

 N° 12 - 2023 January - Interaction between plants and animals for innovative feed solutions

SPECIAL EDITION



BIOSIS DAYS 2022 Third edition focused on digestive efficiency; a key for sustainability and the future of animal production?



Speakers and customers surrounded by part of ID4FEED team in Annecy - France

Leisure time in the "Château de Menthon", a medieval castle standing on a 200 metres tall rock over Annecy Lake

ast October 5th and 6th, ID4FEED once again organized its annual scientific symposium called the "BIOSIS DAYS". As every year, the goal of this conference is to share with the animal nutrition sector the latest scientific knowledge on BIOSIS = interactions between the animals, the plants and their environment.

The conferences were held in Les Pensières for Global Health (Mérieux Foundation), Annecy – France

S S Natural innovative feed solutions

Towards improved sustainability of pig production systems

Dr. Jean-Yves Dourmad, INRAE Saint-Gilles, France

The projections of pork consumption point an increase of 50 % in 2050 at world level (mainly supported by developing countries). The existing trend is then to tend more and more to industrial production systems, increase the size and decrease the number of farms ('pig megafarms'), and specialized the latter, among others. Dr. Jean-Yves Dourmad recalled that the society and consumers are currently asking for more sustainable production and products and this requires to consider simultaneously the economic, environmental, and social dimensions, at short and long term. Brundtland (1987) defined sustainability as 'a development that meets the needs of the present without compromising the ability of future generations to meet their own needs'. Economy remains a driver of sustainability, in relation with the expectations of consumers for more food security, animal welfare, local productions

in a context of feed ingredient price fluctuation while the feed contributes 65 % to the pig production cost (IFIP, 2017), low profitability and poor willingness of the consumers to pay more, except for niche markets. The environmental and welfare dimensions have increased with legislation constraints on greenhouse gas emission, nitrogen excretion, environment footprint,... supported by scientific advances on nutrition, technologies, and, among others, the establishment of an environmental labelling with a Product environmental Footprint score based on a life cycle assessment. More recently, a significant weight of the social dimension has been observed not only with the orientation in the consumer perception through labelling, media, smartphone applications, quality labels but also with the new working conditions of farmers and the recognition of their profession by society. New challenging levers are then emerging to develop innovative sustainable products and production systems.

A) Evolution of sustainability priorities B) Evolution of sustainability priorities C) Evolution of sustainability priorities (before 1990) (1990-2010)(in the future)

Figure 1: Evolution of sustainability priorities before 1990 (A), from 1990 to 2010 (B) and in the future (C)

Review and prospects of feed efficiency concepts in animal production

Dr. Michel Magnin, Consultant in **Animal Nutrition, France**

Animal productions have to face multiple challenges in order to ensure a significant increase in the supply of animal products while being part of an increasingly restrictive sustainability framework. For economic and environmental reasons feed efficiency is one of the main available levers.

There is no single, simple definition and calculation (like ratio or residual approaches) of feed efficiency because they can vary with the target (country, farm, flock, animal), the economic or technical criteria (quantity of feed, content in energy or nitrogen, feed cost ...).

Many factors, such as breed, farming practices, environmental conditions, feed composition and physical presentation, feed additives, digestive and metabolic properties..., affect feed efficiency (Figure 2). The

results of different published studies with various animal species are presented with a particular focus on the possible effects of phytogenics on feed efficiency. Improving feed efficiency via selection can increase productivity or decrease feed intake and maintenance needs (for instance by lowering the anti-inflammatory and the immune responses), but has to take in account the resilience and the sustainability of animals.

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Innovative vectorization of plant actives: from in vitro to in vivo validation

Dr. Camille Rozier, ID4FEED-IDTECH R&D Manager & Dr. Michel Magnin, Consultant in Animal Nutrition, France

Formulate a product require to take in account the couple active / target in the host. Firstly, when the active form is not appropriated, the active is sensitive to oxidation or temperature, hard to handle, or may interact with another ingredient or factory equipment, it might be necessary to encapsulate it in a matrix. In the specific case when the target with the higher response in animal is not reached by diffusion, it might be necessary to use specific process or matrices of vectorization. ID4FEED developed with its sister company ID4TECH proves of concept of: 1) the improvement by encapsulation of the handling / blending of a dusty / irritant / pungent product, as demonstrated by ID4DUST and ID4SENSO internal tools and 2) the targeted release of a vectorized active, in vitro digestibility test. The R&D team is currently working on the development of actives included in cyclodextrins (either α, β, γ) as the latter possess the ability to by-pass some parts of the gut, are partly or totally water-soluble, can complex liquid actives, among others.

Dr. Michel Magnin presented a trial on 48 weaning piglets challenged with Rotavirus, a pathogen that induces intestinal lesions, severe diarrhea and poor performance, the first place impacted is the upper part of the gut (jejunum, ileum), followed by a disturbance in the gut microbiota.

Piglets were randomized over 5 groups including a negative non infected control (NC), and four infected groups including a positive non treated control (NTPC), a treated group with polysaccharides (TPC), a treated group with a chili pepper powder encapsulated in fat (T1) and treated group with the latter plus encapsulated phytogenics in fat and α -cyclodextrins (T2). The ADG was significantly improved with T2 treatment compared to NTPC as T1 showed only a tendency of increase.

T2 was also able to significantly reduce the diarrhea score and increase IgA content in the jejunum mucosa. To conclude, intermediate results were obtained with TPC and T1 whereas the best results in recovering growth rate, limiting diarrhea score and intestinal pathology with modulating IgA were observed with T2, a combination with encapsulated and vectorized actives.

Optimizing feed efficiency to produce more sustainable poultry protein

Dr. Marie-Pierre Letourneau Montminy,

Associate Professor, Laval University, Canada

The consumption of foods of animal origin in general, and in particular poultry meat, has increased rapidly over the past decades and a similar trend is expected for the next decades. With the clear and pressing need to better manage our planet's resources and knowing that poultry feed is the main contributor to greenhouse gas emissions, it is necessary to maximize the conversion of animal feed into meat, the feed efficiency. Strategies to improve feed efficiency includes (1) that the FCR was generally improved with the considered alternatives to AGP (Figure 3). Some phytogenics are also able to reduce litter moisture through mechanisms that need to be better understood but probably related to the metabolism in the caeca.

Nutrient utilization by the animal depends on both diet and non-dietary factors such as level of stress. Heat stress, for example, affects the immune system of the animals and increases the FCR by 0.04 per incremental °C above the thermoneutral temperature. Similarly, coccidiosis has been shown to negatively impact AA digestibility.

the evaluation of precise requirements of birds and precise feedstuff content, (2) the use of enzymes (phytase and especially the new generations which increase the digestible Ca/P ratio, xylanase, carbohydrase, protease), (3) using strategies to improve effectiveness of digestion/absorption/microbiota, (4) balancing the supply of calcium and phosphorus, reducing feed protein content, and (5) the strategy applied for the choice of genetics. In a meta-analysis work performed by Rouissi (2020), it was demonstrated

Database C+ vs C- complication to test the impact of removing antibiotics			
DB prebiotics:	DB probiotics:	DB organic acids:	DB esssential oils:
MOS	Bacillus subtilis	Butyrate	Carvacrol
FCR - 9%	FCR - 8%	FCR - 3%	FCR - 4%
ADG + 8%	ADG + 9%	ADG + 7%	ADG + 7%
A lot of factors are not considered due to lack of information (e.g.			
encapsulation, other compounds)			

Figure 3: Summary of meta-analysis results of the impact of AGP alternatives on average daily growth and feed conversion ratio of broiler chickens

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The incorporation of curcuminoids in gamma cyclodextrins to improve their poor bioaccessibility

Dr. Charles Desmarchelier, Center for Cardio-Vascular and Nutrition research (C2VN), France

Curcuminoids are lipid polyphenols found in turmeric and many dietary supplements. They consist of a mixture of curcumin (CUR) which represents 60-70% of all curcuminoids, but also demethoxycurcumin (dCUR) and bisdemethoxycurcumin (bdCUR). CUR displays a very low bioavailability (around 1%) due to several factors such as its numerous metabolism possibilities or its poor solubilization in the intestinal lumen during digestion. Strategies to increase CUR bioavailability includes (1) the increase of its solubility in water with, for example, the formulation in y-cyclodextrins (products obtained by starch degradation) and (2) the inhibition of intestinal efflux transporters with adjuvants. In a recent publication from Flory et al., 2021, it was demonstrated that y-cyclodextrins are significantly increasing bioavailability of curcuminoids, conversely to some adjuvants such as piperine. Using an in vitro digestion model and HPLC quantification, the study presented by Dr. Desmarchelier showed that curcuminoid bioaccessibility from the common turmeric extract in the absence of food was low and ranked as follows: bdCUR > dCUR > CUR. Curcuminoids incorporated into gamma-cyclodextrins displayed significantly higher bioaccessibilities (x 6.2 to 13.8 times). There was a strong food effect: curcuminoid bioaccessibility was highest in the absence of food and was decreased when a meat- and potato-based meal ("human meal") or a wheat-based meal ("animal meal") were added. To conclude, bdCUR and dCUR show greater bioaccessibilities compared to CUR. Foods diminish curcuminoid bioaccessibilities, likely by adsorption mechanisms. Gamma-cyclodextrins improve curcuminoid bioaccessibilities, which may explain its positive effect on curcuminoid bioavailability.

Foods/supplements containing curcuminoids

Figure 4: Bioaccessibility or curcuminoids in turmeric extract of formulated into gamma cyclodextrins

Definitions

Bioavailability = Proportion of a given nutrient that is absorbed and available for physiological function.

Bioaccessibility = Proportion of a nutrient that is available for absorption after digestion.

For CUR, bioaccessibility is a good predictor of bioavailability (Flory et al., 2021)

Development and application of a cellular model to evaluate porcine digestive absorption of capsaicinoids

Dr. Caroline Prouillac, Lyon National Veterinary School (Vetagro Sup), France

Dr. Caroline Prouillac firstly introduced her work in the context of the use of phytogenics to support animal responses to social, environmental, managerial, feed or pathogenic stresses. The benefits of Capsicum and specifically capsaicinoids, to contribute to the balance of the immune system and the integrity of the digestive tract through pleiotropic

and systemic effects are highly illustrated in the literature. Through an innovative approach and model, IPEC-J2 (non-cancerous and intestinal porcine enterocyte cell line), Dr. Prouillac concluded in the first part that the apical (AP) to basolateral (BL) transfer of capsaicin through the epithelium was mainly a passive transcellular diffusion as the ratio AP-BL/BL-AP remained close to 1.

In this study, capsaicin also increased cell permeability (up to 70 %), in parallel to up-regulate the expression of tight-junction proteins such as occludin and Zo-1, hypothetically helping its own assimilation and nutrient transfer.

For the first time, the expression of ABC transporters was assessed in IPEC-J2 in response to capsaicin, demonstrating an up-regulation in P-glycoprotein and Multidrug resistance protein 1 expression, potentially correlated again with the better absorption of drugs or nutrients.

B S S Natural innovative feed solutions

Digestive efficiency in ruminants: a feed - rumen microbiota - host triangular relationship

Pr. Florian Touitou, Toulouse National Veterinary School (ENVT), France

Feed efficiency is often described by the comparison of the amount of feed ingested either as a ratio (Feed Conversion Ratio; FCR) or a linear relationship (Residual Feed Intake; RFI). Digestive efficiency is characterized by the ability to release nutrients that can be absorbed and metabolized by the host from feed macromolecules. The particularity of ruminants is the importance of microbial digestion in the rumen prior to the stomach and the small intestine. 70 to 75% of the animal's energy is obtained by the ruminal absorption of microbial catabolites called Volatile Fatty Acids (VFA). Hence, an efficient and well-fed microbial community is important to consider when looking at feed efficiency. There are 3 main levers to improve digestive efficiency (Figure 5). The first one is the improvement of the dry matter digestibility that minimizes fecal losses and maximizes nutrient uptake from the feed, for example through technological processes applied to the grain or with the use of pre/probiotics (eg yeasts) or enzymes in feed. The second strategy is the mitigation of methane production

in order to decrease the energy that is lost through eructation production. For this part, it is possible to play with the choice of forages that can increase the propionate/ acetate ratio for example. Another strategy is to add some synthetic compounds in the feed, for instance 3-nitrooxypropanol (NOP) or monensin (antibiotic authorized only outside of EU) or more natural substances such as plant secondary metabolites

(eg saponins or essential oils). The last option is the increase of protein degradability and protein efficiency. This can be achieved with technological processes (eg heat treatment), or by adding tannins or urea (100% degradable in the rumen) to feed. In conclusion, a balance between digestibility and emissions has to be found in order to improve efficiency while reducing methane wastes.

- 1) Improvement of dry matter digestibility
- 2) Mitigation of methane production and emissions
- 3) Balance between microbial and host digestible proteins

Figure 5: Main improvement levers of digestive efficiency in ruminants

Dr. Camille Rozier, presenting ID4FEED agronomical strategies on Capsicum

An aperitif by the lake

Natural innovative feed solutions

From plant to field: ID4FEED agronomical strategies on Capsicum and interest of ID PHYT CAPCIN in a context of rising raw material prices

Dr. Camille Rozier and Clémence Messant, ID4FEED operational manager

The current events (geopolitical issues, rising inflation around the world, higher freight costs, etc) have a direct impact on the availability and price of raw materials. One direct way to better utilize feed is to improve the FCR with the help of the right feed supplements.

As a consequence, one potential strategy, and the one selected by ID4FEED, is to handle its own chili pepper material culture (Capsicum sp.) along with a strong R&D program. This program led to plant genotype screening, plant culture optimized management, in situ application and understanding of a patented technology of elicitation, plant material analysis through metabolomic tools. The underlying added value is the obtention of a database of Capsicum seeds supplier, genotypes, capsaicinoids content, ability to be elicited, fruit yield. Elicitation is a complex and versatile technology that need to be fully studied and analyzed in situ with the corresponding parameters, environmental conditions and Capsicum genotypes (Narayani and Srivastava, 2017). At the end ID4FEED succeeded in obtaining plant with high fruit yield and resistance enriched in capsaicinoids, among other.

As a result of this research of several years, ID4FEED developed ID PHYT CAPCIN, a chili pepper-based feed supplement. The product includes a patented elicited Capsicum powder source and is standardized in capsaicinoids (min 0.5%). It is able to bring benefits in all animal species thanks to the ability of the secondary metabolites included in the totum (ie the whole metabolic content of the dried crushed fruit) to activate specific TRP receptors. Especially, capsaicinoids have shown their interest to directly promote digestibility by promoting saliva production, stimulating the liver to secrete bile rich in bile acids, potentiating the activities of pancreatic and intestinal enzymes and promoting gut morphology (Liu et al., 2021; Long et al., 2021; Ricci et al., 2021). Capsaicinoids can also indirectly promote digestibility through their antioxidant and anti-inflammatory activities. As a result and in line with the literature, zootechnical trials carried by ID4FEED demonstrated this greater digestibility (in a metabolic cages trial) and the improved performance including feed efficiency in broilers, turkeys, growing-finishing pigs, lambs and dairy cows.

Impact of environment on chemical responses to elicitation

- · Changes in the basal level of CAPS due to distinct environmental parameters
- Modifications of the ratio between the 4 main CAPS (- C / + DHC in Management 2)
- Potent modifications of the responses to elicitation due to a specific basal level

genotype effect > environmental effect

Figure 6: Impact of environment on chemical responses to elicitation

Literature

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Liu et al., (2021). Poultry Science, 100(9), 101301. Narayani, M. and Srivastava, S. (2017). Phytochemistry Reviews, 16(6), 1227-1252. Ricci et al., (2021). Frontiers in physiology, 791. Rouissi, A. (2020). Doctoral dissertation, University of Laval.

Globa

ID PHYT CAPCIN in « Journal of Dairy Sciences »

ID4FEED partner NutriQuest Brazil, together with a group of research from the University of Sao Paulo lead by Dr. Francisco Palma Renno, recently published the results of a study done with ID PHYT CAPCIN in dairy in the prestigious peer-reviewed Journal of Dairy Science, the top-ranked dairy research journal in the world. In this article, supplementing ID PHYT CAPCIN to dairy in a mildstress situation supported dry matter intake, milk fat, protein and lactose yield.

Full integration of chili pepper production

During Eurotier 2022, ID4FEED was proud to announce its new partnership with chili pepper producers based in the Indian Ocean. Side by side with ID4FEED technical team specialized in plants, farmers are cultivating chili pepper according to ID4FEED's selected cultivars and specifications. ID4FEED is thus managing the chili pepper culture all the way to the field and makes sure of the sustainability of its plant materials. At the same time, ID4FEED always work further to maximize the content of secondary metabolites in the totum, such as the capsaicinoids.

