DETERMINATION OF THE INTERNAL POTENTIAL OF ENERGY EFFICIENCY IN COMPOUND FEED PRODUCTION

Annotation.
Grass flour is a unique protein-vitamin feed product, the role of which in animal feeding can hardly be overestimated. In 2010, the industry for the production of unique protein-vitamin feed from alfalfa, for example, in Europe included 300 factories and 50 farms, which produced 4200 million tons of products. In Russia, the development of poultry and livestock farming has also increased the demand for this fodder and gradually restored its production. But in Ukraine, due to its high energy intensity, the production of herbal flour has almost ceased. It is shown that the fuel and energy balance of this technology that diesel fuel provides about 92.3% of all equipment needs for energy, and its cost is 90.8% of the total cost of all fuel and energy resources (FER). On the other hand, electricity accounts for only 7.7% of the total needs, and the costs of paying for it also serve 9.2% of the total costs of purchasing fuel and energy resources.

The purpose of the work is to study the energy feasibility of using extrusion for dehydration of wet feed products during their complex processing in feed products. To achieve this goal, the following tasks were solved: the selection and calculation of the necessary technological equipment for the principle technological scheme of the production of feed products with the inclusion of wet forage grasses was carried out; an energy audit of the basic (traditional) and new technologies for the production of compound feed products with the inclusion of forage grasses was carried out. Since the new technology is recommended to be implemented at feed mills of small capacity due to the proximity of raw materials, it must be able to process forage grasses in an amount no less than the basic technology for the production of grass meal. The minimum capacity of the ABM-type drying unit for cooking is 0.65 t/h for grass meal (2.7 t/h for raw materials). Thus, an energy audit of the basic (traditional) and new technology for the production of mixed feed products with the inclusion of forage grasses was carried out and proved that as a result of the use of the extrusion process for the purpose of dehydration, the new technology becomes more energy efficient in comparison with the traditional technology of drying forage grasses and further production of products with the inclusion of grass flour, which means it is economically feasible, since there is a total saving of fuel and energy resources of 875 MJ/h or - in the amount of 514.18 UAH (44%).

Key words: energy efficiency, electricity, fuel, fuel and energy resources, extrusion, compound feed, herbal meal, eco-friendly active substances [6]. Now it has a permanent technology, the main stages and modes of which are almost the same throughout the world. The traditional method of obtaining granulated grass meal involves mowing leguminous grasses with a moisture content of more than 70% at the budding stage (cereals - at the stage of entering the tube) with simultaneous grinding, loading this mass into vehicles that supply it to the drying unit, high-temperature drying to the final moisture 9 - 12%, grinding, granulating and cooling [7-11]. Further use of this fodder agent in compound feed production is accompanied by its purification from impurities, grinding, dosing and mixing with other components, as well as, if necessary, granulation of loose compound feed.

In 2010, the industry for the production of grass meal from alfalfa, for example, in Europe included 300 factories and 50 farms, which produced 4200 million tons of products [12]. In Russia, the development of poultry and livestock farming has also increased the demand for this fodder and gradually restored its production [6]. But in Ukraine, due to its high energy intensity, the production of herbal flour has almost ceased. In the industrial production of granulated grass flour, equipment is used, for example, of the following configuration: the Volgar-5A grinder, an AVM-1.5 R drying unit and a set of equipment for granulating OGM-
Carrriers. Ther a rbalance reduction of feed products, from the begin hioe source of energy, but also fuel. The fuel and loddhxur nological scheme products with the inclusion of forage grasses technologies for the production of compound feed pro
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solved:

Research materials and methods

1.5 [13]. In this case, the specific consumption of electricity for its production is about 177 kWh/t or 636 MJ/t (with an initial moisture content of forage grasses of 70%). Moreover, the analysis of the structure of electrici ty costs shows that most of it, 66%, falls on the drying process [14]. But when drying, not only electricity is used as a source of energy, but also fuel. The fuel and energy balance of this technology (Table 1) shows that diesel fuel provides about 92.3% of all equipment needs for energy, and its cost is 90.8% of the total cost of all fuel and energy resources (FER). On the other hand, electricity accounts for only 7.7% of the total needs, and the costs of paying for it also serve 9.2% of the total costs of purchasing fuel and energy resources.

That is, the conducted fuel and energy balance of the technology for the production of granular herbal flour implies that the most expensive source of energy used in the drying process is fuel. The high market cost of fuel, combined with its growing share in the formation of the cost of finished products, leads to the economic inexpediency of restoring plants for the production of grass meal. Therefore, at one time, a scientific hypothesis was put forward that the technology of processing grass cutting in compound feed production will be energy efficient in terms of replacing the energy obtained from fuel with electric energy or avoiding the drying process altogether.

At the Odessa National Academy of Food Technologies, at the Department of Feed and Biofuel Technology, a new technological method for the production of feed products using wet feed products without their preliminary or subsequent drying has been proposed and scientifically substantiated, which reveals the resource reserves of the raw material base of feed production, including through forage grasses and green mass of cultivated plants, etc. [15]. In the new technology, the leading place belongs to the extrusion process, the task of which, in addition to increasing the feed value and disinfection, is also the dehydration.

The purpose of the work is to study the energy feasibility of using extrusion for dehydration of wet feed products during their complex processing in feed products.

To achieve this goal, the following tasks were solved:

- the selection and calculation of the necessary technological equipment for the principle technological scheme of the production of feed products with the inclusion of wet forage grasses was carried out;
- an energy audit of the basic (traditional) and new technologies for the production of compound feed products with the inclusion of forage grasses was carried out.

The determination of the energy efficiency potential is carried out through a comparative energy audit of innovative and basic technologies. It is based on calculating the amount of consumed energy, energy balance and comparing the values obtained in the study of the existing traditional technology for the production of grass flour, basic and new technologies for the production of feed products.

For this, proceeding from the principle flow diagram of the production of feed products, from the beginning we carry out the selection and calculation of the necessary technological equipment according to the methods given in [16].

At feed mills, energy consumption is recorded by fixing the amount of received energy carriers. Therefore, when carrying out an energy audit of the basic and unchanged section of the improved technology, we use the passport data of the equipment, and in the case of a new technology in the areas subject to changes - the data of experimental studies [17, 18].

Experimental production of samples and a pilot batch of loose and extruded feed concentrate of the developed composition [14] with the inclusion of cutting blue hybrid alfalfa in an amount of 20%, dried to a moisture content of 70%, was carried out in accordance with the recommendations of the "Rules for organizing and maintaining the technological process of production of mixed feed industry" [19].

The technological process of extrusion of experimental feed samples was carried out in ONAFT at the Department of Feed and Biofuel Technology in an EZ-150 extruder (Bronto). The productivity of the extruder was determined by weighing the mass released from the outlet of the screw part of the extruder for 20 minutes. The result obtained, multiplied by 3, characterizes the hourly productivity of the installation. To bring the productivity to the nominal density of 750 kg/m², the obtained value of the productivity is multiplied by the coefficient determined by dividing the conditional density by the actual one. The capacity of the installation is determined under the condition that the current load of the main electric motor is 100%, the quality of the extruded product is satisfactory, and the temperature is correct. Before starting work, an ammeter and a wattmeter are connected to the extruder to determine the power characteristics. After starting, the press is brought to a mode in which its performance, process temperature and current load of the electric motor must correspond to the nominal value.

The power of the electric motor of the extruder was determined at intervals of 2 - 5 minutes by measuring the mains voltage, current consumption and power

### Table 1

| Fuel and energy resources (FER) | Conversion factor in kWh | Energy equivalent kWh | % energy | Cost, UAH | % of the cost | Actual FER costs for evaporation of 1 kg of water, MJ | Specific cost UAH / MJ |
|-------------------------------|--------------------------|-----------------------|----------|-----------|-------------|---------------------------------------------------|-------------------------|
| Electricity                   | 1                        | 177.0                 | 636.0    | 517.0     | 9.2         | -                                                  | 0.812                   |
| Diesel fuel                   | 11.7                     | 2106.0                | 7582.0   | 5085.0    | 90.8        | 3.79                                               | 0.671                   |
| Total                         |                          | 2751.0                | 8218.0   | 5602.0    | 100         | 100                                               |                         |

* The tariff for electricity for enterprises is 292 kopecks / kWh, for 1 liter of liquid fuel - 28.25 UAH
The measurement of these quantities is carried out using a voltmeter, ammeter and phase meter, respectively [20]. Power is calculated by the formula:

$$N = U \cdot I \cdot \cos \varphi$$  \hspace{1cm} (1)

where $U$ – mains voltage, V; $I$ – consumed network current, A; $\cos \varphi$ – power factor.

The total installed power is calculated as the product of the power of the technological equipment electric motor by its quantity. A similar calculation is carried out for each of the technological lines and its results are used to calculate the specific consumption of electricity in energy and estimated terms for each of the technological lines. Specific electricity consumption in energy terms is determined by the formula:

$$N_{\text{num}} = \sum N$$

where $\sum N$ – total power consumption of electric motors of the equipment performing this operation, stage, etc., kW;

$Q$ – productivity of the equipment (lines), kg / h.

Specific electricity consumption in estimated terms is calculated by multiplying the specific electricity consumption in energy terms by the current industrial electricity tariff. Next, the total electricity costs are calculated for the entire technology (basic and new) at actual humidity. For correct comparison and analysis of the obtained values, we list them on dry matter.

**Research results**

Since the new technology is recommended to be implemented at feed mills of small capacity due to the proximity of raw materials, it must be able to process forage grasses in an amount no less than the basic technology for the production of grass meal. The minimum capacity of the ABM-type drying unit for cooking is 0.65 t/h for grass meal (2.7 t/h for raw materials). For the design of the technological process, the selection and calculation of the necessary technological equipment for the basic and new technologies for the production of feed products, we take the capacity of 18 t/h. For the implementation of these technologies, according to the developed recipe, the lines given in Table 2 are provided. [21-23].

To calculate the technological equipment for each of the technological lines, we take the following raw material costs: grain 60%, oil meals 15%, meals - 20%, forage grasses 15%, mineral raw materials 4%, premix - 1%, granulated grass flour - 5%. The final results of the selection and calculation of the required technological equipment are shown in Table 2.

Based on the data obtained, we determine the specific consumption of electricity in energy and estimated terms (Table 3).

Thus, the savings in electricity during the implementation of the new technology with the selected variant of the technological scheme in comparison with the base one are 84.6 kW•h/t or ~247.03 UAH/t of dry matter. However, in the basic technology, the production of grass meal is carried out by high-temperature drying, which uses diesel fuel. Therefore, in order to correctly compare the specific energy consumption of the basic and new technologies, a comprehensive technical and economic analysis of all fuel and energy resources was carried out (Table 4).

The technical and economic analysis of the fuel and energy resources costs showed that the elimination of the energy-intensive drying process even when using non-energy-intensive extrusion can significantly reduce the cost of fuel and energy resources. Fuel economy is 9 l/t (379 MJ/t), and electricity savings - 32 MJ/t (in terms of dry matter of compound feed) or in estimated terms - 252.25 UAH/t and 25.85 UAH/t, respectively.

### Table 2 - Calculation of technological equipment

| Technological line name                        | Line capacity, t/hour | Total installed capacity by technology |
|------------------------------------------------|-----------------------|----------------------------------------|
|                                                |                       | basic kW | basic MJ | new kW | new MJ |
| Grain preparing line                          | 10.0                  | 151.4    | 545      | 151.4  | 545    |
| Grain extrusion line                          | 10.0                  | 1603     | 5760.5   | -      | -      |
| Oil meal preparing line                       | 2.7                   | 57.2     | 205.9    | 57.2   | 205.9  |
| Preparing line of meal ingredients            | 3.6                   | 2.2      | 7.9      | 2.2    | 7.9    |
| Preparing line of mineral ingredients         | 0.72                  | 23.5     | 84.6     | 23.5   | 84.6   |
| Line of pelleted grass meal                   | 0.9                   | 24.2     | 87.1     | -      | -      |
| Line of cut grass                             | 2.7                   | -        | -        | 26.1   | 94     |
| Line mixtures of free-flowing components      | 15.3                  | -        | -        | 23.5   | 84.6   |
| Main dosing and mixing line                  | 18.0                  | 23.5     | 84.6     | 10     | 36     |
| Compound feed pelletizing line               | 18.0                  | 437.3    | 1574.3   | -      | -      |
| Compound feed extrusion line                 | 18.0                  | -        | -        | 2193.7 | 7897.3 |

http://grain-feed.onaft.edu.ua
Table 3 - Comparative energy audit

| Name of technological line                        | Specific electricity consumption for technology in terms of energetic estimated, UAH/t |
|--------------------------------------------------|----------------------------------------------------------------------------------------|
|                                                  | basic kW•h/t MJ/t | new kW•h/t MJ/t | |
| Grain preparing line                            | 15.1 54.5 | 15.1 54.5 | 44.09 44.09 |
| Grain extrusion line                             | 160.2 576.0 | - - | 467.78 - |
| Oil meal preparing line                         | 21.2 76.3 | 21.2 76.3 | 61.90 61.90 |
| Preparing line of meal ingredients              | 0.6 2.2 | 0.6 2.2 | 1.75 1.75 |
| Preparing line of mineral ingredients           | 32.6 117.5 | 32.6 117.5 | 95.19 95.19 |
| Line of pelleted grass meal                     | 26.9 96.8 | - - | 78.55 - |
| Line of cut grass                               | - - 9.7 | 34.8 - | 28.32 - |
| Line mixtures of free-flowing components        | - - 1.5 | 5.5 - | 4.38 - |
| Main dosing and mixing line                     | 1.3 4.7 | 0.6 2 | 3.80 1.75 |
| Compound feed pelleting line                    | 29.3 87.5 | - - | 85.56 - |
| Compound feed extrusion line                    | - - 121.9 | 438.7 - | 355.95 - |
| Total for technology:                           |                        |                 |                 |
| At actual moisture content                      | 282.4 1015.4 | 203.2 731.5 | 838.62 593.33 |
| Based on dry matter                             | 320.9 1153.9 | 236.3 850.6 | 952.98 689.92 |

Table 4 - Feasibility study of fuel and energy resources, per 1 ton of dry matter

| Production technology | Costs for fuel and energy resources in expression energy, MJ | estimated, UAH |
|-----------------------|---------------------------------------------------------------|----------------|
|                       | electricity | diesel fuel | electricity | diesel fuel | total |
| Grass flour           | 636        | 7582       | 517        | 5085       | 5602 |
| Compound feed concentrates | 1154     | -          | 953        | -          | 953  |
| Total (compound feed with 5% grass flour) | 1186    | 379        | 978.85     | 252.25     | 1231.1 |
| Extruded feed concentrates (new) | 689.92 | -          | 689.92     | -          | 689.92 |

Conclusions

Thus, an energy audit of the basic (traditional) and new technology for the production of mixed feed products with the inclusion of forage grasses was carried out and proved that as a result of the use of the extrusion process for the purpose of dehydration, the new technology becomes more energy efficient in comparison with the traditional technology of drying forage grasses and further production of products with the inclusion of grass flour, which means it is economically feasible, since there is a total saving of fuel and energy resources of 875 MJ/t or - in the amount of 514.18 UAH (44%).

REFERENCES

1. Bevz, V.V. Energoefektivnist' pidpryemstv kharchovoy promyslovosty – suchasnyy stan i stratehyy rozvytku [Tekst] // V. V. Bevz // Naukovi pratsi Natsional'noho universytetu kharchovykh tekhnolohiy. – 2010. – T. 1. – № 35 - S. 15 – 17.
2. Bevz, V. V. Enerhoberezhennya – potentsial rozvytku ekonomiky Ukrayiny [Tekst] / V. V. Bevz // Kharchova promyslovist’. – 2010. – № 9. – S. 186–190.
3. Bevz, V. V. Enerhoberezhennya – efektyvnaya shlyakh do znyzhennya vyrobyntstva [Tekst] / V. V. Bevz // Kharchova promyslovist’. – 2010. – № 9. – S. 190–194.
4. Matsvevski, Yu.M. Perspektivy enerho- resursoberezhennya na osnove yntehratsyonnoy modeli razvytya territorial'no-promishlenenskh kompleksov [Tekst] / Yu.M. Matsvevski, V.V. Solovey, A.Y. Vasylov // Tekhnolohchesky audiuy rezerve prozvodstva. – 2014. – № 6/1 (20). – S. 26 – 31.
5. Kavnov, A. Kompleksnyy auduy po prozvodstvu truvyanov muky [Tekst] / A. Kavnov // Kombykorma. – 2012. - № 4. – S.41–42.
6. Zafren, S. Ya. Tekhnolohiy pryhotovlenyia kormoy [Tekst] /S.Ya. Zafren // : Kolos. – 1977. – 239 s.
7. Sokhansanj, S. Kinetics of dehydration of green alfalfa [Text] / S. Sokhansanj, R. T. Patil //Drying technology. – 1996. – T. 14. – № 5. – S. 1197-1234.
8. Wood, H.C. Heat treatment of chopped alfalfa in rotary drum dryers [Tekst] / H.C. Wood, S. Sokhansanj // Journal: Drying Technology. - Volume 8, Issue 3, January 1990. - R. 543-569.
9. Patil, R. T. Thin layer drying of components of fresh alfalfa [Tekst] / R. T. Patil and all// Canadian Agricultural Engineering. – 1992. – T. 34. – S. 343-343.
ВИЗНАЧЕННІ ВНУТРІШНЬОГО ПОТЕНЦІАЛУ ЕНЕРГОЕФЕКТИВНОСТІ У КОМБІКОРМОВОМУ ВИРОБНИЦТВІ

Анотація

Трав'яне борошно – унікальний білково-витамінний кормовий засіб, роль якого в годівлі тварин важко переоцінити. Трав'яне борошно використовується як стартовий кормовий засіб у стартових стадіях відгодівлі молодняку тварин, а також як компонент молодкового гранулованого комбікорму. На жаль, продуктивність тварин, що живуть на трав'яних грунтах, є вдвічі нижча за тварин, що живуть на зернових грунтах.

Розроблено нову комбікормову продукцію, що використовує трав'яне борошно як основний кормовий засіб. Пропонувана комбікормова продукція є конкурентоспроможною на ринку, оскільки забезпечує стабільний високий урожай м'ясо-молочних продуктів.

Ключові слова: трав'яне борошно, комбікормова продукція, висока енергоємність, висока продуктивність, стабільність урожаю м'ясо-молочних продуктів.
значить і економічно доцільною, оскільки відбувається загальна економія ПЕР 875 МДж/т або - на суму 514,18 грн (44%).

Ключові слова: енергоефективність, електроенергія, паливо, паливо-енергетичні ресурси, екструдування, комбікорм, трав'яна мука

ЛІТЕРАТУРА
1. Бевз, В.В. Енергоефективність підприємств харчової промисловості — сучасний стан і стратегія розвитку [Текст] / В. В. Бевз // Наукові праці Національного університету харчових технологій. — 2010. — Т. 1. — № 35 — С. 15 — 17.
2. Бевз, В. В. Енергозбереження — потенціал розвитку економіки України [Текст] / В. В. Бевз // Харчова промисловість. — 2010. — № 9. — С. 186—190.
3. Бевз, В. В. Енергозбереження — ефективний шлях до зниження витрат виробництва [Текст] / В. В. Бевз // Харчова промисловість. — 2010. — № 9. — С. 190—194.
4. Бевз, В. В. Зменшення енергозатрат продукції — інноваційний шлях розвитку підприємств харчової промисловості [Текст] / В. В. Бевз // Фінанси, облік, аудит: зб. наук. праць. — К.: КНЕУ. — 2011. — № 17. — С. 16—24.
5. Макарий, Ю.М. Перспективы энерго- и ресурсосбережения на основе интеграционной модели развития территориально-промышленных комплексов [Текст] / Ю.М. Макарий, В.В. Соловей, А.И. Васильев // Технологический аудит и резервы производства. — 2014. — № 6/1 (20). — С. 26 — 31.
6. Кайнов, А. Комплексная линия по производству травяной муки [Текст] / А. Кайнов// Комбікорма. — 2012. - № 4. — С. 41-42.
7. Зафрен, С. Я. Технология приготовления кормов [Текст]/ С.Я. Зафрен //М.: Колос. — 1977. — 239 с.
8. Sokhansanj, S. Kinetics of dehydration of green alfalfa [Text] / S. Sokhansanj, R. T. Patil // Drying technology. — 1996. — Т. 14. — № 5. — С. 1197-1234.
9. Wood, H.C. Heat treatment of chopped alfalfa in rotary drum dryers [Text]: H.C. Wood, S. Sokhansanj // Journal: Drying Technology. — Volume 8, Issue 3, January 1990. — Р. 543-569.
10. Patil, R. T. Thin layer drying of components of fresh alfalfa [Text] / R. T. Patil and all // Canadian Agricultural Engineering. — 1992. — № 34. — С. 343-343.
11. Wu, H. Alfalfa drying properties and technologies-in review [Text] / H. Wu //Nature and Science. — 2004. — Т. 2. — № 4. — С. 65-67.
12. Guillemot, E. The European alfalfa drying system. URL: http://alfalfa.ucdavis.edu/+symposium/2011/files/talks/11WAS_3_Guillermont_EuropeanSystems.pdf (cited 20/01/2020)
13. Кучинська, З.М. Оборудование для сушки, гранулирования и брикетирования кормов [Текст] / З.М. Кучинська, В.І. Осіобов, Ю.Л. Фрутер. — М.: Агропроміздат, 1988. — 208 с.
14. Егоров, Б.В. Экструдирование при переработке комбикормов повышенной влажности [Текст] / Б. В. Егоров, О. Г. Бурдо, В. В. Гончаренко. В. В. Хоренжий // Хранение и переработка зерна. — 2005. — № 9. — С.33 — 37.
15. Хоренжий, Н.В. Оценка продуктивной дії комбікормової продукції із включенням вологих кормових трав у годівлі великої рогатої худоби [Текст] // Наук. праці / ОНАХТ. — 2014. — Вип. 46. Т. 1. — С. 70 — 76.
16. Єгоров, Б. В. Методичні вказівки до виконання курсового та дипломного проектування для студентів професійних напрямів підготовки 7.05170101, 8.05170101 денної та заочної форм навчання. У 3-му виданні. Київ, 2004. — 239 с.
17. Бурдо, О.Г. Методические указания к изучению курса «Основы энергетического менеджмента» [Текст] / О.Г.Бурдо // Одесса, ОНАПIT, 2003 г. — 40 с.
18. Бурдо, О.Г. Энергетический мониторинг пищевых производств [Текст] / О.Г.Бурдо– Одесса: Полиграф, 2008. — 244 с.
19. Правилах організації і ведення технологічного процесу виробництва комбікормової продукції [Текст]. — К.: Міністерство агропромислового комплексу України, Київський інститут хлібопродуктів, 1998. — 220 с.
20. Праховник, А.В. Енергетический менеджмент [Текст] / А.В. Праховник, А.И. Соловей, В.В. Прокопенко и др. — К.: ІЕНТУУ «КПІ», 2001. — 472 с.
21. Егоров, Б.В. Экструдированные комбикорма на основе люцерновой резки [Текст] / Б. В. Егоров, В.В. Гончаренко, Н.В. Хоренжий // Зернові продукти і комбікорми. — 2004. — № 3. — С. 30 — 34.
22. Єгоров, Б. В. Технологічні основи порційної технології виробництва комбікормів для великої рогатої худоби [Текст] / Б. В. Єгоров, Н. В. Хоренжий // Зб. доп. міжнар. конф."Україна. Комбікорми—2004"— Київ, 2004. — С. 70—72.
23. Егоров, Б.В. Экструдированные комбикорма на основе люцерновой резки [Текст] / Б. В. Егоров, В.В. Гончаренко, Н.В. Хоренжий // Хранение и переработка зерна. — 2004. — № 9. — С. 37 — 39.

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