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STATISTICAL INVESTIGATION OF PARTICLE SIZE DISTRIBUTION OF SOME GRAIN GRIST

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1. Introduction

In the events of the surrounding world the role of heat and mass transfers is highly important. The fundamental living cycles take place in according to these transport processes. In agriculture and food industry the most important areas are the grinding, mixing, former- (molding) and of course the different addition of heat (e.g. drying) processes.

These different transport processes can be more or less similar to each other, which is described by the similitude theory and dimensional analysis through the principle of similarity and the dimensionless numbers. One of the most essential elements of the similarity is the particle size, which determines the (specific) surface. The surface is key property because the heat and mass transfer go on it, which is denoted by the basic thermo-dynamical laws. That is why the particle size and its distribution have central role both theoretically and practically.

The particle size means some of the linear measurement of the particle (e.g. for sphere the particle size is the diameter, for cube it is the length along sides). In case of formless particles – which are the considerable part of the agricultural materials – the size can be determined by measuring a huge amount of data, which sometimes are different from each other. There are basically three groups of definitions of irregularly shaped particle size:

- diameter of an equivalent sphere that would have the same property as the particle itself, such as volume, surface etc.,
- diameter of a circle that would have the same property as the projected outline of the particles,
- a linear dimension, as measured, e.g., by a microscope parallel to a fixed direction.

The different measuring methods can give different values to the same "particle size", which can cause problems in some experiments and their reproduction. In the practice of granulometry the sieve analysis are frequently used. Two or more sieving should be performed with a suitable chosen screen set. In the USA the so called Tyler and ASTM, while in Europe the Renard-type screen sets ($\frac{1}{\sqrt[5,10,20,40]{10}}$) are the standards. The riddlings are measured and the three most important averages can be calculated: the mean, the median and the mode. The calculation is rendered more difficult by the spread of the distribution range, which is rather frequent in the investigation of the grain grist. There are several distribution types, among which in this paper we used the Gaudin-Andrejev-Schuhmann (GAS), the Rosin-Rammler-Sperling-Bennett (RRSB) and the lognormal alias Kolmogorov-Rényi (KR) distributions.

The determination of the (specific) surface is similarly problematic, because the surface is not continuous. For the calculation of specific surface from size distribution, several direct measurements have been developed: methods based on air permeability, gas-liquid adsorption, turbidimetry, laser granulometry, and gas diffusion. All of these methods suffer from the problem of dissolution, which extends the possibility of the error. And of course all methods can give different values for the same surface because of the different methodologies.

In the grinding experiments the simplified equation derived from the Rittinger's energy-size reduction law can be used for calculating specific surface value:

$$\text{Specific Surface} = \sum \frac{6}{\rho \times x} \quad \left[\frac{\text{cm}^2}{\text{g}}\right]$$

where ρ is the density of the material (kg/cm^3)
x is the edge-length of the particle (cm)

It is important to note that the density is the real density of the material, and not the virtual density, because the inergranular space can cause critical error. Further problem that the shape of most of the grains is less similar to a cube, so in that case an approximation based on the actual shape should be used.

2. Object of the investigation

The object of the investigation was threefold, i.e., (i) to determine the geometrical feauters of several varieties of wheat; (ii) with knowledge of those features to determine the factors having influences on the geometrical features; (iii) and to determine the best fitting distributions of grists obtained from grinding grains with different shapes and inner contents.

3. Materials and methods

Investigations have been made in the College Faculty of Food Engineering of University of Szeged. *Triticum Aestivum* as edible wheat was used for the determination of the kernel sizes and the specific surfaces. Wheat (GK-Öthalom), corn (Dekalb 524 sc) and soybean (Bolyi 44) were applied for determining the particle size distribution of the grain grist. The grinding machine was a dismembrator.

4. Results and discussion

The kernel geometry could be very important to further investigation, so we performed the determinations very accurately. The measurements were carried out by kernel after kernel. After the sample preparation 100-100 kernels were measured for the three geometrical sizes. Table 1 shows the results.

After that three grains of different sizes, properties and species were ground, and the distribution of grist was determined. The most well-known and used distribution types were studied, i.e., Gaudin-Andrejev-Schuhmann (GAS), the Rosin-Rammler-Sperling-Bennett (RRSB) and the lognormal alias Kolmogorov-Rényi (KR) distributions.

The equation of GAS:

$$\ln D\% = m(\ln x - \ln k)$$

where m is the slope,
k is the modulus.

The equation of RRSB:

$$\ln \ln \frac{100}{R\%} = n(\ln x - \ln x_0)$$

where n is the slope (uniformity coefficient),
x_0 is the modulus.

The equation of KR:

$$D(x) = \Phi\left(\frac{\ln x - \ln a - 3b^2}{b}\right)$$

where $\Phi(.)$ is the standard normal distribution function,
a, b are coefficients.

Table 1 *Kernel geometrical sizes of the studied wheat varieties*

Varieties of wheat	Width		Thickness		Length	
	Average	SD	Average	SD	Average	SD
Durum 1998	2,976	0,164	2,912	0,144	6,501	0,257
GK-Bétadur 1997	3,137	0,159	2,987	0,153	8,110	0,461
GK-Csörnöc 1995	3,548	0,226	3,100	0,224	7,031	0,317
GK-Csűrös 1997	3,593	0,162	2,903	0,137	6,329	0,286
GK-Csűrös 1998	3,329	0,164	2,832	0,123	6,755	0,256
GK-Duna 1996	3,231	0,184	2,886	0,165	6,455	0,307
GK-Duna 1998	2,945	0,153	2,887	0,125	6,466	0,293
GK-Kata 1995	3,552	0,162	2,953	0,156	6,271	0,216
GK-Kata 1997	3,545	0,191	2,917	0,157	6,374	0,230
GK-Kata 1998	3,218	0,184	2,692	0,158	6,046	0,234
GK-Öthalom 1995	3,429	0,152	3,001	0,187	6,503	0,338
GK-Öthalom 1997	3,408	0,242	3,102	0,173	6,469	0,279
GK-Öthalom 1998	3,209	0,207	2,916	0,176	6,730	0,293
GK-Pinka 1995	3,525	0,220	2,923	0,184	7,010	0,389
Jubilejnaja-50 1996	3,360	0,154	2,932	0,115	6,954	0,320
Tambor (A) 1998	3,304	0,242	2,916	0,206	6,222	0,362

Excluded the detailed measurement data and the calculations Table 2 shows the linearized equations and the determination coefficients. The determination coefficient indicates the strength of the connection between the measured and calculated values. Studying the table asserts that the best-fitted distribution is the KR based on R^2 (see Fig1.).

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Table 2 *The three different types of distribution equation and its determination coefficients*

Species	RRSB		GAS		KR	
	Equation	R^2	Equation	R^2	Equation	R^2
Wheat	Y=2,7514x+1,2211	0,9304	Y=2,7322x+0,6404	0,7955	Y=1,715x+1,2635	0,9711
Corn	Y=3,1791x+1,4446	0,8708	Y=2,3836x+0,4846	0,8755	Y=1,906x+1,3445	0,9740
Soybean	Y=2,9181x+1,3841	0,8934	Y=2,5328+0,6135	0,8284	Y=1,648x+1,1682	0,9754

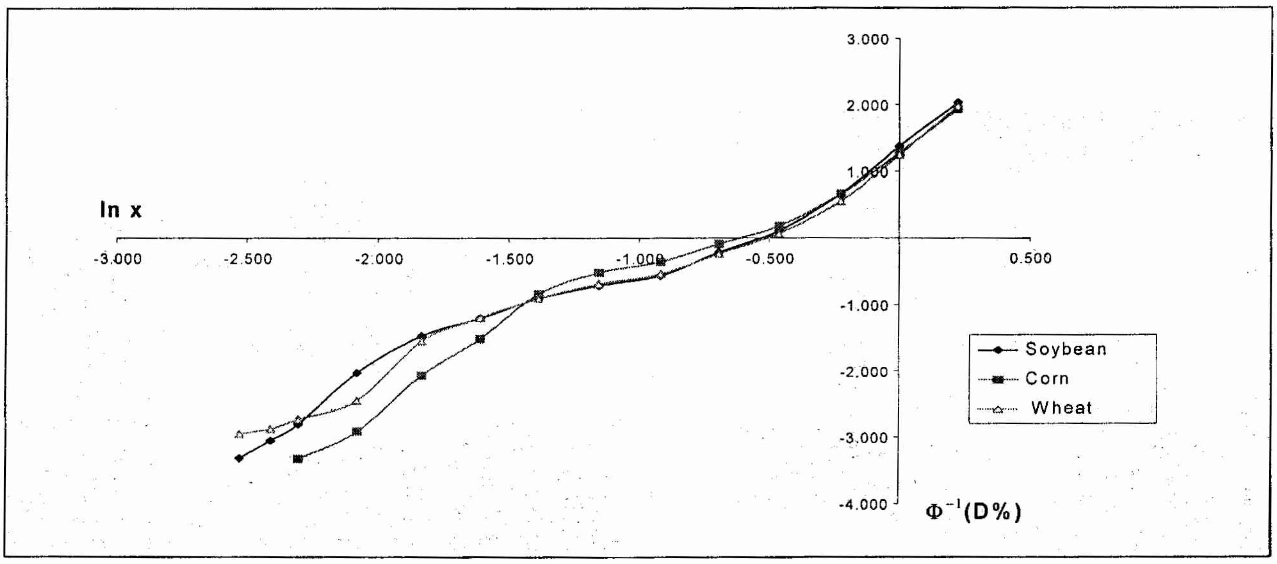

Figure 1 *Kolmogorov-Rényi's lognormal particle size distribution*