Complex Fertilizers Produced from the Sunflower Husk Ash

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Abstract

Sunflower husk ash containing the primary and secondary plant nutrients – phosphorus (10.94% P₂O₅), potassium (25.84% K₂O), calcium (19.07% CaO), magnesium (18.58% MgO), and also some micronutrients (zinc, copper, cobalt, manganese, iron, and molybdenum) may be used for fertilization of variety plants. The sunflower husk has low plasticity, and the granulation process occurs better when binding materials (sugar factory lime, molasses, urea formaldehyde resin) are used. This study investigates determination of the optimal parameters of the granulation process as recycling and moisture content, ratio of ingredients and influence of additives by using laboratory equipment. The main product quality parameters as chemical composition, static crushing strength of granules, granulometric composition, and pH of 10% solution by standard method were examined. The results show that sunflower husk may be used for fertilizers of 0-6-13 grade production.

Keywords: sunflower husk ash, sugar factory lime, molasses, fertilizers, granulation, physicochemical properties, environment

Introduction

Vegetable waste – tree leaves, sawdust, straw, rapeseed stalks and others are increasingly being used as alternative fuels, reducing the consumption of fuel oil or natural gas and environmental contamination. The combustion product of this waste, ash, is a valuable material that can be used to fertilize different plants. Ash contains a significant content of primary and secondary plant nutrients – phosphorus, potassium, calcium, magnesium, and some micro elements (ME): zinc, copper, cobalt, manganese, and iron [1].

During the industrial processing of sunflowers, sunflower husks remain unused. Depending on growing conditions and fertilizer the husks application, the husk contain a variety of plant nutrients and micro elements. Therefore ash obtained from burning husks can be used to fertilize plants.

Ash utilization becomes more efficient when a homogeneous mass is obtained and particle size is uniform. This is achieved by ash granulation.

The granulation method is selected by taking into account the particle agglomeration determining the plasticity of raw materials, as well as the physical-chemical properties of the granulated product (granulometric composition, crushing strength of granules, hygroscopicity), which determines product caking and powdering. In addition, economic indicators of the process are significant (energy consumption, waste generation) and the capacity of the installation. Non-traditional fertilizer granulating equipment is often selected for the granulation of low-plasticity material: tableting equipment, extruders, forming equipment.

Ash has no plasticity and its agglomeration is difficult. Ash granulation in drum granulators can be expected only with the addition of binding materials. It is known that polyamin alkylol [2] or ETEC-dolomite [3] are effective for
Chemical and instrumental analysis of Moldovan sunflower husk ash was carried out (Table 2) (Figs. 1-3).
The data of chemical analysis indicates that ash contains significant content of some primary and secondary nutrients: K₂O 25.84%, CaO 19.07%, and MgO 18.58%, as well as Na₂O and N – only traces. Individual ME content varies across a broad range. The most abundant element found in ashes is iron (2,940.46 mg/kg), there is also a significant content of Mo (472.17 mg/kg), Mn (410.45 mg/kg), and Cu (405.61 mg/kg); less of Zn (167.23 mg/kg) and of Co (0.44 mg/kg).

The data of simultaneous differential scanning calorimetry and thermogravimetry (DSK-TG) analysis (Fig. 1) indicate that at 89.0ºC the DSK curve displays insignificant endothermic effect, and in the TG curve it corresponds to the mass loss, which is attributed to the adsorptive water removal in ashes. At 438.0ºC one can see that another insignificant endothermic effect, by its nature, may be the result of enantiotropic conversions.

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X-ray diffractive analysis curve (Fig. 2) contains the peaks that correspond to calcium carbonate (0.302, 0.285, 0.210, 0.189 nm), potassium carbonate (0.319, 0.285, 0.223, 0.200, 0.170, 0.159, 0.149 nm), magnesium carbonate (0.241, 0.170, 0.149, 0.141 nm), potassium–calcium carbonate (0.264, 0.217 nm), potassium-calcium phosphate (0.270, 0.159 nm), potassium-manganese oxide (0.678, 0.276, 0.241 nm), magnesium-phosphate (0.293 nm) and oxide (0.149 nm), and elemental carbon (0.334, 0.285, 0.159 nm) characteristic diffractive reflexions.

In the spectrum obtained during IR spectral analysis (Fig. 3), in the area of approximately about 3,600-3,400 cm⁻¹, one can distinguish a low-intensity vibration typical of O-H connection valentic vibration of water molecules. Oscillations in the frequency range of approximately 3,200-2,800 cm⁻¹ can be attributed to the CH group, and non-intensive vibrations in the range of 2,500-1,600 cm⁻¹ are typical of the CO connection. The spectrum has a very pronounced vibration of CO₃²⁻ functional group in the frequency range of approximately 1,400 and PO₄³⁻ approximately 1,100 cm⁻¹, and less pronounced in the absorption frequency range of 900-500 cm⁻¹ characteristic to CaO and MgO.

The identified ash physical properties (granulometric composition and bulk density) and the obtained results are presented in Table 3. As we see from the data, the majority of ash consists of particles less than 2 mm in size. Sunflower ash bulk density equals 708 kg/m³.

It was visually determined that ash content depends on various admixtures, for example unburned sunflower particles. These impurities explain some absorption bands in the spectrum characteristic of silicate substances. The view of separate fractions of Moldovan sunflower ash is different and is presented in Fig. 4.

<table>
<thead>
<tr>
<th>Granulometric composition, %</th>
<th>Bulk density, kg/m³</th>
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<tbody>
<tr>
<td>&lt;1 mm</td>
<td>38.84</td>
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<tr>
<td>1-2 mm</td>
<td>31.49</td>
</tr>
<tr>
<td>2-3 mm</td>
<td>7.71</td>
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<tr>
<td>3-5 mm</td>
<td>12.08</td>
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<td>&gt;5 mm</td>
<td>9.88</td>
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Table 3. Physical properties of ash.

Fig. 4. Images of separate fractions of Moldovan sunflower husk ash: 1: – <1 mm; 2 – 1-2 mm; 3 – 2-3 mm; 4 – 3-5 mm; 5 – >5 mm ash fraction.
The properties of granular product – granulometric composition, mass change after drying, pH of 10% solution and static crushing strength of 3-5 mm fraction granules – was identified and these results are presented in Table 4.

Sunflower ash was granulated by moistening with water (sample 1) and granulating ash with 50% of recycling (sample 2). For improvement of product properties, ash was mixed with molasses (samples 3 and 4) or samples were moistened with water solution of molasses at different concentrations (samples 5-8). Molasses content in the mixtures prepared for granulation varied from 9.5 to 30.23%. The best product characteristics, as marketable product (diameter of 2-5 mm) yield approximately 65% and the granule crushing strength equals 21.1 N/gran. are obtained with the minimum molasses additive (sample 5). A significant output of marketable fraction (approximately 60%) is obtained also at larger (21.43%) content of molasses (sample 8), but in this case the crushing strength of granules is reduced up to 14.6 N/gran., as well as the granules drying duration being significantly extended. The results show that the largest quantity of marketable fraction is obtained at the minimum and maximum ratio between the M and W (samples 5 and 8), therefore it is inappropriate to increase the content of molasses additive significantly if it is enough to moisten the mixture with water.

When granulating ash with 50% of recycling and using water solution of molasses for moistening of mixture (M:V=1:1) (sample 9), the output of marketable product is approximately 32%, and the static strength of granules equals 16.9 N/gran.

The sunflower ash mixture with SFL, when both components are taken in equal parts, was granulated by moistening with water (sample 10), and using molasses (samples 11 and 12) or its water solutions (samples 13-
After the experimental study it was identified that the granular product can be obtained by granulating ash. Better granular product parameters were obtained by granulation of ash-SFL. The granulation process and the marketable parameters of the product are improved by using molasses or UFR additives. Returning recycling to the granulated mix changes the marketable parameters of a product insignificantly.

The results of granulating the sunflower husk ash and SFL mixture showed that fertilizer of 0-6-13 grade and suitable marketable parameters may be produce. The granular product photo is provided in Fig. 5. The composition of fertilizers is (%): 0.08 N; 5.94 P₂O₅; 12.97 K₂O, 24.27 CaO, 10.00 MgO, 0.03 Na₂O, 0.27 Fe, 0.02 Cu, 0.01 Zn, 0.04 Mn, and 0.06 Mo.

**Fig. 5. Granulated fertilizer of 0-6-13 grade.**

As a binding additive. M content in other granulating mixtures varied from 5.8 up to 21.05%. Granule strength of granular product depends on the quantity of M added: the highest (21.1 N/gran.) is in sample 13, where M content is 5.86%. The quantity of marketable granule fractions depends not only on the quantity of the binding additive – M – but also on the general humidity of raw material mix. The best yield of marketable production (approximately about 45%) by granulating sunflower husk ash with M additive was obtained in sample 11, when the M content was 13.29%.

When the ash and SFL mixture containing 50% recycling and water was used for mixture moistening (sample 17), approximately about 43% of marketable fraction was received with granule strength of 10.1 N/gran. When the ash and SFL mixture with 50% was moistened with a water molasses solution (M:W=1:1), marketable fraction contain of approximately about 48%, and granules strength was equal 19.5 N/gran. (sample 18).

Sunflower husk ash (samples 19 and 20) and ash-SFL mixture (samples 21 and 22) were granulated by moistening them with water UFR solution. After ash granulation, at 0.30% of UFR (sample 19), very poor quality indicators are obtained: the output of marketable product is approximately 26%, crushing strength of granules is 8.3 N/gran. If the UFR amount is increased to 0.59% (sample 20), the quality parameters improve: yield of marketable product is approximately 7%, and the crushing strength of granules is 14.7 N/gran. When UFR is used as a binding component, the highest strength of granules (15.9 N/gran.) and the largest yield of marketable product (53%) are obtained in sample 22. In this case the ash-SFL mixture (with UFR content in the mixture) was 0.38% granulated.

When granulation of ash (sample 23) as well as ash-SFL and (sample 24) occurs with 50% of recycling and using water UFR solution for mixture moistening, quite similar quality parameters of granular product were obtained. When granulation of the SFL mixture occurs with 50% of recycling, the yield of marketable product increases up to 63.1%, and the average static crushing strength of granules equals 11.7 N/gran.

**References**


13. YUNG G. Instrumental Methods of Chemical Analysis. Moscow. 608, 1989 [In Russian].


15. SIAUCHIUNAS R., BALTIKYKS K., BALTUŠNIKAS A. Instrumental Analysis of silicify materials. Kaunas. 244, 2007 [In Lithuanian].
