COMPARISON OF THE EFFECTS OF TWO LEVELS OF THE BETA-ADRENERGIC AGONIST RACTOPAMINE AND ZILPATEROL, OVER THREE EXPOSURE PERIODS, ON MEAT QUALITY.

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Abstract - The aim of this study was to compare the effects of different levels and exposure times of ractopamine on meat tenderness (Warner Bratzler shear force, WBSF), and purge of beef loin. Twelve treatment groups were represented by a 20 (R20) and 30 ppm (R30) level of ractopamine inclusion, a standard inclusion level for zilpaterol (ZIL) and a control (CO). In addition, three slaughter days including all four treatments represented 28 (S1), 35 (S2) and 42 (S3) days exposure to the three beta-adrenergic agonist treatments with a control group for each (COS1, COS2, COS3, R20S1, R20S2, R20S3, R30S1, R30S2, R30S3, ZILS1, ZILS2, ZILS3). The results showed no consistent evidence that either level or duration of ractopamine exposure has any significant effect on meat tenderness. In contrast, zilpaterol recorded higher WBSF values than control and ractopamine samples at shorter post mortem aging times (3 days). All groups improved in tenderness to levels that should be perceived as acceptable to the consumer. Zilpaterol showed the biggest improvement over 20 days and it was surprising that no differences were recorded between the various R20 groups and zilpaterol after 20 days while R30 groups were still slightly more tender. Very few effects were seen regarding purge.

Key Words – ractopamine, zilpaterol, meat quality.

I. INTRODUCTION

Growth rate and feed efficiency are both important traits in livestock production, and because consumers demand leaner meat, more emphasis has been placed on carcass composition with less fat and more muscle [1]. The introduction of beta-adrenergic agonists represents the latest use of pharmacologically active compounds which have opened up new prospects for improving efficiency and quality of meat products [2]. The beta-agonist is added to feed for the purpose of promoting protein synthesis in muscle tissues and lipolysis in adipose tissue, resulting in a reduction of carcass fat and an increase of muscle mass of the carcass [3]. Beta-agonists significantly influence growth by improving lean content, reducing carcass fat and overall by having a positive effect on growth rate without there being a change in feed intake [4].

Most South African feedlots (75% of meat produced in South Africa) supplement with a beta-adrenergic agonist during the final weeks of finishing. Beta-agonists however, tend to have a negative effect on tenderness and animals supplemented with beta-agonists seem to produce tougher meat [5]. This is due to an increase in the activity of calpastatin, an inhibitor to the calpains. The degree of these changes depends on the species, type of muscle, the particular beta-adrenergic agonist as well as the time and duration of supplementation [2].

Recently a new beta-adrenergic agonist, ractopamine, has been registered for use in South African feedlots. We therefore investigated the effect of two levels of dosage, as well as three exposure periods, of this new product on meat quality, namely tenderness and drip loss, as well as compared its effects to those of the widely used zilpaterol hydrochloride and a negative control (no beta-adrenergic agonist).

II. MATERIALS AND METHODS

From a larger group of animals subjected to the twelve treatments studied in this project, two hundred and forty feedlot type steers were used in the study. The treatments were, control (CO) which received a commercial feedlot diet only, groups that received (on a dry matter basis)

ractopamine supplementation at 20ppm (R20), at 30ppm (R30) and groups which received zilpaterol hydrochloride at 6 ppm (ZIL). Each treatment had three exposure levels namely, S1 which received supplementation for the final 28 days of feeding, S2 which received supplementation for an additional 7 days (35 days) to S1 and S3 which received supplementation for an additional 14 days (42 days) compared to S1. The twelve treatment groups were therefore COS1, COS2, COS3, R20S1, R20S2, R20S3, R30S1, R30S2, R30S3 ZILS1, ZILS2, ZILS3. For meat quality purposes, three post-mortem aging groups (3, 14 and 20 days) were specified for each of the twelve treatment groups.

The longissimus thoracis muscle of a standardised three rib cut (ribs 11 to 13) was sampled from the left side of each carcass at the abattoir the day after slaughter. Samples were packed in plastic bags (not vacuum-packed) and then transported to the Meat Science building at the Agricultural Research Council and stored overnight in a chiller room (±4°C) and processed the following day.

Samples of the loin muscle (LT) were cut into 30mm steaks for shear force measurement, vacuum packed and stored at ±4°C to be aged for 3, 14 and 20 days post-mortem. Aged samples were then frozen at -20°C, since it was impossible to evaluate all samples fresh. Frozen samples were then thawed at ±4°C for 24 h before preparation.

For Warner Bratzler Shear Force (WBSF), thawed steaks were prepared according to an oven-broiling method using direct radiant heat [6]. Steaks were cooked at 200°C until an internal temperature of 70°C was reached. Broiled steaks were then cooled down at room temperature to an internal temperature of ±18°C. Six cylindrical samples (12.5 mm core diameter) of each sample were cored parallel to the grain of the meat, and sheared perpendicular to the fibre direction using a Warner Bratzler shear device mounted on a Universal Instron apparatus (cross head speed = 200 mm/minute, one shear in the centre of each core). The reported value in kg represented the average of the peak force measurements of six cores per steak.

Drip loss or purge for aged samples was determined by measuring the amount of purge remaining in the vacuum bag after removing the 30mm steak for colour (results not discussed here) measurement at 14 and 20 days post mortem. The steak was removed and lightly dried with tissue paper. Drip was expressed as a percentage of the combined mass of the aged steak and the drip.

Data of WBSF and purge were subjected to analysis of variance with the 12 treatment groups used as main effects. Means separation was achieved by Fisher's protected t-test least significant difference (LSD) at the 5% level [7].

III. RESULTS AND DISCUSSION

Table 1 shows means and collective standard error of the means for WBSF at 3, 14 and 20 days aging. Because of slaughter day effects that could not be overcome, and could have had an effect on meat quality, we decided to look at the treatments vs their control within a slaughter group first, then at the groups relative to each other (exposure levels) and finally within a level of supplementation at different exposure periods.

At 3 days aging both ractopamine groups did not differ significantly from their respective control groups. In all three cases however the ZIL groups

Table 1: Mean values and standard error of means for WBSF (kg)

	D3	D14	D20
COS1	5.18^{e}	3.49^{c}	3.38^{e}
COS2	5.36^{de}	4.05^{bc}	3.62^{bcde}
COS3	5.58^{cde}	4.05^{bc}	3.59^{cde}
R20S1	5.43^{de}	4.14^{ab}	4.17^{ab}
R20S2	5.61^{cde}	4.36^{ab}	4.11^{abc}
R20S3	5.95^{bcd}	4.32^{ab}	3.80^{abcde}
R30S1	5.47^{de}	3.85^{bc}	3.55^{de}
R30S2	5.60^{cde}	4.16^{ab}	3.55^{de}
R30S3	5.68^{cde}	3.97^{bc}	3.46^{e}
ZILS1	6.25^{abc}	4.14^{ab}	4.05^{abcd}
ZILS2	6.71^{a}	4.67^{a}	4.05^{abcd}
ZILS3	6.52^{ab}	4.73^{a}	4.06^{abcd}
SEM	0.259	0.219	0.197
P	<0.001	0.009	0.009

^{a,b,c,d}*Means in the same column with different superscripts differ significantly (P<0.05)*
SEM Standard Error of Means

were significantly tougher than all the other groups. The latter was expected as ZIL usually results in tougher meat compared to no beta-adrenergic agonist being used as it increases the level of calpastatin in the muscle which is an inhibitor to the calpains which are responsible for the breakdown of the muscle fibers post mortem and therefore ultimately for meat tenderness [8]. It is also interesting to note that this group was tougher than the ractopamine groups, also a beta-adrenergic agonist as supported by previous studies [8].

When comparing the various levels over the different exposure periods once again there was no significant difference between the control and ractopamine groups but the ZIL groups once again stood out as being significantly tougher. Within the different levels of supplementation there were no significant differences between the three exposure periods however there was a numerical increase in WBSF (an increase in toughness) with an increase in exposure time to the supplementation. This was however also the case for the control group which could mean there was a slaughter day effect. The ZILS2 group had the highest numerical value of the three ZIL groups which was unexpected.

At 14 days aging there was a similar pattern to day 3. There were however some differences in the S1 groups with the R20S1 being significantly tougher than its control group and in fact being as tough as the ZIL group. In both the S2 and S3 exposure groups there was no significant difference between the ractopamine and zilpaterol groups. This is an indication that the ZIL groups aged at a faster/better rate when compared to the ractopamine groups. Again there was no significant difference within a level of supplementation over different exposure periods, there was however a numerical difference with the S2 groups being slightly tougher than the S1 groups but with no real numerical difference between the S2 and S3 groups.

The pattern was slightly different at 20 days aging. In the S1 group the R20 level of supplementation was once again significantly tougher than the control group and as tough as the ZIL group. The R30 group was as tender as the CO group and significantly more tender than the R20S1 and R20S2 groups. Within levels of supplementation there was once again no significant difference over the three exposure periods.

When looking at the improvement over the aging period, the R30 groups show greater aging potential when compared to the R20 groups with a decrease of 1.9 kg, 2.0kg and 2.2kg for R30S1, R30S2 and R30S3 at 3, 14 and 20 days, respectively when compared to R20S1 (1.3Kg), R20S2 (1.5kg) and R20S3 (2.2kg). The final levels of the R30 group were also significantly more tender than the R20 group. The S3 groups also showed a greater improvement from D3 to D20 than any of the other groups but the fact that this was also the case for the control and zilpaterol groups suggests a slaughter day effect. Most of the aging that occurred happened between day 3 and day 14 with minimal aging happening between day 14 and day 20. Interestingly, the S3 group aged more from day 14 to day 20 than did the other 2 exposure periods (0.5 – 0.7 kg compared to 0.1 – 0.4 kg). This shows delayed aging for this particular exposure period. This could however also be explained by a slaughter day effect as the same was seen for the CO group.

It must also be noted that at 3 days aging none of the groups, including the controls, were at an acceptable level of tenderness for consumer satisfaction but at 14 days all the groups were at relatively acceptable levels except for the ZILS2 and ZILS3 groups. There was further improvement with aging up to day 20 with even all the ZIL groups reaching satisfactory levels of tenderness. This is according to Miller *et al*. [9], who reported a transition in consumer perception from tender to tough beef to occur between 4.3 and 4.9 kg of WBSF based on $\geq$ 86% consumer acceptability. Consumer acceptability for tenderness decreased from 86% at 4.3 kg for a "slightly tender" rating to 59% at 4.9 kg for a "slightly tough" rating. Their data further suggested that consumer WBS tenderness values of < 3.0, 3.4, 4.0, 4.3, and > 4.9 kg would result in 100, 99, 94, 86, and 25% customer satisfaction for beef tenderness, respectively.

Table 2 shows that there was a significant difference between treatment groups for purge at

Table 2: Mean values and standard error of means for purge (%)

	Drip % D14	Drip % D20
COS1	3.5^{de}	3.6^{bc}
COS2	4.5^{ab}	3.5^{bc}
COS3	3.4^{de}	2.5^{d}
R20S1	3.0^{e}	3.9^{ab}
R20S2	4.1^{abcd}	3.7^{abc}
R20S3	3.0^{e}	2.7^{d}
R30S1	3.7^{bcde}	4.1^{ab}
R30S2	4.7^{a}	3.7^{abc}
R30S3	3.6^{cde}	3.2^{cd}
ZILS1	4.2^{abcd}	4.5^{a}
ZILS2	4.4^{abc}	4.2^{ab}
ZILS3	3.0^{e}	2.7^{d}
SEM	0.292	0.270
P	<0.001	<0.001

^{a,b,c,d}Means in the same column with different superscripts differ significantly (P<0.05)
SEM Standard Error of Means

14 and 20 days. Day 14 and day 20 showed similar patterns with the various treatment groups within an exposure period not differing significantly from one another. This was surprising as it was expected the ZIL groups would have significantly higher purge as found in previous studies.

Hope-Jones *et al*. [10] and Strydom *et al*. [8] showed that supplementation with zilpaterol leads to higher purge when compared to control groups. The main reason for this phenomenon is the movement in muscle fibre type from red to white fibre types (beta agonists increase proportions of white muscle fibres). The latter type is more prone to protein denaturation during rigor mortis (subsequently causing lower water binding) particularly when electrical stimulation is applied and/or the chilling rate is slow. At 14 days, the S2 group had significantly more purge than the other two exposure periods for both ractopamine groups and the control and at day 20 the S3 group had significantly less purge than the other two exposure times for all treatments. As with shear force, this may be indicative of slaughter day effect, rather than treatment effects and probably of no commercial significance.

IV. CONCLUSION

Within the scope of this trial, supplementing ractopamine at 20 and 30 ppm for 28, 35 or 42 days before slaughter should not impact negatively on meat quality and that meat that is aged for 14 days should present good eating quality. There is a slight but significant indication that aged loin of ractopamine 30 ppm may produce slightly more tender meat than the lower supplementation level of 20 ppm.

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