

PERFORMANCE AND NUTRIENT DIGESTIBILITY IN WEANLING  
PIGS AS INFLUENCED BY YEAST CULTURE, WHEY,  
AND FIBER ADDITIONS TO STARTER DIETS

by

Deanna Rhein-Welker

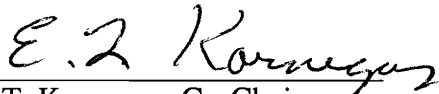
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# **PERFORMANCE AND NUTRIENT DIGESTIBILITY IN WEANLING PIGS AS INFLUENCED BY YEAST CULTURE, WHEY, AND FIBER ADDITIONS TO STARTER DIETS**

by

Deanna Rhein-Welker

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Animal Science

(ABSTRACT)

Three experiments were conducted using crossbred weanling pigs (n=462) to determine the effect of yeast culture (YC) additions to starter diets containing dried whey or a fiber source on performance and nutrient digestibility. An 18% CP corn-soybean meal basal diet was used in all experiments. In Exp. I (n=192), YC (0 or .75%) was used in diets with dried whey (0 or 15%) in two 5-wk trials (1 and 2). In Exp. II (n=174), YC (0 or .75%) was used in diets containing no added fiber, 8% soybean hulls (SH), or 8% peanut hulls (PH) in two 5-wk trials (3 and 4). Fifty-four of the pigs in Trial 4 were continued on test for three additional weeks in a grower phase. In Exp. III (n=96), YC (0 or .75%) was used in diets containing three levels of PH (0, 8, and 16%) in one 6-wk trial. In Exp. III, .05% chromic oxide was added to all six diets, and six grab samples were taken (twice daily every other day) during wk 4 and 6 for determination of the digestibility of DM, N, P, and fibrous components using the indirect method. Pigs in all experiments had ad libitum access to feed and water, and body weight and feed consumption were measured weekly.

Results from all experiments showed that there was no overall effect of treatments on ADFI. In Exp. I, there was no significant overall effect of YC on ADG or G:F in either trial. In Trial 2 of Exp. I, whey depressed overall ADG ( $P < .10$ ) and G:F ( $P < .005$ ). In the nursery phases of Exp. II, there

were no significant dietary treatment effects on ADG. Gain to feed ratios tended to be increased ( $P < .10$ ) by YC additions, but only in diets which also contained fiber. In the grower phase of Trial 4 (Exp. II), fiber additions depressed ADG ( $P < .005$ ), whereas YC additions improved ADG ( $P < .01$ ), particularly in pigs fed diets which also contained SH ( $P < .05$ ). In Exp. III, pigs fed diets containing YC and 8% PH had an overall ADG similar to controls, whereas pigs fed diets containing YC alone or both YC and 16% PH had a lower overall ADG than control pigs ( $P < .10$ ). Overall G:F ratios were decreased by PH inclusion ( $P < .01$ ) and by supplemental YC ( $P < .05$ ). Apparent digestibilities were not influenced by the inclusion of YC. The addition of PH linearly decreased the digestibilities of DM ( $P < .001$ ), N ( $P < .05$ ), NDF ( $P < .001$ ), and ADF ( $P < .05$ ), and increased the absorption of P ( $P < .05$ ).

These results suggest that YC additions had no effect on ADG or ADFI, variable effects on G:F, and no effect on digestibilities of DM, N, NDF, or ADF, or the apparent absorption of P. Fiber additions, particularly PH at the 16% level, appear to depress ADG and G:F, and the digestibilities of DM, N, NDF, and ADF, but increase apparent absorption of phosphorus.

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## TABLE OF CONTENTS

<b>Abstract</b> .....	ii
<b>Acknowledgements</b> .....	iv
<b>List of Tables</b> .....	vi
<b>Chapter I, Introduction</b> .....	1
<b>Chapter II, Review of Literature</b> .....	3
Effects of yeast culture on performance.....	3
Influence of yeast culture on nutrient digestion.....	5
Nitrogen metabolism.....	5
Mineral utilization.....	8
Fiber digestibility.....	9
Fiber digestion in swine.....	9
<b>Chapter III, Objectives</b> .....	12
<b>Chapter IV, Performance and Nutrient Digestibility in Weanling Pigs as Influenced by Yeast Culture, Whey, and Fiber Additions to Starter Diets</b> .....	13
Abstract.....	13
Introduction.....	14
Experimental procedures.....	15
Experiment I.....	16
Experiment II.....	16
Experiment III.....	18
Statistical analysis.....	19
Results.....	19
Experiment I.....	19
Experiment II.....	20
Experiment III.....	21
Pooled experiments.....	22
Discussion.....	22
Implications.....	27
Tables.....	28
<b>Chapter V, Literature Cited</b> .....	39
<b>Appendix</b> .....	44
<b>Vita</b> .....	70

## List of Tables

### Chapter IV:

1. Percentage composition of diets with and without yeast culture (YC) and whey: Exp. I.....	34
2. Percentage composition of diets with or without yeast culture (YC) and soybean hull (SH) or peanut hull (PH) additions to starter diets: Exp. II.....	35
3. Percentage composition of diets with or without yeast culture (YC) and peanut hulls (PH): Exp.III.....	36
4. Average daily gain, feed intake, and gain to feed ratios of weanling pigs as influenced by yeast culture (YC) and whey additions to starter diets: Exp. I.....	37
5. Average daily gain, average daily feed intake, and gain/feed of weanling pigs as influenced by yeast culture (YC) and soybean hull (SH) or peanut hull (PH) additions to starter diets: Exp. II....	38
6. Scour score percentages of pens of weanling pigs as influenced by yeast culture and fiber additions to starter diets: Exp. II, Trial 1.....	39
7. Body weight, average daily gain, average daily feed intake, and average gain to feed ratios of growing pigs as influenced by yeast culture (YC) and fiber additions to diets: Exp. II, Trial 4.....	40
8. Average daily gain, average daily feed intake, and gain to feed ratios of weanling pigs as influenced by yeast culture (YC) and peanut hull (PH) additions to starter diets: Exp.III.....	41
9. Dry matter, N, P, NDF, and ADF apparent digestibilities in weanling pigs as influenced by yeast culture (YC) and peanut hull additions (PH) to starter diets: Exp. III.....	42
10. Average daily gain, feed intake, and gain to feed ratios of weanling pigs as influenced by yeast culture (YC) additions to starter diets: Pooled for Exp. I, II, and III.....	43
11. Average daily gain, feed intake, and gain to feed ratios of weanling pigs as influenced by yeast culture (YC) and 8% peanut hull (PH) additions to starter diets: Pooled for Exp. II and III.....	44

**Appendix:**

1. Calculated and analyzed composition of diets with and without yeast culture (YC) and whey: Exp. I, Trial I.....	45
2. Calculated and analyzed composition of diets with and without yeast culture (YC) and whey: Exp. I, Trial 2.....	46
3. Calculated and analyzed composition of diets with and without yeast culture (YC) and soybean hulls (SH) or peanut hulls (PH): Exp. II.....	47
4. Calculated and analyzed composition of diets with and without yeast culture (YC) and peanut hulls (PH): Exp. III.....	48
5. Least squares means of average daily gain of weanling pigs as influenced by yeast culture (YC) and whey additions to starter diets: Exp. I, Trial 1.....	49
6. Least squares means of average daily feed intake of weanling pigs as influenced by yeast culture (YC) and whey additions to starter diets: Exp. I, Trial 1.....	50
7. Least squares means of average gain to feed ratios of weanling pigs as influenced by yeast culture (YC) and whey additions to starter diets: Exp. I, Trial 1.....	51
8. Least squares means of average daily gain of weanling pigs as influenced by yeast culture (YC) and whey additions to starter diets: Exp. I, Trial 2.....	52
9. Least squares means of average daily feed intake of weanling pigs as influenced by yeast culture (YC) and whey additions to starter diets: Exp. I, Trial 2.....	53
10. Least squares means of average gain to feed ratios of weanling pigs as influenced by yeast culture (YC) and whey additions to starter diets: Exp. I, Trial 2.....	54
11. Least squares means of average daily gain of weanling pigs as influenced by yeast culture (YC) and soybean hull (SH) or peanut hull (PH) additions to starter diets: Exp.II.....	55
12. Least squares means of average daily feed intake (kg) of weanling pigs as influenced by yeast culture (YC) and soybean hull (SH) or peanut hull (PH) additions to starter diets: Exp. II.....	56

13. Least squares means of average gain to feed ratios (g gain/ kg feed) of weanling pigs as influenced by yeast culture (YC) and soybean hull (SH) or peanut hull (PH) additions to starter diets: Exp. II.....	57
14. Least squares means of average daily gain, average daily feed intake, and average gain to feed ratios of growing pigs as influenced by yeast culture (YC) and soybean hull (SH) or peanut hull (PH) additions to diets: Exp. II, Trial 4.....	58
15. Least squares means of average daily gain of weanling pigs as influenced by yeast culture (YC) and peanut hull (PH) additions to starter diets: Exp. III.....	59
16. Least squares means of average daily feed intake of weanling pigs as influenced by yeast culture (YC) and peanut hull (PH) additions to starter diets: Exp. III.....	60
17. Least squares means of average gain to feed ratios (g gain/ kg feed) of weanling pigs as influenced by yeast culture (YC) and peanut hull (PH) additions to starter diets: Exp. III.....	61
18. Nutrient intake (g/day) and fecal nutrient percentages of weanling pigs as influenced by yeast culture (YC) and peanut hull (PH) additions to starter diets: Exp. III, Wk 4.....	62
19. Nutrient intake (g/day) and fecal nutrient percentages of weanling pigs as influenced by yeast culture (YC) and peanut hull (PH) additions to starter diets: Exp. III, Wk 6.....	63
20. Average daily gain of weanling pigs as influenced by yeast culture (YC) additions to starter diets: Pooled for Exp. I, II, and III.....	64
21. Average daily feed intake of weanling pigs as influenced by yeast culture (YC) additions to starter diets: Pooled for Exp. I, II, and III.....	65
22. Average daily gain to feed ratios of weanling pigs as influenced by yeast culture (YC) additions to starter diets: Pooled for Exp. I, II, and III.....	66
23. Average daily gain of weanling pigs as influenced by yeast culture (YC) and peanut hull (PH) additions to starter diets: Pooled for Exp. II and III.....	67

24. Average daily feed intake of weanling pigs as influenced by yeast culture (YC) and peanut hull (PH) additions to starter diets: Pooled for Exp. II and III.....	68
25. Average daily gain to feed ratios of weanling pigs as influenced by yeast culture (YC) and peanut hull (PH) additions to starter diets: Pooled for Exp. II and III.....	69

## CHAPTER I

### INTRODUCTION

Weaning places a great deal of stress, both social and dietary, on a young pig. This stress is often associated with poor performance during the first week following weaning, and may be referred to as postweaning depression or lag (Tzipori et al., 1980). A decrease in rate of gain and an increase in scouring may be a result of the transition from small feedings of milk to larger meals consisting primarily of plant feedstuffs.

Traditionally, producers have attempted to eliminate the lag phase by supplementing starter diets with antibiotics or milk products. Antibiotics have been shown to improve performance of weanling pigs (Stahly et al., 1980), however, the use of antibiotics in general is of public concern because of perceived drug residues in animal products such as meat and milk. While milk products (e.g., dried whey) can ease the dietary transition (Veum et al., 1986; Cera et al., 1988; Lepine et al., 1991), the cost of the feedstuff may outweigh the performance benefits. Thus, there exists a need to identify new dietary additives which could serve as alternatives to antibiotics and prove more cost effective than milk products. A feed additive that could potentially meet the demand is the yeast culture, specifically a culture made from *Saccharomyces cerevisiae*.

Yeast culture products are the result of a two-step fermentation process. The first phase involves the combination of yeast cells and molasses in a liquid fermentation process similar to that used to make wine. In the second phase, the wort is combined with cereal grains in a cereal mash fermentation. Then the yeast culture product is dried and ground to its final form.

Manufacturers of yeast culture products speculate that the beneficial effect of yeast culture additions may be related to the way in which the culture is made. In other words, it is possible that enzymes produced by the yeast, and present on the media, may enhance digestion within the gastrointestinal tract of the animal which consumes the product.

Another suggested mode of action of the yeast culture product is enhanced mineral absorption which has been shown to occur in several studies using poultry (Thayer et al., 1978) and sheep (Peterson et al., 1987; Cole et al., 1992). Other studies have correlated yeast culture use with increased cellulolytic bacterial populations in the rumen (Harrison et al., 1988; Dawson et al., 1990). Although the mechanism of action is yet unclear, yeast culture additions to livestock rations seem to improve performance.

Recent research has suggested that the addition of yeast cultures to the rations of pigs (Veum et al., 1988), poultry (Thayer et al., 1978), and horses (Mason, 1991) may increase feed efficiency and rate of gain. Furthermore, some studies have shown that yeast culture additions to diets may improve fiber utilization (Godbee, 1983; Dawson et al., 1990). Improved utilization of fibrous feedstuffs would be of significant value in growing pigs as a means to reduce feed costs.

The purpose of this research was to evaluate the effect of yeast culture additions to weanling pig diets on performance and nutrient digestibility.

## CHAPTER II

### REVIEW OF LITERATURE

Over the last twenty years, several research reports have shown that yeast culture additions to ruminant rations can significantly improve growth performance, milk yield, and(or) nutrient digestibility (Williams et al., 1985; Wiedmeier et al., 1987; and Wohlt et al., 1991). Some studies have further suggested that these improvements are largely due to enhanced ruminal fermentation (Martin et al., 1989; Dawson et al., 1990). In the nonruminant, it has been speculated that similar improvements may be attributed to enhanced hindgut fermentation (Williams, 1988), but there are only a few studies in the area. This review will focus on research performed with pigs, horses, and poultry.

#### EFFECTS OF YEAST CULTURE ON PERFORMANCE

Some of the earliest work which involved yeast culture additions to animal diets was done with growing/finishing swine. Ceballos et al. (1970) used a yeast culture to provide supplemental protein in 16% CP corn-based diets with and without added methionine. These diets were compared with a typical corn-soybean meal diet, and were fed to finishing pigs. Growth rate and feed utilization were comparable regardless of yeast or methionine inclusion. Similar findings were later observed in early-weaned pigs (Fakler et al., 1991). Thus, the yeast culture could potentially serve as a viable protein supplement with no detrimental effect.

Bowman and Veum (1973) studied yeast culture additions to diets for growing/finishing pigs to determine if yeast culture additions at low levels

would affect performance or carcass characteristics. Two percent yeast culture was added up to 34 kg BW, and 1.5% was added from 34 to 100 kg BW. Despite slight differences in gain to feed ratios with yeast culture inclusion, results showed that supplementation did not significantly affect growth, feed efficiency, carcass length, backfat thickness, loin eye area, or trimmed wholesale cuts.

In another study with finisher pigs, Chapple (1981) found that performance was improved when yeast culture was added as 2% of a low P diet, however, there was no improvement of metacarpal breaking strength, ash or carcass measurements, or when the yeast culture was added to a diet with an adequate P level.

Much of the more recent research using yeast cultures in swine diets has been conducted on the young pig. Continuing their work, Veum and Bowman (1973) conducted two experiments to determine the effects on growth performance and nutrient digestibility of supplementing diets for mechanically-fed neonatal piglets and early-weaned pigs with various levels of yeast culture. Yeast culture fed from days 2 to 23 at 1.5 or 2% of the diet had no effect ( $P < .05$ ) on average daily gain or gain to feed ratio. However, when fed at 2.5% of the diet, performance was depressed. From d 23 through the end of the two experiments (d 65 or 72), there was no difference ( $P < .05$ ) among treatment groups in performance. Further, no differences were observed between pigs fed 2% added yeast culture and controls with regard to the digestibility of fat, fiber, ash, protein, or dry matter.

In contrast, Veum et al. (1988) showed an improvement in growth performance with yeast culture supplementation (0, .75%, 1.25%, and 1.75%)

in weanling pigs. In three similar 5-wk trials, all levels of yeast culture inclusion increased ( $P < .05$ ) ADG, feed consumption, and gain to feed ratios, with the greatest effects seen from d 14 to 35.

Increases in growth rate due to yeast culture supplementation have also been observed in horses. Mason (1991) reported a 60% increase in rate of gain and a 39% improvement in feed efficiency with 2.5% added yeast culture to diets for wild foals.

## INFLUENCE OF YEAST CULTURE ON NUTRIENT DIGESTION

### Nitrogen Metabolism

Horses. The effects of yeast culture supplementation on nitrogen metabolism are well documented in horses. However, one important note is that many studies conducted with horses involve fewer numbers than are typically used in experiments with other domestic species.

In Quarter Horses, Webb et al. (1985) found that the addition of yeast culture at .02% of BW (approximately 113 g) per day to a crimped oat/corn diet produced a slight numerical increase in energy and protein digestibility. Similar results were found by Hall et al. (1990), who used four graded levels of yeast culture (0, 10, 20, and 40 g/day/horse). Their study showed that 10 and 40 g/day/horse of yeast culture numerically increased energy and protein digestibility although there were no significant effects of any treatment.

Two equine studies which focused on the effect of yeast culture additions on nitrogen digestibility found that supplementation enhanced digestibility by 5-10% (Glade and Biesik, 1986; Glade and Sist, 1988). Glade and Biesik (1986) found that, while total nitrogen digestibility was only numerically

increased by yeast culture inclusion, nitrogen retention expressed as g/day was doubled ( $P < .01$ ). This suggests that the biological value of the nitrogen in the diets with added yeast culture was greater than that of the diets without yeast culture. They concluded that the quality of the nitrogenous compounds absorbed from the large intestine must have been improved, and that this could have occurred by enhanced microbial ammonia liberation and amino acid synthesis. Likewise, Glade and Sist (1988) suggested that yeast culture acts to enhance microbial recycling of endogenously secreted nitrogen to synthesize free amino acids. But since colonic absorption of amino acids is inefficient in the horse (Slade et al., 1970), only a small amount of the free nitrogen could be absorbed. Therefore, approximately the same amount of nitrogen would be absorbed across the gut, but the quality of the absorbed nitrogen would be greater, and less nitrogen would be lost in the urine. Thus retention, but not digestibility, would be increased. An increase in nitrogen retention is potentially important in that it results in an increase in feed efficiency.

Yeast culture supplementation not only affects overall nitrogen retention, but also influences specific plasma amino acid profiles. Equine nurslings which were orally supplemented with 10 g/day from 10 to 17 weeks of age had significantly different plasma concentrations of several amino acids (Glade and Sist, 1990). Plasma lysine concentrations were elevated ( $P < .01$ ) on days 8 to 36 of the study. Such increases in lysine, the most growth-limiting amino acid for foals and pigs, have been associated with accelerated growth during the first two months of equine life. In addition, the concentrations of two indirect indicators of tissue catabolism were reduced

with supplementation. Concentrations of hydroxyproline, an indicator of skeletal status, gradually decreased and were reduced ( $P < .05$ ) compared with controls after 36 days of supplementation. Such a reduction may reflect enhanced skeletal development because changes in plasma hydroxyproline generally parallel changes in bone resorption. Decreases in concentrations of 3-methylhistidine, an indicator of the rate of muscle myofibrillar protein degradation, were also observed. Furthermore, concentrations of three amino acids which can stimulate intracellular protein synthesis (leucine, isoleucine, and valine) were elevated throughout the supplementation period. Taken together, these changes indicate that yeast culture additions positively influence muscle and skeletal development.

Ruminants. It also appears that yeast culture supplementation has a positive effect on nitrogen metabolism in the ruminant. At a level as low as .1% of the diet, yeast culture numerically improved crude protein (CP) digestibility in early-lactating Holstein cows (Wohlt et al., 1991). In another study with nonlactating Holsteins, yeast culture supplementation increased CP digestibility ( $P < .01$ ). Values were 79.5%, 82.2%, and 84.4% for controls, yeast culture supplementation alone, and yeast culture in combination with a fungal extract, respectively (Wiedmeier et al., 1987). Cole et al. (1992) used Suffolk lambs in a 14 d metabolism trial to examine the effects of diets containing 0, .75, 1.125, or 1.5% yeast culture on nitrogen and mineral retention. Results showed that lambs fed yeast culture had higher apparent DM and N digestibilities ( $P < .04$ ) and N retention ( $P < .08$ ), as well as somewhat improved Na, Cu, Zn, and Fe retention ( $P = .12$ ).

## Mineral Utilization

The influence of yeast culture on mineral metabolism has been examined in sheep (Peterson et al., 1987; Cole et al., 1992) and poultry (Thayer et al., 1978; Day et al., 1987). Several studies in nonruminants have focused on phosphorus (P) utilization because yeasts are a source of phytase, an enzyme that releases bound phytate phosphorus to a free form, which improves its bioavailability. Most plant feedstuffs contain P in the bound form which is not well utilized by monogastrics. Thus, inorganic P is usually added to diets to meet the phosphorus requirement. As a result, there is not only the expense of adding the additional P, but also a growing concern that the high level of P in waste may be polluting the environment upon application to land.

One industry which has sought relief for the situation through the use of yeast culture is the poultry industry. An additional concern to the poultry nutritionist is the detrimental effect which high levels of P have on eggshell quality (Miles et al., 1983). Therefore, total dietary P and P availability are of critical importance. Thayer et al. (1978) reported that the addition of yeast culture to turkey breeder hen diets brought about an increase in egg production, egg weight, and egg specific gravity, without significantly affecting BW, feed intake, or reproductive performance. Additionally, the response was greatest at P levels below the current recommendations. In contrast, Day et al. (1987) reported that yeast culture supplementation had no effect on egg production, egg weight, egg breaking strength, feed intake, or feed efficiency of chicken hens. The conflicting results from these two studies may be due in part to the fact that different levels of yeast culture were used. Turkey hen diets were supplemented at a level of 2.5% of the

diet, whereas chicken hen diets were only supplemented at either .25 or .50% of the diet. The levels used in the latter study may have been too low to observe any significant response.

### Fiber Digestibility

Nonruminant rations, especially those intended for pigs, are typically low in fiber because these animals mostly lack the ability to utilize fiber.

However, if it were possible to increase fiber utilization through the use of yeast cultures, feed costs could potentially be reduced. Unfortunately, little information exists about the effect of yeast cultures on fiber digestibility, and all published work has been done with the ruminant.

Although yeast culture supplementation has not been found to increase NDF digestibility in sheep (Chadema and Offer, 1990) or in dairy cows (Arambel and Kent, 1990), cellulose digestibility was improved in cattle (Wohlt et al., 1991). In agreement, yeast culture supplementation has been shown to significantly increase concentrations of cellulolytic, or cellulase-producing, bacteria in the rumen (Harrison et al., 1988; Dawson et al., 1990). This implies that it is possible to advantageously alter the gut microflora in such a way that fiber digestion could be enhanced.

### FIBER DIGESTION IN SWINE

To fully examine the influence of yeast cultures on fiber utilization, it is important to first review the effects of fiber alone on performance, and on the digestibility of other nutrients. In swine, high-fiber diets have varying effects

which are largely dependent on the level and type of fiber source used, and on whether or not diets are supplemented with a high-energy source.

Soybean hulls, which contain 59.9% NDF and 44.3% ADF (NRC, 1989), may be one of the best fiber sources to use in swine feeding because they appear to be more digestible than many other fiber sources. Kornegay et al. (1981) showed that the addition of 10% soybean hulls to weanling pig diets had no significant effect on performance or fecal consistency. In a study with growing/finishing swine, Kornegay (1978) reported that soybean hulls actually had a stimulatory effect on growth when used at levels up to 6% of the diet, and in a later study (Kornegay, 1981) using sows and growing/finishing swine, he showed that soyhulls could be fed at levels up to 15% without any detrimental effects. Both grower studies showed, however, that as soyhull levels increased, digestion coefficients for DM, energy, and CP decreased. On the positive side, Moore and Kornegay (1987) showed that 15% soyhulls can enhance Fe balance and Mg absorption in growing pigs.

Several studies have examined the effects of oat hulls, which are poorly digested (66.7% NDF and 36.5% ADF), on performance of swine. Turlington et al. (1985) reported no differences in performance when oat hulls were fed at levels of 0, 6, 12, or 18% of the diet, although the apparent digestibilities of energy and protein were linearly depressed ( $P < .05$ ) with increasing levels of hulls. Jenson et al. (1959) also showed that oat hulls (at 7% of the diet) did not affect performance as long as corn oil was added to equalize energy value. Furthermore, Moser et al. (1982) reported that,

although 10% oat hulls did decrease DM digestibility, retention of P and Ca were unaffected.

Many other fiber sources have been evaluated as well. Lindemann et al. (1986) examined the effects of feeding peanut hulls at 7.5, 15, and 30% of the diet to growing/finishing swine. Despite no differences in ADG, peanut hulls linearly decreased digestibility of DM, energy, N, NDF, and lignin, and decreased net retention of P, Ca, Na, Mn, and Zn ( $P < .02$ ). Similar digestibility results were observed when feeding 50% ground oats by Ravindran et al. (1984), who associated these depressions with an increased rate of passage. Kass et al. (1980) also showed an increased rate of passage using alfalfa meal.

From these studies, it can be concluded that high-fiber diets increase digesta rate of passage, which in turn leads to decreased digestibilities of DM, energy, and protein. Performance may or may not be affected, depending on the level of fiber used and the energy content of the diet. It does appear that fiber can be used in swine diets, although only at lower levels.

## CHAPTER III

### OBJECTIVES

The purpose of this research was to evaluate the effect of yeast culture additions to weanling pig diets on performance and nutrient digestibility. Mineral and fiber digestibilities were chosen as measures because previous research indicated that yeast culture additions may act to enhance performance by increasing those measures. The specific objectives of each of the experiments were as follows:

Exp. I. compare the growth performance of weanling pigs fed starter diets with and without whey and supplemental yeast culture.

Exp. II. determine the effect on growth performance and scouring of yeast culture additions to weanling pig diets which contained either soybean hulls, peanut hulls, or no added fiber source.

Exp. III. a) determine the effect on growth performance of yeast culture additions to weanling pig diets which contained either 0, 8, or 16% peanut hulls, and b) investigate the effects of these diets on the digestibility of dry matter, nitrogen, phosphorus, and fibrous components.

## CHAPTER IV

### PERFORMANCE AND NUTRIENT DIGESTIBILITY IN WEANLING PIGS AS INFLUENCED BY YEAST CULTURE, WHEY, AND FIBER ADDITIONS TO STARTER DIETS

#### Abstract

Three experiments were conducted using crossbred weanling pigs (n=462) to determine the effect of yeast culture (YC) additions to starter diets containing dried whey or a fiber source on performance and nutrient digestibility. An 18% CP corn-soybean meal basal diet was used in all experiments. In Exp. I (n=192), YC (0 or .75%) was used in diets with dried whey (0 or 15%) in two 5-wk trials (1 and 2). In Exp. II (n=174), YC (0 or .75%) was used in diets containing no added fiber, 8% soybean hulls (SH), or 8% peanut hulls (PH) in two 5-wk trials (3 and 4). Fifty-four of the pigs in Trial 4 were continued on test for three additional weeks in a grower phase. In Exp. III (n=96), YC (0 or .75%) was used in diets containing three levels of PH (0, 8, and 16%) in one 6-wk trial. In Exp. III, .05% chromic oxide was added to all six diets, and six grab samples were taken (twice daily every other day) during wk 4 and 6 for determination of the digestibility of DM, N, P, and fibrous components using the indirect method. Pigs in all experiments had ad libitum access to feed and water, and body weight and feed consumption were measured weekly.

Results from all experiments showed that there was no overall effect of treatments on ADFI. In Exp. I, there was no significant overall effect of YC on ADG or G:F in either trial. In Trial 2 of Exp. I, whey depressed overall ADG ( $P < .10$ ) and G:F ( $P < .005$ ). In the nursery phases of Exp. II, there were no significant dietary treatment effects on ADG. Gain to feed ratios

tended to be increased ( $P < .10$ ) by YC additions, but only in diets which also contained fiber. In the grower phase of Trial 4 (Exp. II), fiber additions depressed ADG ( $P < .005$ ), whereas YC additions improved ADG ( $P < .01$ ), particularly in pigs fed diets which also contained SH ( $P < .05$ ). In Exp. III, pigs fed diets containing YC and 8% PH had an overall ADG similar to controls, whereas pigs fed diets containing YC alone or both YC and 16% PH had a lower overall ADG than control pigs ( $P < .10$ ). Overall G:F ratios were decreased by PH inclusion ( $P < .01$ ) and by supplemental YC ( $P < .05$ ). Apparent digestibilities were not influenced by the inclusion of YC. The addition of PH linearly decreased the digestibilities of DM ( $P < .001$ ), N ( $P < .05$ ), NDF ( $P < .001$ ), and ADF ( $P < .05$ ), and increased the absorption of P ( $P < .05$ ).

These results suggest that YC additions had no effect on ADG or ADFI, variable effects on G:F, and no effect on digestibilities of DM, N, NDF, or ADF, or the apparent absorption of P. Fiber additions, particularly PH at the 16% level, appear to depress ADG and G:F, and the digestibilities of DM, N, NDF, and ADF, but increase apparent absorption of phosphorus.

(Key Words: Piglets, Yeast, Whey, Fiber, Performance, Digestibility)

### **Introduction**

Limited research during the last fifteen years has suggested that the addition of yeast cultures to the diets of pigs (Veum et al., 1988), poultry (Thayer et al., 1978), horses (Mason, 1991), sheep (Williams et al., 1985), and cattle (Phillips and VonTungeln, 1985) may increase feed efficiency. Positive effects on N metabolism have been reported in ruminants (Wiedmeier et al., 1987; Cole et al., 1992), and horses (Glade and Biesik,

1986; Glade and Sist, 1988) with dietary supplementation of yeast cultures. A few studies have focused on P utilization because yeast is a source of phytase, which can break up bound phytate phosphorus, making the phosphorus more available for nonruminants. Thayer et al. (1978) reported that the addition of yeast cultures to turkey hen rations caused a significant increase in egg production, egg weight, and egg specific gravity, especially at P levels below recommendations. Furthermore, yeast culture supplementation has been shown to increase concentrations of cellulolytic bacteria in the ruminant (Harrison et al., 1988; Dawson et al., 1990), and may enhance fiber digestibility in the horse (Godbee, 1983). These findings suggest that it may be possible to increase fiber digestibility and phosphorus availability with yeast culture supplementation of swine, and such improvements could mean lowered feed costs.

The objectives of these experiments were 1) to compare the growth performance of weanling pigs fed starter diets with and without whey and supplemental yeast culture, 2) to determine the effect on growth performance and scouring of yeast culture additions to diets containing either soybean hulls, peanut hulls, or no added fiber source, and 3) to determine the effect on growth performance and nutrient digestibility of yeast culture additions to diets containing either 0, 8, or 16% peanut hulls.

### **Experimental Procedures**

Three experiments were conducted using a total of 462 crossbred weanling pigs (barrows and gilts). In all trials, pigs were randomly assigned to treatments from outcome groups based on weight and gender. Littermates

were balanced across treatments as much as possible. Pigs were housed in totally enclosed, climatically controlled rooms in plastic-coated wire bottom pens. Initial room temperatures were set at 28<sup>o</sup> C, and were lowered by approximately 1<sup>o</sup> C weekly for 3 wk. The basal diets were formulated to contain 18% CP using corn and soybean meal, and met or exceeded all NRC (1988) requirements for weanling pigs. Composition of diets is shown in Tables 1 through 3. All pigs had ad libitum access to feed and water. Pigs were weighed and feed consumption calculated weekly. ADG, ADFI, and gain to feed ratios (G:F) were determined for each weekly period and for the cumulative periods.

Exp. I In Exp. I, 192 pigs were used in two 5-wk trials to determine the effect of yeast culture additions to diets with and without whey in a 2 x 2 factorial arrangement of treatments. The basal diet was formulated with or without 15% dried whey (Grande Cheese Co., Brownsville, WI for Trial 1 and American Whey Co., Paramus, NJ for Trial 2), and 0 or .75% XP yeast culture (Diamond V Mills, Inc., Cedar Rapids, IA). In Trial 1, 96 pigs (average initial wt 7.2 kg) were housed two per pen (.61 m x .91 m) and were fed pelleted diets (Table 1). Prior to pelleting, both animal fat and a commercial pellet binder were added to all four diets. In Trial 2, 96 pigs (average initial wt 8.6 kg) were housed four per pen (.91 m x 1.22 m) and were fed diets in a meal form (Table 1).

Exp. II In Exp. II, 174 pigs (average initial wt 7.6 kg) were used in two 5-wk trials to evaluate the addition of .75% yeast culture (YC) to the basal diet

and to diets with 8% soybean hulls (SH) or 8% peanut hulls (PH) in a 2 x 3 factorial arrangement of treatments (Table 2). Soybean hulls were purchased preground (Southern States, Vinton, VA), and peanut hulls (Birdsong Peanuts, Suffolk, VA) were ground through a 5 mm screen prior to mixing diets. One trial was conducted on the Blacksburg campus of Virginia Tech (Trial 3), and a second trial was performed at the Tidewater Agricultural Experiment Station (Trial 4). Because coefficients of variation and mean square errors were low and very similar between trials, data from the two nursery trials were pooled for analysis.

In Trial 3 of Exp. II, only 12 of the 96 pigs used were female, and these composed one of eight replicates. Pigs were housed two per pen (.61 m x .91 m). Rooms were cleaned each evening, and pen fecal deposits were evaluated the following morning for diarrhea and given a scour score. A 5-point system was used as follows: 1=hard feces, 2=normal consistency of feces, 3=soft, partially formed feces (mild scours), 4=loose, semiliquid feces (moderate scours), and 5=watery feces (severe scours). Scour scores were analyzed by two methods. First, the daily pen scores were analyzed for fiber and YC effects. Secondly, the percentage of pens with each scour score was calculated by diet and week and analyzed for fiber and YC effects.

In Trial 4 of Exp. II, 78 pigs were used, with equal numbers of barrows and gilts. There were three replicates of three pigs per pen and one replicate of four pigs per pen (.91 m x 1.22 m) assigned such that barrows and gilts were divided evenly among treatments. Following the 5-wk nursery phase of Trial 4, 54 of the pigs (the three replicates with three pigs per pen) were continued for three weeks in a grower phase to determine the effects of the

diets on heavier, older pigs. These pigs were housed in partially-slotted concrete pens (1.52 m x 3.05 m).

Exp. III In Exp. III, 96 pigs (average initial wt 7.8 kg) were used in a single 6-wk trial. Three levels of PH (0, 8, and 16%) were used in combination with 0 and .75% YC (Table 3). A chromic oxide mixture (chromic oxide mixed with corn starch in a 1:3 weight ratio, and ground through a .5 mm screen) was added to all diets at a level of .20% as an inert indicator (.05% Cr<sub>2</sub>O<sub>3</sub>). Pigs were housed two per pen (.61 m x .91 m). At the end of wk 6, feeders were emptied, and the pigs were fasted for 24 h and reweighed to estimate loss of weight due to gut fill.

During wk 4 and 6, pen fecal samples were taken twice daily (0830 and 2030) every other day for a total of three days per week, as recommended by Dellaert et al. (1990). Only solid deposits of a predetermined length (about 6 cm) were used. Samples were collected and frozen in small plastic bottles with tight-fitting lids until the end of the weekly collection period. The pooled weekly samples were then mixed, dried at 60° C for 48 to 60 h, ground through a 1 mm screen using a Wiley mill, and stored for later analysis.

The DM percentage of both the feed and fecal samples was determined using the current AOAC (1990) procedure. Percent nitrogen of .5 g feed and fecal samples was determined using a semi-automated Kjeldahl apparatus. Phosphorus was determined using a modified molybdovanadate procedure (AOAC, 1990), and read on a Titertek well counter. Phytase activity of the yeast culture product was determined by Dr. Age Jongbloed at the Research

Institute for Livestock Feeding and Nutrition, Lelystad, The Netherlands. Chromium was determined spectrophotometrically using a Perkin-Elmer atomic absorption spectrophotometer. NDF, ADF, and ADL were measured by the Van Soest method (1963). Prior to NDF analysis, feed samples were subjected to  $\alpha$ -amylase treatment. Apparent digestibilities of N, P, NDF, and ADF, and lignin disappearance, were calculated using the following equation:

$$100 - \frac{[100 (\% \text{Cr}_2\text{O}_3\text{feed} \times \% \text{nutrientfeces})]}{(\% \text{Cr}_2\text{O}_3\text{feces} \times \% \text{nutrientfeed})}$$

Statistical analysis All data were analyzed using the General Linear Models procedure of SAS (1990), with pen mean as the experimental unit. All models included effects of trial and(or) room, replicate within trial and(or) room, diet, and interactions. Performance data from the grower phase of Exp. II were analyzed with initial weight as a covariate. Data from Exp. III were also analyzed for linear and quadratic fiber effects. The trial x treatment interactions across experiments were tested and found to be nonsignificant; hence, the data from the treatments common to Exp. I through III, and Exp. II and III, were pooled for a final overall analysis.

## Results

Exp. I: There were no overall effects of YC on ADG or ADFI in either trial (Table 4). However, in Trial 2, YC tended to decrease feed intake during the first four weeks ( $P < .10$ ). The inclusion of whey did not affect

ADG or ADFI in Trial 1, but ADG was depressed during wk 5 ( $P < .05$ ) and tended to be reduced overall ( $P < .10$ ) in Trial 2. A whey x YC interaction ( $P < .10$ ) for G:F during the first four weeks of Trial 1 suggested that YC decreased G:F in the absence of whey, but increased G:F in the presence of whey. The overall effect of whey on G:F in Trial 1 was not significant. In contrast, whey decreased ( $P < .005$ ) G:F during all periods of Trial 2, and there were no significant main effects of YC. A whey x YC interaction ( $P < .10$ ) for G:F in wk 5 revealed that G:F tended to be increased by YC in the absence of whey, but was somewhat decreased in the presence of whey.

Exp. II: ADG and ADFI were not affected by YC or fiber additions to diets in any period with the slight exception of ADFI during wk 1 through 3 (Table 5); ADFI tended to be decreased ( $P < .10$ ) when YC was added to the diets containing fiber. During wk 1 through 3 and overall, YC x SH ( $P < .05$ ) and YC x PH ( $P < .10$ ) interactions indicate that G:F was decreased when either SH or PH was added to the control diet, but was maintained when YC was included in all diets.

Scour scores were inconsistent throughout the trial, and were not influenced by dietary treatment (Table 6). However, when scour scores were expressed as a percentage, pigs fed diets which contained YC tended to have a lower ( $P < .10$ ) incidence of severe scours (score=5) during wk 1. These pigs also tended to have lower scores during wk 2. This is in contrast to a study (Fakler et al., 1991) in which YC supplementation caused a linear decrease in fecal dry matter during the first week. However, in that study YC

was added at very high levels to replace 25, 50, 75, and 100% of the soybean meal used as a protein supplement.

During the grower phase of Trial 4 (Table 7), both SH and PH additions decreased ADG ( $P < .005$ ), while YC additions increased daily gain ( $P < .01$ ). A YC x SH interaction ( $P < .05$ ) revealed that YC was most likely to increase gain in diets which also contained SH. There were no significant effects due to treatment on ADFI or G:F.

Exp. III: During wk 5 through 6, the inclusion of PH caused a decrease in ADG, both linearly ( $P < .01$ ) and quadratically ( $P < .10$ ), with the greatest effect at the highest level of PH inclusion (Table 8). The PH x YC interaction ( $P < .10$ ) for wk 1-6 showed that pigs fed diets containing YC alone and diets containing both YC and 16% PH tended to have a lower overall ADG than control pigs, whereas pigs fed the diet containing YC and 8% PH had an overall ADG similar to controls. Fasted weight loss following wk 6 was not influenced by dietary treatments. Dietary treatments also did not affect ADFI. The addition of YC decreased G:F during wk 1-4 ( $P < .01$ ) and overall ( $P < .05$ ). The inclusion of PH linearly decreased ( $P < .05$ ) G:F during wk 1-4, wk 5-6, and overall.

The additions of PH linearly decreased the apparent digestibility of DM ( $P < .001$ ), N ( $P < .05$ ), NDF ( $P < .001$ ), and ADF ( $P < .05$ ), and increased ( $P < .05$ ) the absorption of P (Table 9). The inclusion of YC did not affect the digestibility of any of the components, and the PH x YC interactions were nonsignificant for all components except for the P ( $P < .05$ ). Phosphorus absorption was linearly increased when PH were added to the diet without

added YC, but was not affected by the addition of PH when the diets contained YC.

Pooled Experiments All trials had data for the basal diet with and without YC, and these were pooled. Pigs fed diets containing supplemental YC tended to have lower ADG and G:F ratios ( $P < .10$ ) than control pigs during the first three weeks of the pooled trials, but not overall (Table 10). ADFI was not affected by YC additions.

Results from pooled data common to Exp. II and III indicate that there were no significant effects on ADG or ADFI due to YC or 8% PH additions (Table 11). During wk 1 through 2, YC increased G:F of pigs fed diets which also contained PH, but not when added to the basal diet alone (YC x PH interaction,  $P < .05$ ). The inclusion of 8% PH decreased G:F ( $P < .05$ ) during wk 3-5, and tended to decrease G:F ( $P < .10$ ) overall.

## **Discussion**

The fact that YC supplementation had so little effect on ADG in weanling pigs is contradictory to the findings of Veum et al. (1988) who observed increases in ADG with .75% YC in three trials, and Mason (1991), who observed a tremendous (60%) increase in gain of horses with 2.5% added YC. Although Bowman and Veum (1973) found no effect of supplementation on growing/finishing pigs using 2.0 and 1.5% YC, results from the grower phase of Exp. II, Trial 4 were positive, and indicate that YC may have a greater potential in grower diets.

In the weanling pig trials, fiber additions (either SH or PH) also had little effect on overall gain. Similar results have been found previously using both soybean hulls (Kornegay, 1981) and peanut hulls (Lindemann et al., 1986), as well as oat hulls (Turlington et al., 1985). Kornegay (1978) reported that 6% SH actually had a stimulatory effect on growth ( $P < .05$ ). The fiber x YC interaction observed in the grower phase of Exp. II and in Exp. III has not been previously encountered, yet indicates that YC may somehow improve fiber utilization.

There were generally no effects of YC or PH inclusion on ADFI. Although Veum et al. (1988) showed increased feed intake with YC supplementation, other studies did not find an effect on intake (Bowman and Veum, 1973; Mason, 1991). The fact that the gain of pigs fed the high-fiber diets was similar to that of controls indicates either that energy intake was adequate or that feed intake was increased. Lindemann et al. (1986) examined the effects of feeding PH at 7.5, 15, and 30% of the diet, and found that pigs fed these diets were able to achieve gains similar to controls by eating more. Such was not the case with our experiments. Because fiber additions had little effect on feed intake, we can assume that pigs were able to meet their energy requirements without increasing intake.

The effects of YC supplementation on G:F were varied between experiments. The pooled data indicate that supplementation has no overall effect on G:F. Previous studies have shown increases in G:F with YC supplementation in weanling pigs (Veum et al., 1988), horses (Mason, 1991), and poultry (Thayer et al., 1978). Again, the interactive effects of fiber and YC observed in Exp. II suggest that YC may enhance fiber utilization. The

pigs fed diets which contained either SH or PH and YC had higher G:F than pigs fed diets which did not contain YC. However, this was not the case in Exp. III. More research into the relationship of YC and fiber is certainly necessary.

It is difficult to explain why whey depressed ADG and G:F in Trial 2, especially since milk products are known to enhance growth in the early-weaned pig (Veum et al., 1986; Cera et al., 1988; Lepine et al., 1991). These effects were not observed in Trial 1, in which a different commercial brand of whey was used. To determine if the problem was a result of feeding low-quality whey, a sample of the whey used in Trial 2 was sent to an independent lab for analysis of protein, salt, ash, and pH. Results were within specifications for high quality. However, there are other factors that could have played a role in reducing whey quality that those analyses would not detect. For instance, the whey could have been overheated during the drying process causing a reduction in protein quality. Dried whey goes through two separate drying processes, evaporation and spray-drying, before it is packaged (La Fondation, 1985). Both of these steps require the use of high temperatures which, if exceeded only slightly, could result in lowered quality. The protein fraction of whey is composed of lactoglobulin and lactalbumin. Lactoglobulin is more easily denatured during the drying process than is lactalbumin, and makes up the majority of the protein fraction. Therefore, the potential exists to substantially lower protein quality with extreme heat. However, a visual examination of our whey indicated good color for high quality.

Another possibility is that the lactose fraction of the whey was somehow tied up or broken down, rendering it practically useless. Mahan (1992) showed that, of the lactalbumin and lactose fractions, lactose is the key component to improved gains and feed intake responses when whey is added to starter diets for pigs. In his study, pigs fed diets containing C-SBM and lactalbumin and corn starch had lower growth rates and feed intakes compared with pigs fed C-SBM-whey diets, but gains and feed intakes similar to those of pigs fed C-SBM only (controls). The depression in performance observed in Exp. I, Trial 2 could be attributed to a combination of problems, however, it is doubtful that such a combination could exist and still allow the whey to analyze so well.

The linear decrease in DM digestibility due to fiber additions was somewhat expected in that such decreases are well documented with high-fiber diets (Ravindran et al., 1984; Lindemann et al., 1986; Moore and Kornegay, 1987), and are often associated with an increase in rate of passage of digesta (Kass et al., 1980; Ravindran et al., 1984).

Nitrogen digestibility was not affected by YC supplementation which agrees with the findings of Reyes et al. (1991) using gestating and lactating sows, and Chapple (1981) using market-weight gilts fed a corn-soybean meal diet with and without YC supplementation. Contrary to these findings, Glade and Biesik (1986) and Glade and Sist (1988) reported improved N metabolism in horses fed diets with added YC.

The inclusion of PH decreased digestibility of NDF and ADF by as much as 10%. Lindemann et al. (1986) found similar results, and Ravindran et al. (1984) observed even greater decreases. The addition of YC had no effects

on digestibility of fibrous components despite the fact that YC additions have been shown to increase cellulolytic bacterial populations in the ruminant (Harrison et al., 1988; Dawson et al., 1990). In agreement with our findings, Chapple (1981) reported that the inclusion of YC as 2% of a corn-soybean meal diet fed to market-weight gilts did not enhance the digestibilities of energy, NDF, or ADF during gestation or lactation.

It has been thought that the inclusion of YC in a corn-soybean meal diet, which contains about two-thirds of the total P as phytate P, would improve the utilization of P due to the phytase activity of the YC. Our results, which indicated a lack of effect of YC supplementation on P absorption, is supported by several other researchers (Cromwell et al., 1978; Chapple et al., 1979a; Chapple, 1981; Murry, 1994) who reported no improvement in phytate P utilization, as measured by performance and apparent absorption of P bone mineralization, when YC was included in the diet at levels of .5 to 2%. In those studies, a combination of deficient and adequate P diets were fed. Chapple et al. (1979b) and Chapple (1981) reported the performance of finisher pigs was improved when YC was included as 2% of a low P (deficient) diet, but no improvement was obtained when YC was added to a diet adequate in P. Metacarpal breaking strength, ash, and carcass measurements were not affected by YC supplementation, regardless of the P level in the diet.

A phytase assay of YC used in our experiments showed an activity of 1440 PTU of phytase per kg of YC, where 1 PTU = the release of 1  $\mu$ mole of orthophosphate per minute from a surplus of Na-phytate at a pH of 5.5 and a temperature of 37.7<sup>o</sup> C. When YC is mixed at a level of .75% in a diet, the

activity of phytase added is only 10.8 U/kg of diet. The failure to observe an improvement in P absorption in our study (and probably other studies) is believed to be due to: 1) the very low level of phytase activity added, and 2) the presence of adequate available P in the diet from inorganic P sources. It is unlikely that one could determine in vivo a measureable response to such a low level of phytase. Furthermore, the measureable responses to much higher levels of phytase are usually small and variable.

### **Implications**

The addition of yeast culture to fortified corn-soybean meal starter diets with or without dried whey or a fiber source (SH or PH) had little effect on ADG and ADFI, and only variable effects on G:F. Furthermore, YC supplementation did not affect the digestibilities of DM, N, NDF, or ADF, or the absorption of phosphorus. These results suggest, however, that a low level (8%) of fiber may be used in starter diets without adversely affecting performance. Higher levels can act to both decrease performance and digestibilities of DM, N, NDF, and ADF.

Table 1. Percentage composition of diets with and without yeast culture (YC) and whey: Exp. Ia

	DIETARY TREATMENTS								
	Trial 1				Trial 2				
	YC, %	0	.75	0	.75	0	.75	0	.75
Ground corn	67.65	66.98	66.98	55.66	54.99	69.46	68.78	57.47	56.80
Soybean meal	27.42	27.34	27.34	25.31	25.24	27.06	26.98	24.95	24.88
L-lysine-HCl	.24	.24	.24	.17	.17	.24	.24	.18	.18
Salt	.40	.40	.40	-	-	.40	.40	-	-
Dical phosphate	1.53	1.51	1.51	1.17	1.15	1.51	1.50	1.15	1.14
Limestone	.87	.88	.88	.79	.79	.88	.89	.80	.80
Vitamin-Se mix <sup>b</sup>	.25	.25	.25	.25	.25	-	-	-	-
Vitamin mix <sup>c</sup>	-	-	-	-	-	.25	.25	.25	.25
Se mix <sup>d</sup>	-	-	-	-	-	.05	.05	.05	.05
Mineral mix <sup>e</sup>	.05	.05	.05	.05	.05	.05	.05	.05	.05
Mecadox <sup>f</sup>	.10	.10	.10	.10	.10	.10	.10	.10	.10
Animal fat	1.00	1.00	1.00	1.00	1.00	-	-	-	-
Pellet binder	.50	.50	.50	.50	.50	-	-	-	-
Yeast culture	-	.75	.75	-	.75	-	.75	-	.75
Dried whey	-	-	-	15.00	15.00	-	-	15.00	15.00

a Rations formulated to contain 18% CP, 1.15% lysine, .80% Ca, .65% P, and .40% NaCl on as-fed basis.

b Supplied per kg of feed: 4405 IU vit A, 441 IU vit D, 11 IU vit E, 1.1 mg vit K, 4.4 mg riboflavin, 22 mg pantothenic acid, 22 mg niacin, .022 mg vit B<sub>12</sub>, 441 mg choline, 441 mg biotin, and .1 mg Se.

c Supplied per kg of feed: 6,883 IU of vit A, 441 IU of vit D, 28 IU of vit E, 2.2 mg of vit K, 4.4 mg of riboflavin, 22 mg of niacin, 22 mg of pantothenic acid, 551 mg of choline, 2.2 mg of folic acid, .275 mg of biotin, and .022 mg of vit B<sub>12</sub>.

d Sodium selenite (45.7% Se) and limestone mixture formulated to provide .3 mg of Se per kg of feed.

e Supplied per kg of feed: Ca 17.5 mg min, 22.5 mg max; 75 mg Zn, 30 mg Mn, 87.5 mg Fe, 8.75 mg Cu, and 1 mg I.

f Provides 11.3 mg Carbadox/kg feed.

Table 2. Percentage composition of diets with or without yeast culture (YC) and soybean hull (SH) or peanut hull (PH) additions to starter diets: Exp. II<sup>a</sup>

	DIETARY TREATMENTS						
	YC, %	0	0	0	.75	.75	.75
SH, %	0	8	0	0	8	0	0
PH, %	0	0	8	0	0	0	8
Corn	69.52	62.74	61.43	68.85	62.07	60.76	
Soybean meal	27.04	25.89	27.17	26.97	25.81	27.09	
L-lysine·HCl	.24	.24	.23	.24	.24	.22	
Salt	.40	.40	.40	.40	.40	.40	
Dical phos	1.51	1.58	1.59	1.50	1.57	1.58	
Limestone	.88	.75	.79	.89	.76	.79	
Vitamin-Se mix <sup>b</sup>	.25	.25	.25	.25	.25	.25	
Mineral mix <sup>c</sup>	.05	.05	.05	.05	.05	.05	
Mecadox <sup>d</sup>	.10	.10	.10	.10	.10	.10	
Yeast culture	-	-	-	.75	.75	.75	
Soybean hulls	-	8.00	-	-	8.00	-	
Peanut hulls	-	-	8.00	-	-	8.00	
<u>Analyzed<sup>e</sup></u>							
Protein	17.51	17.43	17.77	17.65	17.42	17.76	
Phosphorus	.68	.60	.58	.72	.62	.62	
NDF	14.72	16.58	19.60	14.76	16.61	19.71	
ADF	5.00	7.77	9.18	5.02	7.78	9.23	
ADL	1.42	2.74	3.24	1.43	2.75	3.25	

<sup>a</sup> Rations formulated to contain 18% CP, 1.15% lysine, .80% Ca, .65% P, and .40% NaCl (.157% Na). Composition on as-fed basis.

<sup>b</sup> Supplied per kg of feed: 4405 IU vit A, 441 IU vit D, 11 IU vit E, 1.1 mg vit K, 4.41 mg riboflavin, 22 mg pantothenic acid, 22 mg niacin, .022 mg vit B<sub>12</sub>, 441 mg choline, .441 mg biotin, and .1 mg Se.

<sup>c</sup> Supplied per kg of feed: Ca 17.5 mg min, 22.5 mg max; 75 mg Zn, 30 mg Mn, 87.5 mg Fe, 8.75 mg Cu, and 1 mg I

<sup>d</sup> Provides 11.3 mg Carbadox/kg feed.

<sup>e</sup> Values are on an as-fed basis.

Table 3. Percentage composition of diets with or without yeast culture (YC) and peanut hulls (PH): Exp. III<sup>a</sup>

YC, % PH, %	DIETARY TREATMENTS					
	0 0	0 8	0 16	.75 0	.75 8	.75 16
Corn	69.21	61.12	53.03	68.54	60.45	52.36
Soybean meal	27.11	27.23	27.36	27.03	27.16	27.28
L-lysine·HCl	.24	.22	.20	.24	.22	.20
Salt	.40	.40	.40	.40	.40	.40
Dical phos	1.51	1.59	1.67	1.50	1.58	1.66
Limestone	.88	.79	.69	.89	.79	.70
Vitamin premix <sup>b</sup>	.25	.25	.25	.25	.25	.25
Mineral premix <sup>c</sup>	.05	.05	.05	.05	.05	.05
Selenium mix <sup>d</sup>	.05	.05	.05	.05	.05	.05
Cr <sub>2</sub> O <sub>3</sub> mix <sup>e</sup>	.20	.20	.20	.20	.20	.20
Mecadox <sup>f</sup>	.10	.10	.10	.10	.10	.10
Yeast culture	-	-	-	.75	.75	.75
Peanut hulls	-	8.00	16.00	-	8.00	16.00
<u>Analyzed<sup>g</sup></u>						
Protein	21.14	21.34	21.12	21.25	21.17	21.16
Calcium	.87	.85	.88	.84	.90	.87
Phosphorus	.73	.69	.68	.65	.66	.71
Chromium	.033	.032	.033	.031	.035	.035
NDF	14.89	21.02	26.97	14.89	21.02	26.97
ADF	5.06	9.84	15.69	5.06	9.84	15.69
ADL	1.44	3.47	6.00	1.44	3.47	6.00

a Rations formulated to contain 18% CP, 1.15% lysine, .80% Ca, .65% P, and .40% NaCl (.157% Na). Composition on as-fed basis.

b Supplied per kg of feed: 6883 IU vit A, 441 IU vit D, 28 IU vit E, 2.2 mg vit K, 4.4 mg riboflavin, 22 mg niacin, 22 mg d-pantothenic acid, 551 mg choline, 2.2 mg folic acid, .275 mg biotin, and .022 mg vit B<sub>12</sub>

c Supplied per kg of feed: Ca 17.5 mg min, 22.5 mg max; 75 mg Zn, 30 mg Mn, 87.5 mg Fe, 8.75 mg Cu, and 1 mg I

d Sodium selenite (45.7% Se) and limestone mixture formulated to provide .3 mg Se per kg feed.

e Chromic oxide mixed with corn starch in 1:3 weight ratio, and ground through a .5 mm screen prior to mixing in ration.

f Provides 11.3 mg Carbadox per kg feed.

g Values are on a dry matter basis (avg of 97.5%).

Table 4. Average daily gain, feed intake, and gain to feed ratios of weanling pigs as influenced by yeast culture (YC) and whey additions to starter diets: Exp. 1<sup>a</sup>

	DIETARY TREATMENTS				SEM	
	YC, % Whey, %	0	.75 0	0 15		.75 15
TRIAL 1						
ADG, g						
Wk 1-4		406	400	390	408	12
5		652	660	660	670	18
1-5		454	451	443	459	10
ADFI, g						
Wk 1-4		597	616	606	610	15
5		1293	1289	1290	1321	29
1-5		735	748	741	750	15
G:F, g/kg						
Wk 1-4 <sup>b</sup>		680	655	644	671	15
5		509	514	514	510	13
1-5		621	606	599	614	11
TRIAL 2						
ADG, g						
Wk 1-4		319	325	320	296	12
5 <sup>c</sup>		622	642	566	543	35
1-5 <sup>d</sup>		380	388	369	345	14
ADFI, g						
Wk 1-4 <sup>f</sup>		520	514	549	505	14
5		1158	1122	1123	1105	61
1-5		647	636	664	625	21
G:F, g/kg						
Wk 1-4 <sup>c</sup>		618	633	582	587	15
5 <sup>b,e</sup>		537	576	503	489	13
1-5 <sup>e</sup>		589	612	556	553	12

<sup>a</sup> Twelve pens of 2 pigs per pen in Trial 1 and 6 pens of 4 pigs per pen in Trial 2 per treatment mean. Avg initial and final wts for Trials 1 and 2: 7.2 and 23.3, 8.3 and 21.3 kg, respectively.

<sup>b</sup> Whey x yeast culture interaction (P < .10)

<sup>c,d,e</sup> Whey effect (P < .05, P < .10, and P < .005, respectively)

<sup>f</sup> Yeast culture effect (P < .10)

Table 5. Average daily gain, average daily feed intake, and gain/feed of weanling pigs as influenced by yeast culture (YC) and soybean hull (SH) or peanut hull (PH) additions to starter diets: Exp. II<sup>a</sup>

	DIETARY TREATMENTS							SEM
	YC, %	0	0	0	.75	.75	.75	
SH, %	0	8	0	0	0	8	0	
PH, %	0	0	8	0	0	0	8	
<hr/>								
ADG, g <sup>b</sup>								
Wk 1-3	280	282	276	265	272	259	16	
4-5	595	606	605	606	605	633	15	
1-5	405	410	406	400	404	407	12	
ADFI, g								
Wk 1-3 <sup>c</sup>	473	546	515	478	463	479	27	
4-5	1115	1186	1160	1132	1160	1168	39	
1-5	728	799	771	737	739	752	28	
G/F, g/kg								
Wk 1-3 <sup>de</sup>	598	539	552	566	595	567	14	
4-5	536	517	523	540	527	546	13	
1-5 <sup>cde</sup>	559	524	531	549	553	553	10	

a Avg initial and final wts: 7.8 kg and 21.5 kg, respectively.

b Eight pens of two pigs/pen in the Blacksburg trial, and three pens of three pigs/pen and one pen of four pigs/pen in the Tidewater trial for each treatment mean.

c Yeast culture effect (P < .10)

d Yeast culture x soyhull interaction (P < .05)

e Yeast culture x peanut hull interaction (P < .10)

Table 6. Scour score percentages of pens of weanling pigs as influenced by yeast culture and fiber additions to starter diets: Exp. II, Trial 1<sup>a</sup>

		DIETARY TREATMENTS					
		0	0	0	.75	.75	.75
YC, %		0	0	0	.75	.75	.75
SH, %		0	8	0	0	8	0
PH, %		0	0	8	0	0	8
<u>Wk Score</u> <sup>b</sup>							
1 <sup>c</sup>	2	61	76	62	69	53	66
	3	16	14	24	18	31	24
	4	17	7	12	13	16	11
	5	6	4	2	0	0	0
2	2	66	63	57	50	52	60
	3	11	7	11	29	20	18
	4	13	18	20	14	16	13
	5	11	13	13	7	12	10
3	2	73	73	70	58	77	88
	3	26	16	16	28	14	9
	4	2	5	13	9	9	4
	5	0	5	2	5	0	0

a Eight pens of two pigs/pen per treatment mean.

b Values are expressed as the percentage of pens of pigs/treatment that scored 2-5. Columns total were 100% for each week.

c Yeast culture effect (P < .10)

Table 7. Body weight, average daily gain, average daily feed intake, and average gain to feed ratio of growing pigs as influenced by yeast culture and fiber additions to diets: Exp. II, Trial 4<sup>a</sup>

	DIETARY TREATMENTS						SEM
	YC, %	SH, %	PH, %	0	.75	.75	
	0	8	0	0	8	0	
	0	0	8	0	0	8	
Init wt, kg <sup>b</sup>	24.5	24.3	23.6	23.1	23.5	24.5	1.71
Final wt, kg	42.6	40.1	41.0	43.0	42.5	41.3	.36
ADG <sup>cde</sup> (g)	890	770	814	908	885	829	18
ADFI (g)	2544	1886	2110	2180	2226	2076	214
G/F (g/kg)	367	412	391	427	402	392	32

a Three pens of three pigs/pen per treatment mean for the three week trial.

b Data were analyzed with initial wt as a covariate.

c Fiber effect (P < .005)

d Yeast culture effect (P < .01)

e Yeast culture x soyhull interaction (P < .05)

Table 8. Average daily gain, average daily feed intake, and gain to feed ratios of weanling pigs as influenced by yeast culture (YC) and peanut hull (PH) additions to starter diets: Exp. III<sup>a</sup>

	DIETARY TREATMENTS <sup>b</sup>						SEM	
	PH, % YC, %	0	8	16	0 .75	8 .75		16 .75
Wt loss, g <sup>c</sup>		1710	1796	1972	1751	1887	1728	102
ADG, g <sup>d</sup>								
Wk 1-4		337	306	316	293	322	306	14
5-6 <sup>ef</sup>		671	656	619	659	681	600	19
1-6 <sup>g</sup>		437	411	407	403	430	394	11
ADFI, g								
Wk 1-4		542	517	540	507	573	554	26
5-6		1192	1223	1233	1199	1278	1200	27
1-6		737	729	748	714	784	748	24
G/F, g/kg								
Wk 1-4 <sup>eh</sup>		622	593	587	579	565	552	13
5-6 <sup>e</sup>		565	536	502	551	535	499	15
1-6 <sup>ei</sup>		595	565	545	565	550	528	11

a Avg initial and final wts: 6.3 kg and 41.4 kg respectively.

b Eight pens of two pigs/pen per treatment mean.

c Loss in weight following a 24 h fast at the end of the trial.

d ADG, ADFI, and G/F have been calculated using the final weight which was recorded prior to the fasting period.

e Linear peanut hull effect (P < .05)

f Quadratic peanut hull effect (P < .10)

g Peanut hull x yeast culture interaction (P < .10)

h,i Yeast culture effect (P < .01 and P < .05, respectively)

Table 9. Dry matter, N, P, NDF, and ADF apparent digestibilities (%) in weanling pigs as influenced by yeast culture (YC) and peanut hull (PH) additions to starter diets: Exp. III<sup>a</sup>

	DIETARY TREATMENTS						SEM	
	PH, % YC, %	0	8	16	0 .75	8 .75		16 .75
<b>Dry matter<sup>bd</sup></b>								
wk 4		83.7	79.6	73.9	83.6	79.2	74.1	.94
wk 6		81.3	79.4	77.7	83.6	80.7	75.6	.94
<b>Nitrogen<sup>cd</sup></b>								
wk 4		82.4	80.4	78.3	81.7	80.2	79.0	.92
wk 6		78.1	79.2	80.5	81.0	81.0	78.9	.92
<b>Phosphorus<sup>ce</sup></b>								
wk 4		46.7	45.6	50.1	45.5	44.3	46.8	2.10
wk 6		37.6	46.0	49.6	45.9	45.7	44.8	2.10
<b>Neutral detergent fiber<sup>bf</sup></b>								
wk 4		51.1	45.7	43.7	53.3	45.7	38.3	2.82
wk 6		47.2	47.4	48.6	53.2	50.7	44.6	2.82
<b>Acid detergent fiber<sup>cdg</sup></b>								
wk 4		35.5	27.0	29.4	39.7	23.0	21.9	3.33
wk 6		32.5	25.6	36.5	34.7	30.1	32.5	3.33

<sup>a</sup> Eight pens of two pigs/pen per treatment mean.

<sup>b,c</sup> Linear PH effect (P < .001 and P < .05 respectively)

<sup>d</sup> Fiber x week interaction (P < .05)

<sup>e,f</sup> Fiber x YC interaction (P < .05 and P < .10, respectively)

<sup>g</sup> Quadratic PH effect (P < .005)

Table 10. Average daily gain, feed intake, and gain to feed ratios of weanling pigs as influenced by yeast culture (YC) additions to starter diets: Pooled for Exp I, II, and III<sup>a</sup>

	DIETARY TREATMENTS		SEM
	YC, %		
	0	.75	
ADG, g <sup>b</sup>			
Wk 1-3 <sup>c</sup>	278	257	8
4-5	610	617	11
1-5	410	400	8
ADFI, g			
Wk 1-3	444	437	11
4-5	1087	1093	19
1-5	700	698	13
G:F, g/kg			
Wk 1-3 <sup>c</sup>	628	595	12
4-5	565	568	7
1-5	588	578	7

a Twenty-eight pens of two pigs/pen, 3 pens of three pigs/pen and 7 pens of four pigs/pen per treatment mean.

b Avg initial and final wts: 7.3 kg and 21.5 kg, respectively.

c Yeast culture effect (P < .10)

Table 11. Average daily gain, feed intake, and gain to feed ratios of weanling pigs as influenced by yeast culture (YC) and 8% peanut hull (PH) additions to starter diets: Pooled for Exp. II and III<sup>a</sup>

	DIETARY TREATMENTS				SEM	
	YC, % PH, %	0 0	0 8	.75 0		.75 8
ADG, g <sup>b</sup>						
Wk 1-2		174	173	151	175	12
3-5		558	554	552	554	11
1-5		401	398	389	399	9
ADFI, g						
Wk 1-2		316	341	306	320	16
3-5		974	1008	983	1008	24
1-5		705	735	706	727	19
G:F, g/kg						
Wk 1-2 <sup>c</sup>		560	523	496	551	21
3-5 <sup>d</sup>		578	558	568	556	8
1-5 <sup>e</sup>		575	551	556	555	7

a Sixteen pens of two pigs/pen, 3 pens of three pigs/pen, and 1 pen of four pigs/pen per treatment mean.

b Avg initial and final wts: 7.3 and 20.9 kg, respectively.

c Yeast culture x peanut hull interaction ( $P < .05$ )

d,e Peanut hull effect ( $P < .05$  and  $P < .10$ , respectively)

## CHAPTER V

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## **APPENDIX**

Table 1. Calculated and analyzed composition of diets with and without yeast culture (YC) and whey: Exp. I, Trial 1

	DIET				
	YC, %	0	.75	0	.75
Whey, %	0	0	15	15	
<b>CALCULATED</b>					
ME, kcal/lb	1455	1444	1461	1450	
Protein, %	18	18	18	18	
Lysine, %	1.15	1.15	1.15	1.15	
Calcium, %	.80	.80	.80	.80	
Phosphorus, %	.65	.65	.65	.65	
Sodium, %	.16	.16	.16	.16	
<b>ANALYZED<sup>a</sup></b>					
Protein	18.02	17.72	17.47	17.33	
Calcium	.71	.94	.76	.94	
Phosphorus	.71	.68	.62	.68	
Sodium	.19	.19	.06	.07	

<sup>a</sup> Values reported on an as-fed basis.

Table 2. Calculated and analyzed composition of diets with and without yeast culture (YC) and whey: Exp. I, Trial 2

	DIET			
	0	.75	0	.75
YC, %	0	.75	0	.75
Whey, %	0	0	15	15
<b>CALCULATED</b>				
ME, kcal/lb	1476	1464	1469	1458
Protein, %	18	18	18	18
Lysine, %	1.15	1.15	1.15	1.15
Calcium, %	.80	.80	.80	.80
Phosphorus, %	.65	.65	.65	.65
Sodium, %	.16	.16	.16	.16
<b>ANALYZED<sup>a</sup></b>				
Calcium	.89	.87	.63	.63
Phosphorus	.81	.61	.76	.63
Sodium	.17	.17	.09	.10

<sup>a</sup> Values reported on an as-fed basis.

Table 3. Calculated and analyzed composition of diets with and without yeast culture (YC) and soybean hulls (SH) or peanut hulls (PH): Exp. II

	DIET					
	0	0	0	.75	.75	.75
YC, %	0	0	0	.75	.75	.75
SH, %	0	8	0	0	8	0
PH, %	0	0	8	0	0	8
<b>CALCULATED</b>						
ME, kcal/lb	1442	1323	1322	1431	1312	1311
Protein, %	18	18	18	18	18	18
Lysine, %	1.15	1.15	1.15	1.15	1.15	1.15
Calcium, %	.80	.80	.80	.80	.80	.80
Phosphorus, %	.65	.65	.65	.65	.65	.65
NDF, %	11.54	15.55	15.77	11.45	15.46	15.69
ADF, %	5.55	9.12	9.74	5.55	9.12	9.73
<b>ANALYZED<sup>a</sup></b>						
Protein	17.51	17.43	17.77	17.65	17.42	17.76
Phosphorus	.68	.60	.58	.72	.62	.62
NDF	14.72	16.58	19.60	14.76	16.61	19.71
ADF	5.00	7.77	9.18	5.02	7.78	9.23
ADL	1.42	2.74	3.24	1.43	2.75	3.25

<sup>a</sup> Values reported on an as-fed basis.

Table 4. Calculated and analyzed composition of diets with and without yeast culture (YC) and peanut hulls (PH): Exp. III

	DIET						
	YC, % PH, %	0 0	0 8	0 16	.75 0	.75 8	.75 16
<b>CALCULATED</b>							
ME, kcal/lb		1438	1318	1199	1427	1307	1188
Protein, %		18	18	18	18	18	18
Lysine, %		1.15	1.15	1.15	1.15	1.15	1.15
Calcium, %		.80	.80	.80	.80	.80	.80
Phosphorus, %		.65	.65	.65	.65	.65	.65
Chromium, %		.034	.034	.034	.034	.034	.034
NDF, %		11.53	15.77	20.00	11.45	15.68	19.91
ADF, %		5.55	9.74	13.92	5.55	9.73	13.92
<b>ANALYZED<sup>a</sup></b>							
Protein		21.14	21.34	21.12	21.25	21.17	21.16
Calcium		.87	.85	.88	.84	.90	.87
Phosphorus		.73	.69	.68	.65	.66	.71
Chromium		.033	.032	.033	.031	.035	.035
NDF		14.89	21.02	26.97	14.89	21.02	26.97
ADF		5.06	9.84	15.69	5.06	9.84	15.69
ADL		1.44	3.47	6.00	1.44	3.47	6.00

<sup>a</sup> Values reported on a dry matter basis.

Table 5. Least squares means of average daily gain of weanling pigs as influenced by yeast culture (YC) and whey additions to starter diets: Exp. I, Trial 1<sup>a</sup>

	YC, % Whey, %	DIETS				SEM
		0	.75 0	0 15	.75 15	
Initial wt, kg		7.19	7.18	7.19	7.15	.10
Final wt, kg		23.35	23.26	22.97	23.49	.40
ADG, g <sup>b</sup>						
Wk 1		211	186	175	182	18
2		286	262	291	265	28
3		468	476	480	520	18
4		671	690	628	678	24
5		652	660	660	670	18
1-2		248	225	232	224	13
1-3		319	306	312	319	12
1-4		406	400	390	408	12
1-5		454	451	443	459	10

<sup>a</sup> Twelve pens of two pigs/pen per treatment mean.

<sup>b</sup> No treatment effects observed.

Table 6. Least squares means of average daily feed intake of weanling pigs as influenced by yeast culture (YC) and whey additions to starter diets: Exp. I, Trial 1<sup>a</sup>

	DIETS				SEM	
	YC, % Whey, %	0 0	.75 0	0 15		.75 15
ADFI, g <sup>b</sup>						
Wk 1		239	240	246	233	12
2		442	469	464	465	15
3		748	755	767	785	26
4		990	1030	975	987	31
5		1292	1289	1290	1320	29
1-2		337	351	351	345	10
1-3		470	482	486	488	13
1-4		597	616	606	610	15
1-5		734	748	741	750	15

<sup>a</sup> Twelve pens of two pigs/pen per treatment mean.

<sup>b</sup> No treatment effects observed.

Table 7. Least square means of average gain to feed ratios of weanling pigs as influenced by yeast culture (YC) and whey additions to starter diets: Exp. I, Trial 1<sup>a</sup>

	DIETS				SEM	
	YC, % Whey, %	0	.75 0	0 15		.75 15
G/F, g/kg Wk 1		866	748	690	767	60
2		638	574	635	572	56
3		616	619	614	660	22
4		695	691	656	697	16
5		508	514	514	510	13
1-2		732	643	659	650	33
1-3		673	631	637	656	22
1-4 <sup>b</sup>		680	655	644	671	15
1-5		621	606	599	614	11

<sup>a</sup> Twelve pens of two pigs/pen per treatment mean.

<sup>b</sup> Whey x yeast culture effect (P < .10)

Table 8. Least squares means of average daily gain of weanling pigs as influenced by yeast culture (YC) and whey additions to starter diets: Exp. I, Trial 2<sup>a</sup>

	DIETS				SEM	
	YC, % Whey, %	0 0	.75 0	0 15		.75 15
Init wt, kg		8.11	8.50	8.30	8.29	.09
Final wt, kg <sup>b</sup>		21.40	22.09	21.22	20.38	.50
ADG, g Wk 1 <sup>d</sup>		52	20	56	40	13
2		215	266	226	188	26
3		448	433	422	421	18
4		560	580	576	534	32
5 <sup>c</sup>		622	642	566	543	35
1-2		134	143	141	114	16
1-3		238	240	235	217	15
1-4		319	325	320	296	12
1-5 <sup>b</sup>		380	388	369	345	14

a Six pens of four pigs/pen per treatment mean.

b,c Whey effect (P < .10 and P < .05, respectively)

d Yeast culture effect (P < .10)

Table 9. Least squares means of average daily feed intake of weanling pigs as influenced by yeast culture (YC) and whey additions to starter diets: Exp. I, Trial 2<sup>a</sup>

	DIETS				SEM	
	YC, % Whey, %	0 0	.75 0	0 15		.75 15
ADFI, g Wk 1 <sup>bd</sup>		153	131	180	158	10
2		345	337	387	338	18
3		639	635	647	602	20
4		941	954	984	922	31
5		1158	1122	1123	1105	61
1-2 <sup>bd</sup>		249	234	284	248	12
1-3 <sup>c</sup>		379	368	405	366	13
1-4 <sup>c</sup>		520	514	549	505	14
1-5		647	636	664	625	21

<sup>a</sup> Six pens of four pigs/pen per treatment mean.

<sup>b,c</sup> Yeast culture effect (P < .05 and P < .10, respectively)

<sup>d</sup> Whey effect (P < .05)

Table 10. Least squares means of average gain to feed ratios of weanling pigs as influenced by yeast culture (YC) and whey additions to starter diets: Exp. I, Trial 2<sup>a</sup>

	DIETS				SEM	
	YC, % Whey, %	0	.75 0	0 15		.75 15
G/F, g/kg Wk 1		325	140	283	201	80
2 <sup>b</sup>		641	781	580	541	64
3 <sup>e</sup>		710	685	653	711	21
4		597	610	585	579	26
5 <sup>ce</sup>		536	576	503	489	13
1-2 <sup>d</sup>		547	603	490	444	54
1-3 <sup>d</sup>		636	651	579	593	30
1-4 <sup>b</sup>		618	633	582	587	15
1-5 <sup>c</sup>		589	612	556	553	12

<sup>a</sup> Six pens of four pigs/pen per treatment mean.

<sup>b,c,d</sup> Whey effect (P < .05, P < .005, and P < .10 respectively)

<sup>e</sup> Whey x yeast culture effect (P < .10)

Table 11. Least squares means of average daily gain of weanling pigs as influenced by yeast culture (YC) and soybean hull (SH) or peanut hull (PH) additions to starter diets: Exp.II<sup>a</sup>

	DIET						SEM
	SH, % PH, % YC, %	0 0 0	8 8 0	0 8 0	0 0 .75	8 0 .75	
Init wt,kg	7.75	7.77	7.79	7.68	7.74	7.77	.03
Final wt,kg	21.49	21.70	21.59	21.28	21.45	21.60	.44
ADG, g							
Wk 1	90	100	82	82	119	95	20
2	275	277	263	256	249	227	23
3	493	486	499	471	463	475	22
4 <sup>b</sup>	581	622	632	586	591	631	20
5 <sup>c</sup>	612	588	575	626	622	638	25
1-2	183	189	173	169	184	161	17
1-3	280	282	276	265	272	259	16
1-4	357	369	367	347	354	354	14
1-5	405	410	406	400	404	407	12
4-5	595	606	605	606	605	633	15

<sup>a</sup> Eight pens of two pigs/pen in the Blacksburg trial, and three pens of three pigs/pen and one pen of four pigs/ pen in the Tidewater trial for each treatment mean.

<sup>b</sup> Peanut hull effect (P < .05)

<sup>c</sup> Yeast culture effect (P < .10)

Table 12. Least squares means of average daily feed intake (kg) of weanling pigs as influenced by yeast culture and soybean hull (SH) or peanut hull (PH) additions to starter diets: Exp. II<sup>a</sup>

	DIET						SEM
	SH, % 0	8	0	0	8	0	
	PH, % 0	0	8	0	0	8	
	YC, % 0	0	0	.75	.75	.75	
Wk 1	235	253	241	244	230	239	17
2 <sup>b</sup>	445	544	496	433	422	443	34
3	763	866	832	782	761	782	40
4	1045	1138	1100	1031	1104	1104	46
5	1194	1240	1227	1244	1223	1239	42
1-2 <sup>c</sup>	340	399	368	338	326	341	24
1-3 <sup>c</sup>	473	546	515	478	463	479	27
1-4	619	697	664	619	627	638	28
1-5	728	799	771	737	739	752	28
4-5	1115	1186	1160	1132	1160	1168	39

<sup>a</sup> Eight pens of two pigs/pen in the Blacksburg trial, and three pens of three pigs/pen and one pen of four pigs/pen in the Tidewater trial for each treatment mean.

<sup>b,c</sup> Yeast culture effect (P < .05 and P < .10, respectively)

Table 13. Least squares means of average gain to feed ratios (g gain/kg feed) of weanling pigs as influenced by yeast culture (YC) and soybean hull (SH) or peanut hull (PH) additions to starter diets: Exp. II<sup>a</sup>

	DIET						SEM	
	SH, % PH, % YC, %	0 0 0	8 0 0	0 8 0	0 0 .75	8 0 .75		0 8 .75
Wk 1		392	386	392	331	482	393	80
2		618	541	550	596	612	543	39
3 <sup>b</sup>		651	583	611	621	619	627	20
4		556	552	585	575	545	578	22
5 <sup>c</sup>		513	482	468	508	512	515	14
1-2 <sup>c</sup>		540	498	497	506	563	498	27
1-3 <sup>cd</sup>		598	539	552	566	595	567	14
1-4 <sup>e</sup>		580	543	559	570	573	571	12
1-5 <sup>cfg</sup>		559	524	531	549	553	553	10
4-5		536	517	523	540	527	546	13

<sup>a</sup> Eight pens of two pigs/pen in the Blacksburg trial, and three pens of three pigs/pen and one pen of four pigs/pen in the Tidewater trial for each treatment mean.

<sup>b</sup> Soyhull effect (P < .10)

<sup>c</sup> Yeast culture x peanut hull effect (P < .10)

<sup>d,e,f</sup> Yeast culture x soyhull effect (P < .005, P < .10, and P < .05, respectively)

<sup>g</sup> Yeast culture effect (P < .10)

Table 14. Least squares means of average daily gain, average daily feed intake, and average gain to feed ratios of growing pigs as influenced by yeast culture (YC) and soybean hull (SH) or peanut hull (PH) additions to diets: Exp. II, Trial 4<sup>a</sup>

	DIET						SEM
	YC, %	0	0	0	.75	.75	
SH, %	0	8	0	0	8	0	
PH, %	0	0	8	0	0	8	
Init wt, kg	24.5	24.3	23.6	23.1	23.5	24.5	1.71
Final wt, kg	42.6	40.1	41.0	43.0	42.5	41.3	.36
ADG, g							
Wk 1 <sup>bdf</sup>	757	527	688	866	859	666	50
2	852	833	783	894	775	841	60
3	1060	949	972	964	1023	981	67
1-3 <sup>bef</sup>	890	770	814	908	885	829	18
ADFI, g							
Wk 1	1894	1311	1538	1605	1648	1583	169
2	2626	1918	2182	2257	2339	2207	280
3	3112	2428	2610	2677	2691	2440	239
1-3	2544	1886	2110	2180	2226	2076	214
G:F, g/kg							
Wk 1 <sup>cg</sup>	415	403	457	560	528	410	34
2	348	430	363	412	337	381	50
3	353	401	373	370	386	395	35
1-3	367	412	391	427	402	392	32

a Three pens of three pigs/pen per treatment mean for the three week trial.

b,c Yeast culture effect (P < .01 and P < .05 respectively)

d,e Fiber effect (P < .05 and P < .005 respectively)

f Yeast culture x soyhull effect (P < .05)

g Yeast culture x peanut hull effect (P < .05)

Table 15. Least squares means of average daily gain of weanling pigs as influenced by yeast culture (YC) and peanut hull (PH) additions to starter diets: Exp. III<sup>a</sup>

	DIET						SEM	
	YC, % PH, %	0 0	0 8	0 16	.75 0	.75 8		.75 16
Init wt, kg		6.31	6.35	6.33	6.40	6.36	6.29	.05
Final wt, kg <sup>b</sup>		22.04	21.00	20.64	20.77	21.68	20.35	.44
Wt loss, kg <sup>b</sup>		1.71	1.80	1.97	1.75	1.89	1.73	.10
ADG, g								
Wk 1		67	47	41	46	77	52	20
2		247	231	230	196	238	201	21
3		470	440	445	392	439	453	28
4		564	506	547	537	535	517	26
5 <sup>ce</sup>		647	661	600	632	653	599	18
6 <sup>c</sup>		706	648	646	698	719	603	33
1-2		157	139	136	121	157	126	18
1-3		261	240	239	211	251	235	16
1-4		337	306	316	293	322	306	14
1-5		399	377	372	360	388	364	12
1-6 <sup>g</sup>		437	411	407	403	430	394	11
5-6 <sup>df</sup>		671	656	619	659	681	600	19

<sup>a</sup> Eight pens of two pigs/pen per treatment mean.

<sup>b</sup> Loss in weight following a 24 h fast at the end of the trial.

<sup>c,d</sup> Linear hull effect ( $P < .05$  and  $P < .01$ , respectively)

<sup>e,f</sup> Quadratic hull effect ( $P < .05$  and  $P < .10$  respectively)

<sup>g</sup> Hull x yeast culture interaction ( $P < .10$ )

Table 16. Least squares means of average daily feed intake of weanling pigs as influenced by yeast culture (YC) and peanut hull (PH) additions to starter diets: Exp. III<sup>a</sup>

	DIET						SEM	
	YC, % PH, %	0 0	0 8	0 16	.75 0	.75 8		.75 16
ADFI, g								
Wk 1		125	129	128	130	164	144	18
2		396	387	390	352	418	416	33
3		731	691	700	660	757	730	41
4		915	863	943	885	955	925	32
5		1098	1138	1132	1118	1159	1130	25
6 <sup>b</sup>		1323	1343	1374	1311	1444	1299	40
1-2		261	258	259	241	291	280	25
1-3		417	402	406	381	446	430	27
1-4		541	517	540	507	573	554	26
1-5		653	641	659	629	691	669	24
1-6		737	729	748	714	785	748	23
5-6		1192	1223	1233	1199	1278	1200	27

<sup>a</sup> Eight pens of two pigs/pen per treatment mean.

<sup>b</sup> Hull x yeast culture interaction (P < .10)

Table 17. Least squares means of average gain to feed ratios (g gain/kg feed) of weanling pigs as influenced by yeast culture (YC) and peanut hull (PH) additions to starter diets: Exp. III<sup>a</sup>

	DIET						SEM	
	YC, % PH, %	0 0	0 8	0 16	.75 0	.75 8		.75 16
G:F, g/kg Wk I		536	364	320	354	470	361	-
2 <sup>b</sup>		632	604	593	575	574	461	42
3 <sup>b</sup>		644	639	638	599	572	625	24
4		617	586	582	605	563	561	21
5 <sup>e</sup>		592	581	530	564	566	530	14
6 <sup>f</sup>		534	483	471	535	501	457	24
1-2 <sup>c</sup>		592	542	520	496	549	424	39
1-3 <sup>d</sup>		628	599	590	560	564	543	18
1-4 <sup>df</sup>		622	593	587	579	565	552	13
1-5 <sup>de</sup>		612	589	567	574	565	545	10
1-6 <sup>be</sup>		595	565	545	565	550	528	11
5-6 <sup>e</sup>		565	536	502	551	535	499	15

<sup>a</sup> Eight pens of two pigs/pen per treatment mean.

<sup>b,c,d</sup> Yeast culture effect (P < .05, P < .10, and P < .01 respectively)

<sup>e,f</sup> Linear hull effect (P < .005 and P < .05, respectively)

Table 18. Nutrient intake (g/day) and fecal nutrient percentages of weanling pigs as influenced by yeast culture (YC) and peanut hull (PH) additions to starter diets: Exp. III, Wk 4<sup>a</sup>

	DIET						
	YC, % PH, %	0	8	16	.75 0	.75 8	.75 16
ADFI, g		915	863	943	885	956	925
Cr intake		.302	.279	.310	.273	.336	.319
Fecal Cr		.204	.165	.130	.209	.160	.128
N intake		31.0	29.5	31.9	30.1	32.4	31.4
Fecal N		3.7	2.9	2.8	3.8	3.2	2.7
P intake		6.7	6.0	6.4	5.8	6.3	6.6
Fecal P		2.2	1.8	1.3	2.3	1.8	1.4
NDF intake		136.2	181.4	254.3	131.8	201.0	249.5
Fecal NDF		44.2	47.4	59.4	42.1	55.0	64.2
ADF intake		46.3	84.9	148.0	44.8	94.1	145.1
Fecal ADF		20.0	35.3	43.5	19.7	36.5	47.3

<sup>a</sup> Eight pens of two pigs/pen per treatment mean.

Table 19. Nutrient intake (g/day) and fecal nutrient percentages of weanling pigs as influenced by yeast culture (YC) and peanut hull (PH) additions to starter diets: Exp. III, Wk 6<sup>a</sup>

	DIET					
	YC, %: 0	0	0	.75	.75	.75
PH, %: 0	0	8	16	0	8	16
ADFI, g	1323	1343	1374	1311	1444	1299
Cr intake	.437	.434	.452	.405	.507	.448
Fecal Cr	.177	.162	.150	.204	.172	.136
N intake	44.8	45.9	46.5	44.6	49.0	44.0
Fecal N	4.0	3.4	3.0	3.9	3.3	2.8
P intake	9.7	9.3	9.3	8.5	9.5	9.2
Fecal P	2.3	1.8	1.5	2.3	1.9	1.6
NDF intake	197.0	282.3	370.6	195.2	303.5	350.3
Fecal NDF	41.7	53.6	61.9	42.1	53.7	61.2
ADF intake	67.0	132.2	215.6	66.3	142.1	203.8
Fecal ADF	19.3	35.5	44.6	20.0	35.7	43.5

<sup>a</sup> Eight pens of two pigs/pen per treatment mean.

Table 20. Average daily gain of weanling pigs as influenced by yeast culture (YC) additions to starter diets: Pooled for Exp. I, II, and III<sup>a</sup>

	YC, %	DIET		SEM
		0	.75	
ADG, g				
Wk 1		102	83	10
2		262	247	14
3 <sup>b</sup>		478	449	11
4		591	596	17
5		629	637	14
1-2		182	165	9
1-3 <sup>b</sup>		278	257	8
1-4		356	342	8
1-5		410	400	8
4-5		610	617	11

<sup>a</sup> Twenty-eight pens of two pigs/pen, 3 pens of three pigs/pen and 7 pens of four pigs/pen per treatment mean.

<sup>b</sup> Yeast culture effect (P < .10)

Table 21. Average daily feed intake of weanling pigs as influenced by yeast culture (YC) additions to starter diets: Pooled for Exp. I, II, and III<sup>a</sup>

	YC, %	DIET		SEM
		0	.75	
ADFI, g <sup>b</sup>				
Wk 1		198	198	7
2		415	405	14
3		734	723	18
4		989	986	21
5		1188	1203	21
1-2		306	300	10
1-3		444	437	11
1-4		581	575	12
1-5		700	698	13
4-5		1087	1093	19

<sup>a</sup> Twenty-eight pens of two pigs/pen, 3 pens of three pigs/pen, and 7 pens of four pigs/pen per treatment mean.

<sup>b</sup> No yeast culture effects observed.

Table 22. Average daily gain to feed ratios of weanling pigs as influenced by yeast culture (YC) additions to starter diets: Pooled for Exp. I, II, and III<sup>a</sup>

	YC, %	DIET		SEM
		0	.75	
G:F, g/kg				
Wk I		497	176	193
2		634	624	27
3		655	629	13
4		603	611	12
5		533	534	8
1-2		594	551	21
1-3 <sup>b</sup>		628	595	12
1-4		616	601	9
1-5		588	578	7
4-5		565	568	7

<sup>a</sup> Twenty-eight pens of two pigs/pen, 3 pens of three pigs/pen, and 7 pens of four pigs/pen per treatment mean.

<sup>b</sup> Yeast culture effect (P < .10)

Table 23. Average daily gain of weanling pigs as influenced by yeast culture (YC) and peanut hull (PH) additions to starter diets: Pooled Exp. II and III<sup>a</sup>

	DIET				SEM	
	YC, % PH, %	0 0	0 8	.75 0		.75 8
ADG, g <sup>b</sup> Wk 1		86	82	68	103	15
2		263	264	235	246	15
3		477	470	447	461	19
4		577	577	571	575	17
5		620	614	637	626	18
1-2		174	173	151	175	12
1-3		271	268	247	267	11
1-4		349	347	329	345	10
1-5		401	398	389	399	9
3-5		558	554	553	554	11

<sup>a</sup> Sixteen pens of two pigs/pen, three pens of three pigs/pen, and one pen of four pigs/pen per treatment mean.

<sup>b</sup> No treatment effects observed.

Table 24. Average daily feed intake of weanling pigs as influenced by yeast culture (YC) and peanut hull (PH) additions to starter diets: Pooled Exp. II and III<sup>a</sup>

	YC, % PH, %	DIET				SEM
		0 0	0 8	.75 0	.75 8	
ADFI, g <sup>b</sup> Wk 1		201	210	201	212	12
2		431	473	411	429	24
3		753	792	743	771	29
4		1005	1033	994	1052	29
5		1164	1198	1212	1198	29
1-2		316	342	306	320	16
1-3		456	486	446	465	19
1-4		595	625	585	614	19
1-5		705	735	706	727	19
3-5		974	1008	983	1008	24

<sup>a</sup> Sixteen pens of two pigs per pen, three pens of three pigs/pen, and one pen of four pigs/pen per treatment mean.

<sup>b</sup> No treatment effects observed.

Table 25. Average daily gain to feed ratios of weanling pigs as influenced by yeast culture (YC) and peanut hull (PH) additions to starter diets: Pooled Exp. II and III<sup>a</sup>

	DIET				SEM	
	YC, % PH, %	0 0	0 8	.75 0		.75 8
G:F, g/kg Wk 1		428	390	338	486	-
2		617	583	581	591	27
3		640	609	616	603	17
4		578	564	581	552	14
5		537	518	529	526	10
1-2 <sup>b</sup>		560	523	496	551	21
1-3 <sup>b</sup>		603	569	562	581	12
1-4		592	566	570	569	9
1-5 <sup>c</sup>		575	551	556	555	7
3-5 <sup>d</sup>		578	558	568	556	8

<sup>a</sup> Sixteen pens of two pigs/pen, three pens of three pigs/pen, and one pen of four pigs/pen per treatment mean.

<sup>b</sup> Yeast x peanut hull interaction (P < .05)

<sup>c,d</sup> Peanut hull effect (P < .10 and P < .05, respectively)

## VITA

Deanna Rhein was born June 19, 1968 in El Paso, Texas. After attending primary schools in several states, Deanna attended Apex High School in Apex, North Carolina. In 1986, she entered the animal science program at North Carolina State University. While at NCSU, she was active in Alpha Zeta, an agricultural service fraternity, and received scholarships from both Alpha Zeta and the National Feed Ingredients Association. After receiving her B.S. degree in 1990, Deanna came to Virginia Polytechnic Institute and State University on a Pratt Nutrition research assistantship.

In June of 1991, Deanna married Robert Michael Welker, a fellow graduate student from the Department of Horticulture. After finishing their graduate studies, the Welkers returned to North Carolina.

*Deanna Rhein-Welker*