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TOTAL PROTEIN AND CRUDE FIBRE CONTENT AND DRY MATTER DIGESTIBILITY OF CHOSEN LEGUME AND HERB SPECIES FROM EXTENSIVE GRASSLANDS

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Abstract. Legumes and herbs are valuable elements of the meadow sward. In the conditions of extensive meadow-pasture management, for example in protected areas where first cut harvest is delayed, they determine to a large extent fodder quality, for instance total protein content. The aim of the study was the evaluation of total protein and crude fibre contents, as well as dry matter digestibility of chosen legume and herb species from extensive grasslands. Research was conducted in the years 1998-2000 before first cut harvest (June – first ten days of July) in the Olsztyn Lake District. Together, 444 plant samples were studied. The determinant for sample uptake location was the occurrence of phytocenoses with at least 5% area coverage (2 in the Braun-Blanquet scale) with chosen legume species: *Trifolium pratense* L., *Trifolium repens* L., *Lotus corniculatus* L., *Lathyrus pratensis* L., *Lotus uliginosus* Schkuhr., and *Vicia cracca* L., as well as herbs: *Taraxacum officinale* F. H. Wigg., *Achillea millefolium* L., *Plantago lanceolata* L., *Alchemilla vulgaris* L., *Heracleum sibiricum* L., and *Cirsium oleraceum* (L.) Scop. Average total protein content in the legumes oscillated between 176.9 and 196.6 g·kg^{-1}. Total protein content in herbs usually reached 100-120 g·kg^{-1} for *Taraxacum officinale* F.H. Wigg., *Achillea millefolium* L. and *Alchemilla vulgaris* L. and 140-160 g·kg^{-1} for *Heracleum sibiricum* L. and *Cirsium oleraceum* (L.) Scop. Research demonstrated that the legumes contained significantly more total protein and crude fibre than herbs, where no significant differences were found between the particular legume species. However, in the case of herbs, significant diversification of those components occurred, and the highest amount of protein and at the same time the lowest amount of fibre was accumulated by *Heracleum sibiricum* L. and *Cirsium oleraceum* (L.) Scop. Legume digestibility reached 60-65%. Among the herbs, higher digestibility was characteristic for *Heracleum sibiricum* L. (74.1%) and *Cirsium oleraceum* (L.) Scop. (74.4%), whereas the lowest one for *Achillea millefolium* L. (62.2%).

Key words: crude fibre, dry matter digestibility, grasslands, herbs, legumes, total protein

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INTRODUCTION

Species composition of meadow-pasture sward to a high extent affects the nutritional value of the produced fodder, and therefore also the quality of animal products, such as milk [Barłowska *et al.* 2012]. Legumes and herbs are valuable elements of meadow-pasture sward [Grzegorczyk *et al.* 2001, 2013]. Novoselova and Frame [1992], when summing up the positive effects of legumes on grassland productivity, point out to, among others, high yield of total and digestible protein and significant savings in nitrogen fertilization caused by soil enrichment in this component as a result of symbiosis with bacteria that assimilate nitrogen and transfer significant amounts of this element to the grass [Pietrzak 2011]. The most important legume species on grasslands in northern Europe are: *Trifolium repens* L., *Trifolium pratense* L., *Trifolium hybridum* L., *Medicago sativa* L. *ssp. Sativa,* and *Lotus corniculatus* L. In western Europe, where *Trifolium repens* L. plays the leading role, also other species are being paid attention to, such as *Lotus corniculatus* L., and *Lotus uliginosus* Schkuhr*.,* which may be cultivated in extreme conditions, where other legumes fail [Novoselova and Frame 1992, Gaweł 2011].

Also herbs are desirable components of meadow and pasture sward. The plants enrich fodder from grasslands in necessary elements and components of preventive and therapeutic nature, as well as in many macro- and microelements that improve the use of fodder by animals [Budny *et al.* 2012, Grzegorczyk *et al.* 2013, 2014]. In comparison with grass, those plants usually contain much more nutrients, particularly mineral compounds and total protein. Research demonstrated that feeding cows with mixtures with herbal additives may increase their milk productivity and improve the chemical composition and physiochemical indicators of milk and its technological and nutritional value [Kraszewski *et al.* 2004, 2008; Barłowska *et al.* 2012]. Common herb species are, among others, *Taraxacum officinale* F.H. Wigg., *Achillea millefolium* L., *Plantago lanceolata* L., and *Alchemilla vulgaris* L., [Grzegorczyk and Grabowski 2007].

In protected areas, extensive meadow-pasture management determines the preservation of high natural qualities of meadows. In this case, high proportion of herbs and legumes in the sward compensates for the negative effect of late meadow mowing on fodder quality [Zarzycki *et al.* 2005]. Total protein and crude fibre contents in the plants is a species and cultivar characteristic [Dembek and Łyszczarz 2012; Szkutnik *et al.* 2012]. The amount of those components to a high degree determinates fodder nutritional value and digestibility [Pawlak 1990, Brzóska and Śliwiński 2011]. The established study hypothesis assumed that common legume and herb species may to a different degree affect the nutritional value of fodder. Therefore, research was conducted which was to evaluate total protein and crude fibre contents, as well as dry matter digestibility of chosen legume and herb species from extensive grasslands in the Olsztyn Lake District.

MATERIAL AND METHODS

In the years 1998-2000 in the Olsztyn Lake District research was carried out on the occurrence of chosen legume and herb species in extensive grassland sward, in which first cut was harvested in the period of June – first ten days of July. Species composition of the meadow sward was determined with the Braun-Blanquet method, soil samples

were uptaken in order to determine physical and chemical properties, and plant samples were uptaken in order to determine the contents of mineral and organic components. The determinant for sample uptake location was the occurrence of phytocenoses with at least 5% area coverage (2 in the Braun-Blanquet scale) with chosen legume species: *T. pratense*, *T. repens*, *L. corniculatus*, *L. pratensis*, *L. uliginosus*, and *V. cracca,* as well as herbs: *T. officinale*, *A. millefolium*, *P. lanceolata*, *A. vulgaris*, *H. sibiricum*, and *C. oleraceum*.

Together, 444 plant samples were studied (Table 1). In the present work, the results for total protein and crude fibre contents, as well as dry matter digestibility are presented. Total nitrogen was marked with the Kjeldahl method, and crude fibre with the Henneberg and Stohmann method. Total protein content was calculated by multiplying the nitrogen content by 6.25. Total digestibility of dry matter was calculated using the formula [Pawlak 1990]:

$$SO = 87.1 + 0.36x - 1.07\ w$$

where:

x – total protein content in dry matter, %.

w – crude fibre content in dry matter, %.

Statistical processing of the results with the analysis of variance was carried out using the program Statistica v. 9.1.

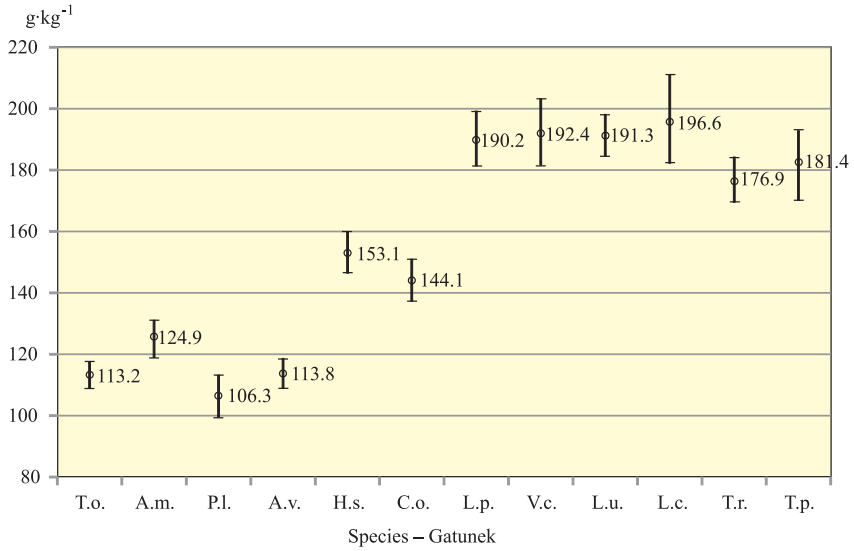
RESULTS

Total protein content in the studied plant species was diversified. The highest amount of this element was found in legumes, where average values oscillated between 177 $g \cdot kg^{-1}$ in *T. repens* and 197 $g \cdot kg^{-1}$ in *L. corniculatus*, although no significant differences between the species were found (Fig. 1). The lowest total protein content was found in four herb species: *A. millefolium*, *A. vulgaris*, *T. officinale*, and *P. lanceolata*, and it amounted to, respectively, 125, 114, 113, and 106 $g \cdot kg^{-1}$. The studied plant species found in extensive grassland sward may therefore be divided into three significantly different groups: a) legumes with the highest protein content, b) herbs *H. sibiricum* and *C. oleraceum* with average protein content, c) herbs *A. vulgaris*, *T. officinale*, *A, millefolium*, and *P. lanceolata* with the lowest total protein content.

Total protein content in herbs oscillated between 100 and 120 $g \cdot kg^{-1}$ for *T. officinale*, *A. millefolium* and *A. vulgaris* and 140 and 160 $g \cdot kg^{-1}$ for *H. sibiricum* and *C. oleraceum.* The lowest diversification in total protein content was found in *T. officinale*, and *H. sibiricum* with the variation coefficients of 11.0% and 11.5% (Table 1). In the case of legumes, total protein content in *V. cracca*, *L. uliginosus* and *T. repens* usually oscillated between 180 and 200 $g \cdot kg^{-1}$, and in *L. corniculatus* and *T. pratense* between 160 and 180 $g \cdot kg^{-1}$ (Fig. 2). The lowest value diversification was obtained for *T. repens* with the variation coefficient of 10.4% (Table 1).

Greater differences in crude fibre content occurred between herb species. In legumes, lower diversification was found as significant differences occurred only between clovers (*T. repens* and *T. pratense*) and *V. cracca* (Fig. 3). Average crude fibre content in legumes oscillated between 256 $g \cdot kg^{-1}$ (*T. pratense*) and 289 $g \cdot kg^{-1}$ (*V. cracca*). Average crude fibre content in herbs oscillated between 165 $g \cdot kg^{-1}$ (*C. oleraceum*) and 275 $g \cdot kg^{-1}$ (*A. millefolium*). In the studied herb species, four groups that differed significantly in

the content of this component were distinguished. The least fibre was accumulated by *H. sibiricum* and *C. oleraceum* and significantly more by *T. officinale*. The next group was made of *P. lanceolata* and *A. vulgaris*, and significantly the most fibre was found in *A. millefolium*.



T.o. – *Taraxacum officinale* F.H. Wigg., A.m. – *Achillea millefolium* L., P.l. – *Plantago lanceolata* L., A.v. – *Alchemilla vulgaris* L., H.s. – *Heracleum sibiricum* L., C.o. – *Cirsium oleraceum* (L.) Scop, L.p. – *Lathyrus pratensis* L., V.c. – *Vicia cracca* L., L.u. – *Lotus uliginosus* Schkuhr., L.c. – *Lotus corniculatus* L., T.r. – *Trifolium repens* L., T.p. – *Trifolium pratense* L.

Fig. 1. Average total protein content in plants (g·kg^{-1}) and confidence levels (95%)
Rys. 1. Średnia zawartość białka ogólnego w roślinach (g·kg^{-1}) i poziomy ufności (95%)

Table 1. Values for protein and fibre contents, as well as dry matter digestibility of chosen legume and herb species, expressed as variation coefficients (%)
Tabela 1. Wahania zawartości białka, włókna i strawności suchej masy wybranych gatunków roślin motylkowatych i ziół, wyrażone współczynnikiem zmienności (%)

Species Gatunek	Number of samples Liczba prób	Total protein content Zawartość białka ogólnego	Crude fibre content Zawartość włókna surowego	Dry matter digestibility Strawność suchej masy
Taraxacum officinale F.H. Wigg.	33	11.0	8.2	2.7
Achillea millefolium L.	52	17.4	15.7	8.1
Plantago lanceolata L.	32	17.8	20.0	8.5
Alchemilla vulgaris L.	48	14.8	11.2	4.3
Heracleum sibiricum L.	29	11.5	15.2	4.3
Cirsium oleraceum (L.) Scop.	49	16.5	14.2	3.3
Lathyrus pratensis L.	42	15.1	8.7	4.6
Vicia cracca L.	34	16.1	10.9	5.2
Lotus uliginosus Schkuhr.	51	12.7	12.9	7.0
Lotus corniculatus L.	23	16.5	10.8	6.7
Trifolium repens L.	26	10.4	11.4	5.7
Trifolium pratense L.	25	15.2	16.6	7.6

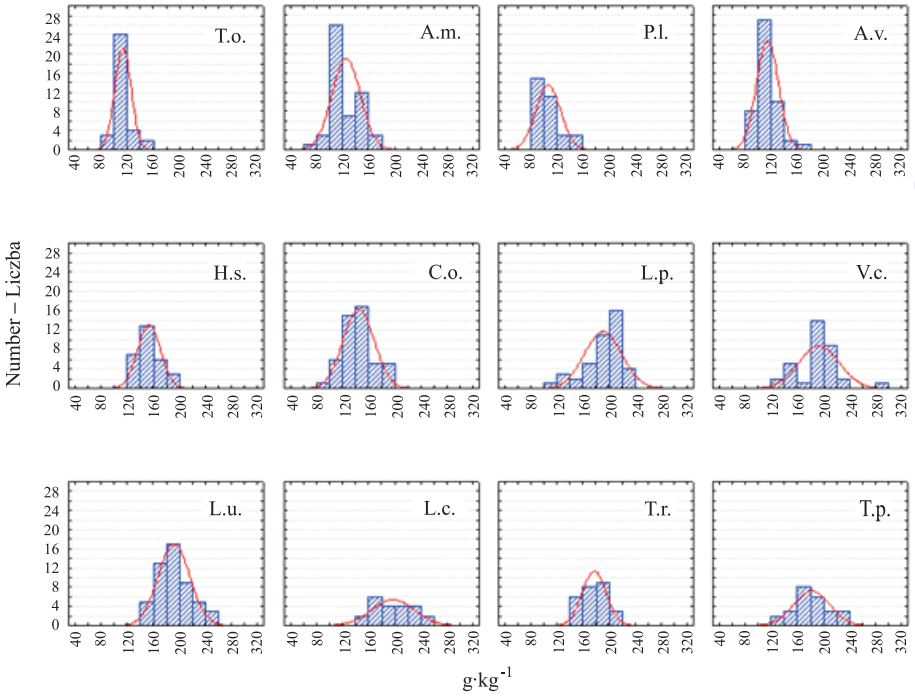


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Fig. 2. Total protein content histogram
Rys. 2. Histogram zawartości białka ogólnego w roślinach

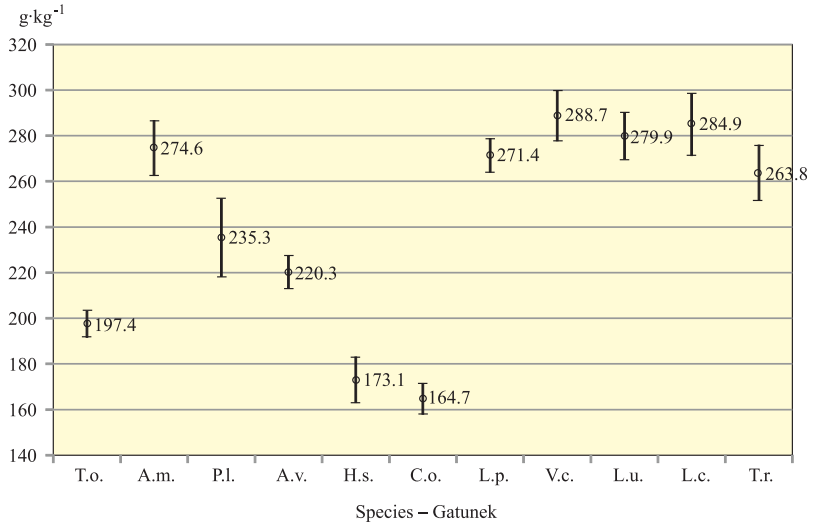

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Fig. 3. Average crude fibre content in plants (g·kg^{-1}) and confidence levels (95%)
Rys. 3. Średnia zawartość włókna surowego w roślinach (g·kg^{-1}) i poziomy ufności (95%)

In all the studied legume species, crude fibre concentration usually reached 250-300 g·kg^{-1}, which meets the nutritional expectations of ruminants. Crude fibre content in herbs usually amounted to 200-250 g·kg^{-1} for *T. officinale*, *P. lanceolata*, and *A. vulgaris* and 150-200 g·kg^{-1} in the case of *H. sibiricum* and *C. oleraceum* (Fig. 4). The lowest diversification in the contents of this element was found in *T. officinale* and *L. pratensis*. Variation coefficients for those species amounted to, respectively, 8.2% and 8.7%. The highest diversification was found in *P. lanceolata*, in which variation coefficient reached 20% (Table1).

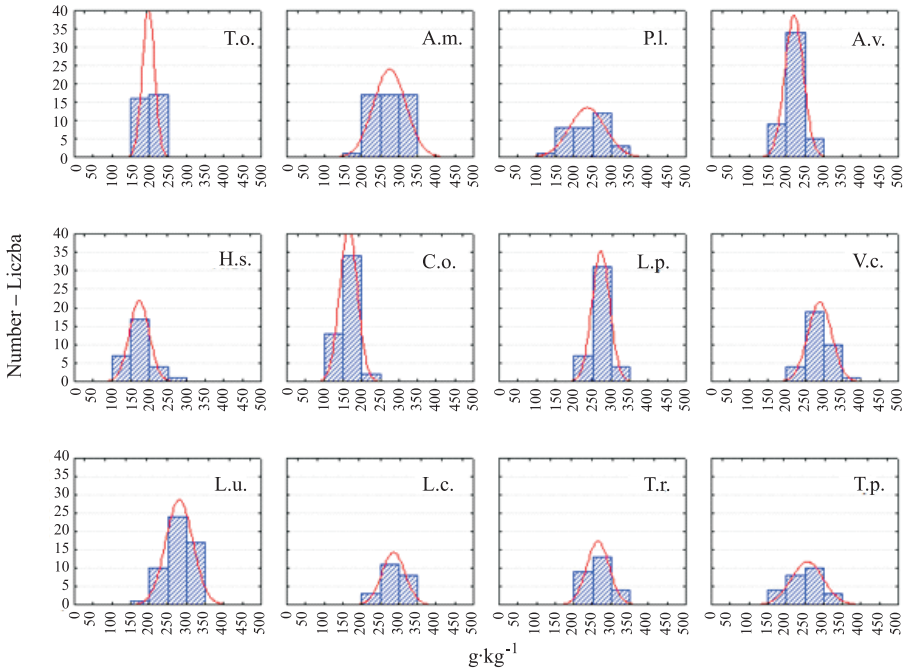

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Fig. 4. Crude fibre content histogram
Rys. 4. Histogram zawartości włókna surowego w roślinach

Calculated on the basis of total protein and crude fibre contents average total dry matter digestibility oscillated between 62.2% (*A. millefolium*) and 74.4% (*C. oleraceum*) (Fig. 5). No significant differences between legume species were found, where average digestibility oscillated between 63.1% (*V. cracca*) and 66.3% (*T. pratense*). Among the herbs, significant differences were found between plant species. The highest digestibility was characteristic for *H. sibiricum* (74.1%) and *C. oleraceum* (74.4%), and the lowest one for *A. millefolium* (62.2%).

The calculated dry matter digestibility for all the legume species usually fell within the range of 60-65% (Fig. 6). In the case of herbs, the range was diversified. For *H. sibiricum* it was 75-80%, for *C. oleraceum* 70-75%, for *T. officinale* and *A. vulgaris* 65-70%, for *P. lanceolata* and *L. pratensis* 60-65%, and for *A. millefolium* 55-60%. Variation coefficients for digestibility results were very low and oscillated between 2.7% and 8.5% (Table1).

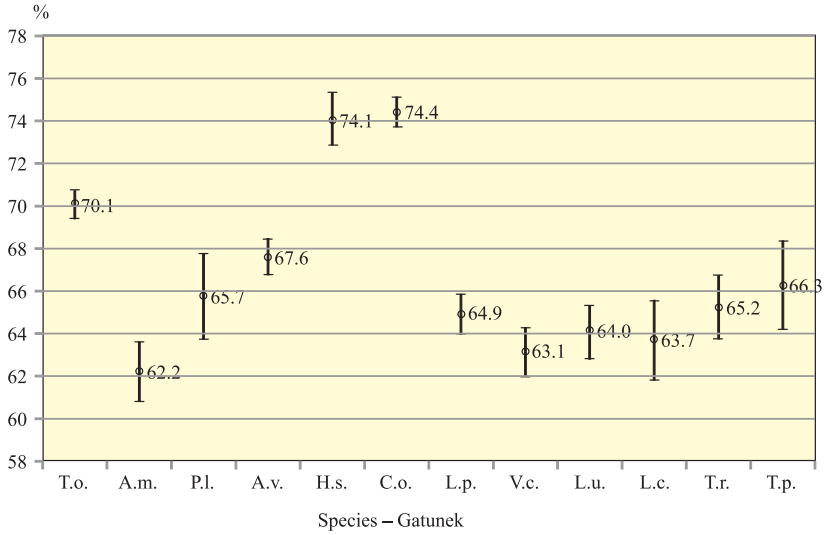

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Fig. 5. Average total dry matter digestibility (%) and confidence levels (95%)
Rys. 5. Średnia strawność ogólna suchej masy roślin (%) i poziomy ufności (95%)

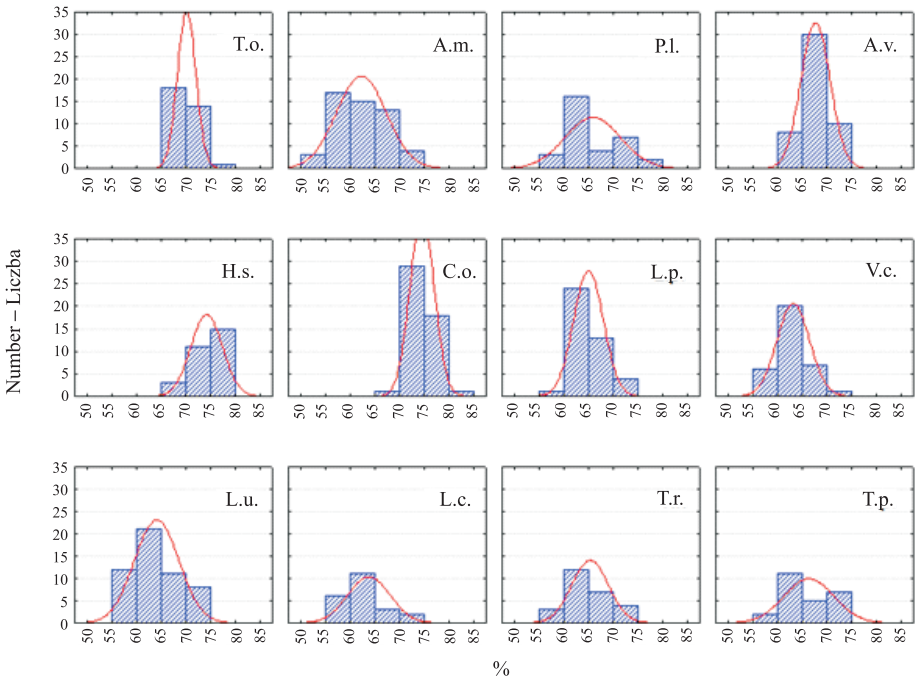

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Fig. 6. Total dry matter digestibility histogram
Rys. 6. Histogram strawności ogólnej suchej masy roślin

DISCUSSION

In the work, study results were presented on total protein and crude fibre contents, as well as dry matter digestibility of 12 meadow plants from extensive grasslands, including six legume species and six common herb species. In scientific literature, there is a lack of this type of studies. More often the studies concern the use of legumes in intensive grasslands [Barszczewski *et al.* 2011, Novoselova and Frame 1992], single herb species [Dembek and Łyszczarz 2012, Jankowska 2012], or the nutritional value of chosen groups of meadow plants [Kacorzyk and Szewczyk 2008].

It was demonstrated in the present study that not only legumes, which is common knowledge, but also herbs contain significant amounts of total protein. It results from the studies by Kacorzyk and Szewczyk [2008] that herbs contain more protein than grass by 16-20%, and among the studied groups of plants that grow in the sword of perennial grasslands, legumes were characterized by the highest total protein content. It may therefore be stated that the presence of legumes in the sward affects positively the nutritional value of fodder [Barszczewski *et al.* 2011, Zarzycki *et al.* 2005, Vázquez-de--Aldana *et al.* 2000, Ammar *et al.* 1999].

In the opinions of many authors, significant participation of legumes and herbs in the sward improves its fodder value not only through increasing total protein content, but also through decreasing crude fibre content [Ammar *et al.* 1999, Vázquez-de-Aldana *et al.* 2000, Zarzycki *et al.* 2005]. This is confirmed by the obtained study results, since the average fibre content in the studied species fell within the range acknowledged as optimum in ruminant feeding [Pawlak 1990].

Dry matter digestibility presented in the work for all the studied legume species usually fell within the range of 60-65%, and for herbs it usually reached higher values, which may affect favourably the use of fodder by animals. According to Preś [1977], digestibility of plants which are fed to cattle should be higher than 65-67%. Numerous studies demonstrate that the majority of herbs and legumes are characterized by higher digestibility than grass, which results from lower content of neutral detergent fibre (NDF) in their chemical composition, which is related to the structural part content in plant tissues. As the plants mature, participation of hard stems in herbs and legumes increases significantly more slowly than in grass [Derrick *et al.* 1993, Wilman and Riley 1993, Ammar *et al.* 1999, Bruinenberg *et al.* 2001].

CONCLUSIONS

1. The studied legume and herb species pose a valuable component of extensive grassland sward and affect favourably the nutritional value of fodder: higher total protein content, lower crude fibre content, and higher dry matter digestibility, although legumes are significantly more valuable in this respect.

2. In regard to average total protein content, the order of the studied herb species (from the highest to the lowest values) is as follows: *H. sibiricum*, *C. oleraceum*, *A. millefolium*, *A. vulgaris*, *T. officinale*, and *P. lanceolata*, and for legumes: *L. corniculatus*, *V. cracca*, *L. uliginosus*, *L. pratensis*, *T. pratense*, and *T. repens*.

3. In regard to average dry matter content, the studied herb species may be ranked as follows (from the highest to the lowest values): *C. oleraceum*, *H. sibiricum*,

T. officinale, *A. vulgaris*, *P. lanceolata,* and *A. millefolium*, and legumes: *T. pratense*, *T. repens*, *L. pratensis*, *L. uliginosus*, *L. corniculatus*, and *V. cracca*.

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ZAWARTOŚĆ BIAŁKA OGÓLNEGO I WŁÓKNA SUROWEGO ORAZ STRAWNOŚĆ SUCHEJ MASY WYBRANYCH GATUNKÓW ROŚLIN BOBOWATYCH I ZIÓŁ Z EKSTENSYWNYCH UŻYTKÓW ZIELONYCH

Streszczenie. Rośliny bobowate i zioła stanowią cenny element runi łąkowej. W warunkach ekstensywnej gospodarki łąkowo-pastwiskowej, np. na terenach chronionych, gdzie zbiór pierwszego pokosu jest opóźniony, decydują w dużej mierze o jakości paszy, m.in. o zawartości białka ogólnego. Celem badań była ocena zawartości białka ogólnego i włókna surowego oraz strawności suchej masy wybranych gatunków roślin bobowatych i ziół z ekstensywnych użytków zielonych. Badania prowadzono w latach 1998-2000 przed zbiorem pierwszego pokosu (czerwiec – pierwsza dekada lipca) na terenie Pojezierza Olsztyńskiego. Łącznie przebadano 444 próby roślinne. Wyznacznikiem miejsc do pobrania prób było występowanie płatów roślinnych z co najmniej 5% pokryciem powierzchni (2 w skali Brauna-Blanqueta) przez wybrane gatunki roślin bobowatych: *Trifolium pratense* L., *Trifolium repens* L., *Lotus corniculatus* L., *Lathyrus pratensis* L., *Lotus uliginosus* Schkuhr., *Vicia cracca* L. i ziół: *Taraxacum officinale* F. H. Wigg., *Achillea millefolium* L., *Plantago lanceolata* L., *Alchemilla vulgaris* L., *Heracleum sibiricum* L. i *Cirsium oleraceum* (L.) Scop. Średnia zawartość białka ogólnego w bobowatych wahała się na poziomie 176,9-196,6 $g \cdot kg^{-1}$. Zawartość białka ogólnego w ziołach mieściła się najczęściej w granicach 100-120 $g \cdot kg^{-1}$ – *Taraxacum officinale* F.H. Wigg., *Achillea millefolium* L. i *Alchemilla vulgaris* L. oraz 140-160 $g \cdot kg^{-1}$ – *Heracleum sibiricum* L. i *Cirsium oleraceum* (L.) Scop. Badania wykazały, że rośliny bobowate zawierały istotnie więcej białka ogólnego i włókna surowego niż zioła, przy czym między gatunkami bobowatych nie stwierdzono istotnych różnic. U ziół wystąpiło natomiast istotne zróżnicowanie tych składników, a najwięcej białka i jednocześnie najmniej włókna gromadziły *Heracleum sibiricum* L. i *Cirsium oleraceum* (L.) Scop. Strawność roślin bobowatych mieściła się w przedziale 60-65%. Wśród ziół wyższą strawnością odznaczały się *Heracleum sibiricum* L. (74,1%) i *Cirsium oleraceum* (L.) Scop. (74,4%), zaś najniższą *Achillea millefolium* L. (62,2%).

Słowa kluczowe: białko ogólne, bobowate, strawność suchej masy, użytki zielone, włókno surowe, zioła

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