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RESEARCH NOTE

Production and meat fatty acids profile of Hereford steers fed on pasture with and without oat grain supplement. Chile, VIII Region

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Abstract

G. Klee, N. Mendoza, and J. Chavarría. 2011. Production and meat fatty acids profile of Hereford steers fed on pasture with and without oat grain supplement. Cien. Inv. Agr. 38(3): 331- 338. Live weight gain (LWG) and meat fatty acid composition (FA) were evaluated in Hereford steers fed on pasture with or without oat grain. The study site was non-traditional pastures were used in the dryland Andes foothills, VIII Region, Chile (36˚ 49’ S, 71˚ 55’ W), including forages such as alfalfa (*Medicago sativa)*, orchard grass (*Dactylis glomerata)* and roadside brome (*Bromus stamineus)*. Ten calves with an average LW of 173 kg were fed with red clover (*Trifolium pretense* L. var. Quiñequeli) during winter. In spring, 50% of steers were fed only pasture (P), and the other half were fed the same pasture in rotational grazing supplemented with oat grain (PO), 2.5 kg steer^{-1} day^{-1}. The LWG was 0.78 and 0.91 kg day-^{1} for the P and PO treatments, respectively. The animals of both treatments reached an average of 380 kg LW at 16.5 months of age. FA composition of beef was different in tenderloin and round, with and without oat grain supplement and in roasted and raw meat. The cholesterol content did not present differences. The linoleic AG (C18:2 n-6) / linolenic AG (C18:3 n-3) ratio in meat was 2.0:1 and 2.45:1 for P and PO, respectively.

Key words: Fatty acid, finishing cattle, pasture, steers.

Introduction

The Andean foothills of the Bío-Bío Region, Chile, have an average temperature of 14 °C, a frost period of five months, an annual precipitation of 1,200 mm (which occurs primarily during the winter months, May to July), and a drought period of 4 to 5 months (November to March). These are very limiting weather conditions for some crops (Klee and Chavarría, 2000; Klee *et al*., 2001). Unmanaged drylands produce low quantities of forage (2.5 ton ms ha^{-1}·year^{-1}) of low quality (Gutierrez *et al*., 1983). To increase livestock production in this area, non-traditional species of forage plants, such as alfalfa (*Medicago sativa*) and red clover (*Trifolium pratense*), have been introduced into these grazing systems. The effectiveness of these plants is well known in irrigated regions, but only recently have they been adopted and evaluated in the dryland soils of the Andean foothills. New methods of pasture

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management, including the aforementioned forage plants, have made it possible to significantly increase forage supply in both quantity and quality. This method, combined with the use of better cattle genetics, has helped to develop new beef production strategies focusing on grasslands as the primary food resource (Klee, 2002). This has contributed to increased weaning weights (up to 220 kg at 6 months of age) and increased live weights (LW) in the fattening stage, resulting in Hereford cattle for slaughter of 380 kg LW, or more than 430 kg between 14 and 20 months of age, depending on the food alternative management used, solely pasture fed or pasture and grains fed (Klee, 2002). This has been accomplished in an area where it is not possible to produce finished animals ready for slaughter using only natural pasture as a food resource.

Numerous studies (Rearte, 2001; Rearte, 2002; INTI, 2005) have shown that beef obtained from solely pasture-fed animals has more health benefits than beef from animals fed with grains. These benefits include less total fat and cholesterol, a greater quantity and more optimal ratio of fatty acids (FA) n-6 and n-3 as well as higher levels of vitamin E. A major study by Rearte (2001), carried out at several INTA research centers in Argentina, assessed the nutraceutical value of beef, *i.e.*, its additional contributions to human health beyond its nutritional value. Rearte concluded that the composition of beef FA is clearly affected by the feeding system of animals and that beef produced in pasture systems or with low concentrate supplementation presents better nutritional characteristics than animals fed on grains and corn silage (INTA, 2003). Other authors (Schindler *et al.*, 2004) have concluded that beef from animals raised in confinement-based production systems is of lower nutritional quality than beef obtained from grazing animals. Although higher daily LW gains are achieved, *i.e.*, animal fattening occurs more quickly than in pasture-based systems, confinement feeding has notable disadvantages: it produces beef high in cholesterol and with less favorable n-6/n-3 ratios, high above the required levels to maintain good health in consumers.

Australian studies (French *et al.*, 2000) have obtained good results in the FA n-6/n-3 ratio of beef from animals fed on pasture. The authors described that, with increasing concentrate in the diet of animals, FA n-3 significantly decreased, increasing the n-6/n-3 ratio. This effect was not seen when animals were fed only on grass pasture or were supplemented with low amounts of concentrate (2.5 kg $steer^{-1} \cdot day^{-1}$). Animals fed only on pasture reached values of n-6 = 3.14 and n-3 = 1.36, with an n-6/n-3 ratio of 2.33.

This study aimed to evaluate the FA production and slaughter weights at a young age (14 to 20 months) of cattle raised on non-traditional forage species and mixtures in the Andean dryland foothills, either as the only food source or supplemented with low amounts of oats. In addition, this study aimed to obtain background information on the fatty acid profile of two cuts of beef subjected to the diets already mentioned and the effect on FA when the beef of these cuts is roasted.

Materials and methods

The experiment was conducted on the San Pedro property located in the Andean foothills of Ñuble, Chile, VIII Region, commune of San Ignacio (36º 49› S, 71º 55› W, 500 m above sea level). It took place on trumao soils of the Santa Bárbara association (Ruiz, 1996).

The study used 10 Hereford calves raised on subterranean clover pastures (*Trifolium subterraneum*) and weaned in March at 6.5 months of age at average 173 kg LW. The animals were vaccinated against major diseases in the area: bacterial anthrax, symptomatic anthrax and enterotoxemia. They were also treated for liver fluke and gastrointestinal parasites, in accordance with results from feces analysis.

Calves weaned at 173 kg live weight were rotated between three different pastures: 0.5 ha of alfalfa; 0.6 ha of subterranean clover (*T. subterraneum*) and fescue (*Festuca arundinacea*); and 1.8 ha of alfalfa (*M. sativa*), orchardgrass (*Dactylis glomerata*) and roadside brome (*Bromus stamineus*). From April 7 to June 14, the animals were pasture supplemented with red clover hay (*T. pretense,* var. Quiñequeli), freely available, and mineral salts. When the weather conditions were adverse, between June 15 and September 25, the animals (mean weighing 205 kg) were housed in a roofed barn with freely available feeders and water. Beginning in September, they gradually became accustomed to pasture. The supply of hay was steadily decreased and ended on October 3. At that time, 50% of the animals began receiving a supplement of oat grain (*Avena sativa*), supplied in the morning (9 AM) on moving feeders at a rate of 2.5 kg $calf^{-1} \cdot day^{-1}$ for 111 days, resulting in two treatments: a) pasture as the only food source (P) and b) pasture plus oats (PO).

Electric fences were used to divide the grasslands into strips, and the animals were moved every 3 to 4 days when the residue was approximately 8 to 10 cm tall. The animals used contiguous random strips from the same meadow.

The voluntary intake of hay was measured during winter. Animal LW was recorded every 28 days, with 14-hour tare, and with daily measured supply of oat grain. Two animals from each treatment, with an average weight of 395 kg, were slaughtered at Ñuble Beef Co. This was a 4% higher weight than average of treatments and was higher than the expected final weight for calves with an initial weight of 220 kg. The following aspects of the carcasses were evaluated: loin area, fat cover, marbling and temperature. A grid-type scale for marbling and fat cover was used. To obtain information regarding meat quality from a human health standpoint, an evaluation of the FA profile in tenderloin (*M. psoas*) and round (*M. semimembranosus*) cuts was performed; these cuts are popular with consumers and command high prices. Carcass measurements of P and PO treatments were performed after 24 hours spent in cold storage at -1 °C; this practice was conducted to identify characteristics of the carcass where the cuts were obtained. The samples were analyzed at the Laboratorio de la Facultad de Química y Farmacia at the Universidad of Concepción in accordance with the procedures set by the Instituto de Salud Pública de Chile (1988). For fatty acid analysis, gas chromatography equipped with a capillary column attached to a flame ionization detector (FID) was used. The FAs were converted to their corresponding methyl esters, and their quantification was performed by internal standardization, yielding the relative percentage of each fatty acid in terms of the total fatty acids that were part of the analyzed fat. The method of analysis does not differentiate isomers of linoleic (C18:2 n- 6) and linolenic fatty acids (C18:3 n-3); therefore, the reported percentage of each is the total sum of all isomers of fatty acids, from which the FA linoleic (C18: 2 n-6) / AG linolenic (C18: 3 n-3) ratio was calculated. Cholesterol analysis was performed using chromatography on a thin layer of high efficiency (HPTLC), and the results are expressed in milligrams per 100 grams of fat (Instituto de Salud Pública de Chile, 1988).

For the statistical analysis of FA, SAS software was used to perform an analysis of variance on the main effects and their first-order interactions: oats level (without oats – with oats), status (roasted - raw) and type of cut (tenderloin-round), with two repetitions. The individualized management of samples helped to calculate each main effect with a total of eight data. The daily LW gains of steers, uncorrected and corrected based on days per metabolic weight for steers of 300 kg LW, were analyzed statistically in a randomized block design (Cochran and Cox, 1992).

Results and discussion

Daily live weight gain and carcass yield

The daily LW gain, uncorrected and corrected to steer metabolic weight of 300 kg LW, did not differ ($P \geq 0.05$) between animals from the PO treatment and animals without supplements (P). The resulting difference in live weight gains was only significant at P = 0.12. It was observed that at the end of the grazing period, the daily weight gain of calves fed pasture only decreased significantly; this was attributed to the loss of forage quality on the pasture. A lack of rain during this period reduced the protein content and energy value of forages in grasslands. Daily weight gain of steers in the PO treatment at the end of the grazing period also decreased, but to a lesser extent, possibly due to supplementation with oats.

The steers of both treatments ended their fattening process with an average LW of 380 kg at 16.5 months of age (Table 1, Figure 1).

With the forage plan implemented under rainfed conditions, using non-traditional species in the area, the stocking rate achieved during the grazing period was 3.4 calf ha^{-1} (animals of 276 kg LW), and the production value (PV) was 719 kg ha^{-1}. This production value is much higher than the production of live weight obtained in the area with natural grasslands, where 28 to 30 kg of LW ha^{-1} yr^{1} was obtained (Ruiz, 1996). Even if this latter production doubled (60 kg LW ha^{-1}·yr^{1}), it would be far from achieving the results obtained in our study.

The average weight of warm carcasses where the cuts were obtained from for FA analysis was 205 kg, with an average cold yield of 52%, as indicated in Table 2. Deboning average yields of

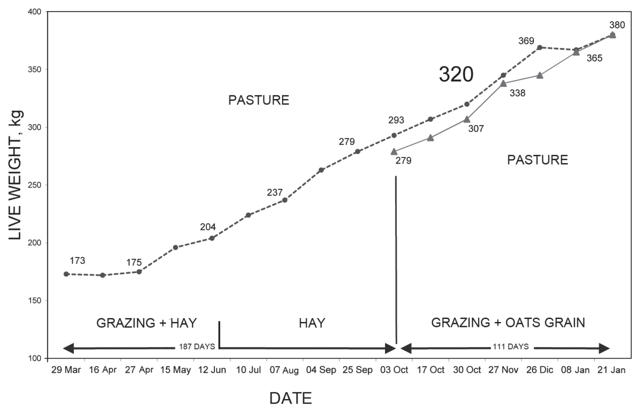

Figure 1. Live weight gain of steers on pasture and pasture plus oat grain.

Table 1. Performance of animals fed on pasture and pasture plus oats in fall –winter and spring - summer.

	Fall – Winter Mar 29 – Oct 3	Spring – Summer Oct 3 – Jan 21	
		Pasture + Oats	Pasture
Days	187	111	111
Initial weight, kg	173	279	293
Final weight, kg	286	380	380
Total gain, kg	113	101	87
Daily gain, kg $calf^{-1}$	0.60	0.91 a	0.78 a
Corrected daily gain, kg $calf^{-1}$(1)	0.74	0.85 a	0.72 a
Hay consumption, kg $cab.^{-1}$ day^{-1}	7.3		
Total hay consumption over 159 days, kg $cattle^{-1}$	1161		
Oat grain consumption, kg $cattle^{-1}$ day^{-1}		2.5	

(1)Corrected steer days $W^{0.75}$ of 300 kg.
Different letters show statistically significant differences according to the Duncan test (P ≤ 0.05).

beef carcasses were within the ranges given for the breed. The animals supplemented with oats (PO) had greater loin area, better marbling and fat thickness than animals fed only pasture (P). The low number of replications did not make it possible to perform a statistical analysis to confirm the differences; the goal was to obtain the necessary cuts to analyze the FA.

Fatty acids

In relation to cuts. Round steaks presented the lowest values (P ≤ 0.05) of saturated fatty acids in 50% of FAs analyzed. The increased presence of mono- and polyunsaturated FA identified in tenderloin was not significant (P ≥ 0.05) (Table 3).

Use of oats. The supplementation of pasture fed steers with oats (PO) decreased significantly (P ≤ 0.05) the presence of linolenic (C18: 2 n-3) FA in the beef. Linoleic fatty acid (C18: 2 n-6) presented a lower value in meat from animals that ate oats compared to those fed exclusively on pasture, but the difference was not significant (P ≥ 0.05).

Meat state. Half of the saturated fatty acids decreased their concentration (P ≤ 0.05) when roasted compared to the concentration found in

Table 2. Carcass characteristics 24 hours after -1 °C in freezer.

Treatment	Loin area	Marbling[1]	Fat thickness, cm	pH	Meat temperature, ˚C	Typification
Pasture	18”	1.00	0.57	5.8	3	V
Pasture + oat grain	20”	1.25	0.85	5.8	3	V

[1]System used by Carnes Ñuble Co: 0= no presence of marble-like patterns; 3= abundant marbling.

Table 3. Fatty acid compositions of tenderloin and round, with and without oat grain, and roasted versus uncooked meat.

	Cut		Oats		State	
Fatty Acids	Tenderloin	Round	With	Without	Roasted	Raw
Saturated (g/100 g lipids)[1] Lauric acid	0.48 a	0.043 a	0.41 a	0.11 a	0.057 a	0.467 a
Myristic acid	3.139 a	2.654 a	2.97 a	2.81 a	2.274 b	3.519 a
Pentadecanoic acid	0.99 a	0.49 b	0.71 a	0.78 a	0.56 b	0.93 a
Palmitic acid	27.09 a	26.36 a	27.29 a	26.16 a	27.71 a	25.71 a
Stearic acid	21.99 a	15.15 b	18.19 a	18.96 a	18.67 a	18.48 a
Heptadecanoic acid	1.63 a	1.28 b	1.25 b	1.65 a	1.30 b	1.61 a
Monounsaturated (g/100 g lipids)						
Myristoleic acid	0.38 a	0.59 a	0.55 a	0.42 a	0.39 a	0.59 a
Palmitoleic acid	2.11 a	2.91 a	2.73 a	2.28 a	2.31 a	2.70 a
Oleic acid	32.95 a	37.79 a	36.05 a	34.70 a	35.57 a	35.18 a
Polyunsaturated (g/100 g lipids)						
Linolenic acid (C18:3 n-3)	1.21 a	1.34 a	1.00 b	1.55 a	1.43 a	1.13 a
Linoleic acid (C18:2 n-6)	2.41 a	3.19 a	2.45 a	3.15 a	3.40 a	2.20 b
Cholesterol (mg/100 g lipids)	533.3 a	474.3 a	566.4 a	441.1 a	428.8 a	578.8 a

[1]Meat samples had 9.24 g fat/100 g muscle.
Numbers with different letters are significant (P ≤ 0.05) on cut, oat, and state rows according to the Duncan test.

raw meat. One possible explanation is that the triglycerides in these low molecular weight fatty acids have low melting points. This would allow them to migrate to the cooking medium and, from there, to undergo volatilization. Because the levels of fatty acids are given in percentages of total fatty acids found, this effect would also explain why the ratios of fatty acids of higher molecular weight increased, as did n-3 and n-6 (Table 3).

Differences in monounsaturated FA concentrations (Table 3) between the two cuts (tenderloin and round) were minimal and not significant ($P \geq 0.05$).

All the meat samples tested showed similar patterns with regard to polyunsaturated FA: the amounts of AG linoleic FA (C18: 2 n-6) were always higher than those obtained with the linolenic FA (C18: 3 n-3); therefore, the ratio of linoleic (C18: 2 n-6) / linolenic (C18: 3 n-3) was always greater than 1. The range of concentrations for linoleic (C18: 2 n-6) was from 2.2 to 3.4. A significant difference ($P \leq 0.05$) was found in raw versus cooked meat; this difference expressed as a percentage indicates that linoleic FA (C18: 2 n-6) increases in concentration by 54.5% in cooked meat compared to raw meat, while linolenic FA (C18: 3 n-3) increases by 26.5%. Both acids showing a relative increase in the cooked meat is a result of the decrease in saturated fatty acids, explained above. The greater increase in the concentration of linoleic FA (C18: 2 n-6) with respect to linolenic FA (C18: 3 n-3) is due to the minor heat stability of the linolenic FA(C18: 3 n-3), which is lost to degradation.

The range of linolenic FA (C18: 3 n-3) ranged from 1.00 to 1.55, which is similar to the range reported by Rearte (2001), who described ranges for linolenic FA (C18: 3 n- 3) between 1.07 and 1.37 and for linoleic FA (C18: 2 n-6) between 2.3 and 2.75. In addition, for animals fed only on pasture, the n-6: n-3 ratio had a value of 1.67, and the animals fed pasture plus supplements, the value was 2.57. In this study, the linoleic FA (C18: 2 n-6) / linolenic FA (C18: 3 n-3) ratio, across all cuts, feed treatments and meat states, ranged from a low of 1.95 to a maximum of 2.45 (Table 3).

The existing literature (Rearte, 2001; Rearte, 2002; INTI, 2005) indicates that meat from animals raised on pasture has better properties for human health because it has a higher content of n-3 fatty acids and a healthier ratio of n-6/n-3 compared to animals intensively grain-fed. These fatty acids cannot be synthesized by humans, and consuming them in the correct ratio is essential for maintaining good health. The ideal ratio of these fatty acids (n-6/n-3) in the diet is 4:1, whereas this ratio in the diets of many Western countries is between 1:15 and 1:50 (Hernandez, 2002). In this study, the significant difference ($P \leq 0.05$) of linolenic FA (C18: 3 n-3) in meat from animals raised on pasture versus grain supplements supports previous studies showing more polyunsaturated FA in meats from animals raised on pasture only. The achieved differences were on average 40.5%. Rosso (1998) and Frensh *et al*. (2000), cited by Rearte (2001), have also found important differences. In the present study, the ratio of linoleic fatty acids (C18: 2 n-6) / linolenic FAs (C18: 3 n-3) obtained for different cuts (tenderloin and round), feeding regimes and beef states roasted and raw were between 2:1 and 2.45:1, respectively; these FA ratios can be classified as appropriate.

Round cuts presented lower cholesterol values than tenderloin. Lower cholesterol values were also observed in roasted cuts from animals fed pasture only, although the differences were not significant ($P \geq 0.05$) (Table 3). These cholesterol values of meat were within the ranges obtained for animals fed on pasture forage, according to Hernandez (2002), who described values of 66 mg/100 g for cuts such as “bife chorizo” (rib steak); this rose to 73 mg/100 g if animals were fed with grains.

It is worth mentioning that many of our analyses had high variation coefficients; this can be attributed to our method for obtaining theoretically representative samples. A different sampling regime, such as using ground meat of whole cut and taking the appropriate aliquots for analysis, may reduce the variability of the results obtained in this study.

This study concludes that using non-traditional forage mixtures in dryland Andean foothills (consisting of alfalfa, subterranean clover with fescue and a mixture of alfalfa, orchard grass and roadside brome), good daily live weight gains and high live weight gains per hectare can be achieved with Hereford cattle fed only with hay and mineral salts their first winter. Animals slaughtered at 16.5 months of age had an average live weight of 380 kg, showing promise for better production results in an area that traditionally does not produce steers for slaughter.

There was significant variation in the fatty acids analyzed, depending on cut (tenderloin versus round), feeding system (P versus PO), and meat state (raw versus cooked).

The linoleic (C18: 2 n-6) / AG linolenic (C18: 3 n-3) ratio of the meat obtained from pasture can be considered very satisfactory.

Resumen

G. Klee, N. Mendoza y J. Chavarría. 2011. Producción y perfil de ácidos grasos de la carne de novillos Hereford a pastoreo con y sin suplementación de avena grano. Cien. Inv. Agr. 38(3): 331-338. Se evaluó la ganancia de peso vivo (PV) y composición de ácidos grasos (AG) de la carne de novillos Hereford, alimentados a praderas, con y sin suplementación de avena grano. Se trabajó con praderas de uso no tradicional, en los secanos de la precordillera andina de la VIII Región de Chile, como: alfalfa (*Medicago sativa)*, pasto ovillo (*Dactylis glomerata),* y bromus (*Bromus stamineus)*. Durante el invierno 10 terneros de 173 kg de PV inicial fueron alimentados con heno de trébol rosado (*Trifolium pratense* L. var. Quiñequeli). En primavera la mitad de los novillos se alimentaron sólo a pradera (P), y la otra mitad fueron alimentados con la misma pradera, en franjas contiguas, y suplementados con avena grano a razón de 2,5 kg novillo^{-1} día^{-1} (PA). La ganancia de PV fue 0,78 y 0,91 kg día^{-1}, para P y PA, respectivamente. Los animales de ambos tratamientos alcanzaron 380 kg de PV a los 16,5 meses de edad. La composición de AG de la carne difirió entre los cortes filete y posta negra, con y sin suplementación de avena grano, y en la carne asada y cruda. El contenido de colesterol de la carne, no presentó diferencias. La relación AG Linoleico (C18:2 n-6)/ AG Linolénico (C18:3n-3), en la carne, varió entre 2,0:1 a 2,45:1, para P y PA, respectivamente.

Palabras clave: Ácidos grasos, engorda, novillos, praderas.

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