EVALUATION OF THE ANTI-NUTRITIVE AND HYPOCHOLESTEROLEMIC EFFECTS OF A β-GLUCAN PREPARATION EXTRACTED FROM NEW ZEALAND BARLEY

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ABSTRACT

The present study evaluated the anti-nutritive as well as the hypocholesterolemic effects of barley β-glucan through the use of a commercially prepared barley β-glucan extract. Two experiments with broiler chickens were performed. In the first experiment (Chapter 3), a commercially prepared barley β-glucan extract was added (15 g/kg diet) to a synthetic diet based on cornstarch and casein. In addition, the diet was heated to evaluate the effects of heat treatment on the anti-nutritive effects of β-glucan. The diet was fed to twenty 15-day-old male broilers for 7 days. Diets containing β-glucan reduced ($P<0.01$) nitrogen (N) and carbon (C) digestibility, increased in the full weight of the whole gut ($P=0.08$) and the caeca ($P<0.05$), and increased ($P<0.01$) the insoluble solids volume (ISV) and water holding capacity (WHC) of digesta of birds. Heating the diets decreased ($P<0.01$) N digestibility and increased the ISV of the digesta.

In the second experiment (Chapter 4), different amounts of the β-glucan extract were added to a barley-based diet to provide three different levels of dietary β-glucan (low (19.8 g β-glucan /kg diet), medium (50.7 g β-glucan/kg diet), and high (68.3 g β-glucan/kg diet)). In addition, a β-glucanase was added to each of the diets to assess its influence on digestibility, performance, and digesta physico-chemical properties. The diets were fed to 36, 15-day-old male broilers for seven days. Results showed variable responses. The values obtained for gross energy (GE) digestibility, and the weights of the whole gut empty and the second part of the small intestine full and empty were similar between diets of low and medium β-glucan content, but lower ($P<0.05$) than the values obtained with diet high. In the case of WHC and ISV, the values obtained with diets medium and high were similar, but higher ($P<0.01$ for WHC; $P<0.05$ for ISV) than the values obtained with diet low. For viscosity, the higher ($P<0.01$) values were obtained with diet low, while the values obtained with diets medium and low were similar. The variable responses were attributed to the soft gelatinisation of β-glucan when dispersed in water, which could have encapsulated the native β-glucan from barley, hindering any anti-nutritive effect it could have. Another possibility suggested was in terms of the threshold level of β-glucan needed to elicit its anti-nutritive effects, which was not reached in some of the diets. The β-glucanase

inclusion improved N, C ($P<0.05$), and GE ($P<0.01$) digestibility, decreased the viscosity of the digesta ($P<0.01$) and the weights of the whole gut and the second part of the small intestine ($P<0.01$), and improved the weight gain and feed conversion ratio (FCR) of the birds ($P<0.05$). The experiment also suggested that viscosity is not the main mechanism needed for the anti-nutritive effects of β-glucan because although the viscosity of most of the diets was low, the β-glucan still elicited some anti-nutritive effects. It is possible that the gelling capacity of the β-glucan extract was one of the main factors influencing the anti-nutritive effects of the extract.

In addition to these two studies, an *in vitro* digestibility method simulating the chicken's gut was developed to evaluate the anti-nutritive effects of β-glucan on N and C digestibility as well as on the physico-chemical properties of the digesta (Chapter 5). The method showed acceptable accuracy ($r=0.93$, $P<0.01$) in the prediction of N digestibility *in vivo* in a wide range of diets. In the case of C digestibility, although a significant correlation ($r=-0.64$, $P<0.05$) between the *in vitro* and *in vivo* values was found, the *in vitro* digestion did not reflect what happened during the *in vivo* digestion. This was possibly due to the fact that the *in vitro* assay was not designed to analyse C digestibility, and the results obtained were in fact an artifact of the data set. The physico-chemical properties of the digesta were not predicted accurately by the *in vitro* method because conditions such as the churning effect of the intestine and the action of the microorganisms present in the intestine, which greatly affect digesta, could not be replicated in the method.

The hypocholesterolemic effects of the β-glucan extract were evaluated in growing male rats through the inclusion of β-glucan in synthetic diets based on cornstarch and casein (Chapter 6). In addition, the effects of coconut oil (rich in saturated fatty acids (SFA)), and flax oil (rich in polyunsaturated fatty acids (PUFA)) in blood lipids were also evaluated. The diets were fed to 36 28-day-old male rats for 28 days. The results of this experiment showed a reduction ($P=0.07$) in total cholesterol (TC) levels by the inclusion of β-glucan. The kind of oil used in the diets did not affect TC levels ($P>0.05$). Serum TG levels were decreased ($P<0.01$) by inclusion of β-glucan. When coconut oil was used, β-glucan inclusion decreased ($P<0.05$) serum TG levels. However, when flax oil was used, β-glucan inclusion did not have any effect on TG ($P>0.05$). In addition, it is suggested that the hypocholesterolemic effects of the β-

glucan extract used were due to a decrease in lipid absorption in the small intestine, which was caused by the β-glucan inducing a gel formation, which delayed nutrient absorption. This gel formation induced by the β-glucan extract is considered to be one of the main factors responsible for the hypocholesterolemic effects of the β-glucan extract.

It is concluded that the anti-nutritive and hypocholesterolemic effects of barley β-glucans were demonstrated through the use of a commercially prepared barley β-glucan extract, and that the gel formation induced by the β-glucan extract could be one of the main mechanisms responsible for the anti-nutritive and hypocholesterolemic effects of this NSP, which could be equally important to increases in viscosity induced by intact β-glucan.

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LIST OF ABBREVIATIONS

ADG	AVERAGE DAILY GAIN
C	CARBON
DFI	DAILY FEED INTAKE
DHA	DECOSAHEXAENOIC
EMP	EMPTY
EPA	EICOSAPENTAENOIC
FA(S)	FATTY ACID(S)
FCR	FEED CONVERSION RATIO
GE	GROSS ENERGY
HDL	HIGH DENSITY LIPOPROTEIN
HMG CoA	β-HYDROXY-β-METHYLGLUTARYL COENZYME A
INT	INTESTINE
ISV	INSOLUBLE SOLIDS VOLUME
LDL	LOW DENSITY LIPOPROTEIN
Lp (a)	LIPOPROTEIN (a)
MUFA(S)	MONOUNSATURATED FATTY ACI(S)
N	NITROGEN
NSP	NON-STARCH POLYSACCHARIDES
PUFA(S)	POLYUNSATURATED FATTY ACID(S)

RO	REVERSE OSMOSIS
SFA(S)	SATURATED FATTY ACID(S)
TC	TOTAL CHOLESTEROL
TG	TRIGLYCERIDES
UFA(S)	UNSATURATED FATTY ACID(S)
UWL	UNSTIRRED WATER LAYER
VISC	VISCOSITY
VLDL	VERY LOW DENSITY LIPOPROTEIN
WHC	WATER HOLDING CAPACITY
β-GLUC	β-GLUCAN