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FODDER GALEGA (*GALEGA ORIENTALIS* LAM.) - CHEMICAL COMPOSITION AND APPLICATION IN ANIMAL NUTRITION

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Abstract

Of the six species of the genus *Galega* known in nature, the most common are the goat's rue - *Galega officinalis* L., and the fodder galega *Galega orientalis* Lam. These economically important, perennial legumes belong to the legume family - Fabaceae (Papilionaceae). Goat's rue is an ornamental and medicinal plant, and due to the content of poisonous alkaloids, it is not suitable for use for fodder purposes, while fodder galega is used for fodder purposes. *Galega* L. plants are a source of many bioactive compounds, including; guanidine derivatives (galegine and 4-hydroxygalegine), quinazoline derivative - peganin, glycosides, stachylose tetrasaccharides and flavonoid glycosides (luteolin, quercetin, kaempferol, isorhamnetin), saponins, tannins and chromium salts. The study aimed to analyze the chemical composition of fodder galega haylage and to assess the impact of its use in feeding dairy cows on productivity (milk yield) - Experiment I, and in feeding bulls on fattening results (daily weight gain) - Experiment II.

Experiment I - The study was carried out on 75 dairy cows of the Ukrainian black and white breed, at the peak of lactation, for 120 days of winter feeding. Cows were divided using the analog method into 3 feeding groups of 25 heads each: I - control - cows fed with a ration typical for the winter period, in which the main succulent fodder was maize silage (42%) with fodder beets (15%), meadow hay (22%), and a concentrate mix (21%). In experimental group II, 50% of maize silage was replaced with fodder galega haylage, while in experimental group III maize silage was replaced in 100% with fodder galega haylage. The animals' diet was balanced in terms of energy and basic nutrients. Experiment II - The research was carried out on 48 black-and-white and red-and-white Ukrainian bulls for 120 days of winter fattening. Bulls were divided using the analog method into 3 feeding groups of 16 animals each: I - control - bulls was fed with a dose consisting of barley straw chaff (10%), maize silage (62.3%), molasses (2.7%), and a concentrate mixture (25%). In experimental group II, 50% of maize silage was replaced with fodder galega haylage, while in experimental group III maize silage was replaced in 100% with fodder galega haylage. The content of basic nutrients in haylage samples was determined using standard AOAC methods, while neutral detergent fiber (NDF), acid detergent fiber (ADF), and lignin content (ADL - acid detergent lignin) were determined using the Van Soest method. Based on the determined chemical composition, the nutritional value of haylage for ruminants was also assessed according to the INRA system in the INRAtion-PrevAlim program. The differences between the mean values of the parameters examined were calculated using one-factor analysis of variance (ANOVA). Calculations were made with the use of Statistica ver. 12 PL (StatSoft, USA).

The fodder galega haylage was of good quality and contained: 46.5% dry matter, 6.2% crude protein,

1.1% crude fat, 21.8% crude fiber, where the neutral detergent fiber (NDF) was 69.4%, and ADF fiber 58.9%. Replacing maize silage with fodder galega haylage in the diet of dairy cows resulted in an increase in milk yield by 17.9 - 17.5% and an increase in fat and protein content in milk by 0.12 - 0.11%, and 0.15 - 0.13%, respectively compared to the control group of cows. The highest average daily gain during the experiment was found in the bulls of the 2nd experimental group, where 50% of maize silage was replaced with fodder galega haylage. These increments were 11.4% ($P < 0.001$) higher when compared to the control group of bulls. The slaughter yield of the bulls of the II experimental group was 1.5% ($P > 0.05$) higher than in the control group.

Based on the obtained results, it can be concluded that fodder galega as feed has a high nutritional and biological value and can be used in feeding dairy cows.

***Key words**: Fodder galega, Chemical composition, Dairy cows, Milk yield.*

1. Introduction

Among the six species of the genus Galega known in nature, the most common are goat's rue - *Galega officinalis* L., and fodder galega *Galega orientalis* Lam. Goat's rue *(Galega officinalis* L.) and fodder galega (*Galega orientalis* Lam.) are economically important perennial legumes [1]. Goat's rue belongs to the family *Fabaceae (Papilionaceae*), legume subfamily - *Faboideae (Papilionoideae)*, tribe *Galegeae* and rue genus - *Galega* [2]. The most common is goat's rue - *Galega officinalis L.*, as well as fodder galega (*Galega orientalis* Lam.). In the literature, these plants are often referred to as galega (English: goat's rue; German: Geissraute). Plant name came from the Greek words, Gala - milk and agen - to increase, i.e. herb that promotes lactation [3]. *Galega officinalis* is a plant commonly found in the wild flora of southern Europe, from Turkey, through the Balkan Peninsula, Italy, and Romania to the Czech Republic, Slovakia, and Germany in the north and Spain in the west, in North Africa and in the Near and Middle East of Asia [4]. It also occurs in South America and New Zealand, where it has become a troublesome weed.

In the 17th century, it was known as an ornamental and medicinal plant in France and Germany, where its diuretic and diuretic effects were used, while in Italy a salad of young goat's rue leaves was recommended as a means to stimulate the secretion of milk in nursing mothers. In some regions, especially in Bulgaria, medicinal galega is officially used for mild forms of diabetes and for strengthening the lactation of milk for newborns [5].

Attempts to use *Galega officinalis* in sheep nutrition did not bring positive results due to the harmfulness of fodder obtained from this plant. Therefore, galegine has been established as toxic to sheep [6 - 9] and showed that clinical signs of poisoning induced by doses as small as 0.8 g of dried plant/kg body weight/ day included dyspnea, anoxia, and foaming nasal discharge. Pathologic signs in animals that died following an overdose of the plant included severe hydrothorax, generalized lung congestion, foamy exudate in bronchioles and trachea, epicardial and endocardial petechiation, and pericardial effusion in severely affected ewes. Microscopic lesions included severe diffuse alveolar and interlobular edema. Ewes administered the plant on several consecutive days developed an apparent adaptation to the toxin of the plant and were thereby able subsequently to tolerate levels 5 - 10 times the pre-treatment lethal dose with no discernible adverse clinical or pathological effects. González-Andrés *et al.*, [10], confirmed the lactogenic value of *G. officinalis* for sheep and hypothesized that *G. officinalis* phytoestrogens could promote estrogenic receptors, which initiates biochemical effects leading to increased milk production. They proved that a controlled daily dose of 2 g DM/kg body weight from 30 to 60 days *postpartum* led to a 16.9% increase in milk yield. Currently, *G. officinalis* is used as an ornamental and medicinal plant, because due to the content of poisonous alkaloids, it is not suitable for use for fodder purposes.

Fodder galega (*Galega orientalis Lam.*) is found in the northern Caucasus, in the forested regions of Georgia, in southern Armenia, in the southwestern part of Azerbaijan, and (rarely) in Crimea. Due to the possibility of using *Galega orientalis* for fodder purposes, the name "fodder galega" was proposed for it [11]. It is cultivated for fodder purposes in Estonia, Lithuania, Finland, and Latvia, as well as in Russia and France, especially on organic farms [12]. Both species of goat's rue are known as efficient melliferous plants in the period just after the orchards bloom, therefore the attractiveness of the nectar for bees and bumblebees may indirectly contribute to a significant increase in the importance and cultivation of goat's rue [13]. Fodder galega in recent years has been gaining popularity, mainly because of its useful characteristics. Foder galega is used in animal nutrition in the form of green fodder, silage, haylage, hay, or protein concentrate. Green fodder especially that made from young plants possesses very good biochemical parameters which allow it to be used in the nutrition of animals including poultry [14]. Many scholars have emphasized the medicinal applications of fodder galega [15 - 17]. Galega, even though it belongs to legumes, is not distinguished by a high content of total protein but is characterized by a low level of sugars, a

high concentration of cellulose and lignins, and a small share of hemicelluloses [18]. Also taking into account the dry matter yield of fodder galega and its calorific value of 17.8 MJ x kg^{-1}dry air mass this plant can be used as a source of energy [19].

The stems of fodder galega can be used as natural fertilizer [20] or constitute a raw material for the production of thermal energy or biogas [21]. Foder galega as a legume plant efficiently binds atmospheric nitrogen thanks to bacteria nodule symbiotic with the plant. As reported by Nõmmsalu *et al.*, [22], and Meripõld *et al.*, [23], the fodder galega can accumulate from 180 to 480 kg N/ha a year. Galega plants are a source of many bioactive compounds, including guanidine derivatives (galegin and hydroxy-4-galegine), quinazoline derivative - peganin, glycosides, and stachylose tetrasaccharide. Rue goat was also found to contain flavonoid glycosides (luteolin, quercetin, kaempferol, isorhamnetin), saponins, tannins, and chromium salts [24, 25]. *G. officinalis* contains some important secondary metabolites such as saponins, flavonoids (e.g., sativan and medicarpin) [26], phytoestrogens (e.g., flavonol triglycosides, kaempferol, and quercetin) [27, 28], tannins [29], and fatty acids (e.g., α-linolenic acid, palmitic acid, and linoleic acid) [28]. The most important active compound in goat's rue is galegine (up to 0.5%) and other guanine derivatives, such as 4-hydroxygalegin. Galegin is a substance with weak hypoglycemic properties. Based on the galegine model, antidiabetic drugs such as buffermin, metformin, and phenoformin, used in type II diabetes, were produced by chemical synthesis.

Taking into account the occurrence of fodder galega in Ukraine, favorable conditions for its growth and cultivation as well as valuable properties, especially stimulating lactation, an attempt was made to use it in the nutrition of dairy cows and the nutrition of slaughtered bulls.

2. Materials and Methods

The green forage *Galega orientalis* (Lam.) of the local variety Vostochnaya which was harvested in the phase of budding - beginning of flowering, was used for haylage. The content of basic nutrients in haylage from *Galega orientalis* (Lam.), samples were determined using standard AOAC methods [30], while neutral detergent fiber (NDF), acid detergent fiber (ADF), and lignin content (ADL - acid detergent lignin) were determined using the Van Soest *et al.*, [31], method. Based on the determined chemical composition, the nutritional value of haylage for ruminants was also assessed according to the INRA system in the INRAtion-PrevAlim program [32, 33].

2.1 Experiment I

The study was carried out on 75 dairy cows of the Ukrainian black and white breed, at the peak of lactation, for 120 days of winter feeding. Cows were divided using the analog method into 3 feeding groups of 25 heads each: I - control - cows fed with a ration typical for the winter period, in which the main succulent fodder was maize silage (42%) with fodder beets (15%), meadow hay (22%), and a concentrate mix (21%). In experimental group II, 50% of maize silage was replaced with fodder galega haylage, while in experimental group III maize silage was replaced in 100% with fodder galega haylage. The animals' diet was balanced in terms of energy and basic nutrients.

Feeding rationing, determination of energy, and nutrient requirements of experimental cows were carried out following applicable standards and recommendations and under the requirements of ISO 17025, taking into account age, live body weight, fat content, lactation period, average daily milk yield, and physiological condition. The daily yield of milk produced by the cows during the 120 days of the experiment was analyzed. Milk was collected as a pooled sample from morning and evening milking. In the collected milk samples, the content of protein, fat, somatic cell count (SCC), and bacterial cell count. Raw milk samples were assayed for the content of fat, protein, lactose, and dry matter by infrared spectrophotometry using a Milkoscan 133B analyzer (FOSS Electric).

Milk energy value (E) was calculated according to the following formula Kleiber [34]: E (kcal/kg) = (% fat × 92) + (% protein × 58.6) + (% lactose × 39.5). The somatic cell count in milk was determined using the Fossomatic lub Somacount 150 (Bentley Instruments, USA), and bacterial cell count was determined using the Bactoskan. The liver profile was determined, including the analysis of such blood biochemical parameters as aspartate aminotransferase (AST), and alanine aminotransferase (ALT).

Blood samples were collected (four hours after morning feeding) on days 1 and 120 of the experiment. The activity of Aspartate aminotransferase (AST; EC 2.6.1.1), and alanine aminotransferase (ALT; EC 2.6.1.2), were estimated using Cobas Integra® 400 plus system (Roche Diagnostics, Switzerland).

2.2 Experiment II

The research was carried out on 48 black-and-white and red-and-white Ukrainian bulls for 120 days of winter fattening. Bulls were divided using the analog method into 3 feeding groups of 16 animals each: I - control - bulls was fed with a dose consisting of barley straw chaff (10%), maize silage (62.3%), molasses (2.7%), and

a concentrate mixture (25%). In experimental group II, 50% of maize silage was replaced with fodder galega haylage, while in experimental group III maize silage was replaced in 100% with fodder galega haylage.

Beef samples were chopped, then placed in a blender and ground until a homogeneous mass was obtained, which was analyzed later using a near-infrared spectrophotometer. The basic chemical composition of meat was determined with a Food Scan™ analyzer (Foss Electric, Denmark).

The differences between the mean values of the parameters examined were calculated using one-factor analysis of variance (ANOVA). Calculations were made with the use of Statistica ver. 12 PL (StatSoft Inc., USA). The significance of differences between means was determined by the Tukey's range test at $P < 0.05$ and $P < 0.01$.

3. Results and Discussion

Table 1 shows the chemical composition of haylage from *Galega orientalis* (Lam). Haylage was characterized by a low content of protein (6.25%) and fat (1.10%) and a high content of fiber (21.8%).

Table 1. Chemical composition of haylage from *Galega orientalis* (Lam.), % natural forage

Components	Content
Dry matter %	46.50
Crude protein %	6.20
Crude fat %	1.10
Crude fiber %	21.80
Nitrogen-free extract (NFE) %	13.10
Ash %	4.30
Acid Detergent Fibre (ADF), %	58.90
Neutral Detergent Fibre (NDF), %	69.40
Acid Detergent Lignin (ADL), %	18.40
Hemicellulose = NDF - ADF %	10.50
Cellulose = ADF - ADL %	40.50

Coşman *et al.*, [35], analyzing the chemical composition and the nutritional value of haylage from *Galega orientalis* Lam., variety Speranţa grown in the Republic of Moldova, found a similar protein (6.37%) and fat (1.43%) content and lower fiber content (15.62%). The haylage was prepared from the withered green mass (2 days after mowing) harvested during the flowering period, while in our research haylage was made from green fodder harvested in the phase of budding - beginning of flowering. In haylage from Ukraine, high content of neutral and acid detergent fiber fractions was found - 69.4 and 58.9%.

Fodder galega is distinguished by a high content of crude fiber and individual structural fractions (NDF, ADF, ADL), and the content depends on the phenological stage of the plant [36]. According to Żarczyński *et al.*, [14], due to the high content of total protein in galega, which reaches 231 g/kg DM. and the presence of certain amino acids (aspartic acid, glutamic acid, phenylalanine), recommended that one can use green fodder as a replacement for post-extraction soybean meal. However, in our research, fodder galega silage contained almost twice less protein (133.3 g/kg DM). Amino acids composition of galega protein can be compared to red clover [37]. The protein content in fodder galega haylage was higher (20.16% DM) compared to withered grass silage (12.02% DM) [36]. Eastern rue (Galega orientalis Lam.) is distinguished by the rich amino acid composition of the protein [28, 38, 39, 40, and 41]. The content of total protein ranges from 15.6% (forage) to 30.4% of dry matter, while the content of true protein ranges from 12.1 to 20.3% of dry matter, respectively [13]. Table 2 shows the amino acid composition of haylage from *Galega orientalis* (Lam.).

Table 2. Amino acids composition (g/kg^{-1}dry matter) of haylage from *Galega orientalis* (Lam.)

Amino acids	Content g/kg^{-1} of dry matter
Exogenous amino acids - Essential amino acids	
Arginine - Arg	5.62
Histidine - His	3.53
Isoleucine - Ile	5.89
Leucine - Leu	9.46
Lysine - Lys	5.87
Methionine - Met	1.49
Phenylalanine - Phe	5.96
Threonine - Thr	3.48
Valine - Val	7.42
Non-essential amino acids	
Alanine - Ala	3.83
Aspartic acid - Asp	13.57
Cysteine - Cys	1.56
Glutamic acid - Glu	11.34
Glycine - Gly	6.28
Proline - Pro	10.55
Serine - Ser	2.09
Tyrosine - Tyr	2.69
Total amino acids	108.48
Total essential amino acids	48.72
Total non-essential amino acids	51.91
Branched-chain amino acids (valine, leucine and isoleucine)	22.77

At haylage from *Galega orientalis* essential amino acids accounted for 48.72 g/kg^{-1} of dry matter natomiast non-essential acids 51.91 g/kg^{-1}of dry matter. According to Żarczyński *et al.*, [14], the

content of exogenous amino acids in the protein of fodder galega ranges within 30 - 46%, depending on the developmental stage of the plant. This plant has a high content of lysine, leucine, isoleucine, phenylalanine, valine, and threonine. The biological value of green fodder protein is limited by the low content of methionine and tryptophan. The low level of cystine is also noteworthy [37]. The amino acid composition of the rue goat protein may be comparable to that of red clover [37]. Eastern rue is a good source of β-carotene. According to research by Skórko-Sajko *et al.*, [42], its content in fodder with natural moisture was at the level of 164 mg x kg^{-1} dry matter. Fatty acid profiles in the fodder galega during growth were characterized by three dominant FA, being: α-linolenic acid (C18:3n-3), palmitic acid (C16:0), and linoleic acid (C18:2n-6). The main fatty acids in the seeds were palmitic, linoleic, and α-linolenic and they represented 86% of total fatty acids [28]. According to Starkovskiy *et al.*, [43], the phase of full bloom - the beginning fruit setting should be considered a favorable period for mowing *Galega orientalis* plants for the production of silage. According to Ignaczak [44], galega has nutritional value comparable to red and Persian clover, while according to Fairey *et al.*, [39], this plant is as nutritious as alfalfa, Swedish clover, or red clover. According to Skórko-Sajko *et al.*, [36], the energy value of rue goat silage after withering is 0.26 JPM, which is equivalent to 1 kg of dry matter corresponds to 0.70 JPM. The value of haylage from fodder galega in the INRA-88 system for ruminants analyzed in our experiment was 0.36 forage unit for lactation (UFL) and 0.32 forage unit for meat production (UFV) - Table 3.

Table 3. Nutritional value of the haylage from fodder galega in the INRA-88 system for ruminants (per kg as weight)

Item	Haylage from fodder galega
Forage Unit For Lactation (UFL)	0.36
Forage Unit For Meat Production (UFV)	0.32
Protein is truly digestible in the small intestine when energy limits microbial protein synthesis (PDIE) (g · kg^{-1} DM)	17.00
Protein is truly digestible in the small intestine when N limits microbial protein synthesis (PDIN) (g · kg^{-1} DM)	26.0

The haylage from fodder galega due to its high nutritional value, which is equal to the nutritional value of alfalfa or clover, can be used as a very good fodder for ruminants. According to Skórko *et al.*, [36], galega silage can be successfully added to maize silage in a ration for dairy cows, because its share in the feed mix does not reduce the milk yield of dairy cows. In our experience, 50% (experimental group II) or 100% (experimental group III) of maize silage for dairy cows of the Ukrainian black and white breed was replaced with fodder galega haylage - Table 4.

The Ukrainian Black and White dairy breed is the most popular breed of dairy cattle in Ukraine. In 2020, the breed's population was 68,829 purebred cows kept in 169 herds. In 2019, the average milk yield of cows of this breed was 7486 kg of milk with a content of 3.74% fat and 3.22% protein [45]. The Ukrainian Black and White dairy breed is characterized by a high fat content in milk [46, 47, and 48]. Moreover, Gritsenko *et al.*, [48], showed the influence of genotype on milk yield, fat, and protein content in the milk of cows of Ukrainian dairy cattle breeds. Replacing maize silage with fodder galega haylage in the diet of dairy cows resulted in an increase in milk yield by 17.5 - 17.9% and an increase in fat and protein content in milk by 0.11 - 0.12%, and 0.13 - 0.15%, respectively compared to the control group of cows.

Table 4. Milk yield and chemical composition of milk from cows receiving the haylage from fodder galega (Experiment I)

Parameters	Feeding groups of dairy cows		
	I - control	Experimental group II	Experimental group III
Milk yield for 305 days of lactation, kg	5836 ± 125.47[a]	6880 ± 182.71[b]	6857 ± 152.32[b]
Milk per 1 day of lactation, kg	19.14 ± 2.22[a]	22.56 ± 2.31[b]	22.48 ± 2.88[b]
Milk protein (%)	3.24 ± 0.54	3.39 ± 0.21	3.37 ± 0.42
Milk fat (%)	3.72 ± 0.75	3.87 ± 0.32	3.85 ± 0.64
Lactose (%)	4.64 ± 0.3	4.68 ± 0.21	4.65 ± 0.43
Milk energy value (E) (kcal/kg)	715.38 ± 89.8	739.55 ± 74.7	735.36 ± 91.2
Somatic cell count (thous./mL of milk)	239.7 ± 759.0	222.5 ± 341.5	234.9 ± 305.5
Bacteria plate count (thous./mL of milk)	18.5 ± 12.4	18.1 ± 6.32	19.8 ± 11.54

Legend: a, b - mean values denoted by different letters in rows are statistically significantly different at $p \leq 0.05$.

Skórko-Sajko *et al.*, [36], showed that haylage made of eastern goat's rue with reduced humidity can be successfully used in a feed ration with maize silage or in a composition with grass silage for cows with high milk yield. Tywończuk *et al.*, [49], obtained

equally satisfactory results of replacing grass silage with withered goat silage in feeding dairy cows in production conditions. Latvietis *et al.*, [50], proved that the addition of goat's rue in the daily diet of cows improves their milk yield. Galega has a lactogenic effect, increasing the milk production of goats and other mammals [51]. Kudrna *et al.*, [52], Sharifyanov *et al.*, [53], and Bikbulatov *et al.*, [54], demonstrated increased milk production when G. officinalis was included in diet cows. Hamed [55], showed improvement in pubertal mammary gland development, increasing milk yield and enhancing productivity of rabbits after aqueous administration extract from galega in drinking water for rabbits. Pałka *et al.*, [56], showed that the addition of extracts of fennel (*Foeniculum vulgare* Mill.) and goat's-rue (*Galega officinalis* L.) to the feed of rabbit has a positive effect on their litter size and milk yield. Effects of *G. officinalis* on milk production of sheep were studied by González-Andrés *et al.*, [10], who found that a controlled daily dose of 2 g DM/kg body weight from 30 to 60 days *post-partum* led to a 16.9% increase in milk yield. They also confirmed the lactogenic value of this plant for sheep and hypothesized that *G. officinalis* phytoestrogens could promote oestrogenic receptors, which initiate biochemical effects leading to increased milk production. Several phytoestrogens (i.e., flavonol triglycosides, kaempferol, and quercetin) have been isolated from metanolic extracts of *G. officinalis* [57]. These results testify to the usefulness of fodder silage from withered goat's gore (*Galega orientalis* Lam.) as an alternative fodder plant to other high-protein plants. In both experiments, the authors found an improvement in the hygienic quality of milk as a result of reducing SCC, which may suggest the bioactive properties of *Galega orientalis* Lam. We found a similar improvement in the hygienic quality of milk in our experiment.

The main active compounds of goat's rue are guanidine and galegine as well as steroidal saponins, which may increase lactation. The probable mechanism of action of the rue herb is based on stimulating the mammary gland to grow [58, 59] - the guanidine alkaloids contained in it can stimulate the maturation of the tissue of this gland [59]. Studies conducted on rats revealed abnormalities in the morphological picture of blood [58], and inhibition of platelet aggregation, which may lead to internal hemorrhage, and liver damage [60]. Medicinal rue consumed in large quantities by grazing cattle can lead to pulmonary edema, pleural effusion, hypotension, sub-endocardial hemorrhage, paralysis, and in extreme cases even death [61].

The concentration of biochemical parameters AST and ALT in serum cows receiving the haylage from fodder galega are shown in Table 5.

Table 5. Concentration of biochemical parameters (LSM ± SE) in serum cows receiving the haylage from fodder galega (Experiment I)

Item	Feeding groups of dairy cows			
	I - control		Experimental group III	
	1st day	30th day	1st day	30th day
AST (unit/L)	40.0 ± 20.0	59.0 ± 8.0	36.0 ± 15.0	61.0 ± 14.0
ALT (unit/L)	22.0 ± 14.0	24.0 ± 12.0	30.0 ± 11.0	45.0 ± 19.0

The analysis of morpho-biochemical indices of cows' blood indicates that they fall within the acceptable physiological norm [62, 63]. Foder galega is rich in ascorbic acid, carotene, alkaloids, and macro- and microelements, therefore it can be useful in treatment. Research shows that *G. orientalis* has properties regulating the body's sugar balance [17, 64], as the guanidines contained in galega are responsible for the hypoglycemic effect. In addition, guanidines inhibit gluconeogenesis and seem to influence the lipid profile of patients. According to Kozłowski *et al.*, [65], the high concentration of calcium in galega may lead to hypercalcemia in animals.

The haylage from fodder galega can also be fodder for fattening bulls and heifers. In our experience, 50% (experimental group II) or 100% (experimental group III) of maize silage for black-and-white and red-and-white Ukrainian bulls was replaced with fodder galega haylage - Table 6. The highest average daily gain during the experiment was found in the 2nd experimental group, where 50% of maize silage was replaced with fodder galega haylage.

Replacing maize silage with haylage from fodder galega did not affect the chemical composition of the meat. Research by Ugnivenko *et al.*, [66], showed that the breed of Ukrainian cattle of black and white meat best meets market requirements. If this breed is fed properly, the result is a rapid increase in muscle tissue and a late build-up of fat tissue. These animals have a specific biological feature that is not found in dairy breeds: at the age of 20 - 22 months, they gain weight mainly due to the accumulation of muscle tissue, with moderate deposition of adipose tissue. Ukrainian cattle of black and white dairy is characterized by higher carcass fatness and higher fat content in the meat [47]. However, when intensively feeding bulls of the Ukrainian Black-Spotted Dairy breed up to the age of 15 months, using Intermix fattening protein-vitamin premix, it is possible to obtain meat with a fat content of 2.33% and a protein content of 21.43% [67]. The beneficial effect of galega (forage, hay, haylage) is the result of the content of bioactive compounds.

Table 6. Production, chemical composition, and quality of meat bulls receiving the haylage from fodder galega (Experiment II)

Item	Feeding groups of dairy cows		
	I - control	Experimental group II	Experimental group III
Body weight on the first day of the experiment (kg)	349.87 ± 0.81	350.20 ± 0.79	348.26 ± 0.90
Body weight on the 120th day of the experiment (kg)	444.53 ± 1.21^{a}	455.60 ± 1.32^{b}	445.60 ± 1.50^{a}
Average daily weight gain (g)	788.53 ± 17.06^{a}	878.30 ± 10.57^{b}	811.17 ± 13.93^{a}
Slaughter efficiency (%)	53.5 ± 3.58^{a}	55.0 ± 2.02^{b}	54.1 ± 2.98^{ab}
Chemical composition (*M. longissimus dorsi* - LD)			
Dry matter, %	23.90 ± 0.41	24.11 ± 0.39	24.03 ± 0.45
Protein (%)	19.8 ± 0.46	20.10 ± 0.51	19.76 ± 0.54
Fat (%)	3.2 ± 0.28	3.0 ± 0.25	3.3 ± 0.31
Ash, %	0.93 ± 0.07	1.01 ± 0.03	0.97 ± 0.05
Fat to protein ratio	1 : 0.162	1 : 0.15	1 : 0.167

Legend: a, b - mean values denoted by different letters in rows are statistically significantly different at $p \leq 0.05$.

Table 7. Content of biologically active substances in the bodies of plants *Galega orientalis* (Lam.) [72]

Biologically active substances	Organs of plant			
	Rosette leaves	Roots stem	Leaves	Petals
Alkaloids	++	N	-	-
Coumarins	++	+++	++	++
Flavonoids	+++	++	++	++
Heart glycosides	-	-	-	-
Saponins	+++	++	++	++
Tannins	++	++	++	+++
Anthraglycosides	-	-	-	-
Water-soluble polysaccharides	++	+++	++	++
Ascorbic acid	+++	+	++	+++

Legend: +++ - the high content of the BAS; ++ - the sufficient level; + - low (traces); N - the content is not determined.

The extracts of *G. officinalis* showed broad-spectrum activity against both gram-positive and gram-negative bacteria [68]. Moreover, extracts of goat's rue exhibited cytotoxic, anti-inflammatory, and antioxidant activity [69]. Studies by Baležentienė [70] and Baležentienė and Kusta [71], have shown that shoots of fodder galega are the main source of its allelochemicals, especially at the flowering stage. According to Baležentienė [70] report, the highest total content of phenols was determined at the budding stage. Darmohray *et al.*, [72], showed that rosette leaves and petals contain the most bioactive compounds fodder galega - Table 7.

Pehlivan Karakas *et al.*, [73], obtained twenty phenolic compounds from methanolic leaf extracts of G. officinalis, and total phenolic content, in this case, was 36.69 mg x g^{-1} of dry extract. Vergun *et al.*, [74], showed that the phenolic acid content of *G. orientalis* plant raw material ranged from 3.52 to 18.52 mg CAE x g^{-1}during vegetation, and the concentration of flavonoids ranged from 6.09 to 46.72 mg QE x g^{-1}. According to Vergun *et al.*, [74], *Galega officinalis* L., and *Galega orientalis* Lam. are a good source of antioxidant compounds with a polyphenol nature such as phenolic acids and flavonoids. They also ranged the phenolic acid content of *G. orientalis* plant raw material from 3.52 to 18.52 mg caffeic acid equivalents CAE x g^{-1} during vegetation. The concentration of flavonoids ranged from 6.09 to 46.72 mg QE x g^{-1}. According to Shymanska *et al.*, [75], plant raw material of two *Galega* L. species is a potential source of antioxidants. During vegetation, antiradical activity of plant extracts of *Galega officinalis* exhibited 11.24 - 95.18%, and *Galega orientalis* 11.74 - 91.72% depending on extract and phase of growing. The content of tannins for *G. officinalis* was in the range of 1.22 to 4.17% and for *G. orientalis* from 1.55 to 4.42% during vegetation. Generative organs such as flowers and fruits had less content of tannins than vegetative. Root and Syrjälä-Quist [76], showed that *G. orientalis* could be used as raw material for silage if harvested just before flowering during the primary growth stage. According to Starkovskiy *et al.*, [43], the phase of 'full blooming - beginning of fruit formation' should be considered a favorable period for mowing *Galega orientalis* plants for making haylage. *Galega ori*entalis may also be a promising raw material for biogas production [77].

4. Conclusions

- Based on the obtained results, it can be concluded that fodder galega as feed has a high nutritional and biological value and can be used in feeding dairy cows and young bulls.
- Obtained results of experimental studies confirm that *Galega orientalis (Lam)* fodder has a high nutritional and biological value, and a high content of organic substances, especially protein and ascorbic acid. It was found that such a combination of the nutritional and biological profile of the tested feeds had a positive effect on their better conversion to the synthesis of dairy products in cows and without a harmful effect on the functioning of the organism during the entire experiment.

5. References

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