THE EFFECTS OF PAYLEAN® ON LIVE ANIMAL PERFORMANCE, CARCASS CUTABILITY AND QUALITY, BELLY FIRMNESS AND FATTY ACID COMPOSITION OF PIGS SORTED INTO PREFINISHING BACKFAT CLASSES USING REAL-TIME ULTRASOUND

by

KELLY J. MIMBS

(Under the direction of T. Dean Pringle)

ABSTRACT

One hundred forty – four finishing pigs were evaluated using real-time ultrasound and selected into fat and lean pens based on 10th rib backfat (fat difference $\geq$ 0.5 cm). All pigs received a basal corn and soybean meal diet containing 18% crude protein and 1.1% lysine and half of the pens received Paylean supplementation of 10 ppm. Pigs were assignment to a 2 x 2 factorial arrangement with two backfat classes (lean and fat) and two levels of Paylean® supplementation (0 and 10ppm). Paylean improved finishing performance by improving feed efficiency and decreasing feed intake but had no affect on average daily gain. Paylean supplementation improved quality and carcass composition. Fatty acid composition and iodine value between ractopamine supplemented and control pigs were similar to those observed in lean versus fat pigs. Thus, Paylean was effective in improving live performance and lean growth while fat and belly quality was not diminished.

Key Words: Paylean, Pork, Ultrasound

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INTRODUCTION

The current US pork production systems use phenotypic selection to enhance lean gain and feed efficiency in finishing pigs; however, producers nevertheless have to overcome the challenge of feeding large pens of pigs where considerable variation in lean growth potentials and performance exist. Even with the application of genetic and nutritional knowledge, it is challenging to improve finishing performance and cutability without detrimentally affecting carcass quality, belly firmness, and fatty acid composition. Thus, the challenge is to find a method to improve performance and leanness while maintaining quality.

A recently approved product, ractopamine (RAC; Paylean®, Elanco Animal Health, Greenfield, IN), is a phenethanolamine that increases average daily gain (Watkins et al., 1990; Stites et al., 1991; He et al., 1993; Dunshea et al; 1998a), improves feed efficiency (FE) (Aalhus et al., 1990; Watkins et al., 1990; Yen et al., 1990; Gu et al., 1991a; Stites et al., 1991; He et al., 1993; Dunshea et al., 1998a) and decreases feed intake (FI) (Crenshaw et al., 1987; Aalhus et al., 1990; Watkins et al., 1990; Gu et al., 1991b;) in swine while reducing fat and increasing lean tissue (Crenshaw et al., 1987; Watkins et al., 1989; Aalhus et al., 1990; Mitchell et al., 1990; Watkins et al., 1990; Bark et al., 1992) by altering metabolism (Liu et al., 1989; Peterla and Scanes, 1990; Bark et al., 1992; Akanbi and Mersmann, 1996). While carcass fat reduction satisfies the consumer's demands, altered lipid metabolism and carcass fat reduction can alter fatty acid profiles, and belly firmness and thickness. However, the limited body of literature

that exists suggests that RAC has little or no effect on fatty acid composition (Lee et al., 1989; McKeith et al., 1990; Engeseth et al., 1992; Perkins et al., 1992). Furthermore, Stites et al. (1991) and Uttaro et al. (1993) reported that RAC supplementation did not affect belly thickness. However, the results from these authors do not address effects of Paylean on various fat depots, such as the belly and leaf fat, nor belly firmness in terms of Paylean elicited changes.

There is also little published data about the response of pigs with varied lean growth potentials (i.e. fat versus lean pigs) to Paylean. Yen et al. (1990) supplemented obese and lean pigs with RAC and reported improvements in feed intake (FI) and feed efficiency (FE). However, there is a lack of sufficient research reporting the response of fat and lean pigs to RAC in regards to cutability, meat quality and fatty acid composition. Thus, the objective of this study was to determine the response in live animal performance, ultrasound lean and fat accretion, carcass cutability and quality, belly firmness and fatty acid composition of pigs supplemented with RAC sorted into prefinishing backfat classes.

LITERATURE REVIEW

Ractopamine, (RAC; Paylean®, Elanco Animal Health, Greenfield, IN), is a phenethanolamine with beta – adrenergic activity and acts as a repartitioning agent. Ractopamine has a structure similar to that of the catecholamines epinephrine (hormone) and norepinephrine (neurotransmitter). Initially, beta – adrenergic agonists (β-AA) were investigated due to their potentially positive effects on human heath (e.g. treating asthmatics, muscle atrophy, and obesity), as these hormones are responsible for regulating smooth muscle contraction, blood pressure, cardiac rate, lipolysis, and glycogenolysis (Mersmann, 1989). As a result, research with β-AA in animals began to emerge and now ractopamine is being used to enhance animal performance and promote lean growth in meat animals.

Beta – Adrenergic Agonist Mechanism

Beta – Adrenergic Receptors: Adrenergic agonist receptors were first classified by Ahlquist in 1948 as alpha (α) or beta (β) receptors. These subclasses have respective G-proteins that serve as secondary signals (G_i and G_s) (Northup, 1985). "Alpha receptors are responsible for gut contraction and cerebral, skin and salivary gland arterioles, and β-receptors are responsible for heart rate, contractility, bronchodilation and stimulation of lipolysis" (Mersmann, 1989). Lands et al. (1967) later classified β-receptors into β_1 and β_2-receptors. Emorine et al. (1989) reported another β-receptor (β_3). This receptor may play a role in mediating catecholamine action. The β_3-receptors are typically more

sensitive to β-AA than β_1 and β_2-receptors and are less prone to agonist-induced desensitization (Ding et al., 2000).

The receptor type varies according to tissue type. McNeel and Mersmann (1999) reported that porcine adipocytes have 70% β_1, 20% β_2, and 10% β_3- receptors and that muscle cells have 60% β_1, 39% β_2, and <1% β_3-receptors. This information is crucial as ractopamine is a nonselective β-AA. Ractopamine has a binding affinity similar to epinephrine; however, ractopamine has a lower capacity to stimulate lipolysis than epinephrine, which is unrelated to its ability to bind to the receptor (Liu et al., 1989).

β-receptors are part of the seven - transmembrane segment receptor family. This classification indicates that the receptors have seven transmembrane helices. In addition, the receptors have two extracellular recognition sites for the ligand and the correct G protein (Mersmann, 1998; Garrett and Grisham, 1999).

β-AA Primary Signal: A β-AA binds to β-adrenergic receptors and activates a G_s-protein. The G_s-protein, in turn, activates adenylyl cyclase. Adenylyl cyclase is the enzyme that synthesizes cyclic adenine 3', 5' - monophosphate (cAMP), which binds to the enzyme protein kinase to phosphorylate and activate proteins such as hormone sensitive lipase and glycogen phosphorylase (Buttery and Dawson, 1987; Mersmann, 1989 and 1998;). It is also noteworthy that phosphorylation of glycogen synthase and acetyl CoA carboxylase by protein kinase is inhibitory (Mills et al., 1990; Mersmann, 1998; Garrett and Grisham, 1999;). Thus, lipolysis and glycogenolysis are stimulated, and glycogen and fatty acid biosynthesis are inhibited under conditions where cAMP is elevated.

After the aforementioned mechanism is initiated, the receptor is phosphorylated and removed from the cell surface (Ding et al., 2000). If the rate of receptor exposure to β-AA is greater than the rate of receptor replacement, the cell is then less sensitive to stimulation and attenuates the effect of the β-AA (Spurlock et al., 1994).

G-Protein the β-AA Mechanism Secondary Signal: Adenylyl cyclase cannot be activated in the absence of the G-protein (Rodbell, 1980). There are two classifications of G-proteins: G_s (stimulates adenylyl cyclase) and G_i (inhibits adenylyl cyclase) (Northup, 1985). G_i and G_s proteins are capable of binding with guanine triphosphate (GTP). These proteins have three subunits (α, β, and γ), and the α-subunit dissociates when GTP binds to the G proteins; the α-subunit binds with adenylyl cyclase, thus eliciting a response (Garrett and Grisham, 1999). The G protein has intrinsic guanine triphosphatase (GTPase) activity. When GTPase hydrolyses GTP to guanine diphosphate (GDP), the α-subunit reassociates with the β and γ-subunits (Rodbell, 1980; Garrett and Grisham, 1999).

Ractopamine-Stimulated Changes in Swine Performance

Dietary ractopamine supplementation has been shown to increase daily gain, improve feed efficiency, and decrease feed intake in swine. The effect of feeding ractopamine on daily gain, feed efficiency, and intake, however, varies. Numerous studies have indicated that feeding ractopamine improves feed efficiency (FE) (Aalhus et al., 1990; Watkins et al., 1990; Yen et al., 1990; Gu et al., 1991a; Stites et al., 1991; He et al., 1993; Dunshea et al., 1998a). Alternatively, few researchers have reported that dietary ractopamine did not affect FE (Crenshaw et al., 1987). Average daily gain (ADG) and feed intake responses are more inconsistent than FE. Researchers have

reported dietary ractopamine significantly increases ADG (Anderson et al., 1987; Watkins et al., 1990; Stites et al., 1991; He et al., 1993; Dunshea et al.; 1998a) and feed intake (Crenshaw et al., 1987; Aalhus et al., 1990; Watkins et al., 1990; Gu et al., 1991b;). Factors, such as protein supplementation, level of ractopamine feeding, age, starting weight, genotype, sex and temporal affects, are factors that maybe partially responsible for inconsistencies reported in performance trials.

The level of ractopamine supplementation varies between studies. Watkins et al. (1990) determined that the efficacious dose for ADG and FE was between 14 and 18 ppm for the maximum response when a 16% crude protein diet was fed. In addition, crude protein level may need to be adjusted in order to maximize lean growth response and potential. Xiao et al. (1999) determined that increased ADG and FE would be evidenced with increased protein. In cases where crude protein was below approximately 13%, growth responses were depressed when compared to higher levels of dietary crude protein (Adeola et al., 1990; Mitchell et al., 1990). Ractopamine supplemented diets containing 17 or 20% crude protein were fed to pigs, and additional crude protein (3%) supplementation did not influence pig performance (He et al., 1993). Many researchers have conducted ractopamine supplementation trials at 16% crude protein and have seen significant increases in ADG, FE, and feed intake (Prince et al., 1987; Watkins et al., 1989; Watkins et al., 1990; Yen et al., 1990; Stites et al., 1991; Sainz et al., 1993b).

It is well defined that different breeds of swine have varied lean gain potential, and swine producers strive to increase ADG and FE because of the financial advantage. The question remains as to whether or not pigs of different genotypes respond differently to ractopamine. Gu et al. (1991a) reported that a favorable heterosis for growth exists in

crossbred pigs: however, no significant interaction between genotype and ractopamine was found.

In temporal studies, chronic exposure led to diminished responses as ractopamine caused down-regulation of receptors (Yang and McElligott, 1989; Dunshea, 1991). Sainz et al. (1993a) reported attenuation in growth enhancement and performance during prolonged exposure to ractopamine. Spurlock et al. (1994) reported that 50% of β-receptors on porcine adipocytes were down regulated when stimulated by ractopamine. In the same study, β-receptors numbers were not decreased in skeletal muscle when pigs were fed ractopamine for 28 days. This attenuation effect on fat cells can be prevented by feeding ractopamine at an alternating feeding schedule where ractopamine feeding is alternated on weekly or biweekly basis. Additionally, step-up feeding programs, which increase the amount of ractopamine fed over the finishing period, are capable of negating the attenuation response (Herr et al., 2001; Armstrong et al., 2003).

Age or starting weight is of concern in the feeding of β-AA. For example, cimaterol, another β-AA given to young pigs had no effect on performance, and Sainz et al. (1993b) reported a 30% greater response in ADG and FE of older, heavier pigs than younger pigs. One reason for this may be that younger animals may have fewer receptors and lower affinities for β-AA (Mersmann, 1989; Metabolic Modifiers, 1994).

Finally, the effect of ractopamine and gender has been investigated. Several experiments have determined that ractopamine improved ADG and FE regardless of sex (Dunshea, 1991; He et al., 1993; Dunshea et al., 1998a), and Dunshea (1991) reported that ractopamine treatment in growing pigs tended to normalize gender differences in performance.

Ractopamine Induced Changes in Live Animal Composition

Ractopamine acts as an analogue for epinephrine and norepinephrine in order to elicit desirable repartitioning affects by altering the rate of lipolysis, lipogenesis, protein synthesis, and breakdown, which in turn changes accretion rates of fat and lean. Determination of accretion rates has been accomplished by pre-trial harvest methods and by ultrasound evaluation.

Changes in Fat Accretion Due to Altered Lipid Metabolism: Fat accretion is a balance between the breakdown and synthesis of lipids (Buttery and Dawson, 1987). Researchers have determined that ractopamine had no affect on backfat accretion (He et al., 1993; Sainz et al., 1993b; Dunshea et al., 1998a). Conversely, Bark et al. (1992) reported a decreased rate of fat accretion when pigs were supplemented with 20 ppm of ractopamine. These changes are potentially due to changes in lipogenesis and lipolysis.

Research conducted to determine the lipolytic and lipogenic activity in response to ractopamine has been done *in vitro* and *in vivo*; however, most has been done *in vitro*. Early data suggest that lipid biosynthesis is reduced in pigs supplemented with ractopamine (Liu et al., 1989; Mills and Liu, 1990a; Peterla and Scanes, 1990) by as much as 40% (Mills et al., 1990b). Alternatively, other studies suggest that ractopamine had no effect on fatty acid synthesis (Dunshea, 1993; Liu et al., 1994; Dunshea et al., 1998c).

In lipogenesis, fatty acids are synthesized using acetyl and malonyl groups. Acetyl Coenzyme A (acetyl CoA) is derived from glucose via a series of reactions of the glycolytic pathway. Acetyl CoA is then converted to malonyl CoA by the enzyme acetyl CoA carboxylase. Subsequently, acetyl and malonyl groups undergo a series of reductive

reactions to add more carbon groups to form fatty acids such as palmitate and oleate. Acetyl CoA carboxylase is inactive when phosphorylated by protein kinase and cAMP. Thus, phosphorylation inhibits *de novo* fatty acid synthesis (Garrett and Grisham, 1999; Mersmann, 1998).

Mills and Liu (1990) determined that lipogenesis is more sensitive to ractopamine than is lipolysis. Liu et al. (1994) found no change in lipid metabolism in pigs supplemented with ractopamine due to acetyl CoA carboxylase activity; however, this study determined that outer backfat had significantly higher acetyl CoA carboxylase activity than middle layer backfat. Additionally, the malic enzyme responsible for converting malate to pyruvate (Garrett and Grisham, 1999) was more active in the middle layer backfat than the outer layer backfat. This is important because malonyl groups are used in fatty acid biosynthesis.

Some researchers have observed an increase in lipolysis in pigs supplemented with ractopamine (Liu et al., 1989; Peterla and Scanes, 1990). However, a number of researchers have determined that ractopamine does not increase the mobilization and oxidation of lipids from adipose tissue (Mills et al., 1990; Mills and Liu, 1990; Dunshea, 1993; Liu et al., 1994; Dunshea et al., 1998c; Dunshea et al., 1998b).

In lipolysis, triacylglycerols are broken down into free fatty acids which are released from adipose tissue into circulation. Fatty acids are stored in adipose tissue as triglycerides and are mobilized by epinephrine, glucagons, and adrenocorticotropic hormone (ACTH), which activate protein kinase to phosphorylate hormone sensitive lipase (HSL). HSL hydrolyzes fatty acids from triacylglycerols. These nonesterfied free

fatty acids then undergo a process called beta oxidation to form acetyl CoA. Acetyl CoA can then be fed back into the Citric Acid Cycle to produce ATP for energy.

Mills et al. (1990b) determined that ractopamine increases the levels of cAMP to allow protein kinase mediated phosphorylation of enzymes. Yet, if cAMP is blocked, protein kinase cannot be phosphorylated and then metabolic enzymes responsible for lipid metabolism cannot be activated or inhibited, thus preventing ractopamine action. Cyclic AMP is sensitive to the presence of intracellular adenosine (Dunshea, 1993). The presence of adenosine deaminase (to reduce amounts of adenosine) ractopamine elicits a lipogenic and lipolytic response (Mills and Liu, 1990a). It is noteworthy that insulin—the pancreatic hormone responsible for glucose utilization and promotion of protein, fatty acid and glycogen synthesis (Garrett and Grisham, 1999)-- antagonizes the action of ractopamine by decreasing the cell sensitivity particularly in adipocytes (Mills and Liu, 1990a). Taking the preceding information into consideration, it is important to realize that fat accretion is a result of lipid metabolism. Thus, any changes in fat accretion are due to ractopamine-directed changes in lipolysis and lipogenesis.

Changes in Protein Accretion Due to Altered Protein Metabolism: Ractopamine enhances protein accretion rates in the skeletal muscles of pigs (Helferich et al., 1988). Muscle accretion is determined by the rate of protein breakdown and synthesis. Ractopamine, included in the diet at 20 ppm, has been shown to increase the rate of carcass muscle accretion (Bark et al., 1992; He et al., 1993; Dunshea et al., 1998c). Conversely, Gu et al. (1991b) determined that ractopamine had no affect on lean accretion.

Postnatal muscle growth is mainly hypertrophic in nature. In the beginning, the nature of β-AA action on muscle was somewhat elusive as to whether degradation or synthesis was responsible for the increase in accretion. Garber et al. (1976) attempted to resolve some of the ambiguity surrounding this issue. He determined that epinephrine decreased the release of amino acids from muscle (alanine and glutamine), and the effect is mediated by β- receptors and adenylate cyclase system, accounting for the inhibition of muscle protein degradation. Furthermore, research with ractopamine showed that decreased protein degradation may be partially due to decreased calpain system I activity, accounting for hypertrophic response (Sainz et al., 1993a). Helferich et al. (1988) administered ractopamine to pigs and determined that *Longissimus dorsi* actin protein synthesis was increased by 50%. These studies suggested that ractopamine affects muscle protein accretion by increased synthesis. Thus, protein accretion is affected by decreased breakdown and increased synthesis or decreased turnover. Bergen et al. (1989) determined that ractopamine increased protein accretion but was accounted for by increases in both protein synthesis and an degradation. Inverse to these positive repartitioning affects, Adeola et al. (1992) determined that fractional synthesis, breakdown, and accretion were not affected by ractopamine supplementation. Within the same study, however, ractopamine did significantly increase the fractional rate of myofibrillar synthesis and absolute protein content of the *Longissimus dorsi* and *Biceps femoris.*

Regardless of the differences in the aforementioned research, it is acceptable to conclude that any ractopamine - related increase in accretion is due to hypertrophy and not hyperplasia. This is demonstrated by the ratio of DNA to protein. Skeletal muscle

fibers are multinucleated, and each nucleus supports a given amount of protein. Ractopamine administered for 42 days caused a decrease in the DNA content of pig muscles (Bergen et al., 1989). This indicated muscle hypertrophy in the absence of new DNA synthesis.

Beta – adrenergic agonist treatment increases RNA transcription for several skeletal proteins such as α-actin and myosin light chain (Mersmann, 1998). This is in agreement with the research conducted by Helferich et al. (1988), as ractopamine increased the amount of α-actin mRNA in *Longissimus* muscle. Other research found no change in RNA concentration in the *semitendenosis* muscle of pigs fed ractopamine (Bergen et al., 1989). Thus, hypertrophy without a concomitant increase in DNA indicates that protein synthesis and degradation are affected by ractopamine (Mills, 2002).

Investigation continues to determine whether the presences of additional hormones or growth factors (such as insulin or growth hormone) are required to obtain a significant protein accretion response (Buttery and Dawson, 1987). It has also been suggested that because β-AA increase blood flow to skeletal muscle, that increased amounts of nutrients are available to the muscle for growth (Mersmann, 1998; Mills, 2002).

Carcass Quality, Composition and Cutability

Carcass Quality: In the past, pork meat quality has been of little concern to the producers and industry. Today, however, many pork packing companies are aware of the need to dedicate more attention to pork quality compared to other red meat species. Feeding some β-AA, such as salbutamol, can negatively affect quality (Warriss et al.,

1990). Conversely, ractopamine has been shown to have little or no effect on pork quality measures. Ultimate pH (Aalhus et al., 1990; Sainz et al., 1993b; McKeith and Ellis, 2001) and L* values of the loin were not affected by the supplementation of dietary ractopamine (Aalhus et al., 1990; Sainz et al., 1993b; Uttaro et al., 1993). As for a* and b* values of the loin, Uttaro et al. (1993) determined that ractopamine significantly decreased a* (redness) and b* (yellowness) values. However, Sainz et al. (1993b) determined that ractopamine had no effect on a* or b*. In a few studies, ractopamine has elicited an improvement in objective color, firmness (Watkins et al., 1990), and marbling scores (Aalhus et al., 1990); however, in several other studies these measurements were not affected by ractopamine supplementation (Stites et al., 1991; Crome et al., 1996; McKeith and Ellis, 2001). Thus is appears that feeding ractopamine will not negatively impact pork quality and cause economic losses due to quality defects.

Carcass composition: Ractopamine feeding has been shown to decrease carcass fat and increase carcass lean, as well as improve dressing percentage and hot carcass weight (HCW). The proportion of carcass fat and lean is the standard by which producers are paid for their product. As the industry moves toward this value-based pricing system, this principle will become more influential on pig production systems. Many researchers have reported an increase in dressing percentage due to ractopamine use (Watkins et al., 1989; Watkins et al., 1990; Stites et al., 1991; Sainz et al., 1993b; Crome et al., 1996; Schinckel et al., 2002), which would indicate an increase in edible carcass tissues and not an increase in viscera mass. Additionally, Watkins et al. (1990) and Bark et al. (1992) reported that ractopamine had no effect on HCW; however, other

studies have reported an increase in HCW (Yen et al., 1990; Stites et al., 1991; Crome et al., 1996).

Many researchers have found that feeding ractopamine decreases average backfat (Hancock et al., 1987; Mitchell et al., 1990; Watkins et al., 1990; Yen et al., 1990; Bark et al., 1992), with 10th rib backfat particularly reduced when compared to other depots (Anderson et al., 1987; Crenshaw et al., 1987; Prince et al., 1987; Watkins et al., 1989; Watkins et al., 1990; Yen et al., 1990; Bark et al., 1992; Crome et al., 1996). Alternatively, some researchers have reported that dietary ractopamine had no effect on 10th rib backfat depth (Adeola et al., 1990; Stites et al., 1991; He et al., 1993; Sainz et al., 1993b). As for other backfat measures, Crome et al. (1996) and Adeola et al. (1990) determined in two separate studies that dietary ractopamine decreased first rib fat and had no significant effect in reducing last rib fat. There were however differences across studies in the effect on last lumbar vertebrae (LLV) fat as one study determined that fat thickness was decreased (Crome et al., 1996) and the other found that there was no significant effect on LLV (Adeola et al., 1990). In the review of literature, it appears that few researchers are interested in reporting the first rib, last rib, and LLV measurements separately, as most instead reported average backfat.

Ractopamine consistently increases carcass lean. In numerous studies, loineye area (Anderson et al., 1987; Crenshaw et al., 1987; Hancock et al., 1987; Prince et al., 1987; Watkins et al., 1989; Adeola et al., 1990; Mitchell et al., 1990; Watkins et al., 1990; Yen et al., 1990; Stites et al., 1991; Bark et al., 1992; Crome et al., 1996; Herr et al., 2002; Schinckel et al., 2002) and depth at the 10th rib were increased by dietary ractopamine (Adeola et al., 1990; He et al., 1993). A limited number of studies exist that

show that ractopamine did not increase loineye area (Sainz et al., 1993b). Carcass muscle scores were increased by ractopamine (Watkins et al., 1990; Crome et al., 1996); however, few studies have reported on this trait.

Carcass Cutability: These improvements in carcass lean and fat are a result of ractopamine-directed changes in lipogenesis, lipolysis, and protein breakdown, and synthesis. These measurements, however, are used only as indicators of actual cutability or yield. Thus, cutability trials have been conducted to determine actual yields and proportions of fat and lean. Carcass dissection has revealed that ractopamine decreases carcass fat and increases carcass lean (Crenshaw et al., 1987; Watkins et al., 1989; Aalhus et al., 1990; Mitchell et al., 1990; Watkins et al., 1990; Bark et al., 1992). He et al. (1993) agreed with this finding and stated that the reduction in fat was due to decreased subcutaneous fat.

The weight and yield of untrimmed and trimmed cuts improved due to the increase in muscle and decrease in fat. The weight of untrimmed carcass cuts was variable between studies. Some researchers reported an increase in untrimmed weight of the ham, loin (Stites et al 1991; Crome et al., 1996), picnic (Yen et al., 1990; Crome et al., 1996), and Boston Butt (Crome et al., 1996). However, most studies found that the weights of untrimmed cuts were not significantly different in pigs supplemented with ractopamine compared to pigs on the control diet (Yen et al., 1990; Stites et al., 1991; Bark et al., 1992; Uttaro et al., 1993; Crome et al., 1996). When cuts in these studies were trimmed and expressed as the weight of fat and lean, however, the data suggest an increase in lean and a decrease in fat. The weight of the trimmed ham, loin, belly, Boston Butt, and picnic increased (Aalhus et al., 1990; Adeola et al., 1990; Yen et al., 1990;

Uttaro et al., 1993; Crome et al., 1996) in numerous studies with a concomitant decrease in the weight of the fat (Aalhus et al., 1990; Bark et al., 1992), yet there were no significant changes in some of the trimmed cuts.

When trimmed weights are expressed as a percentage of side weight, the change in muscle due to ractopamine is evident. Stites et al. (1991) and Crome et al. (1996) observed that an increased percentage of the carcass was composed of trimmed ham and loin. In the same studies, no significant change in the percentage (of side weight) was observed in the belly, picnic, or Boston Butt.

Crome et al. (1996) measured boneless, trimmed retail cuts and denoted an increase in the weight of the *Psoas major*, Boston Butt, picnic, ham, and loin due to ractopamine supplementation. Upon further dissection of the ham, the weights of the inside, outside, and knuckle were increased and the amount of subcutaneous fat was decreased due to ractopamine. In the swine packing industry, increased yields translate into improved economic gains.

Fatty Acid Composition: Ractopamine has been shown to have little or no effect on fatty acid composition in different depots of pork carcasses (Lee et al., 1989; McKeith et al., 1990; Engeseth et al., 1992; Perkins et al., 1992). Ractopamine decreased stearic acid and increased linolenic acid in subcutaneous backfat: however, other fatty acids within this depot were unaffected by ractopamine supplementation (Lee et al., 1989; Engeseth et al., 1992). Additionally, ractopamine increased the linoleic acid content of the *Longissimus dorsi* intramuscular fat and had no effect on other fatty acids present in Longissimus marbling (Perkins et al., 1992). Other researchers indicated similar results, as ractopamine had no effect on the intramuscular fatty acid composition of the

Longissimus dorsi (Lee et al., 1989; McKeith et al., 1990; Engeseth et al., 1992). Accordingly, very little change occurred in the fatty acid profiles of subcutaneous or *Longissimus dorsi* intramuscular fat depots.

Literature Cited

Aalhus, J.L., S.D.M. Jones, A.L. Schaefer, A.K.W. Tong, W.M. Robertson, J.K. Merrill, and A.C. Murray. 1990. The effect of ractopamine on performance, carcass composition and meat quality of finishing pigs. Can. J. Anim. Sci. 70:943 - 952.

Adeola, O., E.A. Darko, P. He, and L.G. Young. 1990. Manipulation of porcine carcass composition by ractopamine. J. Anim. Sci. 68:3633 - 3641.

Adeola, O., R.O. Ball, and L.G. Young. 1992. Porcine skeletal muscle myofibrillar protein synthesis is stimulated by ractopamine. J. Nutr. 122:488 - 495.

Ahlquist, R.P. 1948. A study of adrenotropic receptors. Am. J. Physiol. 153:586.

Akanbi, K.A. and H.J. Mersmann. 1996. Beta-adrenergic receptors in porcine adipocyte membranes: Modification by animal age, depot site, and dietary protein deficiency. J. Anim. Sci. 74.551 – 561.

Anderson D.B., E.L. Veenhuisen, W.P. Waitt, R.E. Paxton, and D.H. Mowrey. 1987. The effect of ractopamine on nitrogen retention, growth performance and carcasscomposition of finisher pigs. J. Anim. Sci. 65 (Suppl. 1):130 (Abstr.)

Armstrong, T.A., T.A. Marsteller, B.T. Kremer, R.D. Muller, and J.E. Weatherford. 2003. Effects of ractopamine step-up programs on finishing pigs under commercial conditions. J. Anim. Sci. 82. (Suppl 2):52 (Abstr.)

Bark, L.J., T.S. Stahly, G.L. Cromwell, and J. Miyat. 1992. Influence of genetic capacity for lean tissue growth on rate and efficiency of tissue accretion in pigs fed ractopamine. J. Anim. Sci. 70:3391 - 3400.

Bergen, W.G., S.E. Johnson, D.M. Skjaerlund, A.S. Babiker, N.K. Ames, R.A. Merkel and D.B. Anderson. 1989. Muscle protein metabolism in finishing pigs fed ractopamine. J. Anim. Sci. 67:2255 - 2262.

Buttery, P.J., and J.M. Dawson. 1987. The mode of action of beta-agonists as manipulators of carcass composition. Pages 30 – 35. In Beta-Agonists and their effects on animal growth and carcass quality. J. P. Hanrahan (Ed.). Elsevier Applied Science, New York.

Crome, P.K., F.K. McKeith, T.R. Carr, D.J. Jones, D.H. Mowrey, and J.E. Cannon. 1996. Effect of ractopamine on growth performance, carcass composition, and cutting yields of pigs slaughtered at 107 and 125 kilograms. J. Anim. Sci. 74:709 - 716.

Crenshaw, J.D., P.M. Swanteck, M.J. Marchello, R.L. Harrold, R.C. Zimprich, and R.D. Olson. 1987. Effects of a phenethanolamine (ractopamine) on swine carcass composition. J. Anim. Sci. 65 (suppl. 1):308.

Ding, S.-T., R.L. McNeel, E. O. Smith, and H.J. Mersmann. 2000. Modulation of porcine adipocytes β-adrenergic receptors by β-adrenergic agonist. J. Anim. Sci. 78:919 - 926.

Dunshea, F.R. 1991. Factors affecting efficacy of beta-agonists for pigs. Pig News and Information. 12:227 - 231.

Dunshea, F.R. 1993. Effect of metabolism modifiers on lipid metabolism in the pig. J. Anim. Sci. 71:1966 - 1977.

Dunshea, F.R., R.H. King, P.J. Eason, and R.G. Campbell. 1998a. Interrelationships between dietary ractopamine, energy intake and sex in pigs. Aust. J. Agric. Res. 49:565 - 574.

Dunshea, F.R., B.J. Leury, and R.H. King. 1998b. Lipolytic responses to catecholamines in ractopamine treated pigs. Aust. J. Agric. Res. 49:875 -881.

Dunshea, F.R., B.J. Leury, A.J. Tilbrook, and R.H. King. 1998c. Ractopamine increases glucose turnover without affecting lipogenesis in the pig. Aust. J. Agric. Res. 49:1147 - 1152.

Emorine, L.J., S. Marullo, M. Briend-Sutren, G. Patey, K. Tate, C. Delavier-Klutchko, and A.D. Strosberg. 1989. Molecular characterization of the human β3-adrenergic receptors. Science (Wash DC). 245:1118 - 1121.

Engeseth, N.J., K.O. Lee, W.G. Bergen, W.G. Helferich, B.K. Knudson, and R.A. Merkel. 1992. Fatty acid profiles of lipid depots and cholesterol concentration in muscle tissue of finishing pigs fed ractopamine. J. Food Sci. 57:1060 - 1062.

Garrett, R.H., and C.M. Grisham. 1999. Pages S1-S7 in Biochemistry. Saunders College Publishing, Orlando.

Garber, A.J., I.E. Karl, and D.M. Kipnis. 1976. Alanine and glutamine synthesis and release from skeletal muscle. Biochem. J. 251:851 - 857.

Gu, Y., A.P. Schinckel, J.C. Forrest, C.H. Kuei, and L.E. Wakins. 1991a. Effects of ractopamine, genotype, and growth on finishing performance and carcass value in swine: I. Growth performance and carcass merit. J. Anim. Sci. 69:2685 - 2693 .

Gu, Y., A.P. Schinckel, J.C. Forrest, C.H. Kuei and L.E. Wakins. 1991. Effects of ractopamine, genotype, and growth on finishing performance and carcass value in swine: II. Estimation of lean growth rate and lean feed efficiency. J. Anim. Sci. 69:2694 - 2702.

Hancock, J.D., E.R. Peo, Jr., and A.J. Lewis. 1987. Effects of dietary levels of ractopamine on performance and carcass merit of finishing pigs. J. Anim. Sci. 65 (suppl 1):309.

He, P., F.X. Aherne, J.R. Thompson, A.L. Schaefer, and J.K. Merrill. 1993. Effect of ractopamine on carcass characteristics and joint cartilage soundness in finishing pigs. Can. J. Anim. Sci. 73:169 - 176.

Helferich, W.G., D.G. Jump, D.M. Skjaerlund, W.G. Bergen, R.A. Merkel, and D.B. Anderson. 1988. Pretranslationational regulation of skeletal muscle alpha actin synthesis in pigs fed ractopamine. FASEB J. 2:3096 -3100.

Herr, C.T., D.C. Kendall, K.A. Bowers, S.L. Hankins, T.E. Weber, A.P. Schinckel, and B.T. Richert. 2001. J. Anim. Sci. 79 (Suppl 2):49 (Abstr).

Lands, A.M., A. Arnold, J.P. McAuliff, F.P. Luduena, and T.G. Brown, Jr. 1967. Differentiation of receptor systems activated by sympathomimetic amines. Nature. 214:597 - 598.

Lee, K.O., W.G. Bergen, W.G. Helferich, N.J. Engeseth, S.M. Stoick, and R.A. Merkel. 1989. Does ractopamine affect fatty acid profiles in lipid depots of finishing pigs? J. Anim. Sci. 67 (suppl 1):151.

Liu, C.Y., and S.E. Mills. 1989. Determination of the affinity of ractopamine and clenbuterol for the beta- adrenoceptor of the porcine adipocytes. J. Anim. Sci. 67:2937 - 2942.

Liu, C.Y., A.L. Grant, K.H. Kim, S.Q. Ji, D.L. Hancock, D.B. Anderson, and S.E. Mills. 1994. Limitations of ractopamine to affect adipose tissue metabolism in swine. J.Anim. Sci. 72:62 - 67.

McKeith, F.K., E.G. Perkins, P.J. Bechtel, D.J. Jones, and D.H. Mowrey. 1990. Effect of ractopamine on fatty acid composition and cholesterol content of pork longissimus muscle. J. Anim. Sci. 68 (suppl 1):336.

McKeith, F.K., and M. Ellis. 2001. Effects of ractopamine on meat quality. J. Anim. Sci. 79 (suppl 1): 239.

McNeel, R.L., and H.J. Mersmann. 1999. Distribution and quantification of beta1, beta2 and beta3-adrenergic receptor subtype transcriptions in porcine tissues. J. Anim. Sci. 77:611 - 621.

Mersmann, H.J. 1998. Overview of the effects of beta-adrenergic receptor agonists on animal growth including mechanisms of action. J. Anim. Sci. 76:160 -172.

Mersmann, H. J. 1989. Potential mechanisms for repartitioning of growth by beta-adrenergic agonists. Pages 337-357 in Animal Growth Regulation. D.R. Campion, G.J. Hausmann, and R.J. Martin (Ed.). Plenum Press, New York.

Metabolic Modifiers. 1994. Page 15. National Academy Press, Washington, D.C.

Mills, S.E. 2002. Biological basis of the ractopamine response. J. Anim. Sci. 80 (suppl 2):E28 - 32.

Mills, S.E., and C.Y. Liu. 1990. Sensitivity of lipolysis and lipogenesis to dibutyryl-cAMP and beta-adrenergic agonists in swine adipocytes in vitro. J. Anim. Sci. 68:1017 - 1023.

Mills, S.E., C.Y. Liu, Y. Gu, and A.P. Schinckel. 1990b. Effects of ractopamine on adipose tissue metabolism and insulin binding in finishing hogs and interaction with genotype and slaughter weight. Domest. Anim. Endocrinol. 7:251 - 264.

Mitchell, A.D., M.B. Solomon, and N.C. Steele. 1990. Response of low and high protein select lines of pigs to the feeding of the beta-adrenergic agonist ractopamine. J. Anim. Sci. 68:3226 - 3232.

Northup, J.K. 1985. Overview of guanine nucleotide regulatory protein system, N_s and N_i, which regulate adenylate cyclase activity in plasma membranes. In: P. Cohen and M.D. Houslay (Ed.). Molecular mechanisms of trans membrane signaling. Pages 91-116. Elsevier Science Publishing., New York.

Perkins, E.G., F.K. McKeith, D.J. Jones, D.H. Mowrey, S.E. Hill, J. Novakofski, and P.L. O'Conner. 1992. Fatty acid and cholesterol changes in pork Longissimus muscle and fat due to ractopamine. J. Food Sci. 57:1266 - 1268.

Peterla, T.A., and C.G. Scanes. 1990. Effect of beta-adrenergic agonists on lipolysis and lipogenesis by porcine adipose tissues in vitro. J. Anim. Sci. 68:1024 - 1029.

Prince T.J., D.L. Huffman, and P.M. Brown. 1987. Effects of ractopamine on growth and carcass composition of finishing swine. J. Anim. Sci. 65 (suppl 1):309.

Rodbell, Martin. 1980. The role of hormone receptors and GTP-regulatory proteins in membrane transduction. Nature. 284:17 - 22.

Sainz, R.D., Y.S. Kim, F.R. Dunshea and R.G. Campbell. 1993a. Effects of ractopamine in pig muscles: Histology, calpains and beta-adrenergic receptors. Aust. J. Agric. Res. 44:1441 - 1448.

Sainz, R.D., Y.S. Kim, F.R. Dunshea, and R.G. Campbell. 1993b. Temporal changes in growth enhancement by ractopamine in pigs. Aust. J. Agric. Res. 44:1449 - 1455.

Schinckel, A.P., B.T. Richert, and C.T. Herr. 2002. Variation in the response of multiple genetic populations of pigs to ractopamine. J. Anim. Sci. 80 (suppl 2):E85.

Spurlock, M.E., J.C. Cusumano, S.Q. Ji, D.B. Anderson, C.K. Smith II, D.L. Hancock, and S.E. Mills. 1994. The effect of ractopamine on beta-adrenoceptor density and affinity in porcine adipose and skeletal muscle tissue. J. Anim. Sci. 72:75 - 80.

Stites, C.R., F.K. McKeith, S.D. Singh, P.J. Bechtel, D.H. Mowrey, and D.J. Jones. 1991. The effect of ractopamine hydrochloride on the carcass cutting yields of finishing swine. J. Anim. Sci. 69:3094 - 3101.

Uttaro, B.E., R.O. Ball, P. Dick, W. Rae, G. Vessie, and L.E. Jeremiah. 1993. Effect of ractopamine and sex on growth, carcass characteristics, processing yield and meat quality characteristics of crossbred swine. J. Anim. Sci. 71:2439 - 2449.

Warriss, P. D., S. C. Kestin, T. P. Rolph and S. N. Brown. 1990. The effects of the beta-Adrenergic agonist salbutamol on meat quality in pigs. J. Anim. Sci. 68:128 - 136.

Watkins, L.E., D.J. Jones, D.H. Mowrey, D.B. Anderson, and E.L. Veenhuizen. 1990. The effect of various levels of ractopamine hydrochloride on the performance and carcass characteristics of finishing swine. J. Anim. Sci. 68:3588 - 3595.

Watkins, L.E., D.J. Jones, J.R. Gillespie, and R.D. Olson. 1989. Effect of ractopamine hydrochloride on the carcass composition of finishing swine- 3 – trial summary. J. Anim. Sci. 67 (suppl 2):104 (Abstr).

Xiao, R.J., S.R. Xu, and H.L. Chen. 1999. Effects of ractopamine at different dietary protein levels on growth performance and carcass characteristics in finishing pigs. Anim. Feed Sci. Technol. 79:119 - 127.

Yang, Y.T., and M.A. McElligott. 1989. Multiple actions of beta-adrenergic agonists on skeletal muscle and adipose tissue. Biochem. J. 261:1 - 10.

Yen, J.T., H.J. Mersmann., D.A. Hill, and W.G. Pond. 1990. Effects of ractopamine on genetically obese and lean pigs. J. Anim. Sci. 68:3705 - 3712.

Materials and Methods

Performance Trial:

Crossbred barrows (n = 144; weight ~ 80 kg) from four farrowing groups were ultrasounded for 10th rib backfat. This measurement was used to phenotypically sort the pigs into lean and fat pens. The backfat difference between the lean and fat groups was ≥ 0.5 cm. Within a farrowing group, pigs were penned (n = 5 pigs/pen with 8 pens per group) such that the average pen weight and backfat of the pigs were nearly equal. All pigs received a basal corn and soybean meal diet containing 18% crude protein and 1.1% lysine. Half of the pens were given a ractopamine supplement of 10 ppm, which was added to the diet at the expense of ground corn. The resulting assignment was a 2 x 2 factorial arrangement with two backfat classes (lean and fat) and two levels of Paylean® supplementation (0 and 10ppm). All pigs had *ad libitum* access to feed and water throughout the 28-day finishing phase.

Feed consumption, live weights and ultrasound images for 10th rib backfat and loin eye area were collected every 7 days. Images were collected using Aloka 500-V ultrasound unit (Corometrics Medical Systems, Wallingford, CT) with a 17.2 cm, 3.5 MHz linear probe and interpreted using Beef Information Manager™ software, version 3.0 (Critical Vision Inc., Atlanta, GA.).

Harvest and Grading:

After finishing, the two average gaining pigs were removed from each pen (n = 8) transported to The University of Georgia Meat Science Technology Center, held

over-night (with access to water), and harvested the following day by standard industry practices. After a 48-hour chill, the left side of the carcasses was ribbed between the 10th and 11th rib. Fat thickness at the 10th rib, last lumbar vertebrae, last rib, and first rib were measured and subjective carcass muscle score was recorded. Tracings of 10th rib loin eye area were measured for area and depth using Sigma-Scan Scientific Measurement software, version 3.90 (Jandel Scientific, Corte Madera, CA.). National Pork Producers Council's subjective color, marbling and firmness scores were recorded. Other quality measures assessed at the 10th rib include ultimate pH (Cole-Parmer meter – model 05669-00) and colorimeter L*, a*, and b* (Minolta Chroma Meter CR – 310).

Pork Carcass Fabrication:

The left sides of the carcasses were then fabricated into bone-in and boneless primals and subprimals, according to the procedures outlined for fresh pork by the National Association of Meat Purveyors (NAMP, 1997). To standardize carcass weight, the diaphragm, wing of the diaphragm and kidneys (if present) and tail (between the 1st and 2nd coccygeal vertebrae) were removed and weighed. Standardized carcass weight was recorded and the rear and fore shanks were removed immediately dorsal to the hock and knee joints and weighed. Each side was then fabricated into the four lean cuts (401 fresh ham, 405 picnic shoulder, 406 Boston butt, and 410 loin), 408 belly, and 416 spareribs using the procedures described by NAMP (1997). The shoulder was separated from the carcass by measuring 2.54 cm posterior to the elbow and cutting perpendicular to the long axis of the carcass approximately between the 2nd and 3rd ribs. Once separated, the subscapularis shall not extend past the dorsal edge of the base of the medial ridge of the scapula. The neck bones were removed from the shoulder and weighed, and

excess lean remained with the Boston butt when separated from the picnic. The neck bones were weighed and discarded. The jowl was removed from a point measured 2.54 cm from the posterior edge of the ear dip. The jowl was skinned and the fore and hind foot, the skinless jowl, and the jowl skin were weighed.

The Boston butt was separated from the picnic shoulder by cutting 1.27 cm from the ventral side of the scapula and cutting perpendicular to the posterior cut surface. The loin and belly were separated from the ham by a straight cut between the second and third sacral vertebrae (3.8 cm from the aitch bone) approximately perpendicular to the shank bones. The loin and belly were separated by a cut beginning 2.54 cm from the foremost rib - vertebral column attachment on the anterior end of the loin and continuing to the ventral edge of the *psoas major* muscle on the posterior end of the loin, following the natural curvature of the chine bone.

Picnic Shoulder: The 405 picnic shoulder was fabricated into the 405A by removing the remaining skin and all bone from the picnic and trimming the fat to 0.32 and 0 cm. Each picnic shoulder subprimal, bone, lean trim, and corresponding skin were weighed.

Boston Butt: The 406 Boston butt was fabricated into a 406A Boston butt, boneless and weighed along with the bone. The 406A Boston butt was further fabricated into the 407 Boston butt, cellar, and lean trim, recording weights for each. The 407 Boston butt was trimmed to 0.32 and 0 cm external fat, weighing the 407 Boston butt and fat trim between each step.

Loin Fabrication. The 410 loin was fabricated into a 411 loin, bladeless, and weights recorded for the 411 loin, blade bone, and lean and fat trimmings. The 411,

bladeless loin was fabricated into the 412C, 11 rib center cut loin by removing the sirloin between the last two lumbar vertebrae and removing the blade, and weights were recorded for the 412C, blade and sirloin portions. The 412C loin, 11 rib center cut was fabricated into a 412D loin, 11 rib center cut, chine bone off; blade end; and sirloin end and each subprimal was weighed. The 412D loin, blade end, and sirloin end were deboned to form a 412E center cut loin, boneless, a boneless blade, and a boneless sirloin, respectively. The 412E center cut loin, boneless blade, and boneless sirloin were further trimmed to 0.32 and 0 cm external fat and the trimmed subprimals and fat trim were weighed between each step.

Belly Fabrication. The 408 belly was skinned to form a 409 belly and the 409 belly and skin were weighed.

Ham Fabrication. The 401 fresh ham was then fabricated into a 402 fresh ham, skinned, and trimmed to 1.27 cm external fat. The 402 ham and skin were weighed and the 402 ham was fabricated into the boneless inside ham (*semimembranosus, gracillis and adductor*), outside ham (*semitendinosus and biceps femoris*), knuckle (*vastus intermedius, vastus lateralis, tensor fasciae latae and vastus medialis*), light butt (*gluteus medius*), heel, and inner shank muscles. The skin, fat trim, and bone were weighed. The ham muscle groups were weighed individually (1.27 cm subcutaneous fat), and progressively trimmed to 0 cm external fat, weighing the muscle groups and fat trim between each step.

Belly Firmness:

The bellies were collected, skinned and trimmed to 46 x 22 cm for uniform size. Bellies were laid on a flat surface, over-wrapped, and held at -1°C over night. Belly

thickness was measured at six points around the belly, which include; anterior, posterior, and two points ventrally and dorsally. Belly firmness was evaluated using the belly – bar technique, and firmness was defined by the distance between the anterior and posterior ends when the belly was draped over a bar at the midway point on the dorsal and ventral sides of the belly. The distance between the anterior and posterior end was measured.

Fatty acid methyl esters for GC determinations:

Fat samples for fatty acid composition analysis were collected during or after harvest from the following depots: 10^{th} rib inner, and outer subcutaneous fat, 10^{th} rib Longissimus dorsi, leaf fat, and belly fat. All Samples were prepared for analysis using the procedure of Park and Goins (1994) with modifications, and analyzed using a Shimadzu Gas Chromatograph GC – 14A with a Supelcowax - 10 fused silica capillary column.

Adipose Samples: Approximately 50 – 100 mg of adipose tissue was weighed into a glass test tube. Added to each sample were 200 μL of methylene chloride, 2 mL of .5 N sodium methoxide in methanol and 1 ml of internal standard (2 mg of C17:0 per mL of methanol). The samples were flushed with nitrogen, vortexed and heated at 90°C for 20 minutes. The samples were cooled to room temperature, and 2 mL of 14% boron triflouride in methanol were added to each sample. The samples were flushed with nitrogen, vortexed and heated 90°C at for 20 minutes. The samples were cooled to room temperature. Water (2 mL) and 2 mL of hexane were added to the solution, vortexed and allowed to separate and anhydrous sodium sulfate was added to remove any residual water.

Longissimus dorsi samples: The longissimus dorsi samples (1 – 2 gm) were frozen in liquid nitrogen and homogenized. Added to each sample were 400 μL of methylene chloride, 4 mL of .5 N sodium methoxide in methanol and 2 ml of internal standard (2 mg of C17:0 per mL of methanol). The samples were flushed with nitrogen, vortexed and heated at 90°C for 20 minutes. The samples were cooled to room temperature, and 4 mL of 14% boron triflouride in methanol were added to each sample. The samples were flushed with nitrogen, vortexed and heated 90°C for 20 minutes. After cooling, the upper layer was separated, dried in a spin vacuum, and resuspended in 2 mL of hexane. Samples were stored at 4°C. Prepared samples were transferred into a vial for GC analysis.

Iodine Value:

Iodine values were calculated from the gas chromatograph analysis data using the following equation: iodine value = C16:1 (0.95) + C18:1 (0.86) + C18:2 (1.732) + C18:3 (2.616) + C22:1 (0.723) (AOCS, 1998; Gatlin et al., 2002).

Lipid extractions:

The belly and dissected carcass tissues were ground twice using a 1.27 cm grinder plate and mixed between grindings for 5 minutes. Sub-samples were taken from the ground belly and carcass, homogenized using a vertical chopper, vacuum-packaged and frozen for lipid extractions. The longissimus dorsi samples were frozen in liquid nitrogen and homogenized. Lipid extractions were prepared in triplicate using the procedures of Folch et al. (1957) with modifications.

Disposable aluminum drying pans were dried overnight in a 90°C oven and equilibrated for 5 minutes in a desiccator. Tissue samples (2.5 g $\pm$ 0.1 g) were placed

into labeled, conical tubes, homogenized with 10 mL of methanol and 5 mL of chloroform (2:1 methanol-chloroform mixture), and allowed to extract for 1 hour. Chloroform (5 mL) and 5 mL of 1 M KCl were added to each sample and vortexed. Samples were placed in a 0°C environment for 5 minutes, and then centrifuged at 2,000 x g for 10 min at 0°C. The top layer was aspirated off without disturbing the meat pellet, and samples were gently poured into aluminum pans. The samples were dried overnight in the fume hood and for 30 minutes at 90°C the following day. Following drying, samples were placed in a desiccator for 5 minutes. The samples were weighed and percent lipid was calculated ((pan with lipid weight – pan weight)/ sample weight x 100%).

Warner-Bratzler Shear Force:

Warner-Bratzler shear force was completed using the American Meat Science Association guidelines (1995) with modifications. Pork chops (2.54 cm thick) were removed from loins free of external fat at approximately the 12th rib. Chops were vacuum packaged, aged (7 days), and frozen. Chops were thawed, and weights were recorded in and out of the package. Purge loss was calculated. Thermocouples were placed in the approximate geometric center of the chops and initial temperatures were recorded. Chops were cooked on Farberware grills, and turned when the internal temperature reached 35 to 40°C. Chops were cooked to a final endpoint temperature of 65°C and endpoint temperature, cooking time, and final cooked weights were recorded. Chops were placed in a 4.4°C cooler for 3 hours. After cooling, the chops were evaluated for degree of doneness, and 1.27 cm cores (n = 4) from each pork chop were taken

parallel to the longitudinal orientation of the muscle fibers. Cores were sheared using a Salter Warner-Bratzler Shear, and the shear force value of the cores were recorded.

Data Analysis:

Data were analyzed using analysis of variance for a 2 x 2 factorial arrangement with the main effects of Paylean® and 10^{th} rib backfat class. Replicate and replicate interactions were included to remove variation. Pen was used as the experimental unit for the performance trial data, while animal was the experimental unit for carcass quality and cutability data. Least squares means were generated and separated using the least significant difference procedures.

Literature Cited

American Meat Science Association and National Live Stock and Meat Board. 1995. Research guidelines for cookery, sensory evaluation and instrumental tenderness measurements of fresh meat. Chicago, IL.

AOCS. 1998. Official Methods and Recommended Practices of the AOCS. 5th ed. Am. Oil. Chem. Soc., Champaign, IL.

Folch, J., M. Lees, and G.H. Sloane-Stanley. 1957. A simple method for the isolation and purification of total lipids from animal tissue. J. Biol. Chem. 226:497 – 507.

Gatlin, L.A., M.T. See, J.A. Hansen, D. Sutton and J. Odle. 2002. The effect of dietary fat sources, levels, and feeding intervals on pork fatty acid composition. J. Anim. Sci. 80:1606 – 1615.

NAMP. 1997. The Meat Buyers Guide. National Association of Meat Purveyors, North American Meat Processing Association, Reston, VA.

Park, P.W. and R.E. Goins. 1994. *In situ* preparation of fatty acid methyl esters for analysis of fatty acid composition in foods. J. Food Sci. 59:1262 – 1266.

CHAPTER 1

GROWTH PERFORMANCE AND ULTRASOUND ACCRETION RATES OF FAT AND LEAN PIGS SUPPLEMENTED WITH RACTOPAMINE[1]

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[1] Mimbs, K.J., T.D. Pringle, M.J. Azain, S.A. Meers, and T.A. Armstrong. To be submitted to *The Journal of Animal Science.*

ABSTRACT Crossbred barrows (~80 kg) from four farrowing groups were ultrasounded and phenotypically segregated into fat (F) and lean (L) pens. The backfat (BF) difference between the L and F groups was $\geq$ 0.5 cm. Within a farrowing group, pigs were penned (n = 5 pigs/pen, with 8 pens per group) such that the average pen weight and backfat of the pigs were approximately equal. All pigs received a corn and soybean meal diet containing 18% crude protein, 1.0% added animal-vegetable fat, and 1.1% lysine, and half of the pens received a ractopamine (RAC) supplement of 10 ppm during the 28-d finishing phase. The resulting assignment was a 2 x 2 factorial arrangement with two BF classes (lean and fat) and two levels of RAC supplementation (0 and 10 ppm). Pig weights, feed intake and ultrasound loin eye area and backfat depth were measured every 7 days. A significant interaction (P = 0.02) between RAC and BF class was found for week 1 ADG, where RAC, L and C,L and C,F pigs gained significantly more than RAC, F pigs. Average daily gain for weeks 2, 3, and 4 and total ADG were not affected (P > 0.25) by RAC. Weeks 2 and 3 ADG were improved (P $\leq$ 0.03) in L pigs; however, weeks 1 and 4, as well as total ADG, were not affected by BF class (P $\geq$ .08). Ractopamine significantly decreased feed intake (FI) in weeks 2, 3, and 4, as well as total FI (P $\leq$ 0.05). Week 1 FI was not affected (P = 0.15) by RAC supplementation. Weekly and total FI were not affected by BF class (P > 0.20). Neither RAC nor BF class affected (P > 0.10) week 1 feed efficiency (FE). Ractopamine significantly improved FE in weeks 3 and 4, as well as FE over the duration of the trial (P $\leq$ 0.04). As well, L pigs had higher (P $\leq$ 0.05) FE in weeks 2 and 3, and higher FE over the duration of the trial. Ultrasound loin eye accretion (ULA) was not affected (P $\geq$ 0.10) by RAC; however, BF class significantly affected ULA as L pigs had higher (P $\leq$ 0.02) ULA in weeks 2 and 4.

Weeks 1 and 3 ULA and total ULA were not affected by BF class ($P \geq 0.14$). Weekly ultrasound backfat accretion (UBA) was not affected ($P \geq 0.10$) by RAC; however, total UBA was significantly lower in RAC vs C pigs ($P = 0.01$). Ultrasound backfat accretion for weeks 2, 3, and 4 and total UBA were not affected ($P \geq 0.19$) by BF class, but week 1 UBA was ($P = .03$) lower in F pigs Given these data, RAC improved finishing performance, primarily through increased efficiency, while enhancing leanness.

Key Word: Pork, Ractopamine, Finishing Performance

Introduction

The repartitioning agent ractopamine (RAC) was approved, by the FDA, for use in swine in 1999. Research has shown it improves performance by increasing average daily gain (ADG) (Watkins et al., 1990; Stites et al., 1991; He et al., 1993; Dunshea et al; 1998), improving feed efficiency (FE) (Aalhus et al., 1990; Watkins et al., 1990; Yen et al., 1990; Gu et al., 1991a; Stites et al., 1991; He et al., 1993; Dunshea et al., 1998), and decreasing feed intake (FI) (Crenshaw et al., 1987; Aalhus et al., 1990; Watkins et al., 1990; Gu et al., 1991b;) in swine while reducing fat and increasing lean (Crenshaw et al., 1987; Watkins et al., 1989; Aalhus et al., 1990; Mitchell et al., 1990; Watkins et al., 1990; Bark et al., 1992).

Current finishing practices in the swine industry involve feeding large pens of pigs, where considerable variation in lean growth potentials and performance characteristics exists. Yen et al. (1990) supplemented obese and lean pigs with ractopamine and reported significant improvements in feed intake (FI) and feed efficiency (FE). There is little known, however, about the response of pigs with varied lean growth potentials (i.e., fat versus lean pigs) particularly in regard to lean and fat accretion over the finishing period. Thus, the objective of this study was to determine the response in animal performance and ultrasound fat and muscle measurements of pigs varying in 10^{th} rib backfat to RAC supplementation.

Performance Trial

Crossbred barrows (n = 144; weight ~ 80 kg) from four farrowing groups were ultrasounded for 10^{th} rib backfat (BF). This measurement was used to phenotypically sort the pigs into lean (L) and fat (F) pens. The BF difference between the L and F

groups was ≥ 0.5 cm. Within a farrowing group **(Table 1.2)**, pigs were penned (n = 5 pigs/pen with 8 pens/group) such that the average pen weight and BF of the pigs were nearly equal. All pigs received a corn and soybean meal basal diet **(Table 1.1)** containing 18% crude protein and 1.1% lysine. Half of the pens were given RAC (Paylean®, Elanco Animal Health, Greenfield, IN) at a level of 10 ppm, which was added to the diet at the expense of ground corn. The resulting assignment was a 2 x 2 factorial arrangement two BF classes (lean and fat) and two levels of RAC supplementation (0 and 10 ppm). All pigs had *ad libitum* access to feed and water throughout the 28-d experimental period.

Feed intake, live weights, and ultrasound images for 10^{th} rib BF and loin eye area were collected every seven days. Images were collected using an Aloka 500-V ultrasound unit (Corometrics Medical Systems, Wallingford, CT) with a 17.2 cm, 3.5 MHz linear probe and interpreted using Beef Information Manager™ software, version 3.0 (Critical Vision Inc., Atlanta, GA.). Weekly ultrasound 10^{th} rib backfat and loin eye area accretion rates were calculated by subtracting the ultrasound values obtained for each scanning session.

Data were analyzed using analysis of variance for a 2 x 2 factorial arrangement with the main effects of RAC and 10^{th} rib BF class. Replicate and replicate interactions were included to remove variation. Pen was used as the experimental unit performance trial data, and animal was the experimental unit for the ultrasound data. Least squares means were generated and separated using the least significant difference procedures.

Results and Discussion

Performance

Starting (79.9 kg vs 79.9 kg) and ending (110.0 kg vs 109.4 kg) weights were not different between C vs PL pigs. As for BF class, the starting weights (80.7 kg vs 79.0 kg; P = .003) were significantly different in F vs L pigs; however the ending weights (109.7 kg vs 109.5 kg) were not different due to BF class. In week 1, an interaction (P = 0.02) between BF class and RAC for ADG was found as RAC-F pigs gained less than, C-L and RAC-L pigs **(Table 1.4)**. Ractopamine had no affect (P > 0.25) on weekly or total ADG **(Table 1.3)**. These results are consistent with those seen by Aalhus et al. (1990) and Yen et al. (1990). Conversely, numerous other studies (Watkins et al., 1990; Stites et al., 1991; Bark et al., 1992; He et al., 1993; Crome et al., 1996; Xiao et al., 1999) have reported that RAC improved ADG. In general, for most of the aforementioned studies, the pigs were fed for a longer period of time, and ADG and slaughter weights were lower than in the current study.

Average daily gains for weeks 2 (P = 0.03) and 3 (P = 0.02) were significantly higher in L vs F pigs; however, week 4 ADG was not affected by BF class (P = 0.89) **(Table 1.3)**. In general, F pigs' ADG decreased over time, while L pigs did not respond similarly. The total ADG for the study was not different (P = 0.20) between L vs F pigs. This agrees with Neely et al. (1979) reported no difference in ADG in F vs L pigs; however, the average BF difference was 0.20 cm. However, Friesen et al. (1994), who reported that pigs compared to lower lean gain potential have decreased average daily gains with their leaner counterparts.

Ractopamine supplementation did not affect week 1 feed intake (FI) ($P = 0.15$); however, FI for weeks 2, 3, 4, and total FI was ($P \leq 0.05$) lower in RAC vs C pigs **(Table 1.5)**. In terms of total FI, the current study agrees with other reports that have observed significant decreases in FI with RAC (Crenshaw et al., 1987; Aalhus et al., 1990; Watkins et al., 1990; Yen et al., 1990; Gu et al., 1991; Bark et al., 1992). Conversely, other researchers have reported no improvement in FI with RAC supplementation (Aalhus et al., 1990; Adeola et al., 1990; Watkins et al., 1990; Gu et al., 1991; Stites et al., 1991; He et al., 1993; Xiao et al., 1999).

Weekly and total FI were not affected by BF class ($P \geq 0.20$), although weeks 1 and 2 FI for the F pigs was numerically higher **(Table 1.5)**. Numerous researchers have reported no significant difference in FI between phenotypes, which is similar to the current study (Neely et al., 1979; Freisen et al., 1994; McNeel et al., 2000). In general terms, for F and L pigs, FI was higher in weeks 2, 3, and 4 than in week 1. Feed intake fluctuated over the course of the study, however it increased over the initial feed intake values.

Ractopamine had no effect ($P > 0.60$) on week 1 and 2 feed efficiency (FE) **(Table 1.6)**. Weeks 3 and 4 FE were ($P < 0.05$) higher in RAC vs C pigs. Total FE over the course of the study was ($P < 0.01$) improved with RAC, and this improvement has been reported in other studies (Watkins et al., 1990; Yen et al., 1990; Stites et al., 1991; Bark et al., 1992; He et al., 1993). Gain:feed in the current study was considerably higher than other reports.

Feed efficiency for weeks 1 and 4 were not affected by BF class ($P > 0.40$); however, weeks 2 and 3 and total FE were significantly ($P \leq 0.05$) higher in L vs F pigs

(Table 1.6). Neely et al. (1979) reported that FE was not significantly different between fat and lean pigs, but Freisen et al. (1994) reported that pigs with higher lean gain potentials had significantly higher gain:feed ratios.

Lean and Fat Accretion

Ractopamine had no affect ($P \geq 0.10$) on ultrasound loin eye accretion (ULA, **Table 1.7**). Ultrasound loin eye area accretion for weeks 1 and 3 were not affected by BF class ($P > 0.13$), but it is interesting to note that the F pigs ULA was numerically higher for those two weeks when compared with the L pigs. Weeks 2 and 4 ULA was ($P < 0.03$) higher in L vs F pigs. However, total ULA was not affected by BF class ($P = 0.59$).

Ractopamine had no affect on weekly ultrasound 10^{th} rib BF accretion (UBA) rates ($P \geq 0.10$); however, total UBA was significantly ($P = 0.01$) lower in RAC than C pigs **(Table 1.8)**. Interestingly, an interaction ($P = 0.04$) between RAC and backfat class was found for week 2 UBA, where C,F and RAC,L had greater fat accretion than C,L and RAC,F pigs **(Table 1.9)**. However, there was no significant difference between the means, as the error was very high. In general, other studies have reported increased muscle (Bark et al., 1992; Sainz et al., 1993; Dunshea et al., 1998) and decreased fat accretion rates (Bark et al., 1992; He et al., 1993). In the cited studies, however, accretion was determined by harvesting animals to determine initial composition and then comparing the initial animals with the treated animals. Ultrasound 10^{th} rib BF accretion for week 1 was higher ($P = 0.03$) in L than F pigs; However, ultrasound 10^{th} rib backfat (UBA) was not different between L and F pigs for weeks 3, 4 or total UBA ($P > 0.18$).

Implications

Ractopamine improves finishing performance by improving feed efficiency and decreasing feed intake, but it had no affect on average daily gain. The performance responses seen due to ractopamine supplementation were essentially the same as those seen due to backfat class, except in terms of feed intake. Ractopamine had greater affects on fat accretion than on lean accretion. Backfat class had limited affect on backfat accretion rates. Based on the results of this study, it is valid to conclude that ractopamine supplementation is a suitable approach by which to improve performance and decrease fat accretion during the finishing of slaughter hogs.

Literature Cited

Aalhus, J.L., S.D.M. Jones, A.L. Schaefer, A.K.W. Tong, W.M. Robertson, J.K. Merrill, and A.C. Murray. 1990. The effect of ractopamine on performance, carcass composition and meat quality of finishing pigs. Can. J. Anim. Sci. 70:943 - 952.

Adeola, O., E.A. Darko, P. He, and L.G. Young. 1990. Manipulation of porcine carcass composition by ractopamine. J. Anim. Sci. 68:3633 - 3641.

Bark, L.J., T.S. Stahly, G.L. Cromwell, and J. Miyat. 1992. Influence of genetic capacity for lean tissue growth on rate and efficiency of tissue accretion in pigs fed ractopamine. J. Anim. Sci. 70:3391 - 3400.

Crome, P.K., F.K. McKeith, T.R. Carr, D.J. Jones, D.H. Mowrey, and J.E. Cannon. 1996. Effect of ractopamine on growth performance, carcass composition, and cutting yields of pigs slaughtered at 107 and 125 kilograms. J. Anim. Sci. 74:709 - 716.

Crenshaw, J.D., P.M. Swanteck, M.J. Marchello, R.L. Harrold, R.C. Zimprich, and R.D. Olson. 1987. Effects of a phenethanolamine (ractopamine) on swine carcass composition. J. Anim. Sci. 65 (suppl. 1):308.

Dunshea, F.R., R.H. King, P.J. Eason, and R.G. Campbell. 1998. Interrelationships between dietary ractopamine, energy intake and sex in pigs. Aust. J. Agric. Res. 49:565 - 574.

Fresien, K.G., J.L. Nelssen, J.A. Unruh, R.D. Goodband, and M.D. Tokach. 1994. Effects of the interrelationship between genotype, sex, and dietary lysine on growth

performance and carcass composition in finishing pigs fed to either 104 or 127 kilograms. J. Anim. Sci. 72:946 - 954.

Gu, Y., A.P. Schinckel, J.C. Forrest, C.H. Kuei, and L.E. Watkins. 1991a. Effects of ractopamine, genotype, and growth on finishing performance and carcass value in swine: I. Growth performance and carcass merit. J. Anim. Sci. 69:2685 - 2693.

Gu, Y., A.P. Schinckel, J.C. Forrest, C.H. Kuei and L.E. Wakins. 1991b. Effects of ractopamine, genotype, and growth on finishing performance and carcass value in swine: II. Estimation of lean growth rate and lean feed efficiency. J. Anim. Sci. 69:2694 - 2702.

He, P., F.X. Aherne, J.R. Thompson, A.L. Schaefer, and J.K. Merrill. 1993. Effect of ractopamine on carcass characteristics and joint cartilage soundness in finishing pigs. Can. J. Anim. Sci. 73:169 - 176.

McNeel, R.L., S.T. Ding, E. O'Brian Smith, and H.J. Mersmann. 2000. Effect of feed restriction on adipose tissue transcript concentrations in genetically lean and obese pigs. J. Anim. Sci. 78:934 – 942.

Mitchell, A.D., M.B. Solomon, and N.C. Steele. 1990. Response of low and high protein select lines of pigs to the feeding of the beta-adrenergic agonist ractopamine. J. Anim. Sci. 68:3226 - 3232.

Neely, J.D., R.K. Johnson, and L.E. Walters. 1979. Efficiency of gains and carcass characteristics of swine of two degrees of fatness slaughtered at three weights. J. Anim. Sci. 48:1049 - 1056.

Sainz, R.D., Y.S. Kim, F.R. Dunshea, and R.G. Campbell. 1993. Temporal changes in growth enhancement by ractopamine in pigs. Aust. J. Agric. Res. 44:1449 -1455.

Stites, C.R., F.K. McKeith, S.D. Singh, P.J. Bechtel, D.H. Mowrey, and D.J. Jones. 1991. The effect of ractopamine hydrochloride on the carcass cutting yields of finishing swine. J. Anim. Sci. 69:3094 - 3101.

Watkins, L.E., D.J. Jones, J.R. Gillespie, and R.D. Olson. 1989. Effect of ractopamine hydrochloride on the carcass composition of finishing swine- 3 – trial summary. J. Anim. Sci. 67 (suppl 2):104.

Watkins, L.E., D.J. Jones, D.H. Mowrey, D.B. Anderson, and E.L. Veenhuizen. 1990. The effect of various levels of ractopamine hydrochloride on the performance and carcass characteristics of finishing swine. J. Anim. Sci. 68:3588 - 3595.

Xiao, R.J., S.R. Xu, and H.L. Chen. 1999. Effects of ractopamine at different dietary protein levels on growth performance and carcass characteristics in finishing pigs. Anim. Feed Sci. Technol. 79:119 -127.

Yen, J.T., H.J. Mersmann., D.A. Hill, and W.G. Pond. 1990. Effects of ractopamine on genetically obese and lean pigs. J. Anim. Sci. 68:3705 - 3712.

Table 1.1 Diet Composition

	Control		Ractopamine	
	%	lb./2 tons	%	lb./2 tons
Corn	68.58	2743.2	68.53	2741.2
Soybean meal	27.51	1100.4	27.51	1100.4
Ractopamine	0	0	0.05	2
Fat	1.00	40	1.00	40
Dical Phosphate	1.19	47.6	1.19	47.6
Limestone	0.85	34.0	0.85	34.0
Salt	0.40	16.0	0.40	16.0
Vitamin premix	0.15	6.0	0.15	6.0
Mineral. Premix	0.15	6.0	0.15	6.0
Lysine	0.17	6.8	0.17	6.8

Table 1.2 Pig genotypes used in the study

Farrowing Group	Number	Genotype
1	24	Y x L x H female x DRU Boar
2	40	Y x L x H female x DRU Boar
3	40	Y x L x H female x DRU Boar
4	40	PIC C-422 female x PIC 426 Boar

Table 1.3 The effects of ractopamine and backfat class on average daily gain ($kg*d^{-1}$)

	Treatment			Backfat Class			T * P
	Control	RAC	P > F	Fat	Lean	P > F	P > F
Week 1	1.15 ± 0.04	1.11 ± 0.04	0.42	1.18 ± 0.04	1.08 ± 0.04	0.08	0.02
Week 2	1.14 ± 0.04	1.10 ± 0.04	0.40	1.06 ± 0.04	1.18 ± 0.04	0.03	0.38
Week 3	1.07 ± 0.04	1.12 ± 0.04	0.27	1.03 ± 0.04	1.16 ± 0.04	0.02	0.46
Week 4	.87 ± 0.04	.88 ± 0.04	0.74	.87 ± 0.04	.88 ± 0.04	0.89	0.15
Total	1.06 ± 0.02	1.05 ± 0.02	0.92	1.03 ± 0.02	1.08 ± 0.02	0.20	0.13

Table 1.4 The effects of the interaction of ractopamine and backfat class on average daily gain

Week 1 ADG ($kg*d^{-1}$): P = 0.02

	Control	RAC
Fat	$1.10^{ab} \pm 0.05$	$1.01^{a} \pm 0.06$
Lean	$1.18^{b} \pm 0.05$	$1.18^{b} \pm .005$

Table 1.5 The effects of ractopamine and backfat class on feed intake (kg*pig^{-1}*day^{-1})

	Treatment			Backfat Class			T * P
	Control	RAC	P > F	Fat	Lean	P > F	P > F
Week 1	2.58 ± 0.07	2.44 ± 0.07	0.15	2.57 ± 0.07	2.44 ± 0.07	0.20	0.43
Week 2	3.15 ± 0.06	2.99 ± 0.06	0.05	3.10 ± 0.06	3.04 ± 0.06	0.46	0.81
Week 3	3.14 ± 0.05	2.87 ± 0.05	0.002	2.96 ± 0.05	3.05 ± 0.05	0.24	0.27
Week 4	2.96 ± 0.08	2.69 ± 0.08	0.02	2.80 ± 0.08	2.87 ± 0.08	0.55	0.71
Total feed	2.96 ± 0.04	2.75 ± 0.04	0.002	2.86 ± 0.04	2.85 ± 0.04	0.90	0.37

Table 1.6 The effects of ractopamine and backfat class on feed efficiency (g:f)

	Treatment			Backfat Class			T * P
	Control	RAC	P > F	Fat	Lean	P > F	P > F
Week 1	.45 ± 0.01	.45 ± 0.01	0.98	.46 ± 0.01	.44 ± 0.01	0.45	0.08
Week 2	.36 ± 0.01	.37 ± 0.01	0.65	.34 ± 0.01	.39 ± 0.01	0.002	0.13
Week 3	.34 ± 0.01	.39 ± 0.01	0.01	.35 ± 0.01	.38 ± 0.01	0.05	0.96
Week 4	.30 ± 0.01	.33 ± 0.01	0.04	.32 ± 0.01	.31 ± 0.01	0.62	0.09
Total	.36 ± 0.005	.38 ± 0.006	0.004	.36 ± 0.006	.38 ± 0.005	0.05	0.24

Table 1.7 The effects of ractopamine and backfat class on ultrasound measured loin eye area accretion ($cm^2 * d^{-1}$)

	Treatment			Backfat class			T * P
	Control	RAC	P > F	Fat	Lean	P > F	P > F
Week 1	.66 ± 0.08	.59 ± 0.07	0.54	.69 ± 0.08	.56 ± 0.08	0.22	0.62
Week 2	.49 ± 0.04	.48 ± 0.04	0.78	.41 ± 0.04	.56 ± 0.04	0.02	0.61
Week 3	.20 ± 0.04	.30 ± 0.04	0.10	.29 ± 0.04	.21 ± 0.04	0.14	0.62
Week 4	.30 ± 0.03	.33 ± 0.03	0.61	.25 ± 0.03	.38 ± 0.03	0.007	0.18
Total	.42 ± 0.02	.42 ± 0.02	0.81	.41 ± 0.02	.43 ± 0.02	0.59	0.12

Table 1.8 The effects of ractopamine and backfat class on ultrasound measured fat accretion ($mm*d^{-1}$)

	Treatment			Backfat Class			T * P
	Control	RAC	P > F	Fat	Lean	P > F	P > F
Week 1	.23 ± 0.06	.16 ± 0.06	0.42	.11 ± 0.06	.28 ± 0.06	0.03	0.40
Week 2	.09 ± 0.05	.09 ± 0.05	0.98	.10 ± 0.05	.09 ± 0.05	0.95	0.04
Week 3	.24 ± 0.04	.17 ± 0.04	0.21	.20 ± 0.04	.21 ± 0.04	0.92	0.43
Week 4	.12 ± 0.05	.02 ± 0.05	0.10	.10 ± 0.05	.05 ± 0.05	0.48	0.67
Total	.17 ± 0.02	.11 ± 0.02	0.01	.12 ± 0.02	.16 ± 0.02	0.19	0.78

Table 1.9 The effects of the interaction of ractopamine and backfat class on week 2 ultrasound backfat accretion

Week 2 UBF ($mm*d^{-1}$): P = .04

	Control	RAC
Fat	$0.017^{a} \pm 0.007$	$0.002^{a} \pm 0.008$
Lean	$0.001^{a} \pm 0.007$	$0.017^{a} \pm 0.007$

CHAPTER 2

CARCASS CUTABILITY, MEAT QUALITY, AND BELLY FIRMNESS OF PAYLEAN® SUPPLEMENTED BARROWS SORTED INTO PREFINISHING ULTRASOUND BACKFAT THICKNESS CLASSES[1]

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[1] Mimbs, K.J., T.D. Pringle, M.J. Azain, and T.A. Armstrong. To be submitted to *Meat Science.*

Abstract: Crossbred barrows (~80 kg) from four farrowing groups were ultrasounded and assigned to a factorial arrangement with two backfat classes (BF, fat (F) vs lean (L)) and two levels of Paylean® (PL, 0 vs 10 ppm). The backfat difference between the L and F groups was $\geq$ 0.5 cm. Pigs were fed a corn/soybean diet (18% CP; 1.1% lysine) for 28-d. After finishing, the two average gaining pigs from each pen were harvested (n = 56). Following a 48 h chill, carcass quality (marbling, color, firmness, L*, a*, b* and pHu), fat depth at the first rib (FR), 10th rib (TRIB), last rib (LR) and the last lumbar vertebrae (LLV), and muscling (*longissimus* area, LMA, and depth, LED; and USDA muscle score, CMS) traits were measured. Sides were fabricated into the four lean cuts (fresh ham, picnic shoulder, Boston Butt, loin, and belly) and further dissected into lean and fat portions. Carcass fat percent (CF) and fat free lean percent (FFL) were calculated and belly thickness and firmness were measured. Data were analyzed using ANOVA for a replicated (n=4), 2x2 factorial arrangement with the main effects of PL treatment, BF class and their interaction. Replicate and replicate interactions were included in the model to remove replicate variation. Backfat class did not affect (P > .25) quality measures and PL did not affect (P > .3) color or L*. However, a* and b* (P < .01) were higher in C vs PL, and marbling (P = .07) and firmness (P < .01) scores, and pHu (P < .01) were higher for PL vs C pigs. Warner-Bratzler shear force was not affected by PL or BF. As expected, fat depths were lower (P < .05) in the L vs F pigs and TRIB was lower for PL vs C pigs (P = .07). Backfat and PL treatment interacted to affect LLV, with the L-C and L-PL pigs being leaner (P < .06) than the F-C pigs and the F-PL pigs being intermediate. Muscling measurements (LEA, LED, and CMS) were greater (P < .05) for the PL vs C pigs and CMS was higher (P < .05) in the L vs F pigs. The picnic and Boston butt at 0

cm trim was not different due to PL or BF class. However, the center cut loin at 0 cm tended to be higher due to PL. Boneless ham (0 cm) was significantly higher in the PL vs C and L vs F pigs. The interaction of BF x PL affected CF (P = .03) with the L-PL, F-PL, and L-C being leaner than the F-C. Weight of FFL was greater in PL vs C (P <.05); however, FFL % was not affected (P >.10) by PL or BF. Belly firmness was not affected by PL or BF (P >.10). Overall, Paylean and BF had greater effects on carcass fat content than on FFL percent. Carcass quality, based on marbling and firmness scores and pHu, was improved slightly with PL treatment, and belly quality, in terms of firmness, was not affected by PL or BF.

Key Words: Pork, Paylean, Cutability, Belly Firmness, Pork Quality

Introduction:

The pork industry strives to improve cutability through genetic and nutritional advancements. Today, feeding practices involve feeding large pens of pigs where lean growth potential varies. Paylean® is a recently approved repartitioning agent that has been shown to improve cutability by decreasing fat and increasing lean (Crenshaw et al., 1987; Watkins et al., 1989; Aalhus et al., 1990; Mitchell et al., 1990; Watkins et al., 1990; Bark et al., 1992) while improving or not affecting carcass quality (Aalhus et al., 1990; Watkins et al., 1990; Stites et al., 1991; Uttaro et al., 1993; Sainz et al., 1993b; Crome et al., 1996; McKeith and Ellis, 2001). Yen and coworkers (1990) concluded that Paylean supplemented at 20 ppm would improve carcass leanness in pigs with different propensities to deposit body fat. There is, however, limited current research reporting the response of lean and fat pigs of similar genotypes supplemented with the label recommended level of 10 ppm of Paylean. Additionally, while the increase in cutability due to fat reduction is an excellent benefit, yet belly thickness and firmness could be affected and negatively impact belly processing traits. Stites et al. (1991) and Uttaro et al. (1993) reported that Paylean supplementation did not affect belly thickness; However, this research does not address firmness in terms of Paylean elicited changes. Therefore, the objective of this study was to determine carcass cutability, quality, and belly firmness of Paylean® supplemented barrows sorted into prefinishing ultrasound backfat thickness classes.

Material and Methods:

Crossbred barrows (~80kg), within a farrowing group, were ultrasounded and phenotypically segmented into lean and fat pens. The 10^{th} rib fat depth difference

between the fat (F) and lean (L) groups was $\geq$ 0.5 cm. All pigs received a diet containing 18% crude protein, 1.0% added animal-vegetable fat, and 1.1% lysine with half of the pens receiving a Paylean supplement of 10 ppm for 28 days. The resulting assignment was a 2 x 2 factorial arrangement with backfat class (BF) and Paylean (PL) as main effects.

Harvest and Grading:

After finishing, the two average gaining pigs (n = 56) from a pen were transported to The University of Georgia Meat Science Technology Center, held overnight with access to water, and harvested the following day by standard industry practices. After a 48-hour chill period, the left sides of the carcasses were ribbed at the 10th rib. The National Pork Producers Council's subjective color, marbling and firmness scores were recorded. Other quality measures assessed at the 10th rib include ultimate pH (Cole-Parmer meter – model 05669-00) and colorimeter L*, a*, and b* (Minolta Chroma Meter CR – 310). Fat thickness at the first rib, 10th rib, last rib, and last lumbar vertebrae were measured and subjective carcass muscle score was recorded. Tracings of 10th rib loin eye areas were measured for area and depth using Sigma-Scan Scientific Measurement software, version 3.90 (Jandel Scientific, Corte Madera, CA.).

Pork Carcass Fabrication:

The left sides of the carcasses were fabricated into bone-in and boneless primals and subprimals, according to the procedures outlined for fresh pork by the National Association of Meat Purveyors (NAMP, 1997). To standardize carcass weight, the diaphragm, wing of the diaphragm and kidneys (if present), and tail (between the 1st and 2nd coccygeal vertebrae) were removed and weighed. Standardized carcass weight was

recorded and the rear and fore shanks were removed immediately dorsal to the hock and knee joints and weighed. Each side was then fabricated into the four lean cuts (401 fresh ham, 405 picnic shoulder, 406 Boston Butt, and 410 loin), 408 belly, and 416 spareribs using the procedures described by NAMP (1997). The shoulder was separated from the carcass by measuring 2.54 cm posterior to the elbow and cutting perpendicular to the long axis of the carcass approximately between the 2nd and 3rd ribs. Once separated, the subscapularis did not extend past the dorsal edge of the base of the medial ridge of the scapula. The neck bones were removed from the shoulder and weighed, and excess lean remained with the Boston Butt (BB) following separation from the picnic. The jowl was removed from a point measured 2.54 cm from the posterior edge of the ear dip. The jowl was skinned, and the skinless jowl and the jowl skin were weighed.

The BB was separated from the picnic shoulder (PS) by cutting 1.27 cm from the ventral side of the scapula and perpendicular to the posterior cut surface. The loin (LN) and belly (BY) were separated from the ham by a straight cut between the second and third sacral vertebrae (3.8 cm from the aitch bone), approximately perpendicular to the shank bones. The LN and BY were separated by a cut beginning 2.54 cm from the foremost rib - vertebral column attachment on the anterior end of the LN and continuing to the ventral edge of the *psoas major* muscle on the posterior end of the LN, following the natural curvature of the chine bone.

Picnic Shoulder: The 405 PS was fabricated into a 405A PS by removing the remaining skin and all bone and trimming the fat to 0.64 and 0 cm. Each PS subprimal, bone, lean trim, and corresponding skin were weighed.

Boston Butt: The 406 BB was fabricated into a 406A BB, boneless and weighed along with the bone. The 406A BB was further fabricated into the 407 BB, and lean trim, recording weights for each. The 407 BB was trimmed to 0.64 and 0 cm external fat; the 407 BB and fat trim were weighed between each step.

Loin Fabrication. The 410 LN was fabricated into a 411 LN, bladeless, and weights were recorded for the 411 LN, blade bone, and lean and fat trimmings. The 411, bladeless LN was fabricated into the 412C, 11 rib center cut LN by removing the sirloin between the last two lumbar vertebrae and removing the blade, and weights were recorded for the 412C, blade and sirloin. The 412C LN, 11 rib center cut was fabricated into a 412D LN, 11 rib center cut, chine bone off, blade end, and sirloin end, and each subprimal was weighed. The 412D LN, blade end, and sirloin end were deboned to form a 412E center cut LN, boneless, a boneless blade, and a boneless sirloin, respectively. The 412E center cut LN, boneless blade, and boneless sirloin were further trimmed to 0.64 and 0 cm external fat and the trimmed subprimals and fat trim were weighed between each step.

Belly Fabrication. The 408 BY was skinned to form a 409 BY and the 409 BY and skin were weighed.

Ham Fabrication. The 401 fresh ham was fabricated into a 402 fresh ham, skinned, and trimmed to 1.27 cm external fat. The 402 ham and skin were weighed and the 402 ham was fabricated into the boneless inside ham (*semimembranosus*, *gracillis,* and *adductor*), outside ham (*semitendinosus* and *biceps femoris*), knuckle (*vastus intermedius*, *vastus lateralis*, *tensor fasciae latae* and *vastus medialis*), light butt (*gluteus medius*), heel, and inner shank muscles. The skin, fat trim, and bone were weighed. The ham muscle

groups were weighed individually (1.27 cm subcutaneous fat) and trimmed to 0 cm external fat. The muscle groups and fat trim were weighed between each step.

Cut Yields and Compositional End Points. Primal and boneless subprimal cut yields are expressed as a percentage of side weight. The PS and BB cut weights used were those recorded during fabrication. For the total LN lean, weights for the *psoas major* muscle and 412E center cut LN, boneless blade, and boneless sirloin at 0 cm fat trim were summed. Weight for total ham lean at 0 cm fat trim was the summation of the weights for the cushion, outside ham, knuckle, light butt, heel, and inner shank muscle groups. After fabrication and lipid analysis of carcass sides, endpoints for carcass fat, fat free lean, and boneless, denuded cuts weights and percent were calculated **(Table 2.1)**.

Lipid extraction:

The belly and dissected carcass tissues were ground twice using a 1.27 cm grinder plate and mixed between grindings for 5 minutes. Sub-samples were taken from the ground belly and carcass, homogenized using a vertical chopper, vacuum-packaged and frozen for lipid extractions. The *longissimus dorsi* samples were frozen in liquid nitrogen and homogenized. Lipid extractions were prepared in triplicate using the procedures of Folch et al. (1957) with modifications.

Disposable aluminum drying pans were used and dried overnight in a 90°C oven and equilibrated for 5 minutes in a desiccator. Tissue samples (2.5 g $\pm$ 0.1 g) were placed into labeled, conical tubes, homogenized with 10 mL of methanol and 5 mL of chloroform (2:1 methanol-chloroform mixture), and allowed to stand for 1 hour. Chloroform (5 mL) and 5 mL of 1 M KCl were added to each sample and vortexed. Samples were placed in a 0°C environment for 5 minutes and then centrifuged at 2,000 x

g for 10 min at 0°C. The top layer was aspirated off without disturbing the meat pellet, and samples were gently poured into aluminum pans. The samples were dried overnight in the fume hood and then for 30 minutes at 90°C the following day. Following drying, samples were placed in a desiccator for 5 minutes. The samples were weighed and percent lipid was calculated ((pan with lipid weight – pan weight)/ sample weight x 100%).

Belly Firmness:

The bellies were collected from the right side of the carcass, skinned and trimmed to 46 x 22 cm. Bellies were laid on a flat surface, over-wrapped, and held at -1°C over night. Belly thickness was measured on two points on the ventral and dorsal sides. Belly firmness was evaluated using the belly – bar technique, and firmness was defined as the distance between the anterior and posterior ends when the belly was draped over a bar at the midway point on the dorsal and ventral sides of the belly. The distance between the anterior and posterior end was measured.

Warner-Bratzler Shear Force:

Warner-Bratzler shear force was completed using the American Meat Science Association guidelines (1995) with modifications. Pork chops (2.54 cm thick) were removed from loins at approximately the 12^{th} rib and trimmed free of external fat. Chops were vacuum packaged, aged (7 days), and frozen. Thermocouples were placed in the approximate geometric center of the chops and they were cooked on Farberware grills. Chops were turned when the internal temperature reached 35 to 40°C. Chops were cooked to a final endpoint temperature of 65°C, and endpoint temperature, cooking time, and final cooked weights were recorded.

Chops were placed in a 4.4°C cooler for 3 hours. After cooling, the chops were evaluated for degree of doneness, and four cores (1.27 cm) from each pork chop were removed parallel to the longitudinal orientation of the muscle fibers. Cores were sheared using a Salter Warner-Bratzler Shear, and the shear force values of the cores were recorded.

Data Analysis:

Data were analyzed using analysis of variance for a 2 x 2 factorial arrangement with the main effects of Paylean® and 10^{th} rib backfat class. Replicate and replicate interactions were included to remove variation. Animal was the experimental unit for this trial. Least squares means were generated and separated using the least significant difference procedures.

Results:

Pork Quality: Paylean supplemented pigs had higher NPPC firmness ($P < .01$, **Table 2.2**) and marbling scores ($P = .07$) than control (C) pigs; however, ether extracted loin intramuscular fat content was not different due to PL supplementation ($P = .30$). These results are consistent with Watkins et al. (1990) who reported that PL supplementation at 10 ppm significantly improved firmness and marbling scores. In this study, subjective color was not affected by PL supplementation. In agreement, Crome et al. (1996) reported PL supplementation had no effect on color, firmness and marbling scores.

In terms of objective quality measurements, L* was not affected by PL supplementation, but a* ($P < .01$) was lower (decreased redness) and b* ($P < .01$) was lower (decreased yellowness) due to PL treatment. Ultimate loin pH was significantly higher ($P < .01$) in PL vs C pigs. Past studies reported that ultimate pH (Aalhus et al., 1990; Sainz et al., 1993b; McKeith and Ellis, 2001) and L* values of the loin were not effected by the

supplementation of dietary PL (Aalhus et al., 1990: Sainz et al., 1993b Uttaro et al., 1993). As for a* and b* values of the loin, Uttaro et al. (1993) reported that PL significantly decreased a* and b* values, while Sainz et al. (1993b) determined that PL had no effect on a* or b* values.

Backfat class had no affect on objective or instrumental quality measures ($P > .25$). Seideman et al. (1989) reported that fat pigs had significantly firmer loin eyes with more marbling than lean pigs; however, objective color was not different between the obese and lean pigs.

Warner-Bratzler shear force of the loin was not affected by PL treatment or BF class ($P > .30$). The effects elicited by PL are similar to those seen in Stites et al. (1994), but Aalhus et al. (1990) found that pigs supplemented with PL had significantly higher shear forces than the control pigs. Seideman et al. (1989) reported that lean pigs had significantly higher shear force values than obese pigs, which was not seen in this study.

Carcass Composition: Paylean supplementation did not affect hot carcass weight (HCW, $P = .58$, **Table 2.3**), which is consistent with Watkins et al. (1990) and Bark et al. (1992); however, other studies have reported an increase in HCW due to PL supplementation (Yen et al., 1990; Stites et al., 1991; Crome et al., 1996). Paylean supplementation did not affect first rib (FR), last rib (LR), and last lumbar vertebrae (LLV) fat depths; however, 10^{th} rib fat (TR) depth tended ($P = .07$) to be lower in PL supplemented pigs. Many researchers have reported that supplementation of PL decreased average backfat (Hancock et al., 1987; Mitchell et al., 1990; Watkins et al., 1990; Yen et al., 1990; Bark et al., 1992), with TR fat being reduced to a greater extent than other depots (Crenshaw et al., 1987; Prince et al., 1987; Watkins et al., 1989;

Watkins et al., 1990; Yen et al., 1990; Bark et al., 1992; Crome et al., 1996). Alternatively, few researchers have reported that dietary PL had no effect on TR fat depth (Adeola et al., 1990; Stites et al., 1991; He et al., 1993; Sainz et al., 1993b). As for other backfat measures, Crome et al. (1996) and Adeola et al. (1990) reported that dietary PL decreased FR fat and had no significant effect on LR fat. There were, however differences across studies in the effect on last lumbar vertebrae (LLV) fat as one study determined that fat thickness was decreased (Crome et al., 1996) and the other found that there was no significant effect on LLV (Adeola et al., 1990).

Carcass muscle score, loin eye area (LEA), and loin eye depth (LED) were significantly ($P \leq .01$) higher in PL vs C pigs, and when LEA was expressed as cm of loin eye per kg of carcass weight, this difference was maintained ($P = .02$). The findings are consistent with other reports of PL on LEA (Crenshaw et al., 1987; Hancock et al., 1987; Prince et al., 1987; Watkins et al., 1989; Adeola et al., 1990; Mitchell et al., 1990; Watkins et al., 1990; Yen et al., 1990; Stites et al., 1991; Bark et al., 1992; Crome et al., 1996; Shinckel et al., 2002) and LED (Adeola et al., 1990; He et al., 1993) at the 10^{th} rib. Conversely, there are a limited number of studies showing that PL had no effect on LEA (Sainz et al., 1993b).

BF class had greater affects on carcass composition than carcass quality, as L pigs had significantly less fat at the FR, LR, LLV, ($P = .02$) and TR ($P < .01$). This was expected because pigs were selected based on the initial ultrasound 10^{th} rib backfat measurements. In terms of carcass muscling, lean pigs had significantly higher USDA carcass muscle scores ($P < .01$); however, LEA and LED were not affected by BF class. Lean pigs tended ($P = .09$) to have more loin eye area per kg of carcass weight than the fat pigs. In

general, these data agree with Pringle and Williams (2001), where increased fat depths and decreased muscle scores were reported when carcass 10^{th} rib backfat increased. In that study, LEA and LED were not affected by backfat category, which is similar to the current study.

Carcass Cutability: Neither PL treatment nor BF class affected the yield of the bone-in, untrimmed PS, BB or LN ($P > .25$, **Table 2.4**). However, the yield of bone-in, untrimmed hams tended to be higher in PL vs C ($P = .08$). Previous studies found that the weights and percent yield of untrimmed cuts were not significantly different in pigs supplemented with PL (Yen et al., 1990; Stites et al., 1991; Bark et al., 1992; Uttaro et al., 1993; Crome et al., 1996). In contrast, there are a few reports in which the untrimmed weight of the ham, loin (Stites et al., 1991; Crome et al., 1996), picnic (Yen et al., 1990; Crome et al., 1996), and Boston Butt (Crome et al., 1996) were increased.

Boneless PS and BB at 0 cm trim were not significantly different across PL treatment or BF class ($P \geq .10$); however, there was a trend for the yield of the boneless, center cut LN ($P = .09$) and boneless sirloin ($P = .06$) at 0 cm trim to be higher in PL pigs. A significant interaction of PL and BF ($P = .03$) was found for the boneless, defatted blade portion where the F,C (1.18%) pigs were the lowest yielding, the F,P (1.34%) and L, P (1.43%) were intermediate in yield, and the L,C (1.70%) pigs had the highest yield. Total LN lean yield at 0 cm trim was numerically higher in PL treated pigs ($P > .20$). The yield of dissected ham muscle groups at 0 cm trim was affected as the cushion ($P = .07$) and outside ($P < .01$) composed a higher percentage of the carcass weight in PL vs C pigs. Paylean did not affect the knuckle, heel, or inner shank yields ($P > .15$). The total ham lean yield was higher in PL vs C ($P = .02$). Stites et al. (1991) and Crome et al. (1996)

reported observations that agree with the present study. The aforementioned studies found that the percentage of the carcass composed of trimmed ham and LN increased. However, no significant change in the percentage of belly, PN or BB due to PL treatment was observed. Moreover, Crome et al. (1996) reported that, upon further dissection of the ham, the weights of the inside and outside were increased, which is consistent with the current study. Kim et al. (1992) studied the effect of cimaterol in rat muscles where he quantified the receptor densities of different muscles, and they reported that the *plantaris* and *soleus* had different receptor densities. This may help explain the cut specific increases in yields.

Backfat class did not affect the yield of the bone-in, untrimmed PS, BB or LN ($P > .25$). However, the yield of bone-in, untrimmed hams were significantly higher in L vs F pigs ($P < .01$). The yield of the boneless PN, BB, belly, and center cut LN at 0 cm trim were not different between L and F pigs. However, the boneless sirloin at 0 cm trim was significantly ($P = .02$) higher in L vs F pigs. The total loin lean yield at 0 cm trim was not affected by BF class, but was numerically higher in L pigs. Upon dissection of the ham, the cushion ($P < .01$), outside ($P < .01$), and knuckle ($P < .03$) had significantly higher yield values in the L vs the F pigs. However, the yield of the heel and inner shank portions was not affected by BF class ($P > .25$). The total ham lean yield at 0 cm trim was significantly higher in L vs F pigs ($P < .01$). These results agree with Seideman et al. (1989), who reported hams from lean pigs had more lean than hams from obese pigs. In contrast, Pringle and Williams (2001) reported significant differences in bone-in PS, BB, and hams yields as TR increased. However, their data agrees with the bone-in full LN, where no significant difference was reported between the lower and mid range fat

categories. Also, the boneless PS, BB, ham, and LN at 0 cm trim were significantly higher yielding in pigs with less 10^{th} rib backfat.

Cutability Endpoints: Paylean did not affect carcass fat weight or the total boneless denuded cuts (BDC) weight ($P > .20$, **Table 2.5**). However the weight of the fat free lean (FFL) was significantly higher in PL supplemented pigs. As expected, F pigs had significantly ($P < .01$) more carcass fat (CF) by weight than the L pigs; however, the weight of FFL and the total BDC weight were not affected by BF class ($P > .50$).

When carcass fat is expressed as a percentage, a significant interaction between PL treatment and BF ($P = .03$) class was seen as PL caused a significant reduction in CF in F pigs, but had no effect on L pigs. The percentage of FFL and BDC was not affected by PL treatment or BF class ($P > .25$). The results of the weight and percentages of fat and lean were consistent with those seen in previous Paylean studies where PL increased the dissected muscle and decreased the dissected fat (Crenshaw et al., 1987; Watkins et al., 1989; Aalhus et al., 1990; Bark et al., 1992; Xiao et al., 1999). In terms of BF class, data concerning FFL, BDC, and CF are consistent with those reported by Pringle and Williams (2001).

Belly Firmness: Belly firmness was not affected by PL treatment ($P = .75$, **Table 2.6**), but F pigs had significantly ($P = .03$) firmer bellies than L pigs. Belly lipid content was not affected by PL supplementation ($P = .32$); however, F pigs had a higher percentage of lipid than the L pigs ($P < .01$). In order to compensate for these differences in belly composition, belly firmness was analyzed using lipid percent as a covariate. Results from the covariate analysis showed no difference in firmness due to PL treatment or BF class ($P \geq .18$).

Belly thickness on the dorsal (P = .69) and ventral (P = .72) sides was not affected by PL supplementation; however, as expected, the fat pigs had significantly thicker bellies on both the ventral (P = .05) and dorsal (P < .01) sides. The thickness difference seen with PL treatment is similar to those seen in previous studies (Stites et al., 1991; Uttaro et al., 1993). The response seen in the F vs L pigs is consistent with Pringle and Williams (2001). In that study, it was reported that as 10^{th} rib backfat depth increased, the belly thickness increased. Due to the differences in thickness, an analysis of firmness with thickness as a covariate was completed. When belly thickness was accounted for in the analysis, neither PL treatment nor BF class affected belly firmness (P = .92).

Conclusion:

Paylean® supplementation improved pork quality, and in terms of carcass composition, PL had a greater affect on carcass muscle measurements than on fat measurements, whereas BF class had greater affects on carcass fat measurements than on muscle measurements. Paylean had a site affect on the carcass by improving the yield of the ham and loin while other carcass cuts were unaffected. Furthermore, PL had greater affects on carcass fat than on lean content, which is contradictory to the initial observations with carcass measurements. These improvements in cutability are similar to those achieved with phenotypic selection for improved leanness. In addition, PL was shown to improve cutability regardless of initial backfat thickness. Finally, BF class had greater affects on the belly in terms of thickness and firmness than PL supplementation.

Literature Cited

Aalhus, J.L., Jones, S.D.M., Schaefer, A.L., Tong, A.K.W., Robertson, W.M., Merrill, J.K., & Murray, A.C. (1990). The effect of ractopamine on performance, carcass composition and meat quality of finishing pigs. *Canadian Journal of Animal Science*, *70,* 943.

Adeola, O., Darko, E.A., He, P., & Young, L.G. (1990). Manipulation of porcine carcass composition by ractopamine. *Journal of Animal Science, 68,* 3633.

AMSA. (1995). Research guidelines for cookery, sensory evaluation, and instrumental tenderness measurements of fresh meat. *National Live Stock and Meat Board, Chicago, IL.*

Bark, L.J., Stahly, T.S., Cromwell, G.L., & Miyat, J. (1992). Influence of genetic capacity for lean tissue growth on rate and efficiency of tissue accretion in pigs fed ractopamine. *Journal of Animal Science, 70,* 3391.

Crome, P.K., McKeith, F.K., Carr, T.R., Jones, D.J., Mowrey, D.H., & Cannon, J.E. (1996). Effect of ractopamine on growth performance, carcass composition, and cutting yields of pigs slaughtered at 107 and 125 kilograms. *Journal of Animal Science, 74,* 709.

Crenshaw, J.D., Swanteck, P.M., Marchello, M.J., Harrold, R.L., Zimprich, R.C., & Olson, R.D. (1987). Effects of a phenethanolamine (ractopamine) on swine carcass composition. *Journal of Animal Science, 65 (suppl. 1),* 308.

Folch, J., Lees, M., & Sloane-Stanley, G.H. (1957). A simple method for the isolation and purification of total lipids from animal tissue. *Journal of Biological Chemistry, 226,* 497.

Hancock, J.D., Peo, E.R., Jr., & Lewis, A.J. (1987). Effects of dietary levels of ractopamine on performance and carcass merit of finishing pigs. *Journal of Animal Science*, *65* (suppl 1), 309.

He, P., Aherne, F.X., Thompson, J.R., Schaefer, A.L., & Merrill, J.K. (1993). Effect of ractopamine on carcass characteristics and joint cartilage soundness in finishing pigs. *Canadian Journal of Animal Science*, *73*, 169.

Kim, Y.S., R.D. Sainz, R.J. Summers, and P. Molenaar. (1992). Cimaterol reduces Beta-adrenergic receptor density in rat skeletal muscles. *Journal of Animal Science. 70:115-122.*

McKeith, F.K., & Ellis, M. (2001). Effects of ractopamine on meat quality. *Journal of Animal Science, 79 (suppl 1),* 239.

Mitchell, A.D., Solomon, M.B., & Steele, N.C. (1990). Response of low and high protein select lines of pigs to the feeding of the beta-adrenergic agonist ractopamine. *Journal of Animal Science*, *68*, 3226 - 3232.

NAMP. (1997). The Meat Buyers Guide. National Association of Meat Purveyors, North American Meat Processing Association, Reston, VA.

Prince, T.J., Huffman, D.L., & Brown, P.M. (1987). Effects of ractopamine on growth and carcass composition of finishing swine. *Journal of Animal Science, 65 (suppl. 1),* 309.

Pringle, T.D., & Williams, S.E. (2001). Carcass traits, cut yields, and compositional end points in high-lean-yielding pork carcasses: Effects of 10^{th} rib backfat and loin eye area. *Journal of Animal Science, 79,* 115.

Sainz, R.D., Kim, Y.S., Dunshea, F.R., & Campbell, R.G. (1993). Temporal changes in growth enhancement by ractopamine in pigs. *Australian Journal of Agricultural Research, 44,* 1449.

Seideman, S.C., Crouse, J.D., & Mersmann, H.J. (1989). Carcass, muscle, and meat characteristics of lean and obese pigs. *Journal of Animal Science, 67,* 2950.

Schinckel, A.P., Richert, B.T., & Herr, C.T. (2002). Variation in the response of multiple genetic populations of pigs to ractopamine. *Journal of Animal Science, 80 (suppl 2),* E85.

Stites, C.R., McKeith, F.K., Singh, S.D., Bechtel, P.J., Mowrey, D.H., & Jones, D.J. (1991). The effect of ractopamine hydrochloride on the carcass cutting yields of finishing swine. *Journal of Animal Science*, *69*, 3094.

Stites, C.R., McKeith, F.K., Singh, S.D., Bechtel, P.J., Jones, D.J., & Mowrey, D.H. (1994). Palatability and visual characteristics of hams and loin chops from swine treated with ractopamine hydrochloride. *Journal of Muscle Foods, 5,* 367.

Uttaro, B.E., Ball, R.O., Dick, P., Rae, W., Vessie, G., & Jeremiah, L.E. (1993). Effect of ractopamine and sex on growth, carcass characteristics, processing yield and meat quality characteristics of crossbred swine. *Journal of Animal Science*, *71*, 2439.

Watkins, L.E., Jones, D.J., Gillespie, J.R., & Olson, R.D. (1989). Effect of ractopamine hydrochloride on the carcass composition of finishing swine - 3 - trial summary. J *Journal of Animal Science, 67 (suppl 2),* 104.

Watkins, L.E., Jones, D.J., Mowrey, D.H., Anderson, D.B., & Veenhuizen, E.L. (1990). The effect of various levels of ractopamine hydrochloride on the performance and carcass characteristics of finishing swine. *Journal of Animal Science, 68,* 3588.

Xiao, R.J., Xu, S.R., & Chen, H.L. (1999). Effects of ractopamine at different dietary protein levels on growth performance and carcass characteristics in finishing pigs. *Animal Feed Science and Technology, 79,* 119.

Yen, J.T., Mersmann, H.J., Hill, D.A., & Pond, W.G. (1990). Effects of ractopamine on genetically obese and lean pigs. *Journal of Animal Science, 68,* 3705.

Table 2.1 Description of carcass endpoint calculations

Carcass Fat Weight, kg (CF)	= carcass soft tissue weight x lipid percentage
Carcass Fat Percent	= CF / standardized side weight
Fat Free Lean Weight, kg (FFL)	= carcass soft tissue weight (kg) - CF
Fat Free Lean Percent	= FFL / standardized side weight
Boneless denuded cut weight, kg (BDC)	= weight of 0 cm trim cuts
Boneless denuded cut percent	= BDC / standardized side weight

Table 2.2 The effects of Paylean supplementation and pre-finishing backfat class on carcass quality traits.

	Paylean Treatment			Backfat Class			D*P
	0 ppm	10 ppm	P > F	Fat	Lean	P > F	P > F
NPPC color score	2.2 ± .11	2.4 ± .12	.44	2.4 ± .12	2.2 ± .11	.44	.44
NPPC firmness score	6.0 ± .33	7.4 ± .35	<.01	6.9 ± .36	6.5 ± .32	.39	.93
NPPC marbling score	1.6 ± .15	2.0 ± .16	.07	1.8 ± .17	1.7 ± .15	.52	.26
Loin fat content, %	2.47 ± .13	2.52 ± .14	.30	2.47 ± .14	2.36 ± .12	.57	.44
Minolta L*	52.3 ± .58	51.4 ± .62	.33	51.7 ± .63	52.1 ± .56	.66	.15
Minolta a*	10.0 ± .23	8.7 ± .25	<.01	9.5 ± .25	9.2 ± .22	.32	.63
Minolta b*	6.4 ± .22	5.0 ± .23	<.01	5.7 ± .24	5.6 ± .21	.76	.23
Loin ultimate pH	5.53 ± .02	5.62 ± .02	<.01	5.60 ± .02	5.56 ± .02	.26	.22
WB shear force, kg	2.17 ± .12	2.34 ± .13	.31	2.33 ± .13	2.18 ± .12	.40	.75

*Table 2: NPPC 5 point firmness scale was converted to a 15 point scale. $1 = 1^{-}$, $2 = 1^{\circ}$, $3 = 1^{+}$, $4 = 2^{-}$, $5 = 2^{\circ}$, $6 = 2^{+}$, $7 = 3^{-}$, $8 = 3^{\circ}$, $9 = 3^{+}$, $10 = 4^{-}$, $11 = 4^{\circ}$, $12 = 4^{+}$, $13 = 5^{-}$, $14 = 5^{\circ}$, $15 = 5^{+}$

Table 2.3 The effects of Paylean supplementation and pre-finishing backfat class on carcass composition.

	Paylean Treatment			Backfat Class			D*P
	0 ppm	10 ppm	P > F	Fat	Lean	P > F	P > F
Hot carcass weight, kg	80.0 ± 1.74	81.4 ± 1.86	.58	82.0 ± 1.91	79.4 ± 1.69	.32	.96
First rib fat depth, mm	37.2 ± .09	36.0 ± .09	.38	38.1 ± .10	35.1 ± .09	.02	.26
Last rib fat depth, mm	20.0 ± .08	20.1 ± .08	.90	21.4 ± .09	18.7± .07	.02	.20
Last lumbar vertebrae fat depth, mm	19.2 ± .08	18.5 ± .08	.49	20.3 ± .08	17.4 ± .07	.02	.06
10^{th} rib fat depth, mm	23.0 ± .10	20.9 ± .10	.07	24.8 ± .11	19.1 ± .09	<.01	.14
USDA Muscle score	5.4 ± .15	6.3 ± .16	<.01	5.6 ± .17	6.2 ± .15	<.01	.82
Loin eye area, cm^2	39.9 ± 1.12	45.9 ± 1.19	<.01	42.0 ± 1.22	43.8 ± 1.08	.27	.99
Loin eye area per kg carcass, cm^2/kg	.50 ± .02	.58 ± .02	.02	0.51 ± .02	0.56 ± .02	.09	.63
Loin eye depth, cm	5.5 ± .17	6.2 ± .19	.01	5.9 ± .19	5.8 ± .17	.66	.91

Table 2.4 The effect of Paylean® supplementation and pre-finishing backfat class on percent of carcass cuts.

	Paylean Treatment			Backfat Class			D*P
Trait	0 ppm	10 ppm	P > F	Fat	Lean	P > F	P > F
Picnic, bone-in	15.2 ± .50	14.8 ± .51	.51	15.3 ± .53	14.7 ± .47	.27	.13
Picnic, boneless at 0 cm	11.1 ± .32	11.2 ± .34	.78	11.1 ± .35	11.2 ± .31	.87	.89
Boston butt, Bone in at .64 cm	9.46 ± .19	9.44 ± .19	.93	9.40 ± .20	9.50 ± .18	.70	.50
Boston butt, boneless at 0 cm	7.08 ± .16	7.26 ± .17	.36	7.01 ± .14	7.33 ± .12	.10	.97
Belly, boneless, Skinless	11.5 ± .30	11.4 ±.31	.93	11.4 ± .32	11.5 ± .29	.88	.80
Bone-in full loin at .64 cm	23.6 ± .29	23.9 ± .30	.39	23.6 ± .31	24.0 ± .28	.30	.47
Boneless, center cut loin at 0 cm	9.24 ± .27	9.92 ± .29	.09	9.46 ± .30	9.70 ± .26	.54	.22
Boneless blade at .64 cm	1.62 ±.07	1.51 ± .08	.30	1.40 ± .08	1.72 ± .07	<.01	.02
Boneless blade at 0 cm	1.44 ± .06	1.39 ± .07	.60	1.26 ± .07	1.56 ± .06	<.01	.03
Boneless sirloin at .64 cm	3.41 ± .08	3.60 ± .08	.10	3.39 ± .08	3.63 ± .07	.03	.36
Boneless sirloin at 0 cm	2.77 ± .07	2.96 ± .07	.06	2.74 ± .08	3.00 ± .07	.02	.32
Tenderloin	1.51 ± .21	1.38 ±.22	.66	1.52 ± .22	1.36 ± .20	.60	.56
Total loin lean at 0 cm	14.9 ± .39	15.6 ± .39	.22	14.9 ± .39	15.6 ± .39	.26	.45
Bone-in, rind-on ham	24.6 ± .21	25.2 ± .22	.08	24.4 ± .22	25.4 ± .22	<.01	.65
Ham cushion at 0 cm	5.34 ± .08	5.56 ± .08	.07	5.29 ± .07	5.62 ± .08	<.01	.85
Ham outside at 0 cm	5.76 ± .09	6.15 ± .10	<.01	5.72 ± .10	6.19 ± .09	<.01	.81
Ham knuckle at 0 cm	3.19 ± .07	3.27 ± .07	.46	3.12 ± .07	3.34 ± .07	.03	.47
Lite Butt	.49 ± .02	.51 ± .02	.57	.50 ± .02	.51 ± .02	.79	.47
Heel	1.62 ± .05	1.69 ± .05	.28	1.62 ± .05	1.69 ± .05	.28	.96
Inner shank	.95 ± .02	.99 ± .02	.19	.96 ± .03	.98 ± .02	.54	.54
Boneless total ham lean at 0 cm	17.4 ± .24	18.2 ± .25	.02	17.2 ± .26	18.3 ± .23	<.01	.51

*Table 4: All cuts are presented a percent of the carcass weight

Table 2.5 The effect of Paylean® supplementation and pre-finishing backfat class on carcass cutability endpoints.

	Paylean Treatment			Backfat Class			D*P
Trait	0 ppm	10 ppm	P > F	Fat	Lean	P > F	P > F
Fat weight, kg	7.80 ± .29	7.35 ± .30	.31	8.21 ± .32	6.99 ± .28	<.01	.09
Lean weight, kg	22.8 ± .59	24.5 ± .61	.05	23.4 ± .64	23.9 ± .57	.55	.77
Boneless denuded cuts, kg	23.4 ± .66	24.6 ± .69	.24	23.9 ± .72	24.0 ± .64	.95	.48
Total fat, %	20.4 ± .54	18.5 ± .56	.02	21.1 ± .59	17.8 ± .52	<.01	.03
Fat free lean, %	60.0 ± 1.24	62.1 ± 1.27	.27	60.1 ± 1.33	62.0 ± 1.18	.31	.95
Boneless denuded cuts, %	61.5 ± 1.42	62.2 ± 1.48	.76	61.5 ± 1.53	62.2 ± 1.37	.74	.67

Table 2.6 The effect of Paylean® supplementation and pre-finishing backfat class on belly firmness, thickness and lipid content

	Paylean Treatment			Backfat Class			D*P
Trait	0 ppm	10 ppm	P > F	Fat	Lean	P > F	P > F
Dorsal belly thickness, cm	3.12 ± .04	3.07 ± .04	.69	3.38 ± .04	2.84 ± .04	<.01	.86
Ventral belly thickness, cm	3.10 ± .03	3.05 ± .03	.72	3.18 ± .03	2.95 ± .03	.05	.21
Belly fat content, %	33.4 ± .78	32.3 ± .76	.32	34.8 ± .76	30.9 ± .78	<.01	.33
Belly firmness, cm	18.9 ± 1.51	18.3 ± 1.51	.75	21.1 ± 1.51	16.1 ± 1.51	.03	.64
Belly firmness with thickness as a covariate, cm	18.7 ± 1.22	18.5 ± 1.22	.92	18.6 ± 1.34	18.6 ± 1.34	.92	.56
Belly firmness with lipid as a covariate, cm	18.6 ± 1.63	18.0 ± 1.58	.78	20.1 ± 1.73	16.5 ± 1.75	.18	.70

CHAPTER 3

THE EFFECT OF RACTOPAMINE ON FATTY ACID COMPOSITION OF PIGS VARYING IN PREFINISHING 10TH RIB BACKFAT

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Abstract: Barrows (~ 80 kg) were ultrasounded, segregated into lean (L) and fat (F) pens (difference $\geq$ .5 cm), and randomly assigned to ractopamine treatment (RAC, 0 vs 10 ppm). After finishing (28 d), the two average gaining pigs from a pen were harvested (n = 56). Fat samples were collected from subcutaneous (inner (IF) and outer (OF)), Longissimus (LD), leaf (LF) and belly (BYF) depots. Iodine values (IV) were calculated using chromatograph fatty acid composition (FAC). Data were analyzed using ANOVA for a replicated (n = 4), 2 x 2 factorial arrangement with the main effects of RAC and backfat class (BF). In IF, L pigs had higher C18:2, C18:3, ($P < .01$) and IV ($P = .02$) than F pigs, and RAC pigs had higher C20:1($P = .02$), C20:2 ($P < .01$) and IV ($P < .03$) than control (C) pigs. Outer fat FAC and IV were not affected by RAC or BF. The LD had higher C18:1 and lower C18:2 in RAC pigs($P \leq .05$), and LD IV was higher ($P < .04$) in C pigs. BF had no effect on LD FAC. Belly C20:1 was higher ($P = .04$) in RAC pigs; otherwise, belly FAC and IV were not affected by RAC or BF. Ractopamine and F pigs had decreased C16:0 in LF ($P \leq .05$), and C18:2 and C18:3 ($P < .01$) were increased in L pigs. Leaf fat IV was higher in L vs F ($P = .01$) and RAC vs C ($P = .05$). Overall, the differences in FAC and IV between RAC and C pigs were similar to those observed in L versus F pigs.

Key Words: Pork, Ractopamine, Fatty acids, Iodine Value

Introduction:

The current U.S. pork production system uses phenotypic selection to enhance lean gain and feed efficiency in finishing pigs. Wood et al. (1989) reported lean pigs had a higher proportion of polyunsaturated fatty acids (PUFA) in fat. Thus, phenotype can affect fatty acid composition which in turn causes soft fat (Maw et al., 2003), affecting processing attributes. A recently approved product, known as ractopamine (RAC) (Paylean®, Elanco Animal Health, Greenfield, IN), is a phenethanolamine that improves feed efficiency (Aalhus et al., 1990; Watkins et al., 1990; Yen et al., 1990; Gu et al., 1991; Stites et al., 1991; He et al., 1993; Dunshea et al., 1998), average daily gain (Watkins et al., 1990; Stites et al., 1991; He et al., 1993; Dunshea et al; 1998), and reduces backfat (Hancock et al., 1987; Mitchell et al., 1990; Watkins et al., 1990; Yen et al., 1990; Bark et al., 1992) by altering metabolism (Liu et al., 1989; Peterla and Scanes, 1990; Bark et al., 1992; Akanbi and Mersmann, 1996). While carcass fat reduction satisfies the consumers demands for lower fat product, altered lipid metabolism can change fatty acid profiles of various depots. The limited body of literature suggests that RAC has little or no effect on fatty acid composition in subcutaneous or loin intramuscular (i.m.) depots of pork carcasses (Lee et al., 1989; McKeith et al., 1990; Engeseth et al., 1992; Perkins et al., 1992). This research leaves depots, such as the belly and leaf fat unaccounted for in terms of fatty acid profile changes due to RAC supplementation. Thus, the main objective of this study was to determine the effects of RAC on fatty acid composition and calculated iodine values (IV) of pigs varying in prefinishing 10^{th} rib backfat.

Additionally, in the pork packing industry, IV in one depot is sometimes used to predict processing characteristics of fat from another depot. Thus, it is important to determine if

IV's from various fat depots are statistically related. Hence, the secondary objective of this study was to determine if fatty acid composition of other depots can be successfully used to predict calculated belly IV.

Materials and Methods:

Crossbred barrows (~80kg), within a farrowing group, were ultrasounded and phenotypically selected into lean and fat pens (n = 5 pigs/pen). The 10^{th} rib fat depth difference between the fat and lean groups was $\geq$ 0.5 cm. Images were collected using Aloka 500-V ultrasound unit (Corometrics Medical Systems, Wallingford, CT) with a 17.2 cm, 3.5 MHz linear probe and interpreted using Beef Information Manager™ software, version 3.0 (Critical Vision Inc., Atlanta, GA.). All pigs received a diet containing 18% crude protein, 1.0% added animal-vegetable fat, and 1.1% lysine, and half of the pens received a ractopamine supplement of 10 ppm for 28 days. After a 28 d finishing period, the two average gaining pigs from each pen were taken to The University of Georgia Meat Science Technology Center for harvest (n = 56).

Fat samples for fatty acid composition analysis were collected from the following depots: 10^{th} rib inner (IF) and outer (OF) subcutaneous fat, 10^{th} rib Longissimus dorsi (LD), leaf fat (LF), and belly fat (BYF). All samples were prepared for gas chromatograph (GC) analysis using the procedure of Park and Goins (1994), with modifications.

Adipose Samples:

Approximately 50 – 100 mg of adipose tissue was weighed into a glass test tube. Added to each sample were 200 µL of methylene chloride, 2 mL of .5 N sodium methoxide in methanol, and 1 ml of internal standard (2 mg of C17:0 per mL of methanol). The samples were flushed with nitrogen, vortexed, and heated at 90°C for 20 minutes. The

samples were cooled to room temperature, and 2 mL of 14% boron triflouride in methanol was added to each sample. The samples were flushed with nitrogen, vortexed, and heated at 90°C for 20 minutes. The samples were then cooled to room temperature. Water (2 mL) and 2 mL of hexane were added to the solution, vortexed, and allowed to separate. Anhydrous sodium sulfate was added to remove any residual water.

Longissimus samples:

The LD samples (1 – 2 gm) were frozen in liquid nitrogen and homogenized. Added to each sample were 400 μL of methylene chloride, 4 mL of .5 N sodium methoxide in methanol, and 2 ml of internal standard (2 mg of C17:0 per mL of methanol). The samples were flushed with nitrogen, vortexed, and heated at 90°C for 20 minutes. The samples were cooled to room temperature and 4 mL of 14% boron triflouride in methanol was added to each sample. The samples were flushed with nitrogen, vortexed, and heated at 90°C for 20 minutes. After cooling, the upper layer was separated, dried in a spin vacuum, and resuspended in 2 mL of hexane. Samples were stored at 4°C. Prepared samples were transferred into a vial for GC analysis.

All samples (adipose and *longissimus*) were analyzed using a Shimadzu Gas Chromatograph GC – 14A with a Supelcowax - 10 fused silica capillary column. Iodine values were calculated from the gas chromatograph analysis data using the following equation: iodine value = C16:1 (0.95) + C18:1 (0.86) + C18:2 (1.732) + C18:3 (2.616) + C22:1 (0.723) (AOCS, 1998; Gatlin et al., 2002).

All data were analyzed using analysis of variance (ANOVA) for a 2 x 2 factorial arrangement with the main effects of RAC and backfat class (BF). Replicate (n = 4) and replicate interactions were included in the model to remove variation. Animal was the

experimental unit used for analysis. Least squares means were generated and separated using the least significant difference procedures.

Iodine value prediction models for the belly were generated using regression procedures of SAS® (SAS inst., Cary, NC). The models reported were chosen based on max R^2 and C(p) were calculated. Additionally, a correlation matrix between belly IV and BYF C18:2 and C18:2 of other depots was generated using the SAS® system.

Fatty Acid Composition

Inner Subcutaneous Fat: Treatment significantly affected C20:1 (P = .02) and C20:2 ($P \leq .01$) as RAC pigs had higher levels of these fatty acids **(Table 3.2)**. Additionally, RAC treatment tended ($P \leq .10$) to decrease C16:0 and C18:0, and tended to increase C18:2. Engeseth et al. (1992) evaluated subcutaneous backfat fatty acid profiles and reported that C18:0 was lower and C18:3 was higher after four weeks of ractopamine supplementation; however, inner subcutaneous backfat was not separated from the outer layer in their study. Saturated fatty acid content was lower (P = .02) in the RAC vs C pigs, and this change was accompanied by a tendency (P = .06) for polyunsaturated (PUFA) to be higher in RAC treated pigs **(Table 3.3)**. Total unsaturated fatty acid (TUFA) content was significantly higher in RAC than in C pigs (P = .02).

Backfat class significantly ($P \leq .01$) affected C18:2 and C18:3, as L pigs had a higher percentage of these two fatty acids when compared to the F pigs. Furthermore, there was a trend for C16:0 to be lower in L vs F pigs (P = .08) **(Table 3.2)**. PUFA was significantly higher ($P \leq .01$) in L pigs, and this was accompanied by a numerical decrease in monounsaturated (MUFA) and saturated fatty acids **(Table 3.3)**. However, TUFA content was not affected by BF. This agrees with Martin et al. (1972) reported

that the proportion of unsaturated fatty acids is inversely proportional to the degree of fatness or finish. Scott et al. (1981) reported that there was a "strong tendency for a higher percentage of saturated fatty acids in pigs that were obese," and fat or obese pigs had proportionally less C18:2 when compared to lean pigs. He also stated that these differences maybe due to decreased lipolytic rates or less desaturase activity in fat pigs.

Outer Subcutaneous Fat: RAC or BF did not affect FAC of OF **(Table 3.4)**. However, there was a trend (P = .07) for C18:2 to be higher in RAC vs C pigs and for 20:1 to be lower (P = .06) in L vs F pigs. Fatty acid saturation level was not affected by RAC or BF; however, there was a trend for PUFA to be higher in RAC pigs **(Table 3.3)**. The lack of change in the saturation levels is not consistent with Scott et al. (1981); this may be a result of fat layer separation. Because inner subcutaneous fat is the site of new lipid deposition, it would appear that it is more sensitive to RAC stimulated changes than outer fat.

Longissimus dorsi: RAC treatment caused a significant increase (P = .05) in C18:1 and a decrease in C18:2 (P = .04) in the LD (**Table 3.5)**. These results are different from other research reports where there were no differences in *longissimus* intramuscular fat fatty acid composition due to RAC supplementation (Engeseth et al., 1992; Perkins et al., 1992). BF class did not affect fatty acid content of the LD (P >.05). Although there were minor changes in FA composition of individual FA, saturation levels were not affected by RAC or BF (P > .05). There was a trend (P = .08) for MUFA to be higher in RAC treated pigs, which is to be expected with the increase in C18:1 mentioned previously **(Table 3.3)**. Overall, TUFA was not affected by RAC or BF.

Leaf Fat: Treatment significantly affected LF C16:0, as RAC pigs had a lower level of this particular fatty acid (P = .05, **Table 3.6**). Additionally, there was a strong trend for C16:1 to be lower and C18:2 to be higher in RAC vs C pigs (P = .06). BF class significantly affected the fatty acid composition of leaf fat, as lean pigs had lower C16:0 (P = .03) and higher C18:2, C18:3 (P $\leq$ .01), and C20:2 (P = .03) percentages. Fatty acid saturation levels tended to change with RAC supplementation, as saturated fatty acids decreased (P = .06) and PUFA increased (P = .07) in leaf fat. As expected, saturated fatty acids were significantly lower (P = .05) and PUFA was significantly higher (P $\leq$ .01) in L vs F pigs **(Table 3.3)**. Overall, TUFA tended to increased in RAC versus C pigs and in L versus F pigs (P = .06).

Belly Fat: The only fatty acid affected by ractopamine supplementation was C20:1, which was higher in RAC treated pigs (P = .04, **Table 3.7**). All other fatty acids were not significantly affected by ractopamine supplementation (P > .10). BF class did not significantly affect fatty acid composition of the belly (P > .10). Neither RAC nor BF affected fatty acid saturation levels of the belly **(Table 3.3)**.

Iodine Value and Prediction Schemes

Inner fat IV was higher in RAC vs C (P < .03) and in L vs F pigs (P = .02) **(Table 3.8)**. Outer fat IV was not significantly (P > .05) affected by RAC or BF, but there was a trend (P = .09) for RAC treated pigs to have a higher IV when compared to the C pigs. LD IV was not affected by BF (P = .10), but was significantly affected by RAC supplementation, as C pigs had a higher IV (P < .04). Leaf fat IV was significantly affected by RAC (P = .05) and BF (P = .01), as L pigs and RAC pigs had higher IV than either the F pigs or the C pigs, respectively. Neither RAC nor BF affected belly fat IV (P

> .10). Davenel et al. (1998) investigated fat hardness and found that iodine value and solid fat content at 20°C were highly correlated (R^2 = .80). Fatty acids C16:0 and C18:0 explained 93.5% of the variability of solid fat content (or hardness). Thus, decreased saturated fatty acid content would decrease the iodine value and in turn produce softer fat.

Belly IV prediction models in this study are based on fatty acid content of IF, OF, LD, and LF **(Table 3.9)**. The best model from IF included the following variables: IF C14:0, C16:1, C18:2, and C20:1, where R^2 = .45 and C(p) = 3.67. This model accounted for more variation in the belly IV than models from other depots (24 – 32%). Based on the low accuracies for the models developed, it does not appear that belly IV can be predicted from the fatty acid composition of other fat depots.

The fatty acid C18:2 was common among the models, so a correlation matrix of the correlations between C18:2 of various depots with belly IV and BF C18:2 was completed **(Table 3.10)**. LF C18:2 most highly correlated with belly IV. IF C18:2 was more highly correlated with BF C18:2 than OF, LF, and loin i.m. fat.

In conclusion, the differences in fatty acid composition and iodine values between ractopamine supplemented and control pigs were similar to those observed in lean versus fat pigs. Ractopamine improved loin i.m. fat quality by increasing saturation levels and decreasing iodine value. Given the regression data, there is no sufficient model that can be used to accurately predict belly IV using the fatty acid composition of IF, OF, LD, or LF.

Literature Cited

AOCS. (1998) Official Methods and Recommended Practices of AOCS. 5th ed. Am. Oil. Chem. Soc., Champaign, IL.

Aalhus, J.L., Jones, S.D.M., Schaefer, A.L., Tong, A.K.W., Robertson, W.M., Merrill, J.K., & Murray, A.C. (1990). The effect of ractopamine on performance, carcass composition and meat quality of finishing pigs. *Canadian Journal of Animal Science*, *70*, 943 - 952.

Akanbi, K.A., & Mersmann, H.J. (1996). β - Adrenergic receptors in porcine adipocyte membranes: modification by animal age, depot site, and dietary protein deficiency. *Journal of Animal Science*, *74*, 551 – 561.

Bark, L.J., Stahly, T.S., Cromwell, G.L., & Miyat, J. (1992). Influence of genetic capacity for lean tissue growth on rate and efficiency of tissue accretion in pigs fed ractopamine. *Journal of Animal Science*, *70*, 3391 - 3400.

Davenel, A., Riaublanc, A., Marchal, P., & Gandemer, G. (1999). Quality of pig adipose tissue: relationship between solid fat content and lipid composition. *Meat Science*, *51*, 73 - 79.

Dunshea, F.R., King, R.H., Eason, P.J., & Campbell, R.G. (1998). Interrelationships between dietary ractopamine, energy intake and sex in pigs. *Australian Journal of Agricultural Research*, *49*, 565 - 574.

Engeseth, N.J., Lee, K.O., Bergen, W.G., Helferich, W.G., Knudson, B.K., & Merkel, R.A. (1992). Fatty acid profiles of lipid depots and cholesterol concentration in muscle tissue of finishing pigs fed ractopamine. *Journal of Food Science*, *57*, 1060 – 1062.

Gatlin, L.A, See, M.T., Hansen, J.A., Sutton, D., & Odle, J. (2002) The effects of dietary fat sources, levels, and feeding intervals on pork fatty acid composition. *Journal of Animal Science*, *80*, 1606 – 1615.

Gu, Y., Schinckel, A.P., Forrest, J.C., Kuei, C.H., & Watkins, L.E. (1991). Effects of ractopamine, genotype, and growth on finishing performance and carcass value in swine: I. Growth performance and carcass merit. *Journal of Animal Science*, *69*, 2685 - 2693.

Hancock, J.D., Peo, E.R., Jr., & Lewis, A.J. (1987). Effects of dietary levels of ractopamine on performance and carcass merit of finishing pigs. *Journal of Animal Science*, *65* (suppl 1), 309.

He, P., Aherne, F.X., Thompson, J.R., Schaefer, A.L., & Merrill, J.K. (1993). Effect of ractopamine on carcass characteristics and joint cartilage soundness in finishing pigs. *Canadian Journal of Animal Science*, *73*, 169 - 176.

Lee, K.O., Bergen, W.G., Helferich, W.G., Engeseth, N.J., Stoick, S.M,. & Merkel, R.A. (1989). Does ractopamine affect fatty acid profiles in lipid depots of finishing pigs? *Journal of Animal Science*, *67* (Suppl 1), 151.

Liu, C.Y., & Mills, S.E. (1989). Determination of the affinity of ractopamine and clenbuterol for the beta-adrenoceptor of the porcine adipocytes. *Journal of Animal Science*, *67*, 2937 - 2942.

Martin, A.H., H.T. Fredeen, G.M. Weiss, and R.B. Carson. 1972. Distribution and composition of porcine carcass fat. *Journal of Animal Science, 35, 534 – 541.*

Maw, S.J., Fowler, V.R., Hamilton, M., & Petchey, A.M. (2003). Physical characteristics of pig fat and their relation to fatty acid composition. *Meat Science*, *63*(2), 185 – 190.

McKeith, F.K., Perkins, E.G., Bechtel, P.J., Jones, D.J., & Mowrey, D.H. (1990). Effect of ractopamine on the fatty acid composition and cholesterol content of pork longissimus muscle. *Journal of Animal Science*, *68* (Suppl 1), 336.

Mitchell, A.D., Solomon, M.B., & Steele, N.C. (1990). Response of low and high protein select lines of pigs to the feeding of the beta-adrenergic agonist ractopamine. *Journal of Animal Science*, *68*, 3226 - 3232.

Park, P.W., & Goins, R.E. (1994). *In situ* preparation of fatty acid methyl esters for analysis of fatty acid composition in foods. *Journal of Food Science*, *59*, 1262 – 1266.

Peterla, T.A., & Scanes, C.G. (1990). Effect of beta-adrenergic agonists on lipolysis and lipogenesis by porcine adipose tissues in vitro. *Journal of Animal Science*, *68*, 1024 - 1029.

Perkins, E.G., McKeith, F.K., Jones, D.J., Mowrey, D.H., Hill, S.E., Novakofski, J., & O'Conner, P.L. (1992). Fatty acid and cholesterol changes in pork longissimus muscle and fat due to ractopamine. *Journal of Food Science*, *57*, 1266 – 1268.

Scott, R.A., Cornelius, S.G., & Mersmann, H.J. (1981). Fatty acid composition of adipose tissue from lean and obese swine. *Journal of Animal Science*, *53*, 977 – 981.

Stites, C.R., McKeith, F.K., Singh, S.D., Bechtel, P.J., Mowrey, D.H., & Jones, D.J. (1991). The effect of ractopamine hydrochloride on the carcass cutting yields of finishing swine. *Journal of Animal Science*, *69*, 3094 - 3101.

Watkins, L.E., Jones, D.J., Mowrey, D.H., Anderson, D.B., & Veenhuizen, E.L. (1990). The effect of various levels of ractopamine hydrochloride on the performance and carcass characteristics of finishing swine. *Journal of Animal Science*, *68*, 3588 - 3595.

Wood, J.D., Enser, M., Whittington, F.M., Moncrieff, C.B., & Kempster, A.J. (1989). Backfat composition in pigs: Differences between fat thickness groups and sexes. *Livestock Production Science*, *22*, 351 – 362.

Yen, J.T., Mersmann, H.J., Hill, D.A., & Pond, W.G. (1990). Effects of ractopamine on genetically obese and lean pigs. *Journal of Animal Science*, *68*, 3705 – 3712.

Table 3.1 Diet Composition

	Control		Ractopamine	
	%	lb./2 tons	%	lb./2 tons
Corn	68.58	2743.2	68.53	2741.2
Soybean meal	27.51	1100.4	27.51	1100.4
Ractopamine	0	0	0.05	2
Fat	1.00	40	1.00	40
Dical Phosphate	1.19	47.6	1.19	47.6
Limestone	0.85	34.0	0.85	34.0
Salt	0.40	16.0	0.40	16.0
Vitamin premix	0.15	6.0	0.15	6.0
Mineral. Premix	0.15	6.0	0.15	6.0
Lysine	0.17	6.8	0.17	6.8

Table 3.2 The effect of ractopamine supplementation and backfat class on fatty acid composition of inner subcutaneous fat

	Diet			Phenotype			D*P
Trait	Ctl	Pay	P > F	Fat	Lean	P > F	P > F
C14:0, %	1.20 ± .04	1.14 ± .04	.23	1.21 ± .04	1.13 ± .04	.15	.62
C16:0, %	21.7 ± .25	21.1 ± .27	.08	21.8 ± .28	21.1 ± .25	.08	.11
C16:1, %	2.07 ± .06	2.01 ± .06	.47	2.07 ± .06	2.01 ± .06	.51	.89
C18:0, %	13.6 ± .03	12.9 ± .03	.10	13.3 ± .31	13.2 ± .38	.92	.34
C18:1, %	41.5 ± .32	41.9 ± .34	.38	42.1 ± .35	41.4 ± .31	.15	.49
C18:2, %	17.6 ± .33	18.5 ± .36	.07	17.3 ± .37	18.7 ± .32	<.01	.23
C18:3, %	.74 ± .02	.78 ± .02	.15	.76 ± .02	.80 ± .02	<.01	.23
C20:1, %	.95 ± .02	1.03 ± .02	.02	1.01 ± .03	.97 ± .02	.23	.58
C20:2, %	.64 ± .01	.70 ± .02	<.01	.66 ± .02	.68 ± .01	.34	.13

Table 2 - *Note all values are expressed as a percentage of the total lipid

Table 3.3 The effect of ractopamine supplementation and backfat class on fatty acid saturation levels

	Diet			Phenotype			D*P
Inner fat	Ctl	Pay	P > F	Fat	Lean	P > F	P>F
Saturated, %	36.5 ± .42	35.1 ± .44	.02	36.2 ± .46	35.4 ± .41	.20	.12
MUFA, %	44.5 ± .34	45.0 ± .37	.39	45.1 ± .38	44.4 ± .33	.13	.51
PUFA, %	18.9 ± .35	19.9 ± .38	.06	18.6 ± .39	20.2 ± .34	<.01	.21
TUFA, %	63.5 ± .42	64.9 ± .45	.02	63.8 ± .46	64.6 ± .41	.20	.12
Outer fat							
Saturated, %	33.4 ± .85	31.5 ± .91	.14	33.0 ± .93	32.0 ± .82	.41	.24
MUFA, %	47.0 ± .68	47.9 ± .72	.38	47.3 ± .73	47.6 ± .64	.73	.53
PUFA, %	19.6 ± .38	20.6 ± .41	.08	19.7 ± .42	20.2 ± .37	.23	.14
TUFA, %	66.6 ± .85	68.5 ± .91	.14	67.0 ± .93	68.0 ± .82	.41	.24
Loin intramusclar fat							
Saturated, %	36.1 ± .44	36.5 ± .47	.53	36.5 ± .48	36.1 ± .42	.59	.60
MUFA, %	47.6 ± .61	49.2 ± .64	.08	48.7 ± .66	48.2 ± .59	.56	.72
PUFA, %	16.1 ± .68	14.6 ± .72	.13	15.1 ± .74	15.6 ± .66	.63	.89
TUFA, %	64.1 ± .36	64.0 ± .37	.84	64.0 ± .38	64.0 ± .34	.99	.73
Leaf fat							
Saturated, %	44.4 ± .53	42.9 ± .53	.06	44.4 ± .53	42.9 ± .53	.05	.28
MUFA, %	39.0 ± .36	39.1 ± .36	.87	39.5 ± .36	38.7 ± .36	.12	.48
PUFA, %	16.5 ± .51	17.9 ± .51	.07	16.1 ± .51	18.4 ± .51	<.01	.54
TUFA, %	55.6 ± .53	57.1 ± .53	.06	55.6 ± .53	57.1 ± .53	.06	.28
Belly fat							
Saturated, %	35.3 ± .55	34.6 ± .59	.34	35.0 ± .61	34.9 ± .53	.92	.37
MUFA, %	46.8 ± .41	47.0 ± .43	.74	47.0 ± .45	46.9 ± .39	.80	.59
PUFA, %	17.9 ± .40	18.4 ± .44	.35	18.0 ± .45	18.3 ± .40	.69	.50
TUFA, %	64.7 ± .55	65.4 ± .59	.34	65.0 ± .61	65.1 ± .53	.91	.37

Table 3.4 The effect of ractopamine supplementation and backfat class on fatty acid composition of outer subcutaneous fat

	Treatment			Backfat Class			D * P
Trait	Ctl	Pay	P>F	Fat	Lean	P>F	P>F
C14:0, %	1.14 ± .05	1.23 ± .06	.23	1.19 ± . 06	1.18 ± .06	.82	.56
C16:0, %	20.3 ± .33	20.1 ± .35	.74	20.1 ± .36	20.2 ± .36	.85	.69
C16:1, %	2.44 ± .08	2.47 ± .08	.81	2.42 ± .08	2.50 ± .07	.51	.88
C18:0, %	12.0 ± 1.06	10.2 ± 1.12	.24	11.7 ± 1.15	10.6 ± 1.02	.48	.42
C18:1, %	43.6 ± .62	44.4 ± .66	.39	43.9 ± .68	44.2 ± .60	.69	.47
C18:2, %	18.1 ± .36	19.1 ± .38	.07	18.3 ± .39	18.9 ± .34	.21	.14
C18:3, %	.78 ± .02	.82 ± .02	.16	.78 ± .02	.82 ± .02	.17	.22
C20:1, %	.92 ± .03	.97 ± .04	.29	.99 ± .04	.90 ± .03	.06	.62
C20:2, %	.64 ± .02	.68 ± .02	.19	.67 ± .02	.66 ± .02	.68	.27

Table 4 - *Note all values are expressed as a percentage of the total lipid

Table 3.5 The effect of ractopamine supplementation and backfat class on fatty acid composition of loin intramuscular fat.

	Diet			Phenotype			D*P
Trait	Ctl	Pay	P>F	Fat	Lean	P>F	P>F
C14:0, %	1.17 ± .04	1.12 ± .04	.36	1.14 ± .04	1.16 ± .04	.69	.86
C16:0, %	23.2 ± .28	23.7 ± .30	.22	23.7 ± .30	23.3 ± .27	.36	.90
C16:1, %	3.30 ± .11	3.40 ± .11	.57	3.43 ± .12	3.26 ± .10	.27	.79
C18:0, %	11.9 ± .20	11.7 ± .21	.38	11.8 ± .22	11.8 ± .19	.97	.42
C18:1, %	43.4 ± .61	45.2 ± .65	.05	44.7 ± .67	43.9 ± .59	.41	.95
C18:2, %	13.2 ± .50	11.6 ± .52	.04	12.3 ± .55	12.5 ± .48	.73	.61
C18:3, %	.36 ± .03	.30 ± .03	.12	.30 ± .03	.36 ± .03	.11	.29
C20:1, %	.60 ± .05	.66 ± .05	.43	.58 ± .06	.67 ± .05	.24	.34
C20:2, %	2.26 ± .22	2.14 ± .24	.72	2.19 ± .24	2.21 ± .21	.44	.96

Table 5 - *Note all values are expressed as a percentage of the total lipid

Table 3.6. The effect of ractopamine supplementation and backfat class on fatty acid composition of leaf fat

	Diet			Phenotype			D*P
Trait	Ctl	Pay	P>F	Fat	Lean	P>F	P>F
C14:0, %	1.40 ± .04	1.35 ± .04	.30	1.39 ± .04	1.36 ± .04	.57	.21
C16:0, %	25.3 ± .30	24.5 ± .30	.05	25.4 ± .30	24.4 ± .30	.03	.29
C16:1, %	1.90 ± .05	1.77 ± .05	.06	1.86 ± .05	1.81 ± .05	.36	.92
C18:0, %	17.6 ± .32	17.0 ± .32	.23	17.5 ± .32	17.1 ± .32	.30	.53
C18:1, %	36.5 ± .33	36.7 ± .33	.68	36.9 ± .33	36.2 ± .33	.12	.50
C18:2, %	15.4 ± .48	16.7 ± .48	.06	15.0 ± .48	17.1 ± .48	<.01	.58
C18:3, %	.69 ± .02	.74 ± .02	.11	.67 ± .02	.76 ± .02	<.01	.64
C20:1, %	.67 ± .03	.69 ± .03	.55	.68 ± .03	.68 ± .03	.85	.30
C20:2, %	.42 ± .02	.47 ± .02	.19	.41 ± .02	.48 ± .02	.03	.15

Table 6 - *Note all values are expressed as a percentage of the total lipid

Table 3.7 The effect of Paylean® supplementation and pre-finishing backfat class on fatty acid composition of the belly.

	Diet			Phenotype			D*P
Trait	Ctl	Pay	P>F	Fat	Lean	P>F	P>F
C14:0, %	1.36 ± .03	1.34 ± .03	.61	1.38 ± .03	1.31 ± .03	.13	.59
C16:0, %	22.5 ± .30	22.2 ± .32	.47	22.5 ± .03	22.2 ± .03	.53	.38
C16:1, %	2.79 ± .08	2.76 ± .08	.81	2.80 ± .09	2.75 ± .08	.66	.99
C18:0, %	11.5 ± .29	11.0 ± .31	.37	11.1 ± .03	11.4 ± .03	.55	.46
C18:1, %	43.2 ± .37	43.4 ± .39	.77	43.3 ± .40	43.2 ± .35	.91	.57
C18:2, %	16.5 ± .36	17.1 ± .38	.22	16.6 ± .39	17.0 ± .35	.50	.36
C18:3, %	.74 ± .02	.75 ± .02	.60	.73 ± .02	.76 ± .02	.41	.29
C20:1, %	.79 ± .02	.87 ± .03	.04	.85 ± .03	.81 ± .02	.25	.65
C20:2, %	.64 ± .12	.54 ± .13	.57	.66 ± .13	.52 ± .11	.42	.56

Table 7 - *Note all values are expressed as a percentage of the total lipid

Table 3.8 The effect of ractopamine supplementation and backfat class on calculated iodine value of different depot sites

	Treatment			Backfat Class			D * P
Trait	Ctl	Pay	P>F	Fat	Lean	P>F	P>F
Inner fat IV	70.8 ± .60	72.8 ± .64	.02	70.7 ± .66	72.8 ± .58	.02	.12
Outer fat IV	74.0 ± .97	76.5 ± 1.03	.09	74.5 ± 1.06	76.1 ± .94	.28	.17
Loin i.m. IV	65.5 ± .62	63.5 ± .64	.04	64.4 ± .67	64.6 ± .59	.90	.26
Leaf fat IV	62.3 ± .84	64.7 ± .84	.05	61.9 ± .84	65.1 ± .84	.01	.40
Belly fat IV	70.9 ± .73	72.3 ± .77	.21	71.3 ± .80	71.9 ± .70	.61	.27

Table 3.9 Regression equations for predicting belly iodine value using fatty acid composition of various depots

Equation Number	Dependent Variable	C(p)	R^2	Intercept	Regression coefficents				P > F
					C18:2	**C20:1**	**C16:1**	**C14:0**	
IF - 1	Belly IV	17.5	.227	59.00	.691				.0002
IF - 2		7.50	.360	46.30	.084	10.346			<.0001
IF - 3		5.40	.406	38.66	.946	9.982	2.960		<.0001
IF - 4		3.67	.448	42.85	.884	9.398	4.462	-4.830	<.0001
					C18:2	**C16:0**	**-**	**-**	
OF - 1	Belly IV	7.20	.143	61.23	.548				.0041
OF - 2		2.78	.236	75.84	.494	-.668			.0008
					C18:0	**C16:0**	**C18:1**	**C18:3**	
OF - 3		1.69	.252	103.86	-.332	-1.411			.0005
OF - 4		2.29	.272	118.69	-.485	-1.431	-.290		.0008
OF - 5		3.33	.286	185.33	-1.142	-2.195	-1.008	-15.401	.0015
					C18:3	**C18:1**	**C18:0**	**C16:1**	
loin - 1	Belly IV	2.78	.109	68.87	8.512				.0206
loin - 2		.030	.197	49.00	11.152	.428			.0064
loin - 3		.397	.228	58.48	11.447	.399	-.701		.0082
loin - 4		1.71	.241	63.93	11.091	.427	-.972	-1.005	.0147
					C18:2	**C18:1**	**C14:0**	**C18:0**	
LF - 1	Belly IV	-1.14	.252	59.83	.717				.0003
LF - 2		-1.39	.292	38.48	.847	.526			.0004
LF - 3		-.675	.314	29.40	.905	.631	3.108		.0008
LF - 4		1.11	.318	9.89	1.104	.872	4.223	.343	.0021

Table 3.10 Correlation of belly iodine value and C18:2 with C18:2 of various depots.

	Depot Sites			
	Inner fat	Outer fat	Loin i.m. fat	Leaf fat
Belly iodine value	.476**	.378*	-.037	.502**
Belly fat C18:2	.736**	.632**	-.075	.589*

Table 10 - ** P < .001 * P = .01

Procedure 1

Preparation of fatty acid methyl esters for gas chromatograph analysis (Park and Goins, 1994)

I. Preparation

1. Weigh 50 - 100 mg of adipose tissue into labeled, glass tube with a Teflon lined cap. For muscle samples, weigh 1 – 2 g

*Note – For muscle samples, twice the volume of chemicals are used for the methylation

II. Procedure

1. Add 200 μL of methylene chloride.

2. Add 2 mL of .5 M sodium methoxide in methanol (NaOH/MEOH).

3. Add 1 mL of internal standard (C17:0, 2 mg/ml methanol).

4. Flush tube with nitrogen, cap and vortex.

5. Heat sample at 90°C for 20 minutes, and cool to room temperature.

6. Add 2 mL of 14% boron triflouride in methanol.

7. Flush tube with nitrogen, cap and vortex.

8. Heat sample at 90°C for 20 minutes, and cool to room temperature.

9. Add 2 mL of water and 2 mL of hexane and vortex.

10. Allow the 2 phases to separate, and then transfer the upper layer into a clean tube and add a small amount of anhydrous sodium sulfate or dry the sample using a spin vaccum. Store the sample at 4°C.

11. Transfer the sample to vial for analysis

Procedure 2

Total lipid extraction (Folch et al., 1957)

I. Preparation

1. Begin with a homogeneous sample, and weigh 2.5 g (± 0.1g) of the sample into labeled, disposable, 50 mL conical centrifuge tube.

2. Place labeled, disposable, aluminum pans into a 90°C oven over night. Place pans into a desiccator for 10 minutes. Weigh the aluminum pans.

3. Prepare a 2:1 methanol and chloroform mixture.

II. Procedure

1. Add 15 mL of the methanol and chloroform solution to the homogenized sample.

2. Homogenize the sample and the methanol and chloroform with a Polytron homogenizer for 30 seconds on medium speed. Clean the homogenizer between samples using the methanol and chloroform solution.

3. Allow samples to stand for 1 hour to extract the lipid portion

4. Add 5 mL of Chloroform and 5 mL of 1 M KCl to each tube and vortex.

5. Place the samples into a centrifuge that is pre-cooled to 0°C for 5 minutes.

6. Centrifuge samples for 10 minutes at 2,000 x g and 0°C.

7. Aspirate the top layer off the sample being careful not to disturb the meat pellet.

8. Gently pour the bottom layer into the dried, labeled, pre-weighed aluminum pans.

9. Evaporate the pans over night in the hood with the fan.

10. Place the pans in the drying oven at 90°C for 30 minutes. After drying, place the samples into a desiccator for 5 minutes.

11. Weigh the pans containing the lipid. Calculate percent lipid using the following: (pan with lipid weight – pan weight)/ sample weight x 100

Procedure 3

Warner-Bratzler Shear Force (American Meat Science Association and National Live Stock and Meat Board, 1995)

I. Preparation

1. Begin with 2.54 cm chops or steaks from the longissimus between the 12th rib and the 5th lumbar vertebrae of the carcass, which are free of external fat or trimmed to not more than .32 cm of external fat. Chops and steaks should be stored frozen.

2. Initial weights should be taken prior to packaging, when frozen or after thawing in the package. If the initial weights are taken in the package, the weight of the packaging should be noted.

3. Thaw chops or steaks in the vacuum package and remove from the package and record the thawed weight.

II. Procedure

1. After initial weights and thawed weights are recorded, temperature probes should be placed in the geometric center of each chop or steak. The initial temperature should be recorded when the probes stabilize.

2. Place chops or steaks on grills and note the starting time in order to determine full cook time.

3. The chops or steaks should be flipped when the internal temperature reaches 35 to 40°C.

4. Cook to a final endpoint temperature of 65°C.

5. Record the cooked weight and note the time when removing the chop or steak from the grill.

6. Place the chops or steaks in the cooler at 4°C for 3 hours. After cooling, trim the chops or steaks to determine degree of doneness using the Meat Board Cooked Color Guide Chart.

7. Obtain 4 to 6 cores using a 1.27 cm coring device. Remove the cores parallel to the longitudinal orientation of the fibers.

8. Measure shear force by orienting the fibers such that they are sheared perpendicular to the longitudinal orientation of the core. Record the shear force.