Distribution of the relative frequency of immersion of pea grains in the liquid depending from the height of transportation

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Abstract. One of the main ways to protect seed material from various diseases is treatment with chemicals. The most effective way to protect seeds from various diseases is wet etching with the simultaneous release of grain impurities. To develop a device for cleaning and etching seeds by wet density, studies were conducted to determine the minimum height of the loading hopper relative to the surface of the water solution of the etcher when transporting spherical grains to it in order to ensure that the surface tension forces are overcome. Practical experiments were conducted on throwing single grains of peas of the Vita variety (spherical grain) with a humidity of 14% into a liquid with a density of \( \rho_{zh} = 1000, 1090 \) and 1150 kg/m\(^3\). Sodium chloride salt (NaCl) was used to change the density liquid. To obtain more reliable information, the experiments were carried out in three-fold repetition. The temperature of the surrounding air and liquid of different densities \( \rho_{zh} \) was 20°C. It is established that when single pea grains fall 100%, the immersion in water (\( \rho_{zh} = 1000 \) kg/m\(^3\)) occurs at a transport height \( h \) of at least 12.0·10\(^{-3}\) m. In the case of 100% immersion of pea grains in an aqueous solution of sodium chloride (NaCl) with a density of \( \rho_{zh} = 1090 \) and 1150 kg/m\(^3\), the minimum transport height \( h \) is 15.0·10\(^{-3}\) and 18.0·10\(^{-3}\) m, respectively.

1. Introduction

Grain is the oldest human food product, later with the development of labor productivity and its sufficient production-feed for farm animals. One of the main reserves for increasing grain production is the use of high-quality grain material for sowing, purified from various impurities and pathogens [1, 2].

Therefore, the main task at present is to prepare high-quality seed material of grain crops for sowing. Sowing infected seeds leads to the transmission of diseases to vegetating plants and thus creates and maintains foci of infection in the field. Therefore, the treatment of seeds with protective and stimulating preparations is a mandatory event of intensive technology in crop production [3, 4, 5].

One of the main ways to protect seed material from various diseases is treatment of seeds with chemicals. At the same time, the simultaneous use of trace elements and growth regulators also stimulate the development of plants and increase their productivity [6-9].

One effective method of seed treatment before sowing is wet etching by watering or soaking the seed material with dilute water solutions of chemicals or a suspension of wetting powders. This method provides a deeper and more complete penetration of the solution of the mordant into the seeds.
and a more complete disinfection of them from infection. At the same time, there is no air pollution [8, 9].

However, in a well-cleaned seed material, after repeated transportation, grain fines are formed again [10]. Therefore, to avoid getting dusty grain into the mordant, it is necessary to additionally clean the seed material with a grain cleaning machine [11-19].

Therefore, for the mechanization of seed etching by wet method, the development of a simple design and low energy consumption device with the function of removing grain fines is an urgent issue [20, 21].

When developing such a device, it is necessary to determine the height of the loading hopper relative to the surface of the water solution of the fungicide in the bath of the device for high-quality performance of the technological process for wet seed etching [22].

Therefore, the purpose of research is to determine the minimum height of the loading hopper relative to the surface of the water solution of the etcher when pea grains fall into it in order to ensure that the surface tension forces are overcome.

2. Materials and methods

To achieve this goal, practical experiments were conducted on throwing single grains of peas of the Vita variety (spherical grain) with a moisture content of 14% into a liquid with a density of \( \rho_{zh} = 1000, 1090 \) and 1150 kg/m\(^3\). Sodium chloride salt (NaCl) was used to change the density liquid. The general view of the pea grains of Vita variety and sodium chloride salt (NaCl) is shown in Figure 1.

![Figure 1. General view of the pea grains of Vita variety (a) and sodium chloride salt (b).](image)

To conduct experiments, a bath made of transparent glass was made, the side walls and bottom of which are glued together with a silicone-based sealant, which is a glass vessel having a length of 0.35 m, a width of 0.20 m and a height of 0.15 m. The volume of water or salt solution poured into this vessel was 9 liters.

The height \( h \) of the grains falling into water or an aqueous solution of salt was changed using a set of metal plates that were installed above the vessel. Each plate had a thickness of 1.5·10\(^{-3}\) m, a length of 0.28 m and a width of 0.04 m. Grains in the amount of 20 pieces were installed on a plate and dumped into water or an aqueous solution of salt (Figure 2).

Measurement of the size of a made transparent glass vessel, the height \( h \) of dropping pea seeds into water or into an aqueous solution of salt was performed using a metal ruler with millimeter divisions.

The relative frequency of immersion of pea grains in a liquid of different density \( \rho_{zh} \) from the height \( h \) of the fall was determined by the expression (%):

\[
p = \frac{n_2}{n_1} \times 100
\]  

(1)
where $n_1$ – is the number of pea grains dumped into a liquid of different density $\rho_{zh}$, $pc$; $n_2$ – the number of sunken pea grains in the liquid, $pc$.

![Figure 2](image)

**Figure 2.** General view of the experimental setup for studying the immersion of pea grains of Vita variety in the liquid from the height $h$ of the fall: a–before dumping pea grains from the plate into the liquid; b–sunken and floating on the surface of the liquid pea grains.

To obtain more reliable information, the experiments were carried out in three-fold repetition. The temperature of the surrounding air and liquid of different density of $\rho_{zh}$ was 20 °C. The experimental data obtained were processed on a personal computer using the Microsoft Excel 2013 office documentation package for statistical information processing.

3. Results and Discussion

Figure 3 shows the distribution of the relative frequency of immersion in water ($\rho_{zh} = 1000 \text{ kg/m}^3$) and an aqueous solution of sodium chloride (NaCl) with a density of $\rho_{zh} = 1090$ and $1150 \text{ kg/m}^3$ of Vita pea grains from the height $h$ of the fall.

When pea grains fall the relative frequency of immersion in water from the height $h$ of the fall is described by the equation (%):

$$p_{1000} = 57.0 + 13.929h - 1.071h^2 \quad R^2 = 0.998; \quad (2)$$

when falling, an aqueous salt solution with a density of $\rho_{zh} = 1090 \text{ kg/m}^3$ has the following dependence (%):

$$p_{1090} = 38.5 + 11.054h - 0.089h^2 \quad R^2 = 0.991; \quad (3)$$

and when falling an aqueous salt solution with a density of $\rho_{zh} = 1150 \text{ kg/m}^3$, the dependence is described by the following expression (%):

$$p_{1150} = 14.286 + 17.798h - 0.774h^2 \quad R^2 = 0.993; \quad (4)$$

The coefficients $R^2$ of confidence in the approximation of dependencies (2), (3) and (4) are almost close to 1.0, which indicates a high degree of compliance of the trend model with experimental data. This characterizes the approximation as a regression model that is almost absolutely reliable.

From the obtained dependences, it follows that 70% of pea grains are able to overcome the surface tension when they arrive from zero height $h$ to the water surface ($\rho_{zh} = 1000 \text{ kg/m}^3$). When the height $h$ increases to $0.003 \cdot 10^{-3} \text{ m}$, the number of pea seeds that can overcome the surface tension of water is
already 80%. The minimum height $h$, from which all pea grains dropped from the plate begin to sink in water, is $12.0 \times 10^{-3}$ m.

From figure 3, it follows that the penetration of pea grains in a liquid with a higher density $\rho_{zh}$ is more difficult than in a liquid with a lower density $\rho_{zh}$. Thus, to overcome the water surface tension force of 70%, the grains of the peas need a zero-height $h$ of the drop. And when immersed in an aqueous solution of salt with a density of $\rho_{zh} = 1090$ and 1150 kg/m$^3$, 70% of the pea grain overcomes the surface tension of the solution from a height $h$ of not less than $0.006 \times 10^{-3}$ and $0.009 \times 10^{-3}$ m, respectively.

Figure 3. Distribution of the relative frequency of immersion in the liquid of Vita pea grains from the height $h$ of the drop.

The remaining 30% of pea grains, which have a lower density of $\rho_z$, overcome the force of the surface tension of water ($\rho_{zh} = 1000$ kg/m$^3$) and an aqueous salt solution ($\rho_{zh} = 1090$ and $\rho_{zh} = 1150$ kg/m$^3$) from a higher height $h$ of the fall. These grains require a large height to acquire sufficient kinetic energy to overcome the surface tension of the liquid. Absolute relative frequency dip beans water salt solution density $\rho_{zh} = 1000$ kg/m$^3$ corresponds to a drop height of $h = 0.015 \times 10^{-3}$ m, and aqueous salt solution of density $\rho_{zh} = 1150$ kg/m$^3$ height of falling $h = 0.015 \times 10^{-3}$ m.

As a rule, pea grains with a higher density of $\rho_z$ are more resistant to various harmful microorganisms, have higher viability, germination energy and germination. This contributes to obtaining high yields and higher grades of flour. Accordingly, this method of grain separation can be recommended for breeding operations to obtain crops with a higher density of $\rho_z$, allowing to obtain high yields [1, 2, 9].

In contrast to the experiments conducted on the immersion of individual pea grains in water, the results of experiments on throwing grains into an aqueous solution of salt show an increase in the height $h$ of the fall for their 100% immersion. This is due to the fact that the water salt solution has a higher density $\rho_{zh}$ and a higher surface tension coefficient than water, so the pea grain must have a greater kinetic energy at the moment of falling into the solution, and, consequently, fall from a higher height $h$ to ensure that the surface tension forces are overcome.

4. Conclusion

Thus, it is experimentally established that when single pea grains of Vita variety fall, 100% immersion in water ($\rho_{zh} = 1000$ kg/m$^3$) occurs at a height $h$ of the fall of at least $12.0 \times 10^{-3}$ m. In the case of 100% immersion of pea grains in an aqueous solution of sodium chloride (NaCl) with a density of $\rho_{zh} = 1090$
and 1150 kg/m$^3$, the minimum height $h$ is $15.0 \cdot 10^{-3}$ and $18.0 \cdot 10^{-3}$ m, respectively.

Acknowledgments
The work was performed in the framework of the State task of the Federal Agrarian Scientific Center of the North-East (No 0767-2019-0094) «Creation of innovative technologies and technologies of a new generation for mechanization of crop and livestock production adapted to the climatic conditions of the North-East of the European part of Russia» and on the scientific topic «Physical and mathematical modeling of grain materials separation» of the Department of mathematics and physics of the Vyatka state agricultural Academy (Kirov, Russia).

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