EFFECT OF TWO BREEDS AND TWO DIETARY CONCENTRATE LEVELS ON FEEDLOT PERFORMANCE, CARCASS MERIT, TENDERNESS PARAMETERS AND FATTY ACID PROFILES

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ABSTRACT

The objectives of this study were to investigate the different characteristics of the newly introduced breed, Waguli (Wagyu x Tuli) when comparing it with the Brahman breed. Twenty-four animals were used. Six steers of each breed were fed 94% concentrate diet (94C) and the other six were fed 86% concentrate diet (86C). Eight steers, two from each group, each were harvested at 128 days, 142 days, and 156 days on feed.

Feedlot performance data indicated that Waguli steers were highly efficient ($P < 0.05$) and gained more than Brahman steers on a daily basis ($P < 0.05$). There were no breed, diet or days on feed effects regarding serum urea nitrogen, but there was a significant interaction between breed x diet and between breed x days on feed ($P < 0.05$).

Carcass characteristic data showed that Waguli steers have larger ribeye area with more 12th rib fat thickness, marbling score and higher quality grade ($P < 0.05$). Moreover, there was a significant difference in carcass protein percentage over the Brahman ($P < 0.05$).

It is well known that Wagyu is a highly marbled and tender Japanese breed. It was found that the reason for the Waguli tenderness and low shear force values to be the low level of calpastatin activity ($P < 0.05$), the inhibitor of the postmortem proteolytic enzyme-calpain. While the toughness of the Brahman meat was due to the high level of calpastatin activity. The calpain activity did not differ between the two breeds. Shear

force values agreed with the calpain and calpastatin activities data, in which the Waguli steaks showed less shear force values at day 7 and 10 postmortem than the Brahman steaks ($P < 0.05$). However, at day 14 postmortem there was no difference in shear force values between the two breeds ($P < 0.05$).

Fatty acid data analysis indicated that Waguli steers had a profile with less saturated fatty acids (SFA) in intramuscular (C17:0) and subcutaneous fat (C14:0 & C16:0) than Brahman steers. However, Brahman steers had less C22:0 in intramuscular (i.m.) fat and less C18:0 in subcutaneous (s.c.) fat than Waguli steers. Also, Waguli steers showed more unsaturated fatty acids (UFA) content (C18: 2, C18: 2c9t11, C18: 2c10t12, C18: 2c12t10, C18: 3, C20: 3, C20: 4, C20: 5, C22: 1, C22: 2, C22: 4, C22: 3& C22: 6) than those in Brahman steers in i.m. fat compartment. Brahman steers possessed more C14: 1& C18: 1c9 than Waguli steers in i.m. fat. On the other hand, in s.c. fat, Waguli steers had more mono- (C11: 1, C12: 1, C13: 1, C14: 1& C20: 1) and polyunsaturated fatty acids (PUFA) than Brahman steers (C18: 2c12t10, C18: 2c9t11, C20: 2& C20: 5). Brahman had more C22: 1, C22: 2& C 18: 1c9 than Waguli steers in subcutaneous (s.c.) fat. Looking at the ratio of unsaturated fatty acids (UFA) to saturated fatty acids (SFA), it is observed that Waguli steers had a greater ratio than Brahman steers.

To our knowledge this is the first report to show a favoring effect of Waguli breed regarding UFA content. In addition, these data might impact the choice of breed with respect to the beef consumer preference and health prospective.

Beef consumers have health related concerns about beef in part due to the high content of SFA, which increase cholesterol level in the blood and the low content of UFA, which decrease cholesterol level in the blood.

In conclusion, Waguli steers produce tender meat with good marbling ability, which likely to satisfy the consumers demand. In addition, they have a desirable average daily gain and feed efficiency with high polyunsaturated fatty acids comparatively with Brahman steers.

1. INTRODUCTION

1.1 Problem Definition

Satisfaction of beef consumers from both the eating quality and health consciousness views is an important goal to achieve. Tenderness and the related palatability is a central consumer perception. In addition, the health concerns of beef consumers regarding consumption of more unsaturated fatty acids rather than saturated fatty acids is increasing. In an attempt to find a breed that possesses superior meat quality with heat tolerance to adapt in southwest USA, and to investigate its different fatty acids profile; Waguli breed has been developed at The University of Arizona V-V ranch, near Camp Verde, Arizona. This was achieved by crossing the Japanese Wagyu breed with the South African Tuli breed.

1.1.1 Objectives of the Current Research

The main objectives of the current research were to 1) investigate the feedlot performance including serum urea nitrogen concentration of the Waguli and Brahman steers, 2) investigate the different carcass characteristics and composition of both breeds, 3) Answer the question regarding tenderness of Waguli meat and toughness of Brahman meat "Is the tenderness Waguli meat due to high calpain activity or low calpastatin activity?" likewise, for the Brahman "Is the toughness of Brahman meat due to high calpastatin activity or low calpain activity?" and 4) Determine the fatty acids profile of subcutaneous and intramuscular fat in both breeds.

1.2. Literature Review

1.2.1. Overview of Wagyu breed

The word Wagyu refers to all Japanese beef cattle where 'Wa' means Japanese or Japanese-style and 'gyu' means cattle (http://www.ansi.okstate.edu/breeds/cattle/wagyu). In Japan, producers use different management procedures than what we use in the USA. Most cattle in Japan are essentially on feed all of their lives because grazing land is not available. So, cattle are raised in total confinement from birth to slaughter. Cattle are often fed a finishing diet for at least 16 months and are 30-34 months of age in the case of steers and up to 46 months old for heifers prior to slaughter. Because cattle are fed so long, and particularly in summer months when the interaction of fat cover, temperature and humidity depresses feed intake, many cattle go off feed. When this happens, beer is fed to the cattle to stimulate appetite. They merely feed beer as part of an overall management program designed to keep the cattle on feed (http://www.briggsranchgenetics.com).

Also, cattle are sometimes massaged in Japan. It is a practice required occasionally for cattle that are tied in one place for months and have no opportunity to exercise. The massaging is done to make the animal more comfortable and relieve stress due to stiffness that can result from inactivity. Cattle often become so lethargic that they will not get up and eat without coaxing. The massaging prolongs the length of time that

cattle can be fed before they go to slaughter and thereby increases fat deposition (http://www.briggsranchgenetics.com).

Brushing cattle with beer or sake is another practice, as Japanese producers believe that hair coat and softness of skin are related to carcass quality in Wagyu cattle. Consequently, judges at livestock shows in Japan, place considerable emphasis on hair coat in the ranking of fed cattle. Thus, brushing the hair coat with sake improves the appearance and softness of the animal's hair coat and is therefore of economic importance in show cattle (http://www.briggsranchgenetics.com). In 1976, two Japanese Black and two Japanese brown sires were imported into the United States from Japan. The bulls were mated to Angus and other breeds of cows. Consequently, the American Wagyu is really a hybrid of Japanese Black and Japanese Brown (http://www.briggsranchgenetics.com).

Moreover, beef breeds such as Japanese Black and Japanese Brown, which are known as Wagyu, have a unique fat deposition pattern characterized by a greater extent of marbling (Lunt et al., 1993). Also, it has been reported that Japanese breeds had greater carcass fat proportions and lesser carcass lean and bone proportions than Holsteins (Ozutsumi et al., 1984) .A study conducted at Washington State University (Xie et al., 1996) showed that Wagyu-sired steers had more marbling and less external fat than Angus-sired steers and there is the possibility to select for improved marbling using the Wagyu breed. It has been reported that American Wagyu beef was more palatable than Angus and Longhorn beef (Busboom et al., 1993).

Marbling is an important factor in determining quality grade, carcasses with inadequate marbling result in two ways loss. One is a monetary loss, when the carcass does not grade USDA Choice or Prime. The other is inadequate marbling which affects eating quality and consumer satisfaction (Smith, 1995). Wagyu cattle are characterized by their genetic capability to produce highly palatable meat via depositing high amounts of intramuscular fat (Kuber et al., 2004; Lunt et al., 1993; May, 1993; Mir et al., 1999a; Mir et al., 2002; Yamazaki, 1981). Moreover many research studies have emphasized the low shear forces values of the longissimus muscle (high tenderness), high quality (USDA choice) and yield grade (1 and 2) of Wagyu carcasses (Kuber et al., 2004; Wheeler et al., 2004). Myers et al., (1999) documented that Wagyu crossed steers had a 76-unit-higher marbling score than Angus crossed steers and Pitchford et al., (2002) found that ribeye area from carcasses of Wagyu-sired steers had a greater percentage of intramuscular fat than that of Hereford sired steers. In order to reach these high levels of marbling, the Japanese utilize a unique management system, as we mentioned earlier, and the animals are fed for an extended period of time (552 days). Therefore, Wagyu genetics may be the final ingredient needed to develop a type of animal that will perform efficiently, improve consistency, and maintain uniformity (Elias Calles et al., 2000).

1.2.2. Overview of Tuli breed

Tuli is a pure African Sanga breed classified as *Bos Taurus*. It has been developed from crosses between Zebu and *Bos Taurus* cattle thousands of years ago in Africa. In its origin, it showed high fertility and maternal performance (Oliver, 1983; Schoemasn, 1989). So, Tuli breed is comparable to the Brahman in its environmental characteristics such as heat tolerance, parasite resistance and foraging ability (http://www.briggsranchgenetics.com). In addition, it is characterized by early maturing traits with maternal superiority (Holloway et al., 2002).

1.2.3. Overview of Brahman breed

The Brahman breed originated from *Bos Indicus* cattle originally brought from India. Through centuries of exposure to inadequate food supplies, insect pests, parasites, diseases and the weather extremes of tropical India, the native cattle developed some remarkable adaptations for survival (http://www.ansi.okstate.edu/breeds/cattle/brahman/).

All the *Bos Indicus* cattle are characterized by a large hump over the top of the shoulder and neck. Spinal processes below the hump are extended, and there is considerable muscular tissue covering the processes. The other characteristics of these cattle are their horns, which usually curve upward and are sometimes tilted to the rear. Their ears, which are generally large and pendulous, and the throatlatch and dewlap, have a large amount of excess skin that help with heat dissipation. They also have more highly

developed sweat glands than European cattle (*Bos Taurus*) and so can perspire more freely. *Bos Indicus* cattle produce an oily secretion from the sebaceous glands, which has a distinctive odor and is reported to assist in repelling insects (http://www.ansi.okstate.edu/breeds/cattle/brahman/). Brahman cattle have favorable environmental characteristics such as heat tolerance, parasite resistance and foraging ability (http://www.briggsranchgenetics.com).

1.2.4. Feedlot performance

The goal to improve production efficiency have immediate the beef cattle industry and researchers to assess the performance of various genotypes of cattle and methods of production that result in higher quality meat. Feeding grain diets to cattle result in more tender, flavorful and juicy meat than that from forage-fed cattle. Steers fed concentrated diet exhibited an average daily gain that was 0.85 kg/d higher than steers fed on pasture(Myers et al., 1999). A study conducted a 194 day feeding trial to compare the feedlot performance of 205 day old calves placed directly on a high concentrate finishing diet with calves allowed a growing period of 76 days before being placed on the finishing diet. At the end of the 76 days growing period, the steers on the high- concentrate finishing diet were 19.5 kg heavier and had gained 0.28 kg/d more than the steers on the high roughage grower diet (Lancaster et al., 1973). Myers et al., (1999) tested the effect of breed type on steers' performance and found that steers (3/4 Simmental × ¼ Angus) were 18 kg heavier than the steers (3/4 Angus × ¼ Simmental) without difference

between steers (3/4 Angus × ¼ Simmental) and steers (1/2 Wagyu × ¼ Angus × ¼ Simmental). In the same study, researchers concluded that no differences existed between breed types for the number of days on feed (Myers et al., 1999).

Different opinions in the literature exist regarding days on feed. For example, only approximately 65 days on feed were needed for purebred Angus steers to reach Choice grade (Greene et al., 1989). Whereas, 210 days were necessary for purebred Hereford steers fed 80 % concentrate diet to reach Choice (Zinn et al., 1970). Moreover, days on feed to reach slaughter end point for Angus steers was greater than for Brahman crossbred groups (Huffman et al., 1990). In a study comparing percentage Brahman and Angus breeding, researchers found that ½ Brahman and ¾ Brahman were heavier at the time they were placed in the feedlot, had heavier final feedlot weights, and consumed more feed per day than the Angus and ¼ Brahman steers (Huffman et al., 1990). Others reported that Angus steers had greater average daily gain and spent fewer days in the feedlot than Brahman steers did (Adams et al., 1982).

Another study was conducted to compare feedlot performance between Angus cross and Wagyu cross-heifers and calves (Wertz et al., 2002). In this study, Wagyu cross calves were heavier than Angus calves, but less efficient gains for Wagyu calves than Angus calves were reported. Also, among early weaned, concentrate fed steers, Wagyu-cross steers tended to be less efficient than British crossbred steers (Myers et al., 1999). Moreover, many researches compared feedlot performance between Brahman-sired steers and Tuli-sired steers (Cundiff et al., 1994; Franke, 1997; Herring et al., 1996) and they

addressed the fact that Tuli-sired steers had lower feedlot daily gains and smaller slaughter weights than steers by Brahman sires.

1.2.5. Serum urea nitrogen

Blood metabolite concentrations fluctuate with nutritional status, and efforts have been made to utilize these fluctuations as indicators of the adequacy of feeding management (Blowey et al., 1973; Russel and Wright, 1983). Thus, monitoring of serum urea nitrogen (SUN) is a tool that can be used for determining protein and energy status in cattle (Hammond et al., 1993). Also, SUN can be used as the mirror that reflects the changes in the rumen as it is highly correlated to ruminal ammonia (Hammond, 1983a; Hennessy and Nolan, 1988; Thornton, 1970).

When the energy level is kept constant in the diet, increasing dietary protein increases SUN concentrations (Hammond, 1983a). Mean SUN concentrations increased from 2.6 mg/dl to 11.1 mg/dl as dietary crude protein increased from 6 to 18 % of the diet (Hammond, 1983a). For growing steers, SUN levels between 11 and 15 mg/dl were associated with maximum rates of gain (Byers and Moxon, 1980). While, for finishing steers, maximum performance was associated with SUN concentrations of 7 to 8 mg/dl (Preston et al., 1978).

Increasing dietary energy intake while keeping protein intake constant would be expected to decrease SUN (Chase et al., 1993). At high level of energy intake SUN averaged 5.6 mg/dl and at low level of energy intake SUN averaged 19.7 mg/dl. Low

SUN concentration was associated with more efficient use of nitrogen in the rumen (Thomas and Kelly, 1976). Moreover, reduction in SUN concentrations has been associated with augmentation in animal performance (Kennedy and Siebert, 1972). Lower concentrations of SUN in Hereford cows compared to Senepol cows (Hammond, 1992) and lower concentrations of SUN in Angus bulls compared to Senepol bulls (Chase et al., 1993) suggests differences in protein utilization between breeds.

Other researchers observed lower concentrations of SUN in Hereford compared to Brahman cattle (Hunter and Siebert, 1985), lower SUN in Angus compared to Brahman (Olbrich, 1996), and lower SUN in Angus × Hereford cattle compared to Brahman crosses (Coleman and Frahm, 1987). A higher plasma urea nitrogen in tropical breeds, Brahman and Senepol than those of temperate Angus bulls was documented (Valencia et al., 2001). In a study comparing Japanese Black, Japanese Brown and Holstein steers, gradual increase in urea nitrogen by time was observed and it seemed to reflect the surplus of substrate for protein metabolism as the fattening process progressed (Matsuzaki et al., 1997).

1.2.6. Carcass characteristics

The society is becoming more health conscious, consequently, current beef consumers tends to shift toward the consumption of leaner beef and beef products. However, at the same time, they do not want to sacrifice eating quality (Savell et al., 1987). Therefore, the ability to produce palatable healthy meat is a challenging task to achieve. Days fed (Dolezal et al., 1982a; Tatum et al., 1980; Zinn et al., 1970b) and

subcutaneous fat thickness (Dolezal et al., 1982b; Tatum et al., 1982) are traits that have been associated closely with beef palatability, especially tenderness. The effect of fat deposition on meat tenderness has been the spotlight of many discussions. As the animal grows, fat is deposited subcutaneously and intermuscularly first, which insulates muscles from the effects of refrigeration and consequently prevent "cold-shortening" which induces toughness. Then, fat is deposited intramuscularly (marbling) in the perimysial connective tissue.

A dilution of fibrous connective tissue by deposited fat decreases the resistance to shearing or chewing resulting in a low shear force values and palatability due to tenderness (Moloney et al., 2001). Brahman cattle have been known to assess low carcass quality traits, mainly marbling (Adams et al., 1982; Butler et al., 1956; Carpenter et al., 1961; Cole et al., 1963; Crockett et al., 1979; Crouse et al., 1989; Cundiff et al., 1993; Huffman et al., 1990; Koch et al., 1982; Peacock et al., 1979; Whipple et al., 1990; Young et al., 1978). The reduction in marbling scores is directly related to the negative reputation of Brahman breed due to tenderness problems (Johnson et al., 1990a). Marbling scores decreased linearly with increasing percentage of Brahman breeding (Pringle et al., 1997). Also, Casas and Cundiff, (2003) showed that animals with Brahman inheritance had lower marbling when compared with British breeds.

On the other hand, others have found higher marbling score for Tuli-sired than for Brahman-sired steers (Cundiff et al., 1998; Franke, 1997; Herring et al., 1996). Wagyu breed is well known for its marbling ability (May, 1993; Mir et al., 1999a; Mir et al., 2002; Yamazaki, 1981) as compared to their Angus contemporaries (Lunt et al., 1993;

Wertz et al., 2002) or Wagyu × Limousin cross (Kuber et al., 2004). Myers et al., (1999) documented that Wagyu crossed steers had a 76-unit-higher marbling score than Angus crossed steers. Also, ribeye area from carcasses of Wagyu-sired steers had a greater percentage of intramuscular fat than that of Hereford sired steers (Pitchford et al., 2002). In a study done to compare carcass characteristics between Wagyu-sired steers, Herford-sired steers and Angus-sired steers, Wheeler et al., (2004) found that Wagyu-sired steers had the highest percentage of USDA Choice, Yield grade 1 and 2 carcasses, but their carcasses were the lightest. Mir et al., (2002) documented the fact that breed of cattle influenced marbling score and as a result quality grade.

In comparing the carcass traits of Wagyu steers, with Wagyu x Limousin and Limousin steers, it has been found that carcasses from Wagyu steers had the highest marbling score, followed by those from crossbred steers, and carcasses from Limousin steers had the lowest marbling scores (Mir et al., 2002). Moreover, 34% of the Wagyu carcasses graded Choice, and 66% of these carcasses graded Prime, while 8% of the carcasses from the crossbred steers graded Select and 92% graded Choice (Mir et al., 1999a; Mir et al., 2002). Comparing Wagyu heifers with Angus heifers, 60% more Wagyu heifers graded USDA Prime than Angus heifers (Wertz et al., 2002). As Wagyu crossed steers had a higher marbling score than Angus crossed steers, 19% more Wagyu crossed carcasses graded greater than or equal to Choice and 82% more graded greater than or equal to Average Choice (Myers et al., 1999). However, as the percentage of Brahman breeding increased the percentage of carcasses graded USDA Choice decreased and those graded select and standard increased (Huffman et al., 1990; Pringle et al.,

1997), and Angus crosses had the most desirable quality grade when compared with Brahman crosses (Damon et al., 1960; Paschal et al., 1995).

Other researchers found no difference in quality grade between Brahman and Tuli steers (Chase et al., 2001; Franke, 1997). Regarding yield grade, researchers indicated that yield grades were higher in Brahman crossbred steers than in Angus crossbred steers (Huffman et al., 1990; Paschal et al., 1995) and higher than Tuli crossed steers (Chase et al., 2001). Young et al., (1978) reported that Brahman-sired steers had poorer yield grades even though they had the least amount of fat opposite the ribeye. Wertz et al., (2002) documented that Wagyu calves had more subcutaneous fat cover and higher yield grade (3.6) than Angus calves (3.1).

1.2.7. Tenderness

Tenderness is an important factor in palatability. Since palatability determines consumer satisfaction, thus tenderness does as well. Calpain and calpastatin are responsible for postmortem tenderness of meat. The calpain system is composed of three molecules, two of which are Ca^{++} dependent proteases (μ and m-calpain) while the third molecule is a Ca^{++} dependent protease inhibitor, which is named calpastatin (Goll et al., 2003). Calpastatin is the only known protein inhibitor for calpain (Goll et al., 2003) and it plays a central role regarding the rate and extent of postmortem proteolytic activity and hence, postmortem tenderness (Koohmaraie et al., 1995). Breed differences are related to difference in tenderness due to variation in postmortem muscle proteolysis (Shackelford et al., 1994; Whipple et al., 1990; Wulf et al., 1996). The calpain and its inhibitor,

calpastatin, are the main elements responsible for postmortem tenderization of beef muscle (Koohmaraie, 1992, 1988).

Selection for low calpastatin activity is thought to be useful for enhancement of meat tenderness especially in *Bos Indicus* breed, as they possess inherently high calpastatin activity resulting in tough meat (Cundiff, 1993). Several researches indicated that the calpain system has an important role in meat tenderization (Dransfield, 1992b; Koohmaraie, 1992; Koohmaraie et al., 1988). However, Morgan et al., (1993) found no difference in calpain activity in muscles of bulls and steers and reached the conclusion that higher calpastatin activity results in less tender meat due to decreased proteolysis by calpain.

Previous researches done on meat from *Bos Indicus* cattle (Shackelford et al., 1991; Wheeler et al., 1990; Whipple et al., 1990), in which it was found that the postmortem activity of calpastatin is highly related to the rate of proteolysis and tenderness in meat from *Bos Indicus* cattle. Moreover, O'Connor et al., (1997) reported lower level of calpastatin activity in *Bos taurus* steers than in *Bos Indicus* steers. On the contrary, Kuber et al., (2004) did not find any breed effect on 0-hour calpastatin activity when compared meat from Wagyu, Limousin and Wagyu x Limousin.

It is well accepted that high level of calpastatin activity is related to reduced proteolysis in beef from *Bos Indicus* cattle (Johnson et al., 1990b; Wheeler et al., 1990; Whipple et al., 1990) and associated with high percentage of Brahman breeding (Pringle et al., 1997).