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CHEMICAL COMPOSITION OF ANIMAL FEED AND ITS INFLUENCE ON THE MILK QUALITY

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Abstract: *Knowledge of the chemical composition of animal feed is important for the normal health of dairy cows and the high production of quality milk. The research presents an examination of the chemical composition of animal feed shown in percentage such as: fodder crop - alfalfa hay and straw - which are a by-product of wheat and two types of fodder mixes (FM). As for the research the following nutrients were examined: protein, crude fiber, fat, moisture, ash and their total values, as well as nitrogen-free extractive substances (NES) in 3 samples of each animal feed from 3 different farms (A, B, C). The highest total value for all nutrient compounds was obtained in alfalfa, at farm A =65.91%. The lowest total value was obtained in straw used in farm A=53.78%. The total value of NES in all three farms was 34.78%. Namely, according to the results farm A=38.54% used FM2, however farm B=39.13%, and farm C=42.15 % used FM1. Analyses of chemical composition of the milk (dry matter, fat, protein, lactose and density) provide a conclusion indicating that the values from the three farms appear to be similar, the milk sample from farm B has the highest value of dry matter with 8.22% and fat 3.65%. The milk sample from farm C appears to have the highest value of protein with 3.20% and a density of 28.56%. The aforesaid refers to the fact that the feed mixture used for dairy cows contain at least 18-22% protein, which is ideally balanced feed in order to obtain a daily production of over 30 liters. The use of alfalfa and straw enriches the animal feed with proteins and influences the milk quality.*

Keywords: *animal feed, fodder mixture, alfalfa hay, wheat straw, chemical compounds.*

1. Introduction

Nutrients are part of the digestible animal feed which are important for the animal organism. They serve to satisfy physiological needs, maintain basal metabolism and reproduction, as well as the productive needs during milk production. The animal feed aimed for the dairy cows is mostly of vegetable origin and partially of mineral origin in order to provide calcium and phosphorus, which are two basic mineral substances for normal health and high milk production. When feeding dairy cows, it is of a particular importance to provide sufficient quality feed with all the necessary nutrients, in proper quantity and ratio for their normal utilization. The diet of dairy cows is quite complex and specific. Quantity and quality of animal feed and water are by far the most important for the high production of milk, meat and eggs, but also for the health of farm animals [1].
Fodder crops are the basic food for feeding farm animals and mostly grown in livestock-developed countries, as they represent low-priced source of food and give large yields. Forage crops in our country are grown in small areas. Thus, in 2012 fodder crop covered 12% of the sown area in R. Macedonia. This represents a

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very low share in contrast to countries with developed animal husbandry, in which fodder crops cover 40% of the sown areas. Alfalfa has the largest share from fodder crops in our country with 55%, and the production is of a great importance because it is characterized by a high protein and according to some researches the presence of the other fodder crops is less represented [2].

The chemical composition and nutritional value of animal feed depend on many factors, however the most important ones are: the type of fodder crops, the conditions in which the fodder crops are grown (climate, soil, fertilize), the harvesting stages, the method of canning, the storage conditions, the method of use, etc. Differences in the chemical composition and general nutritional value of the forage crops used as feed for dairy cows should be known in order to be able to balance the nutrient and energy requirements for each category of livestock in order to meet the physiological needs [3, 4, 5]. In addition to the type and genetic predisposition of animals for higher milk production, suitable and balanced nutrition is crucial. The nutritional requirements of dairy cows are mainly met through the use of fodder crops in fresh or canned state rather than as waste from the food industry (beet chips, bran, beer dregs) and other agro-industrial products [6].

Alfalfa (*Medicago sativa L.)* is one of the most important fodder crops and is a valuable leguminous crop used to feed livestock in the dried state and in the form of hay. Blue alfalfa as a fodder crop mostly grown in areas where there are irrigation conditions is the most cultivated variety. Alfalfa as a forage crop in our country is used in the form of hay and slightly in its green state because it causes bloat in cows and due to this it is not recommended for a green diet [7]. Alfalfa as animal feed is used as fresh and canned. Fresh green alfalfa previously processed by mowing and drying is used as an animal feed for ruminants. Grazing Alfalfa is not practiced due to the cause of bloat in ruminants, and therefore if used fresh it has to undergo a process of drying for a day after mowing and further on to proceed to harvesting and given as feed. In our country preparing hay from alfalfa is not a common practice. It is mostly used as hay and grown on several continents and in more than 80 countries covering an area of over 35 million hectares [8].

Alfalfa is a rich source of protein, flavonoid antioxidants, mainly apigenin, tricyclic lutein and glycoside and phenolic compounds that have anti-inflammatory effects acting as an antioxidant and neuroprotector [9]. The root system of alfalfa is well developed and penetrates to a depth of more than 7m and it absorbs more minerals and vitamins than other plants, therefore it is called "the king of all forage crops". Alfalfa as a forage crop also characterized by having positive health effects. It is believed that Alfalfa has a direct effect on reducing blood cholesterol in cows and control of hormones [10]. The nutritional value of alfalfa is great and it represents the best quality coarse food, because it is rich in protein, crude protein content (18 - 22 %) and crude fiber (25 - 35 %). Alfalfa, in addition to raw proteins, crude fiber, minerals and vitamins, contains a large amount of saponins that are not desirable for daily intake in livestock nutrition. It is believed that feeding dairy cows with alfalfa could produce over 8 liters of milk per day [11].

Wheat straw (*Triticum vulgare*) which is used by some farmers as animal feed (as in the case of one farm in our research), provides physical satiety to cows, and the needs of easily digestible nutrients are provided through the use of alfalfa hay and

fodder mixtures. Wheat straw is quite rich in cellulose and hemicellulose, which is characterized by low digestibility, and the presence of a large amount of lignin contributes to this matter. Straw is a natural fiber that can survive for many thousands of years and remains of straw are found since the ancient Egyptians [12]. Straw indicates a large presence of many chemical elements (21), such as K, Ca, Mg, P, Zn, Fe, e.t.c., crude protein and non-nitrogen extractive substances (NES) [13]. Wheat straw contains several organic chemical compounds, such as carbohydrates (cellulose, hemicellulose, lignin), proteins, minerals (calcium and phosphorus), silica, detergent fibers, acidifiers and ash [14]. According to the analysis by Korr (2017) it is shown that straw contains a small amount of protein, nutrients, calcium and phosphorus from peas, while larger amount of potassium is contained in oat straw. He analyzed the chemical composition of several types of straw such straw from barley, wheat, peas, cinnamon and lentils, as well as different chemical composition of indigestible proteins, processed nutrients, calcium, phosphorus and potassium [15, 16].

Fodder mixtures (FM) or concentrates used to feed dairy cows, are composed of grain fodder crops (corn, barley, bran, sunflower and soybean meal), vitamin supplement (premix) and mineral substances. Depending on the type and category of farm animals, fodder mixtures - concentrates are characterized by a high content of light digestible proteins and carbohydrates, minerals, vitamins and have high energy value. By using the fodder mixtures, the daily meal of dairy cows is balanced with all the necessary nutrients. Macedonian name of the concentrate is KMK-18 as the concentrate contains 18% of crude protein.

The content of crude proteins in different fodder mixtures is varaible and depends on the type and category of animals which they are intended for. The feed mixtures produced in DOO "Agroinvest", 2017, which have their own catalog number are produced according to the Animal Feed Regulations of the Republic of Macedonia [17].

Fodder mixtures provide dairy cows with additional energy because the bulk food consumed by cows (alfalfa hay and wheat straw) cannot meet the nutrient and energy needs for high milk production. Fodder mixtures for dairy cows should be balanced carefully in terms of composition and content of nutrients that are essential for good health and high production of quality milk. Fodder mixtures for dairy cows should ensure high efficient digestion of food and utilization of nutrients by the organism for higher productivity.

The latest studies show that the higher milk production is a result of the large intake of easily digestible nutrients consumed through feed mixtures. The mobilization of the body energy is a result of the body fat and this efficient part (i.e. the usage of the energy) is not being increased during the lactation [18].

To obtain optimal milk production, rations should be balanced well in terms of the content of all nutrients. For economical and profitable milk production, the daily ration of dairy cows should be composed of high-quality coarse feed and feed mixtures for dairy cows, AHDB Dairy (2018) [19].

According to Rumsey (1980) forage for dairy cows should meet energy and protein requirements for maintenance, milk production, growth and reproduction [20].

Forages for dairy cows are mainly a source of easily digestible energy and protein, but they usually contain a large amount of minerals and other important nutrients that cannot be fulfilled through roughage - forage [21, 22].

Composition of the concentrates

Kavanagh (2016), examined the composition of the concentrates and their characteristics [23]. According to the chemical composition, feed mixtures for dairy cows contain water, crude proteins, different types of carbohydrates, crude fiber, fats, minerals and vitamins [7].

In the daily meal of dairy cows, it is necessary to add a certain amount of non-protein nitrogen, which serves as food for the microorganisms in the rumen of the cows [4].

When it comes to the nutrition of farm animals, the largest number of scientific papers on the topic refer to the qualitative and quantitative needs, and as a result, the successful application is seen in the production of milk, meat, etc. In order to get a clear picture of the nutrient needs of the animal organism, a good knowledge of the feed used in the diet of farm animals, its chemical composition and digestibility and utilization of nutrients is necessary.

Proteins as nutrients participate in the building of skeletal muscles, and as structural elements of tissues built from a large number of amino acids [24].

Milk is a colloidal solution of proteins, milk fat, milk sugar and mineral substances. In our country, the most cultivated breed is the black and white breed, which are represented in almost all small and large farms. The black and white breed of cows have successfully acclimatized in our country and bred in all regions of our country. It is characterized by good milk yield, but lately, to improve milk yield, it has crossed with Holstein - Friesian breed. The quality of milk from the black and white breed is standard and it is greatly influenced by the diet of the cows and the use of fodder crops. The quality of the milk also depends on the cow's lactation period. Cows that are at the beginning of lactation have milk with a lower fat content, and at the end of lactation the fat content increases. The use of coarse fodder for feeding cows increases fat content, while concentrated feed mixes reduce it. The type of forage has little effect on protein content and no influence on lactose content [25, 26].

Milk as a product of the mammary gland is characterized by a certain nutritional value, but it also contains a large amount of other biostimulating substances that make it an indispensable food for all age categories of people [27, 28].

Nutrition of dairy cows

According to numerous studies, the amount of milk per dairy cow is a breed characteristic that largely depends on the rearing conditions (accommodation, roughage quality and the quality of forage compounds for dairy cows). Under normal housing conditions and quality coarse feed, a large production of milk of excellent quality can be expected [29].

The chemical composition of milk varies greatly among different types of animals, according to numerous studies carried out by Feskanich et al., (2011), cow's milk contains an average of 3.4% protein, 3.6% milk fat and 4 .6% lactose, 0.7%, minerals (92) with an energy value of 66 kcal of energy in 100 grams [30].

Breed as genetic factors have their own positive influence on the content of milk fat in milk and as a result there are breeds of cows that give milk with higher fat content (Jersey and Holstein). The content of milk fat in cows that are at the beginning of lactation is lowest, and at the end of lactation it is the highest. During the summer, cows give milk with a lower content of milk fat as a consequence of the high temperatures, and during the winter with a higher content of milk fat [25].

However, different breeds of cows have different chemical composition of milk and differ in

the average values of the components. Cows of the black and white breed have

the lowest milk fat and protein content, while the Holstein-Friesian breeds have milk with the highest milk fat content [31]. With the latest research on the chemical composition of milk, especially on the amino acid composition of proteins, new amino acids and other biostimulating substances have been discovered, which are quite significant especially in terms of the quality of milk (although they are present in traces) [32].

2. Materials and methods

As a research material for this study, sampes for animal feed and samples of raw milk have been examined. The test material taken from three farms (A, B, C) randomly selected are from different regions of the R. Macedonia. The samples of animal feed included two types of concentrates (FM1, FM2), produced by DOO "Agroinvest" - fodder mixture for dairy cows with crude protein (KMK-18%), alfalfa hay and straw, [17]. Farm A used alfalfa, straw and both types of concentrate. Farm B used alfalfa, both the same types of concentrate, and farm C used only alfalfa and one type of concentrate. In order to get a complete picture of the state of transfer of nutrients from animal feed to milk, we also provide the following data on the feeding and milking of cows. The cows are of the Holstein-Frisein breed and are indigenous. Feeding was performed three times a day in the morning with concentrate, at lunch with alfalfa and straw, while in the evening with concentrate as well. Milking was done by machine. The main objective of this research is the analysis of animal feed and milk, in order to see the influence of the chemical composition of animal feed on the quality of milk. The moisture, proteins, crude fiber, ash and fat we examined in animal feed, and in fresh milk we examined the dry matter, protein, fat, lactose, milk density and relative volume mass/(g/cm^3) [5].

2.1 Methods for determining the chemical composition of animal feed

Determination of **Proteins** was perforemed by the Kjeldahl method and determination of total **Fats** by the Soxlet method, with diethyl ether extraction. Determination of total mineral substances (**Ash)** was done by the Gravimetric method. The principle of this method is based on burning the sample at a temperature of 600 ˚C and measuring the resulting residue. Determination of the amount of **Water** (moisture) was carried out by the Gravimetric method. The principle is based on drying the sample at a temperature of 105 ˚C to a stable weight. The determination of the amount of raw **Fiber** was based on treating 1 g of the sample with sulfuric acid and sodium hydroxide, and the rest separated by filtering and collecting from the cloth in a porcelain pot of known weight [7, 33, 35].

2.2 Methods for determining the chemical composition of milk

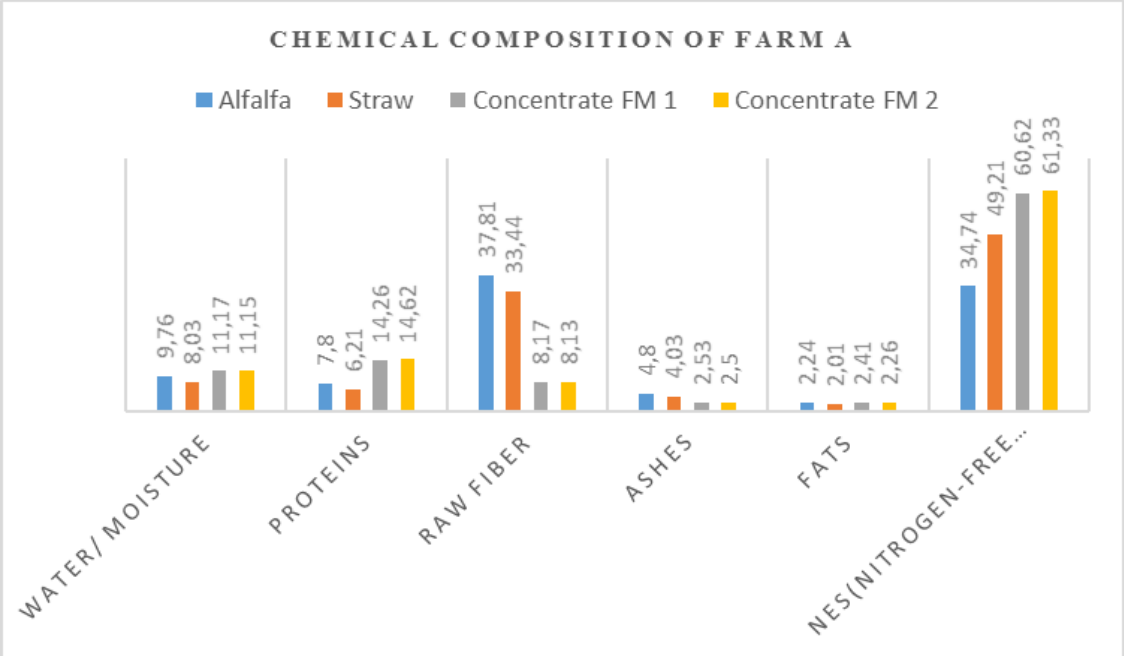
Gerber's method of **Fat** in milk was used for milk fat determination. This method was firstly proposed by Dr. Gerber in 1892 and later applied and renamed in Acidobutrymetric method because it uses sulfuric acid and works in butyrometers. Determination of nitrogen substances such as **Proteins**, and the total Nitrogen (N, Nitrogenium) were examined according the Kjeldahl method. Determination of milk sugar – **Lactose** was done by Iodometric method with reagents: Fehling's solution A - blue solution of copper (II) sulfate; Fehling's solution B – colorless aqueous solution of potassium sodium tartrate (known as Rochell's salt); strong alkali (usually NaOH); 0.5% starch solution dissolved in water; 2% alcoholic solution of phenolphthalein and n/10 solution of iodine. Determination of **Dry**

matter was done by drying milk at a temperature of 105^0C to constant weight. Determination of the **Density** of milk was performed with Lactoscan. The **Specific gravity** of milk varies and depends on the quantitative ratio of its components, such as mineral substances and lactose. If there is fat in the milk with the same ratio of other ingredients, it will show a lower specific gravity and vice versa. The content of all parameters is expressed in percentage [7, 33, 35].

3. Results and discussion

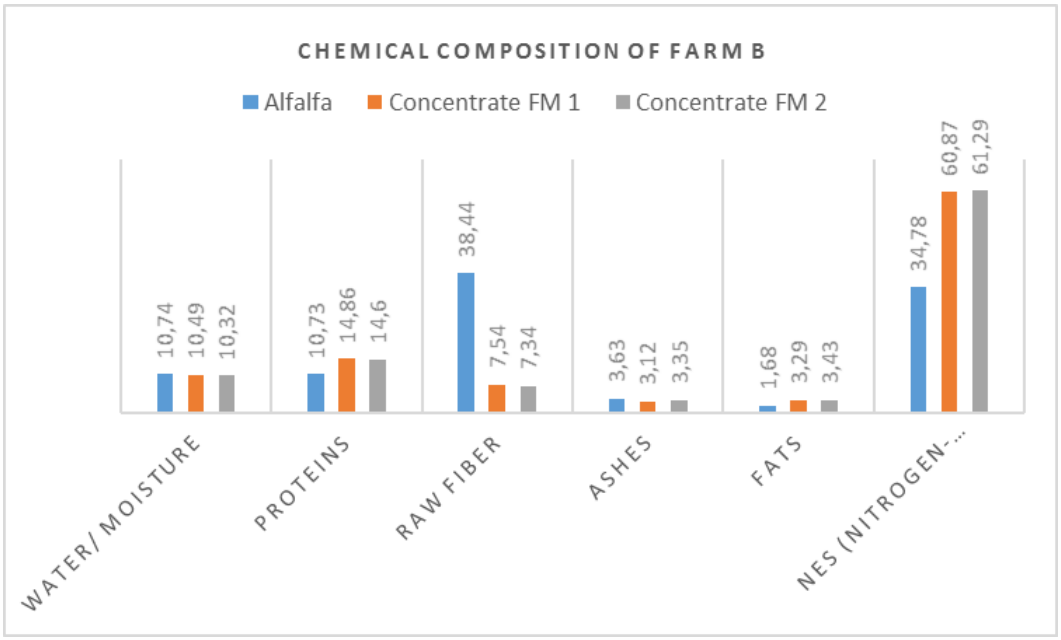
The results of analysis of chemical composition (moisture, protein, crude fiber, ash and fat) and their average value in the feed such as concentates (FM1, FM2), alfalfa hay and straw from farms A, B and C are shown in figures 1, 2, 3. From the figures we observed the total highest average values for all chemical compounds in alfalfa from farm A (65.91%), while for alfalfa from farm B and farm C they are equal to 65.22%. The lowest total value for the chemical composition was measured in the straw from farm A, 53.78%. For nitrogen-free extractives, we have the highest average values in concentrates FM1 from farm A (61.33 %) and FM2 from farm B (61.29 %).

Concentrates, alfalfa hay and wheat straw is a feed that has been applied in the winter period and is different from the feed that cattle consume when they are on pastures, fresh and green. This indicates that the chemical composition of animal feed in the winter period greatly affects the quality of milk in contrast to food in the summer period. The nutritional value of the types of food will depend on several factors, but the first of all on the content of nutrients, which, in turn, will depend on the utilization of the organism itself [3, 4].



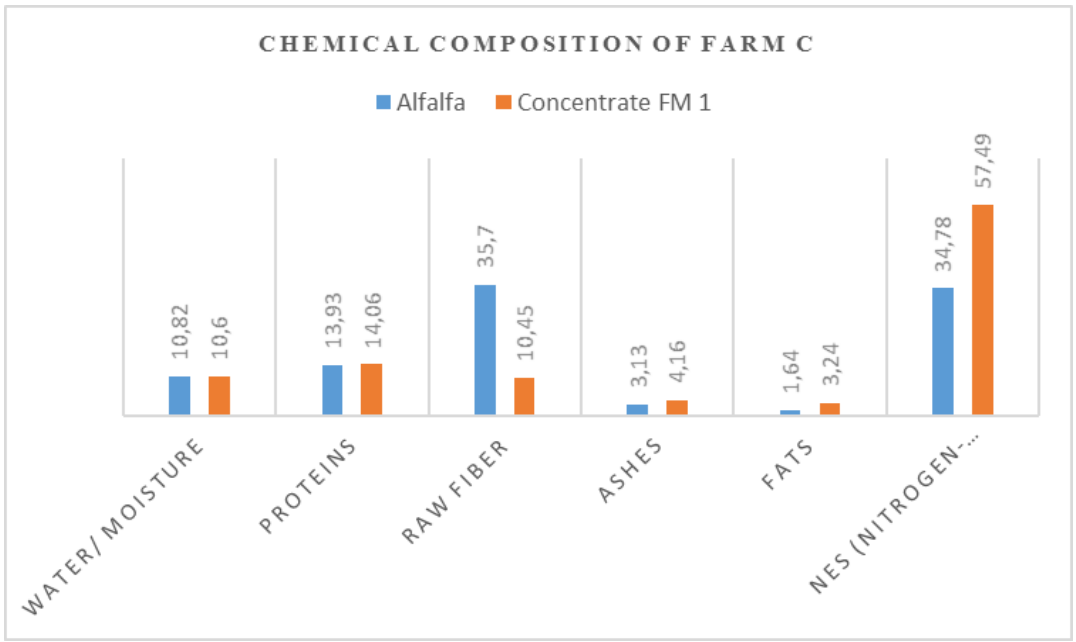
Chemical composition / % - farm A , NES = (nitrogen-free extractive substances)

Fig. 1 Chemical analysis in animal feed of farm A



Chemical composition / % of farm B, NES = (nitrogen-free extractive substances)

Fig. 2 Chemical analysis in animal feed of farm B

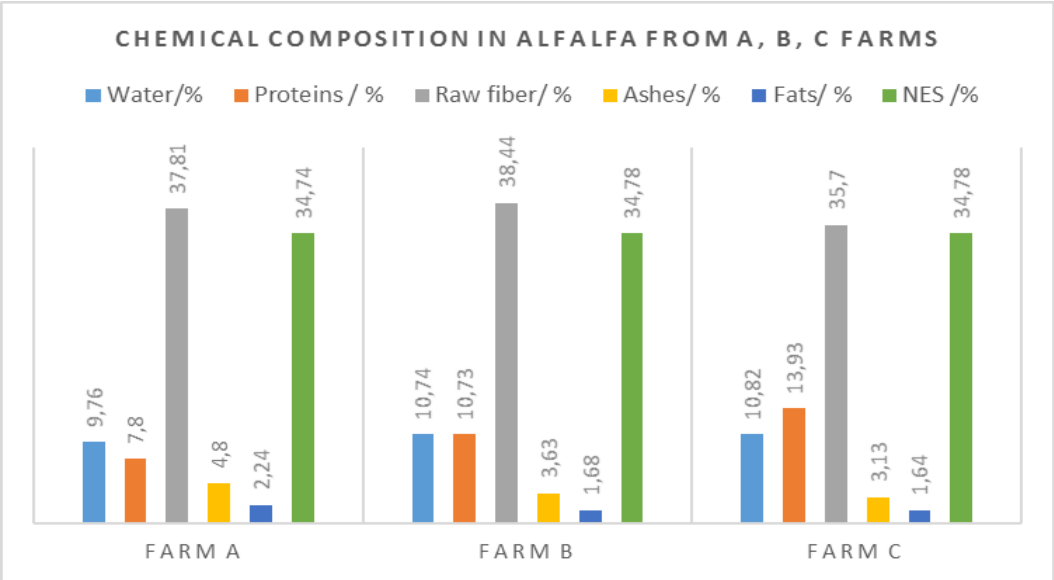


Chemical composition / % - farm C , NES = (nitrogen-free extractive substances)

Fig. 3 Chemical analysis in animal feed of farm C

The average values of chemical composition of alfalfa from the three farms are shown in figure 4. According to the given results it can be observed that the highest value for water (moisture) in alfalfa was measured from farm B (10.82 %), and the lowest from farm A (9.76 %). For protein, the highest value in alfalfa from farm B of (13.93 %), and the lowest from farm A (7.80 %), for crude fiber, the

highest value in alfalfa from farm B (38.44 %), the lowest from farm C (35.70 %). For ash, the highest value in alfalfa from farm A (4.80 %), and the lowest for alfalfa from farm B (13.3 %), and for fat, the highest value in alfalfa from farm A (2.24 %) and the lowest from farm C (1.64 %). All chemical composition has high value in alfalfa hay from farm B.



NES / (%) = 100 – water (%) – protein (%) – fiber (%) – ash (%) – fat (%)

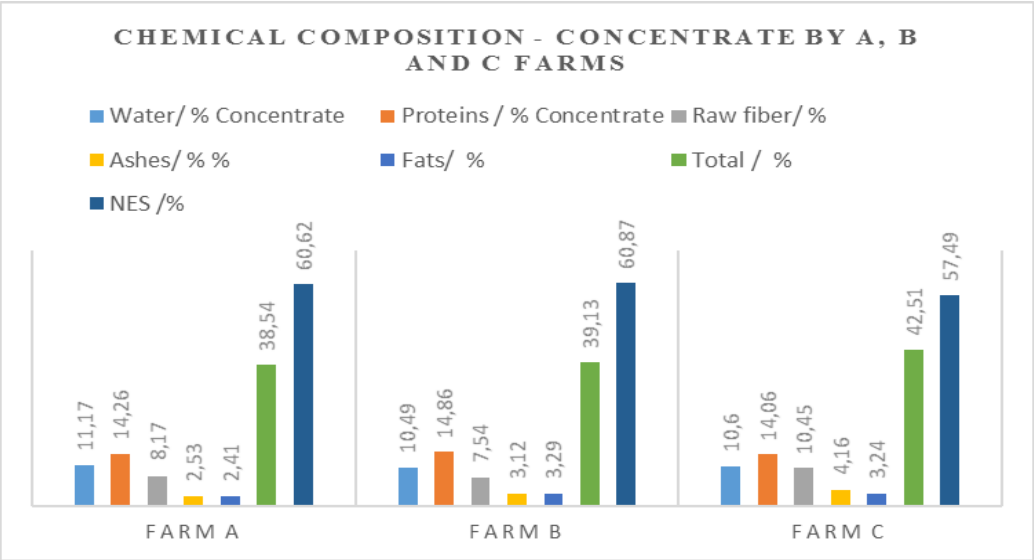
Fig. 4 Chemical composition of animal feed - alfalfa from the three farms

Calculated average values for chemical composition of concentrates (FM1, FM2) from the three farms are shown in figure 5. According to the results above it is seen that the highest value for water (moisture) was measured in FM1 (11.17%) and in FM2 (11.15%) from farm A, lower values in farm B, FM2 (10.32%) and FM1 (10.49%), while the lowest value is from farm C (10.60%) regarding the moisture. For proteins, the highest values were measured in FM1 from farm B (14.86%), then in farm A in FM2, 14.62% and 14.26% were measured in FM1, while lower values were measured in farm C (6.14%). For raw fiber, high values were measured in the concentrate from farm C (10.45%), then in farm A (8.17%), while a lower average value was measured for farm B in FM2 (7.35%) and in the FM1 (7.54 %). A high average value for ash was calculated in the concentrate from farm C (4.16 %), then in FM2 (3.43 %) and FM1 (3.29 %) from farm B, and the lowest values were calculated in FM1 (2.41 %) and FM2 (2.26 %) from farm A.

The content of fat in FM2 (3.43%), and in FM1 (3.29%) farm B, were measured as well. The lowest values in FM1, (2.41%) and in FM2 from farm A, (2 .26 %). 3.24% fat was measured in the concentrate from farm C. For the total value of all chemical compounds (water, protein, crude fiber, ash, fat) it can be said that the highest values were measured in the concentrate from farm C (42.51%), followed by farm B (39.13%), while the lowest total value was calculated in FM1 from farm A (38.54 %).

The highest percentage of moisture and protein was measured in alfalfa from farm C, the highest percentage of fiber was found in farm B, while the presence of ash and fat was the mostly concentrated in alfalfa from farm A. The values for the chemical composition of animal feed and the formation of the necessary compounds

for the growth and development of alfalfa depend on the composition of the soil, irrigation, climate and other factors [39].
Fodder research and extension policies in terms of better quality seeds, seed rate, improved agronomic practices and improved inputs (fertilizers, water and pesticides) [39].
Wheat straw (*Triticum vulgare*) was only detected in farm A. It is a secondary product and is rich in proteins and minerals, such as phosphorus, potassium, etc., [8].



NES / (%) = 100 – water (%) – protein (%) – fiber (%) – ash (%) – fat (%)

Fig. 5 Chemical composition of Concentrate - Feed mixture from three farms

In figure 6 presented results of analysis the chemical composition of the milk obtained from the three farms regarding the dry matter, fat, protein, milk lactose and milk density.
The results of the dry matter are similar in the milk from the three farms: in farm B is 8.22%, in farm C is 8.21%, while in farm A is 7.98%. The values for dry matter are lower, because the tests were done on skim milks and the value obtained from the dry matter tested on skim milks is added to the value of fat and their sum gives the total value of dry matter for raw milks. The concentration of milk fat is similar, in farm B the high values were measured (3.65 %), while in farm C (3.32 %), and in farm A, the values were lower (3.20 %). Approximate value was measured for protein in milk from the three regions. The highest values for lactose were measured in farm B (4.49%), and the lowest in the milk sample from farm A (4.38%). For milk density, it is also noted that the highest values were measured in farm C (28.56%), followed by the milk sample from farm B (28.49%), and the lowest in the milk sample from farm A (28.05%).
Regarding the chemical composition of animal feed, there are many different theses and recommendations due to the content of 18 to 22% crude protein and 25-35% crude fiber compared to maturity. Alfalfa also contains saponins, which are not desirable for daily feeding of livestock [11, 37].
According to research by Ishler et al., (2006), concentrates are mainly a source of energy and a source of proteins and they also contain minerals and other important nutrients that can't be fulfilled by feed from forage crops. Similar findings done

by Ishler et al. are also confirmed by the research in this paper [22, 38].
This means that the fodder mixture has 18% protein and is ideally balanced in order to obtain an optimal level of energy, for higher productivity in cows, with a daily milk production of over 30 liters. The chemical composition of this fodder mixture provides the necessary levels of nutrients and energy, thus enabling optimal production from the cow, while at the same time it were characterized by high quality of milk production in terms of fat and protein level [17, 34].
Results from figure 6 of the chemical composition of milk can be noted that the parameters dry matter (8.22 %), fat (3.65 %) and lactose (4.49 %) dominate in the milk sample from farm B, while in the milk sample from farm C is dominated by protein (3.10 %) and milk density (28.56 %). The lowest values for the chemical composition of milk were measured in milk the sample from farm A.

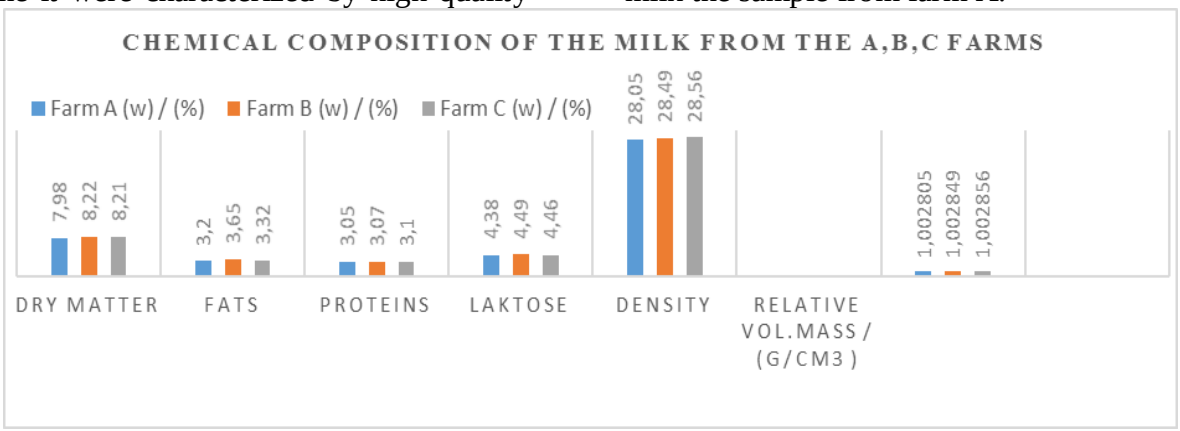


Fig. 6 Chemical composition of Milk from three farms

Our results compared with those already published by the research as of Feskanich et al., (2011), according to which cow's milk contains on average (3.4%) protein (3.6%), fat (4.6%), lactose (0.7%), mineral and supplies 66 kcal of energy per 100 grams, appear to be similar with only decimal minimum deviations observed [30].
Examinations of the chemical composition of milk correspond to the latest research from Cornell University (2018) in the paper "Composition of milk": where the raw cow's milk contains: water 87.3% (85.5-88.7%), fat 3.9 % (2.4 – 5.5 %), protein 3.25 % (2.3 – 4.4 %), casein 2.6 % (1.7 – 3.5 %), serum proteins, small proteins, carbohydrates 4.6% (3.8 – 5.3%) [32].
According to the results from the milk analysis, the content of dry matter, fat, protein and milk lactose, the chemical composition of the milk from the three farms appears to be quite similar, and the results from this study are consistent with the results of research by Douglas (2014). Dry matter (8.22 %), fat (3.65 %) and lactose (4.49 %) dominate in the milk sample from farm B, while the milk sample from farm C dominated in protein (3.10 %) and milk density (28.56 %). The lowest values are registered for the chemical composition of milk measured in milk of farm A [35, 37].

4. Conclusion

As from chemical analysis the animal feed which is characterized with high content of crude protein (18 - 22 %) and crude fiber (25 - 35 %) [11, 36, 37], the obtained results (7.8 - 14 %) and (35.5 - 38.5%) are respectively low due to the additional usage of feed mixture produced by a domestic company according to the feed Regulation of R. Macedonia.

The use of daily meal in the three farms was different, farm A used 20 kg per day, farm B 28 kg, and farm C 31 kg per day. The best chemical composition is the feed from farm B. The lowest values for the chemical composition of milk were measured in the milk sample from farm A, although used in the largest amount of meal. The food for dairy cows should be of known quality, with a known chemical composition and the daily ration should provide all the necessary nutrients for good health and high milk production.

From the chemical analysis of the milk, it is well established that the diet with fodder crops has a great influence on the milk quality. The use of different types of fodder increases fat content. Feed mixtures reduce it and have limited effect on protein content and have no effect on lactose content. The milk that contains the least fat (3.65%) is from farm A, while the least of the protein (3.10%) is registered in the milk sample from farm C. Our research correspondts with numerous studies on the topic due to the fact that the amount of milk per dairy cow is a characteristic of the breed that largely depends on the rearing conditions (accommodation, quality of roughage and quality of forage compounds for dairy cows).

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