
INVESTIGATIONS ON APPLE POMACE USED IN RED DEER NUTRITION**Līga Proskina**¹, Dr.oec.; **Sallija Cerina**², Dr.oec.¹Faculty of Economics and Social Development, Latvia University of Agriculture²State Priekuli Plant Breeding Institute

Abstract. Animal nutrition is directly related with the need to maintain the animal's physiological functions and health, thereby, ensuring a certain level of productivity. However, the quality of food of animal origin is closely related with proper animal nutrition and the choice of feed. It is known that feeding apple pomace to food-producing animals contributes to the functions of their digestive system and increases the level of their productivity. Currently in Latvia, there are only a few studies on the efficiency of use of apple pomace as a feed rich in fibres and natural bioactive substances in livestock farming. Accordingly, the research aim is to determine the efficiency of use of apple pomace in the red deer feed ration in a winter period. The research found that it was efficient to use apple pomace as a valuable source of natural vitamins and minerals available in Latvia in the nutrition of red deer, thus, turning apple pomace into a valuable raw material for the production of high-quality and healthy meat. The daily consumption of feed per red deer in the experimental group amounted to 8.5 kg, i.e. 0.5 kg or 6.25% less than that of feed per red deer in the control group, while the cost of feed for the experimental group decreased by 1.5%. The carcass weight (by 2.49 kg or 4.07% on average) and the amount of muscle tissue (by 8.06%; $p < 0.05$) in the experimental group were greater than in the control group. Feeding apple pomace resulted in higher quality meat – the contents of omega-3 and omega-6 fatty acids increased by 5.20% and 10.62% respectively compared with the control group.

Key words: deer farming.

JEL code: O13

Introduction

Deer farming is a new and non-traditional industry in Latvia, thus, one can assume that economically efficient feed of domestic origin for deer farming has not been sufficiently researched. Animal nutrition is actually directly related with the need to maintain the animal's physiological functions and health, thereby, ensuring a certain level of productivity. However, the quality of food of animal origin is closely related with proper animal nutrition and the choice of feed. It has to be emphasised that quite a few research on the possibilities to raise the quality of meat by using various feeds is available.

Foreign authors (Abdollahzadeh et al., 2010; Alibes et al., 1984; Rust, Buskirk, 2008) point that feeding apple pomace to ruminant animals contributes to the functions of their digestive system and increases the level of their productivity. In Latvia, 20 000-30 000 t of apples on average, depending on apple varieties and yields, are annually produced, of which a great deal is processed into juice. In total, up to 5 000 t of apple pomace or by-products of apple juice production are produced after processing 18 000-20 000 t of apples. Presently no research on the efficiency of use of apple pomace as a feed rich

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in fibres and natural bioactive substances for livestock farming has been conducted in Latvia. It indicates that it is necessary to examine the possibility to feed apple pomace to agricultural animals in Latvia for the purpose of raising the quality of products and the efficiency of production.

The research aim is to determine the efficiency of use of apple pomace in the red deer feed ration in a winter period. To achieve the aim, the following research tasks were set:

- 1) to determine the changes in the cost of feed and in the productivity of animals due to feeding apple pomace;
- 2) to examine the effect of feeding apple pomace to red deer on the quality of products.

Research results and discussion

Research materials and methods

A feeding experiment on red deer (*Cervus elaphus*) raised in a fenced territory was conducted on a deer farm "Saulstari" Ltd in the winter period from January to April 2012 to determine the efficiency of use of apple pomace in the feed ration for red deer. The experiment involved two red deer groups of analogous age and physiological condition: the control group ($n=11$) and the experimental group ($n=11$). The red deer of both groups were fed with the same feed in terms of dry matter, crude protein, and energy value; in the feed ration for the experimental group, the daily haylage portion was replaced with a portion of apple pomace. In the control group, each animal was daily fed with 7.0 kg of haylage and 1.0 kg of rolled grain (oats) and barley grains. In the experimental group, each animal received 6.5 kg of haylage, 1.0 kg of rolled grain (oats), and 1.0 kg of apple pomace.

Table 1

Feed value of apple pomace (as a percentage of dry matter)

Indicators	Apple pomace	Haylage	± compared with haylage
Dry matter, %	14.80	30.08	-15.28
Crude protein	3.86	8.00	-4.41
Crude nitrogen	0.62	2.77	-2.15
Crude fibre	16.14	39.87	-23.73
Crude fats	0.28	3.42	-3.14
Crude ash	2.76	7.31	-4.55
Non-nitrogen extracts	77.02	22.06	+54.96
Calcium	0.34	0.78	-0.44
Phosphorous	3.74	2.10	+1.64
Carotenoids, mg kg ⁻¹	72.84	54.98	+17.86
ADF, %	26.84	45.07	-18.23
NEL MJ kg ⁻¹	6.56	5.07	+1.49
NDF, %	36.97	69.89	-32.92

Source: authors' calculations based on the feeding experiment

The feed value of apple pomace and that of haylage was compared before starting the experiment to determine the necessary amount of apple pomace in the deer feed ration (Table 1).

Since red deer are ruminants, the feed value of apple pomace was evaluated according to feed quality criteria for ruminants, and the data obtained were compared with haylage characteristics. Apple pomace contains less dry matter, crude protein, crude fibre, crude fats, crude ash, and calcium compared with haylage. Yet, a positive fact is that apple pomace contains higher levels of carotenoids (by 17.86 mg kg⁻¹) and phosphorous (by 1.64%) compared with haylage (Table 1). In the winter feed ration for red deer, the contents of carotenoids and phosphorus are not sufficient; thus, their deficit might be offset by apple pomace. In the winter period, especially carotenoids (to stabilise the antioxidative system) and phosphorus (for the formation of antlers) have to be taken in with feed by the organism of red deer.

The quality of feed for ruminants, including red deer, is characterised by the contents of NDF and ADF in the feed. The size of NDF fraction determines the fibrosity of a feed and, indirectly, the animal's ability to consume this feed; thus, directly affecting the animal's productivity (Ositis, 2004). According to the test data, apple pomace is not as fibrous as haylage. The content of NDF in apple pomace was 36.97, i.e. 32.92% lower than in haylage (69.89%) (Table 1). The ADF fraction relates with the digestibility of a feed's organic component as well as the feed value of the feed. The smaller is the ADF fraction, the higher is the digestibility of a feed. The ADF fraction in apple pomace was 26.84% which was 18.23% smaller than in haylage. Adding apple pomace to the feed ration of red deer supplies 1.49% more energy (NEL MJ kg⁻¹) to the organism of red deer.

The proportions of muscle tissue in the carcasses of red deer from the control and experimental groups were ascertained and compared at the end of the experimental period to determine the effect of feeding apple pomace to red deer on their productivity.

Changes in the cost of feed and in the productivity of animals

The feed chosen for feeding animals is a significant production factor which, to a great extent, affects the economic performance of a farm as well as the quality of products (meat) produced.

Table 2

Daily consumption and cost of feed and crude protein per red deer

Indicator	Group 1 – control (n=10)	Group 2 – experimental (n=10)	Changes compared with the control group	
			absolute value	%
Feed:				
haylage, kg	7.00	6.50	-0.5	-7.14
rolled grain, kg	1.00	1.00	0	0
apple pomace, kg	-	1.00	1	100.00
Feed in total, kg	8.00	8.50	0.5	6.25
Feed costs*:				
haylage, LVL	0.133	0.124	-0.009	-6.77
rolled grain, LVL	0.134	0.134	0.000	0
apple pomace, LVL	-	0.005	0.005	100.00
Feed in total, LVL	0.267	0.263	-0.004	-1.50
Cost of 1 kg of crude protein of feed, LVL	0.81	0.82	-0.012	-1.50

Source: authors' calculations based on the feeding experiment

The basic feed for deer raised in captivity, just like for all ruminants, is coarse and juicy feeds: hay, haylage, and silage in the winter period; whereas, it is pasture grass in the summer period. These feeds contain crude fibre which serves as the main sources of energy and protein after being processed in the animal's rumen. Apple pomace can replace only a certain amount of haylage in the diet of deer. For the experimental group, 1.0 kg of apple pomace, in terms of feed value, replaced 0.5 kg of haylage.

Adding apple pomace to the feed ration of red deer increased the real consumption of feed by 0.5 kg, while the costs of this feed for the experimental group decreased by 1.5% (Table 2). Since crude protein comprises an insignificant share of apple pomace, the costs of 1 kg of crude protein do not considerably differ in the feed ration between the control and experimental groups. In total, the daily consumption of feed per red deer in the experimental group was equal to 8.5 kg, i.e. 0.5 kg or 6.25% less than that in the control group.

The proportions of muscle tissue in the carcasses of red deer from the control and experimental groups were ascertained and compared at the end of the experimental period to determine the effect of feeding apple pomace to red deer on their productivity (Table 3).

Table 3

Red deer carcass weight (kg), the proportion (%) and ratio of carcass components

Group	Carcass weight, kg \pm SD	Muscle tissue		Bone tissue		Ratio of muscle to bone tissue
		%	kg \pm SD	%	kg \pm SD	
Group 1, control (n=11)	61.16 \pm 4.92	58.20	35.60 \pm 3.55	32.05	19.60 \pm 1.74	1.81
Group 2, experimental (n=11)	63.65 \pm 5.37	60.43	38.46 \pm 3.89	29.60	18.84 \pm 1.56	2.04
Changes compared with the control group, absolute value	2.49	2.23	2.86	-2.45	-0.76	+0.23
Changes compared with the control group, %	4.07	-	8.06	-	-3.88	-

Source: authors' calculations based on the feeding experiment

The research findings show that adding apple pomace to the feed ration of red deer in the winter period led to an increase in the proportion of muscle tissue in the carcass. It has to be emphasised that the amount of muscle tissue in the carcasses of red deer from the experimental group was considerably greater (by 8.06%) ($p=0.007 < \alpha=0.05$) than in those from the control group and, accordingly, the proportion of bone tissue was lower. Therefore, the ratio of muscle tissue to bone tissue was higher in the carcasses of red deer from the experimental group (2.04), i.e. 0.23 greater than in those from the control group. On the whole, the average weight of carcass from the experimental group was 2.49 kg or 4.07% greater than that from the control group. At the end of the feeding experiment, after comparing the indicators for the experimental and control groups, one can conclude that the economic efficiency is confirmed not only by a lower cost of feed but also an increase in the productivity of animals, as the carcass weight and the proportion of muscle tissue increased.

Changes in the quality of products

One of the key tasks set in the performance improvement programme of the meat production and processing industries of Latvia is "to provide the country's population with quality products from raw

materials produced by domestic producers". In food production, the term quality is defined as a set of product characteristics that is based on the ability of these characteristics to satisfy the needs of consumers (Karklina et al., 1998) and that is a mandatory requirement for every type of products (Jemeljanovs, 2002). The quality of products is equally viewed as one of the basic elements of economic development for producing competitive products (Mihejeva, 1999), as the technological processes of production, processing, and sales form the market demand and supply conditions for final products.

The development of the food industry in Latvia, just like that of the food industry in the world, is affected by changes in the consumer demand for food products. The increasing concerns of consumers about their health contribute to an increase in the demand for healthy food (Vaarst, Hovi, 2004). For this reason, the key goal of food industry is not only to achieve self-sufficiency in food production but also to raise the quality of products. Metabolism processes in the human organism are closely related with the everyday consumption of food products and their quality. It has to be stressed that feeding apple pomace to red deer improved the functional characteristics of this meat compared with the control group, i.e. improving the qualitative indicators of meat.

Feeding apple pomace to red deer led to an increase in the amounts of human health friendly omega-3 fatty acids by 11.28% and omega-6 fatty acids by 15.13% in the total amount of lipids compared with the control group. These fatty acids are not synthesised in the human organism and have to be taken in with food. The research conducted in Latvia concludes that the everyday food products consumed by **Latvia's population contain insufficient amounts of unsaturated fatty acids, vitamins, and micro and macro elements (National Food Consumption..., 2009). On the climatic conditions of Latvia, meat is a source of nutrients which provides the human organism with necessary microelements, fatty acids, amino acids, and energy. The contents and amount ratios of saturated, monounsaturated, and polyunsaturated fatty acids in meat significantly determine the nutritional value of meat and the consumption of it in the diet of humans as well as considerably affect human health (Antipova et al., 2001; Ramins et al., 2002; Zarins, Neimane, 2009).**

Quality and human health friendly meat is characterised by a low content of saturated fatty acids; whereas, the contents of monounsaturated and polyunsaturated fatty acids as well as the ratio of omega-6 and omega-3 fatty acids are higher (Zarins, Neimane, 2009). From the producer perspective, the interest in enhancing the composition of fatty acids in meat is mainly based on the need to find a way how to produce healthier or higher quality meat, i.e. meat with a higher ratio of polyunsaturated fatty acids, and to supply to the market products with greater contents of human health friendly fatty acids, minerals etc.

The muscle tissue of red deer from the experimental group had a 17.31% lower content of saturated fatty acids and a 15.82% higher content of polyunsaturated fatty acids compared with the control group (Table 4).

After examining the profile of polyunsaturated fatty acids in the muscle tissue, one has to note that feeding apple pomace to red deer increased the contents of omega-3 (by 5.20%) and omega-6 (by 10.62%) fatty acids in their muscle tissue compared with the control group. Such increases in the contents of omega-3 and omega-6 fatty acids are very positive for the health of consumers. Compared with other food products, the muscle tissue of red deer had an optimal amount ratio of omega-6 to omega-3 fatty acids which was 3.31:1 for the control group and 2.64:1 for the experimental group.

Table 4

Effect of apple pomace on the content of fatty acids in red deer muscle tissue, %

Indicator	Group 1 – control	Group 2 – experimental	Changes compared with the control group
Saturated fatty acids	50.02	32.71	-17.31
Unsaturated fatty acids:			
monounsaturated fatty acids	26.45	16.16	-10.29
polyunsaturated fatty acids	20.11	35.93	+15.82
Omega-3 fatty acids, in total	4.66	9.86	+5.20
Omega-6 fatty acids, in total	15.45	26.07	+10.62
Σ omega-6 : Σ omega-3	3.31:1	2.64:1	-0.67

Source: authors' calculations based on the feeding experiment

The World Health Organisation (WHO) considers that in ideal food, the ratio of omega-6 to omega-3 fatty acids is within a range from 1:1 to 4:1 (WHO, 2003). The lower is the ratio of fatty acids, the greater is physiological utility and functional activity of fatty acids in the human organism; thereby, feeding apple pomace to red deer leads to producing higher quality meat.

Conclusions

1. It is efficient to use apple pomace as a valuable source of natural vitamins and minerals available in Latvia in the nutrition of red deer, thus, turning apple pomace into a valuable raw material for the production of high-quality and healthy meat.
2. The daily consumption of feed per red deer in the experimental group amounted to 8.5 kg, i.e. 0.5 kg or 6.25% less than that of feed per red deer in the control group, while the cost of feed for the experimental group decreased by 1.5%.
3. The carcass weight (by 2.49 kg or 4.07% on average) and the amount of muscle tissue (by 8.06%; $p < 0.05$) in the experimental group were greater than in the control group.
4. Feeding apple pomace resulted in higher quality meat – the contents of fatty acids omega-3 and omega-6 increased by 5.20% and 10.62% respectively compared with the control group.

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