IMPACTS OF A WINERY WASTE SUPPLEMENTED FINISHING RATION ON THE SENSORY AND CHEMICAL CHARACTERISTICS OF BEEF

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Abstract - A key to ensuring the sustainability of the beef industry is producing novel value-added products. One product, evaluated in this study, was beef from cattle fed diets supplemented with grape fermentation by-products; Wine Finished Beef (WFB). The finishing rations used were initially based around corn silage (30%) and also contained malt, oats and barley (10, 20, and 30%, respectively). As supply diminished, corn silage was switched from the rations in favor of chopped hay (12%) along with barley and malt (20 and 31%, respectively). The caloric density and chemical composition of wine supplemented feed was not statistically different from the control feed. The trim fats of WFB steaks approached a statistically significant finding, suggesting that the fat of WFB steaks was less red in colour ($P > 0.05$) than steaks from cattle not fed wine. However, when rib eye steak samples were ground, the WFB steaks were found to be darker in light intensity ($P < 0.05$) than steaks from animals not fed wine, indicating a change in the internal colouration of the steaks. No differences were observed between WFB steaks and controls with respect to tenderness ($P > 0.20$). Supplementing cattle feeds with winery wastes provides beef producers with a novel product (WFB) that is darker in colour than non-WFB, which may result in higher appeal to consumers.

Key Words – Colour, Tenderness, Wine, Steak

I. INTRODUCTION

The colour and tenderness of beef products are often driving factors behind consumer demand [1]. Beef producers in British Columbia (BC), Canada are currently utilizing winery wastes to supplement beef finishing rations in order to market and produce a novel specialty food affiliated and co-marketed with the provincial wine industry; “wine finished” beef (WFB). It is hypothesized that the multiple chemical constituents in winery wastes (e.g. polyphenols, chlorophores, and tannins) may positively influence the sensory characteristics of this specialty beef product.

Wine lees constitute the largest volume of waste created during grape fermentation and are traditionally disposed of through local waste systems. Current winery best management practices suggest that these wastes should ideally be composted [2], which places an increased financial burden on most wineries, as composting is commonly outsourced. Previous studies have found wine lees to be a valuable source of protein for animal feed [3]. Providing a stable supply of winery waste to complementary industries, such as cattle feedlots, may be a cost effective way of disposing of winery wastes; in turn, allowing beef producers to produce a specialty meat product that allows for differentiation in the marketplace. In this study, standardized measures of meat quality were used to objectively determine if the inclusion of winery waste in finishing rations had an influence on the sensory characteristics (tenderness and colour) of final beef products. In addition, chemical analysis methods employing near infrared spectrometry (NIRS) were used to determine compositional differences between two diets (winery wastes versus control supplemented finishing rations) as well as final meat composition.

II. MATERIALS AND METHODS

Experimental Design: A total of 69 Angus-cross steers were single sourced, and acclimated to the same finishing rations upon arrival at Southern Plus Feedlots, Black Sage Rd, Oliver, BC, Canada. Once acclimated, cattle were randomly separated into 4 pens, 2 pens per treatment, and fed 143-d finishing diets containing either 6 or 7 % winery wastes (WW; 18, 17) or 6 or 7 % water (C; 17, 17) outlined in Table 1. The variation in wine and water feeding volumes was the result of a dietary change from corn silage to chopped hay, which occurred when silage supplies diminished. Feeds were prepared twice daily using industrial feeders equipped with scales (± 4.55 kg) that thoroughly mixed the ingredients via 5 large rotors. Intake was measured by determining the amount delivered to the bunks divided by the number of animal in the pen. Feed was never removed to ensure intake accuracy. Cattle were fed this diet until harvest, and were managed according to the Canadian Council of Animal Care guidelines [5].

Table 1. Diet composition

Item	% Diet (d1-d105)		% Diet (d106-d147)	
	WW	C	WW	C
Corn Silage	30	30	0	0
Chopped Hay	0	0	12	12
Malt	10	10	31	31
Oats	20	20	0	0
Barley	30	30	20	20
LSC[1]	3	3	3	3
Wine	7	0	6	0
Water	0	7	0	6

[1]LSC is a commercial feed additive not containing rumensin.

Ration Analysis: Both WW and C rations were compared using NIRS and bomb calorimetry. Feed samples were collected at the feedlot and processed to determine dry matter (DM) composition by placing the samples in a drying oven at 60°C for 48 h. Samples were ground using a sample mill (FOSS Cyclotec™ 1093, Foss, Hillerød, Denmark). In addition 40 agriculturally relevant components of the feeds were measured using NIRS via the Total Mixed Rations parameters following the manufactures instructions (FOSS InfraXact™, FOSS Hillerød, Denmark). After analyses, samples were subjected to oxygen bomb calorimetry (Parr model 1108 combustible bomb and calorimeter) for determination of kcal/g DM.

Meat Sample Collection: Cattle were weighed and shipped for slaughter to a local abattoir in two batches, the first on d143 (n = 10, 5 per treatment) and the second on d147 (n = 10, 5 per treatment). Cattle were slaughtered and dry aged for 14 days. Two rib eye steaks (2.5 cm thick, longissimus dorsi) were obtained between the 11th and 12th rib from each carcass; one steak was used for tenderness evaluation and the other was used for meat colour and meat chemistry measures. Steaks were analyzed 6 hours after sampling due to the driving distance between the abattoir and the research lab.

Meat Colour Analysis: Dietary impacts on meat colour were determined by first removing debris from sample surfaces and analyzing red steak meat, trim fat surface colours, as well as the surface of ground steak samples using a colorimeter (Hunter Lab ColorFlex® EZ, Reston, VA). Eight readings from each sample were averaged and the results were reported according to the International Commission on Illumination (CIE) profile as Lightness (L*), redness (a*) and yellowness (a*) [6]. Additional bloom time was not provided for meat samples as steaks had been removed from the carcasses for at least 6 hours and stored food safe bags, providing sufficient time to eliminate biases in sample processing from oxygen blooms.

Meat Chemistry: Protein, fat, moisture and collagen contents of beef samples were determined with a NIRS designed for meat samples (FOSS FoodScan™ Meat analyzer, Hillerød, Denmark). Rib eye steak samples were trimmed of excess fat and then placed in a commercial grinder. Ground samples were further evaluated for colour as previously described and then placed in the FoodScan™ analyzer and evaluated according to the manufactures instructions.

Meat Tenderness Evaluation: Meat tenderness was evaluated by removing the bone and tip of rib eye meat samples and cooking the meats in a heated clamshell cooker until an internal temperature of 71°C was reached; samples were flipped at 40°C. All temperature measures were recorded using a meat thermometer (VWR International LLC, Vandor PA). Once cooled to room temperature, eight 1-cm diameter cores were removed from each steak and a shear force (SF) test was conducted using a Lloyd Instruments Texture Analyzer with a 50 kN load cell (C.S.C. Force Measurement Inc., Agawam MA). Cores were sheared using a flat V-shaped blade directed towards the core at a speed of 20 cm/min. The instrument then recorded the force (kgf) required to shear each core.

Student's *t*-tests accommodating unequal sample sizes as well as unequal variance (Welch's *t*-test) were utilized to determine statistical significance of all measures using the following equation [7]:

$$t = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{\frac{s_p^2}{n_1} + \frac{s_p^2}{n_2}}}$$

Where:

$$s_p^2 = \frac{SS_1 + SS_2}{n_1 + n_2 - 2}$$

Treatment differences were considered significant at P ≤ 0.05).

III. RESULTS

The addition of winery wastes to the finishing ration did not significantly alter the chemical composition, caloric density (Table 2), or moisture content of the WW (Table 3) compared to the C ration (P > 0.10). Surprisingly, the weights of half-carcasses did not change between cattle fed WW or C supplemented feeds (*P* > 0.50) (Table 4).

Table 2. Near Infrared analysis of various components of the finishing rations containing of either 6 or 7 % winery wastes (WW) or 6 or 7 % water (C).

Diet	Item	n	Mean[1]	σ[2]	*t*	*P*
WW	Ash	15	4.10	0.37	-1.19	>0.20
C		13	4.68	1.86		
WW	CF[3]	15	7.88	1.31	-0.76	<0.50
C		13	8.71	3.99		
WW	Fat	15	1.03	0.33	-1.34	<0.20
C		13	1.65	1.75		
WW	Moisture	15	30.46	15.15	-1.59	>0.10
C		13	40.63	18.60		
WW	Protein	15	14.07	1.00	-1.20	>0.20
C		13	15.55	4.70		
WW	TDN_TMR[4]	15	78.94	2.01	0.29	>0.50
C		13	78.63	3.48		

[1]Units for mean are in %.
[2]σ= Standard deviation.
[3]CF = Crude fibre
[4]TDN_TMR = Total dietary nitrogen per total mixed ration.

Table 3. Comparison of caloric densities of feeds containing 6 to 7 % winery wastes (WW) or 6 to 7 % water (C).

Diet	n	Mean[1]	σ[2]	*t*	*P*
WW	9	18.5814	1.96	-0.31	>0.50
C	9	19.2954	2.31		

[1]Units for mean are in kcal/g DM.
[2]σ= Standard deviation.

Table 4. Half weights of carcasses observed from cattle fed either 6 to 7% winery wastes (WW) or 6-7% water (C).

Diet	n	Mean[1]	σ[2]	*t*	*P*
WW	10	146.0	7.2	-0.375	>0.50
C	10	148.9	9.1		

[1]Units for mean are Kilograms (Kg).
[2]σ= Standard deviation.

No differences (*P* > 0.10) were observed in the protein, fat, moisture or collagen content of WW and C steak samples (Table 5). Similarly, no treatment differences (*P* > 0.20) were observed in the tenderness of steaks evaluated (Table 6).

Table 5. Near Infrared Analysis of protein, fat, moisture and collagen contained in steak samples from cattle fed either 6 to 7 % winery wastes (WW) or 6 to 7 % water control (C).

Diet	Item	n	Mean[1]	σ[2]	*t*	*P*
WW	Protein	5	21.93	0.91	-0.32	>0.50
C		3	22.11	0.24		
WW	Fat	5	13.17	4.30	-1.03	>0.20
C		3	16.22	3.51		
WW	Moisture	5	64.90	3.24	0.86	<0.50
C		3	62.91	2.95		
WW	Collagen	5	1.96	0.44	0.04	>0.50
C		3	1.95	0.43		

[1]Units for mean are in %.
[2]σ= Standard deviation.

Table 6. Evaluation of tenderness (load at maximum; kgf) using the shear force test between steaks from cattle fed either 6 to 7 % winery wastes (WW) or 6 to 7 % water control (C).

Diet	n	Mean[1]	σ[2]	*t*	*P*
WW	32	2.92	0.77	1.20	>0.20
C	24	2.71	0.51		

[1]Units for mean are load at max force (kgf).
[2]σ= Standard deviation.

The fat of C steers was found to approach a nearly significant red colour (*P* > 0.05) when compared to steaks from WW finished steers (Table 7). When comparing external steak meat colour, no differences (P > 0.20) (Table 8) were observed between the WW or C treatments. Conversely, the colour of ground beef steak samples was darker (*P* < 0.05) (Table 9) in WW than C finished cattle.

Table 7. Trim fat colour observed in ground rib eye steaks from cattle fed either 6 to 7 % winery wastes (WW) or 6 to 7 % water control (C).

Diet	Light	n	Mean[1]	σ[2]	*t*	*P*
WW	L*[3]	10	62.70	5.72	0.49	>0.50
C		6	61.46	3.20		
WW	a*[4]	10	6.77	1.33	-2.13	>0.05
C		6	8.44	1.80		
WW	b*[5]	10	16.39	1.83	-1.42	<0.20
C		6	17.82	2.17		

[1]Units for mean are unit less.
[2]σ= Standard deviation.
[3]L* CIE determination of Light intensity
[4]a* CIE determination of red colouration
[5]b* CIE determination yellow colouration

Table 8. Rib eye meat colour observed from cattle fed either 6 to 7 % winery wastes (WW) or 6 to 7 % water control (C).

Diet	Light	n	Mean[1]	σ[2]	*t*	*P*
W	L*	9	39.86	3.42	-0.64	>0.50
C		8	40.34	1.51		
W	A*	9	19.75	2.33	-1.20	>0.20
C		8	20.58	1.32		
W	B*	9	17.40	1.86	-0.87	<0.50
C		8	17.89	0.90		

[1]Units for mean are unit less.
[2]σ= Standard deviation.
[3]L* CIE determination of Light intensity
[4]a* CIE determination of red colouration
[5]b* CIE determination yellow colouration

Table 9. Ground rib eye steak colour observed from cattle fed either 6 to 7 % winery wastes (WW) or 6 to 7 % water control (C).

Diet	Light	n	Mean[1]	σ[2]	*t*	*P*
W	L*	4	49.02	2.35	-2.61	<0.05
C		3	54.59	3.36		
W	A*	4	23.14	1.20	1.41	>0.20
C		3	2.58	2.58		
W	B*	4	22.04	0.22	-1.16	>0.20
C		3	0.94	0.94		

[1]Units for mean are unit less.
[2]σ= Standard deviation.
[3]L* CIE determination of Light intensity
[4]a* CIE determination of red colouration
[5]b* CIE determination yellow colouration

IV. CONCLUSION

Under the conditions of this study beef cattle fed rations supplemented with winery wastes (wine finished beef) produced ground meat that was “darker” in colour than control fed cattle with no observed changes in tenderness. A possible explanation for this colour change was that the lack of caloric content between the feeds resulted in reduced carcass weights that cooled faster thus producing darker meat products. However, when observing carcass weights, no significant changes were observed between diets, indicating that a different mechanism may have caused the darkening of these meats. Understanding the biochemistry behind this lipid and muscular colour change in beef could prove to be of value to the beef industry in order to produce meats with enhanced red pigments to improve sales. Additional work in this area should investigate the impacts of wine fermentation by-products on other beef attributes such as fatty acid profiles.

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