INFLUENCE OF JERUSALEM ARTICHOKE IN EXTRUDED COMPOUND FEED ON LAMBS PRODUCTIVITY, CARCASS YIELD, MEAT CHEMICAL COMPOSITION AND WOOL PROPERTIES

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Abstract. In this study, effects of using Jerusalem artichoke in extruded compound feed on lambs productivity, carcass yield, chemical composition of lamb meat and quality of wool was analysed. A total number of 24 Lithuanian blackhead breed sheep were assigned into 2 groups (12 lambs in each group). I was control group, II experimental, where farm ratio was supplemented with 200 g/day of Jerusalem artichoke tuber's flour. Lambs were weighed after being born, 21st day of age, 2 months age, 3 months age, 4 months age and 6 months age, i.e. before slaughter. Weighings were performed before morning feeding. Lambs were slaughtered at 6 months of age. In the end of the trial, lamb's from experimental group had 5 percent bigger weight, comparing to control group. Jerusalem artichoke had no effect on lamb's carcass yield, though it influenced meat's chemical composition, concentration of fat in experimental group's meat increased by 1.83 percent ($P<0.05$) comparing to control group. Feed supplementation with jerusalem artichoke tuber's flour had no statistically signifficant effect on lamb's wool quality.
Keywords: jerusalem artichoke, extruded compound feed, lamb, wool

Introduction. One of the promising functional constituents that could be used for developing a functional food is inulin. It has a great potential to be considered as a low glycaemic index (GI) ingredient that could provide a number of health benefits such as managing increased risk of chronic diseases (diabetes, cardiovascular diseases, obesity, stroke and cancer), improving digestive health (prevents constipation), reducing cholesterol and lipids (decrease cardiovascular disease) and enhancing mineral absorption from colon with its prebiotic role (prevents osteoporosis) (Barclay et al., 2008; Brand-Miller et al., 2002; Knudsen & Hessova, 1995; Watzl et al., 2005). Jerusalem artichoke has been used for food or animal feed (Ma et al., 2011; Swanton and Hamill, 1994), and for the past two decades, alternative uses have been explored especially for the production of functional food ingredients such as inulin, oligofructose and fructose (Panchev et al., 2011; Praznik and Cieslik, 2002). Jerusalem artichoke tubers primarily contain two types of carbohydrates, inulin and sugars (fructose and glucose) (Gunnarsson et al., 2014; Baldini et al., 2004). Jerusalem artichoke (JA), from the Asteraceae family, contains high amounts of inulin and phenolic compounds. As one type of fructooligosaccharide (Rodriguez Furlan, Padilla, & Campderros, 2014), the inulin in JA is a prebiotic and a good source of low-calorie ingredient. It can increase faecal bulk, enhance bowel regularity and possesses characteristic properties comparable with other fibers. It also has the potential to influence gastrointestinal functions, which could be attributed to its bio-chemical and physiological properties (Roberfroid, 2005). The tubers of Jerusalem artichoke (JA) possesses higher antioxidant activity, as the polyphenols were accomulated in higher concentrtion mainly in the epidermis (Seljåsen et al., 2005; Saikaew et al, 2010). Phenolics are secondary plant metabolites found in the majority of herbs, vegetables with well pronounced radical scavenging activity (Shao et al., 2008; Mihaylova et al., 2014; Georgieva and Mihaylova, 2014). The data of Jerusalem artichoke's influence on quality of carcass yield, meat chemical composition or wool were not found.

Therefore, the aim of this study was to evaluate the influence of jerusalem artichoke tuber's flour in extruded compound feed on lamb's productivity, carcass yield, chemical composition of lamb meat and quality of wool.

Material and Methods

The experiment was carried out with 24 Lithuanian blackhead breed's lambs, which were divided into 2 groups (12 lambs in each group). First one was control group, where compound feed was supplemented with extruded compound feed and II experimental, where extruded compound feed supplemented with 200g/day of Jerusalem artichoke tuber's flour. Lambs were weighed after being born, 21st day of age, 2 months age, 3 months age, 4 months age and 6 months of age, i.e. before slaughter. Weighings were performed before morning feeding. Lambs were slaughtered at 6 months of age.

Samples were analysed 48 hours after animal's slaughter, samples were taken from *musculus longissimus dorsi*. Before analysis samples were held in + 4°C temperature. The dry matter content was determined by drying meat to constant weight (at 105°C), the fat content was determined by Soxhlet method, the fat extracted with chloroform for 8 hours. Protein content was determined by the Kjeldahl method (King-Brink, Sebranek, 1993).

The main fleece physical, technological properties were analysed. Lamb's fleece color was evaluated 24 hours after their birth and after six months. The wool was estimated by it's wavelet format and fleece curl. Lamb shoulder area was measured for natural fleece length (NL) - not to stretch the ringlets and the real length (TL) - straightening ringlets.

The composition of extruded compound feed: triticale, barley, maize, sunflower meal, oats, rapeseed cake, wheat.

Table 1. Compound feed nutrition value

Parameter	Control group	Experimental group
Crude protein, g	180.10	183.49
ME-ruminants, MJ	12.96	13.00
Crude fat, g	41.80	42.64
Crude fiber, g	354.70	353.16
Crude ash, g	114.70	122.06
Ca, g	8.23	9.33
P, g	3.86	4.21
Na, g	0.70	1.07

Composition of premix (1 kg): vitamin A – 19.999 U, vitamin D – 500 U, vitamin E – 9.90 mg, Fe – 20.00 mg, Mn – 20.00 mg, Zn – 20.00 mg, Cu 2.00 mg, I – 0.10 mg, Se – 0.10 mg, Co – 0.10 mg.

Data statistical analysis was performed with the R statistical package. Following indexes were calculated: the arithmetic mean (x), their dispersion characteristics - standard deviations (SD) and coefficient of variation (CV). The estimated influence of the age difference between statistical significance (P). The difference between the average values of reliability at P<0.05.

Results and discussions. A variety of factors influence the quality of lamb meat, including genotype (Martinez-Cerezo et al., 2005). Additional factors include pre-slaughter stress, carcass cooling rate, aging regimen (Tejeda et al., 2008), sex, diet, feeding sys-tem (Alvarez-Rodrguez et al., 2008) and slaughter weight (Martinez-Cerezo et al., 2005).

Prebiotics, such as probiotics, acidifiers, bacteriocins and some phytobiotics, are homoeostasis promoters of the gastrointestinal tract ecosystem. A prebiotic is a selectively fermented food ingredient that beneficially affects the host by a selective stimulation of the growth and/or activity of one or a limited number of bacteria in the colon and is not digested by the host digestive enzymes (Gibson et al., 2004). Inulin is one of the most commonly used and most effective prebiotics (Dankowiakowska et al., 2013).

Table 2. Influence of Jerusalem artichoke on lamb productivity, kg

Age of lamb	Group	
	I (control group)	II (experimental)
Born lamb weight	3.93±0.59	3.48 ± 0.49
20 days	7.88±0.56	7.14 ± 0.72
2 months	15.75±1.38	15.67 ± 2.52
3 months	19.80±2.02	22.55 ± 3.91
4 months	28.68±1.59	29.25 ± 3.88
6 months	39.67±1.92	41.62 ± 5.54

Lamb growing dynamics is presented in Table 2. Born lamb's weight in experimental group was 11 percent lesser (P>0.05) than control group's. At 20 days of age lamb's from experimental group had this index decreased by 9 percent (P>0.05) comparing to control group. At 2 months of age the body weight of experimental group's lambs was 1 percent lesser (P>0.05). After 4 months, this parameter had increased by 2 percent (P>0.05) compared to the control group. At the end of the trial (6 months age), the body weight of experimental group's lambs increased by 5 percent (P>0.05) comparing to the control group.

Meat is the most important source of animal protein for the human diet (Lawrie, 2005; McAfee *et al*., 2010). However, the parameters that define it's degree of acceptance and quality vary with the point of view and interest of the producer, trade, industry, and consumers.

Table 3. Influence of Jerusalem artichoke in extruded compound feed on lamb carcass yield

Parameter	Group	
	I (control)	II (experimental)
Pre-slaughter weight, kg	39.67±1.92	41.62 ± 5.54
Carcass weight, kg	18.04±0.90	18.31 ± 2.60
Carcass yield, %	45.50±1.21	44.00 ± 3.14

The lamb carcass yield is presented in table 3. In experimental group, pre-slaughter weight was 5 percent (P>0.05) bigger comparingto the control group. The carcass weight also was higher in experimental group, it was higher by 1.5 percent (P>0.05) comparing to the control group. But the carcass yield had tendency to decrease by 1.5 percent (P>0.05) comparing to the control group.

Table 4. Influence of Jerusalem artichoke in extruded compound feed on lamb meat chemical composition, %

Parameter	Group	
	I (control)	II (experimental)
Dry matter	25.22±0.53	25.63 ± 0.61
Protein	20.51±0.85	21,21 ± 0.75
Fat	2.72±0.12	4.55 ± 0.32*
Ash	1.09±0.06	1.03 ± 0.06

*- data statistically significant at P<0.05

The lamb meat chemical composition is presented in Table 4. Dry matter content in *longissimus dorsi* in experimental group increased by 0.41 percent (P>0.05), protein – 0.7 percent (P>0.05), fat – 1.83 percent (P<0.05), but ash content decreased by 0.06 percent (P>0.05) compared to the control group.

Wool is a versatile product in demand mainly because of its physical characteristics that directly influence wearer comfort (Hatcher et al., 2010; Swan, 2010), processing performance, durability (Swan et al., 2008) and textile attributes (Wood, 2003; Warn et al., 2006). Wool processing performance is particularly important as wool buyers explore means of limiting production costs by improving efficiency and profitability through preferential utilisation of wool that requires less processing. However, wool is not a uniform biological product because its physical characteristics vary depending on sheep genetics, environment and management strategies (Warn et al., 2006; Poppi and McLennan, 2010). The mean and range of different diameters in fleece are determined initially by the genotype of the animal, which sets the size and synthetic capacity of follicles, but are also consider rably modified by external factors, especially nutrition (Khan, 2011).

Table 5. Influence of Jerusalem artichoke in extruded compound feed on lamb wool properties

Parameter	Group	
	I (control)	II (experimental)
The fleece color after birth	Gray-brown	Gray-brown
The fleece color after 6 month after birth	White yellowish	White yellowish
The density of fleece, points (1-5)	2	2
Type of wool	Semi-fine	Semi-fine
The color of sweat fat of wool, points (1-5)	2	2
Curls of wool	Normal	Normal

Extruded compound feed supplemented with Jerusalem artichoke tuber's flour did not have effect on the lamb's wool properties such as fleece after birth and 6 months of age, the density of fleece, type of wool, curls of wool and the color of sweat of fat of wool.

Wool production is influenced by the age and sex of animals, and by reproduction in the ewe. Less wool is grown by young animals per unit of feed intake, presumably due to competition for nutrients between follicles and other tissues (Corbett, 2001).

Table 6. Influence of Jerusalem artichoke in extruded compound feed on length of the wool of lambs

Parameter	Group	
	I (control)	II (experimental)
Natural length of wool	6.65±0.40	6.70±0.35
Real length of wool	7.64±0.40	7.65±0.31

After analyzing data of wool length (table 6), we determined that Jerusalem artichoke had marginal influence on natural length of wool, which only increased by 1 percent (P>0.05) whereas it had no effect on real length of wool.

Conclusions

Compound feed's supplementation with Jerusalem artichoke tuber's had effect on lamb's meat (*longissimus dorsi*) fat concentration, yet it had no effect on lamb's productivity, carcass yield and properties and length of wool.

References

1. Alvarez-Rodrguez, J., Sanz, A., Joy, M., Carrasco, S., Ripoll, G., Teixeira, A. Development of organs and tissues in lambs raised on Spanishmountain grassland. Can. J. Anim. Sci. 2008. 89. P. 37–45.

2. Baldini, M.; Danusco, F.; Turi, M.; Vannozzi, G.P. Evaluation of new clones of Jerusalem artichoke (Helianthus tuberosus L.) for inulin and sugar yield from stalks and tubers. Ind. Crops Prod. 2004. 19. P. 25–40.

3. Barclay, A. W., Petocz, P., McMillan-Price, J., Victoria, M., Flood, Prvan T., Mitchell, P. Glycemic index, glycemic load, and chronic disease risk—a meta analysis of observational studies. The American Journal of Clinical Nutrition. 2008. 87. P. 627–637.

4. Brand-Miller, J. C., Holt, S. H. A., Pawlak, D. B., & McMillan, J. Glycemic index and obesity. The American Journal of Clinical Nutrition. 2002. 76. P. 281S–285S.

5. Corbett J.L. Variation in wool growth with physiological state. Univ .New England Publishing Unit, Armidale. 2001. P. 79-98

6. Dankowiakowska, A.; Kozłowska, I.; Bednarczyk, M. Probiotics, prebiotics and snybiotics in Poultry – mode of action, limitation, and achievements. Journal of Central European Agriculture. 2013. 14. P. 467–478.

7. Georgieva L., Mihaylova D. Screening of total phenolic content and radical scavenging capacity of Bulgarian plant species. International Food Research Journal.accepted 2014. (ISSN 1985-4668).

8. Gibson, G. R.; Probert, H. M.; Rastall, R. A.; Roberfroid, M. B. Dietary modulation of the human colonic microbiota: updating the concept of prebiotics. Nutrition Research Reviews. 2004. 17. P. 259–275.

9. Gunnarsson, I.B.; Svensson, S.-E.; Johansson, E.; Karakashev, D.; Angelidaki, I. Potential of Jerusalem artichoke (Helianthus tuberosus L.) as a biorefinery crop. Ind. Crops Prod. 2014. 56. P. 231–240.

10. Khan M.J. Equine and Camel Production. Lambert Acadmic Publishing, Germany. 2011. 50.

11. Knudsen, B. K. E., & Hessova, I. Recovery of inulin from Jerusalem artichoke (Helianthus tuberosus L.) in the small intestine of man. British Journal of Nutrition. 1995. 74. P. 101–113.

12. Lawrie RA. Ciência da carne. 6th ed. Artimed Editora:São Paulo, 2005.

13. Ma M.X., L.H. Zhang, H.B. Shao, G. Xu, F. Zhang, F.T. Ni, M. Brestic, Jerusalem artichoke (Helianthus tuberosus), a medicinal salt-resistant plant has high adaptability and multiple-use values, J. Med. Plants Res. 2011. 5. P. 1272–1279.

14. Martinez-Cerezo, S., Sanudo, C., Panea, B., Medel, I., Delfa, R., Sierra, I.,Beltran, J.A., Cepero, R., Olleta, J.L. Breed, slaughter weight andageing time effects on physico-chemical characteristics of lamb meat. Meat Sci. 2005. 69 (2). P. 325–333.

15. McAfee AJ, McSorley EM, Cuskelly GJ, Moss BW, Wallace JMW, Bonham MP, Fearon AM. Red meat consumption: An overview of the risks and benefits. Meat Sci. 2010. 84. P. 1-13.

16. Mihaylova, D., Lante, A., Krastanov, A. Total phenolic content, antioxidant and antimicrobial activity of Haberlea rhodopensis extracts obtained by pressurized-liquid extraction. Acta Alimentaria. 2014. P. 1-7.

17. Panchev I., N. Delchev, D. Kovacheva, A. Slavov, Physicochemical characteristics of inulins obtained from Jerusalem artichoke (Helianthus tuberosus L.), Eur. Food Res. Technol. 2011. 233. P. 889–896.

18. Pool-Zobel, B., Van Loo, J., Rowland, I., Roberfroid, M.B. Experimental evidences on the potential of prebiotic fructans to reduce the risk of coloncancer. Br. J. Nutr. 2002. 87 (S2). P. 273–281.

19. Praznik W., E. Cieslik, A. Filipiak-Florkiewicz, Soluble dietary fibers in Jerusalem artichoke powders: composition and application in bread, Nahrung. 2002. 46. P. 151–157.

20. Roberfroid, M. B. Introducing-inulin-type fructans. British Journal of Nutrition. 2005. 93 (1). P. 13-26.

21. Roberfroid, M.B. Functional foods: concepts and application to inulin and oligofructose. Br. J. Nutr. 2002. 87 (S2). P. 139–143.

22. Rodriguez Furlan, L. T., Padilla, A. P., & Campderros, M. E. Development of reduced-fat minced-meats using inulin and bovine plasma-proteins as fat replacers. Meat Science. 2014. 96 (2, Part A). P. 762-768.

23. Saikaew, S., Tangwongchai R., Sae-Eaw A. The effect of temperature and storage time on the chemical and physical compositions changes of KaenTaWan (Helianthus tuberosus L.) tubers after harvesting. Agricultural Science J. 2010. 4. (3/1). P. 249-252.

24. Seljåsen, R., Slimestad, R. Fructooligosaccharides and phenolics in flesh and peel of spring harvested Helianthus,SHS Acta Horticulturae 744: I International Symposium on Human Health Effects of Fruits and Vegetables. 2005.

25. Shao, H.B., Chu, L.Y., Lu, Z. H., Kang, C.M. Primary antioxidant free radical. Scavenging and redox signaling pathways in higher plant cells. Int. J. Biol. Sci.2008. 4. P. 8–14.

26. Swan, A.A., Purvis, I.W., Piper, L.R. Genetic parameters for yearling wool production wool quality and bodyweight traits in fine wool Merino sheep. Aust. J. Expt. Agric. 2008. 48, P. 1168-1176.

27. Swan, P. The future of wool as an apparel fibre. In: Cottle, D.J. (Editor). International Sheep and Wool Handbook. Nottingham University Press, Nottingham, UK, 2010. P. 647-660.

28. Swanton C.J., A.S. Hamill, Jerusalem Artichoke. Factsheet, Ministry of Agriculture and Food, Ontario. 1994. P. 77–94.

29. Tejada L., Abellán A., Cayuela J.M., Martínez-Cacha A ., Fernández-Salguero J. Proteolysis in goats' milk cheese made with calf rennet and plant coagulant. International Dairy Journal. 2008. 18. P. 139–146.

30. Warn, L.K., Geenty, K.B., McEachern, S. Wool meets meat: Tools for a modern sheep enterprise. In: Cronjé, P., Maxwell, D.K. (Eds.), Australian Sheep Industry Cooperative Research Centre Conference, Orange, Australia. 2006. P. 60-69.

31. Watzl, B., Girrbach, S., & Roller, M. Inulin, oligofructose andimmunomodulation. British Journal of Nutrition. 2005. 93. P. 49–55.

32. Wood, E. Textile properties of wool and other fibres. Wool Tech.Sheep Breed. 2003. 51, 272-290.

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