

Ming Zhe Fan (范明哲), PhD, Professor of Nutritional Ecology



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Academic Profile and Professional Career Path:

Ming obtained his B.Sc. in Animal Science in July 1985 from Department of Animal Science at Xinjiang Agricultural University (<http://www.xjau.edu.cn/>), Urumqi, Xinjiang Uygur Autonomous Region, China. Ming studied for M.Sc. in animal nutrition in a program (1985.09 – 1988.07) jointly administered by the Jilin Academy of Agricultural Sciences, Gongzhuling, Jilin Province and Northeast Agricultural University, Harbin, Heilongjiang Province, China after going through a national graduate entrance examination and an interview process. Under the mentorship of Prof. Jiashi Yang, Ming started his original animal nutrition and metabolic research and scientific writing through conducting his M.Sc. thesis project. This thesis project focused on estimating metabolizable energy requirements for maintenance (ME_m) in broiler chicks by using the comparative carcass composition analysis technique and the closed-circuit respiration chamber-based indirect calorimetry. Ming obtained M.Sc. majoring in animal nutrition from Northeast Agricultural University (<http://www.neau.edu.cn/>) in July 1988. After graduation from his M.Sc. Program, He continued his research as a Research Associate in Prof. Jiashi Yang's research laboratory, participating in establishing two computerized open-circuit respiration chamber-based indirect calorimetry systems designed for medium-frame size of farm animals such as pigs and sheep (1988.08 – 1989.08). These indirect calorimetric systems were the first sets ever built in China. These research project grants were granted to Prof. Yang by the Chinese Ministry of Agriculture and the Natural Science Foundation of China.

Ming studied for Ph.D. in animal nutrition (1989.09 – 1994.06) in the Department of Animal Science at the University of Alberta, Edmonton, Alberta, Canada. Under the mentorship of Prof. Willem C. Sauer, Ming learned how to design and conduct pig nutrition and *in vivo* digestive physiological studies with pigs such as formulating experimental diets, performing experimental surgery and caring research animals as well as writing original scientific research manuscripts in English. Ming's Ph.D. Dissertation projects focused on investigating the major methodological aspects of measuring distal ileal crude protein and amino acid digestibility and the gastrointestinal endogenous losses of these nutrients associated with test feed ingredients [Fan M.Z. et al. (1994) - *J. Anim. Sci.* 72:2851-2859; Fan M.Z. and W.C. Sauer (1995) - *J. Anim. Sci.* 73:2364-2374; Fan M.Z. et al. (1995) - *J. Anim. Sci.* 73:2319-2328]. Ming obtained Ph.D. majoring in animal nutrition from the University of Alberta (<http://www.ualberta.ca/>) in November 1994.

After graduation from his Ph.D. Program, Dr. Fan pursued his post-doctoral research training under the mentorship of Prof. Michael I. McBurney in the Department of Food and Nutrition in collaboration with Prof. Chris I. Cheeseman in the Department of Physiology at the University of Alberta (<http://www.ualberta.ca/>) (1994.07 – 1994.12). Dr. Fan learned how to conduct basic and classic *in vitro* intestinal cellular nutrient transport physiological research with membrane vesicles in Prof. Cheeseman's laboratory during this period of training, continued his post-doctoral research training and completed his *in vitro* amino acid transport project at Purdue University [Fan M.Z. et al. (1998) - *Comp. Biochem. Physiol. Part A.* 121:411-422]. Dr. Fan continued his post-doctoral research training under the mentorship of Prof. Layi O. Adeola in the Department of Animal Sciences in collaboration with Prof. Eli Asem in the Department of Basic Medical Sciences at Purdue University (<http://www.purdue.edu/>), West Lafayette, Indiana, USA (1995.01 – 1997.06). While Dr. Fan continued the *in vitro* intestinal cellular amino acid transport research with membrane vesicles, he also worked on characterizing physiological and biochemical properties of some of the important porcine gut mucosal apical membrane hydrolases with majority of the

laboratory work being conducted in Prof. Asem's laboratory at Purdue [Fan M.Z. et al. (1999) - *J. Nutr. Biochem.* 10:299-305].

In 1997.07, Dr. Fan was selected and awarded a prestigious USDA/ARS Post-doctoral Research Fellowship to continue his research as a post-doctoral trainee Animal Research Physiologist (GS-11) under the mentorship of Prof. Douglas G. Burrin in the Children's Nutrition Research Centre (CNRC) at Baylor College of Medicine (<http://www.bcm.edu/cnrc/>), Houston, Texas, USA (1997.07 – 1998.10). While Dr. Fan participated in conducting intensive human infant nutrition research with the newborn neonatal pigs fed liquid formula models in combination with *in vivo* stable isotopic tracer kinetics [Stoll B. et al. (2001) - *Am. J. Physiol.* 279:G288-G294], his primary research project focused on studying the expression of major gut mucosal enterocytic apical membrane hydrolases and nutrient transporters during the cellular proliferation and differentiation along the crypt-villus axis in young pigs by adopting the extended intestinal sac technique originated in the rodents for isolating primary porcine small intestinal epithelia in Prof. Burrin's laboratory at CNRC [Fan M.Z. et al. (2001) - *J. Anim. Sci.* 79:371-381; Fan M.Z. et al. (2004) - *Am. J. Physiol.* 287:G385-G398]. This last post-doctoral training opportunity at CNRC had several other long-term impacts on Dr. Fan's academic development as an independent investigator and a research and teaching faculty. These include exposure to major biomedical and human health issues by attending regular academic seminars and discussions, organizing and conducting intensive and integrative animal biology research, developing original research ideas and preparing high-quality competitive research proposals, writing up high-quality, hypothesis-based and concept-driven original research manuscripts for peer-reviewing and publications in high-impact biomedical journals, and preparing and delivering high level of scientific oral and poster presentations.

In November 1998, Dr. Fan was selected and appointed as tenure-track Assistant Professor in Nutritional Ecology in the Department of Animal and Poultry Science, Ontario Agricultural College at the University of Guelph (<http://www.uoguelph.ca/>). He was granted a tenured-faculty status in December of 2001. He was promoted to be Associate Professor in July 2003. Dr. Fan has been promoted to a full Professor since July 2009 at the University of Guelph. In addition to teaching various undergraduate courses at the college level such as experiential education, agri-food problem solving, and independent research, Dr. Fan has taught animal metabolism, introductory animal nutrition and critical analysis of animal sciences for undergraduate students and nutritional technique research and advanced animal nutrition and metabolism courses for graduate students in the Department. Dr. Fan has actively obtained a number of research grants on the continued basis to his laboratory group primarily from the Natural Science and Engineering Research Council of Canada (NSERC), Agriculture and Agri-Food Canada (AAFC), Ontario Ministry of Agriculture Food and Rural Affairs (OMAFRA) and various industrial sponsors such as Ontario Pork, Elanco Animal Health, Inc., the Grant Valley Fortifiers and Metagen Enzyme Corporation.

Dr. Fan's most significant conceptual and novel contributions to research and/or practical applications include the followings largely through training high quality graduate students, post-doctoral fellows and visiting scholars and through effective collaborations with other researchers:

(1) Apical amino acid and sugar transporters are expressed along the entire intestinal crypt-villus axis controlled at transcriptional and translational levels in neonatal pigs in support of high growth rate and efficiency of whole body energy and nitrogen utilization [Yang *et al.* (2011) – *American*

Journal of Physiology 300:G60-G70; Yang et al. (2016) – *Amino Acids* (in press)]. Our study has identified that the EAAC-1 protein expressed on the small intestinal epithelial apical membrane along the crypt-villus axis is the same high-affinity X⁻_{AG}-system transporter expressed in neurons for the uptake of glutamate and other acidic amino acids in mammals including pigs [See: Fan *et al.* (2004) – *American Journal of Physiology* 287:G385-G398]. These research activities have been the continued research and collaboration with Prof. Douglas G. Burrin. Roles of enteral amino acids and short peptides for modulating gut growth and functions have been revealed under challenged conditions such as bowel inflammation in collaboration with Prof. Yoshinori Mine in the Department of Food Science at Guelph [See: Kim et al. (2010) – *The Journal of Nutritional Biochemistry* 21:468-475; Aito-Inoue. (2007) – *Journal of Peptide Science* 13:468-474; and Young D. et al. (2012). *The Journal of Nutrition* 142:363-368].

(2) Intestinal apical alkaline phosphatase is essential for the detoxification of enteral source of lipopolysaccharide endotoxins. Our research has shown that early weaning reduces intestinal alkaline phosphatase affinity, maximal activity and abundances at the transcriptional and translational levels, providing biochemical and molecular mechanisms for early-weaning associated growth check and mortality in pig production [See: Lackeyram *et al.* (2010) – *The Journal of Nutrition* 140:461-468]. Up-regulation of luminal alkaline phosphatase functionality is an effective alternative strategy to antibiotics for the management of monogastric food animal gut health and feed antibiotic-resistance concern [Fan and Archbold (2015) – *Animal Nutrition* 1:138-143].

(3) We have established a novel methodology for rapidly measuring organ and tissue *in vivo* protein synthesis rates through intraperitoneal injection of a flooding dose of a stable isotope tracer L-[ring-²H₅]Phe in piglets. This method work will lead to further progress in understanding factors affecting translational control of gene expression in growth and metabolism [See: Bregendahl *et al.* (2008; 2004) – *The Journal of Nutrition* 138:1976-1981; 134:2722-2728; Fan *et al.* (2006) – *Journal of Animal Science* 84 (suppl. 1):E79-E93].

(4) With pigs fed a high-fat and atherogenic diet, we have revealed that the hypocholesterolemic effects (e.g., reducing LDL cholesterol by 37%) of the viscous soluble fiber guar gum consumption is mediated by increasing hepatic nuclear active sterol regulatory element binding protein 2 (SREBP2) and the low-density lipoprotein receptor (LDLr) protein abundances. This study and its relevant animal model will help develop effective dietary strategies and provide molecular mechanisms for nutritional management of human cardiovascular health and heart disease preventions [See: Rideout *et al.* (2007) – *The Journal of Nutrition* 137:568-572; Rideout et al. (2008) – *Vascular Health and Risk Management* 4:1023-1033]. Consumption of resistant starch increased calcium digestibility and cecal butyrate concentration and reduced cecal indole concentrations. Thermal properties are associated with different resistant starch varieties and these may be useful markers for developing resistant starch varieties with desired specific functionality [See: Rideout *et al.* (2008) – *British Journal of Nutrition* 99:984-992]. Some of these activities have been conducted in collaboration with Dr. Qiang Liu at AAFC Food Research Centre, Guelph.

(5) Development of novel methods for determining the endogenous phosphorus (P) loss and true P digestibility as well as intrinsic phytase activity and phytate P contents associated with various feed or food ingredients. These studies have improved our understanding in mineral nutrition and digestive physiology for both pigs and humans. The application of these results in pig diet formulation can potentially reduce P excretion from pig industry, help the P management issue facing pork producers and save about CAD\$ 15 millions of feeding cost per year (calculated as

saving CAD\$0.75 per pig and 20 millions of pigs marketed per year) by using 30% less supplemental P in Canada [See: Fan *et al.* (2001) – *The Journal of Nutrition* 131:2388-2396; Shen *et al.* (2002) – *The Journal of Nutrition* 132:1199-1206; Shen *et al.* (2005) – *Journal of Agricultural and Food Chemistry* 53:853-859; Fang *et al.* (2007) – *Livestock Science* 109:251-254]. Contribution to the characterization and functional analyses of the transgenic phytase Enviropig™ developed at Guelph by Prof. Cecil W. Forsberg's laboratory. The potential commercialization of these novel pigs will solve the P-pollution issue for the pig industry on the global scale once for all [See: Golovan *et al.* (2001) – *Nature Biotechnology* 19:741-745; and Meidinger *et al.* (2013). *Journal of Animal Science* 91:1307-1320].

(6) Our research has demonstrated that crystalline cellulose is not a functional dietary fibre in both pig and human nutrition because crystalline cellulose in feeds and foods could be effectively and rapidly degraded in the distal small bowel and the large bowel in growing pigs [See: Rideout *et al.* (2008) – *British Journal of Nutrition* 99:984-992]. This has led us to develop a microbial metagenomic library for the discovery of novel and potent cellulases from the porcine gut symbiotic microbiome for potential industrial applications [See: Wang *et al.* (2012) – *Journal of Animal Science* 90:400-402].

Dr. Fan has produced a number of publications including peer-reviewed journal papers, book chapters, research abstracts in peer-reviewed journals through conference presentations, conference and workshop presentations, and short extension publications.

Selected Papers in Press and Published in Refereed Journals:

- Zhang, X., Li Z., Yang H., Liu D., Cai G., Li G., Mo J., Wang D., Zhong C., Wang H., Sun Y., Shi J., Zheng E., Meng F., Zhang M., He X., Zhou R., Zhang J., Huang M., Zhang R., Li N., **Fan M.**, Yang J., Wu Z. 2018. (2018). Novel transgenic pigs with enhanced growth and reduced environmental impact. *eLife* 7:e34286. DOI: 10.7554/eLife.342866.
- Lackeyram, D., Young, D., Kim, C.J., Yang, C., Archbold, T. and Mine, Y. and **M.Z. Fan.** (2017). Interleukin-10 is differentially expressed in the small intestine and the colon experiencing chronic inflammation and ulcerative colitis induced by dextran sodium sulfate in young pigs. *Physiological Research* 66: 147-162.
- Yang, C. Yang X., Lackeyram, D., Rideout, T.C., Wang Z., Stoll, B., Yin, Y., Burrin, D.G. and **M.Z. Fan.** (2016). Expression of apical Na⁺-L-glutamine co-transport activity, B⁰-system neutral amino acid co-transporter (B⁰AT1) and angiotensin converting enzyme 2 along the jejunal crypt-villus axis in young pigs fed a liquid formula. *Amino Acids* (in press, March, 2016).
- Fan, M.Z.** and T. Archbold. (2015). Novel and disruptive biological strategies for resolving gut health challenges in monogastric food animal production. *Animal Nutrition* 1:138-143.
- Forsberg, C.W., R.G. Meidinger, D. Murray, N.D. Keirstead, M.A. Hayes, **M.Z. Fan**, Jeyabarathy Ganeshapillai, M.A. Monteiro, S.P. Golovan, and J.P. Phillips. (2014). Phytase properties and locations in tissues of transgenic pigs secreting phytase in the saliva. *Journal of Animal Science* 92:3375-3387.
- Woodward A.D., **M.Z. Fan**, Geor R.J., L.J. McCutcheon, N.P. Taylor, J.P. Steibel and N. Trottier. (2013). Characterization of D-glucose transport across equine jejunal brush border membrane using the pig as an efficient model of jejunal glucose uptake. *Journal of Equine Veterinary Science* 33:460-467.

- Bach, S., R.Y. Yada, B. Bizimungu, **M.Z. Fan**, and J.A. Sullivan. (2013). Genotype by Environment Interaction Effects on Starch Content and 2 Digestibility in Potato (*Solanum tuberosum* L.). *Journal of Agricultural and Food Chemistry* 61:3941-3948.
- Meidinger, R.G., A. Ajakaiye, **M.Z. Fan**, J. Zhang, J.P. Phillips, and C.W. Forsberg. (2013). Digestive utilization of phosphorus from plant based diets in the Cassie line of transgenic Yorkshire pigs that secrete phytase in the saliva. *Journal of Animal Science* 91:1307-1320.
- Fan, M.Z.**, T. Archbold, D. Lackeyram, Q. Liu, Y. Mine, and G. Paliyath. (2012). Consumption of guar gum and retrograded high-amylose corn resistant starch increases interleukin-10 abundance without affecting pro-inflammatory cytokines in the colon of pigs fed a high-fat diet. *Journal of Animal Science* 90:278-280.
- Lackeyram, D., Y. Mine, T. Archbold, and **M.Z. Fan**. (2012). The small intestinal apical hydrolase activities are decreased in the piglet with bowel inflammation induced by dextran sodium sulfate. *Journal of Animal Science* 90:287-289.
- Wang, W., T. Archbold, M.S. Kimber, J. Li, J.S. Lam, and **M.Z. Fan**. (2012). The porcine gut microbial metagenomic library for mining novel cellulases established from growing pigs fed cellulose-supplemented high-fat diets. *Journal of Animal Science* 90:400-402.
- Lackeyram, D., Y. Mine, T. Widowski, T. Archbold, and **M.Z. Fan**. (2012). The *in vivo* infusion of hydrogen peroxide induces oxidative stress and differentially affects the activities of small intestinal carbohydrate digestive enzymes in the neonatal pig. *Journal of Animal Science* 90:418-420.
- Woodward, A.D., **M.Z. Fan**, Geor R.J., L.J. McCutcheon, N.P. Taylor and N. Trottier. (2012). Characterization of L-lysine transport across equine and porcine jejunal and colonic brush border membrane. *Journal of Animal Science* 90:853-862.
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- Yang, C., D.M. Albin, Z. Wang, B. Stoll, D. Lackeyram, K.C. Swanson, Y.L. Yin, K.A. Tappenden, Y. Mine, R.Y. Yada, D.G. Burrin and **M.Z. Fan**. (2011). Apical Na⁺-D-glucose co-transporter 1 (SGLT1) activity and protein abundance are expressed along the jejunal crypt-villus axis in the neonatal pig. *American Journal of Physiology* 300:G60-G70.
- Lackeyram, D, Yang C, Archbold T, Swanson K, and **M.Z. Fan**. (2010). Early weaning reduces small intestinal alkaline phosphatase expression in pigs. *The Journal of Nutrition* 140:461-468.
- Jayasundara, S., Wagner-Riddle C., Parkin G., Lauzon J. and **Fan M.Z.** (2010). Transformations and losses of swine manure ¹⁵N as affected by application timing at two contrasting sites. *Canadian Journal of Soil Science* 90: 55-73.
- Kim, C., Kovacs-Nolan J.A., Yang C., Archbold T., **M.Z. Fan**, Mine Y. (2010). L-Tryptophan exhibits therapeutic function in a porcine model of dextran sodium sulfate (DSS)-induced colitis. *The Journal of Nutritional Biochemistry* 21:468-475.
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- Wang, W., W. Gu, X. Tang, M. Geng, **M.Z. Fan**, T. Li, W. Chu, C. Shi, R. Huang, H. Zhang and Y.L. Yin. (2009). Molecular cloning, tissue distribution and ontogenetic expression of the

- amino acid transporter b^{0,+} cDNA in the small intestine of Tibetan piglets. *Comparative Biochemistry and Physiology – Part B: Biochemistry & Molecular Biology* 154: 157-164.
- Li, Z., B. Cao, B. Zhao, X. Yang, **M.Z. Fan** and J. Yang. (2009). Decreased expression of calpain and calpastatin mRNA during development is highly correlated with muscle protein accumulation in neonatal pigs. *Comparative Biochemistry and Physiology – Part A: Molecular & Integrative Physiology* 152: 498-503.
- Rideout, T.C., S. V. Harding, P.J.H. Jones and **M.Z. Fan**. (2008). Guar gum and similar soluble fibers in the regulation of cholesterol metabolism: current understandings and future research priorities. *Vascular Health and Risk Management* 4: 1023-1033.
- Bregendahl, K., X. Yang, L. Liu, J. T. Yen, T. C. Rideout, Y. Shen, G. Werchola and **M.Z. Fan**. (2008). Fractional protein synthesis rates are similar when measured by intraperitoneal or intravenous flooding doses of L-[ring-²H₅]phenylalanine in combination with a rapid regimen of sampling in piglets. *The Journal of Nutrition* 138: 1976-1981.
- Fan, M.Z.**, S. W. Kim, T.J. Applegate and M. Cervantes. (2008). Nonruminant nutrition symposium: understanding protein synthesis and degradation and their pathway regulations. *Journal of Animal Science* 86 (E. Suppl.): E1-E2.
- Yang, X., C. Yang, A. Farberman, T. C. Rideout, C. F. M. de Lange, J. France and **M.Z. Fan**. (2008). The Mammalian target of rapamycin-signaling pathway in regulating metabolism and growth. *Journal of Animal Science* 86 (E. Suppl.): E36-E50.
- Yang, X.M., C.F. Drury, T.Q. Zhang, A. Ajakaiye, C.W. Forsberg, **M.Z. Fan** and J. P. Philip. (2008). Carbon dioxide and N₂O emissions from soils amended manure from genetically modified (enviropigTM) pigs. *Nutrient Cycling in Agroecosystems* 80: 153-160.
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- Fan, M.Z.**, L.I. Chiba, P.D. Matzat, X. Yang, Y.L. Yin, Y. Mine, and H. Stein. (2006). Measuring synthesis rates of nitrogen-containing polymers by using stable isotope tracers. *Journal of Animal Science* 84 (E. Suppl.): E79-E93.
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- Golovan, S., R.D. Meidinger, A. Ajakaiye, M. Cottrill, **M.Z. Weiderkehr**, C. Plante, J. Pollard, **M.Z. Fan**, A. Hayes, A.C. Jesper Laursen, J.P. Hjorth, R.R. Hacker, D. Barney, J.P. Phillips and C. Forsberg (2001). Enhanced phosphorus digestion and reduced pollution potential by pigs with salivary phytase. *Nature Biotechnology* 19: 741-745.
- Fan, M.Z.**, T. Archbold, W.C. Sauer, D. Lackeyram, T. Rideout, Y. Gao, C.F.M. de Lange and R.R. Hacker. (2001). Novel methodology allows measurement of true phosphorus digestibility and the gastrointestinal endogenous phosphorus outputs in studies with pigs. *The Journal of Nutrition* 131: 2388-2396.
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Published Books and Book Chapters:

- Fan, M.Z.** (2014). "*Concepts of Animal Nutrition*", 2nd custom edition. Pearson, Boston, MA, USA.
- Fan, M.Z.** (2013). Chapter 16 - Swine Nutrition and Environment. In: "*Sustainable Swine Nutrition*". L.I. Chiba (editor). John Wiley & Sons, Inc., West Sussex, UK. pp. 365-411.
- Zhang H., **M. Fan** and G. Paliyath. (2011). Effects of carotenoids and retinoids on immune-mediated chronic inflammation in inflammatory bowel disease. In: "*Functional Foods, Nutraceuticals, and Degenerative Disease Prevention*". G. Paliyath, M. Bakovic and K. Shetty (eds.). John Wiley & Sons, Inc., the Atrium, Southgate, Chichester, West Sussex, UK. pp. 213-229.
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- Yin X., W. Wang, T. Archbold, N. Burello, M. Scolaro, K. Zhou and **M.Z. Fan**. (2018). Genomic determinants of alkaline phosphatase catalytic affinity along the intestinal longitudinal axis of weanling pigs. *Journal of Animal Science* 96 (supplement 4) (in press).
- Yin X., T. Archbold, N. Burello, M. Scolaro, M. Li, W. Wang, K. Zhou and **M.Z. Fan**. (2018). Increased intestinal alkaline phosphatase maximal activities mediate improvements in growth and gut health status in weanling pigs fed the antibiotic-supplemented diet. *Journal of Animal Science* 96 (supplement 4) (in press).
- Wang, W., T. Archbold, J.S. Lam, M.S. Kimber and **M.Z. Fan**. (2018). A novel monomodular and multifunctional processive β -1,4-endoglucanase has been identified and characterized from porcine gut microbiome. *The FASEB Journal* 32 (No. 1 Supplement): 544.9.
- Cargo-Froom, C.L., Shoveller, A.K., and **M.Z. Fan**. (2017). Apparent and true digestibility of minerals in animal and vegetable ingredient based adult maintenance dog food. *Journal of Animal Science* 95 (supplement 4): 112-112.
- Zhou, K., N. A. Burello, W. Wang, T. Archbold, H. Leung, E. Kiarie, and **M. Z. Fan**. (2017). Broiler chickens express differential alkaline phosphatase activity and enzyme affinity in hydrolyzing ATP along the small intestinal longitudinal axis. *Journal of Animal Science* 95 (supplement 4): 227-227.
- Yin, X., W. Wang, N. Burello, M. Li, T. Archbold, and **M. Z. Fan**. (2017). Kinetic characterization of a porcine intestinal alkaline phosphatase isomer over-expressed in the *E. Coli* BL21 (λ DE3). *Journal of Animal Science* 95 (supplement 4): 120-120.
- Li, M. W. Li, Y. Liu, X. Yin, **M.Z. Fan**. (2017). Effects of lipopolysaccharide challenge and weaning on serum biochemical parameters and hepatic hepcidin gene expression in piglets. *Journal of Animal Science* 95 (supplement 4): 214.
- Burello, N.A., N. Rafiee Tari, K. Zhou, T. Archbold, M. Corredig, and **M. Z. Fan**. (2017) Fractionated dairy cow milk β -casein enhances affinity of the jejunal alkaline phosphatase for hydrolyzing ATP in piglets fed liquid formulas. *Journal of Animal Science* 95 (supplement 4): 227-227.
- Burello, N.A., N. Rafiee Tari, K. Zhou, T. Archbold, M. Corredig, **M.Z. Fan**. (2017). Fractionated dairy cow milk β -casein modulates jejunal alkaline phosphatase activity kinetics in neonatal piglets liquid formulas. *The FASEB Journal* 31 (No. 1 Supplement): 786.28.
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