THE BIOCHEMICAL COMPOSITION AND NUTRITIVE VALUE OF GREEN MASS AND SILAGE FROM SAFFLOWER *Carthamus tinctorius* L.

ŢÎŢEI Victor

Abstract. Safflower – *Carthamus tinctorius* L. – is a climate-smart crop, adaptable to variable environmental conditions as compared with other species in the *Asteraceae* family. The goal of this study was to evaluate the biochemical composition and the nutritive value of green mass and silage from safflower, *Carthamus tinctorius* L., cultivated in the experimental plot of the "Alexandru Ciubotaru" National Botanical Garden (Institute) MSU, Chisinau. The safflower whole plants harvested in the flowering period were found to contain 295.0 g/kg dry matter with 9.22% crude protein, 2.34% crude fats, 27.80% crude cellulose, 51.96% nitrogen free extract, 6.61 % starch, 15.8% soluble sugars, 8.68 % ash, 0.94% calcium, 0.30% phosphorus and feed energy values of 17.82 MJ/kg gross energy, 9.83 MJ/kg metabolizable energy, 5.63 MJ/kg net energy for lactation. The quality indices of prepared safflower silage were: 282.5 g/kg dry matter, pH=4.14, 22.2 g/kg lactic acid, 2.7 g/kg acetic acid, 0.1 g/kg butyric acid, 8.42% crude protein, 3.06% crude fats, 33.51% crude cellulose, 46.22% nitrogen free extract, 7.19 % starch, 4.09% soluble sugars, 8.80 % ash, 0.97% calcium, 0.28% phosphorus and feed energy values 18.05 MJ/kg gross energy, 9.21 MJ/kg metabolizable energy, 5.14 MJ/kg net energy for lactation. Our results suggest that safflower contains many nutrients, which make it suitable to be used as alternative fodder for livestock.

Keywords: biochemical composition, *Carthamus tinctorius*, green mass, nutritive value, silage.

Rezumat. Compoziția biochimică și valoarea nutritivă a masei verzi și a silozului din plantele de șofrănel *Carthamus tinctorius* L. Șofrănelul, *Carthamus tinctorius* L. este o cultură inteligentă din punct de vedere climatic, mai adaptată la condiții variabile de mediu în comparație cu alte specii din familia *Asteraceae*. Scopul acestui studiu a fost evaluarea compoziției biochimice și a valorii nutritive a masei verzi și a silozului preparat din plantele de șofrănel *Carthamus tinctorius* L. cultivate în sectorul experimental al Grădinii Botanice Naționale (Institutul) „Alexandru Ciubotaru" USM, Chișinău. S-a stabilit că plantele de șofran recoltate în perioada de înflorire au conținut 295.0 g/kg substanță uscată cu o concentrație de 9.22% proteină brută, 2.34% grăsimi brute, 27.80% celuloză brută, 51.96% substanțe extractive neazote, 6.61% amidon, 15.8% zaharuri solubile, 8.68% cenușă, inclusiv 0.94% calciu și 0.30% fosfor, iar valoaria energetică fiind de 17.82 MJ/kg energie brută, 9.83 MJ/kg energie metabolizantă și 5.63 MJ/kg energie netă lactație. Indicii de calitate ai silozului preparat din plantele de șofrănel au fost: 282.5 g/kg substanță uscată, pH=4.14, 22.2 g/kg acid lactic, 2.7 g/kg acid acetic, 0.1 g/kg acid butiric, 8.42% proteină brută, 3.06% grăsimi brute, 33.51% celuloză brută, 46.22% substanțe extractive neazote, 7.19% amidon, 4.09% zaharuri solubile, 8.80% cenușă, inclusiv 0.97% calciu și 0.28% fosfor, valoaria energetică de 18.05 MJ/kg energie brută, 9.21 MJ/kg energie metabolizantă și 5,14 MJ/kg energie netă lactație.. Rezultatele noastre sugerează că plantele de șofrănel conține un lot de nutrienți, ceea ce îl face potrivit pentru a fi folosit ca furaj alternativ pentru animale de fermă.

Cuvinte cheie: compoziție biochimică, *Carthamus tinctorius*, masă verde, valoare nutritivă a furajului, siloz.

INTRODUCTION

Asteraceae is recognized as the largest family of flowering plants, thus *The Plant List* mentions approximately 27.773 species, belonging to 1.765 plant genera, ranging from annual herbs to woody shrubs. Some of these species are of particular interest due to their biological peculiarities, tolerance to biotic and abiotic factors, productivity and multiple possibilities of using them in the circular economy. Plants of the *Asteraceae* family have high potential of being used as forage for livestock. In the framework of our previous studies, we determined the biological peculiarities, productivity and fodder value of several taxa of *Cynara cardunculus*, *Echinacea purpurea*, *Helianthus annuus*, *Helianthus mollis*, *Helianthus strumosus*, *Helianthus tuberosus*, *Inula helenium*, *Silphium perfoliatum*, *Silybum marianum* (ŢÎŢEI & TELEUŢĂ, 2014; ŢÎŢEI & COȘMAN, 2016; ŢÎŢEI, 2020, 2024; COȘMAN et al., 2023).

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. *Carthamus tinctorius* is an annual herbaceous plant with a strong erect central stem, it reaches 30-150 cm in height, it is glabrous, with many primary branches which may produce secondary and tertiary branches. Each branch will usually have one to five flower heads. 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. Safflower has a taproot system that elongates to 2 to 3 m in soils with adequate depth. The deep root system in safflower helps to extract the water and nutrients from much deeper layers of soil, as compared with other crop plants, and thus it is an ideal plant for rain-fed cropping systems. 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; EMONGOR & OAGILE, 2017; PEIRETTI, 2017).

The goal of this study was to evaluate the biochemical composition and the nutritive value of the green mass and silage from safflower, *Carthamus tinctorius*, cultivated under the conditions of the Republic of Moldova.

MATERIALS AND METHODS

The introduced spineless ecotype of safflower *Carthamus tinctorius* cultivated in monoculture in the experimental plot of the "Alexandru Ciubotaru" National Botanical Garden (Institute) MSU, Chişinău, latitude 46°58′25.7″N and longitude N28°52′57.8″E, served as subjects of the research, but the traditional crops – the corn hybrid 'GW9003' of *Zea mays* and the sunflower hybrid 'HS9729' of *Helianthus annuus* – were used as controls. The *Carthamus tinctorius* and *Helianthus annuus* plant samples were collected in the flowering stage, but the *Zea mays* plants were collected in the wax stage of grains. The harvested plants were chopped into 1.5-2.0 cm small pieces, with a laboratory forage chopper; the dry matter content was detected by drying samples up to constant weight at 105°C. The silage was prepared from chopped green mass, compressed in well-sealed glass containers, stored at ambient temperature (18-20°C). After 45 days, the containers were opened, and the sensorial and fermentation indices of the conserved forage were determined in accordance with standard laboratory procedures – the standard SM 108* of Republic of Moldova. The green mass and the fermented fodder samples were dehydrated in an oven with forced ventilation at a temperature of 60°C; at the end of the fixation, the biological material was finely ground in a laboratory ball mill. The evaluation of fodder quality: crude protein, crude cellulose, crude fats, nitrogen-free extract, soluble sugars, starch, ash, calcium, phosphorus, silage pH index, concentration of organic acids (lactic, acetic and butyric) in free and fixed state was carried in accordance with the standard methodological indications. The gross energy, metabolizable energy and net energy for lactation were calculated according to the standard 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 DISCUSSIONS

It has been established the green mass yield of *Carthamus tinctorius*, harvested in flowering stage, reached 3.74 kg/m^2 with 29.5% dry matter content. The biochemical composition and nutritive value of the harvested green mass of the studied *Carthamus tinctorius* ecotype are presented in Table 1. The comparative analysis of whole plant nutrient composition showed that safflower fodder was characterized by a significantly higher content of proteins and soluble sugars, but a low content of fats in comparison with traditional forage crops, corn and sunflower. The concentration of crude cellulose and ash in safflower fodder is lower than in sunflower fodder and higher than in corn green mass fodder. The content of nitrogen free extract and starch in safflower fodder is higher in comparison with sunflower green mass fodder, but lower than in corn green mass fodder. The fodder from *Carthamus tinctorius* is characterized by a higher content of calcium and phosphorus in comparison with *Zea mays* green mass fodder. As compared with sunflower green mass fodder, safflower fodder was characterized by lower calcium content and higher phosphorus content. The gross energy concentrations in the fresh fodder from safflower and sunflower do not differ significantly, but they are much lower than in the case of fodder from corn green mass. The fodder from safflower plants was characterized by higher metabolizable energy and net energy for lactation in comparison with the fodder from sunflower green mass.

Different results regarding the biochemical composition and the nutritive value of the green mass *Carthamus* sp. whole plants are given in the specialized literature. According to LESHEM et al., (2000) the *Carthamus tinctorius* dry matter herbage had: 100-146 g/kg crude protein and 489-656 g/kg dry matter digestibility. STANFORD et al., (2001) found that the safflower plants cut in full bloom period contained: 9.7% crude protein, 1.6% crude fats, 32.1% neutral detergent fibre, 23.1% acid detergent fibre with 63.6 % dry matter effective rumen degradability. WEINBERG et al., (2007) reported safflower plants grown under different irrigation and nitrogen fertilization regimes contained: 12.2-22.1 g/kg nitrogen, 287-364 g/kg acid detergent fibre, 410-478 g/kg neutral detergent fibre, 66-104 g/kg water soluble carbohydrate with 521-693 g/kg dry matter digestibility. ARSLAN et al., (2008) revealed that pure safflower herbage quality was: 7.3% crude protein, 27.6% crude cellulose, 35.8 % acid detergent fibre, 44.6% neutral detergent fibre, 17.2 g/kg calcium, 3.4 g/kg phosphorus, but herbages of field pea and-safflower mixtures 12.2-16.4% crude protein, 22.9- 25.7% crude cellulose, 30.8-33.4 % acid detergent fibre, 39.1-42.4% neutral detergent fibre, 12.6-15.4 g/kg calcium, 3.2-3.3 g/kg phosphorus. BAR-TAL et al., (2008) remarked that the nutritional value of safflower forage varied depending on the amount of applied nitrogen fertilizers and the irrigation rates: 13.1-20.5 g/kg nitrogen, 4.8-8.8 % ash, 30.9-43.9% acid detergent fibre, 44.8-56.8% neutral detergent fibre, 4.70-8.98% water soluble carbohydrate and 521-693 g/kg *in vitro* dry matter digestibility. PEIRETTI (2009) found that the concentration of nutrients in safflower plants harvested in five morphological stages was: 83-157 g/kg dry matter, 12.4-27.2% crude protein, 2.2-2.9% crude fats, 17.2%- 41.5% acid detergent fibre, 31.3-49.1% neutral detergent fibre, 10.7-17.1% ash and 16.2-17.8 MJ/kg gross energy. ASGHARZADEH et al., (2013) found that the safflower herbage, depending on the amount and type of applied fertilizers, contained 343-380 g/kg dry matter, 9.5- 13.8% crude protein, 37.2-42.1% neutral detergent fibre, 32.7-35.7% acid detergent fibre, 5.2-5.4 % water soluble carbohydrate, 6.0-11.7% ash, 10-12 g/kg calcium, 2.9-3.9 g/kg phosphorus, 57.1-68.2 % organic matter digestibility and 8.5-10.0 MJ/kg metabolizable energy. DANIELI et al., (2014) remarked that the nutritional characteristics of spineless safflower grown under the climatic

conditions of the Mediterranean region were as follows: 11-17 % crude protein, 1.3-1.8 % crude fats, 39.8-43.9 % crude cellulose, 33.1-35.4% amylase acid detergent fibre organic matter, 42.9-45.9 % amylase neutral detergent fiber organic matter, 7.4-11.7% acid detergent lignin, 12.4-13.2% ash, 24.8-28.3% NFC. RETA SANCHEZ et al., (2014) remarked that the nutrient content of safflower herbage, depending on row spacing, was: 17.1-19.5 % crude protein, 43.7-48.1% neutral detergent fiber, 33.3-35.7% acid detergent fibre, 1.37-1.43 Mcal/kg net energy for lactation. HEUZÉ & TRAN (2015) remarked that the biochemical composition and nutritive value of the dry matter of safflower plants was: 15.0 % crude protein, 1.8 % crude fats, 19 % crude cellulose, 11.3 % ash, 14.0 g/kg calcium, 3.4 g/kg phosphorus, 65.1 % digestible organic matter, 17.5 MJ/kg gross energy and 9.3 MJ/kg metabolizable energy. ÇAĞRI& KARA (2018) mentioned that the chemical composition and energy nutritional value of safflower green mass was: 8.10% crude protein, 6.51% DP, 2.13 % crude fats, 39.05 % amylase neutral detergent fiber organic matter, 31.99 % amylase acid detergent fibre organic matter, 4.75% acid detergent lignin, 2040.83 kcal/ kg metabolizable energy. ÇALIŞKAN & YÜKSEL (2022) reported that, depending on the harvest periods, the quality traits of safflower forage were 8.36-12.29% crude protein, 31.30-47.92% neutral detergent fibre, 27.61-38.59% acid detergent fibre. OCHOA-ESPINOZA et al., (2022a) found that the nutritional composition of spiny safflower cultivars was: 22.6-23.3% crude protein, 46.7-47.7% neutral detergent fibre, 38.1-38.9% acid detergent fibre, 64- 65% *in vitro* dry matter digestibility and 5.36-5.48 MJ/kg net energy for lactation, while for spineless safflower cultivar Selkino - 24.7% crude protein, 47.5% neutral detergent fibre, 39% acid detergent fibre, 67.4% *in vitro* dry matter digestibility and 5.73 MJ/kg net energy for lactation. LÓPEZ-JARA et al., (2022) reported that the nutritive quality of *Carthamus tinctorious* forage was 16.2-17.9% crude protein, 40.2-46.3% neutral detergent fibre, 31.8-38.0% acid detergent fibre and 5.4-6.1 MJ/kg net energy for lactation, but *Brassica napus* forage respectively 17.1- 19.9% crude protein, 36.8-45.7% neutral detergent fibre, 30.4-35.9% acid detergent fibre and 5.7-6.3 MJ/kg net energy for lactation. OCHOA-ESPINOZA et al., (2022b) mentioned that the studied safflower cultivars were characterized by 17.79-24.35% crude protein, 49.46-50.91% neutral detergent fibre, 39.82-43.34% acid detergent fibre, 53.58-58.58% *in vitro* dry matter digestibility and 4.37-4.87 MJ/kg net energy for lactation. JABBARI et al. (2023) studied the effects of the cutting time and cultivar on chemical compositions and found that the maximum crude protein content in safflower plants was observed in the flowering stage (19.22%), as compared with 14.57% in the branching stage.

Table 1. The biochemical composition and the nutritive value of the green mass from *Carthamus tinctorius* plants.

Indices	***Carthamus tinctorius***	***Helianthus annuus***	***Zea mays***
Crude protein, % dry matter	9.22	8.15	6.93
Crude fats, % dry matter	2.34	3.00	2.61
Crude cellulose, % dry matter	27.80	33.11	17.24
Nitrogen free extract, % dry matter	51.96	44.96	69.73
Soluble sugars, % dry matter	15.80	12.30	6.81
Starch, % dry matter	6.61	3.99	23.05
Ash, % dry matter	8.68	10.78	3.48
Calcium, g/kg dry matter	9.4	12.4	2.3
Phosphorus, g/kg dry matter	3.0	2.9	2.4
Gross energy, MJ/kg dry matter	17.82	17.67	18.37
Metabolizable energy, MJ/kg dry matter	9.83	8.89	11.29
Net energy for lactation, MJ/kg dry matter	5.63	4.98	6.93

Feeding the livestock with silage is an important agricultural technique for maintaining and increasing their productivity, especially during the offseason, when there is scarcity of food for the husbandry of herbivorous animals, its preparation being an excellent strategy in reducing feed costs and increasing profitability. During the sensorial assessment, it was found that, in terms of colour, the silage prepared from safflower plants had dark green leaves, yellow stems, with specific, but light and pleasant smell, the consistency was retained in comparison with the initial green mass, without mould and mucus. The fermentation quality and nutrient content of the silage prepared from safflower plants is shown in Table 2. It has been determined that safflower silage contained 282.5 g/kg dry matter. The pH index of safflower silage was 4.14, higher as compared with corn silage and lower as compared with sunflower silage. The concentrations of total organic acids varied from 25.0 g/kg in safflower silage to 45.0-48.9 g/kg in corn and sunflower silages, the most amounts of organic acids were in fixed form. The level of acetic acid in safflower silage was very low in comparison with silages from traditional crops, such as tall fescue silage. The butyric acid in safflower silage was detected in very small quantities (0.1g/kg). It was found that, during the process of ensiling safflower green mass, the biochemical composition changed, the concentrations of crude protein, nitrogen free extract, soluble sugars and starch decreased, the concentrations of crude fats and crude cellulose increased, and ash content did not modify significantly, but the calcium concentration increased, while that of phosphorous diminished. The metabolizable energy and net energy for lactation of safflower silage were lower as compared with the initial safflower fresh mass. We would like to mention that safflower silage is characterized by a higher content of crude protein, crude fats, nitrogen free extract, soluble sugars and starch than in the control – sunflower silage. As compared with corn silage, the silage from safflower plants had high concentration of crude protein,

crude cellulose, soluble sugars, ash, calcium and phosphorus. The energy concentrations in corn silage reached the highest level if compared with safflower silage.

Several studies have evaluated the quality of safflower silage. According to WEINBERG et al., (2002) the silages from safflower wilted plants have 290-411 g/kg dry matter, pH= 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, 15-28 g/kg water soluble carbohydrate, but inoculated safflower silages – pH= 3.9-4.1, 42-47 g/kg lactic acid, 6-8 g/kg acetic acid, 12-20 g/kg water soluble carbohydrate, respectively. CORLETO et al., (2005) found that the safflower silage prepared from harvested plant at 25% of flowering stage had pH= 4.46, 18.7 g/kg lactic acid, 4.7 g/kg acetic acid, 376 g/kg dry matter, 8.0% crude protein, 49.3% neutral detergent fibre, 37.3% acid detergent fibre, 5.9% acid detergent lignin, 5.27 % water soluble carbohydrate, 1.7% crude fats, 6.9% ash, but in silage from plant inoculation with *Lactobacillus plantarum* – pH= 4.15, 29.2 g/kg lactic acid, 5.7 g/kg acetic acid, 399 g/kg dry matter, 8.6% crude protein, 51.2% neutral detergent fibre, 37.6% acid detergent fibre, 6.1% acid detergent lignin, 4.97 % water soluble carbohydrate, 2.0% crude fats, 9.8% ash, respectively. WEINBERG et al., (2007) reported that the characteristics of silage from safflower grown under different irrigation and nitrogen fertilization regimes were pH=4.0-4.8, 34-127 g/kg lactic acid, 4- 15 g/kg acetic acid. ASGHARZADEH et al., (2013) remarked that the safflower silages were characterized by: pH= 4.7-4.9, 90-130 g/kg lactic acid, 290-433 g/kg dry matter, 12.3-14.8% crude protein, 45.3-49.0% neutral detergent fibre, 37.2-42.1% acid detergent fibre, 1.9-2.8 % water soluble carbohydrate, 9.0-12.3% ash, 10-13 g/kg calcium, 3.0-4.2 g/kg phosphorus, 56.2-65.4 % organic matter digestibility and 8.2-9.6 MJ/kg metabolizable energy. HEUZÉ & TRAN (2015) reported that safflower silage contained 12.6 % crude protein, 4.4 % crude fats, 31.4 % crude cellulose, 8.9 % ash, 70.2 % digestible organic matter, 17.5 MJ/kg gross energy and 10.6 MJ/kg metabolizable energy. SÁNCHEZ-DUARTE et al., (2018) remarked than safflower silage contained 372.6 g/kg dry matter, 17.7 % crude protein, 45.16 % neutral detergent fibre, 491.5 g/kg total digestible nutrients and 1.11 Mcal/kg net energy for lactation.

Table 2. The fermentation profile, the biochemical composition and the nutritive value of the ensiled forage.

Indices	***Carthamus tinctorius***	***Helianthus annuus***	***Zea mays***
pH index	4.14	4.39	3.73
Organic acids, g/kg dry matter	25.0	48.9	45.0
Free acetic acid, g/kg dry matter	0.6	4.2	3.6
Free butyric acid, g/kg dry matter	0	0.1	0
Free lactic acid, g/kg dry matter	6.0	10.8	16.7
Fixed acetic acid, g/kg dry matter	2.1	6.5	3.8
Fixed butyric acid, g/kg dry matter	0.1	0.8	0.2
Fixed lactic acid, g/kg dry matter	16.2	26.5	20.7
Total acetic acid, g/kg dry matter	2.7	10.7	7.4
Total butyric acid, g/kg dry matter	0.1	0.9	0.2
Total lactic acid, g/kg dry matter	22.2	37.3	37.4
Acetic acid, % of organic acids	10.80	21.88	16.44
Butyric acid, % of organic acids	0.45	1.84	0.44
Lactic acid, % of organic acids	88.75	76.28	83.12
Crude protein, % dry matter	8.42	7.67	6.83
Crude fats, % dry matter	3.06	2.54	3.50
Crude cellulose, % dry matter	33.51	36.42	16.47
Nitrogen free extract, % dry matter	46.22	42.64	69.69
Soluble sugars, % dry matter	4.09	0.43	0.79
Starch, % dry matter	7.19	0.66	24.82
Ash, % dry matter	8.80	10.73	3.52
Calcium, g/kg dry matter	9.7	10.6	2.3
Phosphorus, g/kg dry matter	2.8	2.1	2.5
Gross energy, MJ/kg dry matter	18.05	17.63	18.53
Metabolizable energy, MJ/kg dry matter	9.21	8.37	11.59
Net energy for lactation, MJ/kg dry matter	5.14	4.82	7.14

CONCLUSIONS

The green mass productivity of introduced safflower spineless ecotype, harvested in flowering stage, reached 3.74 kg/m^2 or 1.10 kg/m^2 dry matter.

The biochemical composition and the nutritive value of the dry matter from the harvested safflower whole plants was: 9.22% crude protein, 2.34% crude fats, 27.80% crude cellulose, 51.96% nitrogen free extract, 6.61 % starch, 15.8% soluble sugars, 8.68 % ash, 0.94% calcium, 0.30% phosphorus and feed energy values of 17.82 MJ/kg gross energy, 9.83 MJ/kg metabolizable energy, 5.63 MJ/kg net energy for lactation.

The quality indices of the prepared safflower silage were: 282.5 g/kg dry matter, pH=4.14, 22.2 g/kg lactic acid, 2.7 g/kg acetic acid, 0.1 g/kg butyric acid, 8.42% crude protein, 3.06% crude fats, 33.51% crude cellulose, 46.22% nitrogen free extract, 7.19 % starch, 4.09% soluble sugars, 8.80 % ash, 0.97% calcium, 0.28% phosphorus and feed energy values 18.05 MJ/kg gross energy, 9.21 MJ/kg metabolizable energy, 5.14 MJ/kg net energy for lactation.

The green mass and the prepared silage from the introduced spineless ecotype of *Carthamus tinctorius* plants contain a lot of nutrients, which make it suitable to be used as alternative fodder for livestock.

ACKNOWLEDGEMENTS

Financially supported, subprogram no. 01.01.02 *"Identification of valuable forms of plant resources with multiple uses for the circular economy"*.

REFERENCES

ARSLAN B., ATES E., TEKELI A. S. ESENDAL E. 2008. Feeding and agronomic value of field pea (*Pisum arvense* L.) - safflower (*Carthamus tinctorius* L.) mixtures. In. *7th international Safflower Conference*. Wagga Wagga, Australia. https://s3.wp.wsu.edu/uploads/sites/2171/2017/11/Pr oducts-Arslan-oral-paper.pdf (accessed February, 2024).

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.

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.

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.

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: 69-73.

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.

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.

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.

EMONGOR V. & OAGILE O. 2017. *Safflower Production*. https://www.ruforum.org/sites/default/files/Safflower %20Manual_BUAN.compressed.pdf (accessed February, 2024).

GUȚU A., ȚÎȚEI 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.

HEUZÉ V. & TRAN G. 2015. Safflower (*Carthamus tinctorius*) forage. *Feedipedia.* https://www.feedipedia.org/node/173 (accessed February, 2024).

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.

IVANOVA R. 2016. Theoretical and practical aspects of the introduction of safflower (*Carthamus tinctorius* L.) in the Republic of Moldova. *Oltenia. Studii şi comunicări. Ştiinţele Naturii*. Muzeul Olteniei Craiova. **32**(2): 48-51.

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.

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.

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.

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.

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.

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 (accessed February, 2024).

PEIRETTI P. G. 2017. Nutritional aspects and potential uses of safflower (*Carthamus tinctorius* L.) in livestock. *Agricultural Research Updates*. **19**: 3-22.

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.

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.

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.

ŢÎŢEI V. 2024. Agroeconomic value of jerusalem artichoke *Helianthus tuberosus* cultivars. *Romanian Agricultural Research*. **41**: 315-327.

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.

ŢÎŢEI V. & COȘMAN 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.

ŢÎŢEI V. & TELEUŢĂ A. 2014. Agro biological peculiarities of giant knotweed and cup plant after fertilization with sewage sludge. *Scientific Papers. Series A. Agronomy*. **57**: 350-356.

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.

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. 10.1016/j.anifeedsci.2006.05.009.

***. SM 108:1995 (1996): *Siloz din plante verzi*. Condiţii tehnice. Moldovastandart. 10.

Ţîţei Victor
"Alexandru Ciubotaru" National Botanical Garden (Institute) of the Moldova State University,
18 Padurii street, MD 2002, Chișinău, Republic of Moldova.
Corresponding author's email: vic.titei@gmail.com; vitcor.titei@gb.usm.md;

Received: April 09, 2024
Accepted: June 25, 2024