

EFFECT OF LIVE YEAST ON FEED DIGESTION AND ENERGY REPARTITION IN SWINE



OVERVIEW

Proper sow nutrition during the animal's whole productive life will help guarantee greater longevity, profitability — and helps ensure more homogenous litters with more viable liveborn piglets, higher piglets average weights and improved vitality. While the benefits of feeding sows with the live yeast *Saccharomyces cerevisiae* var. *bouardii* CNCM I-1079 is well demonstrated, field experience accumulated over the years, indicating a positive effect on energy utilization. Today, the scientific proof finally corroborates what farmers had been telling us for years. New research conducted in metabolic chambers coupled with advanced meta-genomic studies confirm the live yeast effect on fermentation and energy metabolism.

These effects have practical implications on sows nutrition: if it is of great interest for all stages of the cycle, it but has an additional value in gestating sows. It can be applied through a partial energy substitution, partially compensating the inclusion cost of the additive, and still getting all the benefits of its application at farrowing time.

DIFFERENT TYPES OF FIBERS

Most nutrients from the feed are chemically digested and absorbed in the small intestine. This is the case, in general, for water, minerals, protein, lipids, and digestible carbohydrates. However, a big portion of the non-digestible carbohydrates will reach the hindgut where they will be partially consumed by the local microbial communities, the microbiota. Short Chain Fatty Acids (SCFAs) are formed as a product of this microbial fermentation, and can be absorbed locally and used as a source of energy for the host.

The fiber fraction of the feed is very heterogeneous (Fig. 1) and includes:

- Soluble components, which are easily fermented: fructans, gums, pectins,

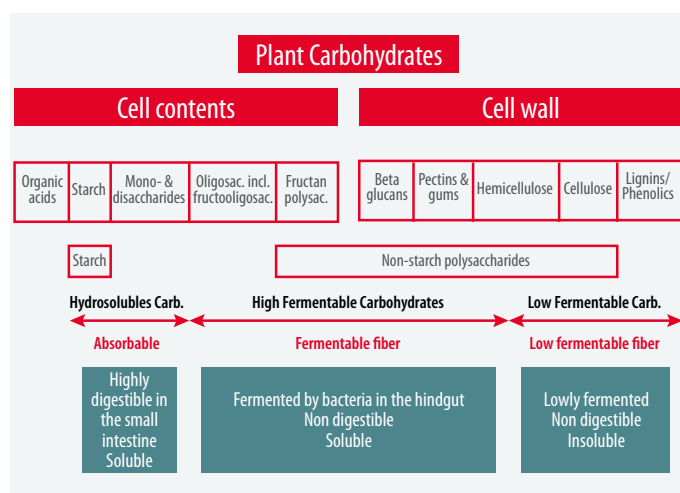


Figure 1:

The different types of fibers and their main characteristics.

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- Partially degradable structural components such as cellulose, hemicellulose,
- Cell wall protecting substances, which are practically indigestible, like cutin and lignin.

The inclusion of fiber in swine diets stimulates the speed of the digestive transit in relation with its content in Neutral Detergent Fiber (NDF) and benefits animal welfare, reducing constipation incidence, stereotypic behaviors and stress (Gerrits and Verstegen, 2006).

The proportion of fermentable fiber is positively associated with the content of soluble fiber and negatively associated with the level of lignin. It is related with changes in the intestinal environment (pH, ammonia concentration, production of SCFAs).

Both types of fiber, soluble low lignified (e.g., sugarbeet pulp) and insoluble lignified (e.g., oats bran) affect swine intestinal health through different mechanisms: a) production of SCFA from hindgut fermentation, and b) improvement of intestinal motility and functionality (Nutritional requirements for swine, FEDNA, 2013)

THE HINDGUT, A FANTASTIC FERMENTER

Sows are well adapted to digest fiber. They are equipped with a more voluminous large intestine than piglets or fattening pigs. The digesta remains in the large intestine for 70-85% of the total digestion time, allowing it to be in contact with the hindgut microbiota. This particularity confers sows a much higher cellulolytic activity than young pigs for example. In fact, many of the bacteria able to digest fiber that are located in the rumen of a cow can also be identified in the colon of sows.

It is important to note that cellulolytic bacteria need an anaerobic environment to proliferate and be metabolically active. However, this is not always the case due to the huge vascularization irrigating the intestinal mucosa, that brings in oxygen and can have a negative impact on the microbial profile.

Thus, the fermentative digestion, or microbial digestion, represents an important contribution to the Net Energy in sows. Digestibility of various components (protein and fiber) differs between growing pigs and sows (Le Goff and Noblet, 2001), but it can also largely differ between individual sows depending on their microbiota!

ENERGY REPARTITION

Energy systems quantify the concentration of energy in the diet and should account for the energy available to the pig. The purposes of energy systems are to (Acosta, 2016):

- 1) Facilitate the blending of diverse ingredients into a diet formulation that results in predictable performance.
- 2) Serve as a basis for assigning relative economic values to ingredients that vary in energy contents

The Net Energy system described by Jean Noblet (Fig. 2) essentially discounts Metabolizable Energy estimates by accounting for the metabolic cost of converting Metabolizable Energy into useful forms of Energy for maintenance and productive functions (Patience, 2012). The relationship between Net Energy and Metabolizable Energy is known as the Coefficient of Metabolizable Energy Retention.

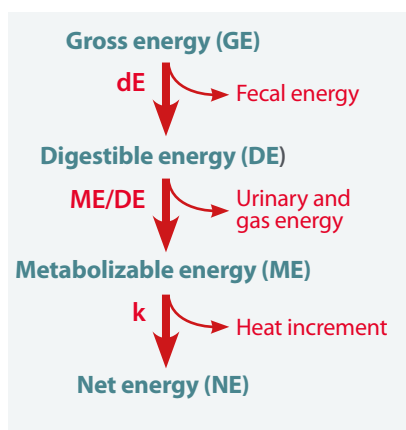


Figure 2:

Energy utilization and description of the Energy systems, from Jean Noblet.

THE EXPERT'S VIEW

Interview with Professor Jean Noblet, international monogastrics nutrition consultant:

Energy utilization in swine



One of the most important outcomes of your research in swine was the development of the Net Energy System. What are the advantages of this system?

The main advantage is that we are getting the best estimate of the "true" energy value of the feed.

What kind of tools did you use for the development of the system?

We developed this program in the late 80s, early 90s, during 10 years. Its originality is that we were able to measure the digestible energy (DE), metabolisable energy (ME) and net energy (NE) value of around 100 diets! All the feeds were characterized and the animals' response was measured thanks to respiratory chambers: this is very complex equipment and very few exist in the world.

What is the expansion of the Net Energy System?

Thanks to the number of feeds measured, we have been able to publish a robust equation, but we are not "the only one." There are different schools. Some don't accept NE system and keep using DE or ME, and other net energy measurements have been proposed or adapted. However, most people in the world are still referring to the original equation.

Does the Net Energy System make any differentiation between different types of animals?

There may be some genetic effects, but I think most of the differences are linked to the age and stage of the animal. When pigs are getting older and heavier, they have better energy digestion. DE and ME are related to the age and body weight of the pigs, but not NE. NE equation is quite robust and can be used at any stage of production.

Are there any feed factors that make the application of the Net Energy System even more precise?

NE is by definition predicted from DE or ME content. Feed parameters such as chemical composition or nature of fibers, particle size, etc., are already taken into account in the DE or ME value. What could be added are some functional effects that cannot be taken into account by chemical analysis, such as the effects of probiotics or enzymes. They could affect DE value and, as a result, the NE.

A big portion of the non-digestible carbohydrates will be partially consumed by the microbiota.

THE LIVE YEAST STORY

Yannig Le Treut, General Manager at Lallemand Animal Nutrition and an experienced swine vet, explains how the research with the live yeast *Saccharomyces cerevisiae boulardii* CNCM 1079 on energy repartition started:

*“Back in 2005, when we started the application of *S. cerevisiae boulardii* in sows in France, certain farmers called us after 5-6 months and told us they had to reduce the feed allowance in gestation in order to prevent the sows from getting too fat. This is what motivated us to look more closely into this effect. We knew that in lactation the probiotic helped reduce body weight loss, but we used to link this benefit to an increased feed intake. After a couple of years, we had accumulated field evidence and could formulate the hypothesis that *S. cerevisiae boulardii* could improve the net energy value of the diet by 2-3%.”*

There are two main drivers explaining why the application of the live yeast has an impact on feed efficiency and energy utilization:

- 1) The probiotic yeast **enhances fiber digestibility by influencing lower gut fermentation.**
- 2) It also modulates the metabolism due to a **better management of inflammatory reactions.**

LIVE YEAST EFFECT ON FIBER DIGESTIBILITY

Part of the mode of action of *S. cerevisiae boulardii* CNCM I-1079 in the gut of sows has to do with the fast consumption of oxygen carried out by the yeast in both caecum and colon. This creates better anaerobic conditions where the cellulolytic bacteria can proliferate leading to an improved fermentation rate. As a result, more energy in the form of SCFA is released from the same diet and in a shorter time.

The first evidence on the impact of the specific yeast on the microbial profile came from trials done in the USA in 2008: for the first time, our team looked at the DNA-fingerprint of the faecal bacterial community of sows. Before farrowing, control and live yeast treated groups clustered together, indicating an effect of the yeast on the microbial composition (Walker, 2008). This has been later confirmed with new metagenomics techniques, in cooperation with the French Agronomic Research Institute (INRA) (See boxed text on 'microbiota analysis').

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could improve the net energy value
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Yannig Le Treut,

General Manager at Lallemand Animal Nutrition and an experienced swine vet, explains how the digestibility research started.

EFFECT ON THE METABOLISM MODULATION AND MANAGEMENT OF INFLAMMATION

The effect of *S. cerevisiae boulardii* on the attenuation of the overreacting inflammatory immune response is well-known in human medicine (Stier, 2016). When it comes to swine, a previous trial (Collier et al., 2010) had already demonstrated how piglets submitted to an acute inflammatory challenge via intra-jugular injection of Lipopolisaccharide (LPS) had developed a different response depending on the *S. cerevisiae boulardii* CNCM I-1079 treatment through the feed.

Among the different findings of this trial, the retarded peak of cortisol concentration in plasma, reduced concentration of Interleukin-1 β (both of them pro-inflammatory hormone and cytokine, respectively) and higher concentration of Interferon- γ (known as the natural antioxidant), following the challenge, indicate that the piglets receiving the live yeast develop a much more controlled inflammatory reaction. This was confirmed by a lower intraperitoneal temperature.

Inflammation has a huge metabolic cost for the animals: energy is used for immune cell differentiation and to increase the body temperature, while amino acids are used to synthesize acute phase proteins. Hence, the nutritional requirements of piglets under inflammation differs from that of piglets under normal conditions. The resources used in the inflammatory response are not used for growth, thus leading to lower feed efficiency and higher feed conversion ratio.

SACCHAROMYCES CEREVISIAE BOULARDII IMPROVES FEED DIGESTIBILITY AND ENERGY UTILIZATION

In order to confirm the effect of the live yeast on feed digestibility and energy repartition, a research project was conducted by INRA Pegase, in France. For this project, fattening pigs were introduced inside metabolic chambers, the same chambers that were used by Prof. Jean Noblet to develop the Net Energy System (picture).

This procedure allowed the researchers to strictly control the environment of the pigs and to measure the temperature and the gases produced by the animals, enabling them to identify their energy expenditure as well.

After two weeks of adaptation to the chambers, the trial was conducted during three weeks: the first week under thermo-neutral conditions, the two remaining weeks under a heat stress challenge, with ambient temperatures kept continuously at 28°C.



Metabolic chambers (INRA Pegase, France)

Among the different findings obtained in this trial, one of the most important was a more efficient use of the metabolizable energy by the pigs. The pigs submitted to the probiotic treatment, under thermoneutral conditions, showed an increased Coefficient of Metabolizable Energy Retention (+3.8% vs. Control). It was hypothesized that this improved efficiency is linked to the more adapted microbiota profile of the pigs, making them able to extract more energy from the feed, especially from the fiber fraction. This could be even more important when we transfer this to sows, for which the amount of fiber in the diet is much higher and the importance of improving the fermentative capacity is crucial.

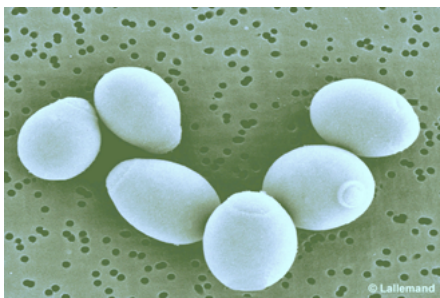
When we look at 2 weeks of heat stress, we notice how the difference in the coefficient of metabolizable energy retention is much higher (35.5 vs. 40.5% during the first week of heat stress, 36.3 vs. 42.8% during the second week). This coefficient is much more stable under heat stress conditions in the *S. cerevisiae boulardii* CNCM I-1079 treated group compared to the control group, where pigs seem to undergo a great change compared with the thermoneutral conditions (Fig. 3).

Why is this different behavior happening? Apart from the better feed efficiency already noticed under thermoneutral conditions, here we could also hypothesize that, as heat stress also represents an important challenge for the pigs, when they receive *S. cerevisiae boulardii* CNCM I-1079, they are able to better manage the way they react to this challenge. In order to confirm that, the skin temperature of the pigs was also measured, showing a better adaptation (lower skin temperature) of the pigs fed with the live yeast under the heat stress conditions.

Another important factor for the improved energy retention can also be explained by the different eating behavior of the pigs under the probiotic treatment. They eat frequently, smaller amounts in each meal, for a higher feed intake along the day. This would allow the pigs not to have an important heat increment after each meal as compared to the control group, and then save that energy for growth instead of increasing their body temperature.

PRACTICAL IMPLICATIONS

While the live yeast's effect on feed digestibility and energy repartition can be found in all animal types, from piglets to adult sows and fattening pigs, it is important to note that it has a bigger impact in adult animals. In sows, the fermentations occurring in the hindgut are an important part of what the animals are able to extract from the feed. Still, in sows, the practical implication is different between gestating and lactating sows.



Saccharomyces cerevisiae boulardii CNCM I-1079 yeast.

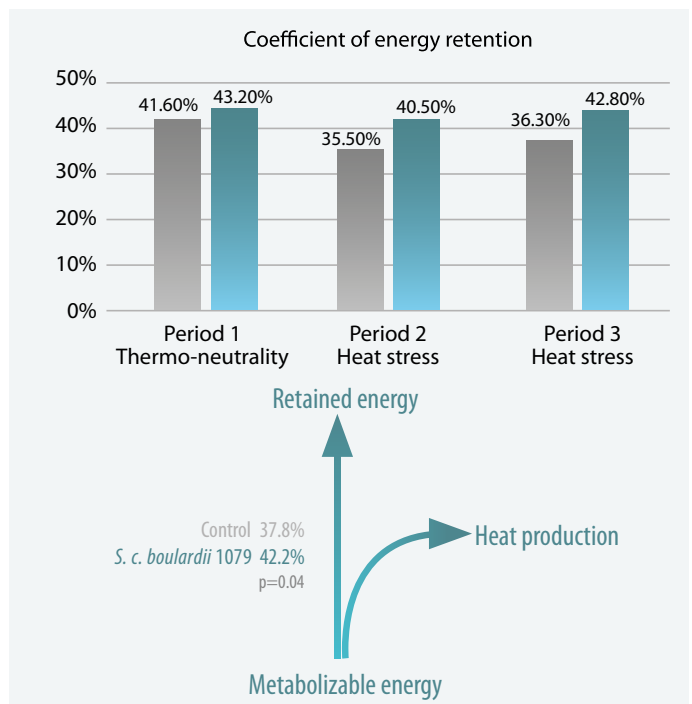


Figure 3:

Effect of live yeast *Saccharomyces cerevisiae boulardii* CNCM 1079 on the ratio between metabolizable energy and retained energy during heat stress and thermos neutral periods (INRA Pegase, 2015).

MICROBIOTA ANALYSIS



Lallemand Animal Nutrition has invested in a human and technical platform using **metagenomics** method to better understand the intestinal microbial ecosystem, its evolution and the effect of Lallemand solutions.

During the INRA Pegase 2015 study, samples were collected for each pig according to their treatment and the period of time.

The results show that a physiological challenge such as the heat stress had an impact on the microbiota composition. It was quite easy to differentiate the microbial profile of the pigs under thermoneutral conditions compared with those under the heat stress challenge (Achar, 2017). Interestingly, the probiotic treatment had also a very clear impact on the microbiota of the pigs, being able to discriminate, according to the microbial composition, those pigs receiving the live yeast.

Even though it is still very difficult to associate a specific function to each group of bacteria involved in these changes, some examples of bacteria which were positively stimulated by the application of *S. cerevisiae boulardii* CNCM I-1079 include:

- *Lactococcus lactis*, which is a lactic acid bacteria commonly recognized as positive in the food industry.
- *Phascolarctobacterium* genus, which is able to produce SCFA and can be associated with the metabolic state of the host and has positive implications in humans (Wu et al., 2017).

In a lactating sow — as the feeding requirements today are very high, and most times the sow is not able to get enough nutrient from the amount of feed it is able to eat — the application of the live yeast represents a great help because it will make the sow extract more energy from the feed and be more efficient in its utilization.

Gestating sows are commonly restricted in terms of feed allowance. They would eat much more feed than the amount they are actually offered. In this case, the application of *S. cerevisiae boulardii* has different purposes, like:

- Regulation of the intestinal transit
- Optimized farrowing conditions
- Better quality (vitality, homogeneity) of the litter at birth
- Improved colostrum quality

So, for gestating sows, it is possible to reduce either the net energy requirement in the formulation software (from 1.5 to 2.5%, depending on the starting energy concentration of the diet) or the daily feed allowance per sow — and still get the same body condition and body weight at farrowing, plus all the benefits produced by the live yeast application at farrowing time.

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CONCLUSION

The fermentation occurring in the hindgut of the sow represents an important energy contribution, the colon of an adult sow being a very efficient fermenter. The application of *S. cerevisiae boulardii* through the feed helps to improve the efficiency of this fermenter, and thus to extract more energy from the feed, by improving the microbial profile and getting a better feed fermentation, especially regarding the fiber portion of the feed.

The specific live yeast also has an impact in helping save energy from metabolism. It generates a lower heat production during the digestion, and so the coefficient of energy retention is improved. Moreover, it has also been shown that the animals react better to stress through the modulation of the inflammatory reactions.

The effect of the probiotic on fermentation and energy metabolism is of great interest in all type of swine, but it has an additional value in gestating sows, as it can be applied through a partial energy substitution, compensating the inclusion cost of the additive, and still getting all the benefits of its application at farrowing time.

Lallemand Animal Nutrition is committed to optimizing animal performance and wellbeing with specific natural microbial product and service solutions. Using sound science, proven results and knowledge, Lallemand Animal Nutrition develops, produces and markets high value yeast and bacteriaproducts including probiotics, forage inoculants and yeast derivatives. These innovative solutions positively benefit animal nutrition and well-being, forage management and animal environment. Lallemand offers a higher level of expertise, leadership and industry commitment with long-term and profitable solutions to move our partners *Forward*. Lallemand Animal Nutrition is *Specific for your Success*.



Lallemand Forward is a range of specifically chosen service solutions that enhance people, knowledge, production practices and profitability.