Торайғыров университетінің
ҒЫЛЫМИ ЖУРНАЛЫ

НАУЧНЫЙ ЖУРНАЛ
Торайгыров университета

ТОРАЙҒЫРОВ УНИВЕРСИТЕТІНІҢ ХАБАРШЫСЫ

Химия-биологиялық сериясы

1997 жылдан бастап шығады

TORAIGHYROV UNIVERSITY

ВЕСТНИК ТОРАЙГЫРОВ УНИВЕРСИТЕТА

Химико-биологическая серия

Издается с 1997 года

ISSN 2710-3544

№ 2 (2025)

Павлодар

НАУЧНЫЙ ЖУРНАЛ
Торайгыров университета

Химико-биологическая серия
выходит 4 раза в год

СВИДЕТЕЛЬСТВО
о постановке на переучет периодического печатного издания,
информационного агентства и сетевого издания
№ KZ84VPY00029266

выдано
Министерством информации и коммуникаций Республики Казахстан

Тематическая направленность
публикация материалов в области химии, биологии, экологии,
сельскохозяйственных наук, медицины

Подписной индекс – 76134

https://doi.org/10.48081/PGFX4116

SRSTI 68.41.29

https://doi.org/10.48081/SYXL1387

T. Zh. Kobzhassarov[1], *Ye. A. Simanchuk[2], J. Miciński[3]
[1,2]Akhmet Baitursynov Kostanay Regional University,
Republic of Kazakhstan, Kostanay;
[3]University of Warmia and Mazury in Olsztyn,
Republic of Poland, Olsztyn
[1]ORCID: https://orcid.org/0000-0002-6157-4652
[2]ORCID: https://orcid.org/0000-0002-4242-9636
[3]ORCID: https://orcid.org/0000-0003-3167-5476
*e-mail: simyeandr.ksu@mail.ru

INFLUENCE OF VARIOUS FACTORS ON THE QUALITY OF SILAGE HARVESTED

The article provides an overview of contemporary scientific findings concerning the effects of various factors on the quality of silage produced from wilted forage grasses. Special emphasis is placed on examining how preliminary wilting influences the nutritional composition and biochemical characteristics of the resulting silage, and technological properties of ensiled feed. The role of dry matter content is revealed in relation to nutrient losses, the activity of enzymatic and microbiological processes, the formation of organic acids, digestibility, and changes in the structure of proteins, sugars, and carotene. The article presents data on the dynamics of forage dehydration as influenced by weather conditions, plant species, and swath arrangement methods, along with information on nutrient losses associated with varying durations of the wilting pricess. The conditions under which wilting becomes inefficient are examined, along with the necessity of using biological preservatives as a compensatory measure under unstable climatic conditions. The dynamics of chemical composition changes at different dry matter levels are presented, and the authors conclude that broader implementation of wilting technology in forage production is justified. The review is based on an analysis of domestic and international scientific publications, primarily from the last 30 years, including classical studies from the first half of the 20th century. The collected findings are systematized and generalized to identify modern

trends and promising directions in the development of silage preparation technology from wilted forage.

Key words: ensiling, forage wilting, nutritional value, organic acids, forage production.

Introduction

Silage is a straightforward yet dependable method for preserving green fodder. Adherence to proper ensiling techniques ensures the production of high-quality forage with minimal nutrient loss. This method represents a biological approach to preservation, relying on lactic acid fermentation. During this process, lactic acid bacteria ferment plant sugars, producing lactic acid that acidifies the forage mass and inhibits the growth of undesirable microorganisms, such as putrefactive and butyric acid bacteria. Once the pH of the mass reaches 4.2–4.3, the activity of these harmful bacteria is entirely suppressed. Therefore, an adequate sugar content in the plant material-sufficient to ensure acidification to a pH of 4.2–is a critical factor in obtaining high-quality silage [1]; [2].

Nevertheless, silage production is inevitably accompanied by significant nutrient losses. Even with strict compliance to technological protocols, microbiological and biochemical processes result in average losses of 12.17 % in energy value and 20.22 % in crude protein content [3]. Attempting to offset these losses by simply increasing forage production is economically inefficient. Moreover, once a certain level of forage productivity is achieved, it becomes more cost-effective to focus on minimizing conservation losses than on further increasing crop yields [4]. Based on their ensilability-determined by sugar content and buffering capacity-fodder plants are classified into three main groups: easily ensilable, moderately difficult to ensile, and non-ensilable.

The aim of the study is to provide a comprehensive review of current scientific data on the impact of preliminary wilting of forage grasses on the nutritional value, biochemical characteristics, and technological quality of silage, as well as to identify the key factors that determine the effectiveness of this technological practice under conditions of unstable climate and diverse forage crops.

Materials and Methods

This review is based on a systematic analysis of scientific literature examining the effects of preliminary wilting of forage grasses on the nutritional, biochemical, and technological properties of silage. Particular emphasis is placed on evaluating how dry matter content influences nutrient losses, concentrations of organic acids, digestibility, protein and carotene levels, as well as other key indicators of silage quality.

The study utilized both domestic and international scientific publications available in databases such as Scopus, Web of Science, eLibrary, as well as in specialized agricultural and zootechnical journals. The selection of sources was carried out using the following keywords: silage, grass wilting, silage quality, organic acids, carotene, nutrient losses, digestibility, biological and chemical preservatives, temperature conditions, perennial grasses, and others.

The analysis included publications mainly from the past 30 years; however, to reflect the evolution of approaches, classical works by scientists of the first half of the 20th century who made a significant contribution to the development of silage technology were also considered. The sources were selected based on their scientific relevance, the reliability of the presented data, and the applicability of the results to the conditions of forage production in temperate climate countries, particularly in northwestern regions.

Review and experimental articles were subjected to content analysis, highlighting quantitative and qualitative parameters, statistical patterns, and practical recommendations. Special attention was paid to comparing data on different wilting methods and their effect on losses of carotene, protein, amino acids, and organic acids during grass ensiling.

The obtained data were systematized, summarized, and structured in a logical sequence in order to identify current trends, unresolved issues, and promising directions for research in the field of silage production technology from wilted forage mass.

Results and Discussion

Silage remains one of the most practical and reliable methods for preserving green fodder. When properly managed, ensiling allows for high-quality forage production with minimal nutrient loss. The preservation is based on lactic acid fermentation, in which lactic acid bacteria ferment plant sugars, lowering the pH to 4.2–4.3, thus inhibiting spoilage and butyric acid bacteria [1; 2]. However, even with optimal techniques, nutrient losses remain significant-averaging 12.17 % of energy value and 20.22 % of crude protein [3]. As increasing forage yield becomes economically less viable, efforts are now shifting toward reducing losses during conservation [4].

Factors Affecting Silage Quality

The quality of silage and associated nutrient losses are influenced by harvesting time, dry matter content, particle size, filling speed, and sealing efficiency [5]. Additionally, during the initial phase of ensiling, the gases produced-such as nitrogen oxides, hydrogen sulfide, and isothiocyanates-play a bacteriostatic role against spoilage bacteria while remaining harmless to lactic acid bacteria [6]. Technological strategies should aim to retain these gases to

suppress the development of harmful microflora. If they escape, putrefactive bacteria proliferate, leading to excessive butyric acid formation and a rise in pH, which deteriorates silage quality [7].

Moisture Content and Silage Preservation

Moisture level is critical in directing fermentation processes. An optimal moisture content of 60–70 % ensures good compaction without significant juice loss or heating, limiting nutrient loss to around 12 % [8]. When moisture exceeds 75–78 %, bacterial activity increases, leading to greater nutrient loss (up to 15 %) and effluent loss (up to 7 %). At 80% moisture, losses can exceed 25 %. Non-ensilable plants at such moisture levels often result in poor-quality silage. Conversely, silage from sugar-rich crops may still be of good quality, but over-acidification (pH < 3.8) reduces feed intake [9].

Chopping length depends on dry matter content: 20 % DM requires 5.7 cm, 25 % DM requires 4.5 cm, and ≥30 % DM requires 2.3 cm [10]. To reduce moisture, grasses are typically wilted in the field, while maize and similar crops are mixed with dry materials like straw or chaff.

Sugar and protein levels in plants are affected by growth stage, fertilization, and time of day during harvesting. Young plants typically have higher protein and lower sugar content. High nitrogen doses also increase crude protein but reduce sugar levels, making wilting essential before ensiling [11].

From a zootechnical standpoint, silage must meet standards in energy value, palatability, and safety. For example, 1 kg of silage DM should provide at least 0.85 feed units, be readily consumed by ruminants (25–27 g/kg live weight), and contain minimal butyric acid, while being rich in lactic acid (pH ~4.3) [12].

Chemical additives are increasingly used to preserve nutrients and enhance silage quality, especially under unstable weather or when ensiling hard-to-ferment species. These methods can reduce nutrient losses 2.3-fold, increase silage yield by up to 20 %, and retain more protein, sugar, and carotene [13]; [14].

Wilting before ensiling, first studied by F. Samarani (1924), reduces bacterial activity and improves feed quality. Numerous studies since then have confirmed that pre-wilted forage has higher nutritional value, more crude protein, less fiber, better palatability, and lower production costs [15]; [16].

Wilting duration and effectiveness depend heavily on weather, plant type, and windrow structure. Under favorable conditions, grasses can reach 45–50% DM in 48 hours with ~5% dry matter loss. However, prolonged wilting (>60 hrs) reduces digestibility and leads to protein losses of up to 40 % [17].

Wilting alters nutrient structure. Enzymatic activity increases sugar concentration but also hydrolyzes starch and proteins. Nitrogenous losses-especially protein nitrogen-rise with longer wilting, with amine nitrogen increasing

significantly. Carotene levels decrease by up to 30% in swaths. However, no significant changes are observed in fiber or mineral content [18].

As dry matter increases, total organic acid content-especially butyric and acetic acids-decreases, while lactic acid becomes dominant. At 36 % DM, butyric acid accounts for just 5 % of total acids compared to one-third at 26 % DM. However, excessively high DM (>37 %) may not improve lactic acid levels further [19].

Despite its advantages, wilting has several drawbacks: it is weather-dependent, requires additional equipment and labor, complicates silo-filling logistics, and can lead to increased nutrient loss under poor conditions. Furthermore, high DM levels may result in significant heating during storage, exacerbating feed losses [20].

Conclusions

Consequently, the question arises regarding the necessity of adding a biological preservative to wilted forage, depending on both the degree and conditions of dehydration. Additionally, under unfavorable weather conditions, there is a need to consider the feasibility of substituting wilted raw material with biologically preserved forage. However, existing literature offers limited insight into the application of biopreservatives, particularly in relation to perennial forage grasses in the northwestern regions-an issue that formed a core objective of our research.

References

1 **Ashbell, G., Weinberg, Z. G., Hen, Y., Pitcovski, J.** Ensiling Forage Sorghum at Two Stages of Maturity with Additives // Animal Feed Science and Technology. – 1991. – Vol. 32. – P. 1–9.

2 **Baytok, E., Aksu, T., Karsli, M. A., Muruz, H.** The Effects of Formic Acid or Bacterial Inoculant on the Fermentation, Aerobic Stability and Ruminal Degradability of Wheat, Sorghum, and Maize Silages // Turkish Journal of Veterinary and Animal Sciences. – 2005. – Vol. 29. – P. 219–226.

3 **Borreani, G., Tabacco, E.** The Relationship Between Silage Management Practices and Silage Quality in Farm Bunker Silos // Proceedings of the XIV International Silage Conference. – 2010. – P. 203–204.

4 **Borreani, G., Tabacco, E.** Improving Corn Silage Quality in the Top Layer of Farm Bunkers: Effects of a New Barrier Film and an Oxygen Barrier Film // Journal of Dairy Science. – 2014. – Vol. 97. – P. 2415–2426.

5 **Borreani, G., Tabacco, E., Schmidt, R. J., Holmes, B. J., Muck, R. E.** Silage Review : Factors Affecting Dry Matter and Quality Losses in Silages // Journal of Dairy Science. – 2018. – Vol. 101. – P. 3952–3979.

6 **Bruno-Soares, A. M., Abreu, J. M. F.** Protein Degradation in Ryegrass and Lucerne During Ensilage with or Without Silage Additives // Animal Research. – 2003. – Vol. 52. – P. 217–230.

7 **Driehuis, F., van Wikselaar, P. G.** The Occurrence and Prevention of Mycotoxins in Silage: A Review // Animal Feed Science and Technology. – 2000. – Vol. 137. – P. 167–190.

8 **Ennahar, S., Cai, Y., Fujita, Y.** Phylogenetic Diversity of Lactic Acid Bacteria Associated with Paddy Rice Silage as Determined by 16S Ribosomal DNA Analysis // Applied and Environmental Microbiology. – 2003. – Vol. 69. – P. 444–451.

9 **Henderson, A. R., McDonald, P.** The Effect of Silage Additives on the Fermentation of Grass in Laboratory Silos // Journal of the Science of Food and Agriculture. – 1977. – Vol. 28. – P. 170–176.

10 **Huhtanen, P., Jaakkola, S., Kukkonen, U.** The Effect of Silage Fermentation on the Proportion of Soluble Non-Ammonia Nitrogen // Animal Feed Science and Technology. – 1998. – Vol. 72. – P. 261–262.

11 **Kaiser, A. G., Piltz, J. W., Burns, H. M., Griffiths, N. W.** Successful Silage // NSW Agriculture. – 2003. – 206 p.

12 **Kung, L. Jr., Shaver, R. D.** Interpretation and Use of Silage Fermentation Analysis Reports // Focus on Forage. – 2001. – Vol. 3. – № 13. – P. 1–5.

13 **McDonald, P., Henderson, A. R., Heron, S. J. E.** The Biochemistry of Silage // Chalcombe Publications. – 1991. – 2nd ed. – 340 p.

14 **Muck, R. E.** Factors Influencing Silage Quality and Their Implications for Management // Journal of Dairy Science. – 1988. – Vol. 71. – P. 2992–3002.

15 **Muck, R. E.** Silage Microbiology and Its Control Through Additives // Revista Brasileira de Zootecnia. – 2010. – Vol. 39 (Suppl. Spe). – P. 183–191.

16 **Muck, R. E., Nadeau, E. M. G., McAllister, T. A., Contreras-Govea, F. E., Santos, M. C., Kung, L. Jr.** Silage Review: Recent Advances and Future Uses of Silage Additives // Journal of Dairy Science. – 2018. – Vol. 101. – P. 3980–4000.

17 **Pitt, R. E.** Silage and Hay Preservation // NRAES Bulletin. – 1990. – № 5. – P. 1–35.

18 **Ranjit, N. K., Kung, L. Jr.** The Effect of Lactobacillus buchneri and Other Additives on the Fermentation and Aerobic Stability of Barley Silage // Journal of Dairy Science. – 2000. – Vol. 83. – P. 526–535.

19 **Weinberg, Z. G., Muck, R. E.** New Trends and Opportunities in the Development and Use of Inoculants for Silage // FEMS Microbiology Reviews. – 1996. – Vol. 19. – P. 53–68.

20 **Weinberg, Z. G., Ashbell, G., Hen, Y., Azrieli, A.** The Effect of Applying Lactic Acid Bacteria at Ensiling on the Aerobic Stability of Silages // Journal of Applied Bacteriology. – 1993. – Vol. 75. – P. 512–518.

Received 22.06.25.
Received in revised form 25.06.25.
Accepted for publication 25.06.25.

*Т. Ж. Қобжасаров[1], *Е. А. Симанчук[2], J. Miciński[3]*
[1,2]Ахмет Байтұрсынов атындағы
Қостанай өңірлік университеті,
Қазақстан Республикасы, Қостанай қ.;
[3]Варминь-Мазур университеті,
Польша Республикасы, Ольштын қ.
22.06.25 ж. баспаға түсті.
25.06.25 ж. түзетулерімен түсті.
25.06.25 ж. басып шығаруға қабылданды.

СҮРЛЕНЕТІН ЖЕМНІҢ САПАСЫНА ӘРТҮРЛІ ФАКТОРЛАРДЫҢ ӘСЕРІ

Мақалада мал азығын сақтау үшін қолданылатын шөптерді алдын ала солдырып (құрғатып) сүрлеу технологиясының сапасына әртүрлі факторлардың әсері туралы заманауи ғылыми деректерге шолу берілген. Негізгі назар сүрленген жемнің азықтық құндылығына, биохимиялық көрсеткіштері мен технологиялық қасиеттеріне алдын ала солдырудың әсерін талдауға аударылған. Құрғақ заттың мөлшерінің қоректік заттардың жоғалуына, ферментативтік және микробиологиялық процестердің белсенділігіне, органикалық қышқылдардың түзілуіне, қорытылу дәрежесіне, сондай-ақ ақуыздардың, қанттардың және каротиннің құрылымдық өзгерістеріне әсері ашып көрсетілген. Өсімдіктерді валоққа салу әдістері мен ауа райының жағдайларына байланысты сусыздану қарқыны, солдыру ұзақтығы кезіндегі қоректік заттардың жоғалуы сипатталған. Қолайсыз климат жағдайларында солдыру тиімді болмай қалған кезде биологиялық консерванттарды қолданудың

маңыздылығы қарастырылған. Құрғақ зат деңгейінің әртүрлі шамаларында жем құрамындағы химиялық өзгерістердің динамикасы ұсынылып, мал азығын дайындауда солдыру технологиясын кеңінен енгізудің орынды екендігі туралы қорытынды жасалады. Шолу отандық және шетелдік әдебиеттерге, оның ішінде XX ғасырдың бірінші жартысындағы классикалық еңбектерге сүйене отырып, соңғы 30 жылдағы ғылыми жарияланымдарды жүйелі талдау негізінде дайындалған. Қорытындылар қазіргі үрдістер мен болашағы бар бағыттарды анықтауға мүмкіндік береді.

Кілтті сөздер: сүрлеу, шөпті солдыру, азықтық құндылық, органикалық қышқылдар, мал азығын өндіру.

*Т. Ж. Кобжасаров[1], *Е. А. Симанчук[2], J. Miciński[3]*
[1,2]Костанайский региональный
университет имени Ахмета Байтурсынова,
Республика Казахстан, г. Костанай;
[3]Вармийско-Мазурский университет в Ольштыне,
Республика Польша, г. Ольштын.
Поступило в редакцию 22.06.25.
Поступило с исправлениями 25.06.25.
Принято в печать 25.06.25.

ВЛИЯНИЕ РАЗЛИЧНЫХ ФАКТОРОВ НА КАЧЕСТВО ЗАГОТАВЛИВАЕМОГО СИЛОСА

В статье представлен обзор современных научных данных о влиянии различных факторов на качество силоса, полученного из подвяленной массы кормовых трав. Основное внимание уделено анализу воздействия предварительного подвяливания на питательную ценность, биохимические параметры и технологические характеристики силосованного корма. Раскрыта роль содержания сухого вещества в потере питательных веществ, активности ферментативных и микробиологических процессов, образовании органических кислот, степени перевариваемости и изменениях в структуре белков, сахаров и каротина. Приведены сведения о зависимости темпов обезвоживания от погодных условий, типа растений и способа их укладки в валки, а также рассмотрены потери питательных веществ при различной продолжительности подвяливания. Отдельное внимание уделено условиям, при которых

подвяливание становится неэффективным, и рассматривается необходимость использования биологических консервантов как меры компенсации при нестабильном климате. В статье представлены данные о динамике изменения химического состава при различных уровнях сухого вещества и делается вывод о целесообразности более широкого внедрения технологии подвяливания в кормопроизводстве. Обзор выполнен на основе анализа отечественных и зарубежных публикаций, преимущественно за последние 30 лет, с привлечением классических работ первой половины XX века. Результаты систематизированы и обобщены с целью определения тенденций и перспектив развития технологии заготовки силоса из подвяленных кормов.

Ключевые слова: силосование, подвяливание трав, питательная ценность, органические кислоты, кормопроизводство.

Теруге 25.06.2025 ж. жіберілді. Басуға 30.06.2025 ж. қол қойылды.
Электронды баспа
2,57 МБ RAM
Шартты баспа табағы 10,13.
Таралымы 300 дана. Бағасы келісім бойынша.
Компьютерде беттеген А. К. Темиргалинова
Корректорлар: А. Р. Омарова, Д. А. Кожас
Тапсырыс № 4428

Сдано в набор 25.06.2025 г. Подписано в печать 30.06.2025 г.
Электронное издание
2,57 МБ RAM
Усл. п. л. 10,13. Тираж 300 экз. Цена договорная.
Компьютерная верстка А. К. Темиргалинова
Корректоры: А. Р. Омарова, Д. А. Кожас
Заказ № 4428

«Toraighyrov University» баспасынан басылып шығарылған
Торайғыров университеті
Павлодар мемлекеттік университеті
140008, Павлодар қ., Ломов к., 64, 137 каб.

«Toraighyrov University» баспасы
Торайғыров университеті
140008, Павлодар қ., Ломов к., 64, 137 каб.
8 (7182) 67-36-69
e-mail: kereku@tou.edu.kz
www.vestnik-cb.tou.edu.kz