EFFECT OF NON-STARCH POLYSACCHARIDES ON BLOOD LIPID METABOLITES, ORGAN WEIGHTS, INTESTINAL MUCIN PRODUCTION AND ENDOGENOUS LOSSES IN WEANER PIGS, AND PROTEIN DIGESTION IN BROILER CHICKENS

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ABSTRACT

This study was undertaken to examine the anti-nutritional influence of soluble non-starch polysaccharides (NSP) in two monogastric species. In experiment 1, the influence of NSP on blood lipid metabolites, organ weights, growth performance, mucin production, and endogenous nitrogen and amino acid flows were evaluated in pigs. In experiment 2, the influence of NSP on ileal nitrogen digestibility and flow were determined in broiler chickens.

In experiment 1, different levels of purified maize arabinoxylan (AX) and barley β-glucan extract Glucagel™ (BG) were substituted for cellulose in enzymatically hydrolysed casein-based (EHC) diets. Five experimental diets consisting of different levels (4% and 7.5%) of AX and BG and EHC, wheat starch, sugars and coconut oil were formulated. These diets contained titanium oxide as an indigestible marker. Each experimental diet was fed to five 3-wk old LWxLR pigs for 21 days. The results showed that AX and BG did not significantly influence ($P>0.05$) the levels of blood metabolites measured after 21 days in fasted and fed states. Some blood metabolites showed significant changes over time. The levels of total cholesterol (TC), high-density lipoprotein (HDL) and low-density lipoprotein (LDL) were significantly increased ($P<0.05$) after 21 days. On the 21st day, fasted and fed states were compared. Fasting significantly increased TC and some HDL levels, but LDL levels were not affected. The increase of blood metabolites over time was attributed to the interplay between increased synthesis in the liver and other tissues or decreased catabolism. Similar LDL values indicated differences of LDL metabolism between humans and pigs, which lack cholesteryl ester transfer protein (CETP) activity. Thus, very little HDL cholesteryl ester is transferred to LDL.

The values obtained for empty organ weight were similar ($P>0.05$) between different diets although gut fill was significantly greater ($P<0.01$) with dietary inclusion of 7.5% BG, indicating the presence of gelling property of BG. Carcass weight and liveweight were similar ($P>0.05$) between diets. Daily feed intake (DFI) was also similar due to the restricted feeding scheme. However, weight gain ($P<0.05$) and feed conversion ratio (FCR) were improved ($P<0.01$) with dietary inclusion of 7.5% AX and BG, indicating high degradation rates of AX and BG molecules in pigs. This improvement was not due to the

difference in gut fill. It could also be proposed that the threshold levels or length of time to initiate increased organ weights and affect growth performance was not achieved.

Evaluation of crude mucin (CM) indicated a significant numerical increase in CM associated with increased level of AX, but not with BG. In the same trial apparent nitrogen digestibility (AND) ranged from 73.1% to 80.9% across diets. When corrected for endogenous losses, the range of true nitrogen digestibility (TND) across all diets became closer (88.36% to 90.7%). However, AND and TND were similar (P>0.05) in pigs fed different NSP. The endogenous nitrogen flow (ENF) showed numerical significant increase with increased level of AX, but not with BG. It is possible that the branched structure of AX molecules, which is difficult to breakdown, and its ability to hold water hampers digestion and absorption process and consequently leads to increased ENF and CM flow. BG may not be an anti-nutritional factor in pigs as implied by its high mechanical breakdown by microbes colonising the pig gut.

Numerical increase in endogenous amino acid flows (EAAF) was observed with increased levels of AX but no definite trend with BG. In fact, EAAF in mixed NSP diets (4%BG and 3.5% cellulose) was even significantly higher than 7.5% BG. When pure NSP diets were compared, EAAF was highest in 7.5% AX (P<0.05), intermediate in BG, and lowest in control diet. Specifically, EAAF was highest for glutamic acid. Significant increased flow (P<0.01) for amino acid threonine, proline and serine with 7.5% AX are consistent with the high level of crude mucin found for this diet (i.e. those amino acids are abundant in mucin).

In the second experiment, different levels (3% or 6%) of purified maize arabinoxylan (AX) and barley β-glucan extract Glucagel™ (BG) were substituted for wheat starch in enzymatically hydrolysed casein-based (EHC) diets. Five experimental diets consisting of EHC, cellulose, wheat starch, dextrose and vegetable oil were formulated. These diets contained titanium oxide as an indigestible marker. Each experimental diet (control, 3% and 6% of BG or AX) was fed for 7 days to 27-day old birds in cages, with 4-5 birds/cage. Inclusion of AX and BG did not significantly influence feed intake (P>0.05). AND was numerically depressed at 90.37% and 90.4% for 6% AX and BG as compared to 91.1% for control diet. Ileal nitrogen content and endogenous nitrogen flow were numerically increased with increased levels of AX and BG, though statistically significant differences were not observed due to high variations among the replicates. Inclusion of 6% BG significantly depressed dry matter digestibility (P<0.05), suggesting preservation of hydration property of gelling BG.

It is then concluded that the anti-nutritional effect of soluble NSP was evident in chicken as indicated by decreased dry matter digestibility ($P<0.05$) and the extent of increase in ileal flow of nitrogen in chicken. The cause of increased nitrogen flow with increased levels of NSP is not clear, but could be due to increased secretion of endogenous protein, decreased reabsorption, or combination of both. In pigs, dietary inclusion of arabinoxylan promotes anti-nutritional activity through its influence in nutrient digestion and absorption. This is shown by the increase of CM, ENF and EAAF ($P<0.05$) with increased level of dietary AX. This effect can be related to the ability of AX to hold water and their branched structure, which is difficult to degrade. Further, it would appear that gelling BG extract is likely well tolerated and its dietary inclusion seemed not a factor to negatively influence pig nutrition, at least with the levels used in this trial. The increase in ENF and EAAF associated with dietary inclusion of mixed NSP (4%BG and 3.5 % cellulose) is difficult to comprehend and is open for speculation. It is indicated that further research is needed to better understand the dynamics of cholesterol-lowering effect of NSP, and the effects of NSP on organ weights, ENF and EAAF. Such experiments should be conducted using relatively older animals and for a longer period of time.

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LIST OF ABBREVIATIONS

AA	Amino acid
ADG	Average daily gain
AFDC	Apparent faecal digestibility coefficients
ANF	Anti-nutritional factor
AX	Arabinoxylan
BG	Betaglucan
CAS	Casein
CDC	Chenodeoxycholic acid
CMC	Carboxymethylcellulose
CETP	Cholesteryl ester transfer protein
CHD	Coronary heart disease
CM	Crude mucin
Da	Daltons
DE	Digestible energy
DFI	Daily feed intake
DM	Dry matter
DMD	Dry matter digestibility
DMI	Dry matter intake
EAAF	Endogenous amino acid flow
EHC	Enzymatically hydrolysed casein
ENL	Endogenous nitrogen losses
EPL	Endogenous protein loss

FCR	**Feed conversion ratio**
GIT	**Gastro-intestinal tract**
HDL	**High-density lipoprotein**
HMG CoA	**3-hydroxy-B-methylglutaryl Coenzyme A**
IRA	**Ileo-rectal anastomosis**
LCAT	**Lecithin:cholesterol acyl transferase**
LDL	**Low-density lipoprotein**
N	**Nitrogen**
NSP	**Non-starch polysaccharides**
PVTC	**Post-valve T caecum**
TC	**Total cholesterol**
TRL	**Triglyceride-rich lipoprotein**
TND	**True nitrogen digestibility**
UWL	**Unstirred water layer**
VLDL	**Very low-density lipoprotein**