

NUTRITIONAL EVALUATION OF STRAW FROM LEGUMINOUS CROPS GROWN IN THE REPUBLIC OF MOLDOVA

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Abstract. This article presents the results of a study on the biochemical composition and nutritive value of crop residues (straw) from several leguminous crops – chickpea (*Cicer arietinum*), soybean (*Glycine max*), grass pea (*Lathyrus sativus*), white lupin (*Lupinus albus*), pea (*Pisum sativum*), fenugreek (*Trigonella foenum-graecum*), and faba bean (*Vicia faba*) – cultivated in the central zone of the Republic of Moldova. The biochemical composition of investigated leguminous crops straw was characterized by the following indices: 75-128 g/kg CP, 57-104 g/kg ash, 380-459 g/kg CF, 400-553 g/kg ADF, 593-807 g/kg NDF, 72-102 g/kg ADL, 328-439 g/kg Cel, 118-256 g/kg HC. The forage value indices of investigated leguminous straw were 460-531 g/kg DDM, RFV=53-90, 7.7-9.4 MJ/kg ME and 3.76-5.43 MJ/kg NEL. These findings suggest that straw from *Glycine max*, *Pisum sativum*, *Vicia faba*, *Trigonella foenum-graecum* and *Cicer arietinum* may be used as a part of diversified livestock diets.

Keywords: biochemical composition, nutritive value, crop residues - straw, *Cicer arietinum*, *Glycine max*, *Lathyrus sativus*, *Lupinus albus*, *Pisum sativum*, *Trigonella foenum-graecum*, *Vicia faba*

INTRODUCTION

Ruminant animals play a major role in the production of meat, milk, and other animal-derived raw materials for various industries, as well as in supporting farmers' livelihoods and rural development. Ruminant animals have a unique ability to utilize roughages. Currently, livestock production is increasingly constrained by feed shortages and rising input costs, driven by climate change, competition for land use, and growing livestock populations. Conventional feeding systems based on cereals and cultivated forages are

becoming less sustainable due to their dependence on costs of oil resources, irrigation, fertilizers, and mechanization. Consequently, there is increasing interest in the rational use of grasslands, the exploration of new forage plant species, and the utilization of alternative and underexploited forage resources, including crop residues, that can support livestock productivity while reducing environmental impacts and production costs (COȘMAN et al. 2023). Plants of the family Fabaceae (syn. *Leguminosae*, *Papilionaceae*) are an important source of protein

and other nutrients for human and animal nutrition, as well as feedstock for biorefineries, various industrial products, and bioenergy. Annual leguminous crops serve as excellent preceding crops for cereals and autumn-sown forage crops, contributing to improved crop rotations and more sustainable agricultural practices. It is expected that the cultivated area and diversity of multipurpose, protein-rich leguminous crops will expand in Europe. This expansion is likely to be driven by EU policies promoting leguminous crops as part of sustainable agriculture and by efforts to reduce dependence on imported genetically modified soybean from the USA, Brazil, Argentina, and China (European Parliament resolution, 2018). At the “Alexandru Ciubotaru” National Botanical Garden (Institute) of Moldova State University, the gene pool of Fabaceae species has been expanded over recent decades through the mobilization of material from both

the spontaneous flora and various floristic regions of the world. Several of these species have been studied for their potential use as food and fodder plants, melliferous resources, and energy crops (TELEUȚĂ et al., 2015; TELEUȚĂ & ȚIȚEI 2016; ȚIȚEI 2021, 2022, 2023, 2025; ȚIȚEI & COZARI, 2022; ABABII et al., 2023; COȘMAN et al. 2023; ȚIȚEI et al. 2024). Among the feed resources commonly used in ruminant nutrition, some remain underutilized, such as leguminous straw, largely due to limited information on their chemical composition and nutritive value. To formulate balanced diets that include leguminous straw, it is essential to understand the nutritive value of this roughage and its variability, as different straw sources differ in nutrient content and digestibility. The objective of this study was to determine the biochemical composition and nutritive value of crop residues (straw) obtained after grain harvest of leguminous crops.

MATERIALS AND METHODS

Chickpea (*Cicer arietinum*), soybean (*Glycine max*), grass pea (*Lathyrus sativus*), white lupin (*Lupinus albus*), pea (*Pisum sativum*), fenugreek (*Trigonella foenum-graecum*), and faba bean (*Vicia faba*) were cultivated in a non-irrigated experimental plot at the “Alexandru Ciubotaru” National Botanical Garden (Institute), Moldova State University, Central

zone, Republic of Moldova. Samples of crop residues (straw) were collected after grain harvest (threshing) and chopped into 1.5–2.0 cm pieces using a laboratory forage chopper. Dry matter content was determined by drying the samples at 105°C until a constant weight was achieved. For biochemical analysis, the straw samples were milled in a beater mill equipped with a 1 mm sieve. Key biochemical parameters –

including crude protein (CP), ash, acid detergent fiber (ADF), neutral detergent fiber (NDF), and acid detergent lignin (ADL) – were assessed using near-infrared spectroscopy (NIRS) with a PERTEN DA 7200 instrument at the Research and Development Institute

for Grasslands in Brașov, Romania. The concentration of hemicellulose (HC), cellulose (Cel), digestible dry matter (DDM), metabolizable energy (ME), net energy for lactation (NEL) and relative feed value (RFV) were calculated according to standard procedures.

RESULTS AND DISCUSSION

The performance, welfare, and health of livestock are strongly influenced by feed quality. The analysis of the biochemical composition of the collected straw from the studied leguminous crops (Figs. 1-6) showed that straw dry matter contained 75-128 g/kg crude protein (CP), 57-104 g/kg ash, 380-459 g/kg crude fiber (CF), 400-553

g/kg acid detergent fiber (ADF), 593-807 g/kg neutral detergent fiber (NDF), 72-102 g/kg acid detergent lignin (ADL), 328-439 g/kg cellulose (Cel), and 118-256 g/kg hemicellulose (HC). The straw from *Pisum sativum*, *Trigonella foenum-graecum*, *Vicia faba*, and *Glycine max* exhibited higher crude protein content, exceeding 10%.

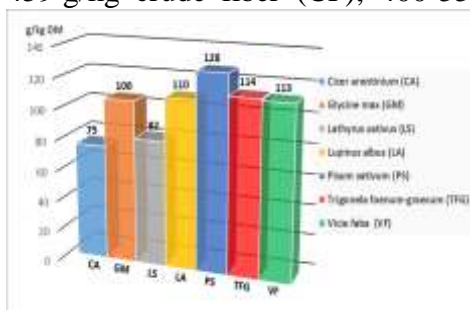


Fig. 1. Crude protein, g/kg dry matter

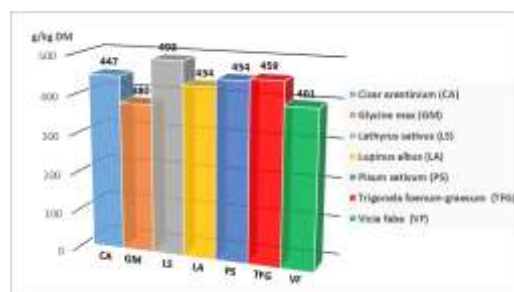


Fig. 2. Crude fibre, g/kg dry matter

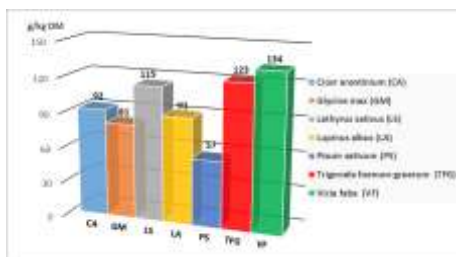


Fig. 3. Minerals, g/kg dry matter

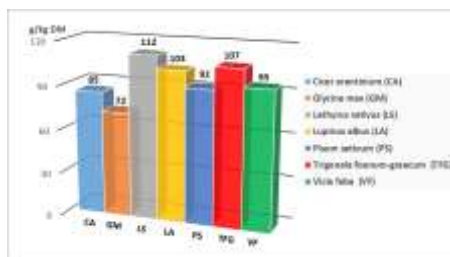


Fig. 4. Acid detergent lignin, g/kg dry matter

Moreover, the straw from *Vicia faba* and *Glycine max*

contained lower amounts of crude fiber, although still higher than that

in *Lathyrus sativus* straw. The mineral content in *Pisum sativum* straw was considerably lower than that in *Trigonella foenum-graecum*, *Vicia faba*, and *Lathyrus sativus* straw. The acid detergent lignin

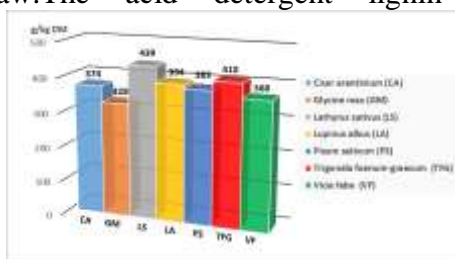


Fig. 5. Cellulose, g/kg dry matter

content in *Lathyrus sativus*, *Lupinus albus*, *Trigonella foenum-graecum* straws reached 103-107 g/kg dry matter, significantly higher than in the *Glycine max* and *Cicer arietinum* straws.

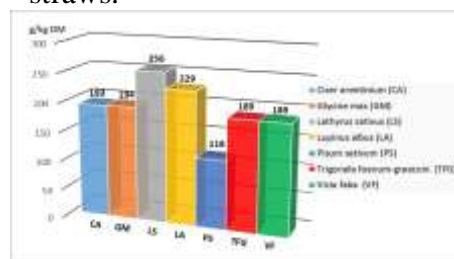


Fig. 6. Hemicellulose, g/kg dry matter

Cellulose content did not differ significantly between *Cicer arietinum* and *Vicia faba* straw and was lower than in *Lathyrus sativus*

and *Trigonella foenum-graecum* straw, but higher than in *Glycine max* straw.



Fig. 7. Digestible dry matter, g/kg dry matter

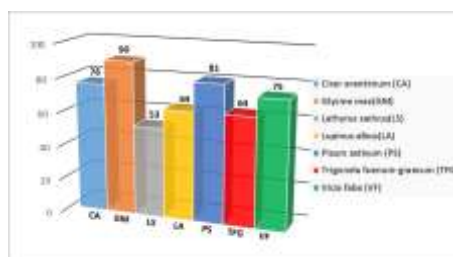


Fig. 8. Relative feed value

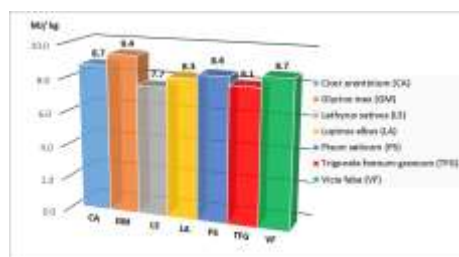


Fig. 10. Metabolizable energy, MJ/kg

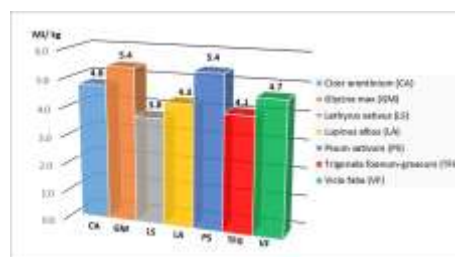


Fig. 11. Net energy for lactation, 9.4 MJ/kg

Hemicellulose concentration was lower in *Pisum sativum* straw and higher in *Lathyrus sativus* and *Lupinus albus* straw. Straw from *Cicer arietinum*, *Glycine max*, *Trigonella foenum-graecum*, and

Vicia faba had comparable hemicellulose concentrations.

The concentration of structural carbohydrates directly influences forage digestibility, feed value, and energy supply. *Glycine*

max straw had 577 g/kg digestible dry matter (DDM), relative feed value (RFV) = 90, 9.4 MJ/kg metabolizable energy (ME), and 5.4 MJ/kg net energy for lactation (NEL), whereas *Lathyrus sativus* and *Trigonella foenum-graecum* straw had 460–486 g/kg DDM, RFV = 53–64, 7.7–8.1 MJ/kg ME, and 3.8–4.1 MJ/kg NEL. Some authors mentioned various findings about the biochemical composition and nutritional value of crop residues after grain threshing of leguminous crops. According to Mustafa et al. (1996) the chemical composition of fenugreek straw was 5.2% CP, 73.7% NDF, 57.1% ADF, 10.6% ADL, 5.8% ash and 424 g/kg IVDDM. NEIJAT & GALLAGHER (1997) reported that nutritive value of pea straw was 974.2 g/kg DM with 5.06% ash, 0.84% N, 73.74% NDF, 55.96% ADF, 9.48% ADL, 46.48% Cel, 17.78% HC and 413 g/kg IVDDM. ABREU & BRUNO-SOARES (1998) mentioned that the nutritional quality of chickpea straw was 5.0% CP, 50.6% CF, 75.5% NDF, 57.9% ADF, 14.2% ADL, 4.7% ash; horse bean straw- 6.60% CP, 46.7% CF, 72.3% NDF, 55.4% ADF, 11.6% ADL, 7.6% ash; field pea straw -9.7% CP, 34.2% CF, 58.0% NDF, 40.0% ADF, 8.3% ADL, 10.1% ash; white lupin straw - 5.9% CP, 55.3% CF, 82.4% NDF, 63.8% ADF, 12.6% ADL, 4.1% ash. LOPEZ et al. (2005) noted that nutritional compositions and feeding quality of straws from *Cicer arietinum* was 920-924 g/kg DM

with 4.3-7.2% CP, 1.0-1.6% EE, 63.9-66.9 % NDF, 46.8-47.7% ADF, 10.1-11.5 % ADL, 6.5-7.2%ADL, 54.3-61.0% DDM and 7.2 MJ/kg ME; *Lathyrus sativus* 907 g/kg DM, 92% CP, 2.4% EE, 53.9% NDF, 38.4% ADF, 8.2% ADL, 68.2 % DMD and 7.6; *Lupinus albus* 943 g/kg DM, 5.6% CP, 0.8% EE, 58.8% NDF, 42.0% ADF, 6.1% ADL, 69.3 % DMD and 7.7 MJ/kg ME, *Pisum sativum* 897 g/kg DM, 6.5 %CP, 2.1% EE, 54.8% NDF, 38.4% ADF, 6.0% ADL, 70.4% DMD and 7.7 MJ/kg ME. SAINI (2005) found that *Trigonella foenum-graecum* straw had 885.0 g/kg DM, 88.40% OM, 11.50% CP, 37.00% CF, 1.20% EE, 38.70% NFE, and 11.60% ash. MULE et al. (2008) revealed that nutritional value of soybean straw was as 884.5 g/kg DM, 7.88%CP, 1.25% EE, 38.10% CF, 38.99% NFE, 13.78% total ash 49.50-54.66% DMD depending of treatment effect. EL-BORDENY & EBTEHAG (2010) remarked that remarked that faba bean straw contained 912.0 g/kg DM, with 83.80% OM, 4.60% CP, 37.50% CF, 1.25% EE, 16.204% ash, 40.45% NFE, while chick-pea straw respectively 876.0 g/kg DM, 94.10% OM 8.10% CP, 32.80% CF, 1.70% EE, 5.9% ash, 51.50% NFE. MAHERI-SIS et al. (2011) mentioned that the forage nutritional quality of soybean straw was 891.8 g/kg DM, 5.10% CP, 2.85% EE, 96.90% OM, 80.80% NDF, 63.20% ADF, 13.00% ADL. GOLSHANI et al. (2012) noted that chickpea straw

had 921.8 g/kg DM, 92.00% OM, 6.05% CP, 5.50% EE, 34.30% CF and 46.15% NFE. MELGAREJO et al. (2014) found that pea residual biomass contained 26% cellulose, 20.5% hemicellulose and 3.92% lignin and soybean hulls respectively 46-51% cellulose, 16-18% hemicellulose and 1.4-2% lignin. SHERASIA et al. (2015) reported that chickpea straw had 91.7% OM, 4.9% CP, 2.0% EE, 45.1% CF, 65.2% NDF, 46.3% ADF, 18.9% HC, 8.3% ash, 7.8 g/kg Ca, 1.3 g/kg P, 50.5 %TDN, 7.5 MJ/kg ME, 4.2 MJ/kg NEL, but fenugreek straw - 94.9% OM, 7.2% CP, 0.7% EE, 59.0% CF, 72.7% NDF, 54.8% ADF, 17.9% HC, 5.1% ash, 4.2 g/kg Ca, 0.9 g/kg P, 41.5 %TDN 5.8 MJ/kg ME, 2.7 MJ/kg NEL. HEUZÉ et al. (2015, 2016) reported that pea straw contained 888g/kg DM with 8.2% CP, 36.3% CF, 54.9% NDF, 38.7% ADF, 7.2% lignin, 9.8% ash, 23.7 g/kg Ca, 1.1 g/kg P, 57.5% DOM, 18.1 MJ/kg GE, 9.8 MJ/kg DE and 7.9 MJ/kg ME; chickpea straw - 904g/kg DM with 5.4% CP, 41.0% CF, 65.6% NDF, 46.9% ADF, 11.9% lignin, 7.4% ash, 9.4 g/kg Ca, 1.6 g/kg P, 45.0% DOM, 18.1 MJ/kg GE, 7.5 MJ/kg DE and 6.1 MJ/kg ME; soybean straw - 890g/kg DM with 6.9% CP, 44.2% CF, 79.7% NDF, 59.9% ADF, 16.4% lignin, 7.9% ash, 52.8% DOM, 19.0 MJ/kg GE, 9.4 MJ/kg DE and 7.5 MJ/kg ME. KILIÇALP et al. (2017) mentioned that nutrients contents of chickpea straw were ranged from 5.61 to 7.42% CP, 51.33 to 56.0% ADF,

63.67 to 67.0% NDF, 8.0 to 9.0% ash, with 49.65 to 54.91% potential degradability and 5.96 to 7.37 MJ/kg ME. MALUSHI SIBAOUEIH (2017) revealed that the nutritive value of pea straws was 915-918 g/kg DM, 7.6-9.8% ash, 7.3-11.1%CP, 36.3-46.3% CF, 1.0-1.9% EE, 53.3- 65.4% NDF, 42.3-50.4% ADF, 8.1-10.7%ADL. DRONCA et al. (2018) reported that nutritional compositions of fenugreek husk were 884 g/kg DM with 7.81% CP, 1.3-1.6% EE. BAL BAHADUR (2019) remarked that chemical composition of soybean straw was 891.8 g/kg DM, 5.10%CP, 2.85% EE, 96.90% OM, 80.80% NDF, 63.20%ADF, 13.00% ADL. MADAVI et al. (2019) observed that soybean straws containing 7.15% CP, 1.52% EE, 38.29% NFE, 41.29% CF and 11.86 % ash. MAWAL NILESH et al. (2019) found that soybean straw containing 876.2 g/kg DM with 6.13% CP, 2.51% EE, 37.29% CF, 44.21% NFE and 9.86% ash. SIBAOUEIH et al. (2021) revealed that the nutritional compositions of chickpea crop residues.was: 8.85% ash, 7.14% CP, 58.76 % NDF, 40.17 %ADF, 10.34%ADL. ALAEI et al. (2022). remarked that the chemical composition of green pea residues was 971.7g/kg dry matter, 9.66% crude protein, 8.49% ash, 47.33% ADF, 62.66% NDF, 44.9% cellulose, 20.4% hemicellulose, and 13.7% lignin. MAIA et al. (2023) mentioned that the nutritive value of straw from *Lupinus albus* was

4.37% ash, 5.30% CP, 0.54% EE, 66.5 % NDF, 51.3% ADF, 10.3% ADL, 18.3 MJ/kg ME, while from *Lupinus angustifolius* 5.11% ash, 6.89% CP, 0.55% EE, 65.9 % NDF, 50.0% ADF, 10.7%ADL, 18.3 MJ/kg ME, but from *Lupinus luteus* respectively 5.32% ash, 5.83% CP, 0.57% EE, 64.8 % NDF, 49.0% ADF, 11.1%ADL and 18.3 MJ/kg ME. KEHSRI al. (2024) reported that nutritional composition of

soybean straw can vary depending on variety, growing conditions, and harvesting methods, on average, it contains: 880-920 g/kg DM, 4-7% CP, 65-75% NDF, 45-55% ADF, 7-10% lignin, 5-8% ash. PIŃKOWSKA et al. (2024) noted that dry matter compositions of white lupin straw was 921g/kg DM with 4.8% CP, 41.54% Cel, 13.45% HC, 19.82% sulfuric acid-insoluble lignin, 5.2% ash.

CONCLUSIONS

Straw from *Glycine max*, *Pisum sativum*, *Vicia faba*, *Trigonella foenum-graecum*, and *Cicer arietinum* demonstrated favorable forage quality and can serve as a valuable feed resource suitable for inclusion in diverse livestock feeding systems, including goats, sheep, cattle, and buffalo. In contrast, straw from *Lathyrus sativus* and *Lupinus albus* has nutritional limitations that require careful diet

formulation and supplementation; however, various treatment methods can improve its feeding value.

Crop residues (straw) from leguminous crops can contribute to cost-effective and sustainable ruminant production systems, particularly in regions with limited grassland availability or where fodder crop production is affected by drought, such as during periods of fodder shortage.

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