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THE SCIENCE OF HEALTHIER PIGS

A conversation with **YULONG YIN**, a member of the Chinese Academy of Engineering

Yulong Yin is a member of the Chinese Academy of Engineering, and a researcher at the Institute of Subtropical Agriculture and the Tianjin Institute of Industrial Biotechnology, both of the Chinese Academy of Sciences. He leads a team of more than 50 researchers and has spent eight years studying the molecular mechanisms behind piglet diarrhoea. Here he explains the development of key technologies and a range of feed products that can reduce its incidence.

Why is diarrhoea a growing concern?

Piglet diarrhoea causes up to 70% of mortality in pig production. Piglets, especially during weaning, face stressors related to their living environment, social interactions, and dietary habits. Because their digestive systems are underdeveloped, they are more sensitive to a diet with a high protein level and non-starch polysaccharides — a type of carbohydrate. Nutritional imbalance results in diarrhoea, and weakens the piglets' immune system.

Historically, high levels of antibiotics, copper, and zinc were used to mask the effects of poor nutrition on piglet diarrhoea. However, with the current ban on antibiotics in China and the trend toward reducing trace mineral supplements, piglets have become more sensitive to the nutritional makeup of their feed. Intestinal diseases and diarrhoea caused by nutritional deficiencies or imbalances are now major challenges on pig farms.

What are some of your team's observations?

Our investigation began with a question — how does diarrhoea occur and persist? To find out, we systematically examined the impact of various compositions of pig feed on intestinal health and piglet diarrhoea, all within the context of an antibiotic-free diet.

Identifying key nutrients that induce diarrhoea presented us with a significant challenge. We had to screen dozens of nutrients, one by one, through rigorous animal testing and find out what amounts elicited a diarrhetic effect.

We have identified crucial factors, including iron deficiency during the suckling period, electrolyte imbalances, niacin deficiency, folic acid deficiency and high protein intake. Interestingly, these factors are also associated with changes in the colonial microbial composition of weaning pigs, specifically the increased abundance of bacteria *Firmicutes*, and decreased levels of *Bacteroidetes*.

Upon further examination of piglets fed with different diets, we uncovered the intricate interplay between nutrients, microbiota and hosts, which may underpin the development of diarrhoea. Overload of undigested nutrients reaching the hindgut or malnutrition induced intestinal damage may both cause imbalanced microbial populations in the gut. It is this so-called 'microbial dysbiosis' that further leads to intestinal inflammation and piglet diarrhoea.

Through use of nutritional stress-induced models of piglet diarrhoea, we were able to identify key pathways involved in the development of this condition. For example, high protein diets serve as a stressor that activates the canonical inflammation pathway, known as NF-κB signalling. Additionally, we discovered that the AMPK/α-ketoglutarate axis, which governs cell energy balance, plays a crucial role in regulating intestinal water and ion balance. When disrupted, this axis can lead to impaired intestinal function.

What technologies have you developed?

Long-term and high-dose use of multiple types of antibiotics can lead to antibiotic resistance, compromised animal immune function, residual antibiotics in pork which may be transmitted to humans through the food chain and environmental pollution.

Our knowledge of diet-microbe-host interactions and key molecular pathways allow us to develop more sustainable and ecological-friendly technologies. These include improving digestion and absorption in the small intestine by using amino acids and their derivative metabolites, functional fatty acids, and betaine; reshaping of the intestinal microbiome through probiotics such as *Pediococcus pentosaceus* and *Bacillus subtilis*; and suppressing the intestinal inflammatory responses using γ-aminobutyric acid, melatonin (tryptophan-related metabolite), and plant extracts. The feed additives and feed products transformed by our technology have reduced piglet diarrhoea incidence by 25–30%.

Besides nutritional science, what else are you focusing on?

China is both the world's largest pork producer and consumer of pork products, so any technological advancement in pig farming will bring huge socio-economic benefits. However, China's pig farming industry is still facing serious problems such as shortage of feed resources, and a high level of environmental pollution. Our team is now conducting research on pig breeding, feed utilization, ecological farming, and alternatives to antibiotics. In particular, we are focusing on utilizing local pig resources, making use of farming waste more efficiently, optimizing the breeding cycle, and using plant extracts, active plant natural products from synthetic microorganisms, and probiotics as feed additives.

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