Summary

The effect of tannins on digestion in sheep and lamb quality Tannins are plant secondary metabolites that belong to polyphenols. They are known as antinutritional factors, but recently it has been shown that in small doses they can exert positive effects on animals. Tannins are divided into hydrolysable and condensed types, with great diversity in chemical structure and properties. These compounds may influence nutrient digestion by forming complexes with protein, carbohydrates, lipids, and minerals. They can also affect the activity and number of microorganisms, which may significantly influence nutrient digestion and probably increase their contents in digesta flowing into the small intestine. Processes affected by tannins (degradation of protein in fodders, fermentation of carbohydrates, and biohydrogenation of fatty acids) may influence the quality of lamb meat. Thus, the aim of the study was to determine the effect of two different sources of tannins on digestion in the rumen, exocrine pancreas activity, blood plasma biochemical profiles in sheep, and long-chain fatty acid profiles of lamb meat. Experiment I was carried out on six ewes of the Polish Mountain breed fitted with rumen cannulae and catheters to the duodenum. The animals were divided into three feeding groups. The basic diet (control group, K) consisted of hay (~60%), barley meal (~30%), soybean meal (~10%), and vitamin-mineral additives. In addition to the basic diet, the experimental groups received the addition of lingonberry leaves (Vaccinium vitis-ideae; LB group) or oak cortex (Quercus sp.; KD group) at a dose of 3 g . day–1, representing sources of condensed and hydrolysable tannins, respectively. Samples of rumen fluid were collected before and 2, 4, and 8 hours after feeding, and protozoa counts, bacterial biomass, and rumen fermentation parameters (volatile fatty acids, methane, and carbon dioxide) were measured in them. Duodenal digesta was taken at 8 hours and its chemical composition and DAPA concentration (parameter of bacterial protein synthesis) were estimated. Experiment II was performed on six ewes of the Coloured Merino breed fitted with catheters to the common pancreatic-biliary duct and simple cannula to the duodenum. The design of the experiment and feeding pattern were similar to those used in experiment I. The collection of pancreatic-biliary juice was carried out for eight hours, where amylase, lipase, trypsin, and chymotrypsin activities and total protein concentration were estimated. Samples of blood were taken from the jugular vein two hours after feeding for measurement of plasma biochemical parameters, protein, lipid, and liver activity profiles. Experiment (III), a growth experiment, was

carried out on 24 lambs of the Corriedale breed. The animals were randomly divided into 4 groups. The "zero" group was slaughtered before fattening to estimate the body composition and fatty acid profile in selected soft parts of the carcass. The other animals were fattened to 35 kg, then slaughtered and simple dissection of the right-half carcass was performed. The control diet consisted of meadow hay (~37%), barley meal (~45%), soybean meal (~16%) and vitamin-mineral additives. Lambs from the experimental groups received similar additives as in experiments I and II, but increased to 10 g/day^{-1}. The basic chemical composition and long-chain fatty acid profiles were measured in the longissimus dorsi (MLD) and semitendinosus leg (MS) muscles. In experiment I, oak cortex increased the total number of protozoa and Entodinium ssp. two and four hours after feeding in comparison with control animals and those receiving lingonberry leaves, and the Diplodinium ssp. count two hours after feeding in comparison with the control ewes. Isotricha ssp. (before feeding) and Dasytricha ssp. counts (after feeding) were also higher in comparison with the control. Oak cortex significantly decreased the protozoa counts 8 hours after feeding in comparison with the other feeding groups, except for Ophryoscolex ssp. Ewes receiving lingonberry leaves had increased Ophryoscolex ssp. numbers in the rumen two hours after feeding in comparison with the control group. Lingonberry leaves added to the diet decreased the number of Diplodinium ssp. before and four hours after feeding in comparison with the control and KD groups, and the number of Dasytricha ssp. eight hours after feeding in comparison with control ewes. Furthermore, the diet enriched with lingonberry leaves increased the bacterial biomass in comparison with animals fed the diet containing oak cortex. Oak cortex added to the sheep diet lowered the rumen fluid pH before feeding in comparison with the other animals. Moreover, an increased concentration of butyric acid in rumen fluid was noted in sheep fed diets with oak cortex before and eight hours after feeding compared with the LB group; and two and four hours after feeding in comparison with groups K and LB. This additive also increased the valeric acid concentration in rumen fluid before feeding in comparison with the group receiving lingonberry leaves and two and four hours after feeding, when compared with the K and LB groups. Furthermore, animals fed the diet with hydrolysable tannins (oak) also had elevated concentrations of branched-chain fatty acids in the rumen in comparison with the remaining animals. Moreover, the addition of oak cortex increased the acetic-to-propionic acid ratio compared with groups K and LB. Two hours after feeding, the methane and carbon dioxide concentrations in the rumen were decreased in sheep receiving lingonberry leaves in comparison with ewes fed the diet with oak cortex. In this experiment, tannins did not affect the amount of digesta flowing to the duodenum, or its total protein concentration (including protein of microbial origin) and ether extract. The addition of oak cortex to the sheep diet decreased the concentration

of starch in the duodenal digesta in comparison with control ewes. Furthermore, no significant differences in the amount of pancreatic-biliary juice secretion or its total protein content after using these additives were observed. Likewise, we also did not find any essential changes in the amylolytic and proteolytic activities of the pancreas after feeding tannins. Only sheep given the diet with oak cortex had increased pancreatic lipase activity in comparison with the other feeding groups. Higher plasma albumin concentrations were noted in ewes fed the diet with hydrolysable tannins (oak) compared with animals from group LB. Nonetheless, the additives used in this study did not affect other blood protein and lipid parameters. However, tannins significantly influenced the liver profile of ewe blood plasma. Adding lingonberry leaves increased the activity of ALT and AST in comparison with groups K and KD. In turn, ALP and GGT activities were higher in animals receiving oak cortex in comparison with the other feeding groups. In the growth study (III) the additives with higher concentrations of tannins did not affect the average daily gain of lambs or weight of selected cuts and organs. In the MLD of ewes fed the diet with lingonberry leaves, a lower content of ether extract was noted in comparison with the control group. Lambs that were fattened had a higher concentration of total unsaturated fatty acids (including C16:1 c9 and C18:1 c11) and higher n-6-to-n-3 ratio in the MLD, while they had decreased concentrations of polyunsaturated fatty acids (including DHA) in the MS in comparison with lambs from the "zero" group. Tannins did not significantly influence the fatty acid profile in the MLD, however, except for condensed tannins, which decreased the n-6-to-n-3 ratio in comparison with animals fed the diet with hydrolysable tannins. This additive also increased ALA and sum of n-3 fatty acids in the MS in comparison with animals from the control group. In summary, the additives containing different types of tannins, affected digestion in the rumen due to changes in microorganism populations and concentrations of carbohydrate fermentation products. The addition of oak cortex to the sheep diet increased lipase activity in the pancreatic-biliary juice. Moreover, lingonberry leaves and oak cortex increased the activity of blood plasma liver-profile enzymes. Furthermore, the addition of lingonberry leaves increased the health-promoting properties of lamb meat by lowering the n-6- to-n-3 ratio and increasing the concentration of n-3 family fatty acids (including α-linolenic acid).

Key words: tannins, digestion, sheep, pancreas, lamb meat