

# The effect of dietary levels of yellow lupin seeds (*Lupinus luteus* L.) on feed preferences and growth performance of young pigs

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## ABSTRACT

Feed preference (Experiment I) and growth performance tests (Experiment II) were carried out on growing pigs fed on diets differing in yellow lupin levels. In Experiment I, dietary choices were determined using the single stimulus method on 12 individually kept young pigs. In Experiment II, basic growth parameters were studied in 36 young pigs. Three diets were used: control (1), with soyabean meal (SBM) as the only high-protein component, and experimental diets in which lupin protein substituted for 75 (diet 2) or 100% (diet 3) of SBM protein. The lupin content in diets 2 and 3 was 19 and 25%, respectively.

During a 28-day feed preference test, daily intake of the three diets amounted to 760, 736 and 700 g, respectively; the differences are statistically significant. The average daily weight gains and feed intake were similar, while the best feed conversion ratio was in pigs fed on the diet with 19% yellow lupin seed meal.

**KEY WORDS:** pigs, nutrition, yellow lupin, cv. Juno, feed preferences, growth performance

## INTRODUCTION

The use of leguminous plant seeds in the diets for monogastric animals is restricted due to the antinutritional factors contained in these seeds. Alkaloids are

considered the most important factors in lupin seeds. This is one of the reasons why the optimum content of lupin in the diets for pigs, and especially for young piglets, has never been established in an unequivocal way. Low-alkaloid sweet lupin varieties have been produced to eliminate the negative effects of these factors on animal health and performance and to make utilization of this high-protein feed in pig nutrition possible as a partial or even total substitute for soyabean meal (Kemmer et al., 1987; Flis, 1993).

Some experiments showed that even a relatively high content of lupin seeds did not affect the performance of piglets and young growing pigs (37%, Pearson and Carr, 1976; 43%, Barnett and Batterham, 1981). Böhme (1988) found that supplementing the diet with up to 30% „Topaz” yellow lupin seeds had a positive effect on the performance of weaned pigs (10-25 kg). In the experiment carried out by Gdala et al. (1996) it was concluded that seeds of yellow and narrow-leaved lupin could be used at a level of up to 41% in diets without depressing growth performance as compared with a soyabean diet. On the other hand, the results of other experiments suggested that lupin seeds could be used in pig feeding at a much lower dietary level (King, 1981; Donovan et al., 1993; McNiven and Castell, 1995).

Many studies have shown the negative effects of alkaloid- (Godfrey et al., 1985; Kemmer et al., 1987), high crude fibre- (McNiven and Castell, 1995), and low lysine- (Batterham et al., 1986b) contents of lupin seeds, but primarily, of their low methionine level (Eggum et al., 1993). Godfrey et al. (1985) recommended that the diets of pigs fed *ad libitum* should not contain more than 0.20 g/kg of alkaloids. These authors found that an increase of alkaloid levels from 0.12 to 0.52 g/kg resulted in a progressive decrease of daily weight gains and feed intake by piglets. An increase in the alkaloid level by 0.1 g/kg was accompanied by a decrease of daily gains by 47 g on average, and of feed intake by 0.12 kg/day. However, alkaloid composition and type are also very important. In the case of white- and narrow-leaved lupin, the main alkaloids are lupanine and sparteine, considered more detrimental than the less-toxic lupinine, which is the dominant alkaloid in yellow lupin (Hill, 1977; Ballester et al., 1980). This is why yellow lupin seeds are regarded as more suitable for pigs.

So far, however, there have been no studies on the effect of high lupin levels on the palatability of diets for young growing pigs or on feed preferences and performance of young pigs.

The objective of this study was to determine the suitability of diets containing high levels of meal from raw seeds of Polish sweet yellow lupin cv. „Juno” for young pigs. Two criteria were used to evaluate the diets: 1. the results of the feed preference test (Experiment I) and 2. the growth performance test (Experiment II).

## MATERIAL AND METHODS

*Composition of the diets*

Three complete diets of the grower type (17.5% crude protein) were prepared according to Nutrient Requirements of Pigs (1993) (Table 1). In the control diet (1), soyabean meal was the only high-protein component. In diet 2 raw ground seeds of sweet yellow lupin, Polish variety „Juno”, constituted 19% of the diet, replacing 75% of the soyabean meal protein. In diet 3, lupin „Juno” replaced 100% of the soyabean meal protein, constituting 25% of the diet. Feeds were supplemented with lysine and methionine according to Polish standards.

TABLE 1

Composition and nutritive value of diets for young pigs (Experiments I and II)

Indices	Diets		
	1	2	3
<b>Ingredients, %</b>			
ground barley	44.10	40.07	40.02
ground wheat	30.00	30.00	30.00
soyabean meal	21.00	6.00	-
lupin ( <i>L. luteus</i> cv. Juno) seed meal	-	19.00	25.00
Formosan *	3.10	3.10	3.10
PP - prestarter premix **	1.50	1.50	1.50
L - lysine (99%)	0.25	0.25	0.28
DL - methionine (99%)	0.05	0.08	0.10
<b>Chemical composition, % DM</b>			
dry matter	90.28	90.00	90.18
crude protein	18.02	18.38	18.03
crude fat	1.66	1.91	1.92
crude fibre	3.96	5.80	6.16
N - free extractives	60.14	58.24	58.08
crude ash	6.50	5.67	5.99
organic matter	83.78	84.33	84.19
total alkaloids, g/kg DM	-	0.074	0.097
<b>Metabolizable energy, MJ/kg</b>			
(calculated)	12.64	12.55	12.54

\* Formosan contains per 1 kg: Ca, 275,0 g; P, 77,0 g; Na, 32,5 g; Cl, 23,2 g; Mg, 9,0 g; Zn, 2,0 g; Fe, 0,78 g; Cu, 0,20 g; Mn, 0,63 g; Co, 0,04 g; J, 0,02 g; S, 0,60 g

\*\* PP - prestarter premix contains per 1 kg: vit. A, 500.000 IU; vit. D<sub>3</sub>, 100.000 IU; vit. E, 0,75 g; vit. K<sub>3</sub>, 0,15g; vit. B<sub>1</sub>, 0,06g; vit. B<sub>2</sub>, 0,125g; vit. B<sub>12</sub>, 0,0015 g; biotin, 0,01 g; nicotinic acid, 0,5 g; calcium pantothenate, 0,4 g; Mn, 1,0 g; Co, 0,005 g; Zn, 2,25 g; Cu, 0,25 g; Fe, 3,5 g; J, 0,025 g; tylosine, 2,0 g; anti-oxidante, 5,0 g; carrier up, to 1000 g

Nutrient contents in the diets and yellow lupin „Juno” were analysed according to the Weende method (Tables 1 and 2). Total alkaloid content in lupin seeds was determined by the method of Wysocka et al. (1989). The contents of crude fibre, neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) in lupin seeds were determined using Fibertec System M by methods described by Van Soest and Wine (1967) and Van Soest (1973). Cellulose and hemicellulose contents were calculated based on NDF, ADF and ADL. The essential amino acid contents of „Juno” seeds was determined with an automatic analyser AAAT 339 Mikrotechna, tryptophan was analysed according to Eggum (1968).

### *Experimental design*

*Feed preference test (Experiment I).* Twelve young pigs (crosses of ♀ Polish Landrace x ♂ Polish Large White), aged 8 weeks, of initial body weight 22.5 kg, were selected based on sex, litter and liveweight (analogue method). Each was

TABLE 2

Chemical composition of yellow lupin seed cv. Juno

Specification	Yellow lupin
Chemical composition, % DM	
dry matter	91.72
crude protein	42.15
crude fat	3.76
crude ash	4.92
crude fibre	16.52
NDF	23.07
ADF	19.38
ADL	0.44
cellulose	18.95
hemicellulose	3.68
alkaloids	0.039
Essential amino acids, g per 16 g N	
His	2.63
Lys	4.97
Phe + Tyr	7.05
Met + Cys	2.90
Thr	3.37
Trp	0.84
Ile	4.29
Leu	7.53
Val	4.19

placed in a 0.7 x 1.2 m flat-deck cage (with slatted floor), in an experimental pig unit. The cages had automatic feeders and nipple watering containers.

The feed preference test lasted 28 days and was carried out using the single stimulus method of Aldinger and Fitzgerald (1966), used also in other experiments (e.g. Baidoo et al., 1986; Falkowski et al., 1998). Each day the animals had free access, successively for 4 h (from 8.00 to 20.00 h), to each of the three feeds. The sequence of feeds changed every day, so that the pigs could not get accustomed to a particular feed. Feed intake was controlled each day. The animals were weighed on days 1, 14 and 28 of the experiment.

*Growth performance test (Experiment II).* Growth performance was evaluated during 28 days on 36 young pigs (crosses of ♀ Polish Landrace x ♂ Polish Large White) aged 8 weeks, of initial body weight 18.8 kg. They were allocated to the three groups according to the analogue method. Two animals (a male and a female) each were placed in a flat-deck cage (0.7 x 1.2 m). The animals were fed *ad libitum* on diets of the composition as in Experiment I. Pigs were weighed on days 1, 14 and 28, feed intake and animal health were controlled daily.

#### *Statistical analysis*

The data were analysed statistically with a one-way analysis of variance and the Duncan's test. The statistical programme SPSS (1995) was used.

## RESULTS AND DISCUSSION

The chemical composition of the diets is presented in Table 1. The increase of raw fibre content in diets 2 and 3 was due to the relatively high content of CF in lupin seeds (16.52%).

The alkaloid content in lupin was 0.039% of DM (Table 2), which is lower than the acceptable level for sweet (low-alkaloid) lupin 0.05% DM, but higher than the level accepted in commercial seeds in the European Union (0.02% DM) and Australia (0.01% DM).

In the first period of Experiment I (days 1-14), the average feed intake did not differ significantly between the groups (Table 3), while in the second period it decreased as the lupin level increased. This tendency was maintained in the whole experiment, but only the diet with the highest lupin level was consumed at a significantly lower rate than the control one (760 g for the control diet, and 736 and 700 g for diets 2 and 3, respectively), which may be explained by the negative effect of lupin alkaloids on diet palatability. A similar experiment, performed on weaned piglets given diets in which narrow-leaved lupin „Emir” was used at a

TABLE 3

Average daily intake of diets per pig, g (Experiment I)

Period of experiment days	Total daily intake	Daily intake of diets		
		1	2	3
		Dietary alkaloids, g/kg DM		
		-	0.074	0.097
1 - 14				
$\bar{x}$	1946	655	651	641
s	213.1	85.1	80.1	89.3
%	100	34	33	33
15 - 28				
$\bar{x}$	2444	865 <sup>A</sup>	821 <sup>B</sup>	759 <sup>C</sup>
s	297.1	107.6	129.1	142.1
%	100	35	34	31
1 - 28				
$\bar{x}$	2195	760 <sup>Aa</sup>	736 <sup>Ab</sup>	700 <sup>B</sup>
s	358.9	142.7	137.4	132.6
%	100	35	33	32

<sup>A,B,C</sup> -  $P \leq 0.01$ ; <sup>ab</sup> -  $P \leq 0.05$ 

level of 14% and replaced 50% of the soyabean protein, showed that there was no effect of lupin on palatability as compared with the control cereal-soyabean diet (Falkowski and Jablonowski, 1993).

The pigs showed very good growth performance throughout the experiment, as reflected by high body weight gains averaging 902 g (918 and 886 g in the first and the second period of the experiment, respectively). In the previous feed preference tests it was also found that the pigs that were allowed to consume more than one feed tended to eat more and to grow faster than normally fed pigs (Baidoo et al., 1986; Falkowski et al., 1998).

In Experiment II, no statistically significant effect of the experimental diets on pig body weight and growth rate was found, but the highest body weight on days 14 and 28 was observed in group 2 fed diets containing 19% of lupin seeds (Table 4).

Average daily feed intake per animal (Table 4) in the first period of the experiment did not differ between groups, ranging from 1.19 kg in group 1 to 1.23 kg in group 3. Similar tendencies were observed in the second period. In the experiment of Böhme (1988), yellow lupin „Topaz” at the level of 30% increased feed intake of weaned piglets up to 7%. The addition of 25.4% of white lupin „Ultra” to the diet for growing pigs significantly increased feed intake in the experiment carried

out by Batterham (1979), while Kemm et al. (1987) found that when the diets for early weaned pigs were supplemented with 12% of white lupin „Buttercup” seeds containing 0.05% of alkaloids, feed intake decreased by 21%.

In the whole period of the experiment, daily weight gains were 676, 706 and 693 g in the three groups respectively, being a little higher in the experimental groups than in the control (Table 4). Daily weight gains obtained in our experiment were similar to those observed by King (1981) (622-693 g) and Donovan et al. (1993) (610-750 g), but slightly lower than those presented by Godfrey et al. (1985) (776-817 g). Lower daily gains (510-528 g) were obtained by Böhme (1988)

TABLE 4

Growth performance of pigs (Experiment II)

Specification	Period of experiment days	Diets		
		1	2	3
		Dietary alkaloids, g/kg DM		
		-	0.074	0.097
Average initial body weight, kg	$\bar{x}$	1	18.7	18.9
	s		5.6	4.3
Average daily feed intake, kg per pig	$\bar{x}$	1 - 14	1.19	1.21
	s		0.33	0.31
	$\bar{x}$	15 - 28	1.86	1.79
	s		0.35	0.40
	$\bar{x}$	1 - 28	1.52	1.49
	s		0.48	0.46
Average daily gain, g	$\bar{x}$	1 - 14	542	597
	s		174	183
	$\bar{x}$	15 - 28	810	815
	s		164	166
	$\bar{x}$	1 - 28	676	706
	s		215	205
Feed /gain ratio	$\bar{x}$	1 - 14	2.28 <sup>A</sup>	2.09 <sup>B</sup>
	s		0.54	0.39
	$\bar{x}$	15 - 28	2.35	2.24 <sup>B</sup>
	s		0.48	0.51
	$\bar{x}$	1 - 28	2.31 <sup>A</sup>	2.17 <sup>B</sup>
	s		0.51	0.46

<sup>A,B</sup> - P ≤ 0.01

in an experiment with diets containing yellow lupin and by Gdala et al. (1996) (391-416 g), when the inclusion level of lupin seed meal (white, yellow or narrow-leaf) in barley-based diets for young pigs ranged from 31 to 41%.

The feed conversion ratio differed significantly between the experimental groups, both in the first and the second period (Table 4). The animals in group 2 on the diet containing 19% of yellow „Juno” lupin seeds utilized the feed better than the other animals (2.17 kg/kg of body weight gain for the whole period of the experiment). Similar results were presented by Batterham et al. (1986a) (1.98-2.53 kg/kg BW), while a better feed conversion ratio was obtained by Gdala et al. (1996) (1.65-1.78 kg/kg) and Böhme (1988) (1.50-1.57 kg/kg). King's suggestion (1981) that increasing levels of lupin in the diet significantly reduced growth performance and increased feed conversion ratio has not been confirmed.

The relatively high content of alkaloids in the diet did not have a negative effect on growth performance of the pigs, but was probably the reason for worse feed utilization in pigs on the diet with the high lupin seed content (25%), which replaced 100% of soyabean meal proteins (Table 4).

## CONCLUSIONS

Increasing the content of yellow lupin seeds from 0 to 19 and 25% in the diets negatively affected the feed preferences of young growing pigs. However, the average growth rate and daily feed intake during the growth performance test were similar and the feed conversion ratio was the best on the diet containing 19% of yellow lupin seed meal.

Yellow lupin seeds may be used as a partial substitute of soyabean meal for young pigs fed on diets supplemented with lysine and methionine.

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## STRESZCZENIE

**Wpływ mieszanek z różnym udziałem nasion łubinu żółtego (*Lupinus luteus* L.) na smakowitość i wyniki odchowu młodych, rosnących świń**

Badano 3 diety: 1. kontrolną, w której jedynym składnikiem wysokobiałkowym była poekstrakcyjna śruta sojowa; 2. w której 75% białka ogólnego poekstrakcyjnej śruty sojowej zastąpiono białkiem ogólnym łubinu żółtego; jego udział w diecie wynosił 19%; 3. 100% białka ogólnego poekstrakcyjnej śruty sojowej zastąpiono białkiem łubinu żółtego; jego udział w diecie wynosił 25%. Przeprowadzono 2 doświadczenia: (I) test preferencji pasz i (II) odchów prosiąt. W doświadczeniu I na 12 indywidualnie utrzymywanych młodych, rosnących świniach (♀ polska biała zwisłoucha x ♂ wielka biała polska) badano preferencje pokarmowe wykorzystując metodę pojedynczego bodźca. W doświadczeniu II na 36 młodych, rosnących świniach (takich samych mieszańcach jak w doświadczeniu I), badano podstawowe parametry zootechniczne.

Podczas 28-dniowego testu preferencji pasz średnie dzienne spożycie 3 mieszanek wynosiło odpowiednio: 760, 736, 700 g i różniło się istotnie. Średnie dzienne przyrosty i średnie dzienne spożycie paszy przez 1 świnie w okresie odchowu były zbliżone. Wykorzystanie paszy na 1 kg przyrostu masy ciała było najlepsze przy stosowaniu diety z 19% udziałem śruty z nasion łubinu żółtego.