

JOURNAL OF ANIMAL SCIENCE

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J Anim Sci 2004. 82:1071-1078.

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Evaluation of a rendered poultry mortality–soybean meal product as a supplemental protein source for pig diets^{1,2,3}

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ABSTRACT: Dehydrated/rendered broiler mortality–soybean meal products (DPS) were evaluated in two trials as high-protein feedstuffs for pig diets. Broiler mortalities, collected and frozen on-farm and transported to a central facility, were minced, blended with soybean meal, and dried with a final product temperature of 120 to 130°C. The final DPS products used contained approximately 30 and 45% (DM basis) dried broiler mortality for the first and second trials, respectively (DPS1 and DPS2). The first trial involved 50 young, growing pigs (9 to 26 kg) and the second, 72 growing and finishing pigs (27 to 111 kg). The trials compared corn-based diets containing either soybean meal (SBM; 48%) or DPS products as the supplemental protein source. The DPS products averaged 50% CP

and 2.9% total lysine; crude fat content of DPS used in the first trial was 8%, and for the second, 14.6% (as-fed basis). The ADG of pigs fed the DPS diets in either trial was similar to that of pigs fed the SBM control diets. In the second trial, pigs fed DPS2 had an overall average G:F ratio that was 9% better ($P < 0.01$) than that of pigs fed the SBM control diets. Carcass characteristics and pork quality from pigs of the growing-finishing trial were not affected by dietary treatment. Subjective carcass fat firmness scores indicated slightly softer fat ($P < 0.05$) from pigs fed DPS2. The mincing, blending with SBM, and dehydration of frozen stored on-farm broiler mortalities produced a safe and nutritious protein feedstuff for pigs, while also offering a viable disposal option.

Key Words: Pigs, Poultry Meal, Poultry Mortality Disposal

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J. Anim. Sci. 2004. 82:1071–1078

Introduction

Disposal of on-farm mortality is a major concern facing commercial poultry production. A typical 100,000-broiler production unit would have to dispose of approximately 5,000 kg of mortalities per seven-week grow-out cycle (Wineland, et al., 1997). Traditional methods of disposal, such as burial, incineration, and use of disposal pits are considered environmentally unacceptable and their uses are restricted in many areas of the

United States. Composting of on-farm mortalities is a viable alternative and is being used more frequently by the broiler industry. Whole broilers, however, are high in protein and fat, both of which are desirable for livestock and poultry feeding. Thus, rendering would be a viable option if carcass deterioration could be minimized and between-farm biosecurity maintained. This study used one possible approach in the collection and subsequent rendering of on-farm broiler mortalities. This approach involved the use of on-farm freezers for the storage of the mortalities and the subsequent use of simple dehydration technology to produce a safe, high-quality rendered product. The rendered product produced could be a potential high-protein, and perhaps a high-energy, feed ingredient for use in livestock and poultry diets. The objective of this study was to evaluate this dehydrated/rendered product as a supplemental protein source in diets for growing and finishing pigs.

Materials and Methods

Two feeding trials were conducted: one with young, growing pigs (10 to 25 kg) and one with growing and finishing pigs (25 to 110 kg). Two different batches of

¹Florida Agric. Exp. Stn. Journal Series No. R-08972.

²Rendered products and some financial assistance provided by Alabama Protein Recycling Inc., Troy, AL.

³The assistance of H. Standland, J. Crawford, R. Croft, M. Chambliss, T. Crawford, D. Perry, D. Bernis, L. Eubanks, and T. Gwin is gratefully acknowledged. Special appreciation is also expressed to M. Tatom and J. Mullins of Alabama Protein Recycling, Inc. and to W. Pace of Pace Plus, Inc., Tallahassee, FL.

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Received September 3, 2002.

Accepted November 14, 2003.

the dehydrated/rendered poultry broiler mortality product (**DPS**) were used. The batch for the young, growing pig trial (Exp. 1) was a pilot test batch produced at an experimental testing facility, and the batch for the growing-finishing trial (Exp. 2) was from an early production run from a full-scale commercial facility. The University of Florida Animal Care and Use Committee approved the experimental protocols for both experiments.

Experiment 1

For this initial trial, fresh broiler mortalities were collected from two southeastern Alabama broiler operations and frozen at a central location. The frozen mortalities were then transported to an experimental dehydration/rendering facility. On arrival, the frozen mortalities were minced and blended with soybean meal (**SBM**; 48% CP). The resulting blend was approximately 40% moisture. The semimoist blend was then pelleted and dried using Jet Pro protocol and equipment (Jet Pro Co., a division of NutraCycle, LLC, Boca Raton, FL). Drying temperature was between 150 and 200°C and product temperature reached 120 to 130°C; transit time through the fluidized bed dryer was 4 to 7 min. The blending of minced broiler mortality with SBM was done to facilitate the drying process and to absorb fat. The final product (**DPS1**) was in the form of dry pellets and was estimated to contain 30% broiler mortality and 70% SBM on a dry basis.

Samples of DPS1, SBM, and corn were analyzed for moisture, CP, ether extract (crude fat), CF, ash, Ca, P, Na, Cl, AA composition, available lysine using the dinitrofluorobenzene procedure, and enzymatic (pepsin) digestibility of the protein. Peroxide value and rancidity development (thiobarbituric acid [**TBA**]; Tarladgis et al., 1960) were also determined for the DPS1 product. Standard microbiological tests were also performed on samples of DPS1 (coliforms, salmonella, and standard plate count). All analyses were done by Woodson-Tenent, Inc. (Memphis, TN) using AOAC (1995) procedures, except for TBA. The AOAC method used for AA was 982.30 (within method); methionine, 994.12; tryptophan, 988.15; available lysine, 975.44; Ca, 965.17 (digestion) and 984.27; P, 965.17; and Cl, 969.10. Amino acid concentrations were not corrected for incomplete recovery resulting from hydrolysis.

The feeding trial involved 50 crossbred pigs (PIC 327 × PIC C15) with an average initial weight of 9.3 ± 1.6 kg. The pigs were blocked by weight, sex, and litter origin and assigned to pens of five pigs each. Dietary treatment consisted of corn-based diets containing either SBM or DPS1 as the supplemental protein source. Diets were formulated using NRC (1998) nutrient guidelines and compositions are given in Table 1. The pelleted DPS1 was ground in a hammer mill before mixing into the diet. Feed and water were available at all times. The pigs were housed in an enclosed environmentally controlled building in 1.2×2.6 m pens with

Table 1. Composition (%) of growing pig diets (Exp. 1)^a

| Ingredient | Supplemental protein source | |
|-------------------------------------|-----------------------------|------------------------|
| | Soybean meal (Control) | DPS1 meal ^b |
| Ground corn | 66.30 | 66.70 |
| Soybean meal (48%) | 30.00 | — |
| DPS1 meal ^b | — | 30.00 |
| Dicalcium phosphate | 1.80 | 1.80 |
| Calcium carbonate | 0.80 | 0.40 |
| Salt | 0.50 | 0.30 |
| Vitamin premix ^c | 0.30 | 0.30 |
| Trace mineral premix ^d | 0.05 | 0.05 |
| L-lysine HCl | 0.10 | 0.20 |
| Sodium bicarbonate | — | 0.10 |
| Antibiotic premix ^e | 0.15 | 0.15 |
| Calculated composition ^f | | |
| Crude protein, % | 19.8 | 20.4 |
| Lysine, % | 1.14 | 1.22 |
| Ca, % | 0.78 | 1.0 |
| P, % | 0.74 | 0.8 |
| ME, kcal/kg | 3,260 | 3,350 ^g |
| ME:lysine, kcal/% | 2,860 | 2,750 ^g |
| Na, % | 0.2 | 0.2 |
| Crude fat, % | 3.0 | 5.0 |
| Analyzed composition | | |
| Moisture, % | 11.6 | 9.9 |
| Crude protein, % | 19.3 | 20.8 |
| Crude fat, % | 2.8 | 4.8 |
| Ash, % | 6.1 | 6.3 |

^aAs-fed basis.

^bDehydrated poultry broiler mortality–soybean meal blended product (DPS1 meal) containing, after dehydration, approximately 30% minced broiler chicken mortality (dry) and 70% soybean meal (48%).

^cProvided per kilogram of diet: vitamin A, 5,500 IU; vitamin D₃, 680 IU; vitamin E, 27 IU; vitamin K activity, 5.5 mg; riboflavin, 7 mg; d-pantothenic acid, 23 mg; niacin, 34 mg; choline chloride, 140 mg; and vitamin B₁₂, 27 µg.

^dProvided per kilogram of diet: zinc (ZnO), 100 mg; iron (FeSO₄), 50 mg; manganese (MnO), 27 mg; copper (CuSO₄), 5 mg; iodine (CaI₂), 0.8 mg; and selenium (Na₂SeO₃), 0.15 mg.

^eProvided 55 mg of tylosin/kg of diet.

^fCalculated using average values reported in Table 1 except for ME; NRC (1988) ME values were used with ME in DPS1 estimated at 3,600 kcal/kg.

^gEstimated from information in the above footnote and from Table 1.

perforated plastic floors. The pigs were fed the experimental diets for 30 d.

Experiment 2

The DPS product used for this trial was provided by Alabama Protein Recycling (Troy, AL). The product was produced from on-farm, frozen-stored broiler mortalities collected from broiler operations within 350 km of Troy, AL. At the plant, the mortalities were minced, blended with SBM (48%), and dried using a direct-fire, rotating-drum dryer. Product temperature reached 130°C during a 5- to 15-min drying time. After cooling, a low level of a formalin-based feed treatment (Termin8, Anitox Corp., Buford, GA) was sprayed on the product (0.5% wt/wt) to inhibit mold and bacterial growth as it was transferred to storage. The processing facility was routinely inspected by personnel from the State of Ala-

bama Veterinarian's office. As in Exp. 1, SBM was used to facilitate the drying process and absorb fat. The final product (**DPS2**) contained approximately 45% broiler mortality and 55% SBM on a dry basis. Because of different drying equipment and increased experience, a higher proportion of mortality was obtained in the final DPS2 product than was obtained in DPS1.

The DPS2 product for Exp. 2 was in meal form. Samples of DPS2 and SBM were collected and analyzed for concentrations of moisture, CP, crude fat (ether extract), ash, and AA using the commercial laboratory described above. Microbiological analyses were not performed because samples from the processing facility were routinely checked (total plate count, fecal coliforms, salmonella, etc.), as directed by the state veterinarian, and were found to be well within acceptable ranges for a livestock feed product (Norton et al., 2001).

The growing and finishing trial involved 72 crossbred pigs (PIC 427 × PIC C22 or Duroc × PIC C22) with an average initial weight of 27 ± 1.8 kg. Dietary treatments consisted of corn-based diets with either SBM or DPS2 as the supplemental protein source (Table 2). The pigs were blocked by initial weight and litter origin within sex, and assigned to pens of six pigs each. Treatments were randomly assigned to pens within each of the six replicates (blocks). Three replicates were of gilts and three of barrows.

A three-phase, split-sex diet regime was used. Grower diets for each treatment within sex were fed from 27 to 53 kg of average weight per pig (replicate basis), Finisher I from 53 to 81 kg, and Finisher II from 81 to 111 kg. Pigs were taken off experiment as complete replicates.

Because of the fat contributed by the DPS2, the dietary treatments were formulated, following NRC (1998) guidelines, to have similar estimated ME:digestible lysine ratios within the grower or finisher diet type within sex. The digestible lysine concentration and ME of DPS2 were estimated from analyzed compositions (Tables 3 and 4), results of *in vitro* analysis of Exp. 1 (Table 3) and *in vivo* analysis done with poultry (Hess et al., 2001b). Digestible lysine, adjusted to analyzed total lysine (Table 4), and ME for SBM and corn were from table values (NRC 1998).

The pigs were housed in an open-sided building in 1.5×4.0 m pens on concrete slotted floors (80% slotted and 20% solid). Feed and water were offered *ad libitum*. At the end of the trial, all pigs were scanned via real time ultrasound for backfat thickness, loin (longissimus) area and marbling at the last rib area. Percentage of carcass lean content was calculated (NPPC, 1991; scanned carcasses with live weight not held constant).

Also, at the end of the trial, the two middleweight pigs in each pen were slaughtered at the University of Florida Meats Laboratory. After chilling for 24 h, each carcass was measured for backfat thickness and loin (longissimus) area (10th rib). Percentage of carcass lean was calculated (NPPC, 1991; ribbed carcass with weight not held constant). Each carcass was also scored

for fat firmness (scale of 1 to 5 with 1 = firm, 5 = soft, oily) and muscling (1 to 3 with 1 = thin, 3 = thick). The exposed loin muscle was scored for lean color, firmness, texture, and marbling (NPPC 1991).

The left side of each carcass was weighed and fabricated into major wholesale cuts to determine the yield of the individual cuts of meat and the yield of four lean cuts. Samples of backfat (all layers) were taken at the 10th rib from carcasses of replicates three and four ($n = 8$). These samples were sent to the commercial laboratory mentioned above for fatty acid analysis.

Statistical Analyses

Gain-to-feed ratio, ADG, and ADFI (as-fed basis) were summarized on a pen basis for the entire trial for the young, growing pig trial (Exp 1). Gain-to-feed ratio, ADG, and ADFI were summarized on a pen basis for the Growing, Finisher I, Finisher II, and for the entire growing-finishing period for the growing-finishing trial (Exp. 2). The experimental unit was the pen in both trials. Carcass data from Exp. 2 were also summarized on a pen basis. Data were analyzed for treatment differences by ANOVA using a randomized complete block design (Steel and Torrie, 1980). The GLM procedure of SAS (SAS Inst., Inc., Cary, NC) was used to perform all analyses. Sex was not included in the model in Exp. 2; gilts and barrows were fed separately to more accurately formulate the diets used (NRC 1998). Statistical significance was accepted at $P < 0.05$.

Results and Discussion

The DPS products used in both trials were beige to tan and had little odor. The products were blended products and were estimated to contain 30 or 45% minced broiler mortality (dry) and 70 or 55% SBM for the products used in Exp. 1 (DPS1) and 2 (DPS2), respectively. The broiler mortalities were finely minced before blending with SBM and then dehydrated; as such, feather particles were small and well dispersed throughout the final product.

Microbiological assessments of the DPS product used in Exp. 1 (DPS1) indicated that the dehydration process was effective in controlling common pathogens. The number of fecal coliforms was essentially undetectable (<3 mpn/g, where mpn = most probable number, a calculated number that is related to the bacterial count observed in a series of dilutions), and no salmonella was detected. Standard plate count was a moderate 8,200 cfu/g and within the range of values (100 to 10,000 cfu/g) typically obtained for poultry by-product meals by the laboratory that did the analysis. Microbiological assessments were not done on DPS2 used in Exp. 2, but have been done and reported previously (Norton et al., 2001). The results were similar to that we found for DPS1. In addition, this was a batch from commercial production and the plant routinely performed microbiological testing under supervision from the state veterinarian's office of Alabama.

Table 2. Composition (%) of growing and finishing pig diets (Exp. 2)^a

| Ingredient | Grower (27 to 53 kg) | | | | Finisher I (53 to 81 kg) | | | | Finisher II (81 to 111 kg) | | | |
|-------------------------------------|-----------------------------|--------|------------------------|--------------------|-----------------------------|--------|--------------------|--------------------|-----------------------------|--------|--------------------|--------------------|
| | Supplemental protein source | | DPS2 meal ^b | | Supplemental protein source | | DPS2 meal | | Supplemental protein source | | DPS2 meal | |
| | Soybean meal | Barrow | Gilt | Barrow | Soybean meal | Barrow | Gilt | Barrow | Soybean meal | Barrow | Gilt | Barrow |
| Ground corn | 69.10 | 72.10 | 69.05 | 72.05 | 74.10 | 77.10 | 74.00 | 77.00 | 79.25 | 82.25 | 78.80 | 81.80 |
| Soybean meal (48%) | 28.00 | 25.00 | — | — | 23.00 | 20.00 | — | — | 18.00 | 15.00 | — | — |
| DPS2 meal ^b | — | — | 29.00 | 26.00 | — | — | 24.00 | 21.00 | — | — | 19.00 | 16.00 |
| Dicalcium phosphate | 1.30 | 1.30 | 0.60 | 0.60 | 1.30 | 1.30 | 0.80 | 0.80 | 1.20 | 1.20 | 1.00 | 1.00 |
| Calcium carbonate | 1.00 | 1.00 | 0.80 | 0.80 | 1.00 | 1.00 | 0.65 | 0.65 | 1.00 | 1.00 | 0.70 | 0.70 |
| Salt | 0.35 | 0.35 | 0.25 | 0.25 | 0.35 | 0.35 | 0.25 | 0.25 | 0.35 | 0.35 | 0.25 | 0.25 |
| Vitamin-TM premix ^c | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.20 | 0.20 | 0.20 | 0.20 |
| L-Lysine HCl | — | — | 0.05 | 0.05 | — | — | 0.05 | 0.05 | — | — | 0.05 | 0.05 |
| Calculated composition ^d | | | | | | | | | | | | |
| Dry matter | 88.0 | 88.0 | 89.6 | 89.5 | 88.0 | 88.0 | 89.4 | 89.2 | 88.0 | 88.0 | 89.1 | 88.9 |
| Lysine | 0.92 | 0.85 | 1.06 | 0.98 | 0.83 | 0.76 | 0.90 | 0.83 | 0.70 | 0.63 | 0.74 | 0.66 |
| Dig. lysine ^e | 0.80 | 0.74 | 0.85 | 0.79 | 0.69 | 0.63 | 0.71 | 0.66 | 0.57 | 0.51 | 0.60 | 0.54 |
| ME, kcal/kg | 3,300 | 3,310 | 3,490 ^f | 3,480 ^f | 3,310 | 3,310 | 3,460 ^f | 3,450 ^f | 3,320 | 3,320 | 3,470 ^f | 3,460 ^f |
| ME:lysine, kcal/% | 3,580 | 3,890 | 3,300 ^f | 3,550 ^f | 3,990 | 4,350 | 3,850 ^f | 4,150 ^f | 4,740 | 5,270 | 4,610 ^f | 5,160 ^f |
| ME:digestible lysine, kcal/% | 4,120 | 4,470 | 4,100 ^f | 4,400 ^f | 4,800 | 5,250 | 4,850 ^f | 5,200 ^f | 5,800 | 6,500 | 5,800 ^f | 6,400 ^f |
| Ca | 0.75 | 0.75 | 0.78 | 0.78 | 0.75 | 0.74 | 0.74 | 0.70 | 0.71 | 0.70 | 0.74 | 0.70 |
| P | 0.60 | 0.60 | 0.62 | 0.62 | 0.60 | 0.59 | 0.60 | 0.58 | 0.54 | 0.54 | 0.59 | 0.57 |
| Crude fat | 3.2 | 3.2 | 6.7 | 6.4 | 3.3 | 3.4 | 6.2 | 6.0 | 3.4 | 3.5 | 5.7 | 5.4 |

^aAs-fed basis.^bDehydrated broiler mortality–soybean meal blended product containing, after dehydration, about 45% minced broiler chicken mortality (dry) and 55% soybean meal (48%).^cAt 0.25% of diet provided per kilogram of diet: vitamin A, 5,500 IU; vitamin D₃, 680 IU; vitamin K activity, 5.5 mg; riboflavin, 7 mg; d-pantothenic acid, 23 mg; niacin, 34 mg; choline chloride, 140 mg; vitamin B₁₂, 27 mg zinc (ZnO), 100 mg; iron (FeSO₄), 50 mg; manganese(MnO), 27 mg; copper (CuSO₄) 5 mg; iodine (CaI₂), 0.8 mg, and selenium (NaSeO₃), 0.15 mg.^dCalculated using values presented in Table 2 (analyzed lysine in corn averaged 0.23%) and NRC (1998) values; ME in DPS meal estimated at 3,900 kcal/kg; Ca, P, Na, and Cl estimated at 1.2, 1.0, 0.1, and 0.25%, respectively.^eTrue ileal digestibility (NRC, 1998; Table 11-6) (coefficients × analyzed values for SBM and corn) lysine in DPS2 was estimated to be 80%.^fEstimate from information presented in above two footnotes and in Table 2.

Table 3. Analyzed nutrient composition and quality assessments of dehydrated broiler mortality-soybean meal blended product (DPS1), soybean meal, and corn used in Exp. 1^a

| Item | DPS1 ^b | Corn | Soybean meal ^c |
|---------------------------------------|-------------------|-----------------|---------------------------|
| Moisture, % | 6.2 | 10.8 | 11.3 |
| Crude protein, % | 48.8 | 8.5 | 47.0 |
| Crude fat, % | 7.9 | 3.9 | 1.2 |
| Ash, % | 7.8 | 1.1 | 6.2 |
| Ca, % | 1.4 | 0.01 | 0.22 |
| P, % | 1.2 | 0.31 | 0.74 |
| Cl (soluble), % | 0.13 | ND ^g | ND |
| Na, % | 0.13 | ND | ND |
| Pepsin digestible protein, % of total | 90 | 85 | 94 |
| Lysine, % | 3.06 | 0.28 | 2.92 |
| Available lysine, % of total | 92 | ND | 96 |
| Threonine, % | 1.92 | 0.30 | 1.86 |
| Methionine + cystine, % | 1.32 | 0.36 | 1.26 |
| Isoleucine, % | 1.88 | 0.24 | 1.86 |
| Tryptophan, % | 0.58 | ND | ND |
| Peroxide value, meq/kg ^d | 33 | ND | ND |
| TBA rancidity, mg/kg ^{ef} | 4.0 | ND | ND |

^aValues are expressed on an as-fed (air-dry) basis. Each value is an average of analysis on two samples.

^bDehydrated broiler mortality-soybean meal blended product (DPS1 meal) containing after dehydration to 6.2% moisture, about 30% minced broiler chicken mortality (dry), and 70% soybean meal.

^cCommercially available, 48% CP product.

^dUnits of peroxide formation per kilogram of fat.

^eThiobarbituric acid.

^fMilligrams malonaldehyde per kilogram of fat.

^gNot determined.

Composition analyses indicated both DPS products to be high in CP, slightly higher than SBM (Tables 3 and 4). Unlike SBM, the DPS products also contained appreciable amounts of crude fat, Ca, and P. The profiles of the most limiting essential AA in the protein of the DPS products, including lysine, were similar to the AA profile of SBM.

Two *in vitro* laboratory tests were also done to assess protein quality of the DPS1 product used in Exp. 1

Table 4. Analyzed composition (%) of dehydrated broiler mortality-soybean meal blended product (DPS2) and soybean meal used in the growing-finishing trial (Exp. 2)^a

| Item ^b | Soybean meal | DPS2 meal ^c |
|-------------------|--------------|------------------------|
| Moisture | 12.2 | 6.3 |
| Crude protein | 46.9 | 51.4 |
| Crude fat | 1.8 | 14.6 |
| Ash | 6.4 | 7.0 |
| Lysine | 2.72 | 2.88 |
| Threonine | 1.80 | 1.88 |

^aAs-fed basis. Each value is an average of two analyses, each on a separate sample.

^bMethionine, cystine, and tryptophan were not determined.

^cDehydrated broiler mortality-soybean meal blended product (DPS2) containing, after dehydration, approximately 45% minced broiler chicken mortality (dry) and 55% soybean meal (48%).

and results are given in Table 3. Pepsin digestibility of protein in the DPS1 was found to be almost as high as SBM. Although the DPS1 was found to contain slightly more lysine than SBM (3.06 vs. 2.92%), the estimated available lysine concentrations were the same (2.8%). Therefore, the protein value of the DPS products for pig diet formulation would be similar to that of SBM (48%), based on available lysine. Hess et al. (2001b) also conducted nutritional analyses, including “*in vivo*” digestibilities of AA using the cecectomized rooster bioassay, of DPS produced from the same plant as the DPS used in our second experiment. They also made a similar conclusion for poultry feeding. The TBA assay values obtained indicate some rancidity development in DPS1; however, this DPS product was not stabilized with an antioxidant.

For young, growing pigs (Exp. 1), average rate of weight gain was not affected ($P > 0.05$) by the substitution of DPS1 for SBM in the diet (Table 5). Average daily feed intake and G:F ratio were also not affected by diet treatment.

In the growing-finishing trial (Exp. 2), over the entire growing-finishing period, ADG by the pigs was not affected ($P > 0.05$) by the inclusion of DPS2 in the diets (Table 6). Pigs fed diets containing DPS2 required, on average, 9% less feed per unit of weight gain ($P < 0.01$) than pigs fed the SBM control diets. The better G:F ratio was likely due to the higher fat content of the DPS2 diets (average of 6 vs. 3%; Table 2). Average daily feed intake overall tended to be lower ($P < 0.06$) for pigs fed DPS2 than for pigs fed SBM, again reflecting the higher energy density of the diets containing DPS2. Average daily feed intake tended to be less during the growing phase when compared with the control (27 to 53 kg; $P < 0.05$) than in the finisher phases (53 to 111 kg; $P > 0.05$; Table 6), perhaps indicating some initial adjustment to the feed containing DPS2.

Average scanned backfat thickness and average LMA were unaffected ($P > 0.05$) by the inclusion of DPS2 in the diets (Table 6). Likewise, average estimated carcass lean content was also unaffected. Average measured backfat thickness from slaughtered pigs was not affected by the inclusion of DPS2 meal in the diets (Table 7). Measured LMA, as well as longissimus color, firmness, and marbling scores, was unaffected by diet treatment. Lean texture score, however, tended to be higher ($P < 0.08$) from pigs fed DPS2 than from pigs fed SBM. Carcass yields of various cuts of meat were also unaffected, except picnic yield, which tended to be greater ($P < 0.07$) from pigs fed DPS2 than from pigs fed SBM.

Carcass fat, as indicated by a higher average score, was softer ($P < 0.05$) from pigs fed DPS2 as compared to pigs fed SBM (Table 7). Subsequent fatty acid analysis of representative backfat samples ($n = 2$) supports the above observation of softer carcass fat (data not shown). Pigs fed DPS2 had greater percentages of monounsaturated (47 vs. 45; $P < 0.05$) and polyunsaturated

Table 5. Performance of young, growing pigs fed a diet containing dehydrated broiler mortality-soybean meal blended product (DPS1) or soybean meal (Exp. 1)^a

| Item | Dietary supplemental protein source | | SEM | P-value |
|--------------------------------------|-------------------------------------|------------------------|------|---------|
| | Soybean meal | DPS1 meal ^b | | |
| Average daily gain, kg/d | 0.55 | 0.56 | 0.02 | 0.88 |
| Daily feed intake, kg/d ^c | 0.92 | 0.90 | 0.03 | 0.42 |
| Gain: feed | 0.60 | 0.62 | 0.01 | 0.20 |

^aFive pens per treatment with five pigs per pen; average initial weight of 9.3 kg; on experiment for 30 d.

^bDehydrated broiler mortality-soybean meal blended product; composition given in Table 1.

^cAs-fed basis.

(15.2 vs. 12.2; $P < 0.01$) fatty acids and lower percentages of total saturated (38 vs. 43; $P < 0.01$) fatty acids than pigs fed SBM.

Results of the above trials show that a safe high quality feed ingredient can be produced from on-farm broiler mortalities. Lyons and Vandepopuliere (1996), using a dehydration process similar to that used in Exp. 1 of our study, found that a spent hen (laying hens no longer in production) wheat middlings dehydrated product supported good growth and feed conversion when included in mixed diets as the supplemental protein source for young, growing broilers. Extrusion of turkey and layer mortalities and of spent hens has been

reported to produce dehydrated products that had nutritional value for poultry diets (Haque et al., 1991; Tadtianant et al., 1993). Extrusion, like the dehydration process used in the present study, involves the mixing of the minced mortalities with a dry feedstock, such as SBM, before dehydration. Traditional rendering of layer mortalities and spent hens has also been shown to produce high quality feedstuffs (Christmas et al., 1996; Douglas et al., 1997; Kersey et al., 1997; Damron et al., 2001). Hess et al. (2001a), using the same product used in Exp. 2 of our study, noted no increase in mortality or negative effects on growth performance of broilers when DPS was used at diet levels

Table 6. Growth performance and ultrasound carcass measurements of growing and finishing pigs fed diets containing dehydrated broiler mortality-soybean meal blended product (DPS2) or soybean meal as the supplemental protein source (Exp. 2)^a

| Item | Dietary treatment ^b | | SEM | P-value |
|---|--------------------------------|------------------------|------|---------|
| | Soybean meal | DPS2 meal ^c | | |
| Grower phase (27 to 53 kg) | | | | |
| Average daily gain, kg/d | 0.92 | 0.93 | 0.02 | 0.83 |
| Daily feed intake, kg/d | 2.11 | 1.94 | 0.04 | 0.04 |
| Gain: feed | 0.44 | 0.48 | 0.02 | 0.08 |
| Finisher I phase (53 to 81 kg) | | | | |
| Average daily gain, kg/d | 0.99 | 1.02 | 0.01 | 0.16 |
| Daily feed intake, kg/d | 2.92 | 2.81 | 0.08 | 0.39 |
| Gain: feed | 0.34 | 0.37 | 0.02 | 0.14 |
| Finisher II phase (81 to 111 kg) | | | | |
| Average daily gain, kg/d | 0.87 | 0.91 | 0.02 | 0.20 |
| Daily feed intake, kg/d | 2.91 | 2.82 | 0.05 | 0.25 |
| Gain: feed | 0.30 | 0.32 | 0.01 | 0.03 |
| Overall (27 to 111 kg) | | | | |
| Average daily gain, kg/d | 0.93 | 0.95 | 0.01 | 0.15 |
| Daily feed intake, kg/d | 2.66 | 2.54 | 0.04 | 0.06 |
| Gain: feed | 0.35 | 0.38 | 0.01 | 0.01 |
| Carcass characteristics (ultrasound) ^e | | | | |
| Backfat, cm | 2.3 | 2.5 | 0.2 | 0.15 |
| Loin area, cm ² | 38 | 38 | 1.2 | 0.70 |
| Estimated lean, % | 54.3 | 53.4 | 0.7 | 0.45 |
| Marbling, average score ^f | 2.1 | 2.3 | 0.3 | 0.57 |

^aSix pigs per pen with six pens per treatment (three pens of gilts and three of barrows).

^bDietary supplemental protein source for corn based diets.

^cDehydrated broiler mortality-soybean meal blended product; composition given in Table 2.

^dAs-fed basis.

^eLast rib area. Average weight, 111 kg.

^fScores of 1 to 5; 2 = traces, 3 = slight, 4 = modest.

Table 7. Carcass cutout and pork quality characteristics from pigs fed dehydrated broiler mortality-soybean meal blended product (DPS2) or soybean meal as the supplemental dietary protein source during growing and finishing (27 to 111 kg; Exp. 2)^a

| Item | Dietary treatment ^b | | SEM | P-value |
|----------------------------------|--------------------------------|------------------------|-----|---------|
| | Soybean meal | DPS2 meal ^c | | |
| Hot carcass weight, kg | 82.0 | 83.4 | 1.2 | 0.36 |
| Muscling score ^d | 2.0 | 2.2 | 0.1 | 0.43 |
| Last rib fat thickness, cm | 2.4 | 2.8 | 0.2 | 0.19 |
| Tenth-rib fat thickness, cm | 2.4 | 2.8 | 0.2 | 0.12 |
| Loin area, cm ² | 40.4 | 42.1 | 1.8 | 0.54 |
| Lean color score ^e | 2.3 | 2.4 | 0.3 | 0.92 |
| Lean firmness score ^f | 3.2 | 3.1 | 0.2 | 0.79 |
| Lean texture score ^g | 2.9 | 3.2 | 0.1 | 0.08 |
| Marbling score ^h | 1.7 | 2.2 | 0.2 | 0.22 |
| Fat firmness score ⁱ | 2.0 | 2.8 | 0.2 | 0.04 |
| Ham yield, % | 23.6 | 23.3 | 0.3 | 0.53 |
| Boston butt yield, % | 8.2 | 7.9 | 0.2 | 0.16 |
| Picnic yield, % | 11.9 | 11.2 | 0.2 | 0.07 |
| Loin yield, % | 20.8 | 20.6 | 0.2 | 0.65 |
| Four lean cuts, % | 64.4 | 62.9 | 0.5 | 0.11 |
| Sparerib yield, % | 3.2 | 3.2 | 0.1 | 0.80 |
| Belly yield, % | 13.7 | 14.0 | 0.3 | 0.33 |

^aEach mean is based on the information of six pens of two pigs each (the two middle weight pigs in each pen of six pigs); equal numbers of gilts and barrows.

^bDietary supplemental protein source for corn-based diets.

^cDehydrated broiler mortality-soybean meal blended product; composition given in Table 2.

^dScores of 1 to 3; 1 = thin, 2 = average, 3 = thick.

^eScores of 1 to 5; 2 = gray, 3 = light pink, 4 = reddish pink.

^fScores of 1 to 5; 2 = firm, 3 = slightly firm, 4 = slightly soft.

^gScores of 1 to 5; 2 = fine, 3 = slightly fine, 4 = slightly coarse.

^hScores of 1 to 5; 2 = traces, 3 = slight, 4 = modest.

ⁱScores of 1 to 5; 1 = very firm, 2 = firm, 3 = slightly soft, 4 = soft, 5 = very soft and oily.

that would probably be used by commercial producers (5 to 15% of diet).

The DPS products used in this study were quite different in regards to sources of raw material than the commercially available poultry by-product meal. Traditional rendered poultry by-product meal is made by rendering by-products from broiler slaughter and processing. This product mainly consists of ground heads and intestines, exclusive of feathers, with very little, if any, mortalities. The mortalities that are included are those that arrive at the processing facility dead (Chiba, 2001; D. Griffin, personal communication). This product usually contains 58% CP and 13% crude fat and is used widely as a feed ingredient in poultry feeding, but has seen only limited use in pig feeding (Chiba, 2001). When used in pig feeding, the general recommendation is to not exceed 15% of the diet (Chiba, 2001). This recommendation is mainly due to the high ash concentration of poultry by-product meal. Due to the lower ash contents and because they were blends with SBM, we were able to completely replace the supplemental protein source in the diets of the pigs with the DPS products, even for young pigs. Because of the predrying blending with SBM, actual maximum diet concentration of broiler mortality per se (dry basis) was estimated to be 11% in the young, growing pig trial and 13% in the growing-finishing pig trial.

Implications

Results of this study indicate that a dehydrated/rendered product produced from on-farm broiler mortalities stored frozen at the farm can be a safe and nutritious feedstuff for inclusion in pig diets. Complete replacements of the supplemental protein source in corn-based diets were achieved with the rendered products evaluated.

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