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Research Article

The impact of different methods of drying and preparation method on the basic chemical composition of hay

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Abstract

The paper presents the results of three different ways of storing the dried mass of hay: bulk, small bales and large roll bales, as well as the impact of three drying methods: natural in the field, artificial drying with cold air and drying with dehumidification (warm air). In the tested meadow in the first swath, the results of chemical analyses showed differences in the method of drying hay. Regarding the tested drying method, the content of dry matter (DM) had significant differences between the storage methods as well as all variants with pre-heated air drying, where the average value of DM was in the interval of 86.18-93.01%. The content of mineral substances for certain methods of preparation and drying ranged from 5.77% to 7.72% on average. The highest content of crude proteins was in all variants of artificial drying and it ranged from 98.6 to 165.7 g/kg DM and had a statistically significant difference. Both methods of artificial post-drying had a significant impact on the cellulose content (33.76% to 28.86%) compared to drying in the traditional way because postponing the mowing time increases the cellulose content. The drying method had a statistically high significant difference on the content of neutral detergent fibres (NDF) and acidic detergent fibres (ADF), while the method of storage had no major impact. Knowledge of changes in the quality of hay during the growing season is of particular importance form the aspect of ruminant nutrition and balanced rations. The amount and quality of obtained hay is significantly affected by the time of mowing, height of mowing, swath, fertilization, floristic composition and weather conditions during drying of the green mass.

Keywords: chemical composition; hay; hay drying; hay quality; method of preparing

Introduction

Hay is a preserved bulk food, obtained by drying mowed plants to a moisture level of 18% which interrupts the impact of enzymes in their cells and minimizes the degree of microorganisms' activity. The

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optimal humidity for safe storage of hay ranges between 12-18% (Adler, 2002). Hay is a necessary component of bulk food for certain categories of livestock: cattle, sheep and other ruminants. In lowland regions, it is mainly prepared from legumes, alfalfa and clover. In hilly regions, hay is made from green mass produced on natural or sown lawns.

Due to the increase in the price of protein and energy components of concentrates in the last few years, farms which basic nutritional base is hay and silage feel the pressure to increase their profitability by improving the quality of their fodder. According to Stockinger (2009), 24% of profit reserves in milk production refer to animal fodder and its quality. For this reason, the economically successful production of milk is becoming more and more important and therefore the production of quality hay is also becoming more and more important. Different types of perennial grasses and legumes make it possible to compose dedicated mixtures that are suitable for certain production conditions, methods of use, length of use, etc. (Lazarević *et al*., 2006). It should be noted that the hilly mountainous areas of our country, due to the specific configuration of the terrain and pedological characteristics of the land, are very favourable for growing perennial grasses, mixed grasses and legumes. Lawns based on mixtures of grasses and legumes, compared to natural meadows or lawns based only on perennial grasses, provide higher yields and quality of biomass, which has an increased content of raw proteins (Kessler and Lehman, 1998). In the Republic of Srpska, significant arable land in the hilly and mountainous area is covered by grassland, where hay production is an important form of agriculture production. According to the data of the Statistical Office in the Republic of Srpska and according to the category of land use, 37% belongs to grassland, out of which 18% are meadows (RZSRS, 2020). According to Stošić *et al*. (2005), the average yield of hay from mountain pastures is about 0.7 t/ha, and from meadows 2.1 t/ha. Hay dried in the field is currently the main way of preserving it in hilly and mountainous regions. It is characterized by low nutritional quality (Hauwuy, 1993) as a result of mowing at a late stage of maturity, significant mechanical losses, often as a result of a subjective factor in the process of applying technical means and often accompanying rain during hay preparation. As the optimal phase for mowing the first swath of alfalfa, the budding (buttoning) is most often mentioned in the literature, and for grasses, the beginning of leafing (Đorđević, 2012). By choosing the optimal phase for use, the maximum in nutritional value is achieved, with the optimal yield of dry matter per unit area. Cost-effective production in livestock, especially bovine animals, is based on the maximum use of high-quality voluminous food which is comparably cheaper than concentrated nutrients. According to its chemical composition and nutritional value, hay is the most variable nutrient which directly affects the production of high-milk cows, especially in the case when hay is the only or dominant nutrient. There are different methods of assessing the quality of hay. Generally, the assessment is based on the results of organoleptic and chemical analyses, including the proportion of leguminous plants, cellulose protein content and others. Crude protein content is an important quality parameter, but ADF and NDF are equally important. ADF consists of cellulose, lignin and ash. Lignin has a very low digestibility and cellulose is usually less than 50% digestible. Thus, plants with high ADF content have low digestibility and lower energy concentration (Henning and Lawrence, 2018). In the vegetative phase of plant development, the share of leaves is equal to or greater than the share of stems, while the proportion of leaf mass decreases with the age of lawn, but the share of stems increases relatively, the amount of crude proteins decreases and the amount of crude fibers increases (Di Marco *et al*., 2002). The decline in the quality of green mass is associated with an increase in the proportion lignin and structural parts of the cell wall, i.e., with a decrease in the content of crude proteins and digestible parts of the plant cell, such as starch, monosaccharides and sucrose (Aman, 1983). At the same time, optional consumption and digestibility of such hay is reduced. Italian research on 7.000 samples have shown that the quality of mountain hay in the first swath is markedly low, with medium values of 63.3% for NDF (in dry matter) and 8.9% for crude protein in dry matter (Borreani, 2005). Since the age of plants at the time of mowing is the main affecting factor on the nutritional value of fodder, (Van Soest, 1994), early conservation in the form of hay and silage is necessary in order to obtain suitable fodder with satisfactory nutritional potential for dairy cows as well as desirable reduction of concentrates in feeding (Jeangros, 2004).

The quality of the hay depends on the quality of the mowed fodder, as well as on the losses and changes of the fodder during drying and storage. Drying or re-drying hay on traditional dryers (haystacks, hayracks), ventilation devices with cold or warm air or on condensation dryers contributes without doubt to a better quality of hay. An Austrian study showed, on a sample of over 500 farms, that less than one third of farmers (27.8%) dried hay on the ground, that 39.0% of farmers used air ventilation of the hay with cold air, and 33.2% with warm air (Resch *et al*., 2011). The indoor drying method was introduced in mountainous areas where there are frequent rains at the harvest time. This technique involves partial drying where natural and heated air were used. Traditional drying of hay in swaths on the ground with the help of solar energy requires a longer phase of field drying and thus the greatest weather risk. High levels of precipitation during May and June significantly prolong the drying time of hay in this way. Depending on the process, drying enables the harvesting of fodder, primarily hay with higher water content. On the one hand, the advantage of this method is the shortening of the drying time in the field and with its reduction of the risk of bad weather, and on the other hand, there is no any decrease in the qualitatively valuable leaf mass at higher humidity. The increase in moisture content of such material is a challenge for different methods of drying, because it is necessary to remove a large amount of water in a very short time in order to prevent mass microbiological activity in fodder and its decay. Additional drying with cold non-preheated air has only a limited drying effect. Especially at low temperatures or high humidity, the water absorption from the air is very low and this reduces the efficiency of hay drying (Nydegger, 2009). Hay drying processes with additional air heating or air dehumidification can remove adequate quantities of water from hay even at unfavourable temperature or air humidity (Gindl, 2002). With adequate energy use, fresh green fodder could also be dried by such a method, which is uneconomical due to the sudden increase in drying costs.

Materials and Methods

Experimental studies on various hay preparations have been carried out on a plot of 1.5 ha, on the farm not far away from Pale (43°52'39“; 18°36'24“). The experimental plot where different aggregates have been tested for hay storage is located at 900 m altitude, with a slightly inclined exposure in the northeast-southwest direction. The plot is approximately rectangular in shape, 300 m long and 50 m wide. The examined meadow in the first swath belongs to the two most common grass associations: Agrostidetum vulgarae and Festucetum vallesiacae according to (Kojić, 2001; Nešić, 2005). These are plant communities in the ecosystem of mesophilic meadows, characteristic of the mountainous regions.

On the first day, the meadow was mowed in the evening. For the determination of dry matter and laboratory analysis of fresh mass, samples were taken on the spot where the yield of grass mass was determined in the field. The moisture content of the grass mass was determined by a laboratory method, a moisture meter for biomass, i.e., by determining the content of dry matter and calculation per hectare. On the second day, with the use of chain finger side delivery rake SIP 220, the swaths were loosened. During the drying process in the field, samples were taken and the moisture content of the material was determined. At the moment of collecting the loosen mass into a bundle, the mass humidity was 31.65%. After the mass was formed into windrows, the dry hay mass was stored in the three most common ways of storage (factor A): loosened, small bales and large round bales.

Then, the stored hay was placed in the dryer, where different variants of the method of drying (factor B) such as artificial drying with cold air and drying with air dehumidification (warm air) were monitored, while the control variant was natural drying in the field.

The stored bales were weighed with a crane scale and the humidity was determined using a hay moisture meter (Hay moisture meter Wile 25) before putting it into the dryer. There are different methods of assessing the hay quality. Basically, the assessment is based on the results of organoleptic and chemical analysis, including the share of leguminous plants, the content of protein, cellulose, and many other groups and organizations

(American Forage and Grassland Council, National Alfalfa Hay Testing Association, National hay Association etc.) have worked together for several years on the development of standards based on the chemical hay analysis (Lacefield, 1988). Standards assigned by Hay Market Task Force of AFGC came the calculation of basic quality indicators: Digestible dry matter, dry matter intake and relative nutrient value.

Digestible dry matter (DDM) is an estimate of the portion of nutrients that is digestible and is calculated using the ADF value: DDM (%) = 88.9-(%ADF * 0.779).

Dry matter intake (DMI) is an estimate of the maximum amount of dry matter from bulk feed that an animal can eat (calculation based on NDF): DMI (%TM) = 120 / %NDF.

Relative feed value (RFV) is an estimate of the value of nutrients in ruminats feed: RFV = (DDM * DMI) / 1.29.

Chemical analyses of hay samples were performed in the laboratory of the Faculty of Agriculture in East Sarajevo and in the authorized certified laboratory of Sistem Qualita, S d.o.o, using standard methods for testing the quality of animal fodder. Laboratory analyses of hay quality from the experiment included:

- content of dry matter, gravimetrically by drying at 105 °C for 24 hours until consant mass
- content of raw ash, by annealing 1 g of air-dried sample at 550 °C for an hour and measuring the residue, and the ash is expressed as a mass percentage.
- protein content (total nitrogen) by the micro-Kjeldahl method. This method covers digestion of the sample using concentrated sulfuric acid in the presence of a catalyst, neutralization after digestion by adding NaOH, and titration of the resulting ammonia with a standard HCI solution in an automatic VELP apparatus. The amount of protein is calculated by multiplying with the appropriate factor.
- cellulose content (crude fibers), according to Weende and Wijkstrom was determined using Fiber Bag FBS 6 – Gerhardt. The method is based on the samples treatment with a solution of sulfuric acid and sodium hydroxide and then the residue is separated by filtration and measured after drying.
- determination of neutral detergent fibers (NDF) according to Van Soest, the method is based on the dissolution of soluble carbohydrates, pectin, lipids, soluble mineral substances and silicon. Soluble content is defined as a neutral detergent fiber (NDF) and
- determination of acidic detergent fibers according to (ADF) Van Soest, the method is based on the dissolution of soluble carbohydrates, pectin, lipids, soluble mineral substances and hemicellulose. The rest of fibers consisting of cellulose, lignin, cutin and mineral substances insoluble in acid, is defined as ADF.

Sorting and statistical processing of data, whether there is a statistically significant difference between storage methods and methods of hay drying in terms of its quality, i.e., the content of protein, raw ash, cellulose, as well as the content of neutral detergent fibres (NDF) and acid detergent fibres (ADF), are carried out using Microsoft Office Excel and IBM SPSS Statistics 21.0. This first part was performed as one-factorial experiment, while mutual interactions were performed as two-factorial experiment.

Testing standard statistical methods using one-way analysis of variance was performed in order to determine if significant differences occurred among treatments. LSD test was performed at a 95% level of significance in order to test the null hypothesis about the difference among the average values of the content of the basic chemical parameters in the hay samples.

Results and Discussion

In the examined meadow in the first swath, the average yield of green mass varied 23.5 – 46.5 t/ha, on average 38.4 t/ha. The representation of certain categories of plants in percentages was grasses 58%, legumes 25% and other plants 17%. Nutrient concentrations, digestibility, sugar and protein content as well as microbilogical status are important parameters in assessing the quality of hay as well as the way it is stored. The following Tables 1 and 2, show the basic chemical composition of hay for three different methods of preparation (bulk and pressed) as well as three different treatments of drying it. Thus, the impact of nine different treatments, the impact on the dry content matter, mineral matter, crude proteins, crude cellulose, as well as the content of neutral (NDF) and acidic detergent fibers (ADF) was examined.

Table 1. Hay quality depending on the storage method (%)

Method of preparing	DM	CA	CP	CF	NDF	ADF
Control	91.88a	7.33	19.60a	26.57b	60.43	33.51b
Bulk	89.65b	6.61	12.08b	33.54a	60.58	39.24a
Small bales	89.98b	6.59	13.66b	33.12a	63.07	39.11a
Roll bales	91.60a	6.88	14.40b	32.20a	60.82	37.86a
Average	90.78	6.85	14.93	31.36	61.22	37.43
LSD	1.327	0.711	2.405	2.913	4.468	2.031

Legend: DM-Dry Matter; CA-Crude ash; CP-Crude protein; CF-Crude fibre; NDF-Neutral detergent fibres; ADF-Acid detergent fibres

*Values marked with lowercase letters in columns are significantly different at the P≤0,05 level according to LSD test.

Table 2. Hay quality depending of the drying method

Drying method	DM	CA	CP	CF	NDF	ADF
Control	91.88	7.33	19.60a	26.57b	60.43b	33.51c
Natural	90.37	6.49	12.22b	34.31a	65.58a	40.36a
Cold air	90.94	6.86	14.92b	31.88a	58.66b	37.69b
Warm air	89.92	6.75	13.00b	32.68a	60.23b	38.16b
Average	90.77	6.85	14.93	31.36	61.22	37.43
LSD	1.692	0.703	2.254	2.659	2.235	1.480

Legend: DM-Dry Matter; CA-Crude ash; CP-Crude protein; CF-Crude fibre; NDF-Neutral detergent fibres; ADF-Acid detergent fibres

*Values marked with lowercase letters in columns are significantly different at the P≤0,05 level according to LSD test.

It is important that in the preparation of hay, the content of dry matter quickly rises above 870 g kg^{-1} to ensure microbiological stability during the storage period (Nydegger, 2009). With the regard to the examined method of drying, the content of dry matter (DM) had significant differences between the methods of storage, bulk – roll bales, small bales – roll bales, as well as variants with pre-heated air drying (Figure 1). Regardless of the fact that the traditional ways of storing hay (drying on the ground) have lower DM values, the drying process itself requires a longer field phase, i.e., drying in the field, which is associated with an increased risk of bad weather conditions (Resch *et al*., 2009). On the other hand, the increase of dry matter in the field leads to increased losses due to shedding and crumbling, according to some authors, up to 10-20% (Buchgraber and Gindl, 2004). In their research, Resch *et al*. (2014), they state that the factor of age and swath per row had the greatest impact on the content of dry matter, while the factor of drying itself had a very significant impact on the content of carotene. According to Čobić *et al*. (1991), the average value of dry matter in grass hay was 86.69%, while in the research of Lakić *et al*. (2008) it ranged on average from 86.27 to 88.35% which is similar to the results obtained in this paper, where the average value of DM ranged from 86.16 to 93.01%.

Table 3 shows the content of mineral substances (ash) for certain methods of preparation and drying. On average, the ash content ranged from 5.77% to 7.72%, minor oscillations and differences occur in terms of the method of drying with cold air and natural drying in the field which mainly depends on the earliness at the time of mowing and on the swath per row (Resch *et al*., 2014). The same authors stated that the greatest growth in mineral substances affected the sodium and copper content. Čobić *et al*. (1991), in their research, they obtained raw ash values of 6.63% which is in accordance with the values listed in Table 3. Lakić *et al*. (2008), reported similar values in their research on grass-leguminous mixtures where the crude ash content varied from

7.13% (*Lotus corniculatus*) to 9.72% (*Lolium perenne*). The crude protein content ranged from 98.5 to 167.5 g kg^{-1} DM and in small variants of artificial drying had a statistically significant and highly significant difference compared to the traditional storage method with a difference of 34.1 g kg^{-1} DM. The method of hay storage had no major differences except in the case of small square bales, which is related to the different mowing time in the test period. Resch *et al*. (2014), stated in their research that the drying factor had a highly significant difference on the content of crude proteins and carotene. The average effect of drying with preheated air was 4.9 g kg^{-1} DM higher compared to traditional drying in the field. Similar results were reported by (Makević *et al*., 2004) where, depending on the method of drying, an increase in crude protein of 23.7 gkg^{-1} DM was reported. In the study by Ferreira (2004), it is stated that the crude protein value is 72 g kg^{-1} DM, whereas (Čobić, 1991) states the crude protein value in the amount of 94.9 g kg^{-1} DM in meadow hay, which is lower than the results obtained. According to Lakić and Maličević (2021), the crude protein content of natural meadow amounted to 96.6 g kg^{-1} DM, while in the variants of grass-leguminous mixtures it ranged from 126.1 – 134.3 g kg^{-1} which is in accordance with the obtained results from our survey. Regarding the cellulose content, Table 3 shows a statistically high significant difference between the drying method, where both methods of artificial post-drying had an impact on the lower cellulose content compared to drying in the field. The results of our research agree with the research results of Makevic *et al*. (2004), Resch (2013), Resch *et al*. (2014). The mentioned authors report raw cellulose values of 33.76% in hay dried on the ground, while its content was 28.86% when dried in a dryer with cold air.

Table 3. Chemical composition of hay depending on the storage and drying method (%)

Quality parameters	DM	CA	CP	CF	NDF	ADF
Method of preparing (A)						
Loosened (A1)	89.65b	6.61	12.08	33.54	60.58	39.24
Small rectangular bales (A2)	89.98ab	6.59	14.22	32.51	62.64	38.90
Large round bales (A3)	91.60a	6.88	13.84	32.82	61.25	38.07
Drying method (B)						
Field drying (B1)	90.65	6.15b	10.39b	35.52a	66.04a	40.83a
Cold air (B2)	90.66	7.19a	14.87a	31.28b	58.63b	34.44b
Warm air (B3)	89.92	6.74ab	14.34a	32.06b	59.80b	37.94b
AxB						
A1B1	90.85b	5.77d	9.85e	36.37a	64.05abc	41.66a
A1B2	90.13bc	7.50ab	12.16cd	32.82bcd	58.56d	38.17cd
A1B3	87.98d	6.55bcd	14.25bc	31.42bcd	59.12cd	37.90cd
A2B1	90.07bc	6.41cd	12.00cde	33.92b	66.29ab	40.67ab
A2B2	90.74b	6.36cd	16.75a	30.53cd	59.37cd	36.73d
A2B3	89.14c	7.01abc	13.91bc	33.06bc	62.24bcd	39.29bc
A3B1	91.04b	6.27cd	10.96de	36.27a	67.77a	40.17ab
A3B2	91.10b	7.72a	15.69ab	30.49d	57.96d	37.42d
A3B3	92.66a	6.67bcd	14.86ab	31.69bcd	58.03d	36.64d
LSD						
A 0.05	0.738	0.553	1.353	1.505	3.071	0.985
0.01	1.011	0.757	1.853	2.062	4.027	1.350
B 0.05	0.738	0.553	1.353	1.505	3.071	0.985
0.01	1.011	0.757	1.853	2.062	4.027	1.350
AB 0.05	1.278	0.957	2.343	2.606	5.319	1.707
0.01	1.751	1.311	3.210	3.570	7.287	2.338

Legend: DM-Dry Matter; CA-Crude ash; CP-Crude protein; CF-Crude fibre; NDF-Neutral detergent fibres; ADF-Acid detergent fibres

*Values marked with lowercase letters in columns are significantly different at the P≤0,05 level according to LSD test.

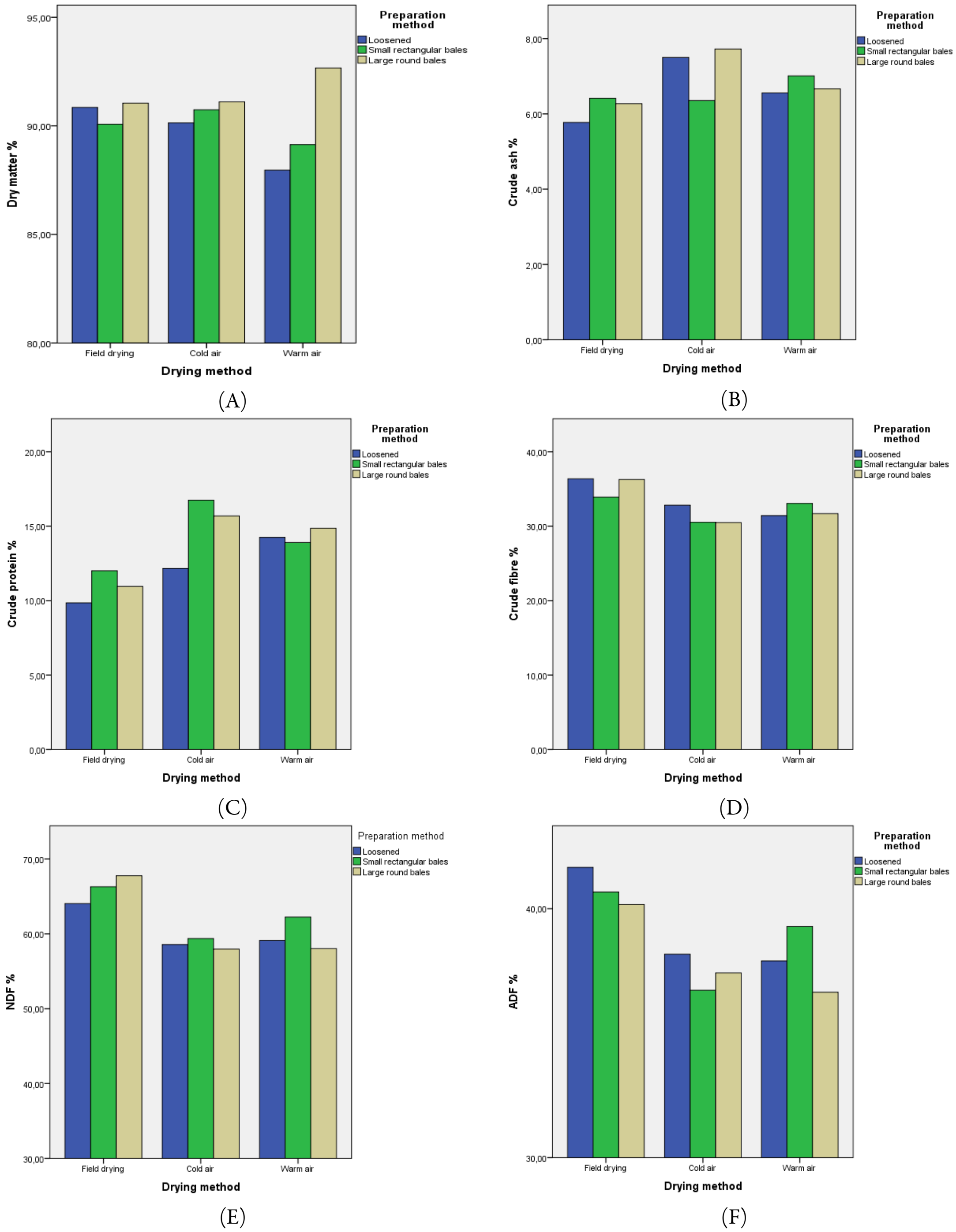

Figure 1. Chemical content depending on the way of preparation and drying (%): (A) Dry Matter; (B) Crude ash; (C) Crude protein; (D) Crude fibre; (E) Neutral detergent fibres – NDF; (F) Acid detergent fibres – ADF

The determined differences are the consequence of the delay in preparing the hay because the cellulose content increases with the age of the plants. Since in our research, there was a greater proportion of grasses in the hay structure, for this reason the cellulose had such values which is in accordance with the research (Lakić *et al*., 2008) where the crude cellulose values for grass-clover mixtures with a higher percentage of grasses where

31.25% and for mixtures with a higher percentage of legumes 29.41% (Lakić, 2012). One of the quality important measures of green mass and hay is the percentage of acidic detergent fibers (ADF) and neutral detergent fibers (NDF). ADF and NDF levels are important because they have a high impact on livestock productivity and digestion. The content of ADF and NDF are very important components and the variation of their percentage composition depends significantly on the maturity stage of plants. ADF is a fodder component that, together with cellulose and lignin, is the least digestible for livestock. Its increase reduces digestibility, so fodder with higher concentrations of ADF is usually lower in energy. NDF are structural components of plants and in particular participate in the cell walls construction. With the increase of the plants age, the NDF content also increases, but it generally refers to nutrients with low nutritional value. Compared to the classical analysis of crude fibers (cellulose), structural carbohydrates can be decomposed much more realistically and as such represent the real state of quality (Gruber, 2009). The drying method had a statistically high significant difference on the content of neutral detergent fibers (NDF), while the storage method had no major impact. The age and the number of cuttings per growth have the greatest influence on the NDF content (Resch, 2013; Resch *et al*., 2014).

The drying method showed a statistically significant difference on the content of acidic detergent fibers (ADF), while the preparation method had no major impact. According to Resch (2013) and Resch *et al*. (2014) the ADF content was influenced by the year of testing and growth, while the drying method had no major influence, which is not in agreement with our results.

The difference is the consequence of the delay in the variants of preparing the trial and the blooming phase of the meadow. The time of mowing plants has a great impact on the content and digestibility of nutrients in them. Young plants have a higher digestibility of nutrients because they are richer in proteins compared to plants in later phenophases of development. With further growth and development of plants, i.e., their aging, the proportion of raw cellulose increases, and then the proportion of lignin in the cellulose. Although the content of dry matter increases with aging, the digestibility of nutrients rapidly decreases precisely because of the cellulose lignification, but also other nutrients such as proteins and minerals (Gatarić, 2014). According to Makević *et al*. (2004), fiber values are most affected by the stage of development of grasses and legumes, and these values range from 55% (heading phase) to more 65% (after heading) for NDF, i.e., from 33% to more than 41% for ADF. The content of both cellulose fiber fractions (NDF, ADF) was higher in the summer period due to higher temperatures and accelerated plant aging (Vasiljević and Pataki, 2012). Storing high-quality hay is a very expensive process, and on the other hand, due to weather conditions and the human factor, large quantities of hay are not often of satisfactory quality. The hay quality is determined by the chemical composition and digestibility of nutrients at individual stages of plant development, as well as by the method of drying and storage, the length storage and the method of use.

Table 4. Hay quality standard parameters (Hay Market Task Force of AFGC)

Preparation variants	DDM (% DM)	DMI (% DM)	RFV	Quality standard
A1B1	56.4	1.9	82.2	3.7
A1B2	59.2	2.1	94.0	3
A1B3	59.4	2.1	94.5	3
A2B1	57.2	1.8	80.6	4.3
A2B2	60.3	2.0	94.6	3
A2B3	58.3	1.9	87.3	3.7
A3B1	57.6	1.8	79.4	4.3
A3B2	59.8	2.1	96.4	2.7
A3B3	60.4	2.1	97.1	2.7

Standard hay of relative nutrient value (RFV) = 100 contains 41% ADF and 53% NDF and has standard quality 3 (Lacefield, 1988). Based on the standards for calcualting the quality of hay assigned by the Hay Market Task Force of AFGC, it was determined that the majority of tested samples, which were dried, had a grade of 3 and below 3, while the hay samples prepared in the classic way had an average grade of 4, i.e. were of poorer quality (Table 4).

Regarding the tested drying method, the content of dry matter (DM) had significant differences between storage methods, bulk – roll bales, small bales – roll bales, as well as variants with pre-heated air drying where the average value of DM ranged from 86.18 – 93.01%. The mineral substances content for certain methods of preparation and drying ranged from 5.77% to 7.72% on average, smaller oscillations and differences occur in the case of cold air drying and natural drying in the field, which mainly depends on the earliness at the time of mowing and from growth per year. The highest content of crude proteins was in the variant with artificial drying with cold air 167.5 g kg^{-1} DM and in all variants of artificial drying it had a statistically significant and highly significant difference compared to the traditional method of storage with a difference of 34.1 g kg^{-1} DM. Regarding the cellulose content, there is a significant difference between the drying methods, where both methods of artificial drying had an impact on the cellulose content compared to drying in the traditional way, because delaying the mowing time extended the vegetation phase, i.e. the plants' age, and with the age of plants, the cellulose content increases.

From the perspective of ruminant nutrition, the relationship between structural (NDF and ADF) and non-structural (starch) occupies a special space in the domain of hay quality. The contents of ADF and NDF are very important nutrition components and variation of their percentage in composition depends significantly on the maturity stage of the plants. The drying method had a statistically high significant difference on the content of neutral detergent fibres (NDF) and acidic detergent fibres (ADF), while the storage method had no major impact.

Knowing the changes in the hay quality during the growing season is of a particular importance from the aspect of ruminant nutrition and ration balance in order to ensure the appropriate ratio of structural and non-structural carbohydrates. A coarse fodder that contains a lot of cellulose while used in the feed of domestic animals gives a feeling of satiety, which causes less consumption of concentrated fodder, which results in reduced production by animals, especially milk

Conclusions

Our research has shown that the method of drying (artificial post drying and natural drying in the field) can partially affect the quality, which mainly depends on the early maturity of the plants at the time of mowing and on the swath order

The amount and quality of the obtained hay are significantly affected by the time of mowing, height of mowing, swath, floristic composition and weather conditions during drying of the green mass. Earlier mowing results in a better quality of the plant mass, i.e. higher protein content and higher digestibility of nutrients, while later mowing results in a higher yield of dry matter, but also a lower digestibility of nutrients, because in plants the proportion of stems in relation to leaves increases. The digestibility of nutrients depends to a large extent on the method of creation and the chemical composition of lignin as part of ADF, which is used to calculate the digestibility of dry matter and the calculation of hay quality parameters. In the majority of tested variants of drying, the quality assessment based on the relevant standards (Hay Market Task Force of AFGC) is at a satisfactory level. By increasing the share of the stem in the plant, the share of cellulose in it increases, and the digestibility of organic matter by animals decreases. Therefore, when mowing the plants, it is necessary to make balance between these two possibilities in order to achieve optimal quality and a satisfactory yield of hay.

Authors' Contributions

Conceptualization: MZ and MI; Methodology: MZ and MI; Formal analysis: MZ; Investigation: MJ; Writing - original draft: MJ and TJ; Resources: TJ and ZM; Writing - review and editing: MZ, MJ and TJ. All authors read and approved the final manuscript.

Ethical approval (for researches involving animals or humans)

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Conflict of Interests

The authors declare that there are no conflicts of interest related to this article.

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