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Dietary supplementation of ferulic acid to steers under commercial feedlot feeding conditions improves meat quality and shelf life

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ABSTRACT

The effect of dietary supplementation of ferulic acid on meat quality from commercial cross-bred steer (3/4 *Bos taurus*) was evaluated under intensive commercial feedlot conditions. One hundred animals (ageing under 24 months old and weighing initially 449 ± 14 kg BW) were randomly assigned to one of four different groups (n = 25): Group 1, control group fed only with the basal diet. Group 2 (FA-30), supplemented with 6 mg/kg BW of ferulic acid (FA) for the last 30 days of the finishing phase; Group 3 (FA-60), supplemented with 6 mg/kg BW of FA for last 60 d of the finishing and Group 4 (ZH-30), supplemented with 6 mg/kg BW of Zilpaterol Hydrochloride (ZH) for last 30 days of the finishing phase. Animals were slaughtered at end of finishing period (558 ± 16 kg BW) and the *Longissimus thoracis* muscle was collected for analyses. Meat quality (Warner Bratzler shear force, pH, objective color, cooking loss, sensory analysis, fatty acid profile, and chemical composition) was evaluated at the time of thawing of samples after transporting the cuts. Additionaly, meat color (objective color L^*, a^* and b^*) and oxidative stability were assesed during 9 days of storage at 4 °C. FA-30 supplementation decreased Warner Bratzler shear force (WBSF) by 30.33% (7.94 vs 10.34 kg) as compared to the ZH-30 supplemented group ($P < 0.05$). FA-60 and ZH-30 groups increased cooking losses by 20.92 and 18.15% respectively, in comparison to the control group ($P < 0.05$). Moisture, intramuscular fat, pH, water holding capacity (WHC) and color evaluations were not affected ($P > 0.05$) by FA or ZH supplementation. Meat from FA-30 treatment had better tenderness, juiciness and flavor sensory, compared to meat from the ZH-30 group ($P < 0.05$). Furthermore, FA-30 supplementation increased the amount of C15:0 and C14:1 fatty acids ($P < 0.05$), while meat from the FA-60 treatment showed the highest content of C18: 2 n6 *cis,* Σ PUFA, n6/n3, and PUFA/SFA ($P > 0.05$). In the shelf life study of meat, it was observed that FA-30 showed low L^* values, while FA-60 treatment caused lower a* values and higher TBARS values at end of storage period, compared to other treatments ($P < 0.05$). In conclusion, FA supplementation of steers for a period of 30 days yielded lower cooking loss, and more tender meat with higher sensory acceptance characteristics, than that observed in meat after ZH supplementation. Additionally, FA-30 supplementation, besides maintaining meat color, delayed lipid oxidation during storage. Despite increasing the content of PUFA, FA supplementation for 60 days was not advantageous due that caused a pro-oxidant effect on meat.

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1. Introduction

Modern beef cattle production has been using growth promoting agents for many years in order to improve animal metabolism, feed efficiency and increase average daily gain (ADG) (Nichols et al., 2002; Johnson et al., 2014). Some of the growth promoters currently used by beef cattle producers, are the β-adrenergic agonists (β-AA). These compounds improve nitrogen retention, reduce fat deposition (Mersmann, 2002), and increase ADG in animals by ca 35% (Avendaño-Reyes et al., 2006). Notwithstanding these benefits, the use of β-AA, can have a detrimental effect on meat quality, increasing WBSF and affecting sensory attributes (Arp et al., 2013). In addition, there may be an increased risk of toxicity by consuming viscera containing these type of compounds (Martínez-Navarro, 1990). The livestock industry has used different strategies to minimize the negative effects of β-AA on meat quality. In this regard, an alternative approach could be the use of ferulic acid (FA), a phenylpropanoid compound with high antioxidant activity and possible effect on muscle growth (Ou and Kwok, 2004). In the 80′s, a study by Gorewit (1983) found that infusion of 100 and 500 mg of FA to beef cattle can stimulate production of somatotropin by the pituitary gland, suggesting that this effect may be due to the similar structure of FA in comparison to normetanephrine (first metabolite of norepinephrine). The food industry has implemented use of FA as antioxidant against oxidation of lipids (Nirmal and Benjakul, 2009). Recently, Peña-Torres (2014) indicated that the FA supplementation for 30 days in heifers, promotes animal growth. Also, some carcass traits of economic importance, such as cold carcass dressing and LM area were improved by this supplementation. However, the use of FA supplementation in animal production is still limited and its impact on meat quality is not fully known. Therefore, the objective of the present study was to evaluate the effect of dietary supplementation of FA to finishing cattle under commercial feedlot conditions on physicochemical and sensory characteristics, fatty acid profile and oxidation of meat. Comparison was also made with the effect of ZH supplementation administered under similar conditions.

2. Materials and methods

All research protocols followed guidelines stated in the Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching (Curtis and Nimz, 1988).

2.1. Animals and treatments

The study was conducted in a commercial feedlot unit located in the region of Guadalajara, Jalisco, Mexico (latitude 20.67° and longitude 103.34°). One hundred commercial crossbred steers (3/4 *Bos taurus*) with similar age and BW (under 24 mo. and 449 ± 14 kg, respectively) were selected for the study. Steers were randomly assigned to four different treatment groups (n = 25 by treatment, allowed in 5 pens with 5 animals each one). The animals were individually weighed and identified with plastic ear tags to be distributed according to treatments. In order to minimize the influence of extrinsic factors, all animals in the study were subjected to the same feeding regime and existing prophylactic program (vaccines, treatments for internal and external parasites, vitamins, etc.). Steers were subjected to a feeding trial during the last 60 days of the finishing phase as follows: Group 1 (Control): animals receiving only the basal diet consisting of 19% forage and 81% concentrate (previously mixed); Group 2 (FA-30): animals receiving the basal diet and supplemented with 6 mg/kg BW of FA during the last 30 d of the feeding trial. Group 3 (FA-60): animals receiving the basal diet supplemented with 6 mg/kg BW of FA during 60 days; and, Group 4 (ZH-30): animals receiving the basal diet supplemented with 6 mg/kg of ZH during 30 days (from day 27 to day 57 of feeding trial). The ZH was withdrawn from the diet 72 h before slaughter, following recommendation of commercial provider. The basal diet was formulated for to contain 11.22% of crude protein and 5.07 MJ of net energy of gain per kg of feed. The FA used as supplement (Wakax Pro) was provided by Laboratorios Minkab S.A. de C.V., Guadalajara, Jalisco, Mexico. It consisted of a FA-rich corn extract (Minimum 80% FA) from "nejayote", a by-product of corn nixtamalization process used in the industrial production of corn tortillas. The basal diet supplemented with FA was prepared by adding 1 kg of Wakax Pro (containing 225 g of FA) to 1000 kg of feed for a total of 225 mg of FA per kg/feed. The two dietary supplements (FA or ZH) were added to a mineral mixture and then incorporated into the experimental rations. The FA concentration in diet was evaluated by HPLC chromatography; diets of treatments 2 and 3 contained 220 ± 7.2 mg of FA. ZH (Zilmax^{TM}) was purchased commercially from Intervet, Mexico City, Mexico.

All animals were individually weighted at the start and the end of the feeding period. The health status of steers was monitored daily throughout the period of study and there were not adverse effects that could be attributed to any of the treatments.

2.2. Longisimus thoracis muscle sampling

At the end of the feeding period, steers were slaughtered (approximately 550 kg), in the municipal slaughterhouse of Guadalajara, Mexico, following conventional procedures. Feed and water were withdrawn 24 h before slaughter. At 24 h postmortem, *Longissimus thoracis* muscle (LTM) was removed from the carcass (4th to 12th intercostal space), frozen at −20 °C and transported under vacuum for analysis to the Research Laboratory of Meat Science and Technology in CIAD A.C. (Centro de Investigación en Alimentación y Desarrollo A.C.) at Hermosillo, Sonora, Mexico. After one week of freezing