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The quality of the mixing process depending on selected technical parameters

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S u m m a r y. Homogeneity is a system, in which particles of all raw materials show constant concentration, in random samples of a mix with defined sizes. It aims at achieving products of desired properties. The aim of the conducted research was to determine the influence of rotational speed of the stirrer and the type of raw material on homogeneity of the mixing process. The scope of research included the assessment of the influence of various rotational speeds of the stirrer on the quality of mixing in relation to the type of a raw material. In order to select the optimal rotational speed of the mixer the research was carried out at 3 different rotational speeds, i.e.: 80, 100 and 120 rpm for cornmeal used as the test raw material. Next, tests for different raw materials at a defined rotational speed were conducted. The research was carried out during a particular time of mixing, namely 5 minutes. The research was conducted in a single-shaft horizontal mixer with a vane working element. The size of particles of the mixed raw material influences the quality of the mixing process. The type of the mixed raw material influences the quality of mixing and particularly its physical properties. The level of CV while mixing cracked wheat indicates insufficient mixing of the raw material. Time of mixing should be lengthened. The results achieved from the research on the assessment of the influence of selected mixing parameters suggest that the research should be extended and take into account various mixing times.

K e y w o r d s: mixing, micro-tracers, feed quality.

INTRODUCTION

In production processes the stage of mixing is one of the most important in the technological process. The aim of mixing is achieving a homogenous, as far as physical properties are concerned, mix of two or more ingredients. The measurement of quality is the degree of homogeneity of the final product. Homogeneity is a system, in which particles of all raw materials show constant concentration, in random samples of a mix which have defined sizes [12]. It aims at achieving products of desired properties. Out of many important factors which influence the quality of the mixing process, the characteristics of materials for mixing should be mentioned. It is the easiest to mix ingredients which have the same size of particles, regardless of the raw material used, but maintaining the properties of the grain material in each of the raw materials, i.e. without excessive grinding [3,1]. This kind of excessive grinding has, in many ways, a negative influence, e.g. in technology – excessive dusting, as well as nutritional reasons. With different sizes of particles, bigger grains while mixing are located in the upper part of the system, and smaller grains in the lower part of the mixer. While mixing, when we deal with a material of various densities, secondary segregation may take place [9]. However, when the proportion of density of heavier material to the density of lighter materials is lower than three, then the influence of sizes of grains predominates over the influence of the difference in density [5]. The disordered state can be achieved only in an ideal system, when the ingredients of the mix do not differ or differ only in properties which are insignificant to the process. The ingredient with the biggest percentage share in the mix plays a dominant role in the process because it displaces other smaller ingredients from the mix. The quality of mixing is also influenced by the shape of grains [8,10,14]. Round and smooth grains move easier than grains with irregular shapes or grains with sharp edges. For the purposes of mixing, mixers are used of different constructions, configurations of stirrers and sizes, depending on the scale of the industry, the type of produced fodder, the precision of ingredient distribution [2,15]. The main features, which should characterise mixers, are the shortest possible time of operation to achieve the appropriate state, the minimum consumption of energy, and ensuring the staff the simplicity of operation and availability of replacement parts [4,7,16].

A very important aspect, however, not only of the process of mixing itself, is low cost of purchasing and utilising the machine. The correct exploitation of ma-

chines has a big influence on the process of mixing, the final product, efficiency and quality. Apart from the basic aspects, i.e. lubricants in wheelworks, cleanliness of the inside, the control system and precision of functioning of the system which feeds the raw material should also be tested. Before using a new machine it should be tested because time and the final quality of product is influenced not only by the technical condition, but also by the scale of production, the order of added ingredients, and the placement in a technological line [6,11,13,17].

The aim of the conducted research was to determine the influence of rotational speed of the stirrer and the type of raw material on homogeneity of the mixing process.

MATERIAL AND METHODOLOGY

The scope of research included the assessment of the influence of various rotational speeds of the stirrer on the quality of mixing in relation to the type of raw material. The research was conducted on sweetcorn extrudate, wheat extrudate and cracked wheat. In order to select the optimal rotational speed of the mixer, the research was carried out at 3 different rotational speeds, i.e.: 80, 100 and 120 rpm for cornmeal used as the test raw material. Next, tests for different raw materials at a defined rotational speed were conducted. The research was carried out during a particular time of mixing, namely 5 minutes. The research was conducted in a single-shaft horizontal mixer with a vane working element.

The assessment of the quality of mixing was made on the basis of ASAE Standard (No.S303) with the use of micro-indicators. The coefficient of variation CV for particular samples was calculated from the following formula:

$$CV = \frac{\delta}{n} \cdot 100\ \%,$$

δ - standard deviation,
n – average.

The micro-indicator MICROTRACER ™ F- BLUE was used as a tracer, using 50 grams per one ton of mix. In one gram of the micro-indicator there are 25000 pieces. Such an amount caused, that with 100% homogeneity

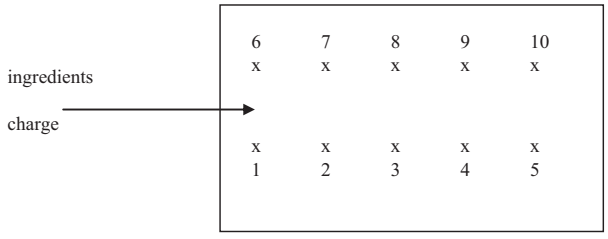

Fig. 1. Points, were the samples were taken for the research

in a sample weighing 80 g taken from the mix there should be 100 pieces of the micro-indicator. Next, 80 g samples taken to define the level of mixing were separated in a machine designated for abstracting micro-indicators - type Rotary Detector, model BL-89, series XO-7. The diagram of points where the samples were taken from the mixer is presented in Fig.1.

An essential parameter of the mixing process is also the level of filling the chute. For selected raw materials, the identical level of filling the chute was established at 75%. As a result of different bulk densities of the raw materials, the portions of the raw materials which underwent mixing differed but the same level of filling the mixer chute was maintained. Bulk density of the tested raw materials, which predominated the mass of the mixed raw materials, is presented in Table 1.

Table 1. Bulk densities of the tested raw materials

Raw material	Bulk density [kg×m^{-3}]		
	Fraction 0-1mm	Fraction 1-2.5mm	Fraction over 2.5mm
Sweetcorn extrudate	185	82	62
Wheat extrudate	287	214	185
Cracked wheat	519	642	695

RESULTS AND DISCUSSION

Results of the research of homogeneity of mixing at different rotational speeds are presented in Table 2. After calculating the amount of micro-indicators in particular samples, the standard deviation and variation coefficient CV were defined on the basis of which homogeneity of mixing was assessed.

Table 2. The amount of micro-indicators in samples, in relation to the speed of the stirrer for fragmented sweetcorn extrudate.

Trial	80 rpm	100 rpm	120 rpm
1	93	93	110
2	109	124	136
3	112	126	141
4	103	102	102
5	106	114	100
6	131	125	109
7	125	119	128
8	100	121	142
9	110	118	111
10	134	106	101
Mean	112.3	114.8	118
Standard deviation	13.532	11.043	16.971
CV	12.05	9.6196	14.382

While assessing the level of mixing of raw materials at different rotational speeds of the stirrer it can be stated that the level depends on rotational speed. For the same conditions of mixing sweetcorn extrudate at the rotational speed of 100 rpm, the highest level of mixing was achieved. When we make an assessment from the point of view of efficiency of the mixing process, we should aim at the shortest possible time of mixing, which indirectly influences the energy consumption of the process. Establishing appropriate rotational speeds and defining the minimal mixing time influence the final efficiency of the mixing process.

As a result of assessing the quality of mixing after preliminary research, for further analyses one optimal mixing speed was adopted at 100 rpm.

The diagram below presents the relation of the mixing process for selected raw materials with the rotational speed 100 rpm and mixing time 300 seconds.

When analysing the diagram of homogeneity of mixing of tested raw materials, it can be stated that the best effect was achieved while using sweetcorn extrudate with particle sizes ranging from 1 to 2.5 mm. High values of the coefficient of variation were achieved for the fraction with particles over 2.5 mm. In case of sweetcorn extrudate, the coefficient was over 35%, which accounts for inadequate mixing of the raw material. When assessing the quality of mixing according to European standards, in which it is assumed that adequate mixing takes place when the coefficient of variation for premixes is over 10%, and for complete mixes below 15%, it can be stated that a product with particles bigger than 2.5 mm was not mixed and technical parameters of the mixer should be changed or mixing time lengthened. However, in case of raw materials whose particle size was below 2.5 mm, homogeneity of mixing was adequate for wheat and sweetcorn extrudates. For cracked wheat homogeneity of mixing was inadequate, regardless of particle sizes.

CONCLUSIONS

On the basis of the conducted research the following conclusions were formulated:

1. The rotational speed of the stirrer influences homogeneity of mixing.
2. The size of particles of the mixed raw material influences the quality of the mixing process. Within the scope of tested parameters, bigger particles mix in a more difficult way and time of mixing should be changed.
3. The type of the mixed raw material influences the quality of mixing and particularly its physical properties. The level of CV while mixing cracked wheat indicates insufficient mixing of the raw material. Time of mixing should be lengthened.
4. The results achieved from the research on the assessment of the influence of selected mixing parameters suggest that the research should be extended and take into account various mixing times.

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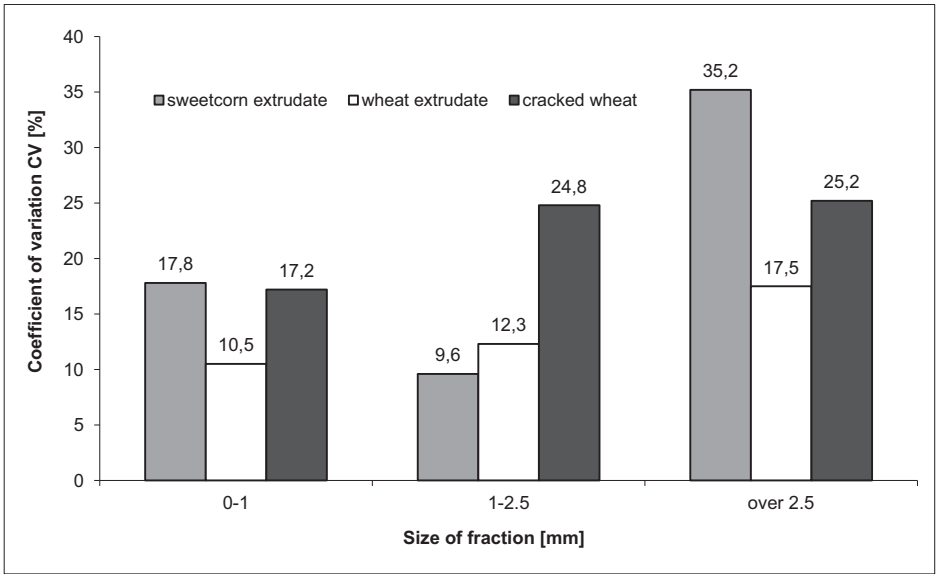

Fig. 2. Coefficient of variation by the type of the used raw material.

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JAKOŚĆ PROCESU MIESZANIA W ZALEŻNOŚCI OD WYBRANYCH PARAMETRÓW TECHNICZNYCH

S t r e s z c z e n i e . Miernikiem jakości jest stopień jednorodności produktu finalnego. Za jednorodność uważa się układ, w którym cząstki wszystkich surowców wykazują stałą koncentrację, w dowolnych, ale o określonych wielkościach, próbach mieszanki. Celem prowadzonych badań było określenie wpływu prędkości obrotowej mieszadła oraz rodzaju surowca na homogenność procesu mieszania. Zakres badań obejmował ocenę wpływu różnych prędkości obrotowych mieszadła na jakości mieszania w zależności od rodzaju mieszanego surowca. Badania przeprowadzono na ekstrudacie kukurydzy, pszenicy oraz śrucie pszennej. W celu wyboru optymalnej prędkości obrotowej mieszarki przeprowadzono badania dla 3 różnych prędkości obrotowych t.j.: 80,100 i 120 obr./min. dla kaszki kukurydzianej jako surowca testowego. Następnie prowadzono badania dla różnych surowców przy określonej prędkości obrotowej. Badania przeprowadzono dla jednego czasu mieszania wynoszącego 5 minut. Badania wykonano na jedno-wałowej mieszarce poziomej z łopatkowym elementem roboczym. Opierając się na uzyskanych wynikach można stwierdzić, że wielkość cząsteczek mieszanego surowca wpływa na jakość procesu mieszania. Na jakość mieszania wpływa rodzaj mieszanego surowca, a w szczególności jego właściwości fizyczne. Poziom CV przy mieszaniu śruty pszennej wskazuje na niedostateczne wymieszanie surowca. Należałoby wydłużyć czas mieszania. Otrzymane wyniki z badań nad oceną wpływu wybranych parametrów mieszania sugerują poszerzenie badań o różny czas mieszania.

S ł o w a k l u c z o w e : mieszanie, mikrowskaźniki, jakość.