Investigation of the Grinding Mode of the Enriched Wheat Products in the Rolling Mill 1-Grinding System of the Milling Mill of Wheat Grinding

Olena Yeremeeva, Yevgen Kharchenko, Hennadii Tkachenko, Iryna Shapoval and Olena Hryhorenko

1 Introduction

In accordance with the accepted structure of wheat grinder, the first grinding system is sub-products of the first quality. This system produces the largest amount of high-grade flour, so the study of the grinding regimes of this system is important for obtaining the highest yield of high-grade flour. The operating mode of the grinding systems is determined by the product of a higher-grade flour.

Investigations of the grinding regimes in the drowning process have established that there are regimes of grinding of grain and ladder products of the drown process in rollers, which achieve the greatest output of circular wheat, which are then sent to enrichment. The largest yield of wheat products that can be obtained in the drowning process enables to increase the yield of flour of high grades, which are obtained on the first three grinding systems. Enriched grains and dunes are fed into grinding systems, which are ground to a particle size of less than 130 μ, forming the highest quality flour. Therefore, the question arises about the efficiency of grinding modes of enriched wheat products in roller mills grinding systems in order to obtain the largest output of flour.

In Ukraine, OLIS LLC has started mass production of ESM marker enthlators-dismemblers, which are structurally different from the typical entolyators of P3-BER;

O. Yeremeeva (✉) · H. Tkachenko · I. Shapoval
Uman National University of Horticulture, Institutska Str, 1, Uman, Cherkassy Region 20305, Ukraine
e-mail: eremeeva.elena1961@gmail.com

Y. Kharchenko
National University of Food Technology, Volodymyrska Str., 68, Kiev 01601, Ukraine

O. Hryhorenko
Tavria State Agrotechnological University, B. Khmelnitsky Av., 18, Melitopol, Zaporizhia Region 72312, Ukraine

V. Nadykto (ed.), *Modern Development Paths of Agricultural Production*,
https://doi.org/10.1007/978-3-030-14918-5_79

therefore, the use of new ESD-1.5 dispensers' entolyators is promising as they have a greater technological efficiency of crushing of first quality products in flour.

2 Analysis of Literary Data and Problem Statement

The cruddust products obtained in the drowning process undergo a process of enrichment and are fed into the grinding process for maximum grinding them into flour [1]. The structure of the milling stage is simpler than the drowning stage.

With the introduction of BUHLER grinding technologies after rollers, additional entrays P3-BER and detergents A1-DBG are used for additional grinding and destruction of particle conglomera. The P3-BER enolators are mainly used on the first three grinding systems that process first-grade grinding products with low ash content.

Several researchers at Campbell G. M., Fistes A., O. Vereschinskii and other researchers took part in the research on grain milling in rollers. Campbell G. M., Fang C., Muhamad I. I., Webb C., Bunn P. J., Hook S. C. W., Sadhukhan J., Mateos-Salvador F. [2–7, 11]. On these grinding systems, the highest amount of high-grade flour is obtained. Anthotics RZ-BER represent a kind of machines of the so-called disintegrator type and detachers—machines of shock-erosion action [3–7]. Studies of domestic and foreign researchers [3–6, 8–10] confirmed the expediency of additional grinding of intermediate grinding products in milling mills of durum wheat milling.

The grinding process is less studied, since the results of its work have less effect on the quality of the output of the flour than the process. In the production conditions, the grinding process is also paid less attention than drained.

Company OLIS LLC has developed enteroliters-dismembers ECM-1.5 [7], which differ from the enthtores RZ-BER with the intensity of action on the crushed product. A similar entolyoresis-dismembler is manufactured by the Dutch company OTTE-VANGER. Anthotics-dismembranes are promising for use in the flour mill industry due to more intense action on intermediate grain milling products than typical RZ-BER entolyores. Proceeding from this, it is expedient to investigate the influence of grinding regimes of the "roller machine—entolyator-dismembler" system.

In the literary and informational sources, there are no data on mathematical models of description of granulometric characteristics from the grinding regimes in the rolling mills of the most important first three grinding systems of the first quality [2–6, 8–10] on which the highest amount of flour of high varieties is obtained. These issues are important for designers in developing the balance of grinding new flour mills, as well as for technologists of existing mills. Proceeding from this, one of the tasks of our research is the study of the modes of crushing cropodundstovyh products in rollers and enteroliths-dismemblers, as well as the effectiveness of their joint action.

3 The Purpose and Task of Research

The purpose of the work is to increase the competitiveness of products of domestic flour mill enterprises by improving the technological process of milling grain of wheat into flour and reducing energy consumption in the process of its production.

During the research, wheat grain was processed with the following quality indices: grain weight—791 g/l, grain moisture content on the I drought system—16.2%, vitreousness—38%, garbage impurity 0.4%, grain impurity—2.3%.

4 Materials and Methods of Research

The research of quality indicators of grain and grinding products was carried out in the production laboratory in the production conditions of a flour mill with a productivity of 330 T per day.

To study the system of "roller mill—entolyator-dismembler", the first three first-class grinding systems were selected, on which enteroliths-dismemblers are installed for the maximum grinding of enriched products into flour.

Changing the grinding regimes and selecting the samples on the first grinding system was carried out as follows: During the work of the grinding unit on the specified system, a product was withdrawn throughout the roll length by means of a tray in the quantity up to 400–500 g. As the grinding products of the first grinding system are fed by pneumatic transport from the roller in the entolyores-dismemblers, and then in the cyclone discharger, then the sampling at different grinding regimes was carried out through the hatches after the cyclone discharger. After selecting the product with a helmet, equipped with rollers, the gap between the rollers was changed and the product was re-selected throughout the roller length and after the entleoter-dismemberer.

The grinding products were sown on a set of sieves No. 27PA-120, No. 33/36PA, No. 41/43PA and No 49/52PA. The mode of operation of the rolling mills of the first three milling systems was determined by the output of the higher-grade flour, since for high-quality wheat mills, the output of the higher-grade flour has the highest value and the main product of the milling at the mill stage is the output of the flour. The evaluation of the working conditions of the crushing equipment of the milling stage shall be carried out on the product of a higher-grade flour.

The output of the high-grade flour was calculated taking into account the under-development by the formula:

$$V_{f.h.g.} = \frac{m_{f.h.g.}}{m_z} * 100 - H \tag{1}$$

where $V_{f.h.g.}$—output of high-quality flour,%; m_z—the total mass of the sample after the roller or entleiter-dismembler, g; $m_{f.h.g.}$—mass of flour of the highest grade

obtained after sieving, s; *H*—shortcomings, determined by sifting the selected sample of the product entering the first grinding system, %.

The obtained results of the output of separate fractions of grinding products were graphically depicted in the coordinates of "the total product of flour—the yield of fraction".

On the first grinding system installed microshock rollers. The rotor speed of the entolyator-dismembler rotors was 50 s–1 (3000 rpm) and during the research did not change.

5 Results and Discussion

5.1 Modes of Grinding of Cereal-Rich Products Enriched in Roller Mills of 1 Grinding System

In order to substantiate the reduction of the milling stage in flour, we investigated the grinding regimes of enriched rounds (large ones) in the roller mill and the enteroliter-dismemberer of the first grinding system in accordance with the generally accepted structure, which includes a consistent combination of the roller machine and the entolyator-dismemberer ESM-1.5. On the basis of our research, it was found that with an increase in the total product of the flour in the rolling mill of the 1st grinding system from 7.3 to 28.7%, the output of the mixture of stair products (medium and small grains) from 80.9 up to 34.9% by curvilinear dependence. At the same time, the output of hard dunst increases, which increased from 5.4 to 10.4% and the output of soft dunst, which increased from 5.1 to 21.3%. In the range of general product flour, the yield of flour of grade 1 increased by a linear dependence of 1.3–5.1%. The results of the research are shown in picture 1. Analysis of data in picture 1 shows that with the increase of the general product of high-quality flour in the rolling mill of the 1st grinding system, not only the grinding of enriched large grains but also the excessive crushing of medium and small grains occurs, as evidenced by the decreasing nature of the corresponding curve 1 in Fig. 1.

1. stair product (a mixture of small and medium cereals);
2. hard dunst;
3. soft dunst;
4. 1st-grade flour.

The increase in the yield of flour did not exceed 28.7%, since the actual capabilities of the existing roller coaster did not allow this to be carried out and could lead to the outlet of the electric motor of the machine. In Fig. 2, the averaged results of the research of the output of stair products and flour of the 1st grade after shredding in the roller machine and the ESM-1.5 enthooler-dismemberer of the 1st grinding system are presented.

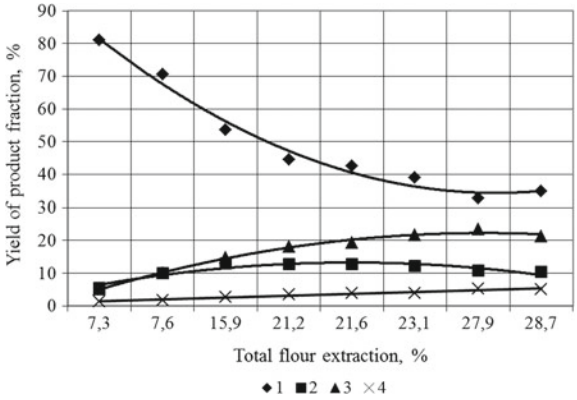

Fig. 1 Output of stair products after grinding in a roller machine 1 of a grinding system taking into account lack of sight

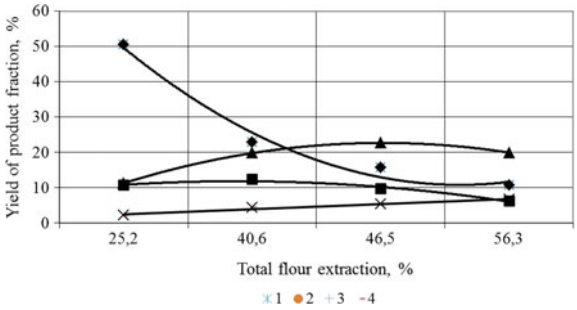

Fig. 2 Averaged output of stair products on 1 grinding system (roller machine + entolyator-dismembler) taking into account lack of access

1. stair product (a mixture of small and medium cereals);
2. hard dunst;
3. soft dunst;
4. 1st-grade flour.

Analysis of Fig. 2 indicates that the highest grade flour is mainly produced by grinding on the 1st grinding system of medium and small grains, as evidenced by the declining nature of curve 1, as well as the increase of the general product of high-quality flour leads to a decrease in the yield of soft and rigid dunes In the general product of high-quality flour on the system of 25.2%, the average yield of the mixture of medium and small grains was 50.5%, the yield of hard dunes—10.6%, soft dunes—1.3%, flour 1st grade—2.3%.

With an increase in the intensity of crushing of enriched turntables on the 1st grinding system from 25.2 to 56.3%, the yield of the mixture of medium and small grains decreased from 50.5 to 10.7%, rigid duns from 10.6 to 6.3%, soft dunes from 11.3 to 20.0%, 1st-grade flour from 2.3 to 6.7%.

From the analysis of Figs. 1 and 2 shows that the nature of the output of products after the roller machine and after the additional passage of the product through the entolyator-dismemberer has not changed significantly, the values of the output of circular dandruff products and flour are different. In addition, the comparative

analysis shows that in the ESM-1.5 distilled entolyator, the medium and small grains that are obtained by the screening of 27PA-120 are shredded the most, and the dunes are slightly ground. The above data shows that in the ESM-1.5 distilled entolyator, the larger particles of the endosperm (medium and small grains) are shredded the most, which leads to the formation of a higher-grade flour from them. Smaller parts are less exposed to the work equipment than larger particles and their conglomerates.

Analysis of data of Figs. 1 and 2 also shows that the use of a roller machine on the 1st grinding system allows the general product of high-quality flour to reach 28.0%, and additional grinding of intermediate products in the entolyator-dismemberer can increase this product twice from 28.0 up to 56.0%.

The output of the grinding products on the 1st grinding system, depending on the general product of the flour of the highest grade Vb.versus, is described by the following equations: yield of a mixture of medium and small cereals, Vsr.kr + dr.kr:

$$V_{m.gr.+sm.gr.} = 0.0343\, V_{f.h.g.}^2 - 4.08\, V_{f.h.g.} + 131.61 \tag{2}$$

where $V_{m.gr.+sm.gr}$—yield of medium and small grains,%; $V_{f.h.g.}$—yield of high-quality flour, %.

The correlation coefficient is 0.99, and the standard deviation is 0.27%. The output of the hard dunst, Wrath, is described by the equation:

$$V_{h.d.} = -0.0136\, V_{f.h.g.}^2 + 0.963\, V_{f.h.g.} - 4.86 \tag{3}$$

where $V_{h.d.}$—the output of hard dunst, %; $V_{f.h.g.}$—yield of high-quality flour, %.

The correlation coefficient is 0.97, and the standard deviation is 0.56%. The output of the soft dunst, Vmd, is described by the equation

$$V_{s.d.} = -0.0207\, V_{f.h.g.}^2 + 1.98\, V_{f.h.g.} - 25.58 \tag{4}$$

where $V_{s.d.}$—output of soft dunst, %; $V_{f.h.g.}$—yield of high-quality flour, %.

The correlation coefficient is 0.98, and the standard deviation is 0.74%.

The output of the first-grade flour, Vb.1c, is described by the equation:

$$V_{f.1g.} = 0.143\, V_{f.h.g.} - 1.35 \tag{5}$$

where $V_{b.1g.}$—output of hard dunst,%; $V_{f.h.g.}$—yield of high-quality flour, %.

The correlation coefficient is 0.99, and the standard deviation is 0.08%.

In the process of milling, the entolyators are auxiliary crushing equipment, which is installed after the roller. The grinding mode of the rolls in the roller machine affects the grinding mode of the grooves in the ESM-1.5 dismemberer entolyator. Researches have shown that the increase of the product of the high-quality flour in the roller machine from 7.5 to 28.3% leads to an increase in the yield of flour and in the entolyator from 17.7 to 28.0%. Dependence is linear.

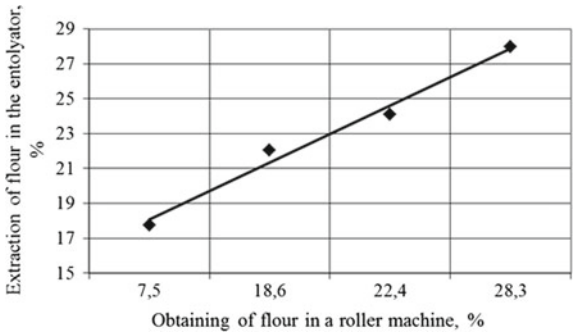

Fig. 3 Dependence of the output of high-quality flour in the enterolter-dismemberer ECM-1.5 from the output of the flour in the roller machine on the 1st grinding system, taking into account lack of time

It can be concluded that the particles of the grinding products that were not crushed to the size of the flour particles in the roller saw, but due to the mechanical effect, reduced the strength of the bonds further grinded through entolyores-dismemblers. Thus, not crushed grains and dunes are further grinded through the impact machines. In addition, the conglomeration of particles formed after passing circular dentate products through the rollers are also destroyed by passing through the entolyores-dismembranes (Fig. 3).

Rolling machine tools of the first three milling systems worked under the following regimes: the ratio of rotation speeds of rollers, K equaled 1.25, speed of rotation of the speed roll, V, −5 m/s, rollers with a micro-hollow surface.

The results of the research show that in order to intensify the grinding process of enriched circular dentistry products, it is necessary to reduce grinding regimes in the rolling mill of the 1st grinding system to 30% of the total product of the grinding, which positively affects the efficiency of the entolyores-dismemberers. During the laboratory study of crushed intermediate products of the 1st grinding system on the fraction, there was a presence of large particles of the nucleus of yellowish color in the east of the screen number 1.0 in the amount of 0.1–0.2% of the total mass of the product in the form of flakes. In the fraction obtained by the passage of the screen number 1.0 and the screen of the screen No. 12PCH-240, there was also a presence of small particles of the embryo, but it was not possible to separate the embryos and shells separately, and the total yield of this fraction of the product varied from 1.6 to 2.9%.

In the framework of the conducted researches to establish the optimal modes of grinding, the 1st grinding system failed. Although it is known from reference sources that an excessive reduction in the size of the gap between the rollers of the grinding systems leads to the splitting of the grinding products. In the production conditions, such modes were not achieved. For production, it is possible to recommend the general product of flour in a roller machine on 1st grinding system 28.0%.

6 Conclusions

The modes of grinding are determined. and the mathematical dependences of the product of flour and wheat products of the first grinding system with the additional equipment by the entolyator-dismemberer ESM-1.5 are proposed. The largest product of flour on the 1st grinding system reaches the regimes of grinding on a roller machine—28%.

At the same time, the use of ESD-1,5 dental emulator allows to increase the total product of flour on the 1st grinding system up to 56%. It has been experimentally established that the dependence between the product of the highest grade flour in the roller mill of the grinding system and the output of the high-grade flour in the ESM-1.5 dental emulator entolyarator has a linear dependence. The results of experimental studies are described by mathematical dependencies, which allow them to be used to calculate the quantitative balance of flour.

References

1. Kharchenko, Y., Sharan, A., Yeremeeva, O.: L. Novak Ukr. Food J. **6**(4), 603–617 (2017)
2. Mateos-Salvador, F., Sadhukhan, J., Campbell, G.M.: Powder Techn. **237**, 107–116 (2013)
3. Mateos-Salvador, F., Sadhukhan, J., Campbell, G.M.: Powder Techn. **208**, 144–157 (2011)
4. Fistes, A., Tanovic, G., Mastilovic, J.: J. Food Engin. **85**, 296–302 (2008)
5. Fistes, A., Rakic, D., Takaci, A., Brdar, M.: Chem. Eng. Sci. **102**, 346–353 (2013)
6. Campbell, G.M., Sharp, C., Wall, K., Mateos-Salvador, F., Gubatz, S., Hutty, A., Shewry, P.: J. Cereal Sci. **55**, 415–425 (2012)
7. Vereshchynsky, A.P.: NUFT, Kiev (2013)
8. Fistes, A., Rakic, D., Takaci, A., Brdar, M.: Powder Techn. **268**, 412–419 (2014)
9. Storage and processing of grain, **4**, 45–48 (2013)
10. Fistes, A., Rakic, D., Takaci, A., Brdar, M.: Powder Tech. **268**, 412–419 (2014)
11. Kharchenko, Y., Perehuda, N., Shnipko, I.: Grain Storage Proc. **6–7**, 62–64 (2015)