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Influence of the β-Agonist, Zilpaterol, on Growth Performance and Carcass Characteristics of Feedlot Steers

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Abstract: One hundred forty crossbred steers (373±22 kg) were used in a randomized complete block design experiment (14 pens, 10 steers/pen) to evaluate the influence of supplementation of a steam-rolled wheat-based finishing diet with 6 mg kg^{-1} (as-fed basis) zilpaterol during the final 6 weeks of the finishing period on growth performance and carcass characteristics. Supplemental zilpaterol did not influence ($p>0.20$) DM intake (8.55 vs. 8.45 kg day^{-1}), but enhanced ($p<0.01$) ADG (33%, 1.45 vs. 1.93 kg day^{-1}) and feed efficiency (26%, 5.90 *vs.* 4.38). Based on observed NE intake, ADG of the non-supplemented steers was 99% of expected. In contrast, with zilpaterol supplemented steers ADG was 24% greater ($p<0.01$) then expected. Zilpaterol supplementation increased carcass weight (4.0%, $p<0.01$), dressing percentage (3.9%, $p<0.01$) and fat thickness (26%, $p<0.05$) and reduced KPH (14% $p>0.05$), but did not influence ($p>0.20$) LM area or marbling score. Adjusting to a constant carcass weight, zilpaterol supplementation increased gross (bone- and trim-in) primal cuts (1.7%, $p<0.01$), boneless closely trimmed primal cuts (2.9%, $p<0.05$) and boneless closely trimmed retail cuts (3.2%, $p<0.10$).

Key words: β-agonist, beef cattle, carcass characteristics, performance, zilpaterol

INTRODUCTION

Zilpaterol chlorhydrate (Zilmax®, Intervet México, México City) is an orally active type 2 β-agonist approved for use in feedlot cattle in Mexico (1996) and in the United States (2006). Feeding zilpaterol improved ADG, feed efficiency, carcass yield grade, HCW and dressing percentage in feedlot cattle when administered at 60 mg/head/day during the last 30 days of the feeding period (Avendaño-Reyes *et al*., 2006).

The objective of this study was to evaluate the influence of zilpaterol supplementation during the last 42 days of the feeding period on growth performance and carcass characteristics of crossbreed steers.

MATERIALS AND METHODS

All procedures involving live animals were conducted within approved animal care guidelines (NOM-051-ZOO-1995: Humanitarian care of animals during mobilization of animals; NOM-024-ZOO-1995: Animal health stipulations and characteristics during transportation of animals; NOM-EM-015-ZOO-2002: Technical stipulations for the controled use of beta agonists in animals and NOM-033-ZOO-1995, Humanitarian care and animal protection during slaughter process).

One hundred forty crossbred steers (approximately 20% Zebu breed with the remainder represented by Hereford, Angus and Charolais breeds in various proportions) with an average initial weight of 373±22 kg were used to evaluate the influence zilpaterol supplementation on growth performance and carcass characteristics. The trial was conducted in Mexicali, Baja California, Mexico. Steers were blocked by weight and randomly assigned, within weight groupings, to 14 pens (10 steers pen^{-1}). Pens were 510 m^2 with 64 m^2 overhead shade, automatic waterers and 17 m fence-line feed bunks. Treatments consisted of a steam-flaked wheat-based finishing diet (Table 1) supplemented (as fed basis) with 0 or 6 mg kg^{-1} zilpaterol (Zilmax; Intervet, SA de CV, México City, México. Steers were implanted with Revalor-S (Intervet, SA de CV, México City, México) upon initiation of the trial. Steers were allowed ad libitum access to experimental diets. Fresh feed was added twice daily. Zilpaterol was withdrawn from the diet during the final 2 day of the trial. Cattle were individually weighed, both at the start of the feeding trial and before shipment to a commercial abattoir (Rastro TIF 54) located 4 km from the feedlot facility. Steers were fed twice daily at 0800 and 1400 h in approximately 30:70 proportions. Daily feed allotments to each pen was adjusted to allow minimal (<5%) feed accumulation in the feed bunk. Feed samples

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were collected daily for DM analysis (forced-air oven; AOAC, 1984). Hot carcass weights were obtained from all steers at time of slaughter. After the carcasses were chilled for 48 h the following measurements were obtained: LM area (ribeye area), taken by direct grid reading of the eye muscle at the twelfth rib; subcutaneous fat over the eye muscle at the twelfth rib taken at a location 3/4 the lateral length from the chine bone end; kidney, pelvic and heart fat (KPH) as a percentage of carcass weight and marbling score (USDA, 1965). Yield of boneless, closely trimmed retail cuts from the round, loin, flank, rib, chuck, brisket and plate, as well as yields of subprimal cuts from tenderloin, knukle, inside round, gooseneck, heel, outside and inside skirt, back rib, short plate, triangle, chuck roll, chuck tender, flank steak, shank and neck were removed and weighed individually from 42 carcass (3 carcass pen^{-1}). In determining steer performance, initial and final weights were reduced 4% to account for digestive tract fill. Steer ADG (kg day^{-1}) was based on carcass adjusted final weights (carcass weight/0.628, where 0.628 is the average dressing percentage of all 140 steers/100). Energy gain (EG, Mcal day^{-1}) was calculated by the equation (NRC, 1984):

$$EG = ADG^{1.097} \times 0.0557\ BW^{0.75}$$

Maintenance Energy (EM) was calculated by the equation (Garret, 1971):

$$EM = 0.077\ BW^{0.75}$$

From the derived estimates of energy required for maintenance and gain, the NE_m and NE_g values of the diet were obtained using the quadratic formula (Zinn and Shen, 1998):

$$\frac{-b \pm \sqrt{b^2 - 4ac}}{2c}$$

where,

a = −0.41EM.
b = 0.877EM+0.41DMI+EG.
c = −0.877DMI.
NE_g = $0.877NE_m - 0.41$.

This trial was analyzed as a randomized complete block design experiment (Hicks, 1973). Pen means were used as experimental units. Treatments effects on yields of trimmed cuts were adjusted to a constant carcass weight by the inclusion of carcass weight as a covariate in the statistical model.

Table 1: Composition of experimental diets fed to steers

Item	Control	Zilpaterol[a]
Ingredient DM basis (%)		
Sudangrass hay	6.0	6.0
Ground wheat straw	3.0	3.0
Alfalfa hay	3.0	3.0
Steam-flaked wheat	73.0	73.0
Tallow	5.0	5.0
Molasses	7.3	7.3
Protein-mineral supplement[b]	2.7	2.7
Zilmax®[c]	---	++
Nutrient composition (DM basis)[d]		
NE_m (Mcal kg^{-1})	2.12	2.12
NE_g (Mcal kg^{-1})	1.46	1.46
Crude protein (%)	12.5	12.5
Ether extract	6.7	6.7
Calcium (%)	0.88	0.88
Phosphorus (%)	0.34	0.34

[a]Zilmax®, Intervet, México City, México, [b]Contained 50% CP and 20% Ca, [c]Supplemented (as fed basis) with 0 or 6 mg kg^{-1} zilpaterol (Zilmax, Hoechst Roussel Vet, D.F., Mexico), [d]Based on tabular values for individual feed ingredients (NRC, 1996)

RESULTS AND DISCUSSION

Dry matter intake averaged 8.5±0.28 kg day^{-1} and was not affected ($p>0.20$) by treatments. Compared with control steers, zilpaterol supplementation increased ($p<0.01$) ADG (33%), gain efficiency (26%) and reduced observed/expected DMI (25%). Based on observed NE intake, ADG of the non-supplemented steers was 99% of expected. In contrast, with zilpaterol supplemented steers ADG was 24% greater ($p<0.01$) then expected. Improved ADG and gain efficiency with no effect on DM intake has been a consist response with β-agonist supplementation in feedlot steers (Avendaño-Reyes *et al*., 2006; Abney *et al*., 2007) and heifers (Walker *et al*., 2006; Sissom *et al*., 2007). The large apparent increase in energy retention per unit DMI (25% reduction in observed *vs*. expected DMI, Table 2) is a reflection of the direct action of supplemental β-agonist on net protein retention and hence, lean tissue growth (Moody *et al*., 2000; Murdoch *et al*., 2005; Johnson and Chung, 2007). Live animal conformational changes (swelling, particularly over the loins and round) was readily observable visually within a few days of zilpaterol introduction into the diet.

Consistent with previous studies (Avendaño-Reyes *et al*., 2006; Vasconcelos *et al*., 2008) zilpaterol supplementation increased HCW (4.0%, $p<0.05$) and carcass dressing percentage (3.9%, $p<0.05$) and reduced KPH fat (14%, $p<0.05$). Increased carcass dressing percentage explained 52% (0.25 kg day^{-1}) of the increase (0.48 kg day^{-1}) in carcass adjusted ADG. Compared to control steers, zilpaterol supplementation increased HCW by 10.9 kg ($p<0.05$) (Table 3). The increase in carcass yield is slightly less than 13.1 kg, that reported by Casey (1998), but much lower than 21.9 and 17.2 kg, respectively

Table 2: Influence of zilpaterol supplementation on 42 day growth performance of feed lot steers and NE value of the diet

Item	Control	Zilpaterol[a]	SEM
Days on test	42	42	
Pen replicates	7	7	
Live weight (kg[b])			
Initial	376	371	4.8
Final[c]	437	454	6.6
Weight gain (kg day^{-1}[c, d])	1.45	1.93	0.9
DM intake (kg day^{-1})	8.55	8.45	0.18
Feed conversion[c]	5.90	4.38	0.20
Diet NE (Mcal kg^{-1})			
Maintenance[c]	2.11	2.57	0.06
Gain[c]	1.44	1.84	0.05
Observed/expected NE[e]			
Maintenance[c]	0.99	1.21	0.03
Gain[c]	0.99	1.26	0.03
DMI observed/expected	1.00	0.75	0.04

[a]Zilmax®, Intervet, México City, México, [b]Initial and final weight reduced 4% to account for fill, [c]Treatments differ (p<0.01), [d]Computed by using final BW = HCW/0.628, where 0.628 is the dressing percent average for all steers, [e]Expected diet NE based on tabular values for individual dietary ingredients (NRC, 1996)

Table 3: Influence of zilpaterol supplementation on carcass characteristics

Item	Control	Zilpaterol[a]	SEM
HCW (kg[b])	274.9	285.8	4.1
CCW (kg[b])	271.2	282.8	4.1
Dressing percentage[c]	61.7	64.1	0.4
KPH (%[b])	2.47	2.12	0.11
Fat thickness (cm[d])	0.45	0.57	0.04
LM area (cm^2)	82.5	84.9	1.5
Marbling score	3.49	3.43	0.04
Quality grade	3.56	3.46	0.07
Yield grade (%)	52.9	53.1	0.24

[a]Zilmax®, Intervet, México City, México, [b]Treatments differ (p<0.05), [c]Treatments differ (p<0.01), [d]Treatments differ (p<0.10)

Table 4: Influence of zilpaterol supplementation on yield wholesale cuts as a percentage of carcass weight

Item	Control	Zilpaterol[a]	SEM
Observations	21.00	21.00	
Wholesale cuts (%)			
Hindquarter			
Round			
Bone-in[b]	32.70	31.84	0.24
Boneless	34.99	34.54	0.42
Sirloin			
Bone-in[c]	8.75	9.21	0.12
Boneless[c]	7.92	8.62	0.14
Shortloin			
Bone-in	5.85	5.96	0.08
Boneless[b]	7.32	6.73	0.17
Flank			
Trim-in	8.78	9.01	0.19
Trim-out	6.50	6.74	0.16
Forequarter			
Rib	9.17	9.22	0.29
Shortplate	11.15	11.60	0.21
Chuck			
Bone-in	18.01	17.72	0.14
Boneless	12.70	12.82	0.13
Brisket			
Bone-in	12.14	11.98	0.13
Boneless	10.24	9.70	0.16
Total			
With trim[c]	73.26	74.38	0.22
Whithout trim[b]	49.66	51.13	0.50

[a]Zilmax®, Intervet, México City, México, [b]Treatments differ (p<0.05), [c]Treatments differ (p<0.01)

Table 5: Influence of zilpaterol on yield of subprimal cuts as percentage of carcass weight

Item	Control	Zilpaterol[a]	SEM
Observations	21.00	21.00	
Chuck tender	1.62	1.60	0.02
Neck[b]	3.73	4.16	0.09
Chuck roll[b]	5.31	4.76	0.09
Back rib[d]	1.06	1.01	0.02
Short rib[c]	1.03	0.96	0.02
Inside round[b]	6.03	6.24	0.07
Knukle[c]	9.27	9.97	0.21
Gooseneck[b]	5.78	5.52	0.06
Round shank[d]	1.64	1.58	0.02
Traingle[b]	0.64	0.75	0.03
Heel	1.46	1.48	0.03
Inside skirt[b]	0.35	0.39	0.01
Tenderloin	1.89	1.90	0.03
Flank steak[b]	0.23	0.14	0.01
Outside skirt[d]	0.96	0.91	0.02
Beef for stew[b]	3.49	3.04	0.08
Shank[d]	2.30	2.21	0.03
Tail	0.44	0.42	0.01
Pelvic fat	6.82	5.91	0.34
Bone	12.23	12.24	0.25
Trim fat	13.34	12.90	0.55

[a]Zilmax®, Intervet, México City, México, [b]Treatments differ (p<0.01), [c]Treatments differ (p<0.05), [d]Treatments differ (p<0.10)

reported by Avendaño-Reyes *et al*. (2006) and Vasconcelos *et al*. (2008).

In contrast with previous studies (Avendaño-Reyes *et al*., 2006; Vasconcelos *et al*., 2008) zilpaterol supplementation did not affect (p>0.20) LM area. There were no treatment effects (p>0.20) on quality grade nor marbling score.

Zilpaterol supplementation increased the percentage yield of boneless (p<0.01) and bone-in (p<0.001) sirloin cut. In contrast zilpaterol reduced the percentage of bone-in round (p<0.01), trimless brisket (p<0.05) and bonless short loin (p<0.05). Overall, zilpaterol supplementation increased both gross (bone- and trim-in) primal cuts (1.5%, p<0.01) and boneless closely trimmed primal cuts (3.0%, p<0.05) as a percentage of cold carcass weight (Table 4).

Zilpaterol supplementation increased yield, expressed as percentage of hot carcass weight, of the following retail cuts: knuckle (p<0.01), inside skirt (p<0.01), neck (p<0.01), inside round (p<0.05) and triangle (p<0.05). But, decreased (p<0.01) percentages of inside skirt, chuck roll, flank steak and short plate (Table 5). This differential responsiveness may be due to differences in the number, affinity, or specificity of the β-adrenergic receptors on the different muscles. It may also reflect differences in muscle fiber types present in these tissues (Chikhou *et al*., 1993). Overall, zilpaterol supplementation increased (3.2%, p<0.10) the yield of subprimal cuts as a percentage of cold carcass weights.

CONCLUSION

Zilpaterol supplementation has marked beneficial effect on growth performance of feedlot steers, enhancing weight gain and feed efficiency. However, because as much as one third of the increase in weight gain can be attributable to increased carcass yield (dressing percentage), cattle finished on zilpaterol should be marketed on a grade and yield basis. In addition to growth performance advantages, zilpaterol also will also improve percentage yields of primal and subprimal cuts. Enhanced growth performance accounts for 55% of the net economic value of zilpaterol supplementation (benefit to the feeder), while increased carcass cutability accounts for 45% of the net value (benefit to the meat packer and retailer). Thus, the economic benefit to zilpaterol supplementation will be optimized through integrated production and meat purveying systems.

REFERENCES

Abney, C.S., J.T. Vasconcelos, J.P. McMeninam, S.A. Keyser, K.R. Wilson, G.J. Vogel and M.L. Galyean, 2007. Effects of ractopamine hydrochloride on performance, rate and variation in feed intake and acid-base balance in feedlot cattle. J. Anim. Sci., 85:3090-3098. http://jas.fass.org/cgi/content/full/85/11/3090.

AOAC, 1984. Official Methods of Analysis. Association of Official Analytical Chemists. Washington, D.C. http://www.aoac.org.

Avendaño-Reyes, L., Torres-Rodríguez and V. Meraz-Murillo, 2006. Effect of two β-adrenergic agonist on finishing performance, carcass characteristics and meat quality of feedlot steers. J. Anim. Sci., 84: 3259-3265. http://jas.fass.org/cgi/content/full/84/12/3259.

Chikhou, F.H., A.P. Moloney, P. Allen, R.L. Joseph, P.V. Tarrant, J.F. Quirke, F.H. Austin and J.F. Roche, 1993. Long-term effects of cimaterol in Friesian steers: II. Carcass composition and meat quality. J. Anim. Sci., 71: 914-922. http://jas.fass.org/cgi/reprint/71/4/914.

Garrett, W.N., 1971. Energetic efficiency of beef and dairy steers. J. Anim. Sci., 32: 451-456. http://jas.fass.org/cgi/reprint/32/3/415.

Hicks, C.R., 1973. Fundamental Concepts in the Design of Experiments. Holt, Rinehart and Winston, Publisher. 2nd Edn. New York. ISBN: 0030617065.

Johnson, B.L. and K.Y. Chung, 2007. Alteration in the Physiology of Growth Cattle with Growth-Enhancing Compounds. Veterinary Clinics of North America: Food Animal Practice. In: Hollis, L.C. and K.C. Olson (Eds.). W.B. Saunders Co. Philadelphia, PA., 23: 321-332. ISBN: 0749-0720.

Moody, D.E., D.L. Hancock and D.B. Anderson, 2000. Phenethanolamine Repartitioning Agents. Farm Animal Metabolism and Nutrition. In: D'Mello, J.P.F. (Ed.). Cabi Publishing, New York, pp: 65-96. ISBN: 0851993788.

Murdoch, G.K., E.K. Okine and R.J. Christopherson, 2005. Metabolic Modifiers in Animal Nutrition: Potential Benefits and Risks. Biology of Nutrition in Growing Animals. In: Mosenthin, R.J. Zentek and T. Zebrowska (Eds.). Elsevier Publisher. Philadelphia, PA. ISBN: 0444512322, 4: 135-178.

NRC, 1984. Nutrient Requirement of Beef Cattle. 6th Rev. Edn. National Academy Press, Washington, D.C. ISBN: 0-309-03447-7.

NRC, 1996. Nutrient Requirements of Beef Cattle. 7th Rev. Edn. National Academy of Press. Washington D.C. ISBN: 0-309-05426-5.

Sissom, E.K., C.D. Reinhardt, J.P. Hutcheson, W.T. Nichols, D.A. Yates, R.S. Swingle and B.J. Johnson, 2007. Response to ractopamine-HCl in heifers is altered by implant strategy across days on feed. J. Anim. Sci., 85: 2125-2132. http://jas.fass.org/cgi/ content/full/85/9/2125.

USDA, 1965. Official United States Standards for Grades of Carcass Beef. C&MS, SRA 99. http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELDEV3002979.

Vasconcelos, J.T., R.J. Rathmann, R.R. Reuter, J. Leibovich, J.P. McMeniman, K.E. Hales, T.L. Covey, M.F. Miller, W.T. Nichols and M.L. Galyean, 2008. Effects of duration of zilpaterol hydrochloride feeding and days on the finishing diet on feedlot cattle performance and carcass traits. J. Anim. Sci., DOI: 10.2527/jas.2008-1032.

Walker, D.K., E.C. Titgemeyer, J.S. Drouillard, E.R. Loe, B.E. Depenbusch and A.S. Webb, 2006. Effects of ractopamine and protein source on growth performance and carcass characteristics of feedlot heifers. J. Anim. Sci., 84: 2795-2800. http://jas.fass.org/cgi/content/full/84/10/2795.

Zinn, R.A. and Y. Shen, 1998. An evaluation of ruminally degradable intake protein and metabolizable amino acid requirements of feedlot calves. J. Anim. Sci., 76: 1280-1289. http://jas.fass.org/cgi/content/full/76/5/1280.