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Objective

The objective of this study was to determine the effects that increasing doses of encapsulated butyric acid and zinc (BPZ) have on finishing phase growth performance, efficiency of dietary net energy (NE) utilization, and carcass characteristics in beef steers.

Study Description

Steers (n = 272; shrunk BW = 794 ± 163 pounds) were assigned to one of four dietary treatments in a 143.5 d feedlot finishing trial: 0 g BPZ/ kg diet dry matter (DM) (CON), 1 g BPZ/ kg diet DM (1BPZ), 2 g BPZ/ kg diet DM (2BPZ), or 3 g BPZ/ kg diet DM (3BPZ). Carcass data and liver health outcomes were collected, and feedlot growth performance data and efficiency of dietary net energy utilization were calculated on a carcass-adjusted basis.

Take Home Points

The addition of BPZ to finishing steer diets had minimal effects on feedlot growth performance, efficiency of dietary net energy utilization, and carcass characteristics. Dressed yield tended to be higher for BPZ vs. CON and increased with dose while liver abscess prevalence tended to decrease when fed intermediate doses of BPZ. Data from this study suggests that the addition of BPZ to feedlot finishing diets for decreasing the prevalence of abscessed livers should be further investigated.

Introduction

Postnatal development of the rumen and intestinal epithelium is stimulated by short chain fatty acids (SCFA). Of the SCFAs attributed to epithelial development, butyric acid has the greatest effect on proliferation of rumen and intestinal epithelial cell proliferation (Sander et al., 1959; Manzanilla et al., 2006). The addition of encapsulated butyric acid to feedlot cattle diets has the potential to improve rumen and intestinal health and subsequently improve nutrient absorption, growth performance, and increase efficiency of dietary net energy utilization. Thus, our hypothesis was that with increasing inclusion of an encapsulated butyric acid and zinc complex in feedlot finishing steer diets, cattle growth performance, carcass characteristics, and efficiency of dietary net energy utilization would be improved.

Experimental Procedures

All procedures involving the use of animals in this experiment were approved by the South Dakota State University Institutional Animal Care and Use Committee (Approval #2101-004E).

Dietary Treatment

This study used 8 replicate pens per treatment and each pen contained 5 to 10 steers (n = 68 steers/treatment). Each pen was assigned to one of four dietary treatments in a randomized complete block design (blocked by location). Dietary treatments included:

1. 0 g BPZ/kg diet dry matter (CON)
2. 1 g BPZ/kg diet dry matter (1BPZ)
3. 2 g BPZ/kg diet dry matter (2BPZ)
4. 3 g BPZ/kg diet dry matter (3BPZ)

No tylosin phosphate was fed over the course of this experiment. All diets contained monensin sodium (Rumensin-90, Elanco Animal Health) at 32.08 mg/kg of diet on a dry matter (DM) basis; all diets were fortified with vitamins and minerals to exceed nutrient requirements for finishing beef steers (NASEM, 2016).

The supplements for dietary treatment inclusion were manufactured in two runs on 18 February 2021 and 26 July 2021 at the SDSU feed mill located in Brookings, SD. The manufactured supplement was stored in bulk ag bags and shipped to the SDSU Southeast Research Farm (SERF) located southwest of Beresford, SD.

Cattle Feeding and Management

Two hundred and seventy-two steers (initial shrunk body weight {BW} = 794 ± 163 pounds) from two sources: 1) Central South Dakota and 2) Northwest Iowa were purchased at the Sioux Falls Regional Livestock Cattle Auction (Worthing, SD) and transported 24 miles to the SERF on 01 March 2021; the two sources of cattle remained segregated for the entirety of the study. Upon arrival, steers were offered long-stem grass hay and ad libitum access to water. The following morning, steers were delivered a 50% roughage diet (DM basis) consisting of dry rolled corn (DRC), modified distillers grains with solubles (MDGS), corn silage, grass hay, and a liquid supplement fed at 2% of BW (DM basis).

On 05 March 2021 steers were processed and applied a unique visual identification ear tag, vaccinated against viral respiratory diseases (Bovi-Shield GOLD 5, Zoetis) and clostridial species (Ultrabac 7/Somubac, Zoetis), administered an appropriate dose of pour-on moxidectin (Cydectin, Bayer), and an individual BW was recorded for allotment purposes. The morning of 08 March 2021, steers were weighed again, and allocated into treatment pens; test diets were initiated following morning processing. The initial on-test BW was the average of the two BW measures collected on 05 March and 08 March 2021. All live BW measures were shrunk 4% to account for digestive tract fill.

Steers were fed in two types of confined feeding systems: 1) Steers (n = 232) from 6 replicates were fed in 115 ft x 46 ft open lot dirt pens (9 to 10 steers/pen) with concrete bunks (20 ft linear bunk space) and skirt (10 ft); 2) Steers (n = 40) from 2 replicates were fed in 40 ft x 15 ft partially covered concrete pens (5 steers/pen) with concrete bunks (15 ft linear bunk space). Dietary ingredients were analyzed weekly for DM content and composited monthly for nutrient determination. Actual diet formulation based upon weekly DM determination and feed batching record along with tabular energy content (Preston, 2016) is presented in Tables 1, 2, 3, and 4. Steers were fed once daily at 0800h and bunks were managed according to a slick bunk management system allowing ad libitum access to feed, with minimal day to day variation in feed deliveries. Feed was manufactured in a commercial mixer wagon (volume 215.5 ft3; Reel Auggie 3120, Kuhn) with a scale resolution of 2 pounds.

On d 19 of the study around 3% of the cattle in the yard exhibited signs of respiratory illness and the veterinarian was called for a herd check. After consultation, it was decided that metaphylaxis with chlortetracycline was the best treatment option. Chlortetracycline (Pennchlor 50G, Pharmgate Animal Health) was fed from d 21 – 25 at a rate of 10 mg / lb of BW / d. During this period, liquid supplement was removed from the diet to stay in compliance with medicated feed regulations.

On study d 28, steers were weighed, implanted with 200 mg trenbolone acetate and 28 mg estradiol benzoate (Synovex Plus, Zoetis) and intranasally vaccinated against Infectious Bovine Rhinotracheitis and Parainfluenza 3 (Nasalgen IP, Merck). On study d 98, steers were weighed, and unique radio-frequency identification (RFID) ear tags were administered to each animal. Steers from sources 1 and 2 were projected to finish at differing days on feed (DOF); thus, ractopamine HCL was fed at a rate of 300 mg/steer-d-1 for the last 28 DOF (Source 1; study d 98-126) and last 35 DOF (Source 2; study d 126-161).

Growth Performance Calculations

Growth performance (live and carcass-adjusted) were calculated on a deads and removals excluded basis. All steers were weighed individually at processing, as well as on d 1, 28, 56, 98, and 126; source 2 cattle were also weighed on d 161. Steers were weighed in a hydraulic squeeze chute mounted on top of load cells (scale readability ± 2 pounds). Pre-ractopamine period growth performance data was based upon initial BW shrunk 4% (SBW) and d 98 SBW (Source 1) and d 126 SBW (Source 2). Ractopamine period growth performance was calculated two ways: 1. Based upon d 98 (Source 1) and d 126 (Source 2) SBW and d 126 (Source 1) and d 161 (Source 2) SBW; 2. Based upon d 98 (Source 1) and d 126 (Source 2) SBW and carcass-adjusted final BW (CAFBW) calculated from: hot carcass weight (HCW)/0.625. Cumulative growth performance is based upon initial SBW (average of 05 March and 08 March 2021 BW) and carcass-adjusted final BW (CAFBW). Average daily gain (ADG) was calculated as the difference between SBW or CAFBW and initial SBW divided by DOF for the respective period; feed conversion efficiency (G:F) was calculated from ADG/Dry matter intake (DMI).

Efficiency of Dietary NE Utilization Calculations

Applied energetics measures (observed dietary NE and the ratio of observed-to-expected dietary NE) were assessed for the cumulative feeding period. Carcass-adjusted growth performance was used to calculate performance-based dietary NE to determine efficiency of dietary NE utilization. The performance based dietary NE was calculated from daily energy gain (EG; Mcal/d): EG = $(ADG)^{1.097} \times 0.0557W^{0.75}$; where W is the mean equivalent shrunk BW [kg; (NRC, 1996)] from median feeding SBW (MBW) and AFBW calculated as: [MBW × (478/AFBW), kg; (NRC, 1996)]. Maintenance energy (EM) was calculated by the equation: EM = $0.077 \times MBW^{0.75}$. Dry matter intake is related to energy requirements and dietary NE for maintenance (NEm; Mcal/kg) according to the following equation: DMI = EG/(0.877NEm – 0.41), and can be resolved for estimation of dietary NEm by means of the quadratic formula $x = \frac{-b \pm \sqrt{b^2-4ac}}{2a}$, where a = 0.41EM, b = –0.877EM + 0.41DMI + EG, and c = –0.877DMI (Zinn and Shen, 1998). Dietary NE for gain (NEg) was derived from NEm using the following equation: NEg= 0.877NEm – 0.41 (Zinn, 1987). Maintenance coefficient (MQ) was determined using the following equation: MQ, Mcal/$W^{0.75}$ = [(DMI-(EG/NEg)) × NEm]/$MBW^{0.75}$.

Carcass Characteristics

Both sources of steers were fed until visually assessed to have 0.50 in rib-fat and were shipped for harvest at a commercial beef abattoir. Steers from source 1 were weighed off study after 126 DOF and harvested the following morning (13 July 2021); source 2 steers were harvested after 161 DOF and harvested the following morning (17 August 2021). On the afternoon following final BW determination for the respective sources, steers were transported 98 km to Tyson Fresh Meats in Dakota City, NE for harvest the subsequent morning. Steers were comingled at the time of shipping and remained this way until harvest. For source 1 steers, trained individuals entered the slaughter facility and individual visual identification tags were recorded, RFID tags were recorded via Allflex RS420NFC Series Stick Reader (Allflex USA), and packer identification tags were recorded to ensure individual carcasses could be traced to live steers. Additionally, livers were visually evaluated to determine health according to the Elanco Liver Check System (Elanco). For source 2 steers, only one trained individual was allowed to enter the slaughter facility due to SARS-CoV-2 protocols; thus, RFID tags and packer identification tags were recorded to trace carcasses to live animal. Livers were visually evaluated to determine abscess prevalence (Abscess or Healthy; no severity was captured). Hot carcass weight was obtained via plant printouts. Following chilling, all carcasses were ribbed for USDA-AMS grading; quality and yield grade attributes were obtained with camera grading and kidney, pelvic, and heart fat (KPH) percentage was determined via plant specific algorithm. Dressing percentage was calculated as: HCW/(final SBW). Yield grade was calculated according to the USDA regression equation (USDA, 2017). Estimated empty body fat (EBF) percentage and final BW and 28% EBF (AFBW) were calculated from observed carcass traits (Guiroy et al., 2002).

Statistical Analysis

Cumulative and interim growth performance, carcass characteristics, and efficiency of dietary NE utilization and frequency data were analyzed as a randomized complete block design using the GLIMMIX procedure of SAS 9.4 (SAS Inst. Inc.) with pen as the experimental unit. A fixed effect of BPZ inclusion and random effect of block was utilized in model analysis. Interim period performance data was analyzed on live basis while cumulative feedlot performance data was analyzed on a carcass-adjusted basis. Pre-planned contrasts for CON vs. BPZ, plus linear, and quadratic responses were tested. Least square means were generated with the LSMEANS option of SAS and means were separated and denoted different ($P \leq 0.05$) using the pairwise comparison PDIFF option of SAS (SAS Inst. Inc.). Significance was determined at ($P \leq 0.05$) and tendencies were observed at ($0.05 < P \leq 0.10$).

Results and Discussion

Cumulative Growth Performance

Results for cumulative carcass-adjusted growth performance and efficiency of dietary net energy are in Table 5. There were no differences ($P \geq 0.14$) observed for CAFBW, DMI, ADG, G:F, observed diet NEm or NEg, observed-to-expected NEm or NEg, or MQ.

Carcass Characteristics

Carcass characteristics are presented in Table 6. There was no difference ($P \geq 0.21$) among treatments for HCW, dressed yield, ribeye area, 12th rib fat thickness, calculated USDA Yield Grade, marbling score, or EBF percentage. For CON vs. BPZ, there was no difference ($P \geq 0.14$) for HCW, ribeye area, 12th rib backfat thickness, marbling score, or EBF percentage; CON vs. BPZ tended to differ for dressed yield ($P = 0.08$; CON = 64.23% and BPZ = 64.86%) and for calculated USDA Yield Grade ($P = 0.10$; CON = 2.94 and BPZ = 3.06). No quadratic effects ($P \geq 0.34$) were observed for any variables tested. No linear effect was observed ($P \geq 0.15$) for HCW, ribeye area, 12th rib backfat thickness, calculated USDA Yield Grade, marbling score, or EBF percentage; however, a linear effect was observed ($P = 0.05$) for dressed yield.

Categorical Carcass Characteristics

Categorical carcass characteristics can be found in Table 7. There were no treatment differences ($P \geq 0.21$) for distribution of USDA Yield Grade 1, 2, 3, 4, or 5. A tendency for a linear effect ($P = 0.07$) was observed for distribution of USDA Yield Grade 2; however, no other linear differences were observed ($P \geq 0.25$) for distribution of USDA Yield Grade 1, 3, 4, or 5. No treatment, CON vs. BPZ, linear, or quadratic differences ($P \geq 0.68$) were observed for distribution of USDA Standard, Select, Low Choice, Average Choice, or High Choice. A tendency for a quadratic effect ($P = 0.08$) for liver abscess prevalence was observed, however, no treatment, CON vs. BPZ, or linear effects ($P \geq 0.32$) were observed in the study.

Implications

Supplementation of BPZ in finishing cattle diets does not appreciably influence growth performance but increases dressed yield. Data from this study suggests that the addition of BPZ to feedlot finishing diets for decreasing the prevalence of abscessed livers should be further investigated.

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Tables

Table 1. Diet formulation (d 1-14)

	d 1-7				d 8-14			
	Dietary BPZ inclusion, g/kg DM				Dietary BPZ inclusion, g/kg DM			
Items	**0**	**1**	**2**	**3**	**0**	**1**	**2**	**3**
DRC, %	20.63	20.63	20.63	20.63	30.14	30.14	30.14	30.14
MDGS, %	19.81	19.81	19.81	19.81	19.64	19.64	19.64	19.64
Soybean Hulls, %	1.80	1.19	0.60	0	1.79	1.19	0.60	0
Corn Silage, %	28.07	28.07	28.07	28.07	27.02	27.02	27.02	27.02
Grass Hay, %	26.22	26.21	26.21	26.21	17.86	17.86	17.86	17.86
Liquid Supplement, %	3.47	3.47	3.47	3.47	3.54	3.55	3.54	3.54
Treatment Supplement, %	0	0.61	1.20	1.81	0	0.60	1.19	1.79
DM, %	65.59	65.59	65.59	65.59	64.57	64.57	64.57	64.57
CP, %	13.34	13.33	13.31	13.30	13.15	13.14	13.13	13.12
NDF, %	38.87	38.87	38.87	38.87	33.79	33.78	33.79	33.79
ADF, %	25.63	25.63	25.63	25.63	21.69	21.69	21.69	21.69
Ash, %	7.48	7.49	7.49	7.49	6.69	6.71	6.70	6.71
EE, %	4.13	4.13	4.13	4.13	4.24	4.24	4.24	4.24
NEm, Mcal/cwt	80.32	80.32	80.32	80.32	84.05	84.04	84.05	84.05
NEg, Mcal/cwt	50.42	50.42	50.42	50.42	54.11	54.10	54.11	54.11

Table 2. Diet formulation (d 15-25)

	d 15-20				d 21-25			
	Dietary BPZ inclusion, g/kg DM				Dietary BPZ inclusion, g/kg DM			
Items	**0**	**1**	**2**	**3**	**0**	**1**	**2**	**3**
DRC, %	38.81	38.81	38.81	38.81	40.07	40.07	40.07	40.07
MDGS, %	19.75	19.75	19.75	19.75	21.04	21.04	21.04	21.04
Soybean Hulls, %	1.84	1.22	0.61	0	2.45	1.63	0.81	0
Corn Silage, %	27.08	27.08	27.08	27.08	35.64	35.63	35.63	35.63
Grass Hay, %	8.96	8.96	8.96	8.96	-	-	-	-
Liquid Supplement, %	3.55	3.55	3.55	3.55	-	-	-	-
Treatment Supplement, %	0	0.62	1.23	1.85	0	0.82	1.64	2.46
CTC Premix[1], %	-	-	-	-	0.80	0.80	0.80	0.80
DM, %	64.45	64.45	64.45	64.45	61.25	61.25	61.25	61.26
CP, %	13.00	12.99	12.97	12.96	13.03	13.01	12.99	12.97
NDF, %	28.89	28.89	28.90	28.90	27.65	27.66	27.66	27.66
ADF, %	17.86	17.86	17.86	17.86	14.73	14.73	14.74	14.74
Ash, %	5.87	5.88	5.88	5.89	3.42	3.43	3.43	3.44
EE, %	4.35	4.35	4.35	4.35	4.54	4.54	4.54	4.54
NEm, Mcal/cwt	87.77	87.77	87.77	87.77	91.51	91.51	91.51	91.51
NEg, Mcal/cwt	57.83	57.83	57.83	57.83	61.29	61.29	61.29	61.29

[1]Chlortetracycline (Penchlor 50G, Pharmgate Animal Health) was fed at a rate of 10 mg / lb BW / hd / d for treatment of herd respiratory illness.

Table 3. Diet formulation (d 26-49)

	d 26-28				d 29-49			
	Dietary BPZ inclusion, g/kg DM				Dietary BPZ inclusion, g/kg DM			
Items	**0**	**1**	**2**	**3**	**0**	**1**	**2**	**3**
DRC, %	38.79	38.79	38.78	38.78	50.31	50.35	50.35	50.31
MDGS, %	22.25	22.25	22.25	22.24	17.29	17.29	17.29	17.29
Soybean Hulls, %	2.55	1.70	0.85	0	2.43	1.63	0.76	0
Corn Silage, %	32.45	32.45	32.45	32.45	26.18	26.18	26.18	26.18
Grass Hay, %	-	-	-	-	-	-	-	-
Liquid Supplement, %	3.96	3.96	3.96	3.96	3.79	3.79	3.79	3.79
Treatment Supplement, %	0	0.85	1.72	2.57	0	0.76	1.64	2.44
DM, %	58.04	58.05	58.05	58.06	60.53	60.53	60.54	60.54
CP, %	14.06	14.04	14.02	14.00	13.00	12.98	12.97	12.96
NDF, %	26.75	26.75	26.75	26.76	21.62	21.60	21.61	21.63
ADF, %	14.35	14.35	14.35	14.35	11.57	11.56	11.56	11.58
Ash, %	5.68	5.69	5.69	5.70	4.89	4.90	4.90	4.91
EE, %	4.49	4.49	4.49	4.49	4.35	4.35	4.35	4.35
NEm, Mcal/cwt	90.00	90.00	90.00	90.00	91.57	91.57	91.57	91.57
NEg, Mcal/cwt	60.41	60.41	60.41	60.41	61.63	61.63	61.63	61.63

Table 4. Diet formulation (d 50-161)

	d 50-59				d 60-161			
	Dietary BPZ inclusion, g/kg DM				Dietary BPZ inclusion, g/kg DM			
Items	**0**	**1**	**2**	**3**	**0**	**1**	**2**	**3**
DRC, %	46.76	46.79	46.79	46.75	60.54	60.58	60.57	60.53
MDGS, %	17.63	17.63	17.63	17.63	21.09	21.09	21.09	21.09
Soybean Hulls, %	2.38	1.60	0.74	0	2.52	1.69	0.79	0
Corn Silage, %	26.68	26.68	26.68	26.67	-	-	-	-
Grass Hay, %	2.83	2.83	2.83	2.83	11.95	11.95	11.95	11.95
Liquid Supplement, %	3.72	3.72	3.71	3.71	3.90	3.90	3.90	3.90
Treatment Supplement, %	0	0.75	1.62	2.40	0	0.79	1.71	2.54
DM, %	61.65	61.65	61.65	61.66	77.08	77.09	77.09	77.10
CP, %	13.09	13.08	13.07	13.06	14.06	14.05	14.04	14.04
NDF, %	23.35	23.34	23.34	23.36	21.92	21.90	21.90	21.93
ADF, %	12.73	12.72	12.72	12.74	12.66	12.64	12.64	12.66
Ash, %	5.25	5.25	5.26	5.27	5.91	5.91	5.95	5.96
EE, %	4.33	4.33	4.33	4.33	4.69	4.69	4.69	4.69
NEm, Mcal/cwt	90.30	90.30	90.30	90.30	93.10	93.10	93.10	93.10
NEg, Mcal/cwt	60.38	60.38	60.38	60.38	61.88	61.88	61.88	61.88

Table 5. Dietary BPZ inclusion (g/kg diet DM) effects on growth performance and dietary net energy utilization.

	Dietary BPZ inclusion					*P*-values	
Item	**0**	**1**	**2**	**3**	**SEM**	**Treatment**	**Contrasts[1]**
Pens, n	8	8	8	8	-	-	-
Steers, n	68	68	68	68	-	-	-
Days on feed	143.5	143.5	143.5	143.5	-	-	-
Initial BW, lbs	794	796	795	795	9.09	0.81	NS
Carcass adjusted performance							
Final BW, lbs	1399	1412	1416	1414	34.7	0.50	NS
DMI, lbs	25.35	25.58	25.51	25.65	0.382	0.78	NS
ADG, lbs	4.22	4.30	4.34	4.32	0.068	0.57	NS
ADG/DMI, lbs (G:F)	0.167	0.168	0.171	0.169	0.0036	0.76	NS
DMI/ADG (F:G) [2]	5.99	5.95	5.85	5.92	-	-	-
Observed diet NE, Mcal/cwt							
Maintenance	91.26	91.86	92.74	91.83	1.084	0.71	NS
Gain	61.44	61.97	62.74	61.94	0.951	0.71	NS
Observed:Expected diet NE, Mcal/cwt							
Maintenance	1.00	1.01	1.02	1.01	0.012	0.71	NS
Gain	1.01	1.02	1.04	1.02	0.016	0.71	NS
Maintenance Coefficient	0.075	0.073	0.071	0.073	0.0033	0.71	NS

[1]Contrasts: 1 = CON vs. average of 3 inclusion levels of BPZ; 2 = Linear; 3 = Quadratic.
**P* ≤ 0.05; [§]0.06 ≤ *P* ≤ 0.10; NS = not significant (*P* > 0.10).
[2] 1/G:F

Table 6. Dietary BPZ inclusion (g/kg diet DM) effects on carcass traits

	Dietary BPZ inclusion					*P*-values	
Item	**0**	**1**	**2**	**3**	**SEM**	**Treatment**	**Contrasts[1]**
Pens, n	8	8	8	8	-	-	-
Steers, n	68	68	68	68	-	-	-
Carcass traits							
Hot carcass weight, lbs	874	883	885	884	21.7	0.50	NS
Dressed yield, %	64.23	64.55	65.05	64.98	0.30	0.21	1*,2§
Ribeye area, in^2	14.34	14.30	14.02	14.15	0.32	0.43	NS
Rib fat, in	0.50	0.53	0.52	0.52	0.03	0.72	NS
Calculated YG	2.94	3.05	3.08	3.07	0.09	0.40	1*
Marbling score	422	415	414	417	9.93	0.94	NS
Estimated EBF, %	29.39	29.78	29.83	29.73	0.42	0.68	NS

[1]Contrasts: 1 = CON vs. average of 3 inclusion levels of BPZ; 2 = Linear; 3 = Quadratic.
*$P \leq 0.05$; §$0.06 \leq P \leq 0.10$; NS = not significant ($P > 0.10$).

Table 7. Dietary BPZ inclusion (g/kg diet DM) effects on categorical carcass outcomes

	Dietary BPZ inclusion				*P*-values	
Item	**0**	**1**	**2**	**3**	**Treatment**	**Contrasts**[1]
Pens, n	8	8	8	8	-	-
Steers, n	68	68	68	68	-	-
Distribution of USDA YG						
YG 1, %	7.5	4.4	3.0	8.8	0.50	NS
YG 2, %	46.3	50.0	41.8	32.4	0.21	2[§]
YG 3, %	41.8	36.8	47.8	48.5	0.49	NS
YG 4, %	4.4	4.4	7.4	8.8	0.66	NS
YG 5, %	0	4.4	0	1.5	0.82	NS
Distribution of USDA QG						
USDA Standard, %	0	0	1.5	0	1.00	NS
USDA Select, %	44.7	48.5	47.0	45.6	0.97	NS
USDA Low Choice, %	46.3	42.7	43.9	44.1	0.98	NS
USDA Average Choice, %	6.0	8.8	6.1	7.4	0.91	NS
USDA High Choice, %	3.0	0	1.5	2.9	0.95	NS
Liver abscess prevalence						
Normal, %	82.1	88.2	88.1	77.9	0.32	3[§]
Abscess, %	17.9	11.8	11.9	22.1	0.32	3[§]

[1]Contrasts: 1 = CON vs. average of 3 inclusion levels of BPZ; 2 = Linear; 3 = Quadratic.
*$P \leq 0.05$; [§]$0.06 \leq P \leq 0.10$; NS = not significant ($P > 0.10$).