Preliminary communication DOI: /10.5513/JCEA01/20.3.2251
Journal of Central European Agriculture, 2019, 20(3), p.796-801

Jerusalem artichoke (Helinathus tuberosus) tops as a natural source of inulin in rabbit diet: effect on growth performance and health status

Nať topinamburu hlíznatého (Helinathus tuberosus) jako přírodní zdroj inulinu v krmné směsi králíků: vliv na výkrmnost a zdravotní stav

Adéla DOKOUPILOVÁ[1] (✉), Lukáš ZITA[2], Jaroslav KVAČEK[3], Karel JANDA[1], Barbora HOFMANOVÁ[1], Renata MASOPUSTOVÁ[1]

[1] Department of Ethology and Companion Animals Science, Faculty of Agrobiology, Food and Natural Resources, Czech University of Life Sciences Prague, Kamýcká 129, 165 00 Prague 6 - Suchdol, Czech Republic

[2] Department of Animal Science, Faculty of Agrobiology, Food and Natural Resources, Czech University of Life Sciences Prague, Kamýcká 129, 165 00 Prague 6 - Suchdol, Czech Republic

[3] Central Institute for Supervising and Testing in Agriculture, Konečná 1930, 58001 Havlíčkův Brod, Czech Republic

✉ Corresponding author: dokoupilova@af.czu.cz

ABSTRACT

Nowadays, both many scientists and breeders are interested in the possibilities of the substitution of allopathic medicinal products for animals by some natural alternatives, as plants products, prebiotics or probiotics. Jerusalem artichoke contains non-starch polysaccharide inulin, which can be used, because of its specific properties, as a natural prebiotic. The aim of this study was to incorporate Jerusalem artichoke tops to the feed mixture of growing rabbits as the natural source of inulin. 80 Hyla rabbits were randomly divided into 2 groups. The control group was fed standard diet, while Jerusalem artichoke group was given diet with 20% tops of Jerusalem artichoke. The experiment took place in commercial farm with standard conditions and was conducted as a preliminary examination, the growth performance and mortality of rabbits were observed. The diet with 20% tops of Jerusalem artichoke decreased feed conversion ratio about 0.39 (11%) and the mortality of rabbits about 10% ($P<0.05$) compared with control group. Jerusalem artichoke tops (20%) may be incorporated to rabbit diets as an appropriate source of carbohydrates with prebiotic properties for growing rabbits and thus may partly replaces some ingredients (starch sources), which burden the not completely developed digestive system of young animals.

Keywords: growth performance, inulin, Jerusalem artichoke, mortality, prebiotics, rabbits

ABSTRAKT

V současnosti se řada vědců i chovatelů zajímá o možnosti náhrady alopatických léčiv určených pro zvířata některými přírodními alternativami jako jsou rostlinné preparáty, prebiotika a probiotika. Topinambur hlíznatý obsahuje neškrobový polysacharid inulin, který může být, díky jeho specifickým vlastnostem, využit jako přírodní prebiotikum. Cílem této studie bylo začlenit nať topinamburu hlíznatého, jako přírodní zdroj inulinu, do krmné směsi rostoucích králíků. 80 Hyla králíků bylo náhodně rozděleno do 2 skupin. Kontrolní skupina byla krmena standardní krmnou směsí, zatímco skupině "topinambur hlíznatý" byla podávána směs s 20% nati topinamburu hlíznatého. Pokus byl uskutečněn ve standardních podmínkách komerční farmy a slouží jako předběžný výzkum, sledována byla výkrmnost a mortalita králíků. Krmná směs

obsahující 20% nati topinamburu hlíznatého ve srovnání s kontrolní snížila konverzi krmiva o 0,39 (11%) a mortalitu králíků o 10% (P<0,05). Nať topinamburu hlíznatého (20 %) je možné zařadit do krmné směsi králíků jako vhodný zdroj karbohydrátů s probiotickými vlastnostmi pro rostoucí králíky, a tím nahradit některé její složky (zdroje škrobu) zatěžující neúplně vyvinutý trávicí systém mladých zvířat.

Klíčová slova: inulin, králíci, mortalita, prebiotika, topinambur hlíznatý, výkrmnost

INTRODUCTION

The health status is essential for growth and reproductive performance and thus for economic performance of rabbit husbandry. The most exacting life period of growing rabbits is the weaning period (21 – 42 days), where the transition from the milk of rabbit does to a solid feed takes place and rabbit digestive system is not completely developed (Gallois et al., 2005). Primarily, amylase and disaccharidase activities remaining low during the period from 25 to 35 days of age (Blas et al., 1994; Gutiérrez et al., 2002; Debray et al., 2003). The dietary starch level is generally in negative correlation with the fibre level. Dietary fibre, especially neutral detergent fibre (NDF), affects the rate of passage of digesta and optimizes caecal fermentation in rabbits (Gutiérrez et al., 2002; Gómez-Conde et al., 2009; Gidenne et al., 2010). Gidenne (2003) described, that cellulose and lignins (poorly digested fiber) play a key role in reducing the incidence of diarrhoea in growing rabbits. Fibre sources rich in digestible fibre can replace sources of starch or protein and they improve the digestive health of animal, if the correct supply of ligninocellulose is respected. Therefore, the suitable source of carbohydrates is substantial for the health of young rabbits. In this view, Volek et al. (2007) considers as the prospect the using of prebiotics; non-starch polysaccharides and oligosaccharides, in rabbit nutrition, which are not digested in the small intestine.

Furthermore, in recent times, many breeders step back from using synthesised allopathic medicinal products to maintain good health of animals (mainly due to food security, the possibilities of negative impact on animal organism and the development of antibiotic resistance) and try to replace it by some natural alternatives, as plants products, prebiotics or probiotics. However, most of such preparations are very expensive.

Jerusalem artichoke (*Helinathus tuberosus*) contains 11–20% carbohydrates and 70-90% of theses carbohydrates are inulin and inulids (Szambelan et al., 2004). Inulin is a polydisperse non-starch polysaccharide naturally occurring as a storage carbohydrate in some 36.000 plant species. It consists of chains of fructose units coupled by β (2, 1)-bonds most often (though not always) terminated by a single glucose moiety. The degree of polymerization of inulin ranges from 2 to 60 and above depends mainly on the type of plant from which is isolated (Roberfroid, 1999; Boeckner et al., 2001; Öztürk, 2008). Inulin-type fructans (fructo-oligosaccharide, FOS) are soluble dietary fibres, which can be used as prebiotics (Bónai et al., 2010). Prebiotics were defined as a non-digestible food ingredient that beneficially affects the host by selectively stimulating the growth and/or activity of one or limited number of bacteria in the colon and thus improves host health (Gibson and Roberfroid, 1995). Inulin is little digested by humans (Kays and Kultur, 2005), because it is resistant to enzymatic hydrolysis in the upper gastrointestinal tract of monogastric species. It is fermented by colonic microflora, which stimulates the growth of *Lactobacillus* and bifidobacterial cultures especially. Cieślik et al. (2011) underlined the high value of proteins and balanced amino acids composition of Jerusalem artichoke too. According to Samanta et al. (2013), dietary oligosaccharides, such as an inulin and oligofructose, are possible substitutes for antibiotics and can improve the gut health and reduce the mortality of rabbits.

Therefore, the aim of this study was to incorporate Jerusalem artichoke tops to the feed mixture of growing rabbits as the natural source of inulin. There are no studies focused on using Jerusalem artichoke in the nutrition of growing rabbits in the scientific literature.

MATERIALS AND METHODS

Experimental diets

The ingredients and chemical composition of diets are shown in Tables 1 and 2, respectively. Jerusalem artichoke diet enriched by 20% tops of Jerusalem artichoke was designed to have fibre in sufficient level with decreased level of starch. Diets were pelleted and animals were given *ad libitum* access to feed and water through the experiment.

Rabbit husbandry and experimental design

The experiment took place in commercial farm with standard conditions. The environmental conditions were controlled by an automatic heating system (16 – 18 °C), and the light: dark cycle was 12 h : 12 h. In the experiment, 80 Hyla rabbits at the age of 42 days were randomly divided into 2 groups and were kept in all-wire cages, two per cage. Fattening cages with rabbits from different groups were homogenously alternated in the barn to minimize the cage effect on the studied parameters. Since this experiment took place in the farm not in experimental conditions, the individual feed intake was not recorded therefore statistical evaluation was not possible. The daily feed intake was calculated as feed intake for the whole group for through experimental period divided by the number of rabbits in the group and by the number of experimental days. Animals were individually weighted at the beginning and in the end of every week. Rabbit mortality was noted during experiments. The experiment was finished by slaughtering at 84 days of age.

Instrumental analysis

Feed samples were air dried at 103 °C to constant weight to estimate the dry matter content. Crude protein content was determined by means of water steam rapid distillation system Vapodest 20s from Gerhardt (Germany). Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were determined according to the procedure of Van Soest et al. (1991), using a Fibertec 1020 from Foss. Starch was measured polarimetrically, simple carbohydrates by means of the titration according to Luff-Schoorl.

Statistical methods

Data on growth performance and feed consumption were examined by t-test procedure of SAS 9.3. Data on mortality were analysed using the χ^2 test. Statistical significance was declared at $P \leq 0.05$ trends were taken into account up to $P \leq 0.1$

Table 1. Ingredient composition (g/kg as fed basis) of the experimental diets

Ingredients	Control	Jerusalem artichoke
Alfalfa meal	250	203
Soybean meal	30	30
Wheat bran	180	150
Sugar beet pulp	70	80
Dried Jerusalem artichoke tops	-	200
Oats grain	50	50
Barley grain	50	50
Apple pomace	150	97
Malt sprouts	50	120
Vitamin supplement[1]	20	20
Lapilest R[2]	150	-

[1] Vitamins: vitamin A – 1200 000 UI, vitamin D3 – 200 000 UI, vitamin E (Alpha-tocopherol) – 5,000 mg, vitamin K3 – 200 mg, vitamin B1 – 300 mg, vitamin B2 – 700 mg, vitamin B6 – 400 mg, vitamin B12 – 2 mg, Niacinamide – 5,000 mg, Calcium pantothenate – 200 mg, Biotin – 20 mg, Folic Acid – 170 mg, Choline chloride – 60,000 mg; Amino acids: L-lysine – 20 g, DL-methionine – 100 g.

[2] Grape pomace, cocoa peels, buckwheat peels (crude protein 12%, crude fibre 24%, fat 5.5%, starch 2.1%, carbohydrates 2.65%).

Table 2. Chemical composition (g/kg as-fed basis unless otherwise stated) of experimental diets and dried Jerusalem artichoke tops

Nutrients	Control	Jerusalem artichoke	Dried Jerusalem artichoke tops
Determined values			
Dry matter	905	888	901
Crude protein	155	132	57.7
Fat	23.8	27.6	13.2
Ash	69.1	75.8	102
Crude fiber	159	162	326
Starch	152	132	-
Saccharose	43	56.6	74.9
Calcium	9.03	14.1	13.3
Sodium	1.99	2.28	0.13
Phosphorus	6.1	3.9	1.2
Magnesium	2.97	2.02	2.21
Zinc	0.96	0.9	0.13
Methionine	2.95	2.84	-
Lysine	7.15	5.88	2.39
Vitamin A (m.j.)	7,870	5,720	4,760
Vitamin E (mg/kg)	59.4	52.2	38.6

RESULTS AND DISCUSSION

In this study were incorporated tops of Jerusalem artichoke as the by-product of tubers harvest, which may be good source of carbohydrates with prebiotic effect for growing rabbit with the highest incidence of diseases.

The Table 3 overviews the results of the growth performance and mortality of rabbits. The moderate increasing in daily weight gain (about 1.6%) and the decreasing of daily feed intake (about 6%) decreased feed conversion ratio about 0.39 (11%) in the group with Jerusalem artichoke supplement compared with control group. Yildiz et al. (2006) reported that the supplementation of Jerusalem artichoke to laying hen improved their feed conversion ratio (about from 5% to 10%) and they noted that this improving was due to oligofructose or inulin addition. These effects did not confirm Farnworth et al. (1992), which fed the weanling pigs Jerusalem artichoke in amount 15 g/kg. They did not observe any differences in daily feed intake, weight gain or feed efficiency.

In comparison with control group, the mortality of Jerusalem artichoke group was significantly lower (about 10%). Volek et al. (2007) recorded lower mortality of rabbits fed by diet supplemented with inulin, while Bónai

Table 3. Growth performance (42 – 84 d of age) and mortality of rabbits fed the experimental diets

Parameters	Control	Jerusalem artichoke	RMSE	P-value
Live weight (g)				
- 42 d	905.13	908.29	65.69	0.84
- 84 d	2,570	2,594.1	172.14	0.55
Daily weight gain (g/d)	39.56	40.21	3.77	0.52
Daily feed intake (g/d)	140.83	132.81	-	-
Feed conversion rate	3.56	3.17	-	-
Mortality	5[a]	1[b]	-	<0.05

[a, b] Means in the same row with different letters differ significantly (P<0.05). RMSE - root mean square error.

et al. (2010) observed no effect of dietary inulin on rabbit mortality (mortality was low in all groups of experiment). The prebiotic effect of Jerusalem artichoke is associated with its ability to support the growth of desirable indigenous bacterial species, including bifidobacteria and lactobacilli (Flickinger et al., 2003).

CONCLUSIONS

Jerusalem artichoke tops (20%) may be incorporated to rabbit diets as an appropriate source of carbohydrates with prebiotic properties for growing rabbits and thus may partly replace some ingredients (starch sources), which burden the not completely developed digestive system of young rabbits. This experiment took place in farm conditions therefore the individual feed intake was not recorded thus the statistical evaluation was not possible on the other hand these conditions are heavy for young organism so the prebiotic effect of Jerusalem artichoke can be better noted. This experiment was conducted as a preliminary examination, so it is necessary to confirm these results by others experiments.

ACKNOWLEDGEMENTS

This research was founded by an "S" grant of the Ministry of Education, Youth and Sports of the Czech Republic.

REFERENCES

Blas, E., Cervera, C., Fernadez-Carmona, J. (1994) Effect of two diets with varied starch and fibre levels on the performances of 4-7 weeks old rabbits. World Rabbit Science, 2, 117 – 121. DOI: https://dx.doi.org/10.4995/wrs.1994.226

Boeckner, L.S., Schnepf, M.I., Tungland, B.C. (2001) Inulin: a review of nutritional and health implications. Advances in food and nutrition research, 43, 1 – 63. Available at: https://epdf.tips/advances-in-food-and-nutrition-research-vol-43.html [Accessed 17 June 2018].

Bónai, A., Szendrő, Z., Fébel, H., Kametler, L., Tornyos, G., Horn, P., Kovács, F., Kovács, M. (2010) Effect of inulin supplementation and age on performance and digestive parameters in weaned rabbits. World Rabbit Science, 18, 121 – 129. DOI: https://dx.doi.org/10.4995/wrs.2010.5883

Cieślik, E., Gębusia, A., Florkiewicz, A., Mickowska, B. (2011) The content of protein and of amino acids in Jerusalem artichoke tubers (*Helianthus tuberosus* L.) of red variety Rote Zonenkugel. Acta Scientarium Polonorum. Technologia Alimentaria, 10 (4), 433 – 411. Available at: https://www.researchgate.net/publication/221734481_The_content_of_protein_and_of_amino_acids_in_Jerusalem_artichoke_tubers_Helianthus_tuberosus_L_of_red_variety_Rote_Zonenkugel [Accessed 12 May 2018].

Debray, L., Le Huerou-Luron, I., Gidenne, T., Fortun-Lamothe, L. (2003) Digestive tract development in rabbit according to the dietary energetic source: colleration between whole tract digestion, pancreatic and intestinal enzymatic activities. Comparative Biochemistry and Physiology Part A, 135 (3), 443 – 455. DOI: https://dx.doi.org/10.1016/S1095-6433(03)00112-0

Farnworth, E.R., Modler, H.W., Jones, J.D., Cave, N., Yamazaki, H., Rao, A.V. (1992) Feeding Jerusalem artichoke flour rich in fructooligosaccharides to weanling pigs. Canadian Journal of Animal Science, 72, 977 – 980. DOI: https://dx.doi.org/10.4141/cjas92-112

Flickinger, E.A., Van Loo, J., Fahey, G.C., Jr. (2003) Nutritional responses to the presence of inulin and oligofructose in the diets of domesticated animals: A review. Critical Reviews in Food Science and Nutrition, 43 (1), 19 – 60. DOI: http://dx.doi.org/10.1080/10408690390826446

Gallois, M., Gidenne, T., Fortun-Lamothe, L., Le Huerou-Luron, I., Lalles, J.P. (2005) An early stimulation of solid feed intake slightly influences the morphological gut maturation in the rabbit. Reproduction Nutrition Development, 45, 109 – 122. DOI: https://dx.doi.org/10.1051/rnd:2005008

Gibson, G.R., Roberfroid, M.B. (1995) Dietary modulation of the human colonic microbiota: Introduction the concept of prebiotics. Journal of Nutrition, 125, 1401 – 1412. Available at: https://www.ilri.org/biometrics/Publication/Abstract/Case%20study%2017%20-1.pdf [Accessed 17 June 2018].

Gidenne, T. (2003) Fibres in rabbit feeding for digestive troubles prevention: respective role of low-digested and digestible fibre. Livestock Production Science, 81, 105 – 117. DOI: https://dx.doi.org/10.1016/S0301-6226(02)00301-9

Gidenne, T., Carabaño, R., Garcia, J., De Blas, C. (2010) Fibre digestion. In: Wiseman, J., De Blas, C., eds. The nutrition of rabbit. Wallingford: CABI, 66 – 82.

Gómez-Conde, M.S., De Rozas, A.P., Badiola, I., Pérez-Alba, L., De Blas, C., Carabaño, R., García, J. (2009) Effect of neutral detergent soluble fibre in digestion, intestinal microbiota and performance in twenty-five day old weaned rabbits. Livestock Science, 125, 192 – 198. DOI: https://dx.doi.org/10.1016/j.livsci.2009.04.010

Gutiérrez, I., Espinosa, A., García, J., Carabaño, R., De Blas, J.C. (2002) Effect of levels of starch, fibre, and lactose on digestion and growth performance of early-weaned rabbits. Journal of Animal Science, 80, 1029 – 1037. DOI: https://dx.doi.org/10.2527/2002.8041029x

Kays, S.J., Kultur, F. (2005) Genetic variation in Jerusalem artichoke (*Helianthus tuberosus* L.) flowering date and duration. HortScience, 40 (6), 1675 – 1678. Available at: http://hortsci.ashspublications.org/content/40/6/1675.full.pdf [Accessed 12 May 2018].

Öztürk, H. (2008) Effects of inulin on rumen metabolism *in vitro*. Ankara Üniversitesi Veteriner Fakültesi Dergisi, 55, 79 – 82. Available at: https://www.researchgate.net/publication/228801489_Effects_of_inulin_on_rumen_metabolism_in_vitro [Accessed 10 May 2018].

Roberfroid, M.B. (1999) Concepts in functional foods: The case of inulin and oligofructose. The Journal of Nutrition, 129, 1398S – 1401S. DOI: https://dx.doi.org/10.1093/jn/129.7.1398S

Samanta, A.K., Jayapal, N., Senani, S., Kolte, A.P., Sridhar, M. (2013) Prebiotic inulin: Useful dietary adjuncts to manipulate the livestock gut microflora. Brazilian Journal of Microbiology, 44 (1), 1 -14. DOI: https://dx.doi.org/10.1590/S1517-83822013005000023

Szambelan, K., Nowak, J., Chrapkowska, K.J. (2004) Comparison of bacterial and yeast ethanol fermentation yield from Jerusalem artichoke (*Helianthus tuberosus* L.) tubers pulp and juices. Acta Scientarium Polonorum. Technologia Alimentaria, 3 (1), 423 – 432. Available at: http://www.acta.media.pl/pl/action/getfull.php?id=539 [Accessed 12 May 2018].

Van Soest, P.J., Robertson, J.B., Lewis, B.A. (1991) Methods for dietary fibre, neutral detergent fibre, and nonstarch polysaccharides in relation to animal nutrition. Journal of Dairy Science, 74, 3583 – 3597. DOI: https://dx.doi.org/10.3168/jds.S0022-0302(91)78551-2

Volek, Z., Marounek, M., Skřivanová, V. (2007) Effect of a starter diet supplementation with mannanoligosaccharide or inulin on health status, caecal metabolism, digestibility of nutrients and growth of early weaned rabbits. Animal, 1 (4), 523 – 530. DOI: https://dx.doi.org/10.1017/S1751731107685012

Yildiz, G., Sacakli, P., Gungor, T. (2006) The effect of Jerusalem artichoke (*Helianthus tuberosus* L.) on performance, egg quality characteristics and egg cholesterol conten in laying hens. Czech Journal of Animal Science, 51 (8), 349 – 354. Available at: https://www.researchgate.net/publication/242713284/download [Accessed 20 May 2018].