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# The Effect of Substituting High Oil Corn as a Replacement for Normal Corn in Nursery Pig Diets

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**Abstract:** The objective of this study was to determine the production and monetary effects of using High Oil Corn (HOC) in a nursery phase feeding program and monitor growth performance differences through marketing. Two groups of weaned crossbred pigs (n = 293 trial 1; n = 265 trial 2) were segregated by sex and weight into small, medium and heavy groups and allotted to 12 nursery pens. Pigs received one of two dietary treatments which included; a transitional phase I diet for 7 days; a commercial corn soy based phase II diet (NCII) for 14 days and a phase III diet (NCIII) for 7 days; a HOC soy based phase II diet for 21 days and the NCIII diet for 7 days. Body weight, Average daily feed intake and Gain/Feed (G/F) ratios were measured weekly during the nursery period. Pigs were transferred to a grow/finish barn on d 28 post-weaning. Body weight, Backfat (BF) and Longissimus Muscle Area (LMA) at the 10th and last ribs were ultrasonically evaluated 4 times prior to market. Average daily gain of nursery pigs on the three-phase NC diet was greater than pigs fed the HOC two-phase diet at d 21 post-weaning (p = .0034) and 28 post-weaning (p = .0128). ADG for heavy pigs was greater (p = .0001) than that of medium and lightweight pigs and no treatment×weight group interactions were observed (p = .2043). Pigs fed the three-phase diet had greater G/F ratios than pigs fed the HOC two-phase diet at d 21 (p = .0137) and 28 (p = .0134). LEA for pigs fed the three-phase diet was greater than pigs fed the HOC two-phase diet when measured on d 28 at the 10th (p = .0565) and last rib (p = .0370). Even though pigs were fed alike in the grow-finish period, ADG of pigs fed the three-phase nursery diet was greater (p = .0106) than that of pigs fed the HOC two-phase nursery diet. There were no differences in the predicted 114 kg weight (p = .2658). However, economic differences were noted for the two treatments with the HOC two-phase diet lowering the cost of production of marketed animals. There were no treatment differences for average daily lean growth per day (p = .8611) or percentage lean of carcasses (p = .2865). The results did not support removal of the transitional phase I diet and the substitution of HOC for NC in a phase II diet fed to nursery pigs for maximal nursery growth, nor was carcass composition of pigs at marketing adversely affected.

**Key words:** Nursery pigs, phase feeding, high oil corn, substituting, normal corn

## INTRODUCTION

The need for swine producers to improve pig production has resulted in earlier weaning ages for pigs (Ravidran and Kornegay, 1993). At weaning, the change in diet from milk based products to animal and plant based products often leads to digestive disturbances and reduced growth performance (Ravidran and Kornegay, 1993). This post weaning lag period will typically occur during the 1st week after weaning and may last up to 2 weeks depending on its severity. Attempts to shorten or eliminate the post weaning lag period have led to the development of relatively expensive, highly digestible transitional diets based on animal proteins.

Producers are now interested in ways to reduce costs of production associated with the feeding of transitional diets. Value-added plant feedstuffs have been developed, marketed and may reduce some of the higher priced animal feedstuffs in transitional diets without negatively affecting performance. Compared to traditional plant feedstuffs, improved plant varieties such as high oil corn have increased nutritional quality and may be absorbed more efficiently in the young pig, reducing the post weaning lag period. Therefore, the objective of this study was to evaluate High Oil Corn (HOC) as an ingredient in nursery diets for weaned pigs to determine production and monetary effects and monitor growth performance differences through marketing.

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Table 1: Dietary treatments fed to pigs following weaning to evaluate the effect of high oil corn compared to normal corn[1]

| | Normal corn treatment | | | High oil corn treatment | |
|---|---|---|---|---|---|
| Ingredient (%) | Transition[2] | Phase II | Phase III | Phase II | Phase III |
| High oil corn | | - | - | 50.3 | - |
| Normal corn | | 50.3 | 51.7 | - | 51.7 |
| SBM (48% CP) | | 26.2 | 24.3 | 26.2 | 24.3 |
| Starter Mix[3] | | 20.0 | 20.0 | 20.0 | 20.0 |
| Lincomix 10[4] | | 1.0 | - | 1.0 | - |
| Mecadox[5] | | - | 1.0 | - | 1.0 |
| Rendered animal fat | | 2.5 | 3.0 | 2.5 | 3.0 |
| Chemical analysis | | | | | |
| Crude protein (N×6.25) | 21.6 | 20.50 | 19.67 | 21.20 | 19.7 |
| Ether extract | 6.5 | 5.66 | 6.19 | 6.90 | 6.29 |
| Lysine | 1.6 | 1.25 | 1.20 | 1.17 | 1.20 |

[1]Percentage of ingredients included on an as fed basis, [2] Ingredients proprietary (supplied as complete pelleted feed, Tennessee Farmers Cooperative, Lavergne, TN, PW 6-13). [3]Supplied as vitamin and mineral premix from Tennessee Farmers Cooperative, Lavergne, TN, ingredient composition proprietary. [4] Lincomycin hydrochloride added to provide 10 mg/lb. [5] Carbadox added to supply 25 g/ton

## MATERIALS AND METHODS

**Animal management:** Pigs were weaned at 28 (±3) days of age, segregated by sex and weight group and placed into 12 nursery pens based on small (5.41 kg), medium (7.21 kg) and heavy (9.41 kg) size groups into a nursery facility at the Ames Plantation; Grand Junction, TN. Pigs were assigned to one of two dietary treatments (Table 1) which included: T1) ad-libitum access to a commercial corn-soy based pelleted transition diet for 7 d (phase I), a ground corn-soy based phase II diet for 14 d, ground corn-soy based nursery phase III diet for 7 d and T2) ad-libitum access to a ground high oil corn-soy based phase II nursery diet for 21 d, then the same previously mentioned phase III diet for 7 d. Pigs were provided ad-libitum access to water via a nipple waterer throughout the nursery period. Animals and feed were weighed using an electronic scale (O'Haus Model I-10) and weights recorded to the nearest one-tenth pound at d 7, 14, 21, 28 post weaning. Feed and animal weights were used to calculate, ADG, ADFI and G/F ratio. At d 14, 5pigs were randomly selected and a button ear tag was placed in the left ear for identification. On d-14 post-weaning, a 2-mL blood sample was obtained via vena cava puncture in the supine position from four of the pigs using a 18 G × 1.5 in. needle (Becton Dickinson and Co., Rutherford, NJ) and 10 mL Vacutainer (Becton Dickinson and Co., Rutherford, NJ) containing sodium heparin or EDTA (two pigs for each type). Blood was placed on ice until taken to the laboratory for analyses. After centrifugation, plasma was separated from whole blood and analyzed for plasma urea nitrogen. On d-28 post-weaning, animals were moved into a fully slatted grow-finish facility, not far from and on the same farm as the nursery unit. Pigs were weighed to determine ADG at time of each diet change in the grow-finish facility. Area of the longissimus dorsi and backfat depth were evaluated ultrasonically and used to estimate lean and fat accretion. Growth data were analyzed for adjusted days to 114 kg (NSIF, 1997) because all animals were not marketed at the same weight.

**Feed analysis:** Prior to diet formulation a 454-g sample of each feed ingredient was randomly obtained to determine energy, protein and amino acid content. After grinding and mixing of diets, 454 g samples were obtained at random to determine energy and protein content of the mixed diets. All diets fed during the trial were ground and mixed using a Gehl Mix-All 125 mixer (Gehl Company, West Bend, WI) in 909 kg batches. Gross energy of all samples was determined using a Parr 1241 oxygen bomb adiabatic bomb calorimeter (Parr Instrument Company, Moline, IL). One-milligram samples were dried at 60° C and placed into stainless steel crucibles. The energy values of all samples were run in triplicate and gross energy values were averaged. Crude protein (N×6.25) content of treatment feeds was determined using standard Kjeldahl procedure.

**Ultrasound measurements:** Estimates of lean and fat accretion rates were made from longissimus muscle area and back fat measurements taken at the 10th and last ribs using real-time ultrasonography (Aloka 500 V with a 3.5 MHz probe, Corometrics Medical Systems, Wallingford, CT). All ultrasonic scans were performed and interpreted by the same technician to minimize variation. The 5th rib was estimated by locating the point of the shoulder and the last rib was determined by palpation. Location of the 10th rib was approximated as the point slightly caudal to the midpoint between the palpated last rib and the estimated 5th rib. After location, the points were marked using a livestock marker. After scanning, images were recorded using a Beta style, video cassette recorder. Images were interpreted and backfat and area of the logissimus dorsi were determined using software image analysis software (Animal Ultrasound Services, Ithaca, NY). Daily lean gain was predicted using the formula ((7.6 + (.308*weight at trial completion)-(16.44*10th rib backfat)+(4.693*10th rib loin muscle area)-(.418*weight at trial initiation)). Carcass percentage leas was predicted by ((3.950 + (.308*live weight in pounds)-(16.440*10th rib fat depth in inches)+(4.693*10th rib LMA in inches squared)/live weight/74*100)), (NSIF, 1997).

**Statistical design:** The statistical model consisted of a randomized complete block design in a 2×3×2 factorial arrangement using repeated measures analysis with pen as the experimental unit. There were six pens per treatment and two pens per weight group. Variables analyzed were: BW, ADG, G:F, ADFI, average daily lean gain, 10th and last rib fat and longissimus dorsi, adjusted days to 114 kg and predicted percentage lean for the carcasses. Data were analyzed using PROC MIXED procedure of SAS (1997) with trial replication as a random effect. Fixed effects in the analysis included treatment, sex and weight group. Variation associated with trial replication was not significant, so data from each growth trial were pooled for final analysis. Variation in BUN due to anti-coagulant type (EDTA or Heparin) was evaluated and found not to be significant. Data among coagulant type were pooled and analyzed using the PROC MIXED procedure with BW at d 14 post-weaning as a covariate. Where appropriate, variable means were compared using pdmix (Saxton, 1998) procedures of SAS (1997).

## RESULTS

Nursery pigs that consumed the three-phase normal corn-based diets were heavier at d 21 post-weaning (p = .0171) (Fig. 1), but not at market (p = .5886) when compared to pigs that consumed the two-phase High Oil Corn-based (HOC) nursery diets. No differences were observed for BW between barrows and gilts at d 21 post-weaning (p = .3752), but barrows were heavier than gilts when pigs reached market weight (p = .0539). As expected, no differences in BW were observed among weight groups (p = .0001) at d 21 post-weaning and at marketing (p = .0005) and no group × treatment interactions (p = .9940) were observed at d 21 post-weaning. At marketing, a group × treatment interaction was observed, with heavy pigs fed HOC diets having larger BW than pigs fed a diet that contained normal corn NC (p = .0009) (Table 2). Average daily gains of nursery pigs (Table 2) receiving NC diets were greater at d 21 (p = .0034) and at market (p = .0128), compared to pigs fed of HOC diets. Pigs in the heavy weight group had a greater average daily gain than pigs in the medium or small weight groups at d 21 (p = .0046) and at market (p = .0027). No differences were observed between treatments in ADFI at any time during the nursery phase. The G:F ratio was higher at d 7 post-weaning (p = .0194) for animals that consumed NC diets (Fig. 2). Additionally, group × sex (p = .4816), treatment × sex (p = .4905), treatment × group (p = .6415) interactions were

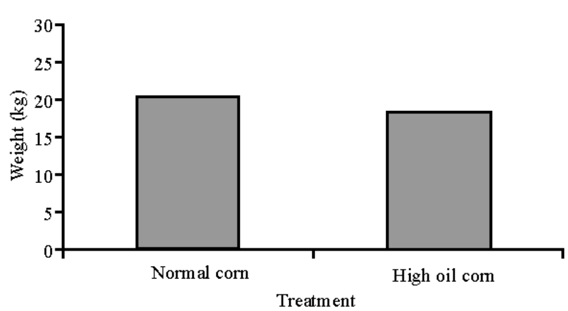


Fig. 1: Body weight at day 21 for pigs fed a Normal Corn (NC) or High Oil Corn (HOC) diet after weaning

Table 2: Average daily gain of nursery pig of various size groups fed a three-phase normal corn diet or a two-phase diet containing high oil corn

| Day on test[1] | Weight group | 3-Phase commercial NC diet[2] | 2-Phase HOC diet | SEM |
|---|---|---|---|---|
| 0-7[3] | Small | 254.5 | 92.6 | ±40.86 |
| | Medium | 215.2 | 62.2 | ±40.76 |
| | Heavy | 326.8 | 163.5 | ±40.78 |
| 7-14[4] | Small | 155.2 | 159.8 | ±36.57 |
| | Medium | 120.3 | 159.6 | ±36.47 |
| | Heavy | 218.0 | 251.1 | ±36.46 |
| 14-21[5] | Small | 304.5 | 286.4 | ±32.94 |
| | Medium | 388.7 | 305.3 | ±32.74 |
| | Heavy | 443.4 | 352.5 | ±32.79 |
| 21-28[6] | Small | 428.8[bc] | 368.6[cd] | ±32.60 |
| | Medium | 445.6[b] | 352.8[d] | ±32.19 |
| | Heavy | 425.0[bc] | 511.2[a] | ±32.19 |
| 0-21[7] | Small | 238.6 | 179.5 | ±25.39 |
| | Medium | 242.7 | 175.8 | ±25.31 |
| | Heavy | 328.6 | 253.1 | ±25.33 |

[1]Data are Least Squares Means measured in grams/day, with × number of pigs represented in each LS mean, [2] Column and row LS means not sharing like superscripts differ at p<.05 within each test period indicated. [3] Treatment*group interaction (p = .9624). [4] Treatment*group interaction (p = .3856). [5] Treatment*group interaction (p = .0829). [6]Treatment* group interaction (p = .0001). [7] Treatment*group interaction (p = .9338)

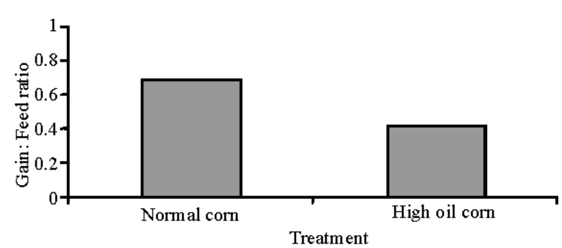


Fig. 2: Gain: Feed ratio at day 21 postweaning for pigs fed a three-phase normal corn or a two-phase high oil corn diet after weaning

not significant sources of study variation. At d 21 post-weaning, pigs that consumed NC nursery diets had higher G:F ratios than those fed HOC (p = .0137). No differences were observed for G:F among sex (p = .4163) or treatment × sex interaction (p = .6454).

No differences were observed among the treatments for last or 10th rib backfat (p = .3866 and p = .5398, respectively) 28 days after weaning. Gilts had less backfat at the 10th rib than barrows (p = .0001, 22.3 mm and 26.1 mm, respectively), but not at the last rib (p = .2244). No interaction of sex × treatment interactions were observed for 10th rib (p = .5493) or the last rib backfat (p = .2416). However, no differences were observed for backfat when body weight was used as a covariate for 10th rib backfat (p = .2692), 10th rib longissimus (p = .4338), or loin muscle area at the last rib (p = .3994). Backfat measurements were still greater for the heavy group pigs when body weight was used as a covariate at the last rib (p = .0001). Compared to barrows, gilts had greater LMA 10th rib (p = .0464), but did not have greater last rib loin muscle area at marketing (p = .1056). No differences were observed for average daily lean gain (p = .8611), .53±.01 lbs/day for NC and .52±.01 lbs $day^{-1}$ for HOC. The estimated percent lean for carcasses was not different between treatments (53.3±.4 for NC and 52.7±.4 for HOC) (p = .2865).

Blood Urea Nitrogen (BUN) was not correlated to BW at d 14 post-weaning (p = .1619). After covariant analysis, no main effects of dietary treatment (p = .4164), sex (p = .2665) or weight group (p = .2421) were observed on serum or plasma urea nitrogen values; however a treatment x group interaction was noted. This interaction was likely due to the animals from the heavy weight group, in both treatments, having much higher BUN values than the small weight group for the HOC and medium group for NC treatments (p = .0195) (Table 3).

No treatment effects (p = .2658) or treatment by replication interactions (p = .1254) were observed after adjusting for BW at marketing. A replication effect was observed (p = .0001), due to animals in the second replication growing at a slower rate compared to the first replication (201.45 and 175.42 days to 114 kg, respectively). As expected, a group effect was noted (p = .0001) animals in the smaller group remaining smaller throughout the finishing phase. No differences in the adjusted days to 114 kg were observed between NC or HOC fed pigs (p = .2658; 187.63±.86, 189.32±.85; respectively); However, numerical differences contributed to a cost savings of $.12 per day/animal for the normal corn fed pigs. The death loss of animals from weaning to market for the two treatments was 6.0 % for HOC fed pigs and 2.2% for pigs fed NC pigs. The three-phase nursery feed cost for NC diets was $6.02 per pig versus $4.65 per pig for two-phase HOC fed pigs for the entire nursery phase. The differential in feed cost amounted to a savings of $1.37 per pig coming out of the nursery for HOC pigs. There was no way to accurately determine feed consumption in the test facilities utilized. Hence, F:G and efficiency of lean growhth could not be determined. The assumption was made that all pigs consumed approximately the same amount of feed and deposited protein at a similar rate since carcass lean percentages were not different between the treatment groups. Taking these assumptions into consideration, there was a difference of $425.16 in overall feed costs for the treatments in favor of HOC. The higher death loss associated with the HOC fed pigs amounted to an estimated $110 loss in income compared to NC fed market animals (assuming a $10 profit potential for each marketed animal). Subtracting the $110 additional income for the increased pigs to market for NC from the $425.16 savings from the feeding of HOC, still provided a $315.16 benefit for feeding HOC. This amounts to an estimated $1.20 greater profit per animal marketed when HOC is utilized in the nursery diets under the conditions of this study.

Table 3: Least squares means of Blood Urea Nitrogen (BUN) values at day 14 for treatment × weight group interaction (P = .0195) from pigs fed a three-phase Normal Corn (NC) or two-phase High Oil Corn (HOC) nursery diet at weaning

| | Treatment[a] | | |
|---|---|---|---|
| Group[b] | Three-phase[c] NC diet | Two-phase[c] HOC diet | SEM |
| Small | 9.40 | 7.65 | ±.85 |
| Medium | 7.26 | 9.29 | ±.76 |
| Heavy | 9.20 | 10.30 | ±.88 |

[a] LS means with different superscripts are different (p < .05). [b] Weight group of pigs fed high oil corn or normal corn diets. [c] BUN is reported for pooled serum and plasma samples in mg $dL^{-1}$

## DISCUSSION

The intent of this experiment, was to determine if a relatively low cost phase two, nursery diet based on HOC could replace a more expensive commercial transitional (phase one) diet without adversely affecting pig performance.

Our results demonstrate that a HOC based diet when used to replace a transitional phase I diet, negatively affects ADG and G:F. ADFI was not affected by treatment diets in this study. De Camp *et al*. (1998) observed increased feed intake for HOC, compared to NC and attributed the increase to greater palatability of HOC. This effect might be significant as the lack of food in the intestine of weanling pigs during the first few days after weaning may lead to alterations in intestinal morphology (Cera *et al*., 1988; Kelly *et al*., 1991; Spurlock *et al*., 1997; Pluske *et al*., 1996). There is also clear evidence that feed intake affects weanling pig performance (McCracken *et al*., 1999) which may lead to atrophy of the mucosa. According to McCracken *et al*. (1999) increased feed intake leads to an increase in enzyme activity.

In the present study, ADG was depressed when HOC was fed. This is in agreement with previous experiments that utilized added corn oil in swine and poultry diets (Lawrence and Maxwell, 1983; Han *et al*., 1987). However, others (De Camp *et al*., 1998) have reported mixed results finding no differences ADG or in BW in one experiment and significant differences in a second experiment. McCracken *et al*. (1999) suggests that intestinal morphology after weaning is affected by two factors: dietary immune response to soy-protein and lack of luminal stimulation due to reduced feed intake, both of which affect gain in the growing pig. In the present study, NC-fed pigs gained at a faster rate than those fed HOC based diets. Differences in ADG might be explained by the protein quality of the NC diet, as that diet contained more costly, but highly digestible animal protein sources that are more easily used by the young pig compared to plant sources. It would appear by the BUN values in our study that the protein quality of the two diets were closely related (Cai *et al*., 1995) however, De Camp *et al*. (1998) saw differences in the serum urea nitrogen values at d 14 and attributed them to better utilization of HOC by growing pigs. There may be other interactions occurring that were not identified in our study that may have caused the NC-fed pigs to gain at a faster rate than pigs fed the HOC treatment. The energy and protein values for the transitional diet were higher than the values measured for the phase two HOC diet. More and higher quality protein and a better energy: Protein ratio in the transitional diet could explain the increased performance of the pigs fed the NC three phase diet.

The G:F ratios were greater for NC fed pigs than those of the HOC fed pigs. The reduction in growth and G/F may be largely related to the results obtained by Han *et al*. (1987). Younger pigs do not digest carbohydrate and protein as well as fat, compared to older pigs, due to less enzymatic activity and inadequate intestinal development. These conclusions may those of Bergstrom *et al*. (1996) who demonstrated no differences in ADG or G:F when comparing HOC to NC and NC plus fat or soy oil. However, in a second study, Bergstrom *et al*. (1996) conducted noted ADG was improved when NC was fed from d 4-14. Enzymatic development in the young pig is a function of diet (McCracken *et al*., 1999) and weaning age (Jensen *et al*., 1997). Adams and Jensen (1987) reported that fat in HOC was effectively utilized when fed to 16 kg pigs. The pigs in the present study averaged smaller BW and likely had less developed digestive tracts than those used by Adams and Jensen (1987) and thus may not have been able to utilize nutrients as efficiently. Differences in protein quality would likely result in the larger body size of the NC pigs. Some of the proteins in the NC transitional diet were of animal origin and would be utilized more efficiently. Fats in the animal products would also contain a fatty acid profile more closely matching the needs of the pig and as a result, be more efficiently used by the pig.

Ultrasonography is accepted as a predictor of live animal and carcass characteristics (Smith *et al*., 1992). Gilts in our study were leaner than the barrows and pigs in the smaller weight group were leaner as well. Being smaller in body weight, these animals were likely at a different state of maturity than the larger pigs, which could explain the difference observed in this study. Since this was the only measured difference that may have affected carcass merit, one might expect that HOC fed animals would have carcasses that were as marketable as the NC fed pigs. As there were no differences noted for ADG throughout the experiment, this may imply that, the HOC fed pigs had similar rates of lean deposition, compared to pigs fed NC. Differences observed in the nursery may have been overcome during the finisher phase. The predicted percentage lean for the carcasses was not different and implies that the effects of the decreased growth during the nursery phase did not promote alterations in fat:muscle ratio during the finisher phase.

Swine producers are consistently seeking methods to improve the efficiency of pork production. In this study, HOC increased the profit of marketed pigs by allowing the elimination of the transition diet. The HOC fed animals only required one extra day to reach a market weight of 104 kg. By using such a feeding regimen, a swine producer would have generated an extra $1.27 per pig marketed without sacrificing carcass composition.

## CONCLUSION

This study found that use of HOC in nursery phase diets decreases growth performance in the early stages of growth and thus should not be used in lieu of transitional diets, which generally contain higher quality animal protein and appear to support a more optimal growth and performance. It is likely that pigs of this age require more digestible components compared to alternate energy sources such as provided by high oil corn. However, this study also indicates that such alterative starter diets might provide positive economic benefits when feed costs and returns are calculated through the marketing phase. Thus strategic use of lower cost feeding regimens, including those that include high oil corn may be warranted for some operations.

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