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TOLERANCE OF GROWING AND FATTENING PIGS TO SWEET WHITE LUPIN ALKALOIDS

TOLERANTNOST SVINJA U PORASTU I TOVU NA RAZINU ALKALOIDA IZ SLATKE BIJELE LUPINE

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SUMMARY

The objective of this research was to examine growing and fattening pigs tolerance to increased levels of total alkaloids from the sweet white lupin (Lupinus albus L.) cv. Bosna.

The experiment was carried out on 132 pigs divided into two repetitions with 33 animals per treatment. Pigs were fed compounded feed in which 0, 33, 66 and 100 % of soy-bean meal was substituted by raw lupin seed (0,075 % of alkaloids).

Dier for growing pigs from 20-60 kg contained 0.0, 34.5, 69.0 and 102.0 mg/kg of total alkaloids, while the diet for growing pigs from 60-100 kg contained 0.0, 31.5, 61.5 and 93 mg/kg of total alkaloids.

Growing pigs achieved lower ($P< 0.05$) final liveweight and daily gain, and feed intake had decreased.

During 77-day period, the influence of alkaloid level was greater on daily gain ($r = -0.802$) than on feed intake ($r = -0.499$). In 52-day fattening period, pigs were sensitible ($P< 0.05$) to higher (61.5 and 93 mg/kg) alkaloid levels. Also, negative correlation of increased alkaloid levels to daily gain ($r = -0.715$), as well as to feed intake ($r = -0.421$) was established.

Cold carcass weight was the lowest ($P< 0.05$) in pigs fed diets averaging 65.3 and 97.5 mg/kg of total alkaloids during the experiment, while dressing proportion and backfat thickness were lowest in groups ($P< 0.05$) with the highest alkaloids level.

Growing pigs from 20 to 60 kg liveweight responded to low alkaloid level (34.5), but fatteining pigs from 60 to 100 kg tolerated up to 69 mg/kg of total alkaloids from sweet lupin cv. Bosna.

Keywords: lupin, alkaloids, pig performances

INTRODUCTION

Most grain legumes contain an array of secondary metabolites which constituent important defenses of the plant against insects and herbivores. These so called antinutritional factors (ANF) often have determinable ef-

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fects on mammalian digestion and metabolism (Dixon and Hosking, 1992).

Although lupin seed is relatively high in protein, lysine, threonine and tryptophan (King, 1990), and contains no factors which interfere with digestion (Wiesman and Cole, 1988), the variable levels of alkaloids, high content of manganese and fungal toxins, inadequacies in content of methionine and possible poor utilization of lysine, and contamination with bitter varieties (Gladstones, 1972) place limitations on the upper levels of dietary inclusion (Eggum et al., 1993). Pigs appear to be particularly sensitive to lupine alkaloids (Hackbarth, 1961) which cause feed rejection, vomiting, retared growth, and even death in growing pigs (Godfrey et al., 1985).

To solve this problem, plant breeders have bred and released several sweet varieties with a low toxic alkaloid content (Gladstones, 1972). There has been a praise to pay in reducing alkaloid levels in cultivated sweet lupins, since the cultivars so produced are more vulnerable to microbial infection and pest attack (Williams, 1984; Wink, 1987). As a consequence, the toxicity associated with sweet lupins - lupinosis- is a special case of micotoxicosis and is not due to lupin chemistry. Lupinosis is caused by micotoxins of the fungus Phomopsis leptostromiformis which infects sweet lupin plants (Mortimer and Ronaldson, 1983). Only the major toxin, phomopsin A, causing severe liver injury, and sometimes photosensitisation (Harborne, 1991).

Alkaloids are detectable in all lupin seed. The content and the composition of alkaloid varies between and within species and cultivars (Cheeke and Kelly, 1989), and is greatly affected by growing conditions (Godfrey et al., 1985) and season (Godfrey et al., 1985). The concentration of alkaloid is higher in seed than vegetative parts of mature lupin plant. Williams and Harrison (1983) measured alkaloids levels throughout the life cycle in cultivated forms of L. albus, L. angustifolius and L. mutabilis and found that vegetative tissue contains between 0.3 and 0.6% dry wt, whereas the seed have up to 1.8%. According to Hudson (1979) and Batterham (1989) 25-fold or higher level of alkaloid are found in bitter (2.5% or more) than in sweet (<0.01 to 0.03%) lupin seed.

The alkaloids of Lupinus, collectively termed lupinus alkaloids (e.g., sparteine, lupinidine, lupanine, hydroxylupanine, lupinine etc.) slightly differ in their chemical structure (Jecsai et al., 1986). They are almost exclusively of the quinolizidine type, with a nucleus of two six members carbon rings fused together and sharing a nitrogen atoms (Waller and Nowacki, 1978) which impart a bitter taste of seed and act as inhibitors of the central nervous system. But, lupin alkaloids are different in toxicity. In toxicity studies on guinea-pigs, d-lupanine proved to be most toxic, followed by sparteine, lupanidine, lupanine and hydroxylupanine (Couch, 1926), Hatzold et al., (1983) stressed that lupanine and sparteine have 10-fold higher toxicity than 13- hydroxylupanine.

Production studies have shown that pigs performance is recorded with dietary inclusion levels of up to 40% L. angustifolius (Pearson and Carr, 1976, Barnett and Batterham, 1981). There is more concern with the tolerance levels of L. albus cultivars (Hill, 1986). As a consequence, maximum tolerance levels of 4-15% have been recommended (Hale and Miller, 1985; Petersen and Schulz, 1978; Rioperez et al., 1987, Godfrey, 1973). However, results are variable and Batterham et al. (1986) reported satisfactory performance of pig given diets containing 37% L. albus seedmeal. The reason for the variable and lower tolerance to cultivars of L. albus has not been positively established. (Batterham, 1989).

Pearson and Carr (1977) reported that young pigs rejected feed which contained 0.33 g/kg of lupin alkaloids, but accepted feed in which the alkaloid level had been reduced to 0.07 g/kg. Godfrey et al. (1985) observed that growing pigs, with ad libitum feeding, could tolerate up to 0.20 g/kg of dietary alkaloids.

In both studies pigs were fed with Australian and New Yealand L. angustifolis cultivars which have less total alkaloid than L. albus. A limited amount of information has been published about adverse effect of total alkaloid from white sweet lupin on pig performance.

The aim of the study was to determine the influence of different levels of total alkaloid from sweet white lupin (L. albus) cv. Bosna on the growing and finishing pigs performance.

MATERIAL AND METHODS

Animals and diets

Two repetitions with four groups per repetition were arranged in randomized block design with 16 or 17 Large White X Swedish Landrace pigs to each group. They were blocked on the basis of age, sex and litter origin and liveweight at approximately 20 kg. Within repetitions and groups animals were allotted dietary treatments at random four isoenergetic and isonitrogenous diets provided four different levels of alkaloids which were formulated so that the soybean meal representing the main protein source was replaced in 0, 33, 66 and 99% with protein of sweet white lupin seed. The similar amino acid

composition was accomplished with simultaneously increasing levels of fish meal in diets with higher level of lupin seeds (Table 3).

The sweet white lupin seed (L. albus) cv. Bosna was produced in the North-West region of Croatia.

The gross composition and nutrient contents of the experimental diets are shown in Table 3. They were formulated to contain adequate concentration of nutrients for growing (20 - 60 kg) and fattening (60 - 100 kg) pigs as recommended by NRC (1988).

Chemical analyses

The lupin seed and feed mixtures were analyzed for dry matter, ash, nitrogen, ether extract and crude fiber by standard procedures on the Association of Official Analytical Chemists (1980) using Tecator equipment (Table 1).

Table 1. Chemical composition and alkaloid content in sweet lupin (Lupinus albus L) cultivar Bosna (% air-dry weight)
Tablica 1. Kemijski sastav i sadržaj alkaloida u slatkoj lupini (Lupinus albus L) kultivar Bosna (% zrako-suhe tvari)

Chemical composition Kemijski sastav			
Moisture Vlaga	11.42	Crude fiber Sirova Vlaknina	10.35
Ether extract Sirova mast	6.08	Crude protein Sirove bjelančevine	34.64
Ash Pepeo	3.88	NFE NET	33.63
Total Alkaloids Ukupni alkaloidi (mg/kg)			750.00

The total amino acids (except tryptophan) of lupin and soybean meal (Table 2) were determined after 24 h hydrolysis with 6 N HCl at 145°C using Milton Roy HPLC (High-Pressure-Liquid-Chromatography) analyzer (Roach and Gherke, 1979). Tryptophan was determinated the same way, after alkaline hydrolysis with litium hydroxide (Mason et al., 1980).

The total amount of alkaloids was assayed according to the procedure described by Bernasconi at al. (1965): alkaloids were extracted qualitatively by four successive macarations of ground seed in ammoniacal diethylether; they were separated by silica gel G chromatography (cyclohexane : diethylamine 7 : 3 v/v) then elated with chloroform-methanol (1 : 1 v/v). Colored complexes of alkaloids and methyl orange at pH 5 were made and these complexes and extracted with chloroform were assayed at 445 nm. The OD values obtained were referred to a stand ard curve of pure alkaloids (Table 1).

Procedure

Pigs were given ad libitum access to feed in self feeders and water by nipple drinkers. Animals were weighted at the beginning and end of both the growing and fattening periods after withdrawing feed for 12 h. In each group feed intakes were recorded as differences between feed offered and feed refused.

Table 2. Amino acid composition of sweet lupin seed (Lupinus albus L) cultivar Bosna and soybean meal (g per 16 g N)
Tablica 2. Aminokiselinski sastav zrna slatke lupine (Lupinus albus L) kultivar Bosna i sojine sačme (g/16 g N)

Amino acid composition Aminokiselinski sastav	Lupin Lupina	Soybean meal Sojina sačma
Alanine Alanin	2,72	4,22
Arginine Arginin	7,34	4,26
Asparic acid Asparaginska k.	8,77	8,75
Cystine Cistin	**2,15**	**1,19**
Glutamic acid Glutaminska k.	34,69	18,85
Glycine Glicin	4,81	3,28
Histidine Histidin	2,15	4,71
Isoleucine Izoleucin	1,98	7,63
Leucine Leucin	4,73	7,63
Lysine Lizin	**5,19**	**6,28**
Methionine Metionin	**0,86**	**1,35**
Phenylalanine Fenilalanin	4,04	4,94
Proline Prolin	2,15	2,40
Serine Serin	5,50	6,69
Threonine Treonin	2,92	3,81
Tryptophan Triptofan	**0,97**	**1,22**
Tyrozine Tirosin	2,75	3,23
Valine Valin	4,38	5,16

Performance was assessed in terms of live-weight gain per day, feed intake and feed conversion ratio over the growth and fattening phases.

Table 3. Percentual composition and nutrient content of fodder mixtures used in growing and fattening pigs (%)
Tablica 3. Postotni sastav krmnih smjesa i sadržaj hranjivih tvari u krmnim smjesama za svinje u porastu i tovu (%)

Phase Faza	Growing 20 - 60 kg Porast 20 - 60 kg				Fattening 60 - 100 kg Tov 60 - 100 kg			
Total alkaloids (mg/kg) Ukupni alkaloidi (mg/kg)	0,0	34,5	69,0	102	0,0	31,5	61,5	93,0
Maize Kukuruz	71.4	70.7	70.7	71.1	75.5	74.7	74.8	74.8
Wheat feed meal Pšenično krmno brašno	5,0	5,0	5,0	5,0	5,0	5,0	5,0	5,0
Sweet lupin Slatka lupina	**0.0**	**4.6**	**9.2**	**13.6**	**0.0**	**4.2**	**8.2**	**12.4**
Soybean meal Sojina sačma	11.0	7.3	3.6	0.0	10.0	6.6	1.5	0.0
Sunflower meal Suncokretova sačma	3.0	3.0	3.0	1.0	3.0	3.0	3.4	1.5
Fish meal Riblje brašno	4.0	4.0	4.1	5.0	1.0	1.0	1.1	1.8
Alfalfa meal Dehidrirana lucerna	3.8	3.5	2.5	2.5	3.5	3.5	2.5	2.5
Limestone Vapnenac	0.6	0.9	0.9	0.8	1.0	1.0	1.0	1.0
Dicalciumphosphate Dikalcij fostat	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Salt Sol	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Premix	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Chemical Analysis Kemijska analiza							
Crude protein Sirove bjelančevine	15.3	15.2	15.1	15.1	13.2	13.1	13.0	13.0
Crude fiber Sirova vlaknina	4.0	4.1	4.1	4.1	4.0	4.1	4.1	4.0
Calcium Kalcij	0.59	0.64	0.63	0.63	0.54	0.54	0.53	0.53
Phosphorus Fosfor	0.49	0.52	0.51	0.51	0.45	0.44	0.43	0.44
	Calculated values Kalkulativne vrijednosti							
Lysine Lizin	0.76	0.77	0.77	0.79	0.58	0.59	0.59	0.61
Methionine Metionin	0.35	0.36	0.34	0.32	0.31	0.30	0.29	0.27
Cystine Cistin	0.23	0.25	0.25	0.25	0.22	0.24	0.24	0.23
ME (MJ/kg)	13.0	13.1	13.0	13.1	13.1	13.1	13.1	13.1

The pigs were slaughtered as soon as possible after 129 days of experiments. Before slaughtering, pigs underwent a 24 h starvation period. The cold carcass measurements were determined after hanging carcass for 72 h in a cold-room.

The results were analyzed by analysis of variance and response to levels of alkaloids separated into linear and quadratic components using the General Linear Models procedure of SAS/STAT (1989).

Results

Sweet white lupin cv. Bosna contained 0.75 g/kg of total alkaloids and was rich in protein and fat (Table 1), particularly in cystine, but was poorer than the soybean meal in content of the most important amino acids, such as lysine, methionine and marginally, thryptophane (Table 2).

Inclusion of lupin into animal feed decreased ($P< 0.05$) finishing weights of growing pigs after 76 days of feeding with lupin (Table 4). The increase of the lupin share in diet to 4.6, 9.2 and 13.6% was followed by progressive decrease ($P< 0.05$) of daily gain. Lupin alkaloids level adversely affected daily gain ($r = -0.802$).

Equation of regression showed a decrease of daily gain by 1.24 g/d for each mg of alkaloids ("x")

$$y = 607 - 1{,}24x \quad (R=0{,}69: N=8);$$

where "y"is daily gain (g/d) and "x" is the level of alkaloids in feed mix (mg/kg).

The effect of level of alkaloids on daily feed intake was also negative ($r = -0.499$). Feed intake was lower (-13.59%) in pigs feed mixes containing higher levels of total alkaloids (69 and 102 mg/kg). The influence of level of alkaloids in lupin on feed conversion ratio was inconsistent.

Table 4. The productivity of growing pigs from 20 to 60 kg liveweight fed diet with various alkaloid levels
Tablica 4. Proizvodni rezultati svinja u porastu hranjene krmnim smjesama s različitim razinama alkaloida od 20 do 60 kg tjelesne mase

	Levels of alkaloids (mg/kg) Razina alkaloida (mg/kg)							
Parameters Pokazatelji	0,0		34,5		69,0		102,0	
	$\bar{x}$	$\pm s_{\bar{x}}$	$\bar{x}$	$\pm s_{\bar{x}}$	$\bar{x}$	$\pm s_{\bar{x}}$	$\bar{x}$	$\pm s_{\bar{x}}$
Number of animals Broj životinja	33		33		33		33	
Initial body weight,kg Početna tjelesna masa,kg	20,85a	0,47	21,06a	0,35	20,50a	0,31	21,11a	0,46
Final body weight,kg Završna tjelesna masa,kg	67,78a	1,28	63,53b	1,39	60,72bc	1,12	58,82c	1,22
Daily gain (g/day) Dnevni prirast (g/d)	618a	14,40	560b	16,94	529bc	14,39	496c	16,42
Feed intake (kg/day) Konzumacija (kg/d)	2,06		1,97		1,78		1,78	
Index%	100		95,63		86,41		86,41	
Feed conversion ratio (feed/gain) Konverzija (kg/kg)	3,33		3,52		3,36		3,58	
Index,%	100		105,71		100,90		107,51	

Values in the same row following different letters are significantly different (P< 0,05)
Vrijednosti u istom redu koje slijede različita slova singifikantno su različite (P< 0,05)

Table 5. The productivity of fattening pigs fed diet with various levels of alkaloids from 60 to 100 kg liveweight
Tablica 5. Proizvodni rezultati svinja u tovu hranjenih krmnim smjesama s različitim razinama alkaloida od 60 do 100 kg tjelesne mase

	Levels of alkaloids (mg/kg) Razina alkaloida (mg/kg)							
Parameters Pokazatelji	0,0		31,5		61,5		93,0	
	$\bar{x}$	$\pm s_{\bar{x}}$	$\bar{x}$	$\pm s_{\bar{x}}$	$\bar{x}$	$\pm s_{\bar{x}}$	$\bar{x}$	$\pm s_{\bar{x}}$
Number of animals Broj životinja	33		33		33		33	
Final body weight,kg Završna tjelesna masa,kg	100,50a	1,37	99,47a	1,54	89,94b	1,54	84,67b	1,62
Daily gain (g/day) Dnevni prirast (g/d)	629a	24,71	691b	21,11	562c	22,08	498d	12,38
Feed intake (kg/day) Konzumacija (kg/d)	2,45		2,71		2,39		2,26	
Index%	100		110,6		97,6		92,25	
Feed conversion ratio (feed/gain) Konverzija (kg/kg)	3,90		3,92		4,25		4,53	
Index,%	100		100,5		108		116	

Values in the same row following different letters are significantly different (P< 0,05)
Vrijednosti u istom redu koje slijede različita slova singifikantno su različite (P< 0,05)

During this experimental period the symptoms of toxic effect of alkaloids were not noticed, nor was vomiting among pigs.

After 52 days of fattening, finishing weights were lower ($P < 0.05$) for pigs fed feed mixes containing 61.5 and 93 mg of alklaoids per kg of feed mix. Pigs given 4.2% of lupin had higher ($P < 0.05$) and other groups had lower ($P < 0.05$) daily gain then the group that was not given the lupin (Table 5).

As in the previous, period concentration of alkaloids of 31.5 mg/kg strongly decreased daily gain ($r = -0.715$). Relation between daily gain and content of alkaloids is shown by the linear regression equation

$$y = 662.8 - 1{,}38x \ (R=0{,}59: N=8);$$

where "y"is daily gain (g/d) and "x" is level of alkaloids in feed mix (mg/kg).

Table 6. The productivity of growing and fattening pigs fed diet with various alkaloid level from 20 to 100 kg liveweight
Tablica 6. Proizvodni rezultati svinja u porastu i tovu hranjenih krmnim smjesama s različitim razinama alkaloida od 20 do 100 kg tjelesne mase

Parameters Pokazatelji	Levels of alkaloids (mg/kg) Razina alkaloida (mg/kg)							
	0,0		33		65,3		97,5	
	$\bar{x}$	$\pm s_{\bar{x}}$	$\bar{x}$	$\pm s_{\bar{x}}$	$\bar{x}$	$\pm s_{\bar{x}}$	$\bar{x}$	$\pm s_{\bar{x}}$
Number of animals Broj životinja	33		33		33		33	
Daily gain (g/day) Dnevni prirast (g/d)	623,5a	9,00	625,5a	11,58	545,5b	11,88	497b	12,38
Feed intake (kg/day) Konzumacija (kg/d)	2,26		2,33		2,08		2,02	
Index%	100		102		92		89	
Feed conversion ratio (feed/gain) Konverzija (kg/kg)	3,62		3,72		3,81		4,06	
Index,%	100		103		105		112	

Values in the same row following different letters are significantly different ($P< 0,05$)
Vrijednosti u istom redu koje slijede različita slova singifikantno su različite ($P< 0,05$)

Table 7. Slaughtering results
Tablica 7. Klaonički rezultati

Parameters Pokazatelji	Levels of alkaloids (mg/kg) Razina alkaloida (mg/kg)							
	0,0		33		65,3		97,5	
	$\bar{x}$	$\pm s_{\bar{x}}$	$\bar{x}$	$\pm s_{\bar{x}}$	$\bar{x}$	$\pm s_{\bar{x}}$	$\bar{x}$	$\pm s_{\bar{x}}$
Cold carcass weight (kg) Masa hladnih polovica (kg)	77,58a	1,40	76,50a	1,13	68,61b	1,31	63,17c	1,43
Dressing (%) Randman (%)	75,50a	0,44	76,28	0,40	76,46	0,33	74,65b	0,40
Backfat (cm) Debljina slanine (cm)	2,92a	0,07	2,94a	0,08	2,75	0,06	2,52b	0,07

Values in the same row following different letters are significantly different ($P< 0,05$)
Vrijednosti u istom redu koje slijede različita slova singifikantno su različite ($P< 0,05$)

The affect of higher concentrations of alkaloids on feed intake was negative and medium strong (r = - 0,421). However, pigs fed the highest level of alkaloids had 7.75% lower, while pigs fed the lowest level had 10.6% higher feed intake. Feed conversion ratio was lower in groups fed higher content (8 and 16%) of lupin.

During the 129 growing and fattening period from 20 to 100 kg, higher levels of total alkaloids (65,3 and 97,5 mg/kg) resulted in lower (P< 0,05) daily gain, depression of feed intake and lower feed conversion ratio (Table 6).

Cold carcass and final body weight was lower (P< 0.05) in groups fed the highest levels of alkaloids (65.3 and 97.5 mg/kg), while dressing percentage and backfat thickness were lower in the group fed 97.5 mg/kg of total alkaloids (Table 7).

DISCUSSION

Cultivar "Bosna" contains more total alkaloids (0.075%) than it is usually believed (less than 0.01%) sweet lupin does (Hudston, 1979). Concentration of alkaloids is not only under the influence of genotype, but productive condition and possible contamination with bitter lupin seed, as well (Hill, 1977). If the high content of total alkaloids is a characteristics of this cultivar, it should not be considered as a sweet, but "medium sweet" lupin cultivar.

General characteristic of lupin and all other legume is the low content of sulfuric amino acids (Green and Oram, 1983). Cultivar used in this experiment contains much more cystine than the soybean meal and 11 cultivars of blue and white lupin examined by Eggum et al. (1993). Same authors noticed that white cultivars of lupin commonly used in Europe have more cystine than blue cultivars. However, higher level of cystine can not substitute the lack of methionine (NRC, 1988). Feed mixes are composed to meet pigs' requirements on methionine according to NRC (1988) recommendations, but methionine may act as a detoxicant of naturally occurring substances (Singleton and Kratzer, 1975). Although, Pearson and Carr (1979) found that a methionine deficiency is not the cause of depressions in feed intake and growth rate of young pigs fed diets containing lupin seed from varieties of high or low alkaloid content.

The results of numerous examinations show that pigs react to the level of alkaloids and content of lupin in feed mixes inconsistently. The inclusion the 30% replacement of soya protein by lupin, or up to 0.02% of alkaloids, does not affect daily gain, feed intake and slaughtering results of growing and fattening pigs (Balkowski et al., 1975; Peterson and Schultz, 1978; Vinaras Garcia et al., 1987; Szelenyi-Galantal et al., 1988; Batterham 1989).

The comparison of the obtained productive results with cited ones shows that pigs fed cultivar "Bosna" are more sensitive to lower levels of alkaloids from this cultivar. Probable cause for that is the composition of total alkaloids of cultivar "Bosna" and the method of alkaloid assay (Priddis, 1983).

Pigs are less tolerant to alkaloids to white than from the other species of lupin (Hill, 1986). The same author found considerable variations in response of pigs to different cultivars of white lupin. paper chromatography used here for the determination of total alkaloids analyzes only the most important alkaloids - lupinine and sparteine and not other 22 alkaloids present in smaller concentrations, but not less toxic (Guillaume et al., 1979). Higher sensitivity to alkaloids by young pigs notice in this experiment is in accordance to the results achieved by Quemere et al. (1984) and Villanueva et al. (1988).

It is generally considered that negative effect of lupin on daily gain is the result of decreased feed intake (Godfrey et al., 1985). Achieved correlations show that the influence of alkaloids is stronger on the daily gain than on the feed intake. This was supported by experiment of Jecsai et al. (1986) who found that lupin, even when completed by other feeds and synthetic amino acids, exercised a certain depressive effect manifested in lower body weight gain of white rats. This depressive effect involved an increase in the urea content of blood and changes in amino acids composition of liver. Also, at the slaughtering, pathological changes are noticed on the liver of pigs. Harborne (1991) reported that the influence of alkaloids from lupin on specific pathological changes of liver are not known. Although, Stupar (1989) connected the liver mitochondria in broilers, fed the same lupin, with alkaloids from lupin. This supports the results of this experiment and underlines direct and indirect effects of alkaloids to productive performances.

Lower dressing percentage and backfat tickness are results of amount of lupin in feed mixes. Row lupin seed contains high level of crude fiber and it's NFE mostly consists of galactanes, which have longer time of digestion in the large intestine (Aguilera et al., 1985). It has been shown by Taverner et al. (1983) that 49% of the energy of lupins is absorbed in the large intestine. The efficiency of energetic substances (volatile fatty acids) resorption from the large intestine is lower (Just et al., 1983), so content of digestible energy of lupin is

overestimated. The consequence of this is higher weight of the large intestine and thicker backfat.

CONCLUSIONS

White lupin cv. "Bosna" contains more alkaloids (0.075%) than it is standard for sweet lupin cultivars.

Young pigs, up to 60 kg, are less tolerant to level of alkaloid than the fattening pigs over 60 kg.

The influence of total alkaloids is stronger on daily gain than on feed intake.

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SAŽETAK

Predmet ovog rada je utvrditi tolerantnost svinja u porastu i tovu na povišene razine ukupnih alkaloida iz slatke bijele lupine (Lupinus albus L) cv Bosna. Istraživanje je provedeno na 132 svinje podijeljene u dva ponavljanja i 33 životinje po tretmanu. Svinje su hranjene krmnim smjesama u kojima je 0, 33, 66 i 100% sojine sačme zamjenjeno sa sirovim zrnom lupine (0,075% alkaloida). Krmne smjese za svinje u porastu od 20 do 60 kg sadržavale su 0.0, 34.5, 69.0 i 102, a za tov od 60 do 100 kg 0.0, 31.5, 61.5 i 93.0 mg/kg ukupnih alkaloida. Svinje u porastu imale su niže ($P< 0,05$) završne mase i dnevne priraste te konzumirale manje hrane. U ovom razdoblju od 77 dana snažniji je utjecaj razine alkaloida na dnevni prirast ($r = -0,802$) nego konzumaciju hrane ($r = -0,499$). U tovu od 52 dana svinje su osjetljivije ($P< 0,05$) na više (61,5 i 93 mg/kg smjese) razine alkaloida. Također je utvrđena negativna povezanost viših razina alkaloida s prirastom ($r = -0,715$) i konzumacijom ($r = -0,412$) svinja u tovu. Isto tako su i težine hladnih polovica najniže ($P< 0,05$) u svinja hranjenih tijekom cijelog pokusa s, u prosjeku, 65,3 i 97,5 mg/kg ukupnih alkaloida, a randman i debljina slanine samo u skupine ($P< 0,05$) koja je dobivala najviše alkaloida.

Svinje u porastu od 20 do 60 kg reagiraju na male količine alkaloida (34.5), a svinje u tovu od 60 do 100 kg toleriraju do 69 mg ukupnih alkaloida po kg krmne smjese iz slatke bijele lupine cv Bosna.

Ključne riječi: lupina, alkaloidi, svinje