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EFFECT OF LUPINE AND FIELD PEA ON GROWTH PARAMETERS AND NITROGEN BALANCE IN RATS

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ABSTRACT

Legumes are a protein rich crop of interest for use in animal nutrition. The effect of lupine seeds (two species – white and yellow lupine) and field pea on nutrition properties, growth parameters and digestibility of crude protein have been evaluated in balance and growth experiment in rats. The experiment was carried out according to the method of Eggum (1973) and Heger et al. (1990). Twenty seven rats individually housed in metabolic cages were used in this experiment. We determined lower amount of nitrogen in excrements (55.1 mg) and in urine (59.9 mg) per day in rats fed white lupine, than in the group of rats fed yellow lupine (56.0 mg and 67.9 mg, resp.). White lupine had higher value of the BPV (99.6%), the CP digestibility (70.1%) and percentage of the retained nitrogen from nitrogen digested by rats (29.4 %) than yellow lupine. From the comparison between lupine and field pea we have found a lower BPV (97.9%) and a higher amount of N in excrements (58.5 mg) of rats fed field pea. The results of the observation between analyzed lupine and pea seeds were evaluated by the statistical programme Statistics, T-test, $P<0.05$.

Key words: lupine; field pea; protein biological value; conversion of nutrients

INTRODUCTION

In the past, the nutrient requirements of monogastric animals were met using the feeds of animal origin and soybean meal. The ban on using the meat and meat-and-bone meal, following the BSE emergency, together with growing market price of soybean meal has lead to growing interest in using legumes.

According to a prospective study (Dijkstra et al., 2003) lupine has been included among eight potential vegetable sources of protein for the use in feed and food production. Sweet lupine is considered to have significant potential as a protein source because of its extremely low content of anti-nutritional factors when compared to other sources. Lupine seed can be cost-effectively integrated into diets of ruminant and monogastric animals. Optimal use of lupines in livestock diets, however, will depend on our ability to understand the unique properties related to nutritional and chemical characteristics of lupine.

The aim of our experiment was to compare the effect of white and yellow lupine and field pea on growth parameters and digestibility of crude protein.

MATERIAL AND METHODS

The experiment was carried out according to the method of Eggum (1973) and Heger et al. (1990). Two species of lupine (white and yellow) and field pea were tested. The crude protein (CP) digestibility, the biological protein value (BPV), net protein utilization (NPU), utilizable protein (UP), protein efficiency ratio (PER) and feed consumption per 1 g of weight gain

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were measured in Wistar rats with an initial weight of approximately 50 g. The animals were kept individually in the balance cages with nipple watering device and were given free access to diets and water. Body weight and feed intake measurements were determined at weekly intervals throughout the experiment. The course of whole experimental period (28 days) was divided into a preliminary period (7 days) and an experimental period (21 days, feeding and balance experiment; balance experiment started from the day 8 and lasted up to day 14 of this period). Urine and faeces were collected and its release was measured once a day during the balance experiment. Urine was collected into 5% solution (v/v) of sulfuric acid. Samples of daily feces were frozen. Afterwards, total content of collected faeces and urine was homogenized and analyzed for the nitrogen and dry matter content. The content of nutrients in tested feeds was determined according to the Decree No. 1497/4/1997 – 100 of the Ministry of Agriculture of Slovak Republic.

Pea and lupine seeds were the only nitrogen source in the experimental diets. The crude protein of seeds formed 10% of a dry matter in the experimental feed rations.

The results of the observation in analyzed lupine and pea seeds were evaluated by the statistical programme Statistics, T-test ($P<0.05$).

RESULTS AND DISCUSSION

The chemical composition of both species of lupine and field pea is shown in Table I. The CP content of white lupine and yellow lupine has often a range from 36% to 52%, although yellow lupine is more variable (Mohamed and Rayas-Duarte, 1995). It depends on lupine cultivar and climatic conditions (Linnemann and Dijkstra, 2002). We determined declared content of CP in the Amiga white lupine variety (360.0 g.kg^{-1} DM) and in the Berette yellow lupine variety (313.5 g.kg^{-1} DM). The content of CP in field pea was lower (204.3 g.kg^{-1} DM) in comparison to lupine. In contrast to other leguminous plants, the lupine seeds contain more crude fibre, a proportion of that is viewed as dietetically beneficial (Johnson and Gray, 1993). We found that lupines have a higher content of fibre (198.6 g.kg^{-1} DM and 162.4 g.kg^{-1} DM, resp.) and fat (55.4 g.kg^{-1} DM and 73.7 g.kg^{-1} DM, resp.) than field pea (Table 1). The field pea was characterized by significant higher amount of starch (485.7 g.kg^{-1} DM) in comparison to lupines (111.5 g.kg^{-1} DM and 90.1 g.kg^{-1} DM, resp.). Similar to Sujak et al. (2006) we found higher content of starch and fibre and lower content of lipid and crude protein in yellow lupine than in white lupine (Table 1).

The CP digestibility and balance of nitrogen related to the protein quality. The knowledge of the major fractions of lupine proteins allows developing a profile of their functional properties and potential nutritional influences (van Barneveld, 1999). The profile of amino acids is characterized by a lower level of sulphur containing amino acids and threonine in comparison to soya (Simon and Jeroch, 1999) and, in contrast, the arginine content is markedly higher (Suchý et al., 2005; Table 3). With the exception of lysine, Gatel (1994) suggested that these characteristics of lupines make them the ideal complements to cereals in the diets for monogastric animals. Thus, from a perspective of a diet formulation, lupines are a valuable source. Eggum et al. (1993) reported a significant increase in biological value and net protein utilization when rats were supplied with methionine from the diets in which a lupine meal was the only protein source. Because non-ruminant animals can convert methionine to cysteine, methionine can satisfy their total requirement for dietary sulfur-containing amino acids (van Barneveld, 1999).

Table 1: Chemical composition of lupine and field pea (g.kg^{-1} DM)

Nutriment	Yellow lupine Berette	White lupine Amiga	Field pea
Crude protein	313.5	360.0	204.3
Crude Fibre	198.6	162.4	76.2
Starch	111.5	90.1	485.7
Fat	55.4	73.7	14.0
Organic matter	959.9	961.8	965.7
Crude Ash	40.1	38.2	34.3

From Table 2 we can see, that white lupine had lower amount of N in faeces and in urine per day in comparison to yellow lupine. The amount of excreted nitrogen with urine and faeces is a result of degradation of amino acids, which cannot be used for the synthesis of body proteins. Analyzing BPV and retained N from digested N in rats Chrenková et al. (1994) found significant positive correlation (r=0.85). Consequently, a quality of CP of lupine can be characterized using basic parameters. We have found higher value of BPV, digestibility of CP and percentage of retained N from digested N by rats fed white lupine than yellow lupine (Table 2). We did not reveal any significant differences in feed consumption per 1 g of weight gain between lupine species.

From the comparison between lupine and field pea we have found a lower BPV and higher amount of N in faeces when field pea was fed. No significant differences in the feed consumption per 1 g of weight gain were observed. Lower digestibility of field pea crude protein could be a result of the presence of trypsin

Table 2: Result of tested field pea and white and yellow lupine in experiments on rats

Parameters	Yellow lupine Berette	White lupine Amiga	Field pea
CP intake, g	22.8a	19.8a	26.7b
SD	2.2	5.8	2.3
Received N from diet per 1 day, mg	181.8a	186.2a	211.7b
SD	17.8	22.8	27.8
N in faeces per 1 day, mg	56.0	55.1	58.5
SD	1.6	1.0	4.4
N in urine per 1 day, mg	67.6a	59.9b	57.1b
SD	4.7	12.3	16.4
Weight gain, g	28.1ab	26.0a	33.7b
SD	5.1	5.2	6.1
Feed consumption per 1 g weight gain, g	9.2	8.9	8.4
SD	1.7	1.5	0.9
Retained N from received N, %	31.6a	38.0b	45.5c
SD	5.9	6.0	4.5
BPV, %	98.5	99.6	97.9
SD	2.5	1.2	2.1
PER	1.2	1.5	2.1
SD	0.2	0.9	1.3
NPU, %	67.9	69.8	70.6
SD	4.1	3.4	2.2
UP, %	6.2a	7.4b	6.8c
SD	0.4	0.4	0.2
CP received from the diet per 1 day, mg	1136.0a	1163.8a	1323.1b
SD	111.4	142.4	173.6
CP digestibility, %	68.9a	70.1ab	72.2b
SD	3.1	3.5	2.0
Retained N from digested N, %	25.0a	29.4b	30.4b
SD	2.2	5.7	5.3

a,b,c - different superscripts of means within line indicate significant differences (P<0.05);

CP – crude protein, N – nitrogen, BPV – biological protein value, PER – protein efficiency ratio, NPU – net protein utilization, UP – utilizable protein, SD – standard deviation

Table 3: Content of some essential amino acids in the seeds of white and yellow lupine

Amino acid	White lupine* g/16 g N	Yellow lupine** g/16 g N
Lys	5.5	4.5
Thr	4.5	2.9
Val	4.6	3.2
Ile	4.6	3.5
Leu	8.1	6.8
His	2.7	2.7
Arg	11.0	10.0
Met	0.9	0.6

* Data from APRC Nitra

** Data from Sujak et al. (2006)

and chymotrypsin inhibitors. In lupines the content of anti-nutritional substances is relatively low and, because of this, the seeds of these cultivars do not require heat treatment and may be fed to the animals unprocessed (Zralý et al., 2007).

CONCLUSION

We determined higher BPV and CP digestibility of white lupine than yellow lupine and field pea. Between tested species of lupine, a higher BPV, CP digestibility and percentage of retained N from digested N in rats were revealed in white lupine than in yellow lupine. However, sown area of lupines in Slovakia is slowly increasing; lupine is still not a common crop in this country. In future it is important to characterize local varieties of some lupines for their chemical composition, alkaloid content,

protein degradability, the suitable rate of incorporation into the ration of different animals and their effect on a feed intake and on the growth and production. Also, additional information on the nutritional role of lupine oligosaccharides and their potential for use in livestock system is required.

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