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МЕХАНИЗАЦИЯ И ЭЛЕКТРИФИКАЦИЯ СЕЛЬСКОГО ХОЗЯЙСТВА
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JUSTIFICATION OF THE TECHNOLOGY OF PREPARATION OF FEED MIXTURE IN SMALL PEASANT FARMS

Abstract

The majority of peasant farms engaged in animal husbandry (71–82%) contain between 50 and 100 heads of cattle and up to 500 sheep. To improve feeding efficiency in small farms, a mobile mini-feed plant equipped with a dispenser-mixer with a hopper volume of 3.0 m³, roughage and grain feed grinders is proposed. The novelty of this research lies in the development of a mobile unit that integrates feed preparation and distribution, eliminating the need for separate grinding and mixing equipment. Compared to existing feed dispensers-mixers, the use of the mini-feed plant eliminates hay transportation and loading operations, reducing the total number of operations by 40%, lowering operating costs by 1.5 times, and decreasing capital investments by 3 times. Additionally, there is no need for farms to have stationary feed grinders and compound feed units, making the technology more universal. This study provides a comprehensive analysis of the design, economic benefits, and technological advancements associated with the mini-feed plant, highlighting its potential application in small-scale livestock operations.

***Keywords**: feed preparation, roughage grinder, grain feed grinder, cost reduction, mechanization, sustainable farming, agroengineering, feed efficiency.*

Introduction

Kazakhstan possesses significant natural resources but does not fully meet its dairy product needs. The majority of cattle (90.8%) and sheep (95.6%) are concentrated in household and small peasant farms. Most of these farms contain between 50 and 100 heads of cattle and up to 500 sheep. During the winter period, hay is the primary feed for livestock, while dairy and fattening farms are virtually absent. The lack of properly balanced feed mixtures and the use of outdated feeding technologies lead to inefficiencies in livestock productivity and increased production costs. Addressing these challenges requires technological advancements in feed preparation and distribution.

The relevance of this study is based on the need for small farms to mechanize feed preparation processes. Research shows that improving feeding technology directly influences milk yield and weight gain in livestock. The level of development in feed processing technology varies across countries, with developed nations employing automated feeding systems, while small-scale farms often rely on manual or semi-mechanized processes. In Kazakhstan, existing feeding equipment is not optimized for small-scale farms, resulting in higher costs and inefficient operations.

This study aims to develop and justify the technological and economic efficiency of a mobile mini-feed plant that ensures grinding of roughage and grain feeds, component mixing, and feed distribution at the feeding table. The research objectives include: analyzing the current state of feed preparation technologies, determining the optimal design parameters for the mini-feed plant, evaluating its economic feasibility, and assessing its impact on livestock productivity. The structure

of this paper consists of a literature review, a description of the research methodology, results and discussion, and conclusions. Kazakhstan possesses significant natural resources but does not fully meet its dairy product needs. The majority of cattle (90.8%) and sheep (95.6%) are concentrated in household and small peasant farms. Most of these farms contain between 50 and 100 heads of cattle and up to 500 sheep. During the winter period, hay is the primary feed for livestock, while dairy and fattening farms are virtually absent. The lack of properly balanced feed mixtures and the use of outdated feeding technologies lead to inefficiencies in livestock productivity and increased production costs. Addressing these challenges requires technological advancements in feed preparation and distribution.

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Figure 1 – Laboratory testing of the mini-feed dispenser-mixer for uniform feed distribution

Materials and Methods

The justification for the hopper volume of the mobile mini-feed plant was based on an analysis of livestock numbers in Kazakhstan's peasant farms. The integration of feed grinders into the mini-feed plant was determined through research on technological feeding processes at dairy and fattening farms. The economic efficiency of the proposed technology was assessed using a comparative

analysis of operating costs. Additional parameters such as mixing time, feed particle uniformity, and energy consumption were also evaluated to ensure optimal functionality of the mobile mini-feed plant. The experimental setup included trials conducted in various small farms to test the efficiency of feed mixing and distribution processes. Data analysis was conducted using statistical methods, including variance analysis to assess cost-effectiveness and performance efficiency.

Results and Discussion

An analysis of international experience revealed that leading global manufacturers (Italy, Germany, France) produce feed dispenser-mixers with capacities ranging from 4 to 20 m³[1-2]. Russian and Belarusian models, such as KIS-8, AKM-10, ISRK-12, and IRK-145, are available; however, their high cost (15,700 to 60,735 euros) and the necessity for additional grinders limit their adoption in small farms in Kazakhstan. Furthermore, the operation of these machines requires additional investments in infrastructure and labor, making them less accessible for small-scale farmers[2-17].

The proposed mobile mini-feed plant, equipped with a 3.0 m³ hopper, eliminates the need for stationary grinders, compound feed units, and transportation operations. The technological process includes grinding roughage and grain feed, loading them into the hopper, mixing, and distributing the feed mixture. Calculations indicate that specific operating costs decrease by 1.51 times (from 3,035.3 to 2,013.6 tenge per ton), resulting in an annual economic benefit of 613,000 tenge for a farm with 100 heads of cattle. Moreover, a 15% increase in milk productivity could yield an additional 9 million tenge per year, ensuring a payback period of 5.3 months for the mini-feed plant.

Figure 2 – Field testing of the mini-feed dispenser-mixer attached to a tractor

The improved mixing technology ensures that feed components are evenly distributed, reducing feed waste and enhancing nutrient uptake by livestock.

Additionally, the study evaluated the environmental benefits of using the mobile mini-feed plant. The reduction in feed transportation and manual handling contributes to lower carbon emissions and decreased energy consumption. Furthermore, the compact design and mobility of the plant allow it to be efficiently used in remote areas with limited infrastructure.

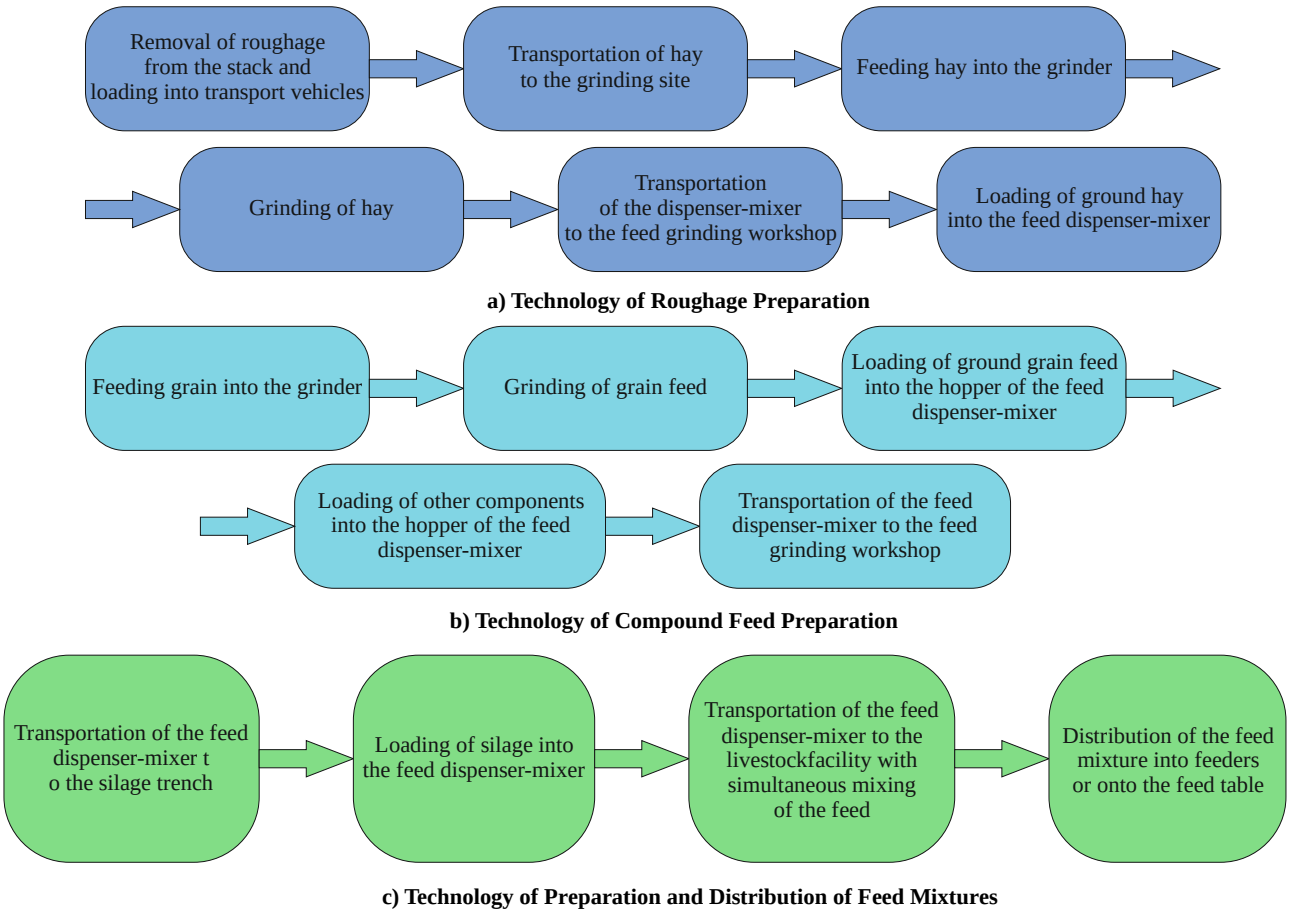

Figure 3 – Technology of feed mixture preparation with existing feed dispensers-mixers (total number of operations: 15, specific operating costs: 3,035.3 tenge/ton).

As shown in Figure 3, the existing feed dispensers-mixers require 15 operations, while the mini-feed plant (Figure 4) reduces this number to 9. (total number of operations: 15, specific operating costs: 3,035.3 tenge/ton).

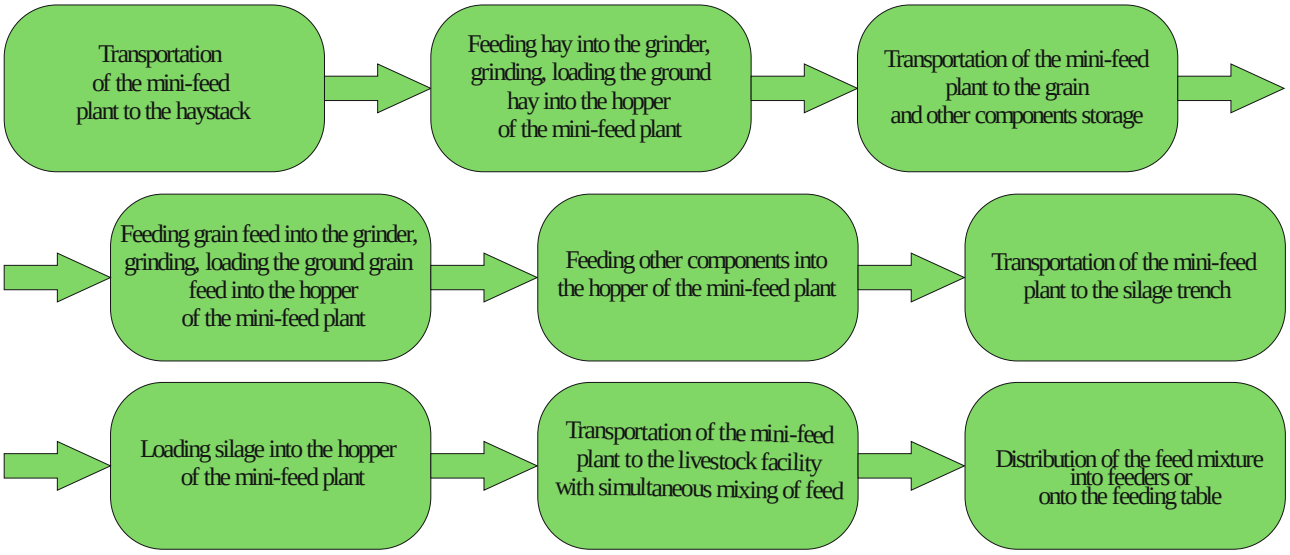

Figure 4 – Technology of feed mixture preparation using the mini feed plant (total number of operations: 9, specific operating costs: 2,013.6 tenge/ton).

The results of the calculations show that when preparing a feed mixture with a dispenser-mixer, the specific operating costs amount to 3,035.3 tenge per ton, whereas with the use of the mini feed plant, they are 2,013.6 tenge per ton. This means that specific operating costs are reduced by 1.51 times, resulting in an annual economic benefit of 613,000 tenge for the farm.

If we consider that many small farms lack mechanized feed preparation and distribution, the economic effect can also be assessed in terms of additional milk yield. It is known that feeding dairy cows with complete feed mixtures increases milk yield by approximately 15%. If the annual milk yield per cow is 3,000 liters, then feeding with complete feed mixtures will provide an additional yield of 450 liters. In this case, the annual economic benefit from the additional milk yield for a farm with 100 cows will be 9 million tenge, and the mini feed plant will pay for itself in 5.3 months.

Conclusions

1. In 71% of peasant farms, there are between 50 and 100 heads of cattle, while 82.5% of farms contain up to 500 sheep. For these farms, a mobile mini-feed plant featuring a 3.0 m³ dispenser-mixer and roughage and grain feed grinders is proposed.
2. The introduction of the mini feed plant reduces the number of technological operations by 1.67 times, lowers operating costs by 1.5 times, and decreases capital investments by 3 times. Furthermore, the need for stationary feed grinders and compound feed units is eliminated, making the feed preparation technology more efficient and accessible for small farms.
3. The improved mixing process enhances the uniformity of feed distribution, leading to better livestock nutrition and productivity. The mobile mini-feed plant also reduces feed waste and optimizes the use of available resources.
4. Environmental benefits include lower energy consumption and reduced carbon emissions, making the mobile mini-feed plant a sustainable solution for small-scale livestock farms in Kazakhstan.

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КІШІ ШАРУАШЫЛЫҚТАРДА КОРМ ҚҰРАМЫН ДАЙЫНДАУ ТЕХНОЛОГИЯСЫН АҚТАРУ

Аңдатпа

Жануарларды бағумен айналысатын шаруашылықтардың көпшілігі (71-82%) 50 мен 100 бас ірі қара мал және 500-ге дейін қой ұстауды құрайды. Шағын шаруашылықтарда азықтандыру тиімділігін арттыру мақсатында 3,0 м³ көлеміндегі бункері бар дозатор-араластырғыш, азық және дәнді азық ұнтақтағыштармен жабдықталған мобильді мини-корм зауыты ұсынылады. Бұл зерттеудің жаңалығы – азық дайындау мен тарату процестерін біріктіретін мобильді қондырғының әзірленуі, бұл ұнтақтау және араластыруға арналған жеке жабдықтардың қажетсіздігін жояды. Қазіргі таңдағы азық дозаторлары мен араластырғыштарымен салыстырғанда мини-корм зауытының қолданылуы шөпті тасымалдау мен жүктеу операцияларын жояды, жалпы операциялардың санын 40%-ға, операциялық шығындарды 1,5 есеге, ал капиталды салымдарды 3 есеге төмендетеді. Сонымен қатар, шаруашылықтарда стационарлық азық ұнтақтағыштар мен қосымша азық қондырғыларын қажет етпейді, бұл технологияны әмбебап етеді. Бұл зерттеу мини-корм зауытының конструкциясы, экономикалық пайдасы мен технологиялық жаңалықтарына жан-жақты талдау жасап, оны шағын мал шаруашылықтарында қолданудың мүмкіндігін көрсетеді.

Кілт сөздер: азық дайындау, азық ұнтақтағыш, дәнді азық ұнтақтағыш, шығындарды азайту, механизация, тұрақты ауыл шаруашылығы, агроинженерия, азық тиімділігі.

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ОБОСНОВАНИЕ ТЕХНОЛОГИИ ПРИГОТОВЛЕНИЯ КОРМОВОЙ СМЕСИ В МАЛЫХ КРЕСТЬЯНСКИХ ХОЗЯЙСТВАХ

Аннотация

Большинство крестьянских хозяйств, занимающихся животноводством (71-82%), содержат от 50 до 100 голов скота и до 500 овец. Для повышения эффективности кормления в малых хозяйствах предлагается мобильный мини-кормовой завод, оснащённый дозатором-смесителем с объёмом бункера 3,0 м³, дробилками для грубых кормов и зерновых кормов. Новизна данного исследования заключается в разработке мобильного устройства, которое объединяет процессы подготовки и распределения кормов, устраняя необходимость в отдельном оборудовании для дробления и смешивания. По сравнению с существующими дозаторами-смесителями кормов использование мини-кормового завода исключает транспортировку и погрузку сена, сокращая общее количество операций на 40%, снижая операционные расходы в 1,5 раза и уменьшая капитальные вложения в 3 раза. Кроме того, нет необходимости в стационарных кормовых дробилках и установках для комбикормов, что делает технологию более универсальной. В данном исследовании представлен всесторонний анализ конструкции, экономических преимуществ и технологических новшеств, связанных с мини-кормовым заводом, подчеркивая его потенциальное применение в малых животноводческих хозяйствах.

Ключевые слова: подготовка кормов, дробилка для грубых кормов, дробилка для зерновых кормов, сокращение затрат, механизация, устойчивое сельское хозяйство, агроинженерия, эффективность кормления**.**

Вклад авторов

Сейпаталиев Олжас Ерланович - Концептуализация; Методология; Администрирование проекта; Надзор; Написание – первоначальный проект; Написание – обзор и редактирование.

Әбілжанұлы Тоқтар - Приобретение финансирования; Методология; Написание – обзор и редактирование.

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