β-mannans Don't Feed the Problem

Houdijk, JGM

Print publication: 03/10/2023

β-MANNANS IN PIG AND POULTRY DIETS – HOW MUCH OF AN ISSUE ARE THEY IN THE UK?

SRUC TECHNICAL SUMMARY

A technical summary authored by Professor Jos Houdijk, Head of Monogastric Science Research Centre at SRUC.

CONTENTS

INTRODUCTION

Animals, including humans, obtain the energy required for their bodily function through ingestion of protein, fat and carbohydrates. Whilst fats have the greatest energy density, by volume within typical rations farmed animals including pigs and poultry derive most of their energy nutrition from carbohydrates.

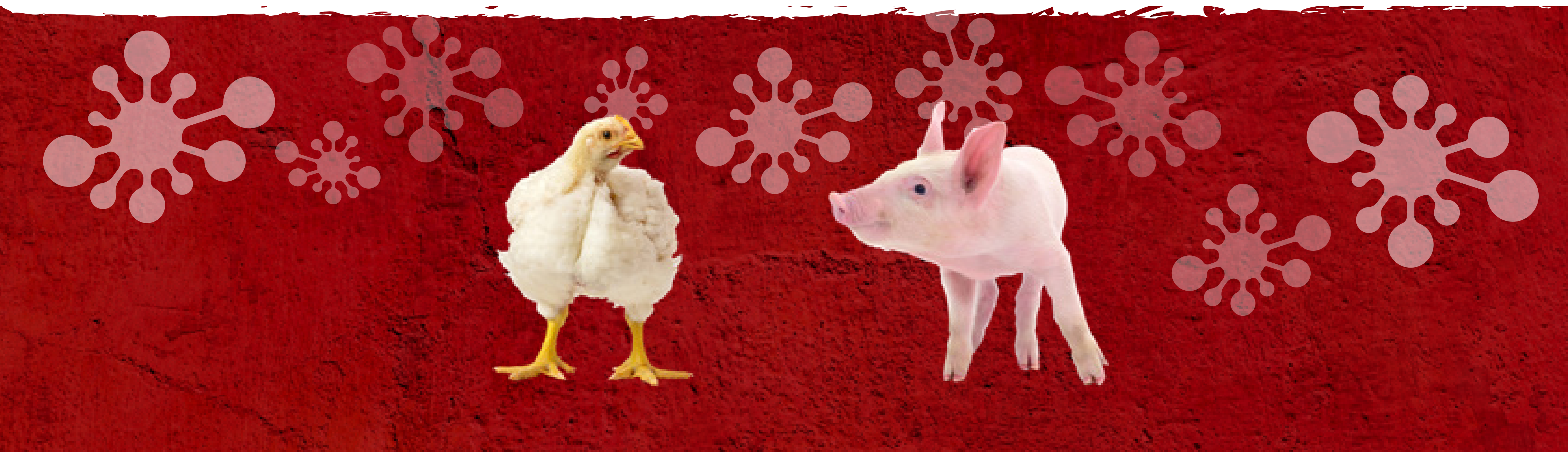
This short report summarises the impact of specific non-digestible carbohydrates, the β-mannans, on pig and poultry performance and considers the benefits of dietary supplementary of β-mannanase to counteract the associated performance losses.

ENERGY FROM CARBOHYDRATES

Not all carbohydrates contribute equally to energy provision, and this is largely determined by their digestibility and/or fermentability.

Most carbohydrates in pig and poultry rations are digestible; they can be broken down to absorbable sugar units through the action of host enzymes secreted into the gastrointestinal tract. For example, glucose is split-off from starch due to the action of endogenously secreted amylase, and after absorption is metabolised to produce energy. Enzymes such as amylase can achieve this because they can breakdown the α-linkages between the monomeric sugar moieties within such digestible carbohydrates.

A significant proportion of carbohydrates consist of monomeric sugar moieties that are bound through β-linkages, and the endogenous secretion does not contain enzymes that are capable of breaking those bonds. Those indigestible carbohydrates are also collectively known as dietary fibre, which can range from small molecules with only two sugar units (disaccharides), and medium-sized ones with up to ~10 sugar units (oligosaccharides), to very large ones, with thousands of sugar units (polysaccharides). What endogenously secreted enzymes lack, microbial enzymes possess, i.e. the capability to breakdown the ß-linkages found in dietary fibre. In this process, volatile fatty acids such as acetic, propionic and butyric acid emerge, which can contribute to energy supply, much in the same way as for glucose though with lower energy yield. This dietary fibre fermentation takes place mostly in the hindgut of pigs and poultry, and amongst those fibres we find β-mannans.



What are β-mannans?

β-mannans are anti-nutritional, non-starch polysaccharide fibres, commonly found in many vegetable feed ingredients. They are high molecular weight molecules formed of a long chain of mannose sugar units with here and there galactose or glucose side chains.

Table 1 provides an overview of total and soluble ß-mannans in various feedstuffs used in poultry and pig nutrition[1]. Feedstuffs generally used as protein sources are relatively rich in β -mannans, which can be reduced by dehulling. A good number of soya alternatives – such as rapeseed meal, peas, and faba beans – contain less but still significant levels of β-mannans.

Table 1 (right)

Content of total and soluble β-mannans from selected feed ingredients, presented as mean with ranges where provided[a].

[a]Adapted from Kairie et al (2021)[1]
[b]CP: Crude Protein

Feedstuff description	β-mannans			
	Total (% DM basis)		Soluble (% as is)	
	Mean	Range	Mean	Range
Coconut meal	32.58	(30.60 - 34.56)	3.36	
Palm kernel meal	30.90		4.83	(3.56-7.27)
Guar meal, assumed ~40% CP[b]	10.41	(8.20-12.62)	4.62	(3.33-5.83)
Soybean hulls	5.00		4.45	(4.29-4.61)
Soybean meal, 44% CP, with hulls	1.67	(1.30-2.07)	0.53	(0.25-0.87)
Wheat DDGS	1.55	(1.30-1.80)		
Corn DDGS	1.28	(0.47-2.00)	0.38	(0.15-0.73)
Soybean meal, 48% CP, dehulled	0.98	(0.65-1.31)	0.39	(0.19-0.67)
Corn gluten feed	0.80	(0.40-1.20)	0.11	(0.07-0.16)
Brewer spent grains	0.80			
Wheat middlings	0.55	(0.30-0.80)	0.19	(0.17-0.20)
Wheat bran	0.50	(0.50-0.50)	0.17	(0.14-0.23)
Canola meal	0.42	(0.39-0.45)	0.12	(0.09-0.25)
Barley	0.40		0.28	(0.25-0.31)
Wheat	0.30	(0.30-0.30)	0.18	(0.07-0.28)
Corn	0.25	(0.20-0.30)	0.09	(0.06-0.15)
Sorghum	0.10		0.11	(0.09-0.12)
Soya, full fat, with hulls			0.47	(0.28-0.70)
Oil seed rape, full fat			0.05	(0.05-0.06)
Peas			0.07	(0.06-0.08)
Faba beans			0.05	(0.05-0.05)
Sunflower meal, ≤32% CP, with hulls			0.41	(0.35-0.46)
Sunflower, >32% CP, dehulled			0.38	(0.28-0.50)
Oats			0.21	
Oats, dehulled			0.11	(0.06-0.15)
Guar meal, >47% CP			1.79	(1.33-2.38)
Rice			0.18	
Cassava/Tapioca			0.15	(0.12-0.18)
Beet flour			0.15	
Rice bran			0.13	
Lentils			0.11	(0.10-0.11)

SO WHAT IS THE ISSUE WITH β-MANNANS?

One might argue that if pigs and poultry, through involvement of their microbiome, can extract at least some of the energy from dietary fibre, then what is the issue with those β-mannans? A main challenge with those specific non-starch polysaccharides, which we find as part of feeds hemicellulose fraction, is their ability to evoke unnecessary immune responses. This is known as a feed induced immune response (FIIR). So how does this come about- and more importantly, why is this an issue[1,2]?

A key requirement for most pathogens to cause infection, and evoke host immune response, is their adherence to the gut wall, and such adherence is mediated through glycoprotein receptors that have a great resemblance to mannose.

On the one hand, the presence of β-mannans may lead to reduced pathogen adhesion to the small intestine in particular; after all, if the pathogens adhere to the β-mannans in the digesta rather than to the gut wall, and are as a consequence “flushed out”, then animals will be at reduced risk of infection.

However, if the β-mannans adhere to the epithelial gut wall, and there they’d get “stuck” as they would be too large to be absorbed, the immune system may recognise this as a pathogen challenge.

Consequently, a cascade of nutritionally costly events is initiated, which requires resources that would otherwise be used for productive functions.

This FIIR results in resources being diverted away from production without providing a benefit as after all, if there are no pathogens involved, then there would be no case of reducing the penalty of pathogen exposure on host traits, including production.

This results in reduced feed efficiency, also observed as an increased feed conversion ratio (FCR), observed in both broilers and pigs, effectively telling us that feed is unnecessarily wasted.

It might be considered that this detrimental impact of FIIR on feed efficiency is maintained until the signals that trigger them are no longer there. For this to happen, the β-mannans need to be broken down, which would then result in absorption of the single, freed mannose molecules.

It is the microbiome, and not the host, that possesses the required enzymes to break down β-mannans – in this case, it is β-mannanase. Can we assist by adding β-mannanase to the feed?

IMPACT OF β-MANNANASE SUPPLEMENTATION

Since microbiome presence and activity is relatively low in the small intestine – and certainly smaller than in the hind gut (caecum and colon) – one might argue that background β-mannanase activity and capacity is limited to reduce the detrimental impact of β-mannans in the first part of the gut.

It then follows that dietary supplementation with β-mannanase such as Hemicell XT™ would be expected to provide benefits, especially on feed efficiency.

This hypothesis is supported by a recent review[1], which concluded that

β-mannanase supplementation improves feed efficiency and also energy digestibility in broilers, weaner and grower-finisher pigs.

This improved digestibility effectively means that β-mannanase supplementation "adds" usable energy to the feed. In part, this may come from absorbed and metabolised released mannose moieties, which much in the same way as glucose, provide additional energy. Thus, feeds formulated with less energy but supplemented with β-mannanase should maintain performance, as shown recently[3]. In addition, it has also been shown[4] that β-mannanase supplementation to β-mannan enriched rations restores both performance and gut microbiome composition in broilers.

Recently, 28 field studies across Europe and the Middle East were evaluated where β-mannanase supplementation was tested, and significant improvement in gut health was observed, as a 1.04 unit improvement in Intestinal Integrity index[5].

The Intestinal Integrity tool, also known as the I^2 index, consists of scoring 23 intestinal health conditions known to affect intestinal health and thus expected to impact performance, welfare and profitability (i.e., sustainability). In response to β-mannanase, the prevalence of several conditions reduced, namely excessive cellular sloughing, poor intestinal tone, excessive feed passage, gizzard erosion, abnormally thin intestines, abnormally thick intestines, and excessive mucus content. This provides a basis of using I^2 outcomes on informing producers to what extent FIIR is hampering their productivity and generates performance expectations for β-mannanase supplementation.

CAN BENEFITS OF β-MANNANASE SUPPLEMENTATION BE EXPECTED IN THE UK?

UK broiler rations are characterised as based on wheat and soya bean meal, and whilst wheat has relatively low levels of β-mannans, soya bean meal is a major source of β-mannans (Table 1).

Rapeseed meal is sometimes included as a home-grown alternative to reduce reliance on soya, which would reduce ration β-mannan levels.

In contrast, when available, wheat co-products from ethanol production are also used in UK diets – this results in elevated levels of β-mannan analysis, most likely arising from combined yeast residue and increased concentration of wheat fibres.

Table 2 shows an example of a composite feed formulation used in broiler trials at SRUC aimed at mimicking commercial rations.

What is shown is a weighted averaged ration composition for Ross308 birds growing to Aviagen (2022) performance objectives for a total of 35 days, with starter, grower, and finisher phases for days 0 to 10 days, 10 to 21 days and 21 to 35 days of age, respectively.

The data from Table 1 have been used to estimate the expected levels of β-mannans. It should thus be noted that although the soya products have greater levels (Table 1), the commodity inclusion levels suggest that the combined cereal and combined soya components contribute very similar levels to the total ration β-mannans levels of around 0.5%.

Table 2

Composite 35 days broiler ration with its estimated levels of total and soluble β-mannans as mean with ranges.

Ingredient	%	Ration β-mannans (%)			
		Total		Soluble	
		Mean	(Range)	Mean	(Range)
Wheat	58.66	0.15		0.11	(0.04 - 0.16)
Barley	5.00	0.02		0.01	(0.01 - 0.02)
Full fat soya	5.00	0.05	(0.03 - 0.07)	0.02	(0.01 - 0.04)
Soya bean meal[a]	24.19	0.21	(0.14 - 0.28)	0.09	(0.05 - 0.16)
Rest[b]	7.14	0.00		0.00	
Ration - total		**0.43**	**(0.35 - 0.52)**	**0.24**	**(0.11 - 0.38)**

[a]High protein, dehulled [b]Ingredients that do not contain β-mannans, e.g. soya oil, minerals, synthetic amino acids etc.

Most of the studies that demonstrated benefits of β-mannanase supplementation are likely to have a corn-soya basis.

The aforementioned review that concluded that β-mannanase improves feed efficiency would have come predominantly from studies with a corn-soya basis. Given that the level of β-mannans is less in corn than in wheat, and that typical UK rations are based on wheat rather than on corn, it might be argued that performance on typical UK rations may be more limited by β-mannans than performance on corn-based rations.

It follows from this that proportionally an even greater benefit of β-mannanase supplementation on performance efficiency can be anticipated on the typical wheat-based UK rations than on the corn-based rations used elsewhere.

ENVIRONMENTAL BENEFIT OF β-MANNANASE SUPPLEMENTATION

Figures from a recent simulation study[6] report that the global warming potential per kg carcass weight for broilers was 2.76 kg CO^2 equivalent, of which 61% was for feed and water, 5% for electricity, 13% for farm gas and oil, 16% for housing, and 4% for manure and bedding.

The consequence of improved feed efficiency is that less feed is required for the same amount of output. Thus improving feed efficiency with β-mannanase supplementation, such as with Hemicell XT™, greatly reduces global warming potential from reduced resource input.

In addition, the observed impact on total tract energy digestibility would indicate that less manure would be produced, and if the expected improved total tract digestibility of nitrogen and phosphorus can be demonstrated, then that would further reduce eutrophication potential and acidification potential, respectively, over and above the benefits on those parameters arising from improved feed efficiency.

Thus, β-mannanase supplementation, such as with Hemicell XT, is expected to significantly reduce environmental footprint.

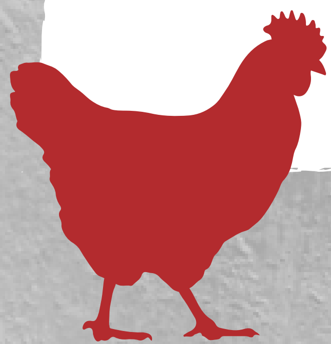
CONCLUSION

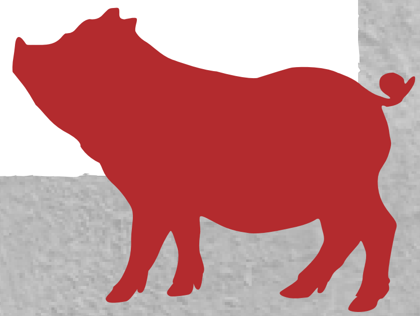
β-mannans are dietary non-digestible carbohydrates that have been associated with reduced feed efficiency and other performance penalties in pigs and poultry.

These negative impacts may arise from their ability to evoke unnecessary and resource-hungry feed induced immune responses.

Since pig and poultry rations can contain significant levels of β-mannans, their breakdown through dietary supplementation of β-mannanase can improve feed efficiency.

This has been demonstrated in many studies world-wide and can be anticipated also under typical UK conditions, with associated improvements in gut health and reduced environmental footprint accordingly.





IT'S TIME TO FEED THE SOLUTION!

LET'S MAKE IT HAPPEN! – THANK YOU

References: 1. Kairie EG, Steelman S, Martinez M, Livingston K, 2021. Significance of single β-mannanase supplementation on performance and energy utilization in broiler chickens, laying hens, turkeys, sows, and nursery-finish pigs: a meta-analysis and systematic review. Translational Animal Science 5, 1-21. **2.** Sareed M et al Brazilian Journal of Poultry Science 2019 1 (v1.0). **3.** Yaqoob MU, Yousaf M, Khan MI, Wang M, 2022. Effect of β-mannanase supplementation on growth performance, ileal digestibility, carcass traits, intestinal morphology, and meat quality in broilers fed low-ME diets. Animals 12, 1126. **4.** Souza MD, Eeckhaut V, Goossens E, Ducatelle R, van Nieuwerburgh F, Poulsen K, Baptista AAS, Bracarense A-PFRL, van Immerseel F, 2023. Guar gum as galactomannan source induces dysbiosis and reduces performance in broiler chickens and dietary β-mannanase restores the gut homeostasis. Poultry Science (in press) doi: https://doi.org/10.1016/j.psj.2023.102810. **5.** Poulsen K, Mathlouthi N, Bargen J, 2022. Meta-analysis on the effect of dietary ß-mannanase on intestinal integrity in broiler chickens. Journal of Applied Poultry Research 32, 100307. **6.** Leinonen I, Williams AG, Kyriazakis I, 2016. Potential environmental benefits of prospective genetic changes in broiler traits. Poultry Science 95, 228-236.

Use medicines responsibly www.noah.co.uk/responsible. Elanco UK AH Limited, Form 2, Bartley Way, Bartley Wood Business Park, Hook RG27 9XA. Telephone: 01256 353131. Email: elancouk@elanco.com

SRUC receives support from Scottish Government (RESAS).

Elanco

Hemicell™-XT™