



SDS III for In Vitro Feed Digestibility: A GAME-CHANGER FOR FEED MILLS

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In modern livestock production, feed accounts for around 70% of total production costs. Among these expenses, energy sources contribute up to 50% and protein ingredients up to 40%. Getting these values right is critical for precision livestock feeding. Overestimating feed energy or protein digestibility risks underfeeding animals and reducing growth performance, while underestimating inflates costs by driving unnecessary supplementation. Precision is not only about economics— it is also about sustainability, since inefficient feed use increases nitrogen excretion and greenhouse gas emissions. This is where the Simulated Digestion System (SDS III) offers a new path forward.

WHY IN VITRO METHODS MATTER

Traditionally, diet formulation has relied on in vivo trials to determine digestible and metabolizable energy. These trials are accurate but slow, costly, and raise ethical concerns. Existing in vitro systems, meanwhile, are often too simplistic or poorly standardized to replace live-animal trials.

Simulated Digestion System (SDS III) changes this. Developed over more than a decade of research, it uses computer-controlled digestion to simulate the full gastrointestinal tract of pigs and poultry. By integrating automation, absorption simulation, and validated prediction equations, SDS III provides fast, reliable, and cost-effective results that closely match in vivo outcomes.

For nutritionists and feed mills, the benefits are clear:

- **High throughput:** Dozens of samples tested within days, versus months for animal trials.

- **Cost efficiency:** Reduced reliance on expensive facilities and animal care.
- **Deeper insights:** Enables study of nutrient release and digestion dynamics not easily observed in animals.
- **Ethical advantages:** Supports the 3Rs principle (Replacement, Reduction, Refinement).

THE SHORTCOMINGS OF CONVENTIONAL IN VITRO METHODS

Despite their promise, most in vitro systems face several issues:

- No simulation of absorption, leading to incomplete energy predictions.
- Technical artifacts, such as digesta sticking to plasticware, evaporation during incubation, and inaccurate pH adjustments.
- Operator variability due to manual pH and enzyme additions.
- Inconsistent enzyme activity across different commercial batches.



- Partial gut simulations, which focus on only one section of the digestive tract.

These weaknesses mean that conventional in vitro methods rarely correlate strongly with in vivo outcomes. For feed companies aiming for precision nutrition, this creates frustration and forces them back to costly live-animal validation.

HOW SDS III OVERCOMES THESE BARRIERS

The SDS III platform addresses the above challenges through several innovations.

Absorption Simulation

SDS III's horizontal digestion module uses dialysis bags to mimic nutrient absorption, allowing amino acids, peptides, sugars, and oligosaccharides to diffuse out. This prevents feedback inhibition of enzymes and yields results that align closely with in vivo trials. A vertical module enables real-time sampling for added flexibility (Image 1).

Full Gut Simulation

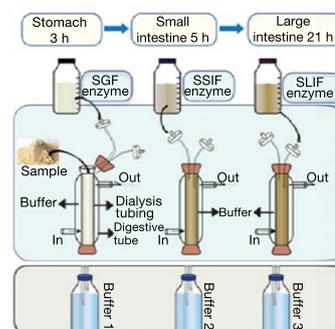
Unlike segmented models, SDS III automates the full gastrointestinal process: stomach, small intestine, and large intestine. Controlled pH shifts, enzyme dosing, and buffer exchanges are managed by a micro-peristaltic pump, while a thermostatic system maintains temperature within $\pm 0.4^{\circ}\text{C}$ of animal body temperature. Together with orbital shaking to simulate chyme mixing, these precise controls allow

Simulated Digestion System (SDS III) for Monogastric Animals

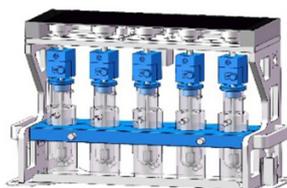


Automated simulation of the digestive tract:

- Stomach
- Small intestine
- Large intestine



Vertical Digestion Module



Horizontal Digestion Module

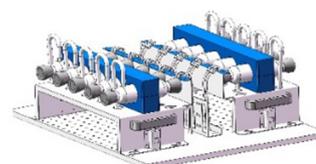


Image 1. The SDS III platform, including its vertical and horizontal modules, and how they simulate the entire gastrointestinal tract

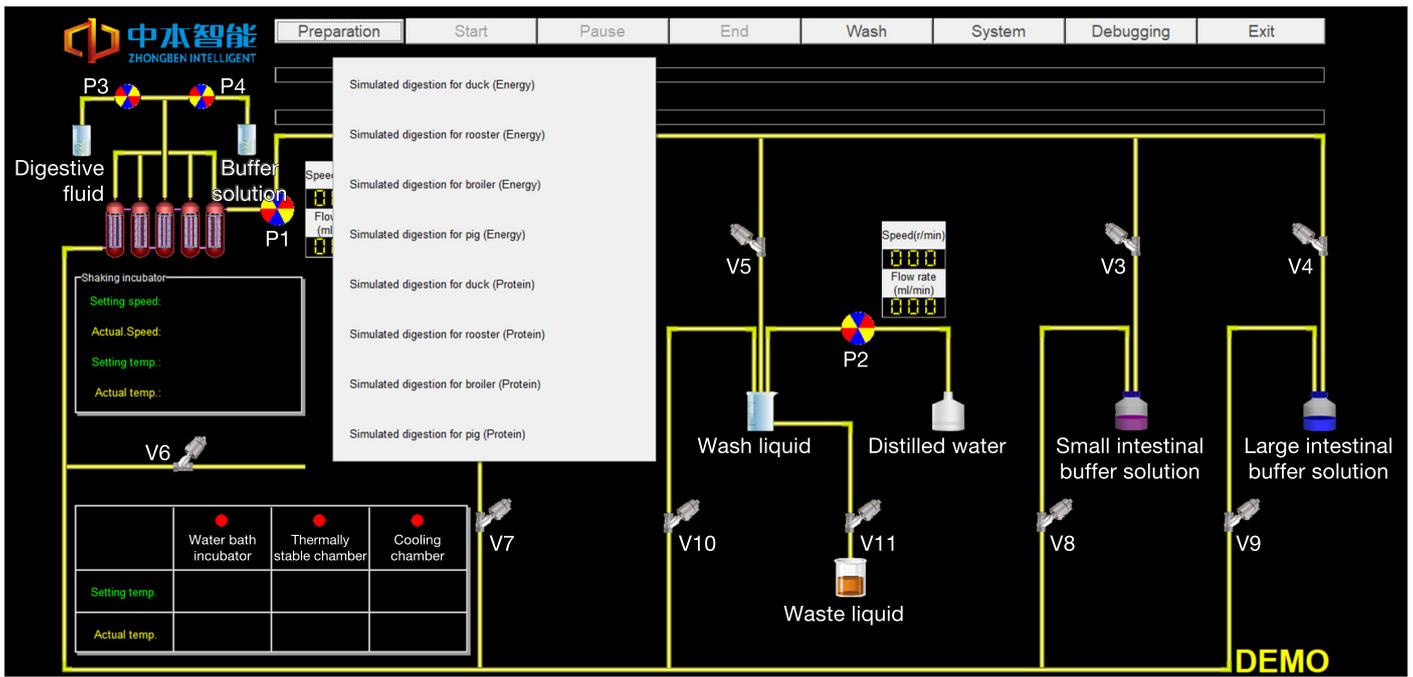


Image 2. The SDS III software interface, showing eight protocols validated through in vivo swine and poultry trials

highly realistic digestive journey that better reflect pig and poultry digestion physiology.

The current SDS III platform includes eight standardized protocols validated against in vivo trials: four for swine and poultry feed energy evaluation and four for protein digestibility. Additional protocols are also available for amino acids, phosphorus, and carbohydrates (Image 2).

VALIDATION WITH POULTRY TRIALS

The crucial test for any in vitro system is whether its results align with in vivo trials. In a duck study with 30 corn samples, SDS III’s in vitro digestible energy showed strong correlation ($R^2=0.8842$, $RSD=45$ kcal/kg) with true metabolizable energy. This correlation demonstrates SDS III’s reliability and its potential to replace many live-animal trials in feed evaluation (Figure 1).

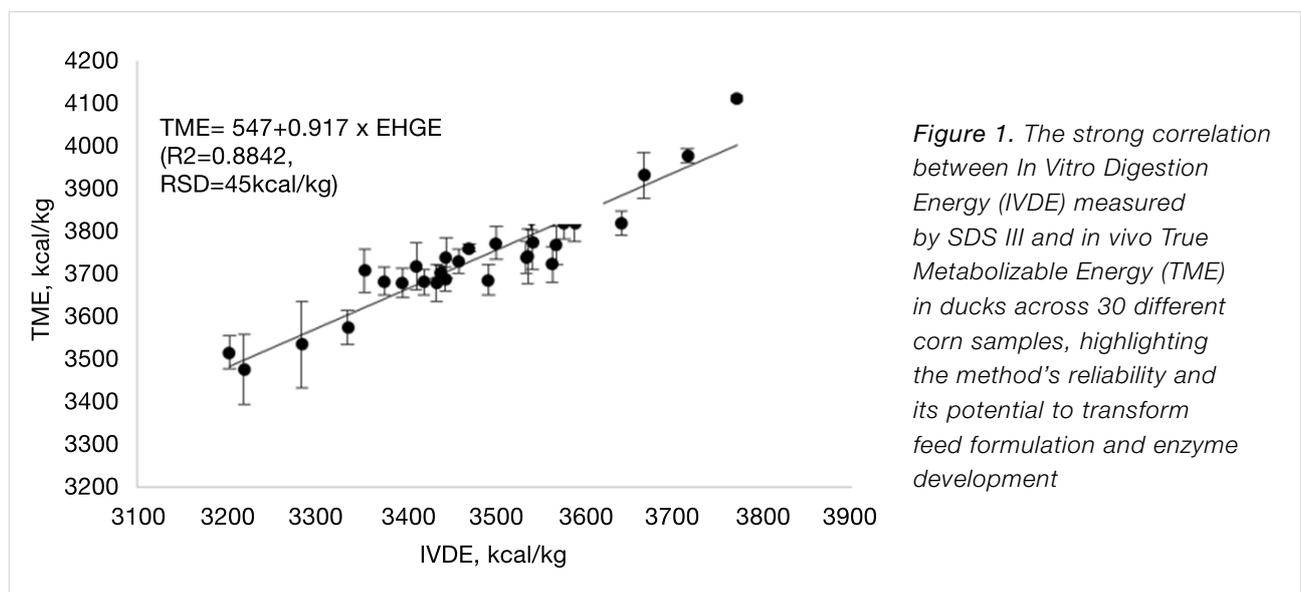


Figure 1. The strong correlation between In Vitro Digestible Energy (IVDE) measured by SDS III and in vivo True Metabolizable Energy (TME) in ducks across 30 different corn samples, highlighting the method’s reliability and its potential to transform feed formulation and enzyme development

Ingredient	IVDE, Cal/g (Trial 1)	CV%	IVDE, Cal/g (Trial 2)	CV%	IVDE, Cal/g (Trial 3)	CV%	Average (Cal/g)	Avg CV%
Corn	3714	0.20	3701	1.14	3704	0.82	3706	0.72
Wheat	3621	0.49	3643	0.33	3630	0.54	3631	0.45
Rapeseed meal	2567	1.51	2611	0.73	2562	2.14	2580	1.46
Cottonseed meal	2042	1.26	2051	0.88	2063	0.54	2052	0.89

Example of Repeatability Results

Table 1 demonstrates SDS III’s repeatability when analyzing common feed ingredients. Across different replicates, the coefficient of variation remained well under 1.5%. In contrast, in vivo trials have usually a CV of 5-10%.

These results highlight SDS III’s reliability, a crucial requirement for consistent feed mill quality control.

In a ring test across 4 labs using SDS III, most EHDE measurements had CVs below 1%, with wheat bran slightly higher at 1.97%, showing strong inter-lab consistency.

PRACTICAL APPLICATIONS IN FEED MILLS AND FEED ENZYME R&D

Ingredient Screening

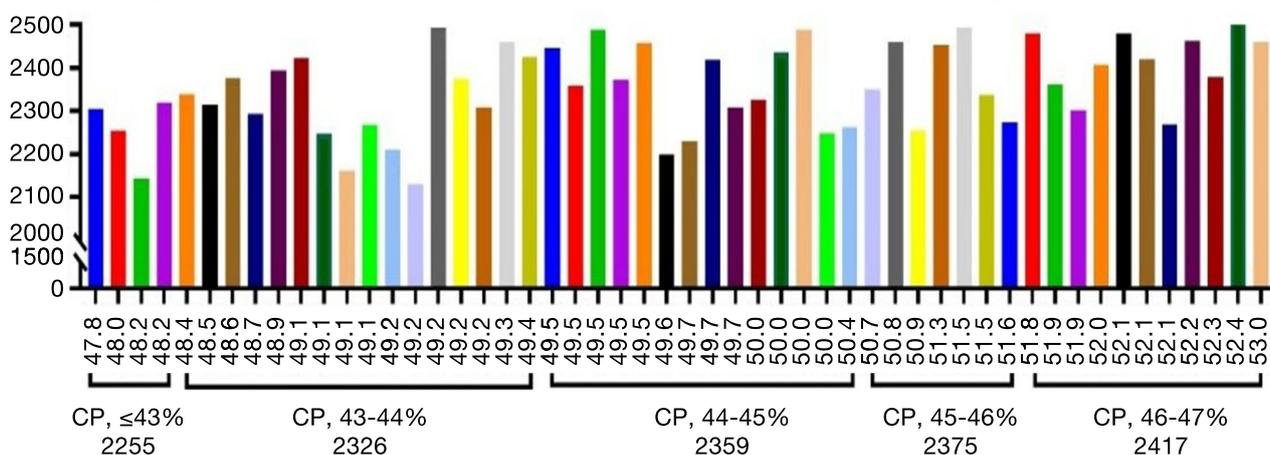
SDS III allows feed mills to rapidly evaluate raw

materials such as corn, soybean meal, rapeseed meal, and cottonseed meal. For example, in tests of 52 soybean samples with varying crude protein contents, the estimated NE (Net Energy) values for swine ranged from 2131 to 2566 kcal/kg. Identifying such variation ensures that mills can adjust formulations proactively, maintaining consistency in animal performance. SDS III can hence detect meaningful energy differences not only between ingredients, but also among the ingredients from different varieties, storage conditions or processing methods (Figure 2).

Diet Formulation

With more reliable in vitro data, nutritionists can fine-tune diet formulations. This helps avoid over-formulation, which adds unnecessary costs, or under-formulation, which risks animal underperformance. The result is both economic and environmental efficiency.

Figure 2



Enzyme Development and Evaluation

Enzyme companies now use SDS III to test the effects of proteases, phytases, amylase and NSPases. This enables faster, more precise R&D cycles, reducing the reliance on lengthy animal trials. For nutritionists, it means access to more robust enzyme data, which supports improved predictions of nutrient release in practical diets.

Sustainability

By improving the accuracy of digestibility predictions, SDS III enables nutritionists to design diets that reduce nitrogen excretion, phosphorus pollution, and greenhouse gas emissions. In an industry under increasing pressure to reduce its carbon footprint, this adds significant value.

Expanding Applications

While the current protocols are standardized for swine and poultry, SDS III is already being extended into pet food, aquaculture, human nutrition, and even ruminant research for evaluating protected nutrients and controlled-release additives.

CASE EXAMPLE: ECONOMIC IMPACT IN A FEED MILL

Consider a feed mill that processes 200,000 tons of feed annually. By switching to SDS III for ingredient screening and formulation, the company can cut live animal trial costs by up to 80% and reduce diet over-formulation.

If energy and protein costs account up to 70% of production expenses, even a 1% improvement in formulation accuracy translates into hundreds of thousands of dollars saved per year. When combined with reduced animal trial costs and faster product development cycles, the return on investment for SDS III becomes compelling.

LOOKING AHEAD

SDS III represents a step change in feed evaluation. Its strengths include:

Accuracy: Strong correlation with in vivo trials (R^2 up to 0.96).

Consistency: CV <1.5%, enabling reliable repeatability.

Efficiency: Cost savings up to 90%, with testing speed 60× faster than live-animal trials.

Ethical benefits: Significant reduction in live-animal testing.

Already adopted by more than 100 agricultural enterprises and validated across millions of tons of feed since SDS II's introduction in 2014, SDS III has proven its worth. With CE certification, it is now ready for broader global adoption.

Future applications may extend the system to a wider range of species, including companion animals (cats and dogs), salmonids, and even humans. In human nutrition, it could support the evaluation of medical foods for individuals with digestion or absorption disorders, as well as the assessment of plant-based meat alternatives. The system could also be linked to digital data platforms, allowing real-time monitoring and streamlined data sharing across feed mills, research centres, and nutrition professionals worldwide. In addition, integration with artificial intelligence (AI) could enable more precise and efficient feed formulation.

CLOSING NOTE

For an industry facing tight margins, volatile raw material costs, and sustainability pressures, SDS III is more than an innovation—it is a necessity. By providing a reliable bridge between lab-based screening and real-world feed formulation, it helps nutritionists and feed companies stay ahead in a competitive market.

About Dr. Shukun Yu

The current senior consultant for UniVOOK Chemical, Dr. Shukun Yu spent 32 years with Danisco, DuPont, and IFF as Technical Fellow, contributing to innovations such as Aextra® Phy (phytase) and Aextra® Pro (protease). Dr. Yu has been adjunct professor at Lund university (Sweden). He now leads efforts to promote SDS III adoption worldwide.

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