Physico-Chemical Quality Analysis of Maize Used as Cattle Feed

Ioana Porosnicu[1,2], Silviu-Ionut Borș[2], Adina-Mirela Ariton[2], Vasile Vintilă[2], Luminita-Iuliana Ailincai[1], Mihai Mares[1]

[1] *„Ion Ionescu de la Brad" Iasi University of Life Sciences, Romania*
[2] *Research and Development Station for Cattle Breeding Dancu, Iasi, Romania*

Abstract
Feed quality is essential for maintaining the health, productivity, and welfare of cattle, directly influencing milk and meat production. Maize, as the main energy source and a key component of the feeding ration, provides carbohydrates, a moderate amount of protein, and lipids necessary for growth and lactation. In this study, maize samples were collected and analyzed at a livestock farm located in the Moldavia region over a two-year period to evaluate the main physico-chemical parameters relevant to animal nutrition and feed safety. Moisture, dry matter, crude protein, total lipids, crude fiber, and ash content were determined using standardized methods (SR ISO and European regulations). The results indicated stable values of moisture and crude protein between years, confirming the consistent nutritional quality of maize, while total lipids and crude fiber showed significant variations influenced by climatic conditions, grain maturity stage, and storage practices. These findings highlight the importance of regular feed quality monitoring and provide valuable insights for optimizing feeding strategies. The study confirms that the analyzed maize meets the quality standards for cattle feed and supports informed management decisions aimed at improving zootechnical performance.

Keywords: fiber, lipids, livestock, moisture, nutrition

1. Introduction

Maize is one of the most important crops globally, with an annual production of approximately 1.2 billion tonnes, significantly exceeding that of rice and wheat [1]. Worldwide, about 56% of dried maize grain is used in animal feed, highlighting its essential role as a feed resource [2]. In Romania, maize represents one of the main crops, with a production of approximately 8.5 million tonnes in 2023 [3]. Due to its high starch content and excellent digestibility, maize is a key source of energy in animal nutrition [4]. It is used in various forms, such as dried grain, silage, or compound meals, being a fundamental ingredient in feed formulations [5]. Through its nutritional value, it contributes to increased meat and milk production, having a significant impact on farm efficiency and productivity [6, 7]. In addition to its role as an energy source, maize influences feed palatability and can positively affect voluntary feed intake in animals [8]. Its composition varies depending on the hybrid, environmental conditions, and cultivation technology, which may lead to fluctuations in physico-chemical parameters from one year to another [9]. Monitoring these parameters is essential to maintain feed quality and ensure its optimal use in animal nutrition [10]. Physico-chemical analyses represent an essential tool for evaluating the nutritional value, stability, and safety of maize used in animal feed, providing objective information necessary for optimizing feed formulations and preventing potential nutritional deficiencies [11]. The determination of parameters such as moisture, dry matter, crude protein, lipids, crude fibre, and ash enables a

* Corresponding author: Silviu-Ionut Borș
0726399084, bors.ionut@yahoo.com

comprehensive characterization of maize quality and highlights the sources of variation associated with climatic conditions, stage of maturity, and storage practices [12]. Thus, physico-chemical analytical studies contribute to maintaining feed quality and safety standards, providing scientific support for decision-making in the nutritional and technological management of livestock farms [13].

2. Materials and methods

The analysed maize grains were harvested at optimal moisture content and stored under appropriate conditions to prevent nutritional losses. The samples were used as feed for dairy cows and young stock, representing an essential component of the feed base.

For nutritional characterization, the main physico-chemical parameters were determined using standardized methodologies:

• *Moisture*: determined by drying the sample in an oven at 105°C until constant weight was achieved [14,15].

• *Crude protein*: determined by the Kjeldahl method, based on total nitrogen content multiplied by the factor 6.25 [15,16].

• *Total lipids*: determined by Soxhlet extraction using organic solvents [17].

• *Crude fibre*: determined by the Gerhardt method, through successive acid and alkaline treatment, using a Fibretherm F12 system [18].

• *Crude ash*: determined by incineration of the sample at 550°C until constant weight was achieved [15,19].

Figure 1. Physicochemical analyses performed on maize samples

All analyses were performed in triplicate, and the results were expressed as mean ± standard deviation (SD). Differences between years or batches were statistically evaluated using analysis of variance (ANOVA) in order to identify variations associated with climatic factors, cultivation technology, and grain maturity stage.

3. Results and discussion

The nutritional quality of maize used in feed rations was evaluated by analysing the main physico-chemical characteristics, with the results presented in Figure 2.

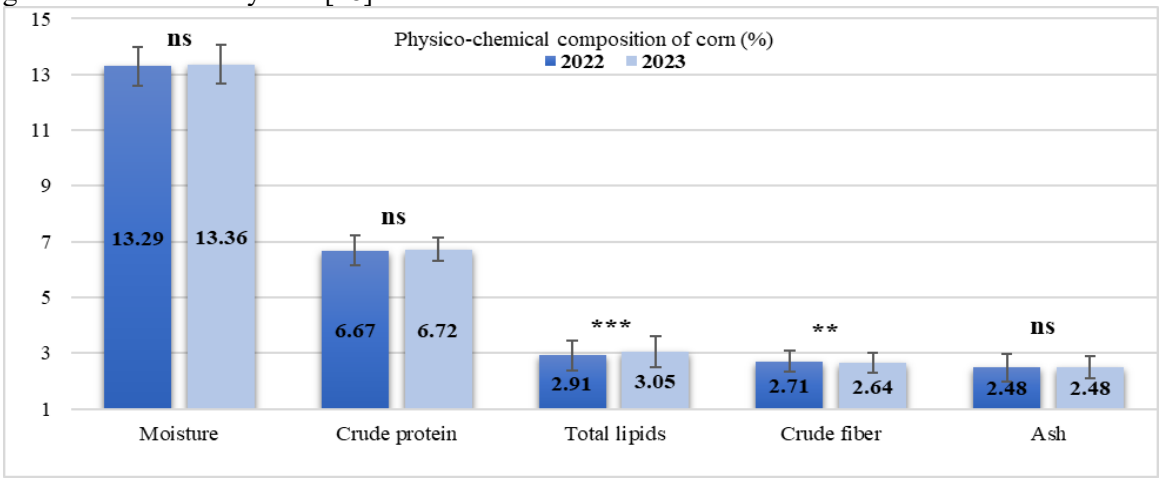

Figure 2. Comparison of physicochemical parameters of maize between 2022 and 2023

The values obtained for the moisture parameter indicate a non-significant difference between 2022 and 2023 ($p > 0.05$), remaining around 13.3%, which meets the specific requirements for feed storage and utilisation. The crude protein content remained relatively constant, with an average of 6.67% in 2022 and 6.72% in 2023, with no significant differences ($p > 0.05$). This confirms

that maize is primarily an energy source, with a limited protein contribution. The analysis of total lipids revealed highly significant differences between years ($p < 0.001$), with higher values in 2023 (3.05% ± 0.54) compared to 2022 (2.91% ± 0.55). These variations can be attributed to environmental factors, climatic conditions, and cultivation practices. Crude fibre content was significantly higher in 2022 ($p < 0.01$), which may influence feed digestibility. The differences are particularly evident in certain months, suggesting an influence of grain maturity stage and storage conditions. Similarly, the analysis of crude ash content showed non-significant differences ($p > 0.05$). For a more detailed assessment of the dynamics of these parameters, a monthly analysis of the physico-chemical composition of maize was performed, and the results are presented in Table 1.

Table 1. Results on the physico-chemical composition of maize used in animal feed

Month	Year	Moisture (%)		Crude protein (%)		Total lipids (%)		Crude fiber (%)		Crude ash (%)	
		X̄ ± SD	p-value	X̄ ± SD	p-value	X̄ ± SD	p-value	X̄ ± SD	p-value	X̄ ± SD	p-value
January	2022	13.26±0.57	0.518	6.76±0.56	0.199	2.55±0.22	0.000	2.60±0.12	0.011	2.89±0.24	0.004
	2023	13.39±0.60	ns	6.53±0.50	ns	3.40±0.11	***	2.33±0.20	**	2.46±0.36	***
February	2022	13.15±0.59	0.676	6.69±0.40	0.194	2.66±0.10	0.301	3.04±0.35	0.011	2.66±0.30	0.174
	2023	13.06±0.50	ns	6.92±0.59	ns	2.52±0.15	ns	2.77±0.09	**	2.86±0.48	ns
March	2022	13.56±0.51	0.613	6.44±0.24	0.016	2.82±0.11	0.448	2.52±0.41	0.000	2.72±0.17	0.029
	2023	13.67±0.43		6.88±0.36	**	2.92±0.17	ns	2.90±0.16	***	2.40±0.21	*
April	2022	13.58±0.35	0.884	6.43±0.61	0.047	3.07±0.54	0.029	2.57±0.28	0.000	2.69±0.47	0.732
	2023	13.61±0.37	ns	6.79±0.56	*	3.36±0.26	*	3.00±0.20	***	2.74±0.13	ns
May	2022	13.09±0.55	0.801	7.37±0.67	0.203	3.51±0.23	0.070	3.24±0.22	0.511	2.68±0.09	0.588
	2023	13.04±0.58	ns	7.14±0.31	ns	3.76±0.49	ns	3.17±0.07	ns	2.76±0.21	ns
June	2022	13.85±0.12	0.801	7.33±0.44	0.000	3.32±0.32	0.000	2.71±0.35	0.003	1.56±0.31	0.000
	2023	13.80±0.35	ns	6.60±0.37	***	2.80±0.29	***	2.40±0.20	***	2.17±0.38	***
July	2022	14.00±0.09	0.169	6.47±0.29	0.001	3.56±0.56	0.271	3.04±0.09	0.058	2.85±0.41	0.002
	2023	14.28±0.55	ns	7.10±0.24	***	3.71±0.30	ns	2.84±0.19	ns	2.40±0.34	***
August	2022	13.56±0.22	0.778	6.97±0.29	0.081	3.55±0.41	0.888	2.25±0.23	0.064	2.15±0.49	0.000
	2023	13.62±0.27	ns	6.65±0.35	ns	3.57±0.44	ns	2.45±0.28	ns	2.87±0.26	***
September	2022	13.80±0.73	0.778	6.26±0.30	0.424	2.28±0.30	0.384	2.80±0.23	0.000	2.68±0.47	0.187
	2023	13.75±0.35	ns	6.40±0.23	ns	2.40±0.21	ns	2.29±0.34	***	2.48±0.39	ns
October	2022	13.05±0.46	0.698	6.29±0.29	0.090	2.34±0.18	0.053	2.40±0.15	0.614	2.34±0.46	0.178
	2023	13.13±0.21	ns	6.60±0.23	ns	2.60±0.19	ns	2.35±0.21	ns	2.15±0.11	ns
November	2022	12.44±0.16	0.478	6.50±0.27	0.561	2.50±0.19	0.179	2.80±0.31	0.000	2.12±0.13	0.328
	2023	12.30±0.82	ns	6.40±0.13	ns	2.68±0.20	ns	2.41±0.17	***	1.97±0.27	ns
December	2022	12.11±0.28	0.004*	6.56±0.44	0.573	2.74±0.18	0.186	2.50±0.15	0.017	2.44±0.22	0.579
	2023	12.70±0.42	**	6.66±0.32	ns	2.91±0.35	ns	2.76±0.22	**	2.52±0.31	ns
OVERALL	**2022**	13.29±0.69	0.214	6.67±0.54	0.332	2.91±0.55	0.000	2.71±0.37	0.027	2.48±0.49	0.997
	2023	13.36±0.69	ns	6.72±0.43	ns	3.05±0.54	***	2.64±0.35	**	2.48±0.40	ns

Statistical significance: *$p > 0.05$ = not significant / ns, $p < 0.05$ = significant / *, $p < 0.01$ = highly significant / **, $p < 0.001$ = very highly significant / *** ANOVA - Analysis of variance*

This analysis highlights significant differences in lipid, protein, and crude fiber content throughout the year, with higher levels of protein and lipids during the summer months and increases in crude fiber in spring and autumn. These fluctuations may be correlated with the stage of grain maturity and storage conditions. Maize kernels are primarily composed of carbohydrates, especially starch, and contain moderate amounts of proteins and lipids, while the proportion of fiber and minerals is low [20]. Typically, maize contains 6–10% crude protein and 3–5% lipids on a dry matter (DM) basis. Crude fiber represents approximately 2% of DM, while total minerals (ash) range between 1 and 2% [21,22]. All analyzed parameters fall within the recommended standard ranges for maize used in animal feed, confirming the quality of the feed. The results of this study regarding the stability of the physicochemical parameters of feed maize are consistent with recent literature, highlighting the importance of standardized determinations of moisture, protein, lipids, and fiber for evaluating nutritional quality. Variability of these parameters is systematically influenced by factors such as maize hybrid, environmental conditions, stage of maturity, and post-harvest handling techniques, supporting our observations regarding significant differences between years for lipids and crude fiber [23]. Significant increases in lipid content

between 2022 and 2023 may be associated with higher temperatures and water stress during grain development, which influence the accumulation of energy in the form of fats [24,25]. In turn, variation in crude fiber has a direct impact on digestibility and feeding behavior in ruminants, as highlighted in numerous animal nutrition studies [26]. The crude protein and lipid values obtained in the present study are consistent with ranges reported in the scientific literature (6–10% crude protein and 3–5% lipids on a dry matter basis), demonstrating stability even under variable climatic conditions [27]. The modern literature also highlights that seasonal fluctuations in protein and lipid content can be correlated with grain maturity and local microclimatic conditions, as also observed in our monthly analysis [28]. Overall, the obtained data confirm that all analyzed parameters fall within the recommended standards for maize used in animal feed, providing empirical support for optimizing feed rations and ensuring consistent and efficient animal nutrition.

4. Conclusions

The physico-chemical analysis of maize used in dairy cow feed over the 2022–2023 period confirms that the main nutritional parameters—moisture, crude protein, lipids, crude fiber, and ash—fall within the recommended standard ranges, demonstrating stability and consistency in feed quality. The observed seasonal fluctuations in lipids and crude fiber reflect the influence of environmental factors, grain maturity stage, and storage practices, highlighting the importance of continuous monitoring of nutritional parameters. The results confirm the role of maize as a primary energy source with a moderate protein contribution and provide a solid basis for adjusting feed rations according to local conditions and productivity objectives. In addition, the finding that controlled storage maintains physico-chemical parameters within optimal limits emphasizes the relevance of adopting efficient management practices, with direct benefits for animal health and performance. This study therefore provides both practical and scientific evidence for feed optimization and may serve as a reference for farms aiming to maintain a high standard of feed quality.

References

1. Chavas, J.-P., Mitchell, P. D., Corn productivity: The role of management and biotechnology. InTech 2018, doi:10.5772/intechopen.77054
2. Carbas, B., Barros, S., Freitas, A., Silva, A. S., Brites, C., Comparative analysis of maize physico-chemical parameters and mycotoxin levels in dual environments. Toxins 2024, doi:10.3390/toxins16060275
3. Csorba, A. B., Maize production in Central and Eastern Europe – Perspectives and challenges. Acta Univ. Sapientiae Agric. Environ. 2024, doi:10.47745/ausae-2024-0009
4. Ferraretto, L. F., Crump, P. M., Shaver, R. D., Effect of cereal grain type and corn grain harvesting and processing methods on intake, digestion, and milk production by dairy cows through a meta-analysis. J. Dairy Sci. 2013, doi:10.3168/jds.2012-5932
5. Cao, H., Yan, L., Song, X., Liu, L., Xu, S., Hu, S., Zhang, S., Determining the nutritional values of new corn varieties on pigs and broilers. Front. Vet. Sci. 2024, doi:10.3389/fvets.2024.1358773
6. Erenstein, O., Jaleta, M., Sonder, K., et al., Global maize production, consumption and trade: trends and R&D implications. Food Sec. 2022, 14, 1295–1319. doi:10.1007/s12571-022-01288-7
7. Matei, A.-C., Creangă, Ș., Davidescu, M.-A., Doboș, B.-I., Poroșnicu, I., Mădescu, B.-M., Research on the economic efficiency of farms in function of the milking system. Sci. Pap. Ser. D Anim. Sci. 2020, LXIII(2), 296–300.
8. Wang, Y., Rassler, S., Stefanovski, D., Bender, J., Deutsch, J., Chen, T., Cui, Z., Dou, Z., Evidence of animal productivity outcomes when fed diets including food waste: A systematic review of global primary data. Resour. Conserv. Recycl. 2024, 203, 107411. doi:10.1016/j.resconrec.2024.107411
9. Hernández-Villaseñor, L. A., Hernández-Estrada, S., Gómez-Rodríguez, V. M., et al., Comparison of the nutritional, physicochemical, technological–functional, and structural properties and antioxidant compounds of corn kernel flours from native Mexican maize cultivated in Jalisco Highlands. Crops 2025, 5(3), 26. doi:10.3390/crops5030026
10. Tomovska, J., Vllasaku, I., Josevska, E., Chemical composition of animal feed and its influence on the milk quality. Food Environ. Saf. 2023, 22(1). doi:10.4316/fens.2023.012
11. Poroșnicu, I., Ailincăi, L.-I., Davidescu, M. A., Mareș, M., Fungal contamination of dairy feed and major mycotoxin transfer: A risk evaluation for animal exposure and health. Toxins 2026, 18(1), 42. doi:10.3390/toxins18010042
12. Melo, C. D., Maduro Dias, C. S. A. M., Wallon, S., Borba, A. E. S., Madruga, J., Borges, P. A. V., Ferreira, M. T., Elias, R. B., Influence of climate variability and

soil fertility on the forage quality and productivity in Azorean pastures. Agriculture 2022, 12(3), 358. doi:10.3390/agriculture12030358
13. Baris, A., Impact of feed quality on livestock productivity. J. Livest. Policy 2023, 2(1). doi:10.47604/jlp.v2i1.2112
14. International Organization for Standardization, ISO 6496:1999, Animal feeding stuffs – Determination of moisture and other volatile matter content. ISO, Geneva, 1999. https://www.iso.org/obp/ui/en/#iso:std:iso:6496:ed-2:v1:en
15. European Commission, Regulation (EC) No 152/2009 of 27 January 2009 laying down methods of sampling and analysis for the official control of feed. Off. J. Eur. Union 2009, L54, 1–130. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32009R0152
16. International Organization for Standardization, ISO 5983-2:2009, Animal feeding stuffs – Determination of nitrogen content and calculation of crude protein content – Part 2: Block digestion and steam distillation method. ISO, Geneva, 2009. https://www.iso.org/standard/52199.html
17. International Organization for Standardization, ISO 6492:1999, Animal feeding stuffs – Determination of fat content. ISO, Geneva, 1999. https://www.iso.org/standard/12865.html
18. International Organization for Standardization, ISO 6865:2000, Animal feeding stuffs – Determination of crude fibre content – Method with intermediate filtration. ISO, Geneva, 2000. Available at: https://www.iso.org/standard/13377.html
19. International Organization for Standardization, EN ISO 2171:2023, Cereals, pulses and by-products – Determination of ash yield by incineration. ISO, Geneva, 2023. Available at: https://standards.iteh.ai/catalog/standards/cen/59edadbf-f2e1-43e5-8d4c-24ae081b033e/en-iso-2171-2023
20. Poroșnicu, I., Ailincăi, L.-I., Neculai-Văleanu, A.-S., Ariton, M.-A., Mareș, M., Legislative aspects regarding the control of mycotoxins. Sci. Pap. Anim. Sci. Biotechnol. 2023, 56(2), 153–162.
21. Ifie, S. E., Dangana, R. S., Swase, D., Ben Okon, M., Makena, W., Agunloye, M. O., Ugwu, C. N., Ifie, J. E., Odoma, S., Babangida, A. I., Aja, P. M., Nutritional composition of Zea mays L.: A comprehensive review of macronutrients, micronutrients, and bioactive compounds. Open Res. Afr. 2026, 8, 15. doi:10.12688/openresafrica.16056.2
22. Qamar, S., Shaikh, A., Memon, A. A., et al., Proximate composition of maize (Zea mays L.). Mater. Today Proc. 2016, 3(10), 3178–3182. doi:10.1016/j.matpr.2016.01.118
23. Jha, R., Mishra, P., Dietary fiber in poultry nutrition and their effects on nutrient utilization, performance, gut health, and on the environment: A review. J. Anim. Sci. Biotechnol. 2021, 12, 51. doi:10.1186/s40104-021-00576-0
24. Lu, D., Cai, X., Yan, F., Sun, X., Wang, X., Lu, W., Effects of high temperature after pollination on physicochemical properties of waxy maize flour during grain development. J. Sci. Food Agric. 2014, 94, 1416–1421. doi:10.1002/jsfa.6433
25. Neculai-Văleanu, A.-S., Sănduleanu, C., Poroșnicu, I., From tradition to precision: leveraging digital tools to improve cattle health and welfare. Front. Vet. Sci. 2025, 12, 1549512. doi:10.3389/fvets.2025.1549512
26. Tafaj, M., Kolaneci, V., Junck, B., Maulbetsch, A., Steingass, H., Drochner, W., Influence of fiber content and concentrate level on chewing activity, ruminal digestion, digesta passage rate and nutrient digestibility in dairy cows in late lactation. Asian-Australas. J. Anim. Sci. 2005, 18(8), 1116–1124. doi:10.5713/ajas.2005.1116
27. Li, X., Zheng, X., Xing, X., Liu, W., Liu, Q., Yang, Z., Yang, H., Wang, Z., Effects of dietary metabolizable energy and crude protein levels on growth performance, carcass traits, and meat quality of goslings from 35 to 63 days of age. Foods 2026, 15(6), 1060. doi:10.3390/foods15061060
28. Kashyap, S., Reddy, B. H. R., Devi, S., Kurpad, A. V., Potential impact of climate change on dietary grain protein content and its bioavailability – a mini review. Front. Nutr. 2024, 11, 1397219. doi:10.3389/fnut.2024.1397219