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Feed Value of Emmer Wheat *(Triticum dicoccum)* and By-products for Ruminant Animals

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ABSTRACT

Ancient wheat species attracts more attention recently due to their health benefits and suitability for organic farming. With this attention, the possibilities of using ancient wheat species and especially their by-products in animal nutrition are emerging. Unlike modern wheat varieties, emmer is known as one of the ancient wheat varieties, has hull covering its grains. Approximately 70% of the total plant weight consists of hulls and stalks. Looking at the literature, limited studies has been conducted regarding the evaluation of the hull and stalk parts of emmer wheat as feed. Herein, this study aims to determine the nutritional values of emmer wheat and its by-products. The feed value of the plant was analyzed in five parts (hulled grain, stalk of plant, hull, naked grain and flour). For each part, dry matter (DM), crude protein (CP), ether exract (EE), crude ash (CA), starch, crude fiber (CF), acid detergent fiber (ADF), neutral detergent fiber (NDF), acid detergent insoluble crude protein (ADICP), neutral detergent insoluble crude protein (NDICP), lignin and mineral analyzes were made. In addition, non-fiber carbohydrate (NFC), digestible dry matter (DDM), dry matter intake by animal body weight (DMI_{BW}), total digestible nutriton (TDN_{1X}), net energy lactation (NE_{L3X}), metabolic energy (ME), net energy maintanence (NE_M), net energy gain (NE_G), energy and digestibility calculations were performed. The protein content of emmer grain was observed higher than that of modern wheat. ADF and NDF values of the emmer wheat stalks are lower than modern wheat stalks and therefore have better digestibility values. Additionally, the higher resistance to starch digestion compared to modern wheat varieties may be a reason for preference in ruminant feeding.

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Gernik (Gacer, Kavılca) Buğdayı (*Triticum dicoccum*) ve Yan Ürünlerinin Ruminant Hayvanlar İçin Yem Değeri

ÖZET

Ata buğday türleri, sağlığa faydaları ve organik tarıma uygunlukları nedeniyle son zamanlarda daha fazla ilgi çekmektedir. Bu ilgi ile birlikte ata buğday türlerinin ve özellikle yan ürünlerinin hayvan beslemede kullanım olanakları ortaya çıkmaktadır. Ata buğday çeşitlerinden biri olarak bilinen gernik (gacer, kavılca), tanelerini kaplayan bir kavuza sahiptir. Toplam bitki ağırlığının yaklaşık %70'i kavuz ve saplardan oluşur. Literatür bilgiler incelendiğinde gerniğin kavuz ve sap kısımlarının yem olarak değerlendirilmesine yönelik sınırlı sayıda çalışma yapıldığı görülmektedir. Bu çalışmada ise gernik ve yan ürünlerinin besin değerlerinin belirlenmesi amaçlanmıştır. Bitkinin yem değeri beş kısımda (kavuzlu dane, bitki sapı, kavuz, kavuzsuz dane ve un) analiz edilmiştir. Her kısım için, kuru madde (KM), ham protein (HP), ham yağ (HY), ham kül (HK), nişasta, ham selüloz (HS), asit deterjan fiber (ADF), nötral deterjan fiber (NDF), asit deterjanda çözünmeyen ham protein (ADICP), nötral deterjanda çözünmeyen ham protein (NDICP), lignin ve mineral analizleri yapılmıştır. Bunlara ilave olarak, fiber olmayan karbonhidrat (NFC), sindirilebilir kuru madde (DDM), hayvan vücut ağırlığına göre kuru madde tüketimi ($DMI_{vücut}$

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ağırlığı), toplam sindirilebilir besin (TDN_{1X}), net enerji laktasyon (NE_{L3X}), metabolik enerji (ME), net enerji yaşama (NE_M), net enerji verim (NE_G) gibi enerji ve sindirilebilirlik hesaplamaları yapılmıştır. Emmer buğday danesinin protein içeriğinin modern buğday çeşitlerine göre daha yüksek olduğu gözlemlenmiştir. Emmer buğdayı sap kısımlarının ADF ve NDF değerleri modern buğday saplarına göre daha düşük belirlenmiştir ve bu nedenle daha iyi sindirilebilirlik değerlerine sahiptir. Ayrıca modern buğday çeşitlerine göre nişasta sindirim direncinin daha yüksek olması ruminant beslemede tercih sebebi olabilir.

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INTRODUCTION

In recent years, it is seen that interest in ancient wheats has increased due to the orientation to healthy and sustainable food resources and genetic erosion of modern species. Einkorn (*T. monococcum*), emmer (*T. dicoccum*) and spelt (*T. Spelta*) are the oldest wheat types and are known as the ancestors of modern wheats. The need for diversification of products, increasing demand for healthy foods, therapeutic properties of foods, increasing obesity and metabolic disorders have increased the interest in the ancient wheat species (Arzani & Ashraf, 2017). Studies have shown that hulled wheats may offer healthier and better nutritional value than modern wheats (Kulathunga et al., 2020). Ancient wheat varieties are sustainable and suitable for organic agriculture (Bencze et al., 2020), and considering that it is advantageous in terms of healthy nutrition, ancient wheat varieties have gained importance. (Longin & Würschum, 2016). Many studies have been conducted on the use of ancient wheat species for food purposes and their benefits to human health, and they are still being grown in different regions of the world. However, the high productivity and other quality related properties of modern wheat varieties resulted in replacement of the ancient wheat varieties.

Emmer (*T. dicoccum*), one of the ancient wheat species, is a hulled wheat. It is called as "gernik, gacer, kavılca" in different regions among the people in Turkey (Bulut, 2022; Atak, 2017). Emmer wheat has durable hull, brittle and thin stalks. After harvest, the hull on the grain should be separated by mechanical operation. By-products such as straw and hull obtained after harvest are used as animal feed. Due to its high adaptability, emmer can be grown in areas such as Kastamonu and Sinop at an altitude of 1000-2000 meters above sea level (Köksel & Çetiner, 2015). It is also grown in rural areas of Çankırı, Kars, Kayseri and used in both human and animal feeding (Gurcan et al., 2017). It is stated in some sources that emmer wheat constitutes 1% of the total wheat production area in the world (Bilalis et al., 2017).

Emmer has gained popularity in recent years in terms of being a healthy food and traditional food products prepared with emmer are preferred in many parts of the world. Although the nutritional content of emmer wheat differs depend upon various environments, it has a rich bioactive and slower digestible starch content. (Dhanavath & Prasada Rao, 2017; Lachman et al., 2012). Emmer wheat is rich in protein (18-23%) minerals and fiber. Studies have shown that as a healthy grain, it is suitable for the diets of people with diseases such as high blood cholesterol, colitis and allergies (Marino et al., 2011). Emmer is resistance to plant diseases, pests, biotic and abiotic stress, and also has high protein quality and rich micronutrient (Zn, Mn, Fe, etc.) concentration of its seed (Zaharieva et al., 2010).

In a study on the use of emmer and spelt wheat as forage, emmer could be recommended for hay production harvested at booting stage given its valuable nutritional characteristics, whereas spelt appears to be more adaptable for silage production when harvested at the early dough stage (Cazzato et al., 2013). In an another research paper, hulled wheat has been evaluated as a new animal feed source with its features such as high organic matter digestion, CP and EE content and low ADF, NDF, methane production (Kaplan et al., 2014).

With the increase in the production amounts of ancient wheats over time, the use of these wheats and their by-products in animal nutrition may become widespread. For emmer wheat, grain constitutes approximately 30% of the total plant weight (Kaplan et al., 2014). The remaining 70% (hull, stalk) is used for animal feeding. Current study, the chemical components, energy and digestibility values of emmer wheat and its by-products in terms of feed value for ruminant animals were determined.

MATERIAL and METHODS

Material

Emmer wheat evaluated in the study was obtained from Develi district of Kayseri and it is called "gacer" by the local people in this the region. Samples were collected during two harvest years (2019 and 2020). For the emmer plant reviewed in five parts (A-straw of emmer, B-hull of emmer, C-hulled emmer, D-naked emmer, E-flour of emmer), 5 replication analyzes were made for each sample group and each year. Samples were taken from the same field. The production process of the harvested emmer plant is schematized (Figure 1). Chemical analyzes were carried out in the feed analysis laboratory in Kayseri Yem Sanayi A.Ş. Mineral analyzes were performed at Erciyes University, Faculty of Agriculture. Pictures of the parts of the emmer plant whose nutritional values were determined are given in Figure 2.

Chemical Analyses

Dry matter (DM), crude protein (CP), ether exract (EE), crude ash (CA), crude fiber (CF), acid detergent fiber (ADF), neutral detergent fiber (NDF), acid detergent lignin (ADL), acid detergent insoluble protein (ADICP), neutral detergent insoluble protein (NDICP) and starch were analyzed. DM values were determined in an oven (~ 48 hours, 60 °C ±1) and approximately 300 g of sample was used for analysis. The dried samples were milled in a 1 mm particle size in a laboratory mill (IKA MF.10) and transferred to locked plastic bags and stored for analysis. Abbreviations of the terms above-mentioned parameters are also used in Table 1.

CP was determined by the DUMAS method (AOAC, 2006). This method, burning the sample in the furnace in the device (VELP NDA 701), reducing all nitrogen forms in it to elemental nitrogen by converting them to nitrogen oxide gases, and determining the amount of nitrogen by thermal conductivity method, multiplying this amount by the protein factor and determining the crude protein value. Crude fat analysis was performed by extraction method (ANKOM XT15) and petroleum ether was used as solvent (AOCS, 2004). Crude ash analysis was performed by burning the samples in a 550 °C ash furnace (CARBOLITE ELF 11/6) (AOAC, 2005). Crude fiber analysis was carried out based on the detection of the burning part by boiling the defatted samples first in sulfuric acid then sodium hydroxide solution and then burning the remaining mass (ISO 6865, 2000). ADF analysis was performed by boiling the sample in acid detergent solution and NDF analysis in neutral detergent solution by determining the amount of remaining mass. Acid detergent lignin analysis was carried out by determining the amount of the remaining samples after ADF analysis treated with concentrated (72%) sulfuric acid for a certain period of time (3 hours) (AOAC, 2002, 1997). ANKOM^{2000} analyzer was used for CF - ADF - NDF and ADL analyzes. For ADICP and NDICP, CP analysis was performed on the basis of the method given above from the residues resulting from ADF and NDF analysis. Starch analysis was determined by polarimetric method (ISO 10520, 1997).

For mineral content (calcium, potassium, magnesium, phosphorus, sulfur, boron, cadmium, copper, iron, manganese, nickel, lead, zinc), 0.5 g of samples were taken into vessel tubes, 10 ml HNO_3 and 2 ml HCl were added and 200 °C was subjected to 15 minute microwave (ANTON PAAR) thawing at 1600 W. After the process, it was cooled to room temperature and the 0.2 µm syringe tip was filtered, and then the mineral amounts were determined in the ICP-OS (AGILENT 5800) device (AOAC, 2009).

Calculated Parameters

Chemical analysis results were placed in the equations specified in Nutrient Requirements of Dairy Cattle (NRC, 2001), digestibility and energy parameters were calculated. These parameters are non-fiber carbohydrate (NFC), hemicellulose, digestible dry matter (DDM), dry matter intake (DMI_{BW} %, body weight of animal), relative feed value (RFV), total digestible nutrients (TDN_{1X}), metabolic energy (ME), net energy maintanance (NE_M), net energy gain (NE_G), net energy lactation (NE_{L3X}) values. The term abbreviations expressed in this section are also used in the Table 1.

Statistical Analysis

Statistical analyses were performed with Minitab 16.1 software using a completely random one-way analysis of variance (ANOVA) procedure. All data are expressed as mean and standard deviation (mean ±stdsap).

RESULTS and DISCUSSION

Emmer plant are divided into 5 parts within the scope of the study. These parts are expressed as A-straw of emmer wheat, B-hull of emmer wheat, C-hulled emmer wheat, D-naked emmer wheat, E-flour of emmer wheat. The chemical contents of these parts regarding nutrients, minerals, digestibility and energy are given Table 1. The contents of the samples with the same name varied according to the years. It has been evaluated that the results are not similar between years, and may be caused by factors such as climate and fertilization.

Straw of emmer wheat is shown Figure 1-A and analysis results are shown in Table 1. According to the results obtained, nutritional values were different on a yearly basis. Looking at the averages of both years, CP, ADF and NDF were determined as 32.7, 424.4 and 690.4 g kg^{-1}. ME and NE_{L3X} were calculated as 1.79 and 0.94 mkal kg^{-1}, respectively. The average of potassium was found to be 11.7 g kg^{-1}, higher than the other macro mineral values. In terms of trace minerals, copper, iron and zinc were higher than other trace mineral results as 60.5, 53.0, 45.5 ppm, respectively. Similar results have not been reported in previous research studies. In one study, the ash value of emmer straw was determined as 37.6 g kg^{-1} (Wiwart et al., 2017). In the present study, the crude ash value was determined as 92.0 g kg^{-1}. For straw of modern wheat, CP, ADF, NDF, ME, potassium, copper, iron and zinc values are given as 42.0, 500.0, 775.0 g kg^{-1}, 1.63 mkal kg^{-1}, 11.2 g kg^{-1}, 4.0, 184.0 and 17.0 mg kg^{-1} in an online reference respectively (Feedipedia Animal feed resources information system, 2021). When compared to the straw of modern wheat varieties, emmer wheat straw has lower ADF and NDF values, so it was evaluated that it would be better digested by ruminants. However, more studies are needed on this subject.

Unlike modern wheats, emmer wheat remains hulled after harvest and than hulls are separated from the grain by mechanical treatment . The pictures of these hulls are shown in Figure 2-B and the analysis results are shown in Table 1. In practice, livestock farmers use these hulls in animal feeding, but they do not know their nutritional value. The nutritional value of hulls varied significantly depend on the year of harvest.

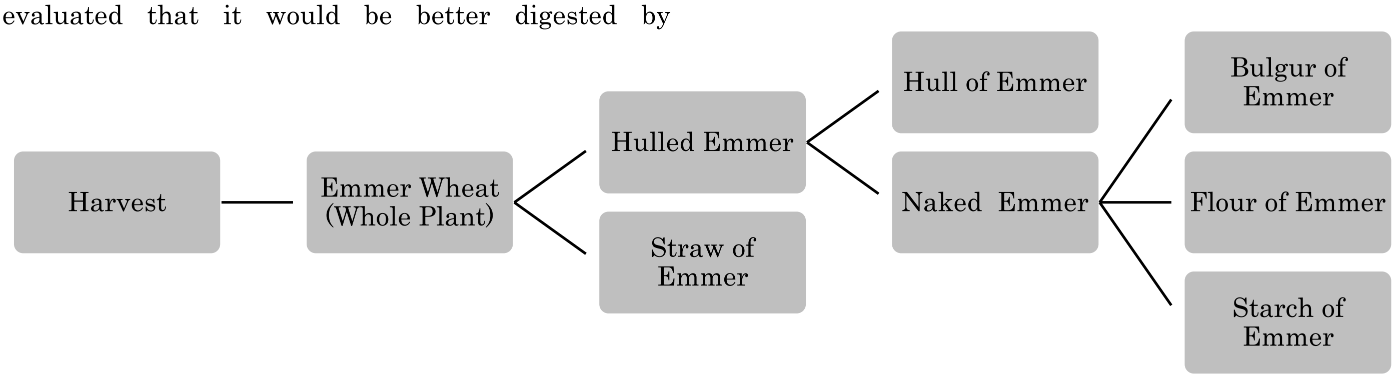

Figure 1. Harvest and process stage process of emmer wheat
Şekil 1. Gernik buğdayının hasat ve işleme süreci

Figure 2. Images of emmer wheat and by-products. A- Straw, B- Hull, C- Hulled emmer, D- Naked emmer, E- Flour of emmer, F- Emmer spike
Şekil 2. Gernik buğdayı ve yan ürünlerinin resimleri. A-Sap, B-Kavuz, C-Kavuzlu gernik, D-Kavuzsuz gernik, E-Gernik unu, F-Gernik başağı

Table 1. Emmer wheat and by-products nutritional value*
*Çizelge 1. Gernik buğdayı ve yan ürünlerinin besinsel değerleri**

	A - Straw	B – Hull	C – Hulled Emmer	D – Naked Emmer	E – Flour of Emmer
Chemical analyzes					
Dry Matter (g kg^{-1})	937.4 ±15.38	947.6 ±5.11	917.7 ±4.36	908.0 ±2.70	910.6 ±5.61
Crude Protein (g kg^{-1})	32.7 ±17.85	40.1 ±14.98	122.8 ±14.80	159.6 ±7.22	159.3 ±1.28
Ether Exract (g kg^{-1})	17.2 ±3.67	17.0 ±1.56	16.0 ±6.92	13.8 ±5.78	20.0 ±4.67
Crude Ash (g kg^{-1})	92.0 ±28.59	123.2 ±19.12	39.3 ±1.07	17.9 ±2.52	19.9 ±1.10
Starch (g kg^{-1})	3.5 ±1.54	53.3 ±41.60	511.2 ±11.52	666.1 ±10.76	663.6 ±9.69
ADF (g kg^{-1})	424.4 ±37.90	434.8 ±18.19	116.5 ±3.76	25.9 ±1.56	19.7 ±3.76
NDF (g kg-1)	690.4 ±79.11	707.5 ±58.88	218.9 ±2.87	62.5 ±4.92	56.5 ±2.20
ADICP (g kg-1)	4.6 ±2.66	4.8 ±1.74	7.9 ±1.11	8.3 ±1.97	8.9 ±1.47
NDICP (g kg-1)	11.0 ±1.96	12.7 ±3.51	15.9 ±3.35	17.9 ±1.69	18.0 ±1.47
Crude Fiber (g kg-1)	363.4 ±52.88	326.4 ±12.36	94.4 ±3.54	21.3 ±6.77	16.4 ±2.45
Lignin (g kg-1)	61.4 ±5.83	80.9 ±4.02	17.1 ±2.93	5.8 ±1.07	4.8 ±1.09
Mineral values					
Calcium (g kg^{-1})	2.6 ±0.10	2.5 ±1.08	1.4 ±0.04	1.51 ±0.04	1.5 ±0.76
Potassium (g kg^{-1})	11.7 ±0.13	7.3 ±0.34	5.3 ±0.74	5.65 ±1.94	4.8 ±0.54
Magnesium (g kg^{-1})	0.9 ±0.21	0.9 ±0.09	1.0 ±0.16	1.36 ±0.46	1.1 ±0.24
Phosphorus (g kg^{-1})	0.4 ±0.20	0.5 ±0.11	1.1 ±0.11	1.89 ±0.81	1.7 ±0.33
Sulfur (g kg^{-1})	1.0 ±0.25	0.8 ±0.08	1.0 ±0.11	1.22 ±0.13	1.0 ±0.22
Boron (mg kg^{-1})	6.5 ±1.72	5.0 ±2.21	6.5 ±6.92	12.5 ±5.89	3.5 ±3.72
Cadmium (mg kg^{-1})	0.0 ±0.00	0.0 ±0.00	0.0 ±0.00	0.0 ±0.00	0.0 ±0.00
Chromium (mg kg^{-1})	1.5 ±0.71	2.0 ±0.47	0.5 ±0.71	0.5 ±0.71	0.0 ±0.00
Copper (mg kg^{-1})	4.5 ±0.85	4.0 ±0.67	6.0 ±1.25	7.5 ±1.90	6.5 ±1.72
Iron (mg kg^{-1})	60.5 ±15.62	115.0 ±67.58	46.5 ±20.76	56.0 ±7.04	55.5 ±23.07
Manganese (mg kg^{-1})	53.0 ±24.49	45.5 ±7.69	33.0 ±5.01	37.5 ±14.55	32.0 ±6.24
Nickel (mg kg^{-1})	1.5 ±0.53	2.0 ±0.67	2.0 ±0.67	1.5 ±0.85	1.5 ±0.85
Lead (mg kg^{-1})	1.0 ±0.00	0.5 ±0.53	0.0 ±0.00	2.5 ±1.65	2.0 ±2.16
Zinc (mg kg^{-1})	45.5 ±3.54	62.0 ±7.76	78.0 ±4.16	109.0 ±17.68	103.0 ±58.20
Calculated parameters					
NFC (g kg-1)	167.8 ±36.37	112.3 ±61.93	603.2 ±9.74	746.3 ±15.38	744.4 ±3.84
Hemicellulose (g kg^{-1})	266.0 ±42.07	272.7 ±41.20	102.4 ±5.57	36.7 ±5.39	36.8 ±5.37
DDM (g kg^{-1})	558.4 ±29.52	550.3 ±14.17	798.2 ±2.93	868.9 ±1.22	873.7 ±2.93
DMI_{BW} %	1.76 ±0.20	1.71 ±0.14	5.5 ±0.07	19.31 ±1.55	21.27 ±0.81
RFV (score)	76.5 ±12.72	72.9 ±7.88	339.3 ±4.10	1300.6 ±104	1440.2 ±52
TDN_{1X} (g kg^{-1})	520.0 ±20.86	453.7 ±42.53	783.5 ±11.75	867.3 ±6.58	874.3 ±7.57
ME (Mkal kg^{-1})	1.79 ±0.07	1.52 ±0.20	3.04 ±0.03	3.44 ±0.04	3.47 ±0.03
NE_{L3X} (Mkal kg^{-1})	0.94 ±0.04	0.77 ±0.13	1.75 ±0.02	2.01 ±0.02	2.03 ±0.02
NE_{M} (Mkal kg^{-1})	0.95 ±0.07	0.67 ±0.20	2.06 ±0.02	2.39 ±0.03	2.41 ±0.02
NE_{G} (Mkal kg^{-1})	0.40 ±0.06	0.14 ±0.19	1.40 ±0.02	1.67 ±0.02	1.69 ±0.02

*Results are given on dry matter basis, for each group n=10

When the average of both years is evaluated, CP, ADF, NDF, ME, NE_{L3X} values were determined as 40.1, 434.8, 707.5 g kg^{-1}, 1.52, 0.77 mkal kg^{-1}, respectively. It has been observed that the levels of iron, manganese and zinc (115.0, 45.5 and 62.0 mg kg^{-1}) in terms of mineral are higher than the other minerals. No information has been found in the literature regarding the nutritional values of emmer wheat hulls. As a result, hulls can be used as forage feed.

Hulled emmer wheat appears as a different product when evaluated in terms of animal nutrition. The combination of both structural and non-structural carbohydrates for hulled emmer wheat may be of interest to animal nutritionists. Hulled emmer wheat is shown in Figure 2-C and its nutritional values are given in Table 1. CP, starch, ADF, NDF, TDN_{1X}, ME, NE_{L3X} were determined as 122.8, 511.2, 116.5, 218.9 and 783.5 g kg^{-1}, 3.04 and 1.75 mkal kg^{-1}, respectively. In terms of mineral matter, the levels of iron, manganese and zinc (46.5, 33.0 and 78.0 mg kg^{-1}) were higher than the other trace mineral values. In a study for hulled emmer wheat, CP, NDF, EE, CA were found as 104.4, 273.2, 18.1 and 4.64 g kg^{-1} in the given order (Zaharieva et al., 2010). Although the hulled emmer is similar in terms of protein content compared to modern wheat but it has less starch content and higher fiber content. In terms of nutritional value of hulled emmer wheat is more similar to barley and it can be used as a combined feed as a source of both fiber and starch. It this sense, further studies should be done on hulled emmer wheat.

Hulless emmer wheat is referred to as naked emmer wheat and is the final product for food. Naked emmer wheat is shown in Figure 2-D and nutritional results are given in Table 1. Analysis results differed according the years. CP, starch, ADF, NDF, TDN_{1X}, ME, NE_{L3X} levels were determined as 159.6, 666.1, 25.9, 62.5 and 867.3 g kg^{-1}, 3.44 and 2.01 mkal kg^{-1}, respectively. In terms of mineral levels, iron, manganese and zinc (56.0, 37.5 and 109.0 mg kg^{-1}) were found higher than other trace mineral values. Calcium, potassium, magnesium and phosphorus values were determined as 1.51, 5.65, 1.36 and 1.89 g kg^{-1}, respectively. In open feed library sources (Dairy One, 2021), the average CP, starch, ADF, NDF, TDN_{1X} values of modern wheat varieties are reported as 135.3, 617.4, 46.5, 129.9 and 838.8 g kg-1, ME and NE_{L3X} values are 3.28 and 1.91 mkal kg^{-1}, respectively. In the same the reference, calcium, potassium, magnesium, phosphorus, sulfur values are expressed as 0.91, 4.44, 1.32, 3.69, 1.48 g kg^{-1}, respectively. In terms of trace mineral, copper, iron, manganese, nickel and zinc were reported as 4.99, 87.58, 41.51 and 30.99 mg kg^{-1}, respectively. In an another reference (Feedipedia, 2021), modern wheat varieties' CP, EE, CA, starch ADF, NDF, CF, lignin are reported 126.0, 17.0, 18.0, 691.0, 36.0, 139.0, 26.0 and 11.0 g kg^{-1} respectively. ME value is 3.13 Mkal kg^{-1}. Calcium, potassium, magnesium, phosphorus 0.7, 4.6, 1.2, 3.6 g kg^{-1} and copper, iron, manganese, zinc are reported as 6.0, 78.0, 40.0 and 31.0 mg kg^{-1}, respectively. When compared with modern wheat grain, protein value of naked emmer wheat was higher, ADF and NDF values were lower, starch value was similar, and ME value was higher. Compared to modern wheat varieties, the mineral content of naked emmer wheat in general is higher, and this is more evident especially in terms of calcium and zinc. In some studies, it has been stated that emmer wheat has high nutritional value (Dhanavath & Prasada Rao, 2017). It has been determined that emmer wheats contain more selenium, iron and zinc compared to other types (Suchowilska et al., 2012). The high value of zinc was similar to the current study.

In one study (Dhanavath & Prasada Rao, 2017), it was determined that the starch of emmer wheat changed between 485.0 and 653.0 g kg^{-1}. In the present study the starch was found to be slightly higher (666.1 g kg^{-1}) than the above mentioned study. In an another study, the starch of emmer wheat was found to be 659.0 g kg^{-1} and it was stated that this value was higher than other ancient wheats (einkorn, spelt) and modern wheats (Kulathunga et al., 2021). These results are similar with our study. In a study examining starch structure in terms of amylose and amylopectin (Dhanavath & Prasada Rao, 2017), amylose content varies between 19.4% and 26.3%. This content is important in terms of starch digestion and the high rate of amylopectin increases the digestive resistance of starch (Singh et al., 2010; Suchowilska et al., 2012). Starch digestion of emmer wheat in *in vitro* studies has been reported to be 40.39 - 47.07 mg glucose/100 g. This results are lower than other cereals (Bhuvaneswari et al., 2004). The slow rate of starch breakdown can be considered as an advantage for ruminants.

In an article in which different studies are compiled, it was stated that the protein ratio in emmer wheat changed between 112.0 and 227.0 g kg^{-1} (Dhanavath & Prasada Rao, 2017). In another study emmer wheat protein was found as 182.0 and 184.0 g kg^{-1} (Gurcan et al., 2017). The study of Biel et al., (2021) CP, EE, CA, CF value of emmer wheat were determined as 154.0, 21.7, 21.6, 50.3 g kg^{-1} respectively. In a paper on the comparison of ancient and modern wheat CP, CA and EE values of emmer wheat were found to be 145.0 - 22.0 - 21.0 g kg^{-1} respectively (Kulathunga et al., 2021). In our study, CP (159.6 g kg^{-1}) is similar with the results of other studies and EE, CA, CF values were determined as 13.8, 17.9, 21.3 g kg^{-1} respectively.

Within the scope of the study, the analyses of emmer wheat flour were also made. In the process of making flour from naked emmer wheat, bran and similar by-products are not separated. When flour is made from modern wheat, by-products such as bran and bonkalit are obtained, whereas in the production of flour from naked emmer wheat, no by-products are formed. In brief, emmer wheat flour is the milled form of naked emmer grains. For this reason, the flour analyzes are similar to the naked emmer wheat analysis results. Analysis results of emmer wheat flour Table 1, its picture is shown in Figure 2-E.

It has been seen in most studies that there is no clear explanation about whether emmer wheat is evaluated as hulled or unhulled. In our present study, the nutritional values of emmer wheat with and without hull were tried to be expressed clearly.

CONCLUSION

The nutritional values of emmer wheat and its by-products vary depending on different factors as in other feeds. The hull of emmer wheat is a different product for feeding animals. Emmer's stalk is thinner and brittle, and its ADF and NDF values are lower than other feeds in the similar category, which can be a positive point in terms of forage quality. The protein content of emmer wheat has been found to be higher than modern wheat. It is thought that further studies should be performed especially on the resistant starch content and this is an advantageous situation in ruminant feeding. Hulled emmer wheat, the combination of both structural and non-structural carbohydrate content in ruminant feeding (both forage and concentrate) may be of interest to animal nutritionists. Nutrient changes in feeds within their own species are an expected situation. In this study, according to the years variability was observed in the nutritional content of the same type of feed. This change may have been caused by factors such as soil and climatic conditions, fertilization, planting and harvesting time. It is considered that more studies should be done *in vivo* and *in vitro* on emmer wheat as feed. With the increasing interest in ancient wheat species in future, amount of production will increase and the use of these wheats and especially by-products as animal nutrition will become widespread.

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Statement Contribution of the Author

All of this work was done by the author.

Conflict of Interest

The author declared that there is no conflict of interest.

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