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Research Note

Juniper Consumption Does Not Adversely Affect Meat Quality in Boer-Cross Goats

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Abstract

Goat browsing can be used as an alternative brush management option for redberry (*Juniperus pinchotii* Sudw.) and ashe (*Juniperus asheii* Buch) juniper instead of more expensive and invasive brush control methods, assuming consumption of juniper does not adversely affect the marketability of offspring. Some wildlife species reportedly retain juniper flavor when consumed. We determined if juniper consumption affected meat quality or flavoring of Boer-cross kid carcasses. Twenty recently weaned, Boer-cross wethers were randomly assigned to one of four treatments with treatments fed different amounts of juniper (0%, 10%, 20%, 30% juniper in the diet). All goats were fed juniper for 28 d at the Angelo State University (ASU) Management, Instruction, and Research Center. All goats were also fed a feedlot ration to meet maintenance requirements (2% body weight). Juniper intake varied ($P < 0.05$) between all treatments (0%, 10%, 20%, 30%) primarily because treatments were fed different amounts of juniper. Following a 28-d trial, goats were harvested at the ASU Food Safety and Product Development Laboratory. Carcass characteristics including live weight, hot carcass weight, dressing percentage, loineye area, body wall fat thickness, and leg circumference were similar ($P > 0.05$) among treatments. Sensory characteristics including tenderness, juiciness, flavor intensity, off-flavor, and overall acceptability were also similar ($P > 0.05$) among treatments. Landowners can utilize goats as a biological management tool without adversely affecting goat meat quality or flavoring.

Resumen

El ramoneo con cabras puede ser usado como una opción alternativa de manejo de arbustivas de junípero rojo (*Juniperus pinchotii* Sudw.) y junípero cenizo (*Juniperus asheii* Buch) en lugar de métodos de control de arbustivas más caros e invasivos, asumiendo que el consumo de junípero no afecta el mercado del cabritos. Algunas especies de fauna silvestre se ha reportado, que mantienen el sabor de junípero cuando son consumidas. Determinamos sí el consumo de junípero afecta la calidad y el sabor de la carne de cabritos de la cruza con Boer. Veinte cabritos recién destetados cruzados con Boer fueron asignados aleatoriamente a 1 de 4 tratamientos con alimentación con diferentes cantidades de junípero (0%, 10%, 20%, 30% de junípero en la dieta). Todos los cabritos fueron alimentados con junípero por 28 d en el Centro de Manejo, Instrucción e Investigación de Angelo State University (ASU). Todos los cabritos también recibieron una ración de engorda para cubrir los requerimientos de mantenimiento (2% PV). El consumo de junípero varió ($P < 0.05$) entre todos los tratamientos (0%, 10%, 20%, 30%). Principalmente, por que los tratamientos suministraban diferentes cantidades de junípero. Después de 28 d de experimentación los cabritos fueron sacrificados en el Laboratorio de Seguridad de los Alimentos y Desarrollo de Productos de ASU. Las características de la canal, incluyendo peso vivo, peso caliente de la canal, porcentaje de rendimiento, área de la Costilla, grosor de la grasa dorsal y circunferencia de la pierna fueron similares ($P > 0.05$) entre tratamientos. Características sensoriales incluyendo suavidad, jugosidad, intensidad y duración del sabor y en general la aceptación fueron similares ($P > 0.05$) entre tratamientos. Propietarios de predios ganaderos pueden usar cabras como una herramienta de control biológico sin afectar de manera adversa la calidad y el sabor de la carne.

Key Words: carcass, conditioning, flavor, *Juniperus*, tenderness

INTRODUCTION

The number of meat goats has increased throughout the United States since the 1990s (Spencer 2008). In 2008, the US Department of Agriculture reported 3 150 000 goats in the United States; yet producers in the United States are still unable to meet demand for goat meat (Spencer 2008). The result has been that the average price per pound for meat goat products is usually higher than other red meat species (Glimp 1995). In addition, goats complement beef cattle operations because of differences in forage preferences (Bryant et al. 1979; Taylor et al. 1980). Both Spanish and Boer breeds of goats are highly adaptable to a wide variety of environmental conditions and are common throughout the southwestern United States.

Two species of juniper, redberry (*Juniperus pinchotii* Sudw) and ashe (*Juniperus asheii* Buch) juniper, are problematic species invading millions of hectares of land in Oklahoma, New Mexico, and Texas (Ansley et al. 1995; Smeins and Fuhlendorf 1997). Increased amounts of juniper cover on rangelands are attributed to overgrazing, the lack of fire, and drought (Ellis and Schuster 1968).

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Juniper contains monoterpenoid oils (Owens et al. 1998; Campbell and Taylor 2007) that cause aversive postingestive feedback (Riddle et al. 1996; Pritz et al. 1997). Fortunately, goats will consume juniper, after exposure to the plant at weaning (Bisson et al. 2001; Ellis et al. 2005; Dunson et al. 2007), and continue to consume juniper after returning to a rangeland situation (Dietz et al. 2010). Despite the interest in using goats to control juniper, the effect of juniper consumption on goat meat quality remains unknown. If juniper consumption does affect meat flavor or quality, goats may not be a viable choice for biological control of juniper in all situations.

Several feed ingredients and some grasses cause undesirable flavors in red meat because compounds are deposited in lipids or lean muscle (Melton 1990). The lipid fraction of meat, such as marbling and other adipose tissue, is partially responsible for characteristic flavors of meat products (Melton 1990). Many hunters argue that in some wildlife species the strong salient flavor of juniper is very prevalent, especially in years of drought when nutritive intake can be limited by lack of food. Indeed, the observation may be warranted; some toxins are partially metabolized and deposited in adipose tissue throughout the body, thereby limiting their effect in a centralized location in the body like the liver (Bidlack 1982; Cheeke 1998). Depositions of toxins in fat tissue could affect meat quality because compounds could be released during cooking affecting meat quality, especially if the toxin had a strong salient flavor like the monoterpenoid oils found in juniper.

It appears that most of the toxins in juniper are partially oxidized in the liver and conjugated with gluconurides in the liver and excreted (Foley et al. 1995; Dunson et al. 2007; George et al. 2010). However, redberry juniper contains 16 identified monterpenoids, and ashe juniper contains 17 identified monoterpenoids (Owens et al. 1998; Dietz et al. 2010). Because of the large variety of monoterpenoids found in juniper, it is unclear how the body handles each individual toxin (E. Campbell, personal communication, 2009). Theoretically, some of the monoterpenoids in juniper may be sequestered within the body in muscle or adipose tissue. Compared to other species, goats deposit little fat in or around muscle fibers. With that in mind, juniper consumption may have little impact on goat meat flavor. The objective of this study was to determine if juniper consumption has an effect on goat meat quality (tenderness and juiciness) and flavor (characteristic goat flavor and off-flavor).

MATERIALS AND METHODS

For this experiment, 20 recently weaned, multiple sire, Boer-cross wethers (*Capra hircus*; 43 kg, approximately 6 mo of age) were randomly assigned to one of four treatments (5 goats per treatment) in August 2008. All wethers were weaned at 4 mo of age and fed a feedlot ration until reaching a target weight of 45 kg. Animals were fed in one large group at the Angelo State University Management, Instruction, and Research Center (lat 31.38, long 100.5). The feedlot ration used consisted of sorghum (45.0%), cottonseed meal (10.0%), soybean hulls (22.5%), alfalfa pellets (17.0%), cane molasses (3.5%), and a vitamin/mineral premix (2.0%). Goats had been dewormed using an Ivermectin sheep drench and vaccinated for Enterotoxemia prior to being placed on feed. After reaching the target slaughter weight, animals were separated into individual pens (1.5 m by 1.5 m) allowing 7 d for pen adjustment. Goats were fed the basal ration at 2% body weight (approximately 900 $kg \cdot d^{-1}$) during the feeding trial (described below) to maintain body condition (NRC 2007). The goats also had access to fresh water ad libitum, and excreta were removed weekly.

After the 7-d pen adjustment period, goats were assigned juniper treatments with different amounts of juniper for each treatment. Juniper and the basal diet were fed separately to monitor intake of both. Treatments included 1) the basal diet alone (control), 2) 10% of the basal diet replaced with redberry juniper, 3) 20% of the basal diet replaced with redberry juniper, or 4) 30% of the basal diet replaced with redberry juniper. Juniper offered in the 10%, 20%, and 30% treatment groups was gradually increased over 14 d during the 28-d trial period to avoid adverse physiological effects and the formation of conditioned food aversions from the toxic monoterpenoid oils found in juniper. Initially, 50 g of juniper was offered to each goat. If an individual goat consumed all juniper offered, the amount fed was increased daily until the target percentage of the diet was reached (10%, 20%, or 30%).

Redberry juniper was fed once daily at 0800 hours for 1 h. Redberry juniper was harvested from randomly selected trees at the Texas AgriLife Research Center, Sonora, Texas (lat 30.58 long 100.65). Leaves were stripped from the stems before feeding and composited to ensure consistency of juniper offered. Juniper was collected 2 d before initiation of the study and stored at 4°C until completion of the study (Utsumi et al. 2006). Juniper refusals were collected and weighed to measure intake. The basal diet was offered from 0900 to 1700 hours, after which refusals were collected and weighed to measure intake.

Within a 24-h period following the 28th day of the trial, animals were harvested at the Angelo State University Food Safety and Product Development Laboratory. Each carcass was surface sprayed with a 2.5% organic acid to reduce microbial contamination of carcasses (ASU 2007). The carcasses were then chilled for a minimum of 24 h in order to reach an internal target temperature at the thickest portion of less than 7.2°C. The carcasses were fabricated with an emphasis on the right longissimus muscle and shoulder, which was used for the experiment. The loin, which contains the 13th rib, was cut from the point between the 12th and 13th rib to a point approximately anterior to the hip bone. It was then split along the back bone with the flank and 13th rib removed at approximately 2.54 cm from the loin muscle. In order to provide a similar sample unit, loin chops from the anterior end were cut at 2.54 cm, and four rib chops from the posterior end were cut providing a 10.16-cm sample of the loin muscle. The samples were then vacuum packaged and frozen at a temperature < 0°C. The right-side square-cut shoulder was deboned and frozen whole at a temperature < 0°C.

Chops and shoulders were thawed at 4°C 24 h prior to assessment of meat flavor, quality, and tenderness. Shoulders were ground through a hamburger grinding plate and made into 114-g patties shaped and formed by a patty press. Temperature and weight were taken both prior to and after

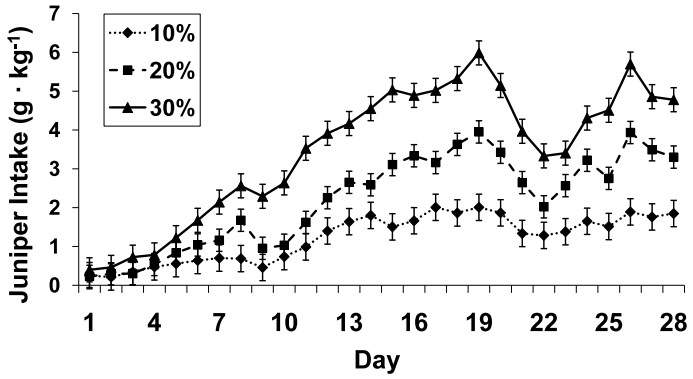

Figure 1. Daily juniper intake (means and standard errors) among treatments (5 goats per treatment) across the 28 d when goats were fed a diet consisting of 10%, 20%, or 30% juniper.

preparation of the samples. The chops and patties were cooked using clamshell grills (Kerth et al. 2003) to 71°C, a medium degree of doneness.

A trained sensory panel, consisting of two faculty and four students, was utilized for sensory evaluation (AMSA 1995). All sensory evaluation panel members were trained to recognize and identify sensory attributes (Cross et al. 1978). Each member tasted a patty and chop from each animal. Trained panelists were asked to evaluate initial and sustained juiciness, initial and sustained tenderness, flavor intensity, and overall acceptability on a scale from 1 to 8 (8 = extremely juicy, tender, intense, acceptable and 1 = extremely dry, tough, bland, prominent off-flavor, unacceptable), and off-flavor was evaluated on a four-point scale (4 = no off-flavor and 1 = extremely prominent off-flavor). This research complies with the guidelines set by the Institutional Review Board for human subject use.

Tenderness was also estimated utilizing Warner-Bratzler shear (AMSA 1995). Warner-Bratzler shear force measurements were taken by a calibrated Warner-Bratzler shear force machine through a 1-cm round core sample of the desired cut (longissimus dorsi muscle) cooked to a medium degree of doneness. Sample analysis and data collection followed the guidelines set by the American Meat Science Association and National Livestock and Meat Board research guidelines manual (1995).

Treatment means for juniper and the basal ration intake were compared among treatments using repeated measures analysis of variance with individual goats as the experimental unit and day of observation as the repeated measure. Meat quality, tenderness, and meat flavor were compared among treatments using the same model but without a day effect. Difference between means were assessed using Tukey's LSD test when $P < 0.05$. Data were analyzed using the statistical package JMP (SAS 2007).

RESULTS

Juniper intake differed ($P < 0.05$) among treatments but did not reach the targeted levels of 10% (2 g · kg^{-1}), 20% (4 g · kg^{-1}), or 30% (6 g · kg^{-1}) of the diet. The treatment fed a diet of 30% juniper ate more juniper (3.5 g · kg^{-1}) than goats fed a diet consisting of 20% juniper (2.2 g · kg^{-1}), which ate more than goats fed a diet consisting of 10% juniper (1.2 g · kg^{-1}). Initially, goats were reluctant to consume the total amount offered. After day 7, goats increased juniper consumption, but intake continued to fluctuate throughout the study ($P < 0.05$, treatment × day interaction; Fig. 1). During the last 7 d of the study, goats fed a diet consisting of 30% juniper ate 4.4 g · kg^{-1} of juniper, goats receiving a diet containing 20% juniper ate 3.0 g · kg^{-1} of juniper, while goats receiving a diet of 10% juniper at 1.6 g · kg^{-1} of juniper. Goats readily accepted the basal diet during a 7–14-d pen adjustment period and consumed the entire amount offered throughout the 28-d trial.

Table 1. Carcass characteristics and shear force means ± SEM among treatments for goats fed different concentrations of juniper (0%, 10%, 20%, or 30% of the diet).

	Percent juniper in the diet				
Characteristic	0	10	20	30	SEM
Live weight (kg)	44.7	37.0	39.9	39.2	2.3
Hot carcass weight (kg)	23.4	20.0	21.8	21.0	1.3
Dressing percentage (%)	52.3	54.0	54.4	54.0	1.4
Loineye area (cm)	4.8	4.7	4.7	4.7	0.2
Body fat thickness (cm)	1.9	1.6	1.7	1.6	0.1
Leg circumference (cm)	57.4	55.2	56.7	56.3	1.1
Shear force[1] (kg)	2.1	2.2	2.9	2.4	0.3

[1]Shear force taken by Warner-Bratzler shear force machine measured in kg.

Carcass characteristics, including hot carcass weight, dressing percent, loineye area, body wall fat thickness, and leg circumference were similar ($P > 0.05$) among treatments (Table 1). Tenderness measurements taken from the loin with a Warner-Bratzler shear force machine were also similar ($P > 0.05$) among treatments (Table 1). Sensory data for loin chops and ground shoulder patties, such as tenderness, juiciness, flavor intensity, off-flavor, or overall acceptability were also similar ($P > 0.05$) among treatments (Table 2).

DISCUSSION

Results of the study suggest that goats consuming a diet consisting of up to 30% juniper in their diet had no affect on carcass quality or meat flavor. Dietz et al. (2010) showed that goats will consume juniper at levels up to 30% of their diet on pasture, when exposed to the plant early in life. Even though the targeted levels of 10%, 20%, and 30% of the diet were not reached, goats consumed juniper throughout the 28-d trial and intake differed among treatments. Thus, consumption of juniper at levels and duration observed in this study did not affect quality or carcass characteristics.

Juniper intake fluctuated daily (Fig. 1). Intake of toxic plants typically cycles with intake increasing until aversive postingestive feedback is experienced followed by a decline in intake on subsequent days (Provenza 1995). Intake fluctuations observed in this study were probably in response to aversive postingestive feedback as intake approached 30%.

It is possible juniper consumption for longer periods of time (e.g., year-long consumption) could affect meat quality or flavor. However, it seems unlikely that monoterpenoids in

Table 2. Loin chop and ground shoulder patty trained sensory means ± SEM for goats fed different concentrations of juniper (0%, 10%, 20%, or 30% of the diet). All sensory attributes were assessed on a scale of 1 (poor) to 8 (excellent).

	Percent juniper in the diet				
Sensory attribute	0	10	20	30	SEM
Loin chop					
Cooking loss (g)	25.9	29.3	29.9	22.5	2.1
Initial juiciness	4.6	3.8	4.4	4.7	0.3
Sustained juiciness	4.8	4.2	4.8	4.9	0.3
Initial tenderness	5.0	4.3	4.5	5.0	0.3
Sustained tenderness	5.4	4.6	5.0	5.3	0.3
Flavor intensity	4.9	4.8	4.9	4.7	0.1
Off-flavor	3.9	3.7	3.9	3.9	0.1
Overall acceptability	5.2	4.2	4.8	5.1	0.2
Ground shoulder patty					
Cooking loss (g)	36.6	32.9	29.9	28.4	1.5
Initial juiciness	4.6	5.2	5.4	5.5	0.2
Sustained juiciness	5.1	5.5	5.8	5.9	0.2
Initial tenderness	5.5	5.6	5.9	6.1	0.1
Sustained tenderness	5.9	5.9	6.2	6.4	0.2
Flavor intensity	5.2	5.2	5.5	5.0	0.1
Off-flavor	3.8	3.8	3.7	4.0	0.1
Overall acceptability	5.4	5.9	5.6	5.8	0.1

juniper would affect meat flavor if most of the toxins are indeed metabolized and excreted through urination (Foley et al. 1995). In addition, most goats harvested for meat production are harvested at a relatively young age (<6 mo). Arguably, if intake had exceeded 30% of the diet for longer periods of time, juniper may have affected meat quality or flavor. In previous studies, juniper intake typically did not exceed 30% of the diet for any length of time (Bisson et al. 2001; Ellis et al. 2005; Dunson et al. 2007) apparently because rumen microbial death occurs when intake exceeds 30% of the diet (Straka et al. 2004).

It is unknown why juniper intake apparently affects the flavor of some wildlife species but not goats. Different species may handle toxic compounds differently. Some, like the wild turkey, may sequester monoterpenoid oils in adipose tissue, thereby affecting meat flavor. In addition, turkeys and other wildlife species may rely on consumption of juniper fruit more so than the foliage. For this study, goats were fed primarily the foliage.

IMPLICATIONS

Using juniper as forage does not appear to adversely affect carcass characteristics or goat meat quality or flavor within the time frame of this study. Other research has also shown that juniper consumption does not adversely affect production or reproduction (Owens et al. 2010). During a year-long grazing trial goats that selected relatively large amounts of juniper (30%) did not suffer from any other observable adverse effects from juniper consumption (Dietz et al. 2010). Ranchers may use goats as a juniper management tool apparently without damaging the goat flock or the products made from goat meat. Therefore, goats should be used as a tool in managing juniper on juniper-dominated rangelands and continue to be a valuable part of the food supply.

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