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Assessing the implications of variability in the digestible protein and energy value of lupin kernel meals when fed to rainbow trout, *Oncorhynchus mykiss*

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Abstract

A series of studies were designed to examine the degree of variability in the digestibility of protein and energy from lupin (*Lupinus angustifolius*) kernel meals when fed to rainbow trout (*Oncorhynchus mykiss*) and the potential implications of this variability. The digestibility of protein and energy from 10 different varieties of lupin kernel meal was assessed where the test ingredient comprised 30% of each test diet. Digesta was collected using faecal stripping techniques. Digestible protein value ranged from 331 to 508 g/kg DM and digestible energy values ranged from 10.6 to 13.3 MJ/kg DM. To examine the implications of variability in digestible protein and energy value, two lupin kernel meals from the extremes of the protein digestibility range (Lupin-1: AD_N~70% and Lupin-2: AD_N~100%) were chosen for assessment in two growth studies. Soybean meal and a reference diet with fishmeal as the only protein source were also included in the study. In the first growth experiment the test ingredients were included at equal concentrations (40%) in protein-limiting diets (350 g protein/kg DM) and fed at either of two ration levels (restricted and satiety). Diets were formulated on a crude basis so as to place the test variable on the variability in digestible protein value of the diets. In the restricted-fed treatments growth of fish fed the reference diet was highest, but not significantly better than lupin-H. Growth of fish fed the lupin-L diet was significantly poorer than both the reference and lupin-H diets, but not poorer than the soybean diet. The growth responses observed from this experiment clearly showed that the differences in feed intake and/or digestible protein value could be demonstrated in terms of significant differences in growth outcomes. In a second growth study high-nutrient dense extruded diets (400 g protein/kg and 23.5 MJ/kg) were prepared with a more practical level of 25% inclusion of the same test materials. Again the diets were formulated on crude basis so as to place the test variable on the variability in digestible protein and energy value of the diets. Growth of fish restrictively fed the lupin-H diet was highest, but not significantly better than the soybean, reference or lupin-L treatments restrictively fed. Growth of fish satietal fed the soybean diet was significantly poorer than the reference and lupin-H diets, but not compared to the lupin-L diet. The growth responses observed from this experiment showed that the differences in digestible protein and energy value could not be demonstrated in terms of significant differences in growth outcomes, and that feed intake variability and excess nutrient supply masked the effect of this variability; particularly at the satietal feed intake levels.

Keywords: Grain; Digest; Variability; Lupin; Legume; Ingredient quality

1. Introduction

Lupin (*Lupinus* spp.) meals have been shown to provide some potential as a useful feed ingredient in fish diets and are being used in commercial diets in increasing quantities (De la

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Higuera et al., 1988; Burel et al., 1998). The Australian narrow-leafed lupin (*Lupinus angustifolius*) dominates world production and lupin use in aquaculture diets worldwide (Glencross and Hawkins, 2004; Glencross et al., 2004a). Typically it is the kernel meals of lupins that are being used in aquaculture diets because of their greater nutritional value than whole-seed meals (Glencross et al., 2007c).

However problems with high (>30%) inclusion levels of lupins in fish diets have been reported, including minor aberrations in digestion, growth and metabolic processes (Burel et al., 1998; Farhangi and Carter, 2001; Glencross et al., 2004b). These have been attributed to a range of issues including some possible anti-nutritional factors (Francis et al., 2001; Glencross et al., 2003b, 2006). In other studies a decline in growth has been noted with progressive inclusion of lupin, although it has been argued that this may be the result of variability in digestible or utilisation value of the diets with increasing inclusion level of lupin (Farhangi and Carter, 2001; Glencross et al., 2004b). However, it has been argued that digestible energy or protein measurement of lupins is not necessarily an adequate descriptor for quality of this grain and that there is a need to assessment of animal growth responses to varying inclusion or intake levels (van Barneveld et al., 1996).

The issue of variability in nutritional value can be resolved by using a pair-fed restricted feeding approach to limit intake variability and thereby place the experimental pressure on the nutritional composition of the diet, rather than the sum of this nutritional value and any feed intake effects. This experimental pressure can be further enhanced by using protein-limiting diets to ensure that the diet protein content becomes a more sensitive test variable (Glencross et al., 2003c, 2007a).

Another way of resolving whether lupin use actually affects the utilisation value of diets is to examine the protein and energy utilisation values of a series of diets using a bio-energetic approach (Cho and Kaushik, 1990; Kaushik and Medale, 1998; Glencross et al., 2007b). In this sense the efficiency with which dietary protein and energy are used for growth with varying feed intake levels can be used to discern the discrete nutritional value of a diet (Lupatsch et al., 2003; Glencross et al., 2007b). By comparing several diets, the relative protein and energy utilisation efficiency among the diets can be used to discern the discrete value of each diet and by inference its formulation variable. The advantage of such an approach is that by comparing regressed utilisation values, effects of variable intake or differences in digestible value of the diets can also be countered and considerable experimental power gained.

This study reports on the evaluation of the variability in the digestibility of a range of lupin kernel meals. The influence that this variability has on the overall nutritional value of the diets fed to rainbow trout, *Oncorhynchus mykiss* is then assessed in two separate experiments. Both protein-limiting and commercially equivalent diets were used to examine and the effects of the variability in digestible value of the lupin kernel meals.

2. Materials and methods

2.1. Raw materials

Ten samples of whole-seed *L. angustifolius* cultivars were obtained from the West Australian Department of Agriculture lupin breeding program at the Wongan Hills Research Station from the 2003 crop-season. The seed from each of the ten cultivars obtained was processed to produce kernel meals from each cultivar. For processing the seed was graded according to seed size using round-holed 7 mm, 6 mm and 5 mm sieves and each segregation, of each variety, separately split using a disc-mill dehulling unit (Department of Agriculture, South Perth, WA, Australia). The split (dehulled) segregation of each variety was then pooled prior to aspiration (air stream mediated density classification) to remove the hulls from the kernels. Any remaining seed hull fragments were manually removed to ensure a 100% pure preparation of seed kernels of each variety. The kernels were then rotor-milled (Retsch, Haan, Germany) through a 750 μm screen. The composition of all experimental diets is also presented in Table 1.

Table 1
Nutrient composition of the ingredients used in the studies (all values are g/kg DM unless otherwise indicated)

Actual	Fish meal	Wheat	Cellulose	Soybean	*L. angustifolius* kernel meals									
					Wonga	Gungurru	Kalya	Jindalee	Danja	Yorrel	Tallerack	Mandelup	Coromup	Myallie
Dry matter (g/kg)	931	905	941	913	916	914	916	921	914	916	917	916	919	921
Protein (N × 6.25)	749	142	0	531	487	538	508	485	514	481	515	505	505	452
Fat	87	24	2	15	70	63	60	74	70	71	52	62	66	73
Ash	161	11	2	68	34	38	39	34	39	29	37	35	36	33
Carbohydrate [a]	3	823	996	386	409	361	392	407	377	419	397	397	393	441
Energy (MJ/kg DM)	20.52	18.43	16.98	18.94	20.62	20.62	20.54	20.63	20.47	20.85	20.18	20.53	20.44	20.26
Sum of amino acids [b]	670	152	9	505	448	537	494	447	473	440	443	460	466	417
Arginine	41	7	0	36	54	66	59	54	57	51	54	52	59	48
Cysteine	10	4	0	10	7	7	8	7	8	7	7	8	6	6
Histidine	13	1	0	9	9	11	11	9	11	9	9	9	10	8
Isoleucine	29	5	0	22	18	20	19	17	19	17	17	18	17	16
Leucine	56	10	0	39	33	38	36	32	35	33	32	33	34	30
Lysine	55	5	4	32	21	24	23	20	22	21	21	22	23	20
Methionine	21	2	0	7	3	3	2	3	2	2	2	3	3	2
Phenylalanine	30	6	0	24	18	21	19	17	18	17	17	18	18	16
Threonine	32	5	1	20	16	18	17	16	17	17	16	18	19	16
Valine	33	6	0	23	17	18	17	16	17	16	16	18	18	15

[a] Based on dry matter minus protein, fat and ash content.
[b] Includes all amino acids except tryptophan which was unable to be determined using the hydrolysis method used in this work.