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Research Article

The Effect of Duration of Finishing Period on the Performance, Slaughter, Carcass, and Beef Quality Characteristics of Eastern Anatolian Red Bulls

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Abstract: Seventeen Eastern Anatolian Red (EAR) bulls at 20 months of age were divided into 2 treatment groups and fed for either 168 days (S) or 210 days (L). Initial and final weights were not significantly different. While bulls in the L group had the highest total weight gain (149.0 vs. 177.2 kg), feed efficiency ratio was superior for the cattle fed for 168 days. Carcass weight, spleen and front + hind feet weights as a percentage of slaughter weight, weight of kidney fat, percentage of kidney, pelvic, and heart fat, and yield grade all increased ($P < 0.05$) with feeding time. Bulls in the L group received a higher ($P < 0.05$) panel rating for juiciness, and the panel juiciness score was closely associated with tenderness measurements such as panel tenderness score, Warner Bratzler shear force value, and number of chews before swallowing. It is concluded that duration of finishing significantly influenced carcass, slaughter, and organoleptic beef quality traits of young EAR bulls.

Key Words: Beef, carcass composition, Eastern Anatolian Red cattle, duration of finishing, meat quality

Doğu Anadolu Kırmızısı Tosunlarında Besi Süresinin Performans, Kesim, Karkas ve Et Kalite Özellikleri Üzerine Etkisi

Özet: Bu çalışmada, yirmi aylık yaşta 17 adet Doğu Anadolu Kırmızısı (DAK) tosun iki muamele grubuna ayrılarak 168 gün (K) ve 210 gün (U) süreyle beslenmişlerdir. DAK tosunlarının besi başı ve besi sonu ağırlıkları arasındaki fark istatistiksel olarak önemli bulunmamıştır. U grubundaki tosunlar en yüksek toplam canlı ağırlık artışına (149,0 kg karşılık 177,2 kg) sahip olurken, 168 gün süre ile beslenen sığırların yemden yararlanma dereceleri daha üstün bulunmuştur. Besi süresinin artışıyla birlikte karkas ağırlığı, dalak ve ön + arka ayakların kesim ağırlığına oranları, böbrek yağı miktarı, toplam kalp, pelvis ve böbrek yağı oranı ve verim düzeyi önemli derecede ($P < 0,05$) yükselmiştir. K grubundaki tosunların S grubundakilerden daha yüksek ($P < 0,05$) panel sululuk değeri aldığı ve bu skorun panel gevreklik skoru, Warner Bratzler Shear değeri ve yutmadan önceki çiğneme sayısı gibi gevreklik ölçütleri ile yakın ilişkili olduğu da saptanmıştır. Besi süresinin, DAK tosunlarının karkas, kesim ve duyusal et kalite özelliklerini de önemli derecede etkilediği sonucuna varılmıştır.

Anahtar Sözcükler: Sığır eti, karkas kompozisyonu, Doğu Anadolu Kırmızısı, besi süresi, et kalitesi

Introduction

Turkey has several distinctive geographical regions differing in environmental conditions, which affect livestock production. In recent years, the percentage of native cattle breeds reared in all regions of the country except for Eastern and South-Eastern Turkey has fallen 50.0% (1). The percentage of indigenous cattle breeds in Eastern Turkey is still about 60.9%. Eastern Anatolian Red (EAR) cattle are the most populous and dominant cattle breed of this area (2), and are predominantly used for fattening.

Duration of the finishing period can influence fattening performance, carcass, slaughter, and beef quality traits. In the past, a number of studies were carried out to investigate the influence of different durations of finishing on the fattening performance,

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carcass, and slaughter characteristics of native EAR as well as European cattle breeds (3-7). However, organoleptic, textural, and chemical properties of the beef from EAR bulls were not investigated in these studies. Therefore, a research project was undertaken to determine the effects of 2 finishing periods (168 and 210 days) on the fattening performance, slaughter, and carcass traits as well as sensory attributes and chemical compositions of beef obtained from the longissimus dorsi (LD), gluteus medius (GM), and quadriceps (Q) muscles of EAR bulls.

Materials and Methods

Seventeen male EAR bulls 20-months old were used in this study. The finishing bulls were fattened in a tethered barn and fed individually. The animals were adapted to the finishing diet over 2 weeks. Cattle were fed a ration consisting of concentrate and dry alfalfa. Amounts of feed offered to the bulls were determined according to live weights obtained at 14-day intervals throughout the trial (8). The chemical composition of the concentrate was 88.7% dry matter, 12.2% crude protein, 12.0% crude cellulose, 8.0% crude ash, 3.1% ether extract, and 53.4% nitrogen free extract. Dry alfalfa had 92.9% dry matter, 19.0% crude protein, 26.5% crude cellulose, 9.5% crude ash, 1.9% crude ether extract, and 35.9% nitrogen free extract. Amounts of feed offered and refused were recorded daily. The 2 finishing periods were 168 days (short: S) and 210 days (long: L).

On each of 2 days at the beginning and end of the finishing period, the bulls were weighed after 12 h starvation. The averages of these weights were recorded as the initial and final weights. Data concerning average daily weight gain and feed efficiency ratio were also obtained during the fattening.

All bulls were conventionally slaughtered in a state-owned abattoir. The head, hide, feet, liver, lungs, and heart were removed and weighed immediately after slaughter. Some carcass measurements, e.g., carcass length, length of round, width of round, thoracic depth, and width of round from the medial side were also recorded (9,10). Hot and cold carcass weights were also determined. After the carcasses were chilled at 4 °C for 24 h, they were ribbed, scored, and graded by 2 trained carcass evaluators (11). The ribbing site was at the 12^{th} and 13^{th} rib interface. The area of LD, the subcutaneous fat depth, and marbling and colour scores were determined at the ribbing site. The scale used for marbling ranged from 1 to 18 (1 = slight^{-}, 2 = slight^{0}, 3 = slight^{+}, 4 = small^{-}, 5 = small^{0}, 6 = small^{+},……., 17 = Abundant^{0}, 18 = Abundant^{+}). Colour scores were determined using Standards for Beef Colour, developed by New Mexico State University, Agricultural Experiment Station, USA (12). The scale used for colour assessment ranged from 1 to 8 (1 = bleached red, 2 = very light cherry red, 3 = moderately light cherry red, 4 = cherry red, 5 = slightly dark red, 6 = moderately dark red, 7 = dark red, 8 = very dark red). The quantities of kidney, pelvic, and heart (KPH) fat were also recorded. The percentage of boneless, closely trimmed retail cuts from the round, loin, rib and chuck (cutability) and yield grade of all carcasses were predicted using the equation reported by Boggs and Merkel (13).

Beef samples were taken from LD, GM, and Q muscles excised from the 10 carcasses 24 h post-mortem. The muscle portions were cut perpendicular to the muscle fibre into 2 pieces and allocated for chemical and organoleptic analysis. The meat samples for sensory evaluation were cooked in a plastic bag, in a water bath at 90 °C until they reached an internal temperature of 70 °C as reported by Yanar (14). Cooking yield was determined by recording uncooked and cooked weights of the samples used for sensory evaluation. Cooked samples were placed on a paper towel for 5 min to remove cooking drip. Cooking yield was calculated by dividing cooked weight by uncooked weight. A panel evaluated the cooked beef samples for tenderness, juiciness, flavour intensity, and acceptability using a 9-point hedonic scale (9 = extremely tender, 1 = extremely tough; 9 = extremely juicy, 1 = extremely dry; 9 = extremely strong beef flavour, 1 = extremely weak beef flavour; 9 = extremely high acceptability, 1 = extremely low acceptability). Number of chews before swallowing was also recorded by the panel members. Mechanical assessment of tenderness of beef samples cooled to 20 °C was also performed using the Warner Bratzler Shear (WBS) device (15).

Raw beef muscle samples were analysed according to the procedure outlined by Gökalp et al. (16) for crude protein, moisture, ether extractable lipid, and ash. Crude protein was determined as N × 6.25 (Kjeldahl method).

The statistical analysis was conducted using the independent-samples t test procedure in SPSS (version 11.5) for data on finishing performance, and slaughter and carcass traits. The remaining data were statistically analysed using the GLM procedure in SPSS. The statistical model used for analysis of variance was as follows:

$$Y_{ijk} = \mu + a_i + b_j + (ab)_{ij} + e_{ijk}$$

where

Y_{ijk}: Proximate analysis, sensory panel scores, cooking yield, WBS value, and number of chews before swallowing,

μ: Overall mean

a_i: Effect of duration of finishing

b_j: Effect of muscles

$(ab)_{ij}$: Effect of interaction between duration of finishing and muscles

e_{ijk}: Random error.

The Duncan method was applied for comparison of subclass means when F-tests for main effects were significant (17). Correlations among organoleptic and chemical test parameters as well as cooking yield, WBS measurements, and number of chews before swallowing were also determined.

Results

Least squares means for the finishing performance traits are presented in Table 1. Initial and final weights, and average daily weight gains were not significantly different, but total weight gain was significantly ($P < 0.01$) higher for the L group. Feed efficiency ratio (kg feed per kg gain) was significantly ($P < 0.01$) greater for the L finishing period.

Neither slaughter weight nor dressing percentage was significantly affected by the duration of the finishing periods. Both were numerically greater for L, and, as a result, hot carcass weight was also significantly greater (Table 2). Head, hide, heart+lung, liver, and kidney weights as a percentage of slaughter weight were not significantly influenced by finishing period. However, bulls in the S group had significantly higher ($P < 0.05$) proportions of spleen and fore+hind feet than those in the L group.

Measurements of carcass fatness, such as average fat thickness over LD muscle, amount of pelvic fat, and marbling scores, indicated no significant differences between the S and L treatments (Table 3). However, weight of kidney fat and percent of KPH fat were greater ($P < 0.05$) in the L group. Yield grade was higher ($P < 0.05$) and cutability value was lower ($P < 0.05$) for L bulls.

Least squares means for carcass measurements (carcass length, length of the round, thoracic depth, width of the round, and width of the round from the medial side) are presented in Table 4. Generally, all carcass measurements except for width of the round from the medial side, which was higher ($P < 0.01$) for L, were not

Table 1. Least squares means with standard errors for finishing performance traits.

Duration of finishing (days)	168 days (N = 11)	210 days (N = 6)	S
Initial weight (kg)	199.2 ± 8.3	195.3 ± 11.7	NS
Final weight (kg)	348.2 ± 11.2	372.5 ± 15.9	NS
Average daily weight gain (kg)	0.887 ± 0.031	0.844 ± 0.042	NS
Total weight gain (kg)	149.0 ± 4.2	177.2 ± 7.1	**
Feed efficiency ratio[1]	7.7 ± 0.2	8.9 ± 0.3	**

**: $P < 0.01$, S: Significance, NS: Nonsignificant,
[1]Feed efficiency ratio: Consumed dry matter of feed (kg)/weight gain (kg)

Table 2. Least squares means with standard errors for slaughter and non-carcass components.

Duration of finishing (days)	168 days (N = 11)	210 days (N = 6)	S
Slaughter weight (kg)	346.8 ± 17.8	371.4 ± 16.04	NS
Hot carcass weight (kg)	207.0 ± 13.8	234.2 ± 10.9	*
Hot carcass dressing (%)	59.6 ± 1.43	62.9 ± 0.72	NS
Proportions of non-carcass components (%)			
Head	3.73 ± 0.13	3.40 ± 0.09	NS
Hide	6.93 ± 0.47	6.82 ± 0.33	NS
Heart + Lung	1.61 ± 0.07	1.50 ± 0.08	NS
Liver	1.74 ± 0.09	1.49 ± 0.09	NS
Fore + hind feet	1.58 ± 0.06	1.36 ± 0.05	*
Kidney	0.28 ± 0.02	0.24 ± 0.01	NS
Spleen	0.22 ± 0.01	0.17 ± 0.01	*

*: P < 0.05, S: Significance, NS: Nonsignificant,

Table 3. Least squares means with standard errors for carcass characteristics.

Duration of finishing (days)	168 days (N = 11)	210 days (N = 6)	S
Fat thickness over LD[1] (mm)	8.4 ± 1.2	9.3 ± 1.1	NS
LD area (cm^2)	76.0 ± 3.4	71.5 ± 5.1	NS
LD area for 100 kg carcass weight (cm^2)	37.3 ± 2.8	30.6 ± 1.8	*
Marbling score	3.4 ± 0.6	3.8 ± 0.6	NS
Pelvic fat (g)	675 ± 162.8	750 ± 76.4	NS
Kidney fat (kg)	5.19 ± 0.35	7.38 ± 0.72	*
KPH fat (%)	2.95 ± 0.16	3.69 ± 0.26	*
Colour score	6.7 ± 0.3	6.3 ± 0.4	NS
Yield grade	1.14 ± 0.20	1.74 ± 0.19	*
Cutability (%) [2]	54.1 ± 0.29	52.9 ± 0.42	*

*: P < 0.05, S: Significance, NS: Nonsignificant, [1] LD: *Longissimus dorsi* muscle,
[2] The percentage of boneless, closely trimmed retail cuts from the round, loin, rib, and chuck.

Table 4. Least squares means with standard errors for carcass measurements (cm).

Duration of finishing (days)	168 days (N = 11)	210 days (N = 6)	S
Carcass length	123.70 ± 2.96	126.33 ± 1.47	NS
Length of round	64.00 ± 2.86	69.33 ± 1.41	NS
Thoracic depth	39.80 ± 3.74	42.08 ± 1.21	NS
Width of the round	36.60 ± 1.29	36.83 ± 0.87	NS
Width of the round from medial side	19.80 ± 0.58	23.50 ± 0.67	**

**: P < 0.01, S: Significance, NS: Nonsignificant significantly affected by the duration of the finishing period.

Duration of the finishing did not significantly affect muscle chemical composition (Table 5). However, type of muscle had a significant ($P < 0.01$) effect on the percentages of moisture and protein. Moisture percentage was higher ($P < 0.01$) and protein percentage was lower ($P < 0.01$) for LD than for the other 2 muscles. There was no significant interaction between duration of finishing and muscle except for in percentage of ash.

Duration of finishing only had a significant influence on the juiciness scores (Table 6). Type of muscle affected both panel acceptability score and WBS force. Acceptability score was significantly greater ($P < 0.05$) for LD than for GM while WBS value was lower ($P < 0.05$) for LD than for Q.

Correlation coefficients between chemical and organoleptic properties of beef from young EAR bulls are tabulated in Table 7. Correlations among panel tenderness, juiciness, acceptability, WBS, and number of chews before swallowing were statistically significant ($P < 0.01$). Percentage of water was negatively correlated with WBS, and percentages of protein and ash.

Discussion

Final weight increased with increasing duration of the fattening period as expected. Although the final weight difference between S and L was 24.3 kg, it was not statistically significant (Table 1). The result could be attributed to the high variation in final weight data. The result is in accordance with the findings reported by Yanar et al. (6) and Şeker et al. (7). The average daily weight gain of the finishing bulls decreased from 0.887 to 0.844 kg with increasing length of finishing period, but total weight gain significantly ($P < 0.01$) increased. Feed efficiency ratio of the L group increased considerably ($P < 0.01$) compared to that of the S group. These data agree with previous research evaluating changes in live weight gains and feed efficiency ratio (18,19).

As intended, there was a significant increase in carcass weight ($P < 0.05$) with increasing length of finishing period. Results reported by Pyatt et al. (18), Keane et al. (19), Camfield et al. (20), and Rule et al. (21) are consistent with the findings of the present study. Dressing percentage was not significantly altered by the duration of the finishing. This is in agreement with the results published by Şeker et al. (7) and Van Koevering et al. (22).

Table 5. Least squares means with standard errors for proximate analysis and cooking yield.

	N	Moisture (%)	Fat (%)	Ash (%)	Protein (%)	Cooking yield (%)
Duration of finishing (D)		NS	NS	NS	NS	NS
168 days	15	75.2 8 ± 0.27	1.53 ± 0.17	1.01 ± 0.03	20.99 ± 0.17	65.91 ± 1.38
210 days	14	75.79 ± 0.28	1.47 ± 0.18	0.99 ± 0.03	21.36 ± 0.18	65.86 ± 1.44
Muscles (M)		**	NS	NS	**	NS
LD[1]	10	76.69 ± 0.33[a]	1.13 ± 0.21	0.95 ± 0.03	20.48 ± 0.21[b]	66.59 ± 1.70
GM[2]	9	74.90 ± 0.35[b]	1.52 ± 0.23	1.02 ± 0.04	21.74 ± 0.21[a]	63.37 ± 1.80
Q[3]	10	75.03 ± 0.33[b]	1.84 ± 0.21	1.02 ± 0.03	21.30 ± 0.21[a]	67.70 ± 1.70
D M interactions		NS	NS	*	NS	NS
168 × LD	5	74.30 ± 0.46	1.92 ± 0.30	1.04 ± 0.05[ab]	21.45 ± 0.29	66.58 ± 2.40
168 × GM	5	74.52 ± 0.46	1.49 ± 0.30	1.11 ± 0.05[a]	21.55 ± 0.29	62.89 ± 2.40
168 × Q	5	77.02 ± 0.46	1.17 ± 0.30	0.88 ± . 005[c]	19.98 ± 0.29	68.27 ± 2.40
210 × LD	5	75.75 ± 0.46	1.77 ± 0.30	1.01 ± 0.05[abc]	21.15 ± 0.29	68.83 ± 2.40
210 × GM	4	75.27 ± 0.52	1.56 ± 0.34	0.93 ± 0.05[bc]	21.94 ± 0.29	63.86 ± 2.68
210 × Q	5	76.36 ± 0.46	1.09 ± 0.30	1.01 ± 0.05[abc]	20.98 ± 0.29	64.91 ± 2.40

*: $P < 0.05$, **: $P < 0.01$, S: Significance, NS: Nonsignificant

[1]LD: *Longissimus dorsi* muscle, [2]GM: *Gluteus medius* muscle, [3]Q: *Quadriceps* muscle

Table 6. Least squares means with standard errors for sensory panel scores, number of chews before swallowing and WBS.[1]

	N	Tenderness	Juiciness	Flavour intensity	Acceptability	NCBS [2]	WBS
Duration of finishing (D)		NS	*	NS	NS	NS	NS
168 days	15	5.14 ± 0.28	5.39 ± 0.21	6.00 ± 0.18	5.97 ± 0.17	41.02 ± 1.51	7.34 ± 0.47
210 days	14	5.60 ± 0.30	6.10 ± 0.23	6.23 ± 0.19	5.85 ± 0.18	39.60 ± 1.57	6.10 ± 0.49
Muscles (M)		NS	NS	NS	*	NS	*
LD [3]	10	6.00 ± 0.35	6.13 ± 0.27	6.28 ± 0.22	6.32 ± 0.21^{a}	40.16 ± 1.85	5.76 ± 0.58^{b}
GM [4]	9	4.79 ± 0.37	5.21 ± 0.28	5.62 ± 0.24	5.44 ± 0.21^{b}	40.00 ± 1.96	6.60 ± 0.61^{ab}
Q [5]	10	5.31 ± 0.35	5.90 ± 0.27	6.38 ± 0.22	5.97 ± 0.22^{ab}	40.75 ± 1.85	7.85 ± 0.58^{a}
D M interactions		NS	NS	NS	NS	NS	NS
168 × LD	5	4.70 ± 0.49	5.66 ± 0.38	6.25 ± 0.32	5.87 ± 0.29	42.81 ± 2.61	9.44 ± 0.82
168 × GM	5	4.69 ± 0.49	4.59 ± 0.38	5.70 ± 0.32	5.68 ± 0.29	41.41±2.61	7.19 ± 0.82
168 × Q	5	6.03 ± 0.49	5.93 ± 0.38	6.19 ± 0.32	6.38 ± 0.29	38.84 ± 2.61	5.40 ± 0.82
210 × LD	5	5.92 ± 0.55	6.16 ± 0.38	6.50 ± 0.32	6.07 ± 0.29	38.70 ± 2.61	6.27 ± 0.82
210 × GM	4	4.89 ± 0.49	5.83 ± 0.42	5.53 ± 0.35	5.20 ±. 033	38.59 ± 2.91	5.92 ± 0.91
210 × Q	5	5.98 ± 0.49	6.33 ± 0.38	6.37 ±. 032	6.27 ± 0.29	41.47 ± 2.61	6.12 ± 0.82

*: P < 0.05, S: Significance, NS: Nonsignificant, [1] WBS: Warner Bratzler Shear force, [2] NCBS: Number of chews before swallowing, [3] LD: *Longissimus dorsi* muscle, [4] GM: *Gluteus medius* muscle, [5] Q: *Quadriceps* muscle

Table 7. Correlations among sensory panel scores, proximate analysis, number of chews before swallowing, and WBS.[1]

	WBS	Tenderness	Juiciness	Flavour intensity	Acceptability	NCBS [2]	Fat (%)	Ash (%)	Protein (%)
WBS [1]									
Tenderness	–0.530**								
Juiciness	–0.531**	0.589**							
Flavour intensity	–0.134	0.710**	0.457*						
Acceptability	–0.285	0.831**	0.481**	0.870**					
NCBS [2]	0.480**	–0.722**	–0.457*	–0.605**	–0.675**				
Fat (%)	0.172	0.290	–0.141	0.225	0.185	–0.239			
Ash (%)	0.295	–0.050	–0.351	–0.078	–0.146	0.121	0.320		
Protein (%)	0.208	–0.251	–0.219	–0.186	–0.277	–0.091	0.326	0.427*	
Moisture (%)	–0.459*	0.246	0.163	0.009	0.152	0.084	–0.235	–0.428*	–0.529**

[1] WBS: Warner Bratzler Shear force, [2] NCBS: Number of chews before swallowing, *: P < 0.05, **: P < 0.01

Although carcass weights increased, LD muscle area was not significantly altered by feeding time. This response is similar to the results reported by Van Koevering et al. (22). Comparing measurements of fatness, such as amount of kidney fat and percentages of kidney, heart, and pelvic fat (KPH) indicated significant ($P < 0.05$) difference between the S and L groups. Additionally, yield grade and cutability values were significantly ($P < 0.05$) influenced by the duration of the fattening period (Table 3). The results agree with those of Camfield et al. (20) and May et al. (23), who reported that yield grade and percentage of KPH together with weights of kidney fat increased with extending the feeding period. Tatum et al. (24) also stated that cattle fed longer (160 days) had higher percentage of KPH and less desirable yield grades than carcasses from cattle fed for a shorter period (100 days).

Most carcass measurements were not significantly influenced by the duration of finishing. The results are in agreement with the findings reported by Keane et al. (19), who found that carcass length, carcass depth, and leg width of finishing steers fed for 105 and 175 days were not significantly different.

The absence of a significant effect of finishing period on muscle chemical composition contrasts with the findings of Van Koevering et al. (22), who reported significant differences among durations of finishing period for proximate analysis in crossbred steers. On the other hand, type of muscle did not significantly affect cooking yield, as already noted by Özlütürk et al. (25).

Beef from the young bulls in the L group was rated higher ($P < 0.05$) for juiciness than meat from bulls in the S group. Other than juiciness, which was higher for L, organoleptic attributes and WBS force value were not influenced by the duration of the fattening. Camfield et al. (20), Tatum et al. (24), and Dinius and Cross (26) also reported that tenderness, as measured by a taste panel or WBS force, did not change significantly as time on feed increased. The type of muscle was a significant source of variation in sensory panel ratings for acceptability score and WBS force value. The absence of a muscle type effect on the sensory panel attributes is in accordance with findings of Özlütürk et al. (25).

Significant correlations ($P < 0.01$) for panel tenderness score ($r = -0.530$) and number of chews before swallowing ($r = 0.480$) with WBS force indicated that data from mechanical (objective) and organoleptic assessments of tenderness were in agreement. This result could be due to the trained panel members employed in this study. Panel juiciness score was closely associated with WBS force value ($r = -0.531$), tenderness score ($r = 0.589$), number of chews before swallowing ($r = -0.457$), and acceptability score ($r = 0.481$). Percentage of moisture in EAR beef samples was also significantly ($P < 0.05$) related to WBS value ($r = -0.459$). Panel juiciness score had a significant correlation with flavour intensity ($r = 0.457$). Overall associations revealed that panel tenderness, general acceptance, and flavour intensity scores were mostly related to the moisture content of the meat. A similar finding was reported by May et al. (23), who found a significant association between panel juiciness score and flavour intensity.

Overall, the results of this study suggest that duration of finishing significantly influenced some carcass, slaughter, and organoleptic beef quality traits in young EAR bulls.

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