

### 植酸酶对大米副产品表观、标准总肠道磷消化率的影响

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本试验研究了植酸酶对大米副产品（全脂米糠 FFRB、脱脂米糠 DFRB、糙米、碎米和统糠）磷总肠道表观消化率（ATTD）和标准消化率（STTD）的影响。将 96 头生长猪（初始体重  $19.4 \pm 1.4\text{kg}$ ）随机分为 12 组，每组 8 头。对照组为玉米豆粕型日粮，其余五组为日粮中添加全脂米糠 FFRB、脱脂米糠 DFRB、糙米、碎米和统糠，所有日粮中玉米和豆粕的比例相似。另六种日粮在此基础上额外添加植酸酶 1000U。通过直接法计算每种日粮中磷的 ATTD 和 STTD，通过差值法计算得到。试验结果表明植酸酶可以显著降低粪中磷含量（ $P < 0.05$ ）。基础日粮和碎米日粮的磷消化率没有显著差异，但是无论是否添加植酸酶这两种日粮磷 ATTD 和 STTD 都显著高于其它组。在大米副产品中，碎米的磷 ATTD 和 STTD 最高（ $P < 0.05$ ），无论日粮中是否添加植酸酶。在无植酸酶添加情况下，糙米、全脂米糠、脱脂米糠、统糠的磷标准全肠道消化率没有显著差异，但是添加植酸酶后，糙米的磷标准全肠道消化率和表观消化率均高于全脂米糠、脱脂米糠、统糠（ $P < 0.05$ ）。添加植酸酶能提高糙米、全脂米糠和统糠的磷标准全肠道消化率（ $P < 0.05$ ）。日粮中添加植酸酶同样能够显著提高大米副产品的钙表观全肠道消化率（ $P < 0.05$ ）。总之，碎米比其它大米副产品磷标准全肠道消化率都高。由于糙米、全脂米糠、脱脂米糠中较高的植酸含量，其磷标准全肠道消化率较低，但是添加植酸酶可以提高大部分大米副产品的磷标准回肠消化率。

### Effects of microbial phytase on the apparent and standardized total tract digestibility of phosphorus in rice coproducts fed to growing pigs

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The objectives of this experiment were to determine the apparent total tract digestibility (ATTD) and the standardized total tract digestibility (STTD) of P and the effect of microbial phytase on ATTD and STTD of P in full-fat rice bran (FFRB), defatted rice bran (DFRB), brown rice, broken rice, and rice mill feed when fed to pigs. Ninety-six barrows (initial BW of  $19.4 \pm 1.4\text{ kg}$ ) were allotted to 12 diets with 8 replicate pigs per diet in a randomized complete block design. A basal diet based on corn and soybean meal was formulated. Five additional diets containing corn, soybean meal, and each rice coproduct were also formulated, and the ratio between corn and soybean meal in these diets was similar to that in the basal diet. Six additional diets that were similar to the initial 6 diets with the exception that 1,000 units of microbial phytase were added to the diets were also formulated. The ATTD and STTD of P were calculated for each diet using the direct procedure, and the ATTD and STTD of P in each rice coproduct were calculated using the difference procedure. Results of the experiment indicated that the concentration of P in feces was reduced ( $P < 0.05$ ) from pigs fed diets with microbial phytase compared with pigs fed diets without phytase. No differences were observed between the basal diet and the broken rice diet, but the ATTD and the STTD of P in those diets was greater ( $P < 0.05$ ) than in all other diets both without and with phytase. Among the rice coproducts, the greatest ( $P < 0.05$ ) ATTD and STTD of P were observed for broken rice regardless of inclusion of phytase. If no microbial phytase was used, the values for STTD of P in brown rice,

FFRB, DFRB, and rice mill feed were not different, but if microbial phytase was included in the diet, ATTD and STTD of P in brown rice was greater ( $P < 0.05$ ) than in FFRB, DFRB, and rice mill feed. The STTD of P in brown rice, FFRB, and rice mill feed was greater ( $P < 0.05$ ) if microbial phytase was used than if no microbial phytase was used. Addition of microbial phytase to the diets also increased ( $P < 0.05$ ) the ATTD of Ca regardless of the rice coproducts used. In conclusion, the STTD of P is greater in broken rice than in all other rice coproducts. The STTD of P in brown rice, FFRB, DFRB, and rice mill feed is relatively low due to the high concentration of phytate in these ingredients, but addition of microbial phytase will increase the STTD of P in most rice coproducts.

## Effects of protein intake on rate of growth, protein deposition, and carcass traits of heavy Iberian pigs<sup>1</sup>

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A feeding, digestibility, and balance trial was performed to determine the effect of the incorporation of increasing amounts of soybean protein concentrate (SPC) to a basal acorn diet at a fixed energy intake on the rate of growth, protein deposition (PD), and carcass traits of heavy Iberian (IB) pigs. Sixteen purebred IB barrows ( $103.9 \pm 0.9$  kg initial BW) were used. The pigs were individually confined and allocated to 4 groups of 4 pigs each. Whole acorns were provided with slight restriction to minimize acorn kernel (AK) remains. Water was freely available. The incorporation of SPC raised the available CP from 49.1 g/kg DM (1.91 g total Lys/kg DM) in AK up to 135 g/kg DM (7.24 g total Lys/kg DM). After 72 d of trial, the pigs achieved  $134.4 \pm 1.3$  kg BW and were then slaughtered. Average daily BW gain increased with increasing dietary CP (linear,  $P < 0.001$ ; quadratic,  $P < 0.01$ ), with a plateau at dietary CP concentrations (provided by AK and SPC) beyond 72.2 and 100 g/kg DM, respectively, for which an ADG of 449 g was achieved. There was a linear and quadratic effect of dietary CP and Lys level on the apparent digestibility of CP (linear,  $P < 0.001$ ; quadratic,  $P < 0.05$ ) and on the efficiencies of utilization of total N (retained N/N intake; linear,  $P < 0.001$ ; quadratic,  $P < 0.001$ ) and N apparently absorbed (retained N/apparent digestible N; linear,  $P < 0.05$ ; quadratic,  $P = 0.067$ ). Protein deposition ranged between  $-4.59$  g/d in pigs not provided with SPC to 61.4 g/d in pigs fed the greatest level of SPC inclusion. The lowest daily intake of total Lys resulting in maximum PD (69.5 g/d) at the fixed level of energy intake observed ( $2.36 \times$  ME maintenance requirements) was 21.0 g. Hot carcass and cold carcass weights, but not carcass yield, increased when feeding the daily ration containing 100 g SPC and leveled off thereafter (linear,  $P < 0.01$ ; quadratic,  $P < 0.01$ ). An average increase of 8.3% and 8.7% was obtained, respectively. The provision of SPC had no effect on back fat thickness. Primal cuts, but not yield (except for loin), increased (sirloin: linear,  $P < 0.05$ ; loin: linear,  $P < 0.001$ ; quadratic,  $P < 0.05$ ; ham: linear,  $P < 0.05$ ) or showed a tendency to increase (butt lean: linear,  $P = 0.068$ ; quadratic,  $P = 0.077$ ; ribs: quadratic,  $P = 0.067$ ; shoulder: quadratic,  $P = 0.064$ ) with the provision of dietary protein. No effect of the level of incorporation of SPC to the diet was observed on CP, total fat, total ash, and energy contents or on relative fatty acid profile of loin and sirloin.

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Effect of supplementing a fibrous diet with a xylanase and  $\beta$ -glucanase blend on growth performance, intestinal glucose uptake, and transport-associated gene expression in growing pigs

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The present study evaluated supplemental carbohydrase effect on performance, intestinal nutrient uptake, and transporter mRNA expressions in growing pigs offered a high-fiber diet manufactured with distillers dried grains with solubles (DDGS). Twenty-four pigs ( $22.4 \pm 0.7$  kg BW) were randomly assigned to 1 of 3 nutritionally adequate diets (8 pigs per diet) based on corn and soybean meal (SBM) with either 0 (control) or 30% DDGS (high fiber [HF]). The third diet was supplemented with a xylanase and  $\beta$ -glucanase blend (XB) in addition to the 30% DDGS (HF+XB). Parameters determined were ADFI, ADG, G:F, plasma glucose and plasma urea nitrogen (PUN) concentrations, jejunal tissue electrophysiological properties, and mRNA expressions of the sodium-dependent glucose transport 1 (SGLT1) and cationic AA transporter,  $bo,+AT$ , in the jejunal and ileal tissues. In addition, mRNA expressions of the short-chain fatty acid transporters, monocarboxylate transporter 1 (MCT1) and sodium-coupled monocarboxylate transporter, and mucin genes were quantified in the ileum. Feed intake, plasma glucose, and jejunal tissue electrophysiological properties were not affected ( $P > 0.05$ ) by diet. However, control-fed pigs had superior growth rate and feed efficiency and higher PUN ( $P < 0.05$ ) than HF- and HF+XB-fed pigs. The HF diet increased ( $P < 0.05$ ) SGLT1 mRNA expression in the jejunum and decreased ( $P < 0.05$ )  $bo,+$  mRNA expression in the ileum. The XB supplementation also increased  $bo,+$  mRNA expression in the ileum relative to HF-fed pigs. Additionally, MCT1 mRNA expression was greater ( $P < 0.05$ ) in the ileum of the HF- and HF+XB-fed pigs. In the present study, XB supplementation influenced nutrient transporter mRNA expression, although it was not accompanied by improved pig performance.

In vitro and in vivo digestibility of corn starch for weaned pigs: Effects of amylose:amylopectin ratio, extrusion, storage duration, and enzyme supplementation

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The objective of this study was to investigate the effects of amylose (AM):amylopectin (AP) ratio, extrusion, storage duration, and enzyme supplementation on starch digestibility of corn. Three corn varieties with high (0.60; HA), medium (0.44; MA), and low (0.39; LA) AM:AP ratios, respectively, were selected from 74 corn samples to evaluate the in vitro and in vivo digestibility of starch. In Exp. 1, during wk 4 after extrusion, resistant starch (RS) content of the 3 selected corn varieties (LA, MA, and HA) increased ( $P < 0.05$ ) each week and starch digestibility in vitro decreased as storage time increased ( $P < 0.05$ ). The AM:AP ratio affected the formation of RS ( $P < 0.01$ ). The RS content of the 3 corn varieties was ranked as  $LA < MA < HA$  in each week ( $P < 0.05$ ). Correlation analysis showed that AM:AP ratio and storage duration were both positively correlated with RS content ( $P < 0.01$ ). Furthermore, a significant quadratic relation was found between storage duration and RS content in each corn variety as well as storage duration and digestibility. Starch digestibility was negatively correlated with RS content ( $P < 0.001$ ). In Exp. 2, digestion trials were performed on cannulated pigs with BW of  $13.20 \pm 0.94$  kg. Extrusion increased ileal digestibility of GE and starch of either HA or LA compared with the enzyme-supplemented diets ( $P < 0.001$ ). Enzyme supplementation did not improve ileal energy and starch digestibility. The ileal digestibility of starch and GE of LA varieties was greater than HA samples ( $P < 0.05$ ). The results implied that AM:AP ratio and storage duration after extrusion may be important determinants of RS formation and digestibility of starch for corn. In addition, RS content could be an important indicator of digestibility of starch in extruded corn. Using a lower AM:AP ratio corn or reducing the storage duration of extruded corn would help to reduce the formation of RS and improve the starch bioavailability of corn for piglets.

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后备母猪日粮代谢能和赖氨酸水平对初情期、排卵数和子宫长度的影响

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本试验的目的在于研究在商业饲养模式下不同标准回肠可消化赖氨酸 (SID 赖氨酸) 和代谢能对后备母猪生长发育的影响。试验日粮的平均 SID 赖氨酸和代谢能水平是对美国养猪工业调查投票后获得的数据。1221 头大白×长白二元母猪随机分为 6 组, 试验采用 2×3 因子设计, 2 个 SID 赖氨酸水平、3 个代谢能水平。母猪为群体饲养, 日粮为玉米-豆粕型日粮。后备母猪日粮 SID 赖氨酸水平包括 1.02% (对照组, 为调查平均值)、0.86% (比对照组水平降低 15%), 代谢能水平 2.94、3.25、3.57 Mcal/kg (平均值上下 10%), 饲喂期为 100 日龄至约 90kg 体重。然后饲喂育肥日粮, 日粮中 SID 赖氨酸水平为 0.85% (对照组, 为调查平均值)、0.73% (比对照组水平降低 15%), 代谢能水平为 2.94、3.26、3.59 Mcal/kg (平均值上下 10%), 饲喂至 260 日龄。试验开始时以及每过 28 天测定后备母猪体重、背标后和眼肌面积。后备母猪从 160 日龄开始接触切除输卵管的公猪, 并观察发情状况。在约 260 日龄时, 将后备母猪屠宰, 收集生殖系统样品。每个样品检查测定是否处于发情期、发情期的哪个阶段、排卵数和子宫长度。所有数据使用正态分布和混合模型进行统计分析。初情期在 160-265 日龄, 平均日龄为 193 天。若以静立发射为发情标准, 试验中 160 日龄后备母猪有 91.0% 已经开始发情。日粮处理对初情期日龄和生殖系统的影响不显著。在公猪从 160 日龄开始刺激母猪的情况下, 后备母猪 100-160 日龄的生长速度不会影响母猪初情时的日龄。

Age at puberty, ovulation rate, and uterine length of developing gilts fed two lysine and three metabolizable energy concentrations from 100 to 260 d of age

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The objective of this study was to determine the effect of ad libitum feeding diets differing in standard ileal digestible (SID) lysine and ME concentrations that bracket those fed to developing gilts in U.S. commercial settings. Average SID lysine and ME concentrations in diets currently fed to developing gilts were obtained from a poll of the U.S. commercial swine industry. Crossbred Large White × Landrace gilts ( $n = 1,221$ ), housed in groups, were randomly allotted to 6 corn-soybean diets in a  $2 \times 3$  factorial arrangement formulated to provide 2 SID lysine and 3 ME concentrations. Gilts received grower diets formulated to provide 1.02% (control = survey average) or 0.86% (control minus 15%) SID lysine and 2.94, 3.25, or 3.57 (survey average ME  $\pm$  10%) Mcal of ME/kg from 100 d of age until approximately 90 kg BW. Then, gilts were fed finisher diet containing 0.85% (control = survey average) or 0.73% (control minus 15%) SID lysine and 2.94, 3.26, or 3.59 (control  $\pm$  10%) Mcal of ME/kg until 260 d of age. Gilts were weighed, and backfat thickness and loin muscle area were recorded at the beginning of the trial and then every 28 d. Starting at 160 d of age, gilts were exposed daily to vasectomized boars and observed for behavioral estrus. At approximately 260 d of age, gilts were slaughtered and their reproductive tract was

collected. Each reproductive tract was examined to determine whether the gilt was cyclic, the stage of estrus cycle, ovulation rate, and uterine length. Data were evaluated for normality and analyzed using mixed model methods. Average age at puberty was 193 d of age with a range from 160 to 265 d. When all gilts on trial at 160 d of age were included in the analysis, 91.0% reached puberty as determined by observation of standing estrus. Differences between dietary treatments on age at puberty or measurements of the reproductive tract were not detected. Growth rates to 160 d were not limiting for attainment of puberty in response to daily boar stimulation from 160 d.