The relevance of this work relates to the problems of dispersion systems investigation and improvement of the experiment accuracy. These problems’ solution requires new experimental methods. Trends of modern science, its orientation to new technologies require a differentiated approach to conducting experiments and training. Using the latest experimental methods is intended to provide clear and sufficiently accurate results that can be used in the future. In this regard, the authors of the article discuss the goals, objectives and requirements posed to the experimenter working in modern science.

This article presents one of the methods of dispersive analysis for improving the data accuracy and comparative analysis of the described method with other popular methods of mathematical statistics.

The methods of dispersive analysis are widely used for food raw material analysis. There are several methods of dispersive analysis at the modern stage of the development of science. A microscopic technique allows analyze the shape, texture and surface structure of the considered samples of food raw materials. This fact is of high importance in cases, when the powders are used for further preparation of reactive heterogeneous mixtures, which are used in food industry. The calculation of dispersion for modelling powder sample is shown and the optimal size of its particles is determined. The most optimal approximating curves for powders of different dispersion are chosen.

The authors of the article give a number of conclusions and recommendations for the analysis of food powders.

**Keywords:** microscopic method, dispersion of powders, screen analysis of powders, differentiated distribution function.

**Statement of the problem.** Microscopic method differs from other methods by the possibility not only to define geometrical dimensions of the analyzed objects, but also to see the features of their form, texture and surface structure. The last fact is of high importance in cases, when powders are further used for the preparation of reactive heterogeneous mixtures, which are used in food industry. Microscopic method allows to measure particles of 0.3–100 micrometers in dimension. The disadvantage of microscopic method is its high laboriousness. Reliable results of particles determination by microscopic method can be derived only by measuring several hundreds of particles. Consequently, duration of microscopic analysis could take several hours. This
disadvantage is easily eliminated by means of modern computer technologies. Application of the computer techniques allows both to evaluate rapidly the average dimension of the particles of powder, and to define parameters of the distribution law describing dispersed composition of the powdered food raw material in the best possible way [1; 2].

**The objective of the research.** The purpose of the research is to develop methods of calculation of powders’ dispersion and to select the most optimal variant of approximating function for powders with different dispersion.

**Presentation of the research material.** To define dispersion of particles it is necessary to prepare the samples in a special way. The pattern of the powder is carefully mixed in full volume, and then a needle moves the sample on a slide with a water drop, which disperses. The particles of the sample are uniformly allocated on the drop and are covered with cover glass. The cover glass is carefully pressed to the sample to make monolayer of particles in the sample. After this, microphotographs are taken.

To describe the dispersed composition of powders four equations are used: Goden-Andreev equation, Rozin-Rammmler equation, normal (ND) and lognormal distribution law (LND) [3]. Goden-Andreev equation derived under the generalization of the results of particle size analysis of powders disintegrated on various industrial equipment is the following:

\[ D(\delta) = 0.8 \left( \frac{\delta}{A} \right)^l, \]  

(1)

where \( D(\delta) \) is an integral function of distribution, \( \delta \) – size of particles, \( A \) – constant, parameter \( l \) characterizes direction and rate of inflection of distribution curve: if \( l = 1 \) curve changes to straight line; if \( 1 < l \) curve \( D(\delta) \) is convex; if \( l > 1 \) curve \( D(\delta) \) is concave.

After the differentiation of its relative distribution function, the following comes out:

\[ \varphi(\delta) = 0.8 \cdot l \cdot A^{-l} \cdot \delta^{l-1}. \]  

(2)

In Rozin-Rammler equation, [1] distribution curves according to screen analyses’ data, can be expressed by the formula:

\[ D(\delta) = 1 - \exp \left[ -\left( \frac{\delta}{B} \right)^A \right], \]  

(3)

where \( A \) and \( B \) are constants, easily defined in logarithmic form of this equation according to data of the research.

As a result of previous equation density of mass distribution by diameters is defined by formula [4]:
If $A < 1$ and $\delta \to 0$, distribution density $\varphi(\delta) \to \infty$, though $D(\delta)$, if $\delta = 0$, stays finite. Therefore, if $A < 1$, the formula (4) doesn’t give correct description of the distribution of very small fractions. Normal distribution is normal Gaussian function, which looks like:

$$D(\delta) = \frac{1}{\sigma \sqrt{2\pi}} \int_{-\infty}^{\delta} \exp \left[ -\frac{(\delta - \delta_{S0})^2}{2\sigma^2} \right] d\delta,$$

(5)

where $\delta_{S0}$ is median of distribution; $\sigma$ – mean-square of deviations of diameters from their mean value. Differentiation of distribution function $D(\delta)$ by $\delta$ provides distribution density function:

$$\varphi(\delta) = \frac{1}{\sigma \sqrt{2\pi}} \exp \left[ -\frac{(\delta - \delta_{S0})^2}{2\sigma^2} \right] = \frac{1}{\sigma} F(t),$$

(6)

where $0 < \delta < \infty$,

$$F(t) = \frac{1}{\sqrt{2\pi}} \exp\left( -\frac{t^2}{2} \right),$$

(7)

where $t$ is normalized quantity normally distributed, which can be found in reference literature.

Lognormal distribution is obtained, if the argument in normal Gaussian function substitutes not the particles’ diameter, but logarithm of diameter. LND function looks like:

$$D(\delta) = \frac{1}{\ln(\sigma) \sqrt{2\pi}} \int_{-\infty}^{\ln(\delta)} \exp \left[ -\frac{(\ln(\delta) - \ln(\delta_{S0}))^2}{2 \ln^2(\sigma)} \right] d\ln(\delta),$$

(8)

where $\delta_{S0}$ is a distribution median; $\ln(\sigma)$ – mean-square mediation of logarithms of diameters from their mean value. Differentiation of distribution function $D(\delta)$ by $\delta$ results in relative distribution function:

$$\varphi(\delta) = \frac{1}{\ln(\sigma) \sqrt{2\pi}} \exp \left[ -\frac{(\ln(\delta) - \ln(\delta_{S0}))^2}{2 \ln^2(\sigma)} \right] = \frac{1}{\ln(\sigma) \sqrt{2\pi}} \exp \left[ -\frac{(\ln(\delta) - \ln(\delta_{S0}))^2}{2 \ln^2(\sigma)} \right] d\ln(\delta).$$
\[ \varphi(\delta) = \frac{1}{\sqrt{2\pi} \cdot \delta \cdot \ln(\sigma)} \exp \left[ -\frac{(\ln(\delta) - \ln(\delta_{S0}))^2}{2 \ln^2(\sigma)} \right] = \frac{1}{\sqrt{2\pi} \cdot \delta \cdot \ln(\sigma)} F(t), \quad (9) \]

where $0 < \delta < \infty$. If distribution of particles’ mass by dimensions follows lognormal law, then it will also be followed by the distributions of quantity and specific surface area of particles by dimensions [5; 6].

Obtained from food raw material, the powders of different dispersion are studied by means of USB Digital Microscope. After removing the microscopic bar, the division value of microphotography is obtained. At least five fields from different angles of vision are shot for each sample. With photo-editing program PhotoM 1.21, linear dimensions of particles are defined. The results are presented in table 1.

<table>
<thead>
<tr>
<th>Intervals</th>
<th>2 min.</th>
<th>5 min.</th>
<th>8 min.</th>
<th>12 min.</th>
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</tbody>
</table>

In this table, the columns (except the first one) respond to the powders of different dispersion, rows – to the number of particles of different dimension. The highest dispersion has the powder in the fourth column, and the lowest – in the second. Our calculations started from the last one. First, the percentage of the particles of different dimensions is found by the formula [7]:

\[ z = \frac{\sum_{i}^{data(1)}}{\sum_{i}^{data_{i,1}}} \cdot 100\% \cdot (10) \]
According to the formula (2), we divide the amount of particles of the defined dimension by the total amount of particles and multiply by 100%. By the formula:

$$\sum Q = Q_0 + Q_1 + ...$$

(11)

Integral function of distribution is build:

![Integral distribution function for powder 2 min](image)

**Fig. 1. Integral distribution function for powder 2 min**

Then using Mathcad software environment, we build differentiating distribution function.

**Conclusion.** After the analysis of different methods for the determination of the powders’ dispersion, microscopic method is selected for the study of food raw material for powders, which allows to obtain much information about the features of shape, texture and surface structure of the observed samples of food raw materials. The study of modeling samples of food raw materials of various grinding allowed to develop a method of calculating the dispersion of food powders. In the analysis obtained during the experiment of dispersion curves selection of the most rational approximation curves for powders of different dispersion was carried out.
From our point of view, a comparative analysis of two pairs of food powders with significantly different dispersion was appropriate.

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Погожих Микола Іванович, д-р техн. наук, проф., зав. кафедрой фізико-математичних та інженерно-технічних дисциплін, Харківський державний університет харчування та торгівлі. Адреса: вул. Клочківська, 333, м. Харків, Україна, 61051. Тел.: (057)349-45-00.

Погожих Николай Иванович, д-р техн. наук, проф., зав. кафедрой физико-математических и инженерно-технических дисциплин, Харьковский государственный университет питания и торговли. Адрес: ул. Клочковская, 333, г. Харьков, Украина, 61051. Тел.: (057)349-45-00.

Pogozhikh Micola, prof., Head of the department of physical and mathematical and engineering sciences, Kharkiv State University of Food and Trade of Ukraine, Address: Klochkivska str., 333, Kharkiv, Ukraine, 61051. Tel.: (057)349-45-00.

Павлюк Ігор Миколайович, ст. викл., кафедра фізико-математичних та інженерно-технічних дисциплін, Харківський державний університет харчування та торгівлі. Адреса: вул. Клочківська, 333, м. Харків, Україна, 61051. Тел.: (057)349-45-00.

Павлюк Игорь Николаевич, ст. преп., кафедра физико-математических и инженерно-технических дисциплин, Харьковский государственный университет питания и торговли. Адрес: ул. Клочковская, 333, г. Харьков, Украина, 61051. Тел.: (057)349-45-00.

Pavliuk Igor, Senior Lecturer of the department of physical, mathematical and engineering sciences, Kharkiv State University of Food Technology and Trade. Address: Klochkivska str., 333, Kharkiv, Ukraine, 61051. Tel.: (057)349-45-00.

Дьяков Олександр Георгійович, канд. техн. наук, доц., кафедра енергетики та фізики, Харківський державний університет харчування та торгівлі. Адреса: вул. Клочківська, 333, м. Харків, Україна, 61051. Тел.: (057)349-45-00; e-mail: dyakov_ag@mail.ru.

Дьяков Александр Георгиевич, канд. техн. наук, доц., кафедра энергетики и физики, Харьковский государственный университет питания и торговли. Адрес: ул. Клочковская, 333, г. Харьков, Украина, 61051. Тел.: (057)349-45-00; e-mail: dyakov_ag@mail.ru.

Diakov Aleksandr, PhD (technical sciences), associate professor, Department of energetics and physics, Kharkiv State University of Food Technology and Trade. Address: Klochkivska st., 333, Kharkiv, Ukraine, 61051. Tel.: (057)349-45-00; e-mail: dyakov_ag@mail.ru.

Борисова Аліна Олексіївна, канд. психолог. наук, доц., зав. кафедри іноземних мов, Харківський державний університет харчування та торгівлі.
Knowledge of basic rheological indicators forming a structure of semi-finished and finished food products, allows us to properly assess their quality, in a timely manner to ensure the control and regulation of technological processes in various stages of production.

Important technological characteristics defining the ability of such semi-finished products to the formation, through which most reliably possible to judge the consistency and therefore the quality characteristics of meat is the threshold voltage shift.

The article presents the results of experimental investigations of rheological properties of dispersed systems to create multi-component stuffing masses. The dependences of the main realnogo indicator for the stuffing system of the limiting shear stress. Investigated the change in the marginal shear stress from the change in the ratio of components. Three of the investigated multicomponent systems: "cutlet meat – cheese", "hamburger meat – carrots", "onions – mushrooms". The authors
found the variation index limit stress sdvigom the degree of interaction of the system components among themselves.

The total threshold voltage shift pureed carrot mass exceeds the threshold voltage shift cutlet of meat by 12.04...of 13.03% and therefore increase the concentration of carrots in the system by 10% increases the threshold voltage shift system 3.7...6.5% based on the total concentration cutlet of meat in the system.

The threshold voltage shift cutlet of meat higher than that in acidic cheese on 35,01...37,30%. Therefore, the increase in the percentage of meat in the system by 10% increases the threshold voltage shift system...by 3.82 to 4.01%, and the percentage sour cheese 10% reduces the threshold voltage shift by 4.71...4,32%.

The increase in the percentage of mushrooms in the system by 10% increases the total threshold voltage shift of a disperse system by 1.66...of 1.78% and the increase in percentage of onions in the system decreases by 1.17..of 1.34%.

The obtained rheological characteristics of disperse systems can be used to select the optimum technological processes of mixing, portioning, moulding) for the production of semi-finished products based on multicomponent stuffing masses. Implementation studies will allow to obtain finished products permanent, pre-determined quality at a centralized production cross section of products.

The obtained experimental data and mathematical relationship will be used when designing the prescription of new semi-finished products with plant and animal components.

**Keywords:** disperse system, shear stress, forcemeat mass.

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**ESTABLISHMENT OF THE NATURE OF THE JOINT ANTIOXIDANT INFLUENCE OF TOCOPHEROLS AND FLAVONOIDS TO PROCESS OF VEGETABLE OILS OXIDATION**

O. Aksenova, O. Demidova, A. Kindrashina, T. Berezka

Plant flavonoids are not only physiologically important substances and antioxidants, which have been intensively studied in decades. For oil industry it is interesting to establish cooperation between flavonoids and the most common natural antioxidant oils – tocopherols. Tocopherols and flavonoids are antioxidants of type 1, that their inhibitory effect not associated with open circuit, and the destruction of molecules hydroperoxides.

To improve the efficiency of tocopherol as an antioxidant, it should be used in mixtures with other inhibitors of oxidation. One of the areas of search oxidation inhibitors is highly efficient search of synergistic mixtures. Synergist provide significant increase antioxidant effects, so they can be used in smaller quantities. Studies have proven the existence of synergies between the studied substances. Antioxidant Research conducted on the impact of inhibitors of Volumetric installation by determining the oxidation kinetics of oils, such as setting the length of the induction period. The study was conducted in conditions of initiated oxidation, is the sample oil added a certain amount of nitrile ızo-oleic acid. Constant speed
initiation achieved by adding the same number of nitrile 1z-oleic acid. As plant extracts contain flavonoids, oak bark, nettle, marigold, mint, blueberry shoots were selected. Inhibitory effect of antioxidants mounted relative to the sample of refined sunflower oil. Oils always contain a certain amount of tocopherols, since the last addition does not add oil and natural investigated antioxidant effect of tocopherols’ number. The values of synergies between tocopherols sunflower oil and flavonoids of various plants were quantified. Flavonoids derived from plant materials exhibit approximately the same amount of synergies with tocopherols (except flavonoids mint). The effect of antioxidant previously unexplored blueberry shoots was also found.

**Keywords:** oxidation, tocopherols, flavonoids, synergy.