THE QUALITY INDICES OF FODDER FROM *Cichorium intybus* AND *Carthamus tinctorius*, GROWN UNDER THE CONDITIONS OF THE REPUBLIC OF MOLDOVA.

ŢÎŢEI Victor

"Alexandru Ciubotaru" National Botanical Garden (Institute), Moldova State University, Republic of Moldova, MD 2002 Chisinau, 18 Pădurii str.
Corresponding author's email: vic.titei@ gmail.com; victor.titei@gb.usm.md;

Abstract. *We evaluated the quality indices of fodder produced from chicory (Cichorium intybus) and safflower (Carthamus tinctorius) grown in monoculture on the experimental plots of the "Alexandru Ciubotaru" National Botanical Garden (Institute), MSU, Chişinău, Republic of Moldova. The results revealed that the dry matter of whole plants of studied species contained: 9.22-11.50% CP, 8.68-10.84% minerals, 27.80-32.91% CF, 40.93-51.96% NFE, 5.02-15.80% soluble sugars, 6.61-9.04 % starch, 9.40-11.80 g/kg Ca, 3.00 g/kg P; the nutritive energy value was 9.10-9.83 MJ/kg ME and the net energy for lactation (NEl) – 5.04-5.63 MJ/kg. The prepared silages had the following characteristics: pH=4.14-4.19, 25.0-35.7 g/kg lactic acid, 2.7-5.12 g/kg acetic acid. The dry matter of the silages contained 8.42-9.22% CP, 9.76-8.425% minerals, 33.20-33.51% CF, 41.95-46.22% NFE, 2.09-4.09% soluble sugars, 7.19-10.00 % starch, 9.70-15.10 g/kg Ca, 2.50-2.80 g/kg P, with nutritive energy value 9.18-9.21 MJ/kg ME and net energy for lactation 5.09-5.14 MJ/kg. The green mass and the silage prepared from Cichorium intybus and Carthamus tinctorius contain a lot of nutrients are rich in essential nutrients, making them suitable alternatives for the traditional livestock fodders.*

Keywords*: biochemical composition, forage value, green mass, hay, Cichorium intybus, Carthamus tinctorius, silage.*

INTRODUCTION

In the context of climate change, diversifying the range of forage crops used to provide livestock with a stable and balanced diet plays a crucial role in the restoration and sustainable development of agriculture, as well as in ensuring food safety and security.

The *Asteraceae* family, the largest group of flowering plants, comprises approximately 27,773 species. Several of these species play important roles as food, forage, industrial, medicinal, ornamental or energy crops.

As part of ongoing activities to conserve and sustainably utilize plant genetic resources, new taxa from the *Asteraceae* family have been identified and mobilized over the years. These taxa originate both from local flora and from other floristic regions, and possess a wide range of economic uses. Research has led to the identification of valuable plant forms suitable for the development of new varieties. Notably, studies have highlighted the biological characteristics and forage potential of species such as *Cynara*

cardunculus, Echinacea purpurea, Helianthus annuus, Helianthus mollis, Helianthus strumosus, Helianthus tuberosus, Inula helenium, Silphium perfoliatum, Silybum marianum etc. (ȚÎȚEI et al., 2013; ȚÎȚEI & COȘMAN, 2016; ȚÎȚEI, 2020, 2024; COȘMAN et al., 2023 GUȚU et al., 2023). *Cichorium* L. is a small genus of the *Asteraceae* family, consists of six species, while the two cultivated *Cichorium intybus* and *Cichorium endivia* (BIRSA et al., 2023). Chicory, *Cichorium intybus* L. is native to Europe, temperate Asia, northern Africa, and has been naturalized in other regions. It is perennial herbaceous plant characterized by fusiform, twisted roots, up to 1-1.5 cm thick and up to 1.5 m long. It has an erect, branched stem with prominent grooves and is covered in rough hairs, reddish brown, wooded at base, containing latex, 30–120 cm tall. The basal leaves arranged in a rosette, oblanceolate, petiolate 7–30 cm long, 1–12 cm wide, apex acute, margins toothed to pinnatisect with toothed lobes, pubescent to glabrous; the lower stem leaves similar to the basal ones; the upper leaves alternate, sessile, smaller, cordate at the base, covered with hairs. The ligulate flowers are blue, found in flower head inflorescences, which are typically solitary or grouped by 2-3, terminal or sometimes axillary. The fruit is an achene, 2-3 mm long, with a very short pappus. It blooms from July to September. *Cichorium intybus* has good tolerance to drought and frost and low tolerance against waterlogging and salt. It requires deep, well-drained fertile soil with good nitrogen content. *Cichorium intybus* has been researched and cultivated in several research centers as a food, fodder and medicinal plant (MORARU et al., 2012; CIOCÂRLAN, 2014; DRAGOMIR et al., 2018; BIRSA et al., 2023), also it is a good source of protein feed and nectar for bees, honey productivity 166.59 - 301.34 kg/ha. (ADAMCHUK et al. 2017).

The genus *Carthamus* L., *Asteraceae* family comprises 48 accepted species names, of which only *Carthamus tinctorius* L., is cultivated and the rest are wild and weedy in habit. The areas of origin of safflower, *Carthamus tinctorius*, are Africa, the Middle-East and Asia. It is an annual herbaceous plant with a strong erect, glabrous, branched stem, 30-150 cm in height. The leaves are ovate- obovate, alternate, the lower ones are sessile and acuminate. The inflorescence is a dense capitulum of flowers, surrounded by an involucre of green ovoid bracts. The florets are small, tubular, sessile, composed on type 5. The fruit is a smooth, shiny and angular achene. This species is a drought, heat, cold and salinity tolerant crop, it is considered as a climate-smart crop, adaptable to more variable environmental conditions and soils as compared with other species in the Asteraceae family. Safflower is a multipurpose oil seed crop that can be used for the production of cooking oil, as a food crop, cut flowers, fodder crop for both fresh and preserved animal feed, industrial crop for dye

production and as a medicinal crop (DOBRIN & MARIN, 2015; HEUZÉ & TRAN, 2015; IVANOVA, 2016; KOCAMAN et al., 2016; EMONGORN & OAGILE, 2017; PEIRETTI, 2017; SEENO 2023; LÓPEZ-JARA et al. 2025).

The main objective of this study was to evaluate the quality indices of fodder from two *Asteraceae* species – *Cichorium intybus* and *Carthamus tinctorius* – cultivated under the conditions of the Republic of Moldova.

MATERIALS AND METHODS

The study was conducted using a local ecotype of chicory (*Cichorium intybus*) and an introduced spineless ecotype of safflower (*Carthamus tinctorius*), both cultivated in monoculture on an experimental plot at the "Alexandru Ciubotaru" National Botanical Garden (Institute) of Moldova State University (MSU), located in Chişinău (latitude 46°58′25.7″N, longitude 28°52′57.8″E). Traditional crops, specifically the corn hybrid 'GW9003' (*Zea mays*) and the sunflower hybrid 'HS9729' (*Helianthus annuus*), served as controls. Plant samples of *Cichorium intybus*, *Carthamus tinctorius*, and *Helianthus annuus* were collected at the flowering stage, while *Zea mays* was harvested at the wax stage of grain development. The harvested biomass was chopped into 1.5-2.0 cm pieces using a laboratory forage chopper. The dry matter content was determined by drying samples to a constant weight at 105°C. Silage was prepared from the chopped green mass by compressing it into well-sealed glass containers, which were stored at ambient temperatures (18–20°C). After 45 days, the containers were opened, and the sensorial and fermentation characteristics of the preserved forage were assessed according to the standard SM 108* accepted in the Republic of Moldova.

Both green mass and fermented fodder samples were dehydrated in a forced-ventilation oven at 60°C. Once dried, the biological material was finely ground using a laboratory ball mill. Fodder quality was evaluated based on several parameters: crude protein (CP), crude fiber (CF), crude fat (EE), nitrogen-free extract (NFE), soluble sugars (SS), starch, ash, calcium (Ca), phosphorus (P), silage pH, and concentrations of organic acids (lactic (LA), acetic (AA), and butyric (BA) in both free and fixed forms.

Energy values, namely: gross energy (GE), metabolizable energy (ME), and net energy for lactation (NEl), were calculated following standard methodological procedures:

GE=23.9xCP+39.8xEE+20.1xCF+17.5xNFE;

ME=14.07+0.0206xEE-0.0147xCF--0.0114xCP+4.5%;

NEl=9.10+0.0098xEE-0.0109xCF-0.0073xCP.

RESULTS AND DISCUSSION

At harvest, *Cichorium intybus* plants averaged 120-126 cm in height, while *Carthamus tinctorius* plants

measured 97-105 cm. The fresh mass productivity of the introduced spineless safflower ecotype reached 3.74 kg/m², corresponding to 1.10 kg/m² of dry matter. In comparison, the local ecotype of chicory yielded 5.89 kg/m² of fresh mass, or 1.31 kg/m² of dry matter.

Several studies have reported varying productivity levels for these species. CAZZATO et al. (2011) found that safflower dry matter productivity ranged from 4.5 to 11.6 t/ha. ELGERSMA et al. (2014) reported a herbage productivity of 9,960 kg/ha for chicory. UMAMI et al. (2019) observed that *Cichorium intybus* could achieve up to 28.12 t/ha/year of organic matter. NECIU et al. (2017) indicated that under different natural and technological conditions, pure chicory cultures yielded between 30–60 t/ha of green mass or 7-15 t/ha of dry matter. DRAGOMIR et al. (2018) noted a dry matter yield of 6.59 t/ha for non-fertilized chicory, increasing to 8.54 t/ha with fertilization. OCHOA-ESPINOZA et al. (2022b) reported that safflower dry matter productivity varied from 4,461 to 10,816 kg/ha. JABARI et al. (2023) recorded the highest forage yield among the studied safflower cultivars at 52,103 kg/ha of fresh mass or 11,900 kg/ha of dry matter. Similarly, KARGAR et al. (2024) found that the 'Golmehr' cultivar of safflower, harvested at the branching stage, achieved yields of 42,229 kg/ha fresh mass and 11,266 kg/ha dry matter.

The nutrient composition and energy value of the harvested fresh fodder from *Cichorium intybus* and *Carthamus tinctorius* are presented in Table 1. Comparative analysis of the whole-plant nutrient content showed that the fresh forage of both species had a higher crude protein level than that of traditional forage crops such as corn (*Zea mays*) and sunflower (*Helianthus annuus*). Chicory forage was notable for its significantly higher crude fat content, while safflower fodder had a lower crude fat concentration compared to corn and sunflower. The crude fiber content in safflower fodder was within the optimal range, while in chicory forage, it did not differ significantly from that in sunflower forage. Safflower fodder had higher levels of nitrogen-free extract and starch than sunflower, but these values were lower than those found in corn forage. Chicory forage contained less soluble sugar but more starch compared to both sunflower and safflower. The ash content in chicory fodder was similar to that of sunflower but higher than in safflower and corn. For both *Carthamus tinctorius* and *Cichorium intybus*, the calcium and phosphorus content exceeded that found in corn forage. However, as compared to sunflower, both fodders had lower calcium content but higher phosphorus levels. The gross energy concentrations in safflower and sunflower fresh fodder were similar, but both were lower than those in chicory and corn forage. Safflower forage had higher metabolizable energy (ME) and net energy for lactation (NEl) than chicory and sunflower, though still lower than in

corn. Various studies in the specialized literature report differing results regarding the nutrient content of harvested green biomass from *Carthamus tinctorius* (safflower) and *Cichorium intybus* (chicory) plants. According to LESHEM et al. (2000), safflower herbage contained 10.0-14.6% crude protein (CP) and 489–656 g/kg dry matter digestibility (DMD). STANFORD et al. (2001) reported that *Carthamus tinctorius* harvested at full bloom had a forage composition of 9.7% CP, 1.6% ether extract (EE), 32.1% neutral detergent fiber (NDF), 23.1% acid detergent fiber (ADF), and 636 g/kg effective rumen degradability of dry matter. BROWN & MOOT (2004) observed that the palatable fraction of *Cichorium intybus* forage contained 18% CP and 13.3 MJ/kg metabolizable energy (ME), while the unpalatable fraction had 8% CP and 9.4 MJ/kg ME. WEINBERG et al. (2007) reported safflower herbage nutrient values of 12.2-22.1 g/kg nitrogen, 287-364 g/kg ADF, 410-478 g/kg NDF, 66-104 g/kg water-soluble carbohydrates (WSC), and 521-693 g/kg DMD.

Table 1.

The nutrient composition and energy value of fresh forage biomass from *Cichorium intybus* and *Carthamus tinctorius* as compared with traditional crops

Indices	*Cichorium intybus*	*Carthamus tinctorius*	*Helianthus annuus*	*Zea mays*
Crude protein, % dry matter	11.50	9.22	8.15	6.93
Crude fats, % dry matter	3.82	2.34	3.00	2.61
Crude cellulose, % dry matter	32.91	27.80	33.11	17.24
Nitrogen free extract, % dry matter	40.93	51.96	44.96	69.73
Soluble sugars, % dry matter	5.02	15.80	12.30	6.81
Starch, % dry matter	9.04	6.61	3.99	23.05
Ash, % dry matter	10.84	8.68	10.78	3.48
Calcium, g/kg dry matter	11.80	9.40	12.40	2.30
Phosphorus, g/kg dry matter	3.00	3.00	2.90	2.40
Gross energy, MJ/kg dry matter	18.04	17.82	17.67	18.37
Metabolizable energy, MJ/kg dry matter	9.10	9.83	8.89	11.29
Net energy for lactation, MJ/kg dry matter	5.04	5.63	4.98	6.93

Table 2.

The fermentation profile, chemical composition and energy value of silage from *Cichorium intybus* and *Carthamus tinctorius* as compared with traditional crops

Indices	*Cichorium intybus*	*Carthamus tinctorius*	*Helianthus annuus*	*Zea mays*
pH index	4.19	4.14	4.39	3.73
Organic acids, g/kg dry matter	35.7	25.0	48.9	45.0
Free acetic acid, g/kg dry matter	1.0	0.6	4.2	3.6
Free butyric acid, g/kg dry matter	0	0	0.1	0
Free lactic acid, g/kg dry matter	2.3	6.0	10.8	16.7
Fixed acetic acid, g/kg dry matter	4.1	2.1	6.5	3.8
Fixed butyric acid, g/kg dry matter	0.1	0.1	0.8	0.2

Fixed lactic acid, g/kg dry matter	28.2	16.2	26.5	20.7
Total acetic acid, g/kg dry matter	5.1	2.7	10.7	7.4
Total butyric acid, g/kg dry matter	0.1	0.1	0.9	0.2
Total lactic acid, g/kg dry matter	30.5	22.2	37.3	37.4
Acetic acid, % of organic acids	14.29	10.80	21.88	16.44
Butyric acid, % of organic acids	0.30	0.45	1.84	0.44
Lactic acid, % of organic acids	85.41	88.75	76.28	83.12
Crude protein, % dry matter	10.92	8.42	7.67	6.83
Crude fats, % dry matter	4.17	3.06	2.54	3.50
Crude cellulose, % dry matter	33.20	33.51	36.42	16.47
Nitrogen free extract, % dry matter	41.95	46.22	42.64	69.69
Soluble sugars, % dry matter	2.09	4.09	0.43	0.79
Starch, % dry matter	10.00	7.19	0.66	24.82
Ash, % dry matter	9.76	8.80	10.73	3.52
Calcium, g/kg dry matter	15.10	9.70	10.60	2.30
Phosphorus, g/kg dry matter	2.50	2.80	2.10	2.50
Gross energy, MJ/kg dry matter	18.37	18.05	17.63	18.53
Metabolizable energy, MJ/kg dry matter	9.18	9.21	8.37	11.59
Net energy for lactation, MJ/kg dry matter	5.09	5.14	4.82	7.14

ARSLAN et al. (2008) found that pure safflower herbage contained 7.3% CP, 27.6% crude fiber (CF), 35.8% ADF, 44.6% NDF, 17.2 g/kg calcium (Ca), and 3.4 g/kg phosphorus (P). In contrast, mixtures of field pea and safflower showed improved nutrient profiles: 12.2-16.4% CP, 22.9-25.7% CF, 30.8-33.4% ADF, 39.1-42.4% NDF, 12.6-15.4 g/kg Ca, and 3.2-3.3 g/kg P. BAR-TAL et al. (2008) indicated that the forage value of *Carthamus tinctorius* varied depending on nitrogen fertilization and irrigation levels, with results ranging between the following indices 13.1-20.5 g/kg nitrogen, 4.8-8.8% ash, 30.9-43.9% ADF,44.8-56.8% NDF, 4.70-8.98% WSC, and 521-693 g/kg *in vitro* dry matter digestibility (IVDMD).

CHAPMAN et al. (2008) reported that during its establishment year, chicory produced 1,350-1,924 kg/ha of dry matter with a CP content of 14.4-16.6% and 59.2% NDS. MASSOUD et al. (2009) found that chicory leaves contained 14.70% CP, 10.91% ash, 16.78% CF, 70.71% total carbohydrates, 7.80% total soluble sugars, and 0.29% Ca. PEIRETTI (2009) analyzed safflower forage harvested at five morphological stages, finding nutrient and energy concentrations ranging from 83–157 g/kg DM, 12.4–27.2% CP, 2.2–2.9% CF, 17.2–41.5% ADF, 31.3–49.1% NDF, 10.7–17.1% ash, and 16.2–17.8 MJ/kg gross energy. HAYES et al. (2010) noted that whole chicory plants harvested in early summer contained 13.1% CP, 43.2% NDF, 24.8% ADF, 12.6% ash, 64.24% DMD, and 9.07 MJ/kg ME. SUN et al. (2011) reported that chicory forage had 89 g/kg DM, 11.7% CP, 28.1% NDF, 21.3% ADF, 8.0%

ADL, and 14.4% ash. Finally, KHAN et al. (2013) found that *Cichorium intybus* contained 13.51% CP, 49.50% NDF, 38.73% ADF, 2.86% ash, and 0.62% Ca. For comparison, *Medicago polymorpha* showed higher values: 21.54% CP, 53.64% NDF, 42.83% ADF, 11.28% ash, and 1.02% Ca. DANIELI et al. (2011) reported that the nutritional characteristics of spineless safflower grown under Mediterranean climatic conditions were as follows: 11-17% CP, 39.8-43.9% CF, 33.1–35.4% aADF, 42.9-45.9% aNDF, 7.4-11.7% ADL, and 12.4-13.2% ash. ASGHARZADEH et al. (2013) found that *Carthamus tinctorius* herbage, depending on the amount and type of applied fertilizers, contained 343-380 g/kg dry matter, 9.5-13.8% CP, 37.2-42.1% NDF, 32.7-35.7% ADF, 5.2-5.4% WSC, 6.0-11.7% ash, 10-12 g/kg Ca, 2.9-3.9 g/kg P, 57.1-68.2% OMD, and 8.5-10.0 MJ/kg ME. DANIELI et al. (2014) confirmed similar findings for spineless safflower under Mediterranean conditions, reporting values of: 11-17% CP, 39.8–43.9% CF, 33.1-35.4% aADF, 42.9-45.9% aNDF, 7.4-11.7% ADL, and 12.4-13.2% ash. PILUZZA et al. (2014) reported that the chemical composition of chicory leaves included 162-200 g/kg CP, 290.6-336.8 g/kg ADF, 366-406.5 g/kg NDF, 570.4-638.2 g/kg total digestible nutrients, 621.6-662.6 g/kg digestible dry matter, a relative feed value of 143.7-170.6, and 1.401-1.539 Mcal/kg NEl.RETA SANCHEZ et al. (2014) found that *Carthamus tinctorius* herbage, depending on row spacing, contained 17.1-19.5% CP, 43.7-48.1% NDF, 33.3-35.7% ADF, and 1.37-1.43 Mcal/kg NEl. HEUZÉ & TRAN (2015) reported that the biochemical composition and nutritive value of safflower dry matter was: 15.0% CP, 11.3% ash, 14.0 g/kg Ca, 3.4 g/kg P, 65.1% digestible organic matter, 17.5 MJ/kg GE, and 9.3 MJ/kg ME. Muir et al. (2015) found that forage from a second-year chicory crop contained 271 g/kg dry matter and the following composition: 13.57% ash, 6.1% CP, 48.8% NDF, 32.4% ADF, with an estimated digestible energy of 7.6 MJ/kg. KIRILOV et al. (2016) reported that *Cichorium intybus* contained 7.56% ash, 7.16% CP, 35.26% CF, and 46.68% NFE, whereas *Medicago sativa* had 8.14% ash, 16.92% CP, 1.41% EE, 27.53% CF, and 46.00% NFE. ÇAĞRI & KARA (2018) reported that the forage value of safflower green mass was: 8.10% CP, 6.51% DP, 39.05% aNDF, 31.99% aADF, 4.75% ADL, and 2040.83 kcal/kg ME. DRAGOMIR et al. (2018) found that the crude protein content in chicory forage was 22.62% in the non-fertilized variant and 25.06% in the nitrogen-fertilized variant. NIDERKORN et al. (2019) reported that chicory forage contained 103 g/kg dry matter, 14.2% CP, 35.3% NDF, 20.8% ADF, and 6.3% ADL. SUN et al. (2020) noted that chicory forage had 11.4% CP, 23.9% NDF, 18.8% ADF, 5.1% hemicellulose (HC), 10.6% cellulose (Cel), and 19.6% ash. AMALYADI et al.

(2022) stated that chicory forage harvested at 45 days had the following nutritional values depending on treatment: 17.23-19.41% CP, 12.12-13.43% CF, 76.11-77.53% DDM, and 70.36-73.69% OMD. ÇALIŞKAN & YÜKSEL (2022) found that the nutrient composition of safflower forage dry matter was: 8.36–12.29% CP, 31.30–47.92% NDF, and 27.61–38.59% ADF. OCHOA-ESPINOZA et al. (2022a) found that the forage value of spiny safflower cultivars was as follows: 22.6-23.3% CP, 46.7-47.7% NDF, 38.1-38.9% ADF, 64-65% IVDMD, and 5.36-5.48 MJ/kg NEl. In contrast, the spineless safflower cultivar 'Selkino' contained 24.7% CP, 47.5% NDF, 39% ADF, 67.4% IVDMD, and 5.73 MJ/kg NEl. LÓPEZ-JARA et al. (2022) reported that the forage value of *Carthamus tinctorius* was 16.2-17.9% CP, 40.2-46.3% NDF, 31.8-38.0% ADF, and 5.4-6.1 MJ/kg NEl, while *Brassica napus* forage had, respectively, 17.1-19.9% CP, 36.8-45.7% NDF, 30.4-35.9% ADF, and 5.7-6.3 MJ/kg NEl. OCHOA-ESPINOZA et al. (2022b) revealed that the forage from *Carthamus tinctorius* cultivars was characterized by 17.79-24.35% CP, 49.46-50.91% NDF, 39.82-43.34% ADF, 53.58-58.58% IVDMD, and 4.37-4.87 MJ/kg NEl. STOYCHEVA & GEORGIEVA (2022) reported that chicory green mass contained 212.4 g/kg dry matter, with 8.16% ash, 9.48% CP, 27.84% CF, and 51.27% NFE. VERMA et al. (2022) found that the chemical composition of first-cut chicory plants included 12.2-18.1% CP, 34.6-46.4% NDF, and 21.2-28.1% ADF. At the second cut, chicory fodder had 13.7-22.0% CP, 30.1-44.9% NDF, and 23.2-30.1% ADF. BASBAG & SAYAR (2023) reported that the fodder harvested at the blooming stage from *Cichorium intybus* contained 20.55% CP, 30.19% NDF, 21.78% ADF, 1.46% Ca, 0.30% P, 71.74% DMD, 11.43 MJ/kg ME, and a relative feed value of 221.7. In comparison, the fodder from *Sylibum marianum* had 18.59% CP, 30.38% NDF, 24.61% ADF, 1.54% Ca, 0.34% P, 69.73% DMD, 11.01 MJ/kg ME, and RFV = 219.3. MIKULOVÁ et al. (2023) reported that the nutrient composition of dry matter from chicory plants included 19.8% CP, 38.4% NDF, 28.2% ADF, and 7.4% ash. SEENO (2023) found that the nutritive value of harvested chicory monoculture in spring was: 12.9-16.3% CP, 32.3% aNDF, 23.7-24.1% ADF, and 11.8-12.1% ash, but in summer, the values were 10.4-11.3% CP, 35.4-37.0% aNDF, 26.7-27.9% ADF, and 12.4% ash, respectively. JABARI et al. (2023) observed that the crude protein content in safflower plants harvested at the branching stage was 14.57%, while the maximum CP content, 19.22%, was observed at the flowering stage. KARGAR et al. (2024) reported that safflower forage harvested during the stem elongation stage contained 11.6-13.9% CP, 8.5-15.7% WSC, 28.6-32.0% CF, 9.5-10.2% ash, 61.8-66.9% DDM, 52.5-59.8% TDN, and an RFV of 85.5-107.6, in contrast,

the forage harvested at the branching stage had 18.5-19.8% CP, 8.4-13.2% WSC, 31.5-35.5% CF, 10.1-10.6% ash, 65.9-71.5% DDM, 56.0-64.2% TDN, and an RFV of 86.1-129.0. Silage making is a widely used and effective method of forage preservation and serves as a critical strategy for ensuring a consistent, high-quality fodder supply throughout the year. During sensory evaluation, the ensiled mass of *Carthamus tinctorius* and *Cichorium intybus* was found to contain dark green leaves and yellow stems. The silage emitted a specific but mild and pleasant smell. Its texture remained consistent as compared to the original green mass, showing no signs of mold or mucus formation. The results of the silage quality indices for safflower and chicory are presented in Table 2. Safflower silage had a dry matter content of 282.5 g/kg, while chicory silage contained 264.4 g/kg. The pH value, a key indicator of fermentation quality, ranged from 4.14 to 4.19 for both silages. These values were higher than those typically observed in corn silage but within the optimal range when compared with sunflower silage. Total organic acid concentrations ranged from 25.0 g/kg in safflower silage to 35.7 g/kg in chicory silage – both lower than those found in corn and sunflower silages. Most organic acids were present in bound form. Acetic acid concentrations in both safflower and chicory silages were lower than in corn and sunflower silages. Butyric acid was detected only in trace amounts (0.1 g/kg), significantly lower than in sunflower silage. Lactic acid constituted 85.4–88.7% of the total organic acids in both silages, indicating a favorable fermentation process and good silage quality. During ensiling, the biochemical composition underwent noticeable changes. The levels of crude protein, soluble sugars, and phosphorus decreased, while crude fat and calcium concentrations increased. In safflower silage, crude fiber content rose significantly, while nitrogen-free extract declined. The metabolizable energy (ME) and net energy for lactation (NEl) in safflower silage were lower than in the original fresh mass. In contrast, chicory silage showed no significant difference in energy values as compared to its initial green mass. It is worth noting that chicory and safflower silages were characterized by higher contents of crude protein, crude fat, soluble sugars, starch, phosphorus, metabolizable energy and net energy for lactation compared to sunflower silage. When compared with corn silage, both chicory and safflower silages had higher concentrations of crude protein, crude fiber, soluble sugars, ash, calcium, and phosphorus. However, corn silage had the highest overall energy values among the four silage types. Several literature sources describe the quality indices of silage prepared from *Carthamus tinctorius* and *Cichorium intybus* plants. For example, WEINBERG et al. (2002) found that the silage made from wilted *Carthamus tinctorius* plants

contained 290-411 g/kg dry matter, with a pH of 4.46, 19-20 g/kg lactic acid, 4-6 g/kg acetic acid, 85-89 g/kg crude protein, 86-92 g/kg ash, and 15-28 g/kg water-soluble carbohydrates. Inoculated safflower silages had improved fermentation characteristics: pH 3.9-4.1, 42–47 g/kg lactic acid, 6-8 g/kg acetic acid, and 12-20 g/kg WSC. CORLETO et al. (2005) reported that safflower silage produced from plants harvested at 25% flowering stage had a pH of 4.46, 18.7 g/kg lactic acid, 4.7 g/kg acetic acid, and 376 g/kg dry matter. The nutritional profile included 8.0% CP, 49.3% NDF, 37.3% ADF, 5.9% ADL, 5.27% WSC, and 6.9% ash. In contrast, the silage made from plants inoculated with *Lactobacillus plantarum* showed improved values: pH 4.15, 29.2 g/kg lactic acid, 5.7 g/kg acetic acid, 399 g/kg dry matter, 8.6% CP, 51.2% NDF, 37.6% ADF, 6.1% ADL, 4.97% WSC, and 9.8% ash. WEINBERG et al. (2007) noted that *Carthamus tinctorius* silage produced under different irrigation and nitrogen fertilization regimes had a pH range of 4.0-4.8, and contained 34-127 g/kg lactic acid, and 4-15 g/kg acetic acid. ASGHARZADEH et al. (2013) found that safflower silages had pH values of 4.7-4.9, and contained 90-130 g/kg lactic acid, 290-433 g/kg dry matter, 12.3-14.8% CP, 45.3-49.0% NDF, 37.2-42.1% ADF, 1.9-2.8% WSC, 9.0-12.3% ash, 10-13 g/kg Ca, 3.0-4.2 g/kg P, 56.2-65.4% OMD, and 8.2–9.6 MJ/kg ME. HEUZÉ & TRAN (2015) reported that safflower silage contained 12.6% CP, 31.4% CF, 8.9% ash, 70.2% DOM, 17.5 MJ/kg gross energy, and 10.6 MJ/kg ME. PEÑA-ESPINOZA et al. (2016) indicated that chicory silage had 357 g/kg dry matter, 20.7% ash, 9.3% CP, 32.6% NDF, 62% OMD, and 6.5 MJ/kg ME. SÁNCHEZ-DUARTE et al. (2018) reported that *Carthamus tinctorius* silage contained 372.6 g/kg dry matter, 17.7% CP, 45.16% NDF, 491.5 g/kg TDN, and 1.11 Mcal/kg NEl. STOYCHEVA et al. (2019) observed that *Cichorium intybus* silage had 195 g/kg dry matter and a pH of 4.69, while chicory haylage contained 521 g/kg dry matter and a pH of 4.25. CAN et al. (2020) found that chicory silage was characterized by a pH of 4.19, 17.8 g/kg lactic acid, 1.43 g/kg acetic acid, and 0.16 g/kg butyric acid. The silage had 267.5 g/kg dry matter, 11.21% ash, 1.13% Ca, 0.37% P, 15.35% CP, 33.11% NDF, and 26.30% ADF. STOYCHEVA &GEORGIEVA (2022) reported that chicory silage contained 212.4 g/kg dry matter, with a pH of 4.04, 8.73% ash, 9.15% CP, 31.53% CF, and 46.72% NFE. FORD et al. (2024) stated that chicory silage had 8.7% CP, 51.7% NDF, 46.0% ADF, 1.06 Mcal/kg NEl, and a relative feed value of 96. LÓPEZ-JARA et al. (2025) found that the silage prepared from *Carthamus tinctorius* had a pH of 4.97, 448.1 g/kg dry matter, 17.88% CP, 37.10% NDF, 28.45% ADF, 10.11% ADL, 19.12% ash, 657.0 g/kg TDN, and 1.57 Mcal/kg NEl. In comparison, *Avena sativa* silage had a pH of

4.75, 388.0 g/kg dry matter, 13.76% CP, 52.02% NDF, 32.20% ADF, 4.26% ADL, 12.84% ash, 604.2 g/kg TDN, and 1.38 Mcal/kg NE.

CONCLUSIONS

The green mass forage and the silage prepared from *Cichorium intybus* and *Carthamus tinctorius* are rich in crude protein and other essential nutrients, making them suitable alternatives for the traditional livestock fodders.

ACKNOWLEDGEMENTS

The study has been carried out in the framework of the subprogram no. 01.01.02 *"Identification of valuable forms of plant resources with multiple uses for the circular economy""*

REFERENCES

1. Adamchuk L., Bilotserkivets T., Šimková J. (2017). Nectar and pollen productivity of common chicory. *Agrobiodiversity for Improving Nutrition Health and Life Quality*, Nitra, 1-7
2. Amalyadi R., Umami N., Fitrianto N.A., Hanim C., Suwignyo B. (2022). Effect of compost tea and harvest age on productivity, nutrient content, and in vitro digestibility cichorium intybus. *Buletin Peternakan*, 46(3): 140-147.
3. Arslan B., Ates E., Tekeli A.S., Esendal E. (2008). Feeding and agronomic value of field pea (*Pisum arvens*e L.)- safflower (*Carthamus tinctorius* L.) mixtures. In. *7th international Safflower Conference*. Wagga, Australia.
4. Asgharzadeh F., Nasri M.H.F., Behdani M.A. (2013). Effects of nitrogen and phosphorus fertilizers on nutritive value of safflower forage and silage. *Journal of Animal and Poultry Sciences*, 3:66-75.
5. Bar-Tal A., Landau S., Li-Xin Z., Markovitz T., Keinan M., Dvash L., Brener S., Weinberg G. (2008). Fodder quality of safflower across an irrigation gradient and with varied nitrogen rates. *Agronomy Journal*, 100: 1499–1505.
6. Basbag M., Sayar M. (2023). Forage quality traits of some *Asteraceae* family species found in natural flora of Southeastern Anatolia. *Journal of Agricultural, Food and Environmental Sciences*, 77:29-37.
7. Birsa M.L.; Sarbu L.G. Health benefits of key constituents in *Cichorium intybus* L. (2023). *Nutrients*, 15:1322.
8. Brown H., Moot D. (2004). Quality and quantity of chicory, lucerne and red clover production under irrigation. *Proceedings of the New Zealand Grassland Association*, 66:257–264.
9. Çalişkan R., Yüksel O. (2022). The effects of different sowing density and harvest periods on dry matter yield and some quality traits of safflower (*Carthamus tinctorius* L.) *Akademik Ziraat Dergis*. 11(1): 147-154.

10. Can M., Ayan I., Gülümser E., Acar Z., Öztürk E. (2020). Determination of silage quality of different companion crops with chicory (*Cichorium intybus* L.). *Turkish Journal of Agricultural Research*, 7(3): 296-304.
11. Çağrı A., Kara K. (2018). The effect of safflower on the in vitro digestion parameters and methane production in horse and ruminant. *Acta Veterinaria Eurasia*, 44(2): 73-84.
12. Ciocârlan N. (2014). Cicoarea - un remediu ideal pentru sănătatea ta. *Mediul Ambiant*, 6(78):39-40.
13. Chapman G., Bork E., Donkor N., Hudson, R. (2008). Forage yield and quality of chicory, birdsfoot trefoil, and alfalfa during the establishment year. *The Open Agriculture Journal*, 2: 68-74.
14. Corleto A., Cazzato E., Laudadio V., Petrera F. (2005). Evolution of biomass and quality of safflower during the reproductive stage for hay and ensiling purposes. In. *6th International Safflower Conference*, Istanbul, Turkey, 69-73.
15. Coșman S., Danilov A., Petcu I., Țîței V., Coșman V., Bahcivanji M. (2023). *Diversificarea bazei furajere prin studierea și valorificarea unor resurse furajere noi și mai puțin cunoscute în Republica Moldova.* Maximovca. Print-Caro. 340 pp
16. Danieli P.P., Primi R., Ronchi B., Ruggeri R., Rossini F., Del Puglia S., Cereti C.F. (2011). The potential role of spineless safflower (*Carthamus tinctorius* L. var. *inermis*) as fodder crop in central Italy. *Italian Journal of Agronomy*, 6: 19-22.
17. Dobrin A., Marin D. (2015). Research on safflower (*Carthamus tinctorius* L.) crop in the conditions of southeastern Romania. *Scientific Papers. Series A. Agronomy*. 58: 181–184.
18. Dragomir N., Horablaga M., Moraru N., Camen D., Neciu F., Dragoș M., Rechițean D. (2018). Forage chicory (*Cichorium intybus* L.): an alternative source for livestock feeding. *Research Journal of Agricultural Science*, 50 (3):33-36.
19. Elgersma A., Søegaard K., Jensen S.K. (2014). Herbage dry-matter production and forage quality of three legumes and four non-leguminous forbs grown in single-species stands. *Grass and Forage Science*, *69*(4), 705-716.
20. Emongor V., Oagile O. (2017). *Safflower Production*.
21. Ford H., Hasan D., Ates S., Puerto-Hernandez G., Klopfenstein J.J., Trevisi E., Smallman M., Matra M., Bionaz M. (2024) Feeding chicory silage, but not Se-yeast or a single injection of inorganic Se, affects metabolism, fat in milk, and type I immunity in transition ewes *Frontiers in Animal Science*, 5:1499480. *doi: 10.3389/fanim.2024.1499480*
22. Guțu A., Ţîţei V., Cîrlig N., Ababii A., Covalciuc D. Gadibadi M., Doroftei V., Mocanu N., Gudima A.; Cozari S. (2023). Biological features and biomass quality of some *Helianthus* species under the conditions of the Republic of Moldova. *Scientific Papers. Series A. Agronomy*. 66 (1): 697-708.

23. Cazzato E., Laudadio V., Corleto A., Tufarelli V. (2011). Effects of harvest date, wilting and inoculation on yield and forage quality of ensiling safflower (*Carthamus tinctorius* L.) biomass. *Journal of the Science of Food and Agriculture*, 91(12):2298–302.
24. Hayes R.C., Dear B.S., Li G.D., Virgona J.M., Conyers M.K., Hackney B.F., Tidd J. (2010). Perennial pastures for recharge control in temperate drought-prone environments. Part 1: Productivity, persistence and herbage quality of key species. *New Zealand Journal of Agricultural Research*, 53(4), 283-302.
25. Heuzé V., Tran G. (2015). Safflower (*Carthamus tinctorius*) forage. *Feedipedia.*
26. Jabbari H., Golzardi F., Shariati F., Asadi H. (2023). Effect of harvesting time on quantitative and qualitative characteristics of safflower cultivars forage in autumn planting. *Journal of Crops Improvement*, 25 (1), 65-81.
27. Ivanova R. (2016). Theoretical and practical aspects of the introduction of safflower (*Carthamus tinctorius* L.) in the Republic of Moldova. *Oltenia. Studii și comunicări. Științele Naturii*. 32(2):48-51
28. Khan R., Khan M., Sultan S., Marwat K., Khan M., Hassan G., Shah H. (2013). Nutritional quality of sixteen terrestrial weeds for the formulation of cost-effective animal feed. *Journal of Animal and Plant Sciences*, 23(1): 75-79.
29. Kirilov A., Georgieva N., Stoycheva I. (2016). Determination of composition and palatability of certain weeds. *International Journal of Agricultural Science and Food Technology*, 2:41-43.
30. Kocaman I., Istanbulluoglu A., Konukcu F. (2016). Effects of deficit irrigation regimes on yield and growth components of winter safflower (*Carthamus tinctorius* L.). *Romanian Agricultural Research*. 33:267-275.
31. Kargar, M., Sayfzadeh, S., Jabari, H., Zakerin, H. and Golzardi, F. (2024) Forage yield, seed, and forage qualitative traits evaluation by determining the optimal forage harvesting stage in dual-purpose cultivation in safflower varieties (*Carthamus tinctorius* L.). *Open Agriculture*. 32. Leshem Y., Bruckental I., Landau S., Ashbell G., Weinberg Z., Brosh A. (2000). Safflower — new forage crop in Israel. *Meshek Habakar Vehachalav*, 286:27– 32.
33. Li G.D., Nie Z., Bonython A., Boschma S.P., Hayes R. C., Craig A.D., Hughes S.J. (2010). Evaluation of chicory cultivars and accessions for forage in south-eastern Australia. *Crop and Pasture Science*, 61(7): 554-565.
34. López-Jara A.G., Reta-Sánchez D.G., Reyes-González A., Santana O.I., López-Calderón M.J., Sanchez- Duarte J.I. (2022). Composición nutritiva y productividad de forrajes alternativos de otoño- invierno en diferentes fechas de siembra del norte de México. *Revista Mexicana de Ciencias Agrícolas*, 125-135
35. López-Jara A.G., Reta-Sánchez D.G., Santana O.I., Reyes-González A., Rodríguez Hernández K., Granados-Niño J.A., López-Calderón M.J., Sánchez-Duarte J.I. (2025). Rendimiento de forraje y valor nutritivo del

ensilado de forrajes alternativos y tradicionales de otoño-invierno. *Revista Mexicana de Ciencias Pecuarias*, 16(1): 208-223.

36. Massoud M.I., Amin W.A., Elgindy A.A. (2009) Chemical and technological studies on chicory (*Cichorium intybus* L.) and its applications in some functional food. Journal of Advanced. *Agricultural Research*, 14(3):735–756.
37. Mikulová K., Petrič D., Komáromyová M., Batťányi D., Kozłowska M., Cieslak A., Ślusarczyk S., Várady M., Váradyová Z. (2023). Growth performance and ruminal fermentation in lambs with endoparasites and in vitro effect of medicinal plants. *Agriculture*, 13(9), 1826.
38. Moraru N., Dragomir N., Pădeanu I., Ghiocel C. (2012). Forage chicory. *Research Journal of Agricultural Scienc*e, 44 (4):125-128.
39. Muir S.K., Ward G.N., Jacobs J.L. (2014). Milk production and composition of mid-lactation cows consuming perennial ryegrass-and chicory-based diets. *Journal of Dairy Science*, 97(2): 1005-1015.
40. Muir S.K., Ward G.N., Jacobs J.L. (2015). Herbage intake and milk production of late-lactation dairy cows offered a second-year chicory crop during summer. *Journal of Dairy Science*, 98(12):8825-8835.
41. Neciu F.C., Săplăcan G., Rechițean D., Dragomir N. (2017). Forage chicory (*Cichorium intybus* L.)-Pretability in crops and effects in ruminants feeding. Review. *Scientific Papers Animal Science and Biotechnologies*, 50(1): 170-176.
42. Niderkorn V., Martin C., Bernard M., Le Morvan A., Rochette Y., Baumont R. (2019). Effect of increasing the proportion of chicory in forage-based diets on intake and digestion by sheep. *Animal*,*13*(4): 718-726.
43. Nwafor I.C., Shale K., Achilonu M.C. (2017). Chemical composition and nutritive benefits of chicory (*Cichorium intybus*) as an ideal complementary and/or alternative livestock feed supplement. *The Scientific World Journal*, 2017(1), 7343928. *https://doi.org/10.1155/2017/7343928*
44. Ochoa-Espinoza X.M., Reta-Sánchez D.G., Cano- Ríos P., Sánchez-Duarte J.I., Ochoa-Martínez E., García-Martínez J.E., Reyes-González A., Quiroga-Garza H.M. (2022a). Rendimiento y valor nutritivo de cereales y cártamo forrajero en la Comarca Lagunera. *Biotecnia*. 24(2):142-148.
45. Ochoa-Espinoza X.M., Reta-Sánchez D.G., Cano- Ríos P., Sánchez-Duarte J.I., Ochoa-Martínez E., García-Martínez J.E., Reyes-González A. (2022b). Nutritional yield and composition of spiny and spineless varieties of safflower (*Carthamus tinctorius* L.) forage harvested at four phenological stages. *The Open Agriculture Journal*. 16. *10.2174/18743315-v16-e2201250.*
46. Peiretti P.G. (2009). Effects of growth stage on chemical composition, organic matter digestibility, gross energy and fatty acid content of safflower (*Carthamus tinctorius* L.). *Livestock Research for Rural Development* 21(12). *http://www.lrrd.org/lrrd21/12/peir21206.htm*

47. Peiretti P.G. (2017). Nutritional aspects and potential uses of safflower (*Carthamus tinctorius* L.) in livestock. *Agricultural Research Updates*. 19: 3-22
48. Peña-Espinoza M., Valente A.H., Thamsborg S.M., Simonsen H.T., Boas U., Williams A. R. (2018). Antiparasitic activity of chicory (Cichorium intybus) and its natural bioactive compounds in livestock: a review. *Parasites & Vectors*, 11: 1-14.
49. Pena-Espinoza M., Thamsborg S.M., Desrues O., Hansen T.V., Enemark H.L. (2016). Anthelmintic effects of forage chicory (*Cichorium intybus*) against gastrointestinal nematode parasites in experimentally infected cattle. *Parasitology*, 143(10): 1279-1293.
50. Piluzza G., Sulas L., Bullitta S. (2014). Dry matter yield, feeding value, and antioxidant activity in Mediterranean chicory (*Cichorium intybus* L.) germplasm. *Turkish Journal of Agriculture and Forestry*, 38(4):506-514.
51. Rambaud C., Croy M., Choque E. (2025). The great diversity of products from *Cichorium intybus* L. culture: how to valorize chicory byproducts: a review. *Discover Plants*, 2(1): 107. https://doi.org/10.1007/s44372-025-00195-3
52. Reta-Sánchez D.G., Serrato-Corona J.S., Gaytán Mascorro A., Quiroga H.M., Hernández G.O., Payán García J.A. (2014). Forage potential of safflower in response to row spacing in the Comarca Lagunera. *Agrofaz*, 14:65-71.
53. Sánchez-Duarte J.I., Reta-Sánchez D.G., Reyes-González A., Ochoa-Martínez E., Rodríguez Hernández K., Maldonado-Jáquez J.A. (2018). Evaluación comercial del ensilaje de cártamo forrajero en la Comarca Lagunera. In. XIV Congreso Nacional sobre Recursos Bióticos de Zonas Áridas *"Hacia el Uso Sustentable de los Recursos Naturales de Zonas Áridas"*, 18-20.
54. Seeno, E. (2023). Forage production, dual use potential, and trait variation in chicory grown in the Pacific Northwest. Dissertation for the degree of Doctor of Philosophy. Oregon State University. 156p.
55. Stanford K., Wallins G.L., Lee B.M., Mündel H-H. (2001). Feeding value of immature safflower forage for dry ewes. *Canadian Journal of Animal Science*. 81: 289–292.
56. Stoycheva I., Georgieva N. (2022). Chemical composition and suitability for ensiling of main weeds in agrocenoses of forage crops, using a biological preparation for ensiling. *Journal of Mountain Agriculture on the Balkans*, 25 (5):168-180.
57. Stoycheva I., Georgieva N., Nikolova I. (2019). Determination of the suitability for silage of basic weeds in agrocenoses of forage crops. *Journal of Mountain Agriculture on the Balkans*, 22 (4): 79-87.
58. Sun X., Chen A., Pacheco D., Hoskin S.O., Luo D. (2020). Sheep rumen fermentation characteristics affected by feeding frequency and feeding level when fed fresh forage. *Animals*, 10(1): 7.
59. Sun X.Z., Hoskin S.O., Muetzel S., Molano G., Clark H. (2011). Effects of forage chicory (*Cichorium intybus*) and perennial ryegrass (*Lolium*

perenne) on methane emissions in vitro and from sheep. *Animal Feed Science and Technology*, 166-167:391–397
60. Ţîţei V. (2024). Agroeconomic value of jerusalem artichoke *Helianthus tuberosus* cultivars. *Romanian Agricultural Research*. 41:315-327.
61. Ţîţei V. (2020). The biochemical composition and the feed value of green mass and silage from *Cynara cardunculus* and *Helianthus tuberosus* in the Republic of Moldova. *Scientific Papers, series D, Animal Science*. 63 (1):122-127.
62. Ţîţei V., Coşman S. (2016). Biochemical characteristics of the *Asteraceae* species silage and possible use as a feedstock for livestock and biogas production in Republic of Moldova. *Research Journal of Agricultural Science*. 48(2):105-112.
63. Ţîţei V., Teleuţă A.; Muntean A. (2013). The perspective of cultivation and utilization of the species *Silphium perfoliatum* L. and *Helianthus tuberosus* L. in Moldova. *Bulletin UASMV Cluj-Napoca, serie Agriculture,* 70(1):160-166.
64. Umami N., Abdiyansah A., Agus, A. (2019). Effects of different doses of NPK fertilization on growth and productivity of *Cichorium intybus*. *IOP Conference Series: Earth and Environmental Science*, 387(1): 012097.
65. Verma S., Wolffram S., Salminen J.P., Hasler M., Susenbeth A., Blank R., Malisch C.S. (2022). Linking metabolites in eight bioactive forage species to their in vitro methane reduction potential across several cultivars and harvests. *Scientific Reports*, 12(1): 10454.
66. Weinberg Z.G., Ashbell G., Hen Y., Leshem Y., Landau Y.S., Brukental I. (2002). A note on ensiling safflower forage. *Grass and Forage Science*. 57: 184-187.
67. Weinberg Z.G., Bar-Tal A., Gamburg M., Brener S., Dvash L., Markovitz T., Landau S. (2007). The effects of irrigation and nitrogen fertilization on the ensiling of safflower (*Carthamus tinctorius*). *Animal Feed Science and Technology*. 134:152-161.
68. Verma S., Wolffram S., Salminen J.P., Hasler M., Susenbeth A., Blank R., Malisch C.S. (2022). Linking metabolites in eight bioactive forage species to their in vitro methane reduction potential across several cultivars and harvests. *Scientific Reports,12*(1), 10454.
* SM 108:1995 (1996): *Siloz din plante verzi*. Condiţii tehnice. Moldovastandart. 10.