NATIONAL AGRICULTURAL AND FOOD CENTRE
RESEARCH INSTITUTE FOR ANIMAL PRODUCTION NITRA

The 4th International Scientific Conference "Animal Biotechnology"
Slovak J. Anim. Sci., 49, 2016 (4): 147–150

ISSN 1337-9984

WHITE LUPINE IS A SUITABLE FEED COMPONENT IN RABBIT DIETS: A REVIEW

Z. VOLEK

Institute of Animal Science, Department of Physiology of Nutrition and Quality of Products, Prague, Czech Republic

ABSTRACT

The paper reports the recent results regarding a possible utilization of white lupine seeds (*Lupinus albus* cv. Amiga) for rabbit feeds. The white lupine based diets were compared with the diets containing a commonly used protein sources, i.e. soybean or sunflower meals. The range of white lupine dietary inclusion used in different experiments varied between 60 and 250 $g.kg^{-1}$. The main attention was focused on the growth performance, total tract apparent digestibility of diets, digestive health and meat quality of growing-fattening rabbits, as well as rabbit doe milk yield and milk composition, and the growth of their progeny. No adverse effect of feeding white lupine-based diets on the average daily weight gain, feed intake, final live weight, or feed conversion ratio of growing-fattening rabbits, as well as milk production was observed. Due to its fatty acid composition, the dietary inclusion of white lupine has the potential to change both meat and milk fatty acid profile in a beneficial way, without the need for the addition of dietary fat. Protein source did not affect the total tract apparent digestibility of crude protein and gross energy. From the point of view of chemical composition and performance, white lupine is the important component for rabbit feeds.

Key words: rabbit; protein source; white lupine; growth performance; milk yield; health

INTRODUCTION

Protein sources mostly used in rabbit diets in Europe are soybean (SBM) and sunflower (SFM) meals, with inclusion levels of 80-150 $g.kg^{-1}$ (Volek and Marounek, 2009; Villamide *et al.*, 2010; Volek and Marounek, 2011). As reported by Kelly *et al.* (1990), whole white lupine seeds (WLS) may represent an alternative protein source for rabbit feeds. In comparison with SFM and WLS, SBM contained higher concentrations of crude protein (CP) and most of limiting amino acids (AA), and lower content of fibre fractions (Volek and Marounek, 2009). The biological quality of WLS, however, can be improved by adding synthetic AA (Ballester *et al*., 1980). Cellulose is the predominant constituent of the structural polysaccharides of lupine hulls (Volek *et al.*, 2013). When compared with soybean hulls, white lupine hulls contain more neutral-detergent fibre (NDF) and acid-detergent fibre (García *et al*., 1997; García *et al.*, 1999; Volek *et al.*, 2013). The favourable effect of a higher dietary fibre intake on rabbit digestive health is well known (Gidenne, 2015); thus removed lupine hulls might represent an agro-industrial by-product suitable for use in rabbit feed. White lupine seeds have higher levels of ether extract (EE), water-insoluble pectin and oligosaccharides of the raffinose series than SBM and SFM (Volek and Marounek, 2009). As far as the fatty acid (FA) composition of SBM, SFM, or WLS is concerned, monounsaturated fatty acids are the main FA in WLS, whereas polyunsaturated fatty acids (PUFA) and saturated fatty acids (SFA) are present at lower amounts than in SBM and SFM (Volek and Marounek, 2011; Volek *et al*., 2014). White lupine seeds contain less palmitic acid (C 16:0) and linoleic

Correspondence: E-mail: volek.zdenek@vuzv.cz
Zdeněk Volek, Institute of Animal Science, Department of Physiology of Nutrition and Quality of Products, Přátelství 815, 104 00 Prague, Czech Republic

Received: September 26, 2016
Accepted: October 4, 2016

acid (C 18:2n-6) and more eicosanoid acid (C 20:1n-9), oleic acid (C18:1n-9) and α-linolenic acid (C 18:3n-3) than SBM and SFM. Oleic acid is the predominant FA in WLS (Volek and Marounek, 2009; Volek *et al*., 2014). A high PUFA n-3/PUFA n-6 ratio is typical for WLS (Boschin *et al*., 2008; Volek and Marounek, 2011; Volek *et al*., 2014). Apart from the chemical composition, leguminous seeds may be also important for a greater self-sufficiency regarding the supply of protein to balance the diets of animals (Carrouée *et al*., 2003), as well as for the increasing of the sustainability of European crop-livestock systems (Jensen and Hauggaard-Nielsen, 2003; Annicchiarico *et al*., 2010; Sulas *et al*., 2016). In this respect, lupine seed, as one of the grain legumes, may be a useful European-grown source of protein (Chiofalo *et al*., 2012).

The aim of this paper was to report the recent results regarding the effect of the WLS (*Lupinus albus* cv. Amiga) based diets on the growth performance, total tract apparent digestibility, digestive health and meat quality of fattening rabbits, as well as rabbit doe milk yield and milk yield composition and the growth of their progeny.

Growth performance and carcass traits of fattening rabbits

In comparison with the diets based on SBM or SFM, Volek and Marounek (2009) did not observe adverse effect of feeding WLS on rabbit performance. Regardless of rabbits' weaning age (between 30 and 37 days of age), also other authors confirmed that WLS can fully replace traditionally used protein sources (SBM and SFM) without an impairment of the average daily weight gain, feed intake, final live weight or feed conversion ratio (Volek and Marounek, 2011; Volek *et al*., 2014; Uhlířová *et al*., 2015b; Uhlířová *et al*., 2016). Volek and Marounek (2009) recorded the higher dressing-out percentage in rabbits fed the WLS diet in comparison with those fed the SFM or SBM diet. Uhlířová *et al.* (2015b) reported a higher chilled and reference carcass weight in rabbits fed with WLS diet than in rabbits fed with the SBM diet but the dressing-out percentage was not affected by dietary treatments. Similarly, Volek and Marounek (2011) did not observe any effect of dietary treatments (WLS vs. SFM diet) on the dressing-out percentage. These contradictory results regarding the dressing-out percentage may be related to a full digestive tract and skin weight, as well as slaughter weights of rabbits used for the determination of carcass characteristics in different experiments.

Total tract apparent digestibility

There is an agreement with the literature, that CP sources (SBM, SFM, WLS) did not affect the total tract apparent digestibility of CP and gross energy (Fekete and Gippert, 1986; Volek and Marounek, 2009; Volek and Marounek, 2011; Volek *et al*., 2014; Uhlířová *et al.*, 2015b).

Digestive health of weaned rabbits

Digestive disorders are the main pathological events affecting weaned or fattening rabbits (Rosell *et al.*, 2009). Volek and Marounek (2009) observed a higher incidence of diarrhoea in rabbits fed the SBM diet than in rabbits fed the WLS diet (8 vs. 2 rabbits; 30 rabbits per group; P = 0.083). Similarly, Volek *et al.* (2014) reported the lower sanitary risk index (as the sum of morbid and dead rabbits; Fernández-Carmona *et al.*, 2005) caused by digestive disease in rabbits fed the WLS diet, than in rabbits fed the SBM diet (3.0 vs. 16.7 %; 66 rabbits per group; P = 0.016). Uhlířová *et al.* (2015b) observed both lower morbidity (1 rabbit vs. 9 rabbits; P = 0.014) and the sanitary risk index (2 rabbits vs. 12 rabbits; 40 rabbits per group; P = 0.006) in the *ad libitum* fed WLS rabbits compared with the *ad libitum* fed SBM rabbits. On the contrary, Uhlířová *et al.* (2016) observed the non-significant effect of dietary treatments on digestive health, although a lower number of animals at sanitary risk was observed in the rabbits fed the diet based on WLS than in those fed with the SBM diet (5 vs. 13 rabbits; 130 rabbits per group; P = 0.085). The above mentioned findings suggest that feeding with the WLS diet is probably safer than with the SBM diet. However, the other experiments on a larger number of animals (Gidenne, 2015), and mainly under the conditions affected by Epizootic Rabbit Enteropathy (ERE, a high mortality disease of rabbits), are necessary.

Fatty acid profile and indexes related to human health in hind leg meat and perirenal fat

Volek and Marounek (2011) studied the effects of a diet supplemented with WLS on FA composition and characteristics of hind leg meat and perirenal fat of growing-fattening rabbits in relation to human health. A total of 20 weaned rabbit (10 animals per treatment) were fed one of the two diets included SFM or WLS as the main protein and FA source. The WLS diet significantly decreased SFA and PUFA content, as well as the PUFA n-6/PUFA n-3 ratio and saturation, atherogenic and thrombogenic indexes in hind leg meat. The FA profile and indexes related to human health in perirenal fat were similar to hind leg meat. These results are consistent with the findings of Laudadio and Tufarelli (2011), who observed in broiler chickens that feeding the lupine diet (*Lupinus albus* L. cv. Multitalia) resulted in lower SFA content in meat, as well as the PUFA n-6/PUFA n-3 ratio, and saturation, atherogenic and thrombogenic indexes.

Milk yield and milk composition

A short-term lactation experiment (one lactation period) revealed that WLS may be a perspective dietary CP source for lactating rabbit does, which can fully replace commonly used SBM (Volek *et al.*, 2014). Uhlířová *et al*. (2015a) studied the effect of the lactation and weaning diets based on WLS (in comparison with the diets based on SBM) on milk yield and milk composition of rabbit does, as well as on the growth of their progeny through the longer lasting experiment (over two lactation periods). Significant differences were observed in terms of the daily milk production. During the 1st lactation period, average milk yield was higher between day 22 and day 32 of lactation in does fed the WLS, whereas in the 2nd lactation period, milk yield was significantly higher over the whole lactation (35 days) in these does. Milk dry matter, protein, fat or ash contents were not affected by dietary treatments. When expressed per kg of metabolic weight, milk output and fat output were significantly higher in the does fed the WLS diet. These findings are related to the higher dietary EE content in the WLS diet (Pascual *et al*., 2003), due to higher EE content in WLS than in SBM, and are consistent with our previous results (Volek *et al.*, 2014). The milk of does fed the WLS diet contained significantly less caprylic acid, capric acid, lauric acid and C 18:2n-6 and more C 18:1n-9, C 18:3n-3 and eicosapentaenic acid. Different milk fatty acid profile of does fed the WLS diet corresponds with fatty acid profile of WLS, and confirmed our previous findings (Volek *et al*., 2014). Growth of litters was not affected by dietary treatments. The longer lasting experiment confirmed that the WLS is a suitable CP source for the lactation diet of rabbits in terms of milk yield and composition, feed efficiency and growth of litters.

Lupine hulls as a dietary ingredient in rabbit feed

Volek *et al.* (2013) studied the effect of the inclusion of lupine hulls (50 g of WLS hulls.kg^{-1}) in a rabbit diet on the digestibility on nutrients and growth performance. The results revealed that WLS hulls can serve as a suitable by-products for rabbit feed. Other experiments should be focused on determining the maximal dietary level of lupine hulls.

CONCLUSION

No adverse effect of feeding white lupine based diets on the average daily weight gain, feed intake, final live weight, or feed conversion ratio of growing-fattening rabbits, as well as milk production was observed. Due to its fatty acid composition, the dietary inclusion of white lupine has the potential to change both meat and milk fatty acid profile in a beneficial way, without the need for the addition of dietary fat. Protein source did not affect the total tract apparent digestibility of crude protein and gross energy.

ACKNOWLEDGEMENTS

This study was supported by the grant No. QJ 1510136, provided by the Ministry of Agriculture of the Czech Republic.

REFERENCES

ANNICCHIARICO, P. – HARZIC, N. – CARRONI, A. M. 2010. Adaptation, diversity, and exploitation of global white lupin (*Lupinus albus* L.) landrace genetic resources. *Field Crops Research*, vol. 119, 2010, p. 114–124.

BALLESTER, D. – YÁÑEZ, E. – GARCÍA, R. – ERAZO, S. – LÓPEZ, F. – HAARDT, E. – CORNEJO, S. – LÓPEZ, A. – POKNIAK, J. – CHICHESTER, C. O. 1980. Chemical composition, nutritive value, and toxicological evaluation of two species of sweet lupine (*Lupinus albus* and *Lupinus luteus*). *Journal of Agricultural and Food Chemistry*, vol. 28, 1980, p. 402–405.

BOSCHIN, G. – D'AGOSTINA, A. – ANNICCHIARICO, P. – ARNOLDI, A. 2008. Effect of genotype and environment on fatty acid composition of *Lupinus albus* L. seed. *Food Chemistry*, vol. 108, 2008, p. 600–606.

CHIOFALO, B. – LO PRESTI, V. – CHIOFALO, V. – GRESTA, F. 2012. The productive traits, fatty acid profile and nutritional indices of three lupin (*Lupinus* spp.) species cultivated in a Mediterranean environment for the livestock. *Animal Feed Science and Technology*, vol. 171, 2012, p. 230–239.

CARROUEE, B. – CREPON, K. – PEYRONNET, C. 2003. Les protéagineux: intérêt dans les systèmes de production fourragers français et européens. *Fourrages*, vol. 174, 2003, p. 163–182.

FEKETE, S. – GIPPERT, T. 1986. Digestibility and nutritive value of nineteen important feedstuffs for rabbits. *Journal of Applied Rabbit Research*, vol. 9, 1986, p. 103–108.

FERNÁNDEZ-CARMONA, J. – BLAS, E. – PASCUAL, J. J. – MAERTENS, L. – GIDENNE, T. – XICCATO, G. – GARCÍA, J. 2005. Recommendations and guidelines for applied nutrition experiments in rabbits. *World Rabbit Science*, vol.13, 2005, p. 209 – 228.

GARCIA, J. – VILLAMIDE, M. J. – DE BLAS, J. C. 1997. Energy, protein and fibre digestibility of soya bean hulls for rabbits. *World Rabbit Science*, vol. 5, 1997, p. 111–113.

GARCÍA, J. – CARABAÑO, R. – DE BLAS, J. C. 1999. Effect of fiber source on cell wall digestibility and rate of passage in rabbits. *Journal of Animal Science*, vol. 77, 1999, p. 898–905.

GIDENNE, T. 2015. Dietary fibres in the nutrition of the growing rabbit and recommendations to preserve digestive health: a review. *Animal*, vol. 9, 2015, p. 227–242.

JENSEN, E. S. – HAUGGAARD-NIELSEN, H. 2003. How can increased use of biological N-2 fixation in agriculture benefit the environment? *Plant and Soil,* vol. 252, 2003, p. 177–186.

KELLY, J. D. – CHEEKE, P. R. – PATTON, N. M. 1990. Evaluation of lupin (*Lupinus albus*) seed as a feedstuff for swine and rabbits. *Journal of Applied Rabbit Research*, vol. 13, 1990, p. 145–150.

LAUDADIO, V. – TUFARELLI, V. 2011. Dehulled-micronised lupin (*Lupinus albus* L. cv. Multitalia) as the main protein source for broilers: influence on growth performance, carcass traits and meat fatty acid composition. *Journal of the Science of Food and Agriculture*., vol. 91, 2011, p. 2081–2087.

PASCUAL, J. J. – CERVERA, C. – BLAS, E. – FERNANDEZ-CARMONA, J. 2003. High-energy diets for reproductive rabbit does: effect of energy source. *Nutrition Abstracts and Reviews*, vol. 73 (5), 2003, p. 27R–39R.

ROSELL, J. M. – DE LA FUENTE, L. F. – BADIOLA, J. I. – FERNANDEZ DE LUCO, D. – CASAL, J. – SACO, M. 2009. Study of urgent visits to commercial rabbit farms in Spain and Portugal during 1997-2007. *World Rabbit Science*, vol. 17, 2009, p. 127–136.

SULAS, L. – CANU, S. – LEDDA, L. – CARRONI, A. M. – SALIS, M. 2016. Yield and nitrogen fixation potential from white lupine grown in rainfed Mediterranean environments. *Scientia Agricola*, vol. 73 (4), 2016, p. 338–346.

UHLÍŘOVÁ, L. – VOLEK, Z. – MAROUNEK, M. – SKŘIVANOVÁ, V. 2015a. Replacement of soybean meal with white lupin in the nutrition of rabbit does: effect on milk yield, milk composition and growth performance of their litters over two lactation periods. In: *Proc. 14th International Lupin Conference*, 21-26 June, 2015, Milan, Italy, p. 128.

UHLÍŘOVÁ, L. – VOLEK, Z. – MAROUNEK, M. – TŮMOVÁ, E. 2015b. Effect of feed restriction and different crude protein sources on the performance, health status and carcass traits of growing rabbits. *World Rabbit Science*, vol. 23, 2015, p. 263–272.

UHLÍŘOVÁ, L. – VOLEK, Z. – MAROUNEK, M. – SKŘIVANOVÁ, E. 2016. The effect of a diet based on whole lupin seed (*Lupinus albus* cv. Amiga) on sanitary risk index and the growth of growing-fattening rabbits. In: Proc. 11th World Rabbit Congress, June 15-18, 2016, Qingdao, China, p. 459–462.

VILLAMIDE, M. J. – NICODEMUS, N. – FRAGA, M. J. – CARABAÑO, R. 2010. Protein digestion. In: DE BLAS, J. C. – WISEMAN, J. (eds.): *Nutrition of the rabbit*, 2nd Edition. Wallingford: CAB International, 2010, p. 39–55.

VOLEK, Z. – MAROUNEK, M. 2009. Whole white lupin (*Lupinus albus* cv. Amiga) seeds as a source of protein for growing-fattening rabbits. *Animal Feed Science and Technology*, vol. 152, 2009, p. 322–329.

VOLEK, Z. – MAROUNEK, M. 2011. Effect of feeding growing-fattening rabbits a diet supplemented with whole white lupin (*Lupinus albus* cv. Amiga) seeds on fatty acid composition and indexes related to human health in hind leg meat and perirenal fat. *Meat Science*, vol. 87, 2011, p. 40–45.

VOLEK, Z. – VOLKOVÁ, L. – MAROUNEK, M. 2013. Effect of a diet containing white lupin hulls (*Lupinus albus* cv. Amiga) on total tract apparent digestibility of nutrients and growth performance of rabbits. *World Rabbit Science*, vol. 21, 2013, p. 17–21.

VOLEK, Z. – MAROUNEK, M. – VOLKOVÁ, L. – KUDRNOVÁ, E. 2014. Effect of diets containing whole white lupin seeds on rabbit doe milk yield and milk fatty acid composition as well as the growth and health of their litters. *Journal of Animal Science*, vol. 92, 2014, p. 2041–2049.