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Development of a Methodology for Determining the Nutritional Value of Pasture Feed Considering the Fractions of Easily Digestible Carbohydrates in the Desert Zone of Southern Kazakhstan

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Abstract: Due to the absence of easily digestible carbohydrates (sugar and starch, which are of great importance in animal nutrition) in the existing methods of assessing the nutritional value of feed, the need to include them in the methods for improving the overall nutritional value is a particularly urgent matter in feed manufacture for desert livestock industries. The study was carried out in the distant pastures of the Kyzylkum sandy desert and the ephemeral pastures of the foothill desert of southern Kazakhstan. The purpose of the study was to evaluate the sugar and starch content in the composition of the main forage plants and herbage to improve the methodology for determining the nutritional value of feed, considering the fractions of easily digestible carbohydrates. A total of 105 samples representing 58 different species of forage plants were analyzed for carbohydrates. As a result of the study, the content of carbohydrates in the composition of the herbage of various types of desert pastures and individual types of feed was determined. The authors established that the pasture feeds of most of the studied types of desert pastures had an average of 25 g/kg of sugar and 12 g/kg of starch in their composition at natural humidity. As the study data showed, due to the low content of easily digestible carbohydrates in the herbage of desert pastures, the provision of sheep with sugar remains at a low level, which undoubtedly affects the productivity of sheep and, in general, the efficiency indicators of animal husbandry in the region. The results of the study are of practical importance in the organization of cattle breeding in Kazakhstan and countries with similar conditions for the sheep industry.

Keywords: Carbohydrate Nutrition, Sugar, Starch, Forage Plants, Chemical Composition

Introduction

The availability of local feed resources in different seasons can influence the main sources of carbohydrates and proteins, which significantly affects the fermentation of the rumen and the subsequent productivity of ruminants (Wanapat, 2009). Ruminants and some herbivores receive much more energy-giving nutrients from plant carbohydrates than monogastric carnivores and omnivores, for whom fibrous materials have little or no energy value (Holden and Loosley, 2018).

Wanapat *et al*. (2013); Devendra and Leng (2011) stressed the extreme importance of using local forage resources as a key driving force for increasing animal productivity in Asia. Therefore, there is a growing interest in improving the existing methods of assessing the Nutritional Value (NV) of pasture feed, considering the fractions of easily digestible carbohydrates, which is an urgent matter of modern research and practice concerning feeding farm animals.

Proteins and carbohydrates are the most important nutrients for determining the productivity of animals

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(Tedeschi and Fox, 2020). Nitrogen-Free Extractive Substances (NFES), especially sugars and starch, are nutrients for the animal and are also used for synthesizing bacterial protein. The quantity and ratio of these elements of carbohydrate nutrition of ruminants in a certain way affect their metabolism and productivity, which, ultimately, is associated with the use of nutrients in the diet (Gibbs and Saldias, 2022).

Studies have found that starch can be transferred in amounts from 5-50% of what is taken with food from the stomach to the intestines. Scientists (Kudasheva *et al*., 2015) consider the main amount of raw fiber and easily digestible carbohydrates in the dry matter of diets: Mono and disaccharides are utilized almost completely in the digestive tract and the degree of fermentation of starch, hemicellulose, and cellulose depends on their content in the feed.

Carbohydrates in the body of animals are used not only as an energy material but also turn into fats. Carbohydrates play a big role in the synthesis of the components of animal milk. In case of their deficiency, glucose synthesis in the liver decreases and then the reserves of the body are included in the metabolic processes, which can lead to metabolic pathology and the development of ketoses, a decrease in productivity and fatness of animals, deterioration of milk quality and disruption of reproduction processes (Niwińska, 2012; Kudasheva *et al*., 2015).

The ability of ruminants, such as cattle, sheep, and goats, to convert polysaccharides present in grass and similar feeds into protein provides the main source of protein for humans. Most animals get their energy from carbohydrates and fats, which provide energy for growth and muscle activity and support vital functions. Animals need much more energy for growth, work, or milk production than for simple care (Holden and Loosley, 2018).

Currently, research by scientists (Kudasheva *et al*., 2015) has established that Easily Fermentable Carbohydrates (EFC) determine the palatability and digestibility of feed and therefore affect the productivity of animals. Studies have shown that the absence of an easily accessible supply of fermentable carbohydrates can lead to increased concentrations of ammonia in the ruminant glands (Niwińska, 2012; Soder *et al*., 2016).

Natural meadows are found on all continents of the world, but their use and conservation success require adopting sustainable management methods (Nasiyev, 2016). The use of pasture environments necessarily implies control over the grazing of livestock. Methods of agriculture management, in particular, pasture management (for example, grazing management) are the main sources of temporary variability of soil properties and forage grasses (Nasiyevich, 2013). Depending on the maturity of the herbs and the management of the grass, the concentration and availability of protein and carbohydrates vary (Shamsutdinov *et al*., 2014).

The content of easily soluble carbohydrates changes significantly during the preparation and storage of feed. Therefore, it is necessary to choose technologies that ensure minimal changes in the content of carbohydrates (Nasiyev *et al*., 2018). The sugar content in green feed depends on the botanical composition of herbs, the phase of their use, the place of cultivation, and the density of sowing (Nasiyev *et al*., 2021a).

Carbohydrates are the connecting link between the production of high-quality feed and the efficiency of its use. According to research, the carbohydrate content in forage plants (legumes, perennial cereals) is not stable and is associated with the type of plant, the phase of vegetation, the growing area, and other factors (National Research Council, 2007). This is because carbohydrate fractions are the main energy supplier when feeding animals and are characterized by various physiological effects on digestion and the use of nutrients in the body, both in the production of milk and meat (Kudasheva *et al*., 2015).

There is a need to implement the previously existing methodology, where carbohydrate nutrition was determined by the content of only NFES. Considering the significant role of easily digestible carbohydrates in metabolism and their variability under the influence of various factors, in the process of studying the carbohydrate composition, special attention was paid to the sugar and starch content in the composition of the main forage plants and pasture feeds of the desert zone of southern Kazakhstan.

The study aimed to improve the methods for determining the overall energy NV of pasture feed, considering the actual content of easily digestible carbohydrates from sugar and starch in the composition of the main plant species.

Materials and Methods

Studies on the content of easily digestible carbohydrates in the composition of forage plants and pasture herbage as a whole were carried out on shrubby grassland herbage in the sandy desert of Kyzylkum (northern part) and the foothill ephemeral desert of the Turkestan region of the Republic of Kazakhstan in the period from 2021-2023. The study of the chemical composition of pasture feed and certain types of forage grasses was carried out in the testing center of the Kazakh scientific research institute of animal husbandry and feed production Limited Liability Partnership (LLP).

A characteristic feature of the climate of the desert zone, especially the southern subzone, is its pronounced continentality, which consists of sharp transitions between seasons, small amounts of precipitation, and aridity.

The change in the rational and thermal balances determines the air temperature.

The average temperature in January ranges from 7-11°C and in July-from 28-45°C. On a large part of the plains, the annual amplitudes of average monthly temperatures are 37-39°C.

There is little precipitation in the deserts: An average of 100-150 mL per year.

The main types of pastures of the sandy desert on ridge-bumpy desert-baked soils include white saxaul and sedge (*Haloxylon persicum*, Carex physodes) white saxaul, sedge, and wormwood (*Haloxylon persicum*, Carex physodes, Seriphidium badhysi), black saxaul, forbs and ephemerae (*Haloxylon aphyllum*, Microcephalalamellate, Strigosella grandiflora) and black saxaul and saltwort (*Haloxylon aphyllum*, Salsola leptoclade, Suaeda arcuata).

The main types of the foothill ephemeral desert are bluegrass and Eremopyrum (*Poa bulbosa*, Eremopyrum buonapartis), bluegrass and sedge with spots of wormwood (*Poa bulbosa*, Carex pachystylis, Seriphidium) and bluegrass and sedge with forbs (*Poa bulbosa*, Carex pachystylis).

The objects of the study were pastures of the Kzylkum sandy desert and the foothill desert of southern Kazakhstan.

Following the methods of the study and the work plan, we set the following objectives:

- To study and determine the content of EFC in the composition of the main (individual) forage plants of the desert zone, depending on the season of use
- To study the chemical composition, NV and sugar and starch content in the composition of herbage of various types of pastures of the sandy desert of Kyzylkum and the foothill desert of southern Kazakhstan
- To determine the availability of easily digestible carbohydrates (sugar and starch) for sheep in the pasture feed of the sandy desert of Kyzylkum and the foothill desert of southern Kazakhstan in the spring and summer seasons with different systems of pasture use

The study of the carbohydrate composition of pasture feed was carried out with different systems of pasture use according to the specified scheme of field experiments and studies (Table 1 and Figs. 1-2).

Based on this, during the systematic grazing with grazing rotation (on grazing units), sandy pastures were used for the first time in early spring, when early spring ephemeral, ephemeroids and pasture forbs are mostly grazed with an optimal load for 7-10 days (from March 20 to April 1 at the rate of 2.5 heads of sheep per 1 ha). The area of the experimental plot is 20 ha. Sandy pastures were grazed up to 60-70% of their fodder mass. All pasture plants grazed in early spring showed growth after 15 days and were well preserved from over-grazing and trampling. The experimental section of sandy pastures would be re-grazed from April 15-April 22 in compliance with the optimal load. Afterward, rough-haired sheep in the summer season were kept in the second field of the two-field pasture rotation of subshrub and ephemeral sandy pastures in compliance with the recommended loads until the autumn season.

Samples of forage grasses were taken from the designated areas, cutting the grasses in the phases of tillering, stem elongation, earing, flowering, and seed maturation. On the site of the herbage, five accounting sites with a size of $5\times2 = 10$ m^2 each were established. The herbage was cut at a height of 3-5 cm. The green mass obtained from all accounting sites was thoroughly mixed to compile an average sample. The samples were placed in a polymer bag and sent to an accredited laboratory of the Kazakh Research Institute of Animal Husbandry and Feed Production (Almaty) for analysis to determine the composition and NV.

The yield of grasses on the pasture during the pasture period consisted of the yield in each grazing. The yield of grass on pastures is expressed in green mass, dry matter, feed units, and exchange energy. In geobotanical surveys, the gross yield of pastures must be determined in non-grazed areas. However, it is advisable to collect some materials to establish the pasture use rate. In our experiment, this was done by considering the remains of feed in the grazed areas with a mandatory assessment of the degree of grazing (over-grazing, normal grazing, half-grazing, slight grazing).

Fig. 1: Locations of pastures of the foothill desert of southern Kazakhstan

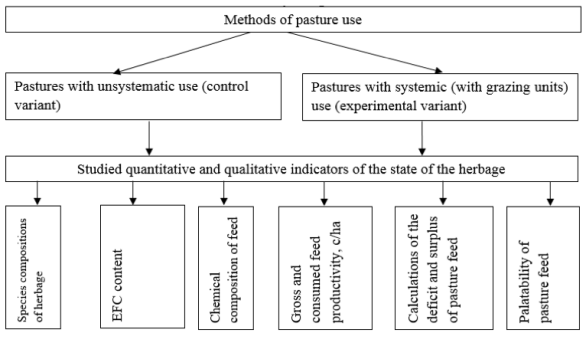

Fig. 2: Study design

Table 1: Study of the use of distant pastures of the Kyzylkum sandy desert and the foothill zone of southern Kazakhstan

Pasture zones	Pasture use variants
Pastures of the sandy desert of Kyzylkum	Pastures with unsystematic grazing (control variant)
	Pastures with systemic (unit rotation grazing) use (experimental variant)
Pastures of the foothill desert of southern Kazakhstan	Pastures with unsystematic grazing (control variant)
	Pastures with systemic (unit rotation grazing) use (experimental variant)

On grass and subshrub pastures with uniform vegetation coverage, the yield was considered by cutting grass on sites of 2.5 m^2 in 4-fold repetition or 1 m^2 in 10-fold repetition, on specially leveled herbages of 1 m^2 in 4-fold repetition, i.e., on one site in 10 m^2. The plants were cut at a height of 4-6 cm for tall grass and 2-3 cm for small grass. For sparse overgrown herbages on the sand, new warp soils, rocky soils, and narrow platforms were used (transects of 50 m ×20 cm = 10 m^2) of 2-4-fold repetition, where all vegetation was cut completely. Transects of 150-200×2 m (300-400 m^2) were also used on desert very sparse pastures.

Deviations of yields in dry and wet years are recommended to be indicated as a percentage of the yield in the average year. The correctness of the application of these amendments was checked using the following formulas:

$$M = D + \frac{M.CD}{100} \text{ for a dry year} \quad (1)$$

$$M = W - \frac{M.CW}{100} \text{ for a wet year} \quad (2)$$

where,
M = The yield in the average year
D = The yield in the dry year
W = The yield in the wet year
CD = The correction factor (percentage) for the dry year
CW = The correction factor for the wet year

Correction factors were established according to the methodology of the All-Russian Williams Fodder Research Institute.

The average yield of pastures for several seasons was calculated together according to the rules of the weighted average, considering the duration of each season (in months or days).

The coefficients of the use of pasture feed, with the help of which the part of the feed consumed as part of the gross harvest is determined, were established based on data from experimental stations. This was done by calculating the coefficients of use of plant groups (for deserts with sparse herbage), as well as individual plants that are part of pasture feed.

The part of the feed consumed by pasture types was calculated for the specific materials of the expedition surveys, the following formulas were used.

For the warm season:

$$EW = \left(GY - \frac{GY.AC}{100}\right).\frac{CW}{100} \quad (3)$$

For the cold (winter) period of the year:

$$EC = GY - \frac{\left(\frac{GY.S}{GY-100}\right).CC}{2.100} \quad (4)$$

where,
EW = The eaten part of the feed in the warm period
EC = The same, in the cold period (winter)
GY = The gross yield in the autumn period
AC = The after-growth coefficient (%)
S = The feed survival capacity (%)
CW = The coefficient of feed consumption in the warm period (%)
CC = The same, in the cold period (winter)

The collected samples were dried to an air-dry state, after which they were weighed on electronic scales: Grass samples up to one-tenth of a g and samples from model bushes up to a g. The obtained figures were used to calculate the gross and consumed feedstock for individual species and groups of plants.

After determining the gross stock for the accounting season, we started calculating the gross and consumed stocks for all seasons of the year.

The recalculation of gross stock for all seasons of the year, as well as the calculation of the consumed stock, was carried out using tables compiled based on long-term stationary observations.

The study of the chemical composition of pasture feed and certain types of forage grasses was carried out on the feed analyzers INFRAXACN 7500 (Sweden) according to State Standard (GOST) 32040-2012. The analyzer works with ISIscanTM software, which supports the latest calibration technologies. The INFRAXACN 7500 provides high analytical reliability, with a robust design, obtaining very accurate results.

The NIRS DS 2500 feed analyzer made by FOSS (Sweden) was used to determine the chemical composition of the feed. NIRS DS 2500 provides Infrared (IR) analysis of feed with exceptional accuracy in a specialized wavelength range from 850-2,500 nm. It performs direct analysis of feed and feed samples in ground form. Global calibrations of FOSS include fat, protein, moisture, ash, sugar, starch, crude fiber, Neutral Detergent Fiber (NDF),

Acid Detergent Fiber (ADF), amino acids (lysine, threonine, methionine, tryptophan), calcium, phosphorus, potassium, sodium, magnesium, and chlorides according to GOST 13496.3-92 and 13979.6-69.

We determined the NV of pasture feed as a function of its quality, usually absorbed energy or Metabolized Energy (ME), and quantity Voluntary Feed Intake (VFI) as the main indicators.

For grasses of grain and forbs and ephemeral pastures, based on chemical compositions, the coefficients of protein digestibility were taken to be 68%, fat digestibility 74%, fiber digestibility 58%, and NFES digestibility 72%. The data of further calculations are presented in Table 2.

The energy NV of the feed was calculated using regression equations (formulas):

$$Y = A^{*} X \tag{5}$$

where,

Y = The total energy NV of 1 kg of feed, feed units
A = The calculated coefficient set for each type of feed
X = The sum of the energy of organic substances of the feed except for fiber (energy/fiber) in mega calories is equal to:

$$\frac{5.6xP + 9.3xF + 4.3NFES}{1,000} \tag{6}$$

The equation Y=A * X can be represented as follows:

$$Y = \frac{A * 5.6xP + 9.3xF + 4.3NFES}{1,000} \tag{7}$$

where,

P = The crude protein content, g/kg
F = The crude fat content, g/kg
$NFES$ = The content of nitrogen-free extractible substances, g/kg
1,000 = The translation of results into mega calories, Mcal

The energy coefficients of raw nutrients (protein in 1 kg: 5.6 kcal, fat in 1 kg: 9.3 kcal, NFES in 1 kg: 4.3 kcal) were reviewed and approved by the Commission of Experts of Food and agricultural organizations at the United Nations (UN).

For different types of feed, feed units are calculated using the following regression equations:

$$GrassY = 0262xX \tag{8}$$

$$HayY = 0.210xX \tag{9}$$

Experiments to determine the amount of feed eaten by experimental animals on pasture were carried out by the method of a double indicator. The digestibility of organic matter and crude protein was determined by two indicators, one external and one internal. This formula has the following form:

$$Digestibility\,coefficient(\%) = 100 - 100.\left[\frac{X\frac{100-\alpha}{100}}{Z}\right].\frac{n_1}{n_2} \tag{10}$$

where,

X = The content of the indicator in the feed (%)
Z = The indicator content in feces (%)
A = The digestibility of the indicator, determined in the experiment by digestibility (standard methodology)
n_1 = The content of protein or, respectively, organic matter in feces
n_2 = The content of protein or organic matter in the feed

The evaluation of digestibility by two indicators allows us to significantly increase the accuracy of the determination.

When using the method of two indicators (one external and one internal) the weight of the grass consumed by the animal on the pasture was determined. This method makes it possible to avoid the complete collection of feces and conduct a standard experiment on the digestibility of grass. Calculations were made according to the following formula:

$$Weight\,consumed = \frac{Amount\,of\,chromeoxide\,fedperday}{Amount\,of\,chromeoxide \in 1g\,offeces} \times \frac{Plantindicat\,or\,content \in feces(\%)}{plantindicator\,content \in grass(\%)} \tag{11}$$

All weight indicators were converted to dry matter. Lignin and chromogen were used as the plant indicator.

The amounts of feed consumed by pasture feed of experimental animals were compared for verification with a detailed norm developed by the department of feeding farm animals of the All-Russian institute of animal husbandry.

Along with the optimal norms of fiber in the department of feeding farm animals of the VIZh, the norms of EDC (easily digestible carbohydrates expressed in glucose) for all age and sex groups of sheep have been established. The amount of EDC was calculated according to the formula:

$$EDC,g\,\frac{Sugar,g}{0.950} + \frac{Starch,g}{0.925} \tag{12}$$

Table 2: Methods for calculating the NV of feed in feed units

Indicator	Nutrients			
	Protein	Fat	Fiber	NFES
Contains nutrients in 100 kg of feed by chemical composition, kg	4.70	1.300	10.100	16.1000
Coefficient of digestibility, %	68	74.000	58.000	72.0000
Digestible nutrients, kg	3.196	0.962	5.858	11.5920
Coefficients of the productive value of starch	0.94	1.910	1.000	1.0000
The productive value of starch	3.00	1.840	5.860	11.5900
The sum of the productive value of starch, kg	3.0+11.84+5.86+11.59=22.29			
Hollow fiber, kg	10.1*0.43=4.34			
Starch equivalents (kg) per 100 kg of feed	22.29-4.34=17.95			
Feed units (kg) per 100 kg of feed	17.95:0.6-29.92:100-0.299=0.3			
Digestible protein 1 kg of feed	3.196:100=0.03196 kg per 1 kg of feed or 31.96 g =32 g			

Results

Brief Feed Characteristics of the Pastures of Sandy Deserts of Southern Kazakhstan

In the sandy deserts of Kyzylkum, where shrubby and grassy sandy pastures are common (Fig. 3), the most characteristic plant species are white and black saxaul (*Haloxylon persicum* Bunge ex Boiss, *Haloxylon aphullum*), bushes such as *Calligonum* (*Calligonum leucocladum Bunge*), sandhill wattle (Ammodendzon conollyi Bunge) and astragalus (Astragalus villosissimus Bge), shrubs ephedra (Ephedza strobilacea Bunge) and dwarf shrubs gray wormwood (Artemisia terrae-albae Krasch) and beach wormwood (Artemisia tschernieviana, arenaria), winter fat (Ceratoides papposa Botsch, et lkonn), prostrate summer cypress (*Kochia prostrata* (L) Schrag), eastern saltwort (Salsola orientalis S.G. Gmel)) and grasses desert sedge (Carex physodes M.B.), beaked sedge (Carex physodes M.B.), desert wheatgrass (*Agropyrum desertorum* (Fisch), bulbous bluegrass (*Poa bulbosa* L.), cheatgrass brome (Anisantha tectorum, Bromus tectorum), Eremopyrum buonapartis and Aristida karelinii.

The development of these plants is associated with the ability to accumulate nutrients in storing underground organs (rhizomes, bulbs, and tubers) and grow lush rosettes of large juicy leaves in the spring.

On the sands of Kyzylkum, there are areas of the most valuable perennial cereals, such as wheatgrass, desert wheatgrass (Agropyron desertorum), and Hohenakker's feather grass (Stipa hohenackeriana).

In the sandy desert of Kyzylkum, the basis of the herbage and the feed eaten are ephemeral plants, of which the main place (more than 60% of the feed eaten) is occupied by beaked sedge (Carex physodes Bied). Other common plants are cheatgrass brome (Anisantha tectorum) (Fig. 4), oriental false wheatgrass (Eremopyrum orientale), woad (Isatis Boissieveriana, Isatis emarginata), Malcolm stock (Malcolmia turkestanica litv.), annual astragalus, Turkestan rhubarb, etc.

Fig. 3: Shrubby and grassy sandy pastures of Kyzylkum

Fig. 4: *Cheatgrass brome* (Anisantha tectorum)

A lesser role both in the herbage and in the feed balance is played by the following grasses: Long-term vegetation: Agriophyllum arenarium M.V. and Horaninovia and spring/summer vegetation: Euphorbia (*Euphorbia pulcherrima)* and turnsole *(Chrozophora*).

Brief Feed Characteristics of the Pastures of Foothill Deserts of Southern Kazakhstan

Foothill ephemeral pastures stand out sharply among other forage lands with original vegetation in the form of spring grasses covering the loessic foothills of the adyrs and foothill desert plains (Fig. 5).

Fig. 5: Ephemeral pastures of the foothill desert

Fig. 6: Sedge with ephemerae and cereals, and sedge and bluegrass with tall grasses

These herbs are mainly ephemera (annuals) and ephemeroids (perennials). They vegetate during the wet and warm enough spring season and with the onset of the summer dry season, they finish the vegetation and dry out.

The main associations on the foothill adyrs are mainly the following: sedge, sedge with forbs, sedge with ephemerae and cereals, sedge and bluegrass, and sedge and bluegrass with tall grasses (Fig. 6).

The large-stemmed plants are represented by Cousinia spiridonovii, Psoralea drupacea Bge, camel thorn (Alhlagi pseudalhagi), and Jerusalem sage (Phlomus thapsoldes Bge).

Ephemera and ephemeroids in the spring are very nutritious forage crops for sheep. In the green state, they are equal to the best meadow plants and mountain pastures. In summer, dry plants can be compared to hay of average quality. The fodder stock of ephemeral plants on foothill pastures by the autumn/winter period is sharply reduced due to drying, breaking off, and scattering. Therefore, foothill ephemeral pastures are good only for spring and, partly, purely ephemeral pastures of the foothill zone only serve 4-5 months a year as good forage lands, and the rest of the time they lose their value significantly.

The exception is the subshrub ephemeral pastures of the desert zone, which occupy a significant territory of the foothill desert plains and desert lowlands.

In the south of Kazakhstan, they are found on dense fine-grained soils, often saline and gypsum, and sometimes on dense sands.

On these pastures of subshrubs, the largest distribution is noted in gray wormwood (Artemisia terrae-albae Krasch). There are also other subshrubs, as well as unifoliate astragalus (Astragalus villosissimus), bindweed (Convolvulus hamadae), and eastern saltwort (Salsola orientalis). These subshrubs create the upper tier in the herbage and the lower one consists of herbaceous plants such as ephemera and ephemeroids; often annual saltworts are mixed with them. Often the vegetation cover is complex due to the peculiarities of the soil cover and the degree of salinity of the soil. Annual saltworts are very characteristic of saline habitats.

The special value of the pastures of the foothill desert of southern Kazakhstan of the wormwood/ephemerae type is due to their being fit for grazing all year round and twice a year: The first time in spring (due to spring grasses consisting of ephemera, ephemeroids and pasture grass) and the second time in autumn or winter (due to wormwood, dried remnants of ephemera, annual saltwort, and tall grass).

A negative feature of these pastures is the large varietal fluctuations in the yield of the fodder mass due to the hydrothermal conditions of the economic year.

Results of the Assessment of Carbohydrate Nutrition of Pasture Feed of the Sandy and Foothill Deserts of Southern Kazakhstan

The results of studying the content of sugar and starch and, in general, EFC in the main forage plants and various forage products of the desert zone of southern Kazakhstan, depending on the seasons of their use, are shown in Table 3.

As can be seen from the results of laboratory studies, many types of the main forage plants of sandy and foothill deserts, depending on the seasons of the year, have different amounts of sugar and starch in their composition.

It was found that in the spring season, sugar (103 g/kg) and starch (63 g/kg) content was higher in cheatgrass brome than in other types of cereals, or higher than in bulbous bluegrass (89 and 47 g/kg) from the same growing area by 14 g/kg (15.7%) and 16 g/kg (6.4%). The composition of the wheatgrass (desert wheatgrass), even in a dry state in the autumn season, includes a significant amount of sugars (68 g) and starch (73 g/kg).

Among the studied subshrubs, the largest amount of sugar and starch in the spring season is contained in the white wormwood at 39 g/kg, and in paniculate wormwood, there are more sugars (71 g/kg) and less starch (11 g/kg).

In the summer, the reeds from the southern desert subzone have the highest sugar content (87 g/kg).

Table 3: The content of EFC in the composition of the main forage plants of the desert zone, depending on the season of use, g/kg of air-dry matter

Types of pasture forage plants	Seasons of use	Sugar, g/kg of dry matter	Starch, g/kg of dry matter	Amount of EFC, g/kg of dry matter
Bulbous bluegrass (*Poa bulbosa*)	spring	89	47	136
Cheatgrass brome (*Anisantha tectorum* (L.)	spring	103	63	166
Desert wheatgrass (*Agropyron desertorum*)	autumn	68	73	148
White wormwood (*Artemisia terrae-albae Krasch*)	spring	39	39	78
Paniculate wormwood (*Artemisia paniculata Lam.*)	spring	71	11	82
Eastern saltwort (*Salsola orientalis*)	spring	29	16	45
Grey winter fat (*Ceratoides papposa*)	spring	24	32	56
Prostrate summer cypress (*Kochia prostrata (L.*)	summer	39	13	52
Peacock poppy (*Papaver pavoninum*)	spring	79	31	110
Ferula foetida	spring	40	36	76
Iris songarica	spring	57	-	57
Common reed (*Phragmites commúnis*)	summer	87	26	113
Syrian rue (*Peganum harmala*)	spring	29	18	47
White saxaul (*Haloxylon persicum*)	summer	50	17	67
Sandhill wattle (*Ammodendron bifolium*)	summer	57	24	81
Pasture grass (cereal/grass)	spring	89	47	136
	Summer	39	17	56
Grass and forbs hay	summer	44	21	65

Table 4: Chemical composition, NV, and sugar and starch content in the composition of herbage of various types of pastures of the sandy and foothill deserts at natural humidity

	Content in 1 kg of feed														
Pasture grass of various types Desert pastures	Feed units	Energetic feed units (EFU)	Exchange energy, MJ	Digestible protein, g	Ca, g	P, g, mg	Carotene g, g	Dry matter g	Crude protein g	fat, g	Fiber, g	NFES, g	Starch, g	Sugar, g	Ash,
Pasture grass (wormwood, saltwort, forbs)	0.27	0.25	2.75	15.45	4.4	0.9	22.2	365.4	30.3	4.3	157.1	140.3	13.8	-	33.6
Wormwood and ephemerae with saxaul	0.25	0.39	4.13	46.90	5.2	-	13.0	503.3	69.0	10.8	189.2	220.6	46.9	7.2	13.7
Prostrate summer cypress and wheatgrass with winter fat	0.31	0.34	3.65	29.10	6.7	0.4	-	514.0	44.2	12.1	214.9	239.8	25.0	-	3.0
Wheatgrass and white wormwood with winter fat	0.29	0.40	4.23	36.70	6.5	0.7	37.5	414.0	49.7	10.4	147.8	151.6	22.5	-	54.5
Forbs and ephemerae with saxaul	0.27	0.24	2.57	26.15	5.1	0.3	15.8	401.2	53.4	7.8	140.4	145.8	31.4	10.2	53.1
Wormwood, prostrate summer cypress and winter fat	0.30	0.30	3.26	29.57	6.7	0.4	22.4	453.8	59.0	9.8	164.3	173.4	22.7	-	47.3
Forbs, ephemerae, and saltwort	0.21	0.33	3.54	47.07	8.7	0.4	37.7	453.7	82.6	10.8	149.7	154.6	40.9	12.6	56.0
Forbs and white wormwood	0.26	0.27	2.93	19.34	5.8	0.3	19.3	418.3	37.2	8.8	165.2	151.6	11.2	-	55.5
Wormwood and eastern saltwort	0.25	0.19	2.08	29.15	6.3	0.5	19.8	352.3	55.0	8.1	18.3	140.5	25.2	14.4	50.4
Wormwood, forbs and ephemerae	0.29	0.33	3.53	34.49	3.5	0.3	19.5	392.5	53.9	8.0	124.3	177.9	21.1	4.1	28.4
Bluegrass and sedge with wormwood	0.35	0.41	4.34	39.04	1.0	0.1	39.6	413.0	71.4	5.0	162.3	109.7	49.6	22.7	64.6
Bluegrass and sedge with tall grasses	0.36	0.42	2.60	15.35	6.4	5.3	-	456.0	23.5	13.0	140.2	257.0	47.5	12.9	22.8

Of the studied species of shrubs, the white saxaul is slightly inferior to the bifoliate sandhill wattle (57 and 24 g/kg) in terms of the EFC content (50 g/kg of sugar and 17 g/kg of starch).

The carbohydrate NV of subshrub/ephemerae/forbs type of desert pastures was studied depending on the area of growth and the seasons of pasture use. Studies established a significant number of EFC in the herbage of these pastures of the southern desert subzone of the spring period in terms of sugar content (89 g/kg) and starch (47 g/kg).

In summer, due to severe parching, the EFC content in the composition of the indicated herbage of the southern desert subzone decreases to 39 g/kg of sugar and 17 g/kg of starch.

The studied samples of cereal/grass hay from the southern desert (Kyzylkum) contained only 21 g/kg of starch, while the sugar content there was higher (44 g/kg).

The results of laboratory studies on the composition and NV of herbage of various types of desert pastures in the south of Kazakhstan with the determination of sugar and starch in their composition in g/kg of feed are shown in Table 4.

We established that the composition and NV of pasture herbage depend on its botanical composition and the structure of the content of its components.

In the spring/summer pasture season, depending on the phase of vegetative development and maturation of the main types of forage plants, the dry matter content in the grass of sandy desert pastures averages 430 g/kg of pasture feed at a natural humidity of 43%.

The analysis of the sugar content in the composition of the herbage of various types of desert pastures shows that more sugar is contained in the composition of bluegrass and sedge herbage with an admixture of wormwood (49.6 g/kg) and the herbage of desert ephemeral pastures with tall grasses (47.5 g/kg).

We established that pasture feeds of most of the studied types of desert pastures have an average of 25 g/kg of sugar with minor differences in their composition.

There is no starch in the herbage of the following types of desert pastures: Wormwood, saltwort, and forbs; prostrate summer cypress and wheatgrass with winter fat; wheatgrass and white wormwood with winter fat; wormwood and prostrate summer cypress and winter fat; and forbs and white wormwood.

Table 5: Availability of EDC (sugar and starch) to sheep in pasture feed of the sandy and foothill deserts in the spring and summer seasons with different systems of pasture use

	Seasons of use							
	Spring				Summer			
	Shrub/ephemerae pastures the sandy desert		Ephemeral pastures of the foothill desert		Shrub/ephemerae pastures sandy desert		Ephemeral pastures of the foothill desert	
EFC and their consumption norms		Unsystematic (economic)	Systematic (with grazing units)	Unsystematic (economic)	Systematic (with grazing units)	Unsystematic units)	Systematic (with grazing units)	unsystematic (economic)	Systematic (with grazing units)
Amount of pasture feed consumed, kg		6.60	7.90	7.30	8.90	4.90	5.45	4.20	4.90
Nutrient content in the pasture feed consumed									
Sugar	According to the VIZh Standards (2003), g	170.00	170.00	170.00	170.00	150.00	150.00	150.0	150.00a
	Consumed, g	165.00	137.50	182.50	222.50	122.50	136.20	105.0	122.50
	Availability, %	97.06	80.88	107.35	130.88	81.66	90.80	70.0	81.66
Starch	According to the VIZh Standards (2003), g	260.00	260.00	260.00	260.00	2200.00	220.00	220.0	
	Consumed, g	79.20	94.80	87.60	106.80	58.80	65.40	50.40	58.80
	Availability, %	30.46	36.46	33.69	41.07	26.73	29.73	22.91	26.73

In general, the composition of most desert pasture herbage types contains a small amount of starch (on average 12 g/kg of pasture feed at natural humidity).

Determination of the sugar and starch content in the pasture herbage allowed us to establish the level of their deficit and surplus in pasture feed according to the seasons of the year with different systems of pasture use and, in general, the carbohydrate availability to sheep in pasture conditions (Table 5).

Despite the relatively good provision of general, energy and protein nutrition, as well as the main macromineral substances (except for phosphorus), to coarse-haired sheep in the concentration of dry matter in the pasture diet, the sheep's need for EFC in pasture feed is not satisfied. In particular, it was found that only with the rational use of foothill desert pastures in the spring season, it was possible to satisfy the needs of the sheep in sugar at the level of complete normalized feed (130.88%). This is because ephemera and ephemeroids of foothill deserts in the spring are very nutritious pasture feed for sheep. In the green state, they are equal to the best meadow plants and mountain pastures. In summer, dry plants can be compared to hay of average quality. With unsystematic (economic) use of desert pastures only in good years, the sheep are provided with sugar at the following rate on average: In spring: 80.88%, in summer: 64.3%, in autumn: 77.50%.

Due to the increased need for starch in the animals and the low average content of it in the grass of desert pastures, the starch consumption in sheep remains at a low level in all seasons of the year and, with rational use of pastures, amounts to an average of 31.62% of the required amount in spring, 24.0% in summer and 37.50% in autumn, which indicates a significant shortage of starch content in the herbage of desert pastures in the south of Kazakhstan, regardless of the season and the system of pasture use.

Discussion

The floral composition of sandy pastures is much richer than the loamy plains of the desert zone. The most characteristic plant species are white and black saxaul (Haloxylon persicum Bunge ex Boiss, Haloxylon aphullum), bushes such as Calligonum (Calligonum leucocladum Bunge), sandhill wattle (Ammodendzon conollyi Bunge), astragalus (Astragalus villosissimus Bge), shrubs: Ephedra (Ephedza strobilacea Bunge), dwarf shrubs gray wormwood (Artemisia terrae-albae Krasch) and beach wormwood (Artemisia tschernieviana, arenaria), winterfat (Ceratoides papposa Botsch, et lkonn), prostrate summer cypress (Kochia prostxata (L) Schrag), eastern saltwort (Salsola orientalis S.G. Gmel)) and grasses desert sedge (Carex physodes M.B.), beaked sedge (Carex physodes M.B.), desert wheatgrass (Agropyrum desertorum (Fisch), bulbous bluegrass (Poa bulbosa L.), cheatgrass brome (Anisantha tectorum, Bromus tectorum), Eremopyrum buonapartis and Aristida karelinii.

The development of these plants is associated with the ability to accumulate nutrients in storing underground organs (rhizomes, bulbs, and tubers) and grow lush rosettes of large juicy leaves in the spring.

In the sandy desert of Kyzylkum, the basis of the herbage and the feed consumed by animals are ephemeral plants, where the main place (over 60% of the consumed feed) is occupied by beaked sedge (Carex physodes Bied). Other common plants are cheatgrass brome (Anisantha tectorum), oriental false wheatgrass (Eremopyrum orientale), woad (Isatis Boissieveriana, Isatis emarginata), Malcolm stock (Malcolmia turkestanica litv.), annual astragalus, Turkestan rhubarb, etc. The main associations on the foothill adyrs are mainly the following: Sedge, sedge with forbs, sedge with ephemerae and cereals, sedge and bluegrass, and sedge and bluegrass with tall grasses.

The analysis of the results of studies on the influence of grazing on the state of pastures allows us to conclude that the primary issue of environmentally sustainable management of pasture farming in arid areas is the amount of removal and grazing of pasture grass (Seidakhmetova *et al*., 2022; Yesmagulova *et al*., 2023).

We established that on free grazing pastures, even with a normal load, by the end of the spring season, more than half of the plants are not grazed. Starting from the specified period, the aftergrowth of the grazed plants grows poorly, it is not enough for animals and cattle involuntarily begin to eat plants that have never been grazed and are usually in the phases of flowering, fruiting, and seeding when their NV will be 1.5-2.5 times lower than the NV of young grass (Coleman and Henry, 2002).

The special value of the pastures of the foothill desert of southern Kazakhstan of the wormwood/ephemerae type is due to their being fit for grazing all year round and twice a year: The first time in spring (due to spring grasses consisting of ephemera, ephemeroids and pasture grass) and the second time in autumn or winter (due to wormwood, dried remnants of ephemera, annual saltwort, and tall grass). A negative feature of these pastures is the large varietal fluctuations in the yield of the fodder mass due to the hydrothermal conditions of the economic year. Many types of the main forage plants of sandy and foothill deserts, depending on the seasons of the year, have different amounts of sugar and starch in their composition.

Studies (Nasiyev *et al*., 2021b) show that the sugar content in the grass of forage crops depends on the type, phase of development, cultivation zone, and harvesting technology. As plants grow, the amount of easily and hardly soluble carbohydrates naturally increases. Legumes and cereals have the largest number of them during the flowering phase. When converted to absolute dry matter, there is a natural decrease in the amount of easily soluble carbohydrates. The maximum number of them in cereals coincides with the phase of stem elongation and in legumes with flowering. According to Kozłowska *et al*. (2007), the level of carbohydrates increased regardless of the earlier stimulation of the appearance of shoots. At the stage of vegetative growth, the content of reducing sugars in leaf blades was 2.5 times higher than in control plants, which suggests stimulation of photosynthetic activity.

It was found that in the spring season, sugar (103 g/kg) and starch (63 g/kg) content was higher in cheatgrass brome than in other types of cereals, or higher than in bulbous bluegrass (89 and 47 g/kg) from the same growing area by 14 g/kg (15.7%) and 16 g/kg (6.4%). The composition of the wheatgrass (desert wheatgrass), even in a dry state in the autumn season, includes a significant amount of sugars (68 g) and starch (73 g/kg).

Among the studied subshrubs, the largest amount of sugar and starch in the spring season is contained in the white wormwood at 39 g/kg, and in paniculate wormwood, there are more sugars (71 g/kg) and less starch (11 g/kg). In the summer, the reeds from the southern desert subzone have the highest sugar content (87 g/kg).

Of the studied species of shrubs, the white saxaul is slightly inferior to the bifoliate sandhill wattle (57 and 24 g/kg) in terms of the EFC content (50 g/kg of sugar and 17 g/kg of starch).

The carbohydrate NV of subshrub/ephemerae/forbs type of desert pastures has been studied depending on the area of growth and the seasons of pasture use. Studies have established a significant number of EFC in the herbage of these pastures of the southern desert subzone of the spring period in terms of sugar content (89 g/kg) and starch (47 g/kg).

We established that pasture feeds of most of the studied types of desert pastures have an average of 25 g/kg of sugar with minor differences in their composition.

In general, the composition of most desert pasture herbage types contains a small amount of starch (on average 12 g/kg of pasture feed at natural humidity).

Due to the increased need for starch in the animals and the low average content of it in the grass of desert pastures, the starch consumption in sheep remains at a low level in all seasons of the year and, with rational use of pastures, amounts to an average of 31.62% of the required amount in spring, 24.0% in summer and 37.50% in autumn, which indicates a significant shortage of starch content in the herbage of desert pastures in the south of Kazakhstan, regardless of the season and the system of pasture use.

Similar studies on the EDC content (sugar and starch) in the herbage of desert pastures in Kazakhstan have not been conducted before. An in-depth study of EFC in the composition of pasture feed and individual forage plants of the desert zone of southern Kazakhstan currently remains an urgent matter in improving the technology of rational use of pastures and forage production in the region.

Conclusion

The results of the conducted studies allow us to conclude that it is necessary to improve the existing methods for determining the NV of pasture feed, considering the content of fractions of EFC, sugars, and starch, which fully characterize the biological usefulness of feed. To do this, NFES must be deciphered with the analytical determination of sugar and starch in feed, as this has great theoretical and practical value for the physiological and scientific justification of the effectiveness of detailed norms and diets for feeding farm animals.

The research data serve as a prerequisite for improving the existing methodology for determining the NV of pasture feed and diets to increase the potential of using local feed resources in Kazakhstan and beyond, in countries and regions with similar conditions and pasture management systems.

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Author's Contributions

All authors equally contributed to this study.

Ethics

This article is original and contains unpublished material. The corresponding author confirms that all of the other authors have read and approved the manuscript and that no ethical issues are involved.

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