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Influence of soil and climatic conditions on the chemical composition and nutritional value of *Kochia prostrata* feed in the arid zone of Western Kazakhstan

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ABSTRACT

The forage kochia, *Kochia prostrata* is used in agriculture as a high-quality pasture plant, however, it has not shown itself to be a stable pasture-haymaking plant. Therefore, in this study, a new direction was chosen for using forage kochia as fodder, i.e., using it for the production of fruit and fodder products that are more nutritious than its hay. The study aimed to determine the influence of soil and climatic conditions on the alteration in the chemical composition and nutritional value of fruit and fodder products, hay, and straw of the forage kochia. The study was carried out in the desert zone of the Atyrau region, Western Kazakhstan with annual precipitation of 130.2 mm. Experiments in 2016 and 2017 were established on meadow-brown soils, and in 2020 on alluvial-meadow soils. The conducted studies have shown that the content of fodder units and protein in fruit and fodder products is much higher than that of hay (0.88 versus 0.65 fodder units and 21.80 g versus 17.25 g protein), and also much higher than those of its straw, which are 0.39 fodder units and 11.21 g, respectively. Natural forage plants of the desert of Western Kazakhstan are unproductive (2-3 kg ha^{-1}) and nutritionally poor. As an alternative, it is proposed to produce fruit-based fodder of forage kochia, a new type of high-quality, nutritionally balanced feed, 10 or more times (39 kg ha^{-1}) superior in productivity to natural hayfields and pastures.

Keywords: Plant, Semi-shrubby, Pastures, Straw, Fruit-based fodder, Hay.
Article type: Research Article.

INTRODUCTION

One of the strategic directions of increasing the productivity of farm animals is the organization of complete feeding of them with a variety of feeds balanced with all the necessary nutrition elements, such as protein, fat, nitrogen-free extractable substances (NFES), mineral elements, carotene, and fiber. The solution to this problem requires testing various types of arid plants in harsh desert conditions and studying the productivity, chemical composition, and nutritional value of feed from them (Dosmanbetov *et al*. 2020; Al-Dulaimy *et al.* 2022; Amraei 2022; Ibragimov *et al*. 2022; Yessimbek *et al*. 2022). The species composition of the selected forage crops is primarily determined by climatic conditions, in particular the availability of precipitation (Ibragimov & Umakhanov 2021; Keler & Shram 2021; Al- Abbasi *et al.* 2022). In the desert zone of Western Kazakhstan, traditional forage crops are not cultivated on non-irrigated lands due to the aridity of the climate (with an annual precipitation rate of 130.2 mm), and arid forage plants are tested here, such as forage kochia, winterfat, camphor-

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fume, *Salsola orientalis*, *Salsola richteri*, *Salsola paletzkiana*, and *Aellenia subaphylla*. Among them, the forage kochia has a high yield of pasture and hay mass, so it is widely tested in the USA, Turkey, Uzbekistan (Toderich *et al.* 2015; Ou *et al.* 2018; Acar & Koç Koyun 2019), Russia, Kazakhstan, and China (Shamsutdinov *et al.* 2014; Bademuqiqige *et al.* 2018; Shuyskaya *et al.* 2020; Shuyskaya *et al.* 2022) mainly for research purposes against the background of plowing the soil to a depth of 20-22 cm. Studies show that the forage kochia does not germinate annually, appearing approximately two years out of five years and then with patches, where in one place full-fledged shoots are observed (18-25 pcs m^{-2}), and in another one they are absent (0 pcs m^{-2}). That is, tillage does not provide the necessary efficiency (Mukhambetov *et al.* 2019).

With this in mind, an agriculture system was developed aimed at the accumulation and preservation of moisture in soil strips (5-10 cm wide and deep, repeated after 50-55 cm in virgin soil untouched by vegetation), treated by surface raking of a loose seedbed layer with the formation of a solid compacted bed, where an ideal condition for seed germination is created (Mukhambetov *et al.* 2019). Against this background, the fruit-based fodder weight of the forage kochia equaled 3.9 ton ha^{-1} on average for four years.

Based on the negative experience of using the forage kochia as a pasture and hay crop, we chose a new direction of using it as feed, in the production of its fruit-based fodder products.

Fruit-based fodder is a loose mixture consisting of three parts:

1) The forage kochia fruit, occupying up to 40-42 in the total fruit-based fodder production (%);
2) Thin generative stems, no more than 8-12 cm long, 0.2-0.3 cm wide, making up to 26-28%;
3) The bark of stems with buds, inflorescences, and leaves, easily turning into a fluffy loose mass, the proportion of which is 30-34%.

The analysis of the current state of knowledge of the forage kochia, which is a high-quality full-fledged forage plant (Nidyulin *et al.* 2020; Ibragimov & Umakhanov 2021), shows that scientific research on it can be conditionally divided into two directions, physiological and biochemical as well as ecological and agronomic. The second direction covers the issues of studying ecotypes (Nidyulin *et al.* 2020), survival rate (Voronin *et al.* 2019; Imomov *et al.* 2020) and productivity of forage kochia with various methods of soil treatment (Shamsutdinov *et al.* 2014; Acar & Koç Koyun 2019; Mukhambetov *et al.* 2019), the influence of forage kochia herbage on changes in soil fertility (Nasiyev 2013; Nasiyev *et al.* 2015; Smith *et al.* 2016) and water-physical properties of soils (Nasiyev 2016; Bulakhtina *et al.* 2021; Rozentsvet *et al.* 2022) along with the reduction of water runoff and sediment concentration (Li *et al.* 2017; Nasiyev *et al.* 2018). Physiological and biochemical studies were aimed at evaluating drought and salt resistance (Gao *et al.* 2015; Plotnikova *et al.* 2019; Wang *et al.* 2019), the composition of enzymes (Rakhmankulova *et al.* 2015; Dzhapova *et al.* 2020; Irfan *et al.* 2020) and proteins (Rakhmankulova *et al.* 2021; Trubakova 2021) with a relatively small study on the biochemical analysis of the nutritional value in green mass and hay of forage kochia (Acar & Özköse, 2012; Ibragimov & Umakhanov 2021), while works focused on the study of the nutritional value of its fruit are not found in the literature. We are developing the scientific foundations of the cultivation of forage kochia for the production of fruit-based fodder, no less valuable new type of feed than green mass and hay of forage kochia, for the first time.

There are few works devoted to the study of the nutritional value of the forage kochia. Under similar conditions, in the semi-desert zone of the northwestern Caspian Sea (Ibragimov & Umakhanov 2021; Ibragimov *et al.* 2022), positive results were tested and obtained for *Calligonum aphyllum*, Pamirian winterfat, *Krascheninnikovia ceratoides*, forage kochia, common wormwood, *Artemisia taurica*, tall wheatgrass, *Elytrigia elongata*, crested wheatgrass, *Agropyron pectinatum*, and sainfoin, *Onobrychis biebersteini*, their energy nutritional values, both in terms of digestible protein (55-99 g kg^{-1}), feed units (FU; 0.43-0.65), and energy FU (EFU; 0.58-0.81), are inferior to the corresponding nutritional elements in the fruit of the forage kochia (134.77, 0.88 and 0.81 respectively). The relevance of the work is conditioned by the fact that the proposed method of using forage kochia feed as a fruit-based fodder is justified for the first time based on establishing its high nutritional value, approaching the nutritional standard of comparison (oats).

The purpose of this study was to determine the influence of soil and climatic conditions on the alteration in the chemical composition and nutritional value of fruit-based fodder products, hay, and straw in the forage kochia, *K. prostrata*.

MATERIALS AND METHODS

Place and Period of the study

The study of the forage kochia was carried out in the desert zone of the Atyrau region, Western Kazakhstan with annual precipitation of 187 mm. It is located in a dry, hot agro-climatic area, where traditional fodder crops are not grown due to the aridity of the climate (Fig. 1). Zoo-technical feed analyses were performed in 2016-2021 in the laboratory of Zootechnical Feed Analysis, Kazakh Research Institute of Animal Husbandry and Feed Production, Ministry of Agriculture, Republic of Kazakhstan.

Fig. 1. Map of Kazakhstan with the Atyrau region indicated in red.

Natural and climatic conditions aw well as characteristics of experimental plots

In the Atyrau region, the climate is formed under the predominant influence of Arctic, Iranian, and Turanian air masses. In the warm period of the year, the overheated tropical air masses coming from the deserts of Central Asia and Iran dominate, which causes the dryness of the air. The frost-free period lasts for 171-181 days. The last spring frosts in the air stop in the region in the period from April 13 to 27. In the average annual period with a temperature above 10°C, 70-115 mm of precipitation falls, which does not provide the necessary need for moisture for plants. Therefore, rain-fed agriculture with traditional crops has not been developed here. The soil cover of the Caspian lowland, where the study was carried out, is highly complex and on a small area (0.5-1.0 ha), meadow-brown and alluvial-meadow soils are found. The purpose of this work was to determine the influence of both soil and climatic conditions on the change in the chemical composition and nutritional value of forage products, hay and straw obtained from forage kochia, *K. prostrate*. Therefore, according to the method for performing field experiments, which was used by the authors in the present work (Dospekhov, 2018), the experiments were carried out on all types of soils that were found in soil complex (meadow-brown and alluvial-meadow soils), as well as in different years (2016, 2017 and 2020), which differed in climatic conditions (Table 1). Thus, the approach used made it possible to obtain data on the composition of products obtained from *K. prostrate* grown in different soil and climatic conditions, which corresponded to the objectives of the research. So, it was possible to obtain data valuable from a practical point of view for the further development of approaches in order to use plants of the arid zone for fodder production. This work was prepared using the data of the experiments which were carried out with a break of two years (2016, 2017, 2020) due to organizational reasons and limitations. Despite this, this fact did not prevent obtaining data that correspond to the stated objectives of the work, as well as to the existing needs in the field of development of feed production from various plant raw materials. Experiments in 2016 and 2017 were established on meadow-brown soils, while in 2020 on alluvial-meadow soils. In the latter, the horizon of maximum salt accumulation was located at a depth of 50 cm and further down. According to the granulometric composition, the soils were medium and heavy loamy. The humus, total nitrogen, phosphorus and potassium contents were 0.9-1.2%, 0.15-1.1%, 1.3% and 1.75% respectively. Soils were provided with mobile forms of nitrogen (4.5 mg/100 g soil) and phosphorus (1.4 mg/100 g soil) to a weak degree, while potassium (38 mg/100 g soil) to a high degree. The soils were saline to a weak, medium, and strong degree, where the content (%) of toxic ions were 0.3, 0.6, and 0.9, respectively. The type of salinization was chloride-sulfate.

Study Samples

The forage kochia *Kochia prostrata* (L.) Schrad. belongs to perennial semi-shrubs, egalo-xerophytes in life form, and from the point of view of ecology and adaptive strategy, it is an extremely drought-resistant, salt- and alkali soil-tolerant forage plant in desert pastures (Fig. 2).

Table 1. Weather data for sampling sites

Month	Average month and annual air temperature (°C)				Precipitation (mm)				Relative air humidity (%)			
	2016	2017	2020	Long-term	2016	2017	2020	Long-term	2016	2017	2020	Long-term
XI	1.4	3.5	0.2	0.5	18	7.9	4.2	3.4	79	65	66	82
XII	6.7	-5.1	-10	-5.3	26	11.2	2.1	4.3	82	78	84	85
I	-7.5	-9.9	-1.8	-7.4	12	8.7	7.6	11	86	77	82	85
II	-8.6	-6.5	0.3	-7.3	14	6.0	5.6	11	88	77	73	85
III	1.0	-1.2	6.6	0.1	10	17.2	6.7	10	84	72	48	82
IV	15.1	10.0	9.9	10.6	16	20.9	6.0	14	69	56	46	64
V	22.4	20.9	20.1	17.8	26	1.5	24.4	16	67	34	45	53
VI	23.5	23.6	26.9	24.0	24	6.2	39.5	19	54	33	30	53
VII	25.4	30.3	29.5	26.4	25	2.2	0.7	16	57	34	32	55
VIII	28.4	24.5	22.9	24.2	2	1.9	21.6	11	41	35	48	62
IX	14.2	18.5	17.6	17.3	12.1	5.7	46.5	11	72	41	44	71
X	7.1	10.3	10.0	8.8	12	11.1	1.8	3.5	65	62	52	66
Annual	10.4	9.9	11.0	9.1	331	100.5	166.7	130.2	66	55	54	65

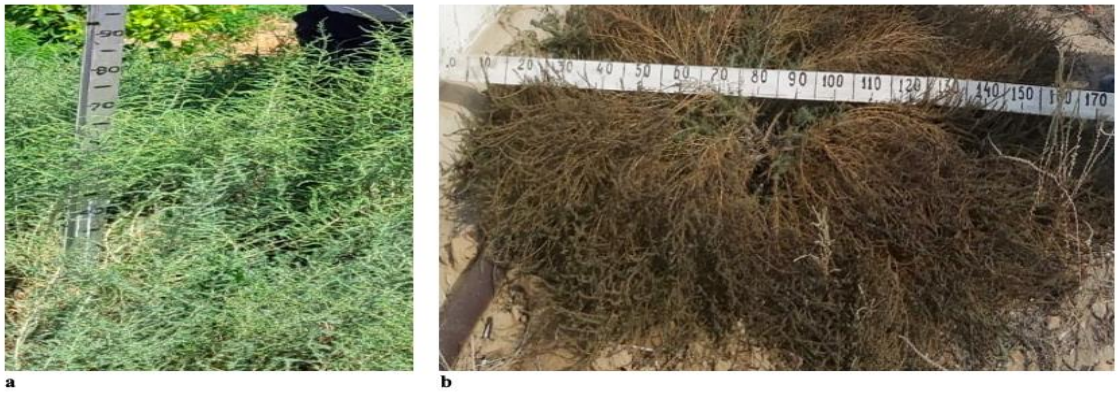

Fig. 2. (a) Height of forage kochia; and (b) the width of its crown.

A total of 40-44 samples of forage kochia seeds, differing in plant height, bushiness, leafiness, and fruit mass were collected manually in the vicinity of Atyrau. All of them belonged to the clay ecotype of the forage kochia. An experiment was carried out on feeding sheep with fruit-based fodder and hay of the forage kochia with the determination of chemical composition and nutritional value. Unlike hay and straw, it is not necessary to crush its fruit-based fodder with feed crushers, since it is a loose material. Other types of feed were not included in the diet of animals. We took the nutritional value of young pasture grass and oat grain as a basis for comparison since oat fodder units remain to be a measure of assessing the nutritional value of feed in the dry steppe and desert zones of Kazakhstan. On the other hand, grain- and fruit-based forages are the same concepts, since in one case, the grain of cereals, and in the other case, the fruit of forage kochia is used as fodder. Therefore, we consider it correct to compare the nutritional value of fruit-based forage with the nutritional value of oats.

Feed study

Zootechnical feed analyses were performed by scanning with preliminary sample preparation. Chemical analyses of the feed were performed on the INFRAXACN 7500 feed analyzer (Sweden). Protein, fat, fiber, ash, sugar, starch, carotene, calcium, and phosphorus were determined on the Infrazak device (Denmark). In the laboratory of Feed Quality Analysis, Kazakh Research Institute of Animal Husbandry and Forage Production (Kazniizhik) LLP, a complete zootechnical analysis of feed was carried out, including 18 indicators: initial moisture (IM), hygroscopic moisture (HM), total moisture (TM), dry matter (DM), crude protein (CP), crude fat (CF), crude fiber, nitrogen-free extractive substances (NFES), starch, sugar, ash, Ca, P, carotene, feed units (FU), digestible protein (DP), metabolizable energy (ME), and energy FU (EFU).

Data analysis

The IM was determined by drying the feed to a constant mass at 65-70°C, and HM by determining moisture by drying the 2 g sample to a constant mass at 100-105°C. The TM was determined using the formula:

$$TM = IM + HM \times (100 - IM) \div 100 \quad \textbf{(1)}$$

where: TM, IM and HM are total moisture, initial moisture and hygroscopic moisture respectively.
The DM was determined using the formula:

$$DM = 100 - TM \quad \textbf{(2)}$$

where: DM is dry matter and TM is total moisture.

FU, DP, ME and EFU were determined using the following formulas:

$$FU = (1.176 \times P + 1.953 \times F + 0.903 \times NFES) \div 1000 \quad \textbf{(3)}$$

where: FU, F and NFES are feed units, fat and nitrogen-free extractive substances respectively.

$$DP = CP \times Fb \div 100 \quad \textbf{(4)}$$

where: DP, CP and Fb are digestible protein, crude protein, and fiber respectively.

$$MEt = 17.71 \times dP + 37.89 \times dF + 13.44 \times dFb + 14.78 \times dNFES \quad \textbf{(5)}$$

where: ME, P, F, Fb and NFES are metabolizable energy, protein, fat, fiber, and nitrogen-free extractive substances respectively.

$$EFUt = MEt \div 10 \quad \textbf{(6)}$$

where: EFU is energy feed units and ME is metabolizable energy.

RESULTS

Tables 2 - 3 provide data on the chemical composition, and nutritional value of fruit-based fodder, hay, and straw of the forage kochia.

Table 2. Chemical composition and nutritional value of the fruit-based fodder products of the forage kochia.

Years	In natural form (%)														
	DM	**Protein**	**Fat**	**Fiber**	**NFES**	**Ash**	**Ca**	**P**	**Carotene (mg)**	**FU in 1 kg**	**DP (g)**	**ME (MJ)**	**EFU (MJ)**	**CME in DM**	**CP in DM**
2016	91.35	26.79	7.18	20.86	27.63	8.90	0.21	0.48	30.61	1.04	203.58	10.80	1.08	11,82	29.33
2017	92.85	18.37	5.43	6.38	55.63	7.04	0.83	0.10	46.54	0.85	95.5	7.45	0.74	8,02	19.78
2020	83.15	20.24	3.07	26.81	23.75	9.31	0.61	0.12	18.44	0.76	105.22	6.23	0.62	7,90	24.34
Average ± SD	89.12 ± 5.97	21.80 ± 3.43	5.23 ± 2.16	18.02 ± 11.64	35.67 ± 11.92	8.42 ± 1.38	0.55 ± 0.34	0.23 ± 0.13	31.86 ± 13.42	0.88 ± 0.12	134.77 ± 39.27	8.16 ± 1.93	0.81 ± 0.19	9.11 ± 1.21	24.48 ± 4.7

Note: DM: dry matter, NFES: nitrogen-free extractive substances, Ca: calcium, P: phosphorus, FU: feed unit, DP: digestible protein, ME: metabolizable energy, EFU: energy feed unit, CP: crude protein, CME: coefficient of metabolic energy.

From the data in Table 2, it can be seen that the protein content (%) varied slightly over the years, from 18.37 to 26.79, with an average content of 21.80 over three years. The data obtained indicate that in a moisture-favorable

year, the protein content in the fruit-based fodder was significantly higher compared to average and dry years (26.79 vs. 18.37 and 20.24%). NFES and fiber occupy 60-65% of all components characterizing the nutritional value of the fruit-based fodder. Their content in the DM of the fruit-based fodder determines such basic nutritional characteristics as ME, EFU, and FU. In the years with high precipitation (2016) and insufficiently precipitation (2017), the NFES content was higher than fiber content (27.63 and 55.63, respectively, versus 20.86 and 6.38%), while in the year with average precipitation (2020) their contents were almost equal, with a slight excess of fiber content (26.81%) versus NFES (23.75%). The ash content remained stable over the years (7.04-9.31%). The average calcium content for 3 years was 5.5 g kg^{-1} dry weight, which was also equal to its content in young pasture grass consisting of cereals and legumes. It contained slightly less FU (0.89) compared to oats (0.96), however, at the same time, it exhibited twice the protein content (21.81%) compared to the latter (10%). From the data in Table 3, it follows that the hay of the forage kochia contained less protein (17.25%) and more fiber (24.44%) in comparison with the fruit-based fodder, with almost equal amounts of fat, NFES, and carotene. The FU content was 0.65, which was higher than in the hay of natural pastures and hayfields (Altunin 1986). The DP, ME, and EFU values in hay were much lower than in the fruit-based forage, equaling respectively 95.77 g, 7.27 MJ, and 0.73 MJ versus 134.77 g, 8.16 MJ, and 0.81 MJ respectively. During the production of fruit-based fodder, farms were provided with additional feed, i.e., straw, which contained 0.39 FU, 30.27 g DP, 5.22 MJ of ME, and 0.52 EFU.

Table 3. Chemical composition and nutritional value of hay and straw of the forage kochia

		In natural form (%)												
	Year	**DM**	**Pro.**	**Fat**	**Fb**	**NFES**	**Ash**	**Ca**	**P**	**Caro. (mg)**	**FU in 1 kg**	**DP (g)**	**ME, (MJ)**	**EFU**
Straw	2016	96.04	17.73	2.23	26.45	43.43	6.20	1.26	0.39	22.09	0.64	131.19	9.20	0.92
	2017	95.01	15.04	4.66	21.35	45.23	8.73	1.65	0.10	44.64	0.68	78.2	7.26	0.73
	2020	87.02	19.00	4.19	25.52	35.09	3.21	1.70	0.45	30.07	0.62	77.92	5.34	0.53
	Average ± SD	92.69 ± 5.67	17.25 ± 2.21	3.69 ± 1.46	24.44 ± 3.09	41.25 ± 6.16	6.05 ± 2.84	1.54 ± 0.28	0.31 ± 0.21	32.27 ± 10.18	0.65 ± 0.03	95.77 ± 17.85	7.27 ± 1.93	0.73 ± 0.20
Hay	2016	85.15	11.25	3.08	47.02	14.76	9.05	1.11	0.62	22.23	0.23	39.37	5.31	0.53
	2017	87.93	10.76	4.73	34.27	32.18	6.00	1.17	0.30	35.45	0.51	24.75	5.06	0.51
	2020	86.35	11.61	6.64	29.50	37.62	0.97	1.15	0.35	45.27	0.43	26.69	5.29	0.53
	Average ± SD	86.48 ± 1.33	11.21± 0.45	4.82 ± 1.74	36.93 ± 7.43	28.19 ± 13.43	5.34 ± 4.37	1.14 ± 0.03	0.42 ± 0.12	34.32 ± 12.09	0.39 ± 0.16	30.27 ± 5.52	5.2 2 ± 0.16	0.52 ± 0.01

*DM: dry matter, NFES: nitrogen-free extractive substances, Ca: calcium, P: phosphorus, FU: feed unit, DP: digestible protein, ME: metabolizable energy, EFU: energy feed unit, Pro.: protein, Fb: fiber, Caro: carotene.

DISCUSSION

In modern research, the majority of studies focus on productivity and methods of soil treatment during the cultivation of forage kochia, *Kochia prostrata* hay. At the same time, it is important to compare the results of the present work with those of previous research as the data obtained under different conditions depends on soil and climate conditions of various habitats. The survey of the data published in different researches will make possible the confirmation of prospects of *K. prostrata* application for fodder production. Unfortunately, the data on the composition of fodder products obtained from *K. prostrata* are limited in literature. Only in few works (Bademuqiqige *et al.* 2018; Ibragimov & Umakhanov 2021; Mukhambetov *et al.* 2021) the chemical composition of the forage kochia hay has been studied, including the amino acid composition (Nidyulin *et al.* 2020). The studies note (Ibragimov & Umakhanov 2021) the FU content (0.45 – 0.5), which is lower than the same indicator of the studied feed (0.65) and slightly higher in straw (0.39; Table 3).

According to reports (Acar & Özköse 2012), *K. prostrata* contains up to 16.5% protein, 2.7% fat, 34.5 NFES, and 29.6% fiber, which approximately corresponds to the indicators of the studied feed. The data obtained in the present study allow to compare nutritional value of *K. prostrata* with those of other crops used for forage production. The high-quality bulky feed includes some types where the DM contains at least 10 MJ of ME, 14% CP, and 26% fiber (Fitsev & Gaganov 2010). According to the present data, the fruit-based fodder of the forage kochia contained slightly less ME (8.16; Table 2), however, in terms of protein content, it met the criterion of high-quality feed, as it was highly saturated with protein (21.80 vs. 14%). The DP content in the forage kochia

fruit (134.77 g kg^{-1}; Table 2) was equal to the hay of the 1st class of legumes (according to the State Standard (GOST; 150 g/kg; Rosstandart 2021) and it was much higher than that of oats (92.2 g kg^{-1}; Shumilin 1986). The fat content in fruit-based fodder was higher than in oats (5.23 versus 4.2%; Tomme 1964) and also much higher than in meadow hay and bean hay (Fitsev & Gaganov 2009). The fiber content in the feed-based fodder of forage kochia varied between 26.81 and 6.38%, with an average of 18.02% over three years, which corresponds to high-quality feeds (up to 26%; Fitsev and Gaganov 2009, 2010), i.e., in terms of fiber content, the fruit-based fodder of forage kochia is equated to green young pasture grasses containing ME of 10-11 MJ kg^{-1}. Not only the nutritional value of the feed depends on the amount and chemical nature of carbohydrates, but also the degree to which animals use the nitrogenous and mineral substances contained in the feed, i.e., carbohydrates contribute to better assimilation of nitrogenous and mineral substances, while fats to the assimilation of vitamins A, D, E, and K. The fruit-based fodder of the forage kochia was well provided with carotene (31.86 mg kg^{-1}; Table 2), which covers the daily need of animals for this vitamin more than 1.5 times (Petukhova *et al.* 1989). By a sufficiently high supply of the fruit-based fodder of the forage kochia with all the necessary nutrition elements including protein, fat, NFES and fiber (within the norm), carotene, and minerals, however, contrary to expectations, the CME (9.11 MJ) and EFU (0.81; Table 2) was not high, i.e. less than in the oats (ME: 9.3MJ) and much lower than in young pasture grass (ME: 10-11 MJ; Shumilin 1986; Fitsev & Gaganov 2010). According to research, only young pasture grasses that have reached the stem elongation phase and the beginning of earing in cereals and budding in beans can provide highly energy-saturated feeds with ME of 10-11 MJ and concentrates that have an extremely high ME content of 11-12 MJ (Shpakov 2018; Kosolapov *et al.* 2021).

According to Fitsev & Gaganov (2010), of the qualitative characteristics that determine the nutritional value of feed, the most important ones are the CME and CP in dry matter. The fruit-based fodder of the forage kochia contained 9.11 CME, 24.48 CP in DM and 0.88 FU (Table 2). Thus, Altunin (1986) stated that the higher the productivity of the animal, the greater the concentration of energy in the DM of the feed. The following indicators have been established: for cows with the following milk yield per day: for 15-20 kg of milk, 0.85-0.95 FU, and when feeding, for example, with the same fruit-based fodder containing 9.11 CME and 0.88 FU, their productive actions coincided, yielding 15-20 kg milk per day.

According to Tomme (1964), 1 kg dry matter of young grass that has reached the stem elongation phase in the conditions of the Central Region of the non-chernozem zone of Russia contained 0.84-0.99 FU or 8.4-11 MJ CME. The author noted that these energy concentrations in the dry matter of young pasture grass satisfy the needs of even the most highly productive cows. If so, then 9.11 CME of the forage kochia (Table 2) should also meet the needs of the same cows. According to Altunin (1986), the CF content in the DM of pasture young grass rarely exceeds 40-50 g kg^{-1} or 4-5%. To meet the needs of an average productive cow, approximately 300 g CF will be required for 1 head per day. This amount of cow fat can be obtained with green feed on pasture and, as the data in Table 2 show, also from the fruit-based fodder products of the forage kochia. The most significant component determining the quality of feed is fiber. The researchers found that the content of fiber in a bulky feed was highly reliable and negatively correlated with the ME concentration in dry matter ($r = -0.96$; Fitsev & Gaganov 2009, 2010). Harvesting herbs in the late phase leads to a decrease in energy nutritional value by 1% daily. The average protein loss per day is 0.25%, and the fiber content increases by 0.33% (absolute) per DM (Fitsev & Gaganov 2010). Thus, the analysis of the data obtained in the present study, as well as those regarding other forage crops, suggests that fruit-based fodder of forage kochia is a promising product for using in the arid zone cattle breeding. At the same time, the given data on the nutritional value of feeds (including fruit-based fodder of the forage kochia) obtained from different plant species have shown that the productive actions of the COE, OE MJ, and FU do not coincide.

So, it is necessary to develop another indirect method for determining the nutritional value of feed. The analysis of recent publications demonstrates that search of promising crops for arid and semi-arid zone is urgent area due to need to improve breeding productivity under extremal conditions. Numerous crops have been proposed to be used in arid zone including *Aspalathus hispida*, *A. angustifolia*, *A. nigra* and *A. submissa* (Chimphango *et al.* 2020), *Megathyrsus maximus* and *Urochloa mosambicensis* (Coêlho *et al.* 2021), forage cactuses *Nopalea cochenillifera*, *Opuntia fícusindica*, *O. stricta*, and *O. undulata* (Filho *et al.* 2021), as well as *Sorghum bicolor* (Paye *et al.* 2022). Thus, the results obtained in the present study correspond to current trend in forage crop studies.

CONCLUSION

Natural forage plants of the desert in Western Kazakhstan are unproductive (2-3 kg ha^{-1}) and nutritionally poor. As an alternative, it is proposed to produce fruit-based fodder of forage kochia, a new type of high-quality, nutritionally balanced feed, 10 or more times (39 kg ha^{-1}) superior in productivity to natural hayfields and pastures. The conducted studies on the chemical composition and nutritional value of the forage kochia feed allowed us to conclude a fairly complete balanced composition of the fruit-based fodder with all the elements of nutrition (protein, NFES, fat, fiber, carotene, minerals) and on this basis recommend it for production as a high-quality winter emergency feed. The forage kochia, as a representative of the semi–shrubby and semi-woody plants, has a strong individual variability – plants of the same age vary greatly in leafiness and fruit productivity, which has a very noticeable effect on the variation of the chemical composition of the studied feeds. In further studies, it is necessary to continue developing new methods for determining the nutritional value of forage kochia fruit-based fodder.

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