	2.72^{c}	1.98^{c}	0.54	<0.000
(PF/HC) ratio, %	3.5^{a}	3.2^{ab}	2.6^{b}	2.0^{bc}	1.5^{c}	0.022	<0.000
	Noncarcass components weights						
Head, kg	12.20^{a}	12.00^{a}	12.66^{a}	11.00^{ab}	9.90^{b}	0.55	<0.013
Hind, kg	23.50^{a}	19.80^{b}	20.83^{ab}	17.90^{b}	19.20^{b}	0.98	<0.008
Front + hind feet, kg	5.51^{a}	5.42^{a}	5.27^{ab}	4.66^{b}	4.60^{b}	0.23	<0.031
Kidney, g	680^{a}	620^{ab}	690^{a}	530^{c}	560^{bc}	0.03	<0.001

[1]Group 1 (G1, in the individual pens inside) consisted of 2-year-old bulls (n = 5) fed once daily at 07:30 am. Group 2 (G2, in the individual pens inside) consisted of 2-year-old bulls (n = 5) fed twice daily at 07:30 AM and 3:30 PM. Group 3 (G3, in the paddocks outside) consisted of 2-year-old bulls (n = 5) fed once daily at 07:30 AM. Group 4 (G4, in the individual pens inside) consisted of 1-year-old bulls (n = 5) fed once daily at 7:30 AM. Group 5 (G5, in the paddocks outside) consisted of 1-year-old bulls fed once daily at 7:30 AM.
A–C: different letters on the same line are statistically different. PF/HC: pelvic fat/hot carcass

Table 5. Haircoat and general behavior of animals in the research.

		Groups[1]				
Observed factors	Months	G1	G2	G3	G4	G5
Haircoat structure	January	Bh	Bh	Mv	Bh	Mv
	February	Bh	Bh	Mr	Bh	Mr
	March	Bh	Bh	Mr	Bh	Mr
	April	Bh	Bh	Mr	Bh	Mr
	May	Bh	Bh	Bh	Bh	Bh
General behavior	January	Sc	Msc	Sc	Sc	Sm
	February	Sc	Msc	Sc	Sc	Sc
	March	Sc	Msc	Sc	Sc	Sc
	April	Msm	Msm	Sm	Sc	Sm
	May	Sc	Sc	Sm	Sc	Sm

[1]Group 1 (G1, in the individual pens inside) consisted of 2-year-old bulls (n = 5) fed once daily at 07:30 am. Group 2 (G2, in the individual pens inside) consisted of 2-year-old bulls (n = 5) fed twice daily at 07:30 am and 3:30 pm. Group 3 (G3, in the paddocks outside) consisted of 2-year-old bulls (n = 5) fed once daily at 07:30 am. Group 4 (G4, in the individual pens inside) consisted of 1-year-old bulls (n = 5) fed once daily at 7:30 am. Group 5 (G5, in the paddocks outside) consisted of 1-year-old bulls fed once daily at 7:30 am.
Bh: bright horizontally; Mr: matt raised; Mv: matt vertical; Sc: stomach and calm, Msc: mediocre stomach and calm; Sm: stomach and moving; Msm: mediocre stomach and moving

Table 6. Impacts on treatments groups and the Wind Chill Index values in the research.

Months	Groups	Impacts		Wind chill index (WCI) °C
		Variation in feed consumption	Variation in live weight	
January	G3 versus G1	in dry feed, as increase as 0%	13.9% decrease in weight gain	−0.45 to −15.49
	G5 versus G4	3.1% increase in dry feed	3.6% decrease in weight gain	
February	G3 versus G1	14.7% increase in dry feed	19.3% decrease in weight gain	5.74 to −13.27
	G5 versus G4	2.1% increase in dry feed	6.3% decrease in weight gain	
March	G3 versus G1	12.4% increase in dry feed	16.1% increase in weight gain	11.03 to −5.34
	G5 versus G4	14.0% increase in dry feed	7.3% decrease in weight gain	
April	G3 versus G1	16.2% increase in dry feed	4.2% increase in weight gain	16.01 to −1.37
	G5 versus G4	14.5% increase in dry feed	4.1% increase in weight gain	
May	G3 versus G1	17.7% increase in dry feed	23.3% increase in weight gain	17.84 to 5.03
	G5 versus G4	9.4% increase in dry feed	42.8% decrease in weight gain	

[1]Group 1 (G1, in the individual pens inside) consisted of 2-year-old bulls (n = 5) fed once daily at 07:30 AM. Group 2 (G2, in the individual pens inside) consisted of 2-year-old bulls (n = 5) fed twice daily at 07:30 AM and 3:30 PM. Group 3 (G3, in the paddocks outside) consisted of 2-year-old bulls (n = 5) fed once daily at 07:30 AM. Group 4 (G4, in the individual pens inside) consisted of 1-year-old bulls (n = 5) fed once daily at 7:30 AM. Group 5 (G5, in the paddocks outside) consisted of 1-year-old bulls fed once daily at 7:30 AM.

placed in pens inside the barn that provided comfort and welfare. The comfort of the fattening environment, fattening model, and the animal welfare are among the factors that have a positive effect on the yield [6]. Although the G2 was fed twice daily in barn, their performance was poorer than that of the other groups. The G3 was in paddocks outside and consumed more feed than the other groups, perhaps due to the cold environment (from −2.2 to −17 °C). In general, voluntary intakes tended to decrease as ambient temperature increased, and to increase when ambient temperatures decreased. The rate of growth and development of local animal breeds was reported to be slow [7]. However, when the environmental factors such as rearing, feeding, and housing conditions are improved, their young can achieve a better fattening performance. The bulls in the G4 group had the highest growth rate (37%), followed by the G5. Similar findings were reported by Ozluturk et al. [8], who observed significant differences in feed efficiency between age groups. Yüksel et al. [9] and Pazdiora et al. [10] reported similar results in hot carcass dressing of old bulls, and Yüksel et al. [11] and Catrileo et al. [12] reported similar results in hot carcass dressing of young bulls, but different from the values determined for Hungarian Grey by Hollo et al. [7] and Lopez-Campos [13]. Pelvis fat is a factor that affects the quality grade of the carcass, yield grade score, and fattening cost. Carcasses with 3.5% kidney, pelvic, and heart fat (KPH) have zero adjustment for yield grade [14]. The G1 produced a higher amount of pelvic fat (3.5% of the warm carcass) than the other groups, and the G5 had the lowest amount of pelvic fat. This suggests that freely moving environment in paddocks outside the barn is superior to pens inside the barn. Other than environment, age is also important for pelvic fat, as reflected by differences between the G2 and the G4. As the bulls got older, they accumulated more pelvic fat than the younger bulls. The finding differs from the results reported by Barham et al. [15]. They are lower than values reported by Hollao et al. [7], and are higher than those reported by Yüksel et al. [9] and Yüksel et al. [11]. Hot carcass, edible meat, and pelvic fat are interrelated. In this study, it was determined that the direction of the ratio between pelvic fat and hot carcass changes according to the age of the bulls. On the other hand, this rate also changed according to the housing conditions and the feeding style. In the bulls fed in individual compartments, this rate increased, depending on the movement constraint. Finally, the ratio of noncarcass components measured in this study was lower than the results reported by Yüksel et al. [9] and Ozluturk et al. [16]. Since the EAR bull is adaptable to cold climatic conditions and uneven terrain conditions, the skin structure is thicker and the feet and head are sturdy.

Comfort in fattening cattle relates to many environmental factors, such as climatic condition, rearing, feeding, and housing conditions. Cold stress varies by type, size of animal, and how they interact with the environment [17]. The EAR breed is a medium-sized animal of heavy climatic conditions. Due to its features, it has high tolerance of environmental factors. The body mechanism of this breed does not have a characteristic that requires a high feed consumption as expected in temperatures below −10 °C. Tolerance capabilities of the younger animals are higher than those of the animals that have the same physiological characteristics but are housed in a different environment. As a matter of fact, when the G4 and the G5 groups were compared according to the WCI values in January, the decrease in weight gain and the increase in feed consumption (3.6% and 3.1%, respectively) were close to each other. It was reported by researchers [17] that cold stress might occur at temperatures of approximately −6.6 °C or below. In the present study, unlike literature reports, the animals were found to be tolerant to lower temperatures. The impact of low air temperature did not continue for a long time. In March and later periods, the negative situation disappeared and weight gain increased rapidly. It was determined that the haircoat structure of the animals was different in January and February. A matt appearance formed in the color of the haircoat. However, any abnormality was not observed in animals housed inside the barn.

In conclusion, when these animals experienced continuous feeding and fattened in a calm environment, their feed efficiency characteristic was activated and growth rates were around 30%. The growth rates of the younger animals were higher, and the ratio of inside fat, such as the pelvic region to hot carcass, was especially close to the standards. Their tolerance to cold conditions was high, and feed consumption did not increase much in these conditions. There was no sudden change in temperament due to decreasing environmental temperatures.

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