THE USEFULNESS FOR ENSILING OF CHOSEN PLANT FORMS OF SPECIES OF SILPHIUM GENUS

PRZYDATNOŚĆ DO ZAKISZANIA WYBRANYCH FORM GATUNKU ROŚLIN Z RODZAJU SILPHIUM

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Manuscript received: October 10, 2007; Reviewed: November 5, 2007; Accepted for publication: November 29, 2007

ABSTRACT

Chemical composition and usefulness for ensiling of the chosen forms of species: S. perfoliatum was determined in different stages of vegetation. Forage fermantation coefficient of species form: I, II ,III during vegetation period from vegetative phase to seed setting phase was lower than 35. The fermentation coefficient IV form of species during the initial phase of seed setting amounted to 36,54, which ensured the correct fermentation. The high phenol acids content in I, II, III species form limits the possibility of using them for forage purposes. These species may constitute a potentially good raw material for the pharmaceutical industry.

ABSTRACT

Określono skład chemiczny i przydatność do zakiszania wybranych form gatunków: S. perfoliatum roślin z rodzaju Silphium w różnych fazach wegetacji. Wartość współczynnika fermentacji zielonek I, II i III formy gatunku: w okresie wegetacji od fazy wegetatywnej do fazy początku wiązania nasion była niższa niż 35. Współczynnik fermentacji IV formy gatunku zebranej w fazie początku wiązania nasion wynosił 36,54 co gwarantowało prawidłowy przebieg i kierunek fermentacji w zakiszanym materiale. Wysoka zawartość kwasów fenolowych w I , II i III formie gatunku: ogranicza możliwość wykorzystania ich na cele paszowe. Gatunki te mogą stanowić potencjalnie dobry surowiec dla przemysłu farmaceutycznego.

KEY WORDS: Silphium, forms of species, stage of vegetation, chemical composition, coefficient of ensiling ability

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DETAILED ABSTRACT

Rośliny z rodzaju Silphium charakteryzują się wielokierunkowymi cechami użytkowymi: jako rośliny do rekultywacji terenów zdegradowanych, paszowe oraz pszczelarskie i energetyczne. Wtórne metabolity stanowić mogą surowiec dla przemysłu farmaceutycznego [15, 13, 5, 7]. W badaniach określono skład chemiczny wybranych form gatunku Silphium. perfoliatum w fazach od wegetatywnej do fazy wiązania nasion według standardowych metod [1] , wartość współczynnika fermentacji zielonek [12] oraz poziom kwasów fenolowych w przeliczeniu na kwas kawowy [8]. Zakiszanie zielonek form gatunku I, II oraz III w fazach od wegetatywnej do początku wiązania nasion oraz IV formy gatunku do fazy początku kwitnienia jest możliwe tylko z dodatkami bogatymi w łatwo fermentujące węglowodany. Optymalna wartość współczynnika fermentacji (36,54) zielonki IV formy gatunku w fazie początku wiązania nasion gwarantuje prawidłowy przebieg i kierunek fermentacji w zakiszanym materiale bez udziału dodatków węglowodanowych. Wysoka zawartość kwasów fenolowych w formach I, II i III gatunku może ograniczać ich wykorzystanie na cele paszowe. Testowane formy gatunku z rodzaju Silphium o wysokiej zawartości kwasów fenolowych stanowić mogą dobry surowiec dla przemysłu farmaceutycznego. Na podstawie przeprowadzonych badań IV forma gatunku roślin z rodzaju Silphium jest najbardziej odpowiednia na cele paszowe wśród testowanych form gatunku.

INTRODUCTION

Within Silphium genus, the most well-known species are: S. perfoliatum L., S. integrifolium Michx. and S. laciniatum L. [15]. The cup plant (S. perfoliatum) is a perennial plant originating from the central regions of North America [14]. Plants of Silphium genus have varied applications. Because of their low soil requirements and easy acclimatization S. perfoliatum can be used for restoring of degraded soil, as a forage plant and an apiarian plant [15, 13 ,5] and energetic plant [8]. The cup plant contains a range of secondary metabolites such as: volatile oils [16, 5], flavonoids [5, 2], triterpenoidal saponins and oleanosides [2, 5], tannins [14], phenol acids [6]. Secondary metabolites can be a valuable raw material for the pharmaceutical industry. Phenol acids react toxically with microflora of rumen which is responsible for the decomposition of structural carbohydrates [16]. The aim of research was to determine the usefulness for ensiling of different plants species of Silphium genus in vegetation phases.

MATERIALS AND METHODS

The studies were conducted from April to September 2006. An experimental material here were used perennial plants forms of species Silphium from Botanical Garden of Medical Academy in Lublin (forms of species I, II), III form of species from Botanical Garden Cluj-Napoca (Romania) ,IV form of species from Bee-keeping Institute ISK in Puławy. The agricultural part of the experiment was conducted in Botanical Garden of Plant Breeding and Acclimatization Institute in Bydgoszcz, Poland. The plants were collected in the following phases of vegetation:

- vegetative phase (VS) - at the 54th day of vegetation (days counted from the 1st of April),
- beginning of flowering (BF) - at 108th day of vegetation),
- beginning of seed setting (SS) – at 125th day of vegetation.

The samples were collected from 3 points on plantation, each point of 1 m^2. Forage was cut with a hand collector at 3 cm above the ground. Further analysis was performed in the Laboratory of Animal Nutrition and Feed Management Economy, Faculty of Animal Breeding and Biology, University of Technology and Life Sciences in Bydgoszcz. After drying, the components content was determined according to standard procedures [1]: dry matter [DM], organic substance [OM] and crude protein [CP] on 2200 Kjeltec auto distillation Foss Tecator, crude fat [CFa] on Soxtec HT 1043 Extraction Unit Tecator, crude fibre [CF] on Fibertec System 1010 Heat Extractor Tecator. Neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were determined according to Goering and Van Soest [3] on Ankom 220-Fiber Analyzer [Ankom Technology 8/98]. Water soluble carbohydrates (WSC) were determined according to Lane-Eynon method with Nizowkin and Jemialinowa's modifications [7]. Buffer capacity of plants (BC) was determined according to Weissbach [11] and expressed in grams of lactic acid per 100g of dry mater. Forage fermentation coefficient (FC) was calculated according to Weissbach [12]. The lever of phenol acids in relation to caffeic acid was marked by spectrometer MARCEL MEDIA EKO PLUS, with the wave length of 490 nm [9].

RESULTS AND DISCUSSION

During the observed phases of vegetation a change in nutrient content was detected. During the vegetative phase plants of Silphium genus (independently of a form of species) were characterized by high general protein content, which ranged from 140,5 g·kg^{-1} (form

Table 1. Chemical composition of chosen plant species of *Silphium* genus in vegetative phase

Form of species	DM (g)	Content in dry master ($g \cdot kg^{-1}$)						
		OM	CP	CFa	CF	NDF	ADF	ADL
I	92,60	868,80	140,5	29,50	136,40	248,90	195,40	Nd.
	±6,60	±5,70	±9,20	±1,40	±1,20	±3,30	±3,00	
II	104,80	862,60	143,20	23,00	119,40[A]	245,60[A]	186,20	Nd.
	±5,40	±6,10	±15,90	±2,30	±6,20	±4,50	±3,40	
III	115,50	865,05	162,60	38,00	128,20	259,90	191,6	Nd.
	3,70	±6,30	±12,60	±2,00	±3,20	±17,10	±6,30	
IV	87,70	874,80	170,30	42,70	142,90[B]	282,90[B]	200,0	Nd.
	±3,70	±3,10	±4,70	±0,4	±6,20	±11,80	±3,70	

DM- Dry matter; OM - Organic matter; CP- Crude protein; CFa- Crude fat , CF-Crude fibre;
NDF-Neutral detergent fibre ; ADF- acid detergent fibre ; ADL- acid detergent lignin
a,b,....$p<0,05$; A,B,.....$p<0,01$

Table 2. Chemical composition of chosen plant species of *Silphium* genus at the beginning of flowering

Form of species	DM (g)	Content in dry matter ($g \cdot kg^{-1}$)						
		OM	CP	CFa	CF	NDF	ADF	ADL
I	214,10	894,90	59,10[a]	18,80	271,40	353,30	306,60	425,00[a]
	±13,20	±2,31	±2,10	±1,90	32,50	±20,40	±29,20	±5,40
II	208,10	894,10[a]	64,10	19,20	260,30	346,80	299,60	435,00
	±6,20	±5,30	±4,70	±1,20	±8,30	±7,20	±3,10	±2,80
III	222,20	901,90	63,30	22,00	278,70	401,20	353,20	541,00
	±1,50	±4,20	±1,50	±0,90	21,30	±36,70	±27,70	±3,30
IV	213,90	909,80[b]	68,90[b]	20,60	302,90	410,50	347,00	552,00[b]
	±2,40	±3,40	±1,10	±1,40	±17,40	±21,00	±18,90	±3,00

DM- Dry matter; OM - Organic matter; CP- Crude protein; CFa- Crude fat , CF-Crude fibre;
NDF-Neutral detergent fibre ; ADF- acid detergent fibre ; ADL- acid detergent lignin
a,b,....$p<0,05$; A,B,.....$p<0,01$

Table 3. Chemical composition of chosen plant species of *Silphium* genus at the beginning of seed setting

Form of species	DM (g)	Content in dry matter ($g \cdot kg^{-1}$)						
		OM	CP	CFa	CF	NDF	ADF	ADL
I	239,90	880,10	61,80	29,00	284,90	339,90	300,60	483,00
	±0,74	±1,39	±4,30	±1,50	±31,40	±25,80	±18,60	±5,10
II	236,00[a]	868,70	71,40	23,40	285,00	295,80	261,50	379,00
	±0,57	±0,82	±6,20	±0,90	±18,40	±25,00	±12,40	±1,70
III	256,60[b]	886,30	66,60	21,70	302,40	382,50	331,20	551,00
	0,35	±1,28	±11,40	±2,70	±59,60	±67,30	±62,00	±8,70
IV	251,30	904,20	78,60	23,50	293,40	389,40	315,70	565,00
	±0,34	±1,69	±15,90	±3,00	±34,10	±68,80	±56,60	±6,30

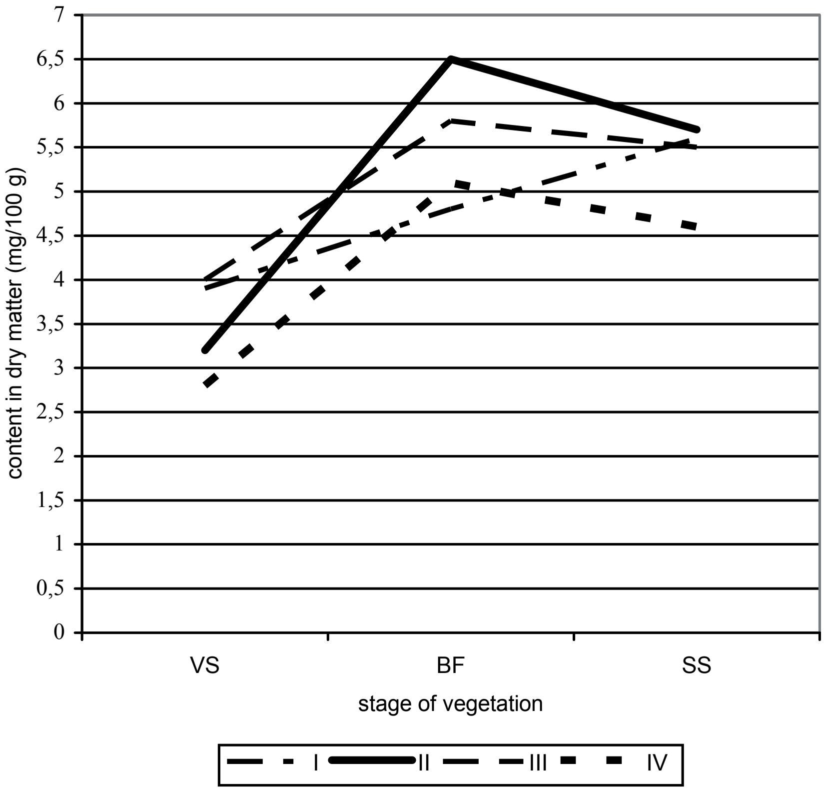
DM- Dry matter; OM - Organic matter; CP- Crude protein; CFa- Crude fat , CF-Crude fibre;
NDF-Neutral detergent fibre ; ADF- acid detergent fibre ; ADL- acid detergent lignin
a,b,....$p<0,05$; A,B,.....$p<0,01$

Table.4 Water soluble carbohydrates content, buffer capacity and forage coefficient of plants forms of species *Silphium* in phases of vegetation.

Form of species	WSC ($g \cdot kg^{-1}$)			BC (grams of $C_3H_6O_3$ per 100g of DM)			WSC/BC			FC		
	VS	BF	SS	VS	BF	SS	VS	BF	SS	VS	BF	SS
I	19,82 ±0,34	17,36 ±1,59	12,94 ±1,16	13,98 ±0,23	11,77[a] ±0,59	13,11 ±1,37	1,42 ±0,05	1,48 ±0,11	1,00 ±0,17	20,60 ±0,92	33,25 ±1,61	31,99 ±1,85
II	19,19 ±2,19	15,99 ±1,32	11,66 ±1,29	15,22[B] ±0,13	11,18 ±0,74	14,69 ±0,46	1,26 ±0,16	1,45 ±0,20	0,80 ±0,11	20,57 ±1,78	32,39 ±1,88	29,98 ±1,45
III	15,13[A] ±1,15	13,89 0,13	10,54 ±1,13	12,84[A] ±0,22	10,44 ±0,60	11,58 ±1,88	1,18[a] ±0,07	1,33 ±0,06	0,95 ±0,22	20,96 ±0,72	32,89 ±0,66	33,24 ±1,38
IV	21,71[B] ±1,01	15,73 0,42	13,05 ±1,99	13,88 ±0,70	9,58[b] ±0,16	9,79 ±1,77	1,53[b] ±0,05	1,64 ±0,02	1,43 ±0,53	20,99 ±0,16	34,54 ±0,37	36,54 ±1,11

a,b,....$p<0,05$; A,B,.....$p<0,01$

Water soluble carbohydrates (WSC), Buffer capacity (BC), fermentation coefficient (FC)
vegetative phase (VS) , beginning of flowering (BF), beginning of seed setting (SS)



vegetative phase (VS) , beginning of flowering (BF), beginning of seed setting (SS)

Fig.1. Phenolic acids content of chosen plant species of *Silphium* genus in stages of vegetation.

I), to 170,3 g·kg^{-1} (form IV) in dry matter (tab.1). In later phases of development (the beginning of seed setting) a decrease in this component content from 61,80 g·kg^{-1} (form I) to 78,6·kg^{-1} (form IV) in dry matter was detected. Literature on the subject shows that this component content in dry matter of S. perfoliatum at the beginning of flowering measured 147 g·kg^{-1}, whereas in the phases of: inflorescence setting and the beginning of flowering, it measured 132 and 107 g·kg^{-1} respectively [10]. In later experiments lower values were noted. The level of crude fibre changed together with growth and development of the plants. During vegetative phase the amount of fibre ranged from 119,4 g·kg^{-1} (form II) to 142,9 g·kg^{-1} (form IV) of dry matter (tab.1). The quantity of this component at the beginning of seed setting ranged from 284,90 g·kg^{-1} (form I) to 302,4 g·kg^{-1} (form III) of dry matter. The crude fibre content at the beginning of flowering was almost in accordance with the literature data. The level of this component in dry matter of S. perfoliatum in the phase of inflorescence setting reached 250 g·kg^{-1}, and at the beginning of flowering 280 g·kg^{-1} [10]. Acid-detergent fraction constituted (independently of form of a species) about 200 g·kg^{-1} of dry matter during vegetative phase (tab.1). The level of this fraction at the beginning of flowering increased from 299,6 g·kg^{-1} (form II) to 347 g·kg^{-1} (form IV) of dry matter (tab.2). The quantity of this component in the phase of seed setting ranged from 261,5 g (form II) to 331,2 g·kg^{-1} of dry matter (tab.3). The subject literature on S. perfoliatum species in the phase of inflorescence setting and at the beginning of flowering gives the value of 309 g·kg^{-1} and 341 g·kg^{-1}, respectively in dry matter. Water soluble carbohydrates and buffer capacity quotient for different plant species of Silphium genus depended on the phases of vegetation. In vegetative phase this value ranged from 1,18 (form III) to 1,53 (form IV) (tab.1). During the beginning of flowering period, independently of a species, a decrease of the parameter value was reported. Its lever ranged from 0,8 (form II) to 1,43 (form IV) (tab.3). Water soluble carbohydrates and buffer capacity (WSC/BC) quotient in vegetative phase was close to this parameter value estimated for dried green forage of grass (1,37), containing 55,2 % of dry matter [4]. Tested species of Silphium genus (with the exception of form IV) in the seed setting phase are characterized by water soluble carbohydrates and buffer capacity quotient close to those of clover and lucerne. Janicki & Piłat [4] state that the value of this parameter for the clover with 35,4% of dry matter measures 1,16g and for lucerne (34,1% of dry matter) 0,67. Forage fermentation coefficient (FC) for the chosen species of Silphium genus depended on the phase of vegetation. During the vegetative phase the values ranged from 20,57 (form II) to 20,99 (form IV). In the later phase of vegetation (the beginning of flowering), independently of a species an increase of fermentation coefficient was reported. It ranged from 32,39 (form II) to 34,54 (form IV). During the seed setting phase for plants of I and II form of species a decrease of this parameter was registered, whereas for III and IV form of species its increase was observed (tab.4). Forage fermentation coefficient (FC) for IV form of species (34,54) during the seed setting phase ensures correct fermentation process in the material which is being ensiled [12]. Phenol acids content in form of species of Silphium genus varied in the phases of vegetation. During a vegetative phase a low component content was registered, it ranged from 2,8 (form IV) to 4,0 (form III) mg·100g^{-1} of dry matter (fig.1). The component content increased during the beginning of flowering, whereas at the beginning of seed setting the phenol acid content decreased (with the exception of species I). Kowalski & Wolski [6] detected the presence of free phenol acids. Their quantity ranged from 5,686 mg·100g^{-1}of dry matter (in leaves) to 7,676 mg·100 g^{-1} of dry matter in inflorescence. Low phenol acids content for S. perfoliatum species in the period of vegetation indicates its potential as a forage source.

CONCLUSIONS

1. Forage ensilage of form of species: I,II,III from vegetative phase to the beginning of seed setting and in case of form IV to the beginning of flowering, is possible only with a supplement containing a large quantity of easily-fermenting carbohydrates or wilted plants.
2. Optimum value of the forage fermentation coefficient for form IV in a phase of the beginning of seed setting alludes correct fermentation in the ensiled material without carbohydrate-supplement contribution.
3. A high phenol acids content in forms of species I, II, III can limit their exploitation for forage purposes.
4. Tested form of species of Silphium genus with a high phenol acids content can constitute a good raw material in the pharmaceutical industry.
5. According to one-year research IV form of species is the most suitable form for forage purposes among tested species.
6. Changing chemical chemical composition of species forms of S. perfoliatum indicates the necessity of continuine research into the usage of these plants as a potential forage plants

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