

**METHODS AND TOOLS FOR CHECKING THE RESULTS OF MEASUREMENTS IN
EXPERIMENTAL EQUIPMENT FOR NORMAL DISTRIBUTION**

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Abstract

This article examines the statistical analysis of measured quantities in experimental equipment, specifically their verification using a normal distribution. It provides information on the theoretical foundations of the normal distribution, its important properties, and practical applications. A literature review demonstrates that this distribution is of great importance in statistical analysis, regression, hypothesis testing, and quality control. Using the Statistica program as an example, an analysis of the conformity of measurement results with a normal distribution is conducted using visual and statistical methods. This paper serves as an important methodological foundation for scientific and practical research.

Keywords

Normal distribution, Statistical analysis, Central limit theorem, Measurement results, Descriptive statistics, Statistica program, Gaussian curve, Quality control.

In statistics, the normal distribution is one of the most common and best-studied distributions of random variables. It is sometimes called the Gaussian distribution, because it was first fully developed by the German mathematician Carl Friedrich Gauss. This distribution accurately describes many real-life statistical phenomena, such as people's height and weight, exam scores, or manufacturing errors.

One of the main properties of the normal distribution is that it is symmetrical. That is, its graph — a bell curve — is symmetrical about the mean value (the mathematical expectation). This means that values decrease with equal probability to the right and left of the mean value. The most common value in this distribution is the mean value itself.

The normal distribution is characterized by two main parameters: the mathematical expectation (μ) and the variance (σ^2). The mean is the center (i.e., the highest point of the distribution), and the variance is how spread out the values are around that center. The smaller the variance, the closer the values are to the mean; the larger the variance, the more spread out the values are.

This distribution is used as the basis for many statistical analysis and probability theory methods. For example, regression analysis, hypothesis testing, and interval estimation rely on the normal distribution. Many statistical formulas and methods are also based on the assumption of a normal distribution, that is, they assume that the data obey a normal distribution.

Another important aspect of the normal distribution is related to the Central Limit Theorem. This theorem states that if a sufficiently large number of independent random variables are taken, their distribution will almost always approach a normal distribution. This fact allows the normal distribution to be used very widely in statistics.

The normal distribution is one of the most widely studied and used probability distributions in statistics. The scientific and textbook literature written about this distribution

provides the main theoretical platform for statistical analysis, scientific research, and practical economic calculations. The following is a review of important literature in this field and provides references to them.

First of all, one of the classic works of statistical theory — William Feller's "An Introduction to Probability Theory and Its Applications" (1950) — provides a thorough theoretical analysis of the normal distribution. The author places the normal distribution at the center of probability distributions and proves its reasonable application through the Central Limit Theorem[1,8].

Also, the work "Statistical Methods" (8th edition) by George W. Snedecor and William G. Cochran also pays great attention to the normal distribution. The book explains in detail how the normal distribution is used in practical statistical analysis, especially in hypothesis testing and calculating confidence intervals[2,7].

Another important source is Douglas C. Montgomery and George C. Runger's "Applied Statistics and Probability for Engineers." This book explains how to use the normal distribution in engineering, such as quality control and manufacturing processes, with practical examples.[3,6]

There are also many modern approaches to the normal distribution. For example, "The Elements of Statistical Learning" (Hastie, Tibshirani, Friedman) examines how the normal distribution is used in mechanical engineering, artificial intelligence, and data science. This work examines the role of the normal distribution in the context of Bayesian statistics, regression, and classification models[4,5].

In Uzbek, this topic is covered in statistics textbooks, including R. K. Mamatov's book "Statistics." This textbook explains the definition, properties, graphs, and calculation methods of the normal distribution in simple language. Currently, some Uzbek universities are using this book as a basic textbook.

Literature analysis shows that the normal distribution is a very important distribution not only theoretically, but also practically. This distribution is used to model, analyze and predict many real-life phenomena. Therefore, every specialist studying statistics needs to have a deep understanding of the normal distribution.

To facilitate the process of checking the normal distribution of measured values, it is recommended to use ready-made software.

In order to easily understand the use of this software, we can take the measurement results in the following example as an example.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Obs ID	NIT no	product group	type	Product	harvest year	Productio n site	error comment	Productio n line	Loaf volume	Water content	Ash	Protein	Falling number	Gluten index	Wet gluten
1	1000410540	1	WW 2019	WW 19	Normalvet	19			A kvarn	1890	15,7	0,53	11,1	356	86,4	31
2	1000388780	2	WW 2018	WW 18	Normalvet	18			A kvarn	1750	14,8	0,48	10,9	407	93,8	28,5
3	1000393867	4	WW 2019	WW 19	Normalvet	19			A kvarn	2060	13,2	0,62	11,8	381	81,7	35,9
4	1000402954	5	SW 2019	SW 19	Kvalitetsvi	19				2480	16,5	0,6	13,6	345	99,3	35,5
5	1376293	6	Blend 201	Blend 18	BB Sjuhohlr	18			A kvarn	2230	14,6	0,57	13,1	430	93,8	36,1
6	1376292	10	WW 2018	WW 18	Normalvet	18			A kvarn	1930	15,2	0,55	12,4	411	92	35,2
7	1366814	13	WW 2018	WW 18	Normalvet	18				1890	14,5	0,55	11,3	391	81,9	31,8
8	1000390110	14	WW 2018	WW 18	Normalvet	18			A kvarn	1770	14,6	0,55	11,1	412	89,2	31,6
9	1366427	15	Blend 201	Blend 18	BB Sjuhohlr	18				2509	14,5	0,61	13,4	431	93,3	34,7
10	1000409440	17	WW 2019	WW 19	Normalvet	19	S	late test baking room temp		1936	15,4	0,59	11,7	347	86,17	32,94
11	1000394459	18	WW 2019	WW 19	Normalvet	19			A kvarn	1990	14,4	0,53	11,1	402	86,7	31,9
12	1000411867	19	WW 2019	WW 19	Normalvet	19			A kvarn	1880	15	0,61	11,5	380	96,4	32,3
13	1000397798	20	SW 2019	SW 19	Kvalitetsvi	19	S		B	2576	14,1	0,67	14	321	93,79	39,67
14	1380024	21	Blend 201	Blend 18	BB Sjuhohlr	18			A kvarn	2200	14,8	0,59	13,3	413	94,8	35,7
15	1000392795	23	Blend 201	Blend 19	BB Sjuhohlr	19	S	late test baking	A	2584	15,2	0,62	12,9	411	91	35,7
16	1000398225	24	WW 2019	WW 19	Normalvet	19			A kvarn	2010	14,6	0,52	11,4	380	85,6	31,9
17	1000403908	25	SW 2019	SW 19	Kvalitetsvi	19				2480	15,6	0,6	14,2	384	95	37,6
18	1000389720	26	WW 2018	WW 18	Normalvet	18			A kvarn	1890	13,1	0,59	11	388	89	32,2
19	1000413587	28	WW 2019	WW 19	Normalvet	19			A kvarn	2020	15,3	0,58	11,4	399	92,6	31,8
20	1000398363	29	Blend 201	Blend 19	BB Sjuhohlr	19		late test baking		2787	15,6	0,54	13,6	419	97,1	37
21	1000387992	30	WW 2018	WW 18	Normalvet	18			A kvarn	1800	14	0,54	10,6	375	95,3	30
22	1000387167	32	WW 2018	WW 18	Normalvet	18			A kvarn	1710	13,9	0,67	10,5	386	88,9	27,6
23	1371382	33	WW 2018	WW 18	Normalvet	18			A kvarn	1920	14,6	0,6	12,3	400	95,1	33,3
24	1000394666	34	WW 2019	WW 19	Normalvet	19			A kvarn	1930	13,2	0,5	11,4	370	91,9	30,8
25	1363629	35	Blend 201	Blend 18	BB Sjuhohlr	18		late test baking		2500	14,9	0,6	13,4	374	86,9	35,6
26	1373254	36	WW 2018	WW 18	Normalvet	18			A kvarn	1810	14,1	0,58	11,3	397	89,7	35,3
27	1382089	37	Blend 201	Blend 18	BB Sjuhohlr	18			A kvarn	2540	15,4	0,63	14,4	395	88,7	39,4
28	1364848	38	WW 2018	WW 18	Normalvet	18	S	late test baking	A	1954	15,5	0,63	12,5	414	78,52	34,85
29	1000408110	39	WW 2019	WW 19	Normalvet	19			A kvarn	1840	13,1	0,49	11,1	377	96,5	30,5
30	1000403691	40	WW 2019	WW 19	Normalvet	19				2020	16,1	0,59	11,1	379	96,8	29,2

Picture-1. The data measured based on the results of the NIR equipment measurement of flour products and the experience of the sample.

After downloading the data into the "Statistica" program, selecting the necessary variables from the "Descriptive Statistics" section, and selecting the necessary settings, we will obtain normal distribution results.

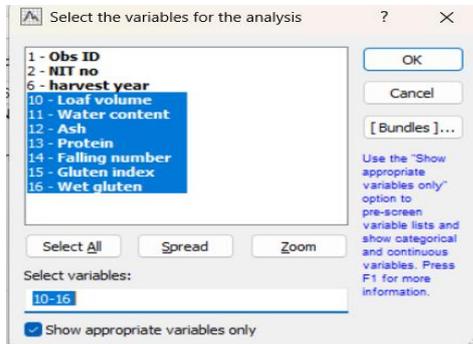


Figure 2. The window for selecting variables to be tested for normal distribution in the Statistica program.

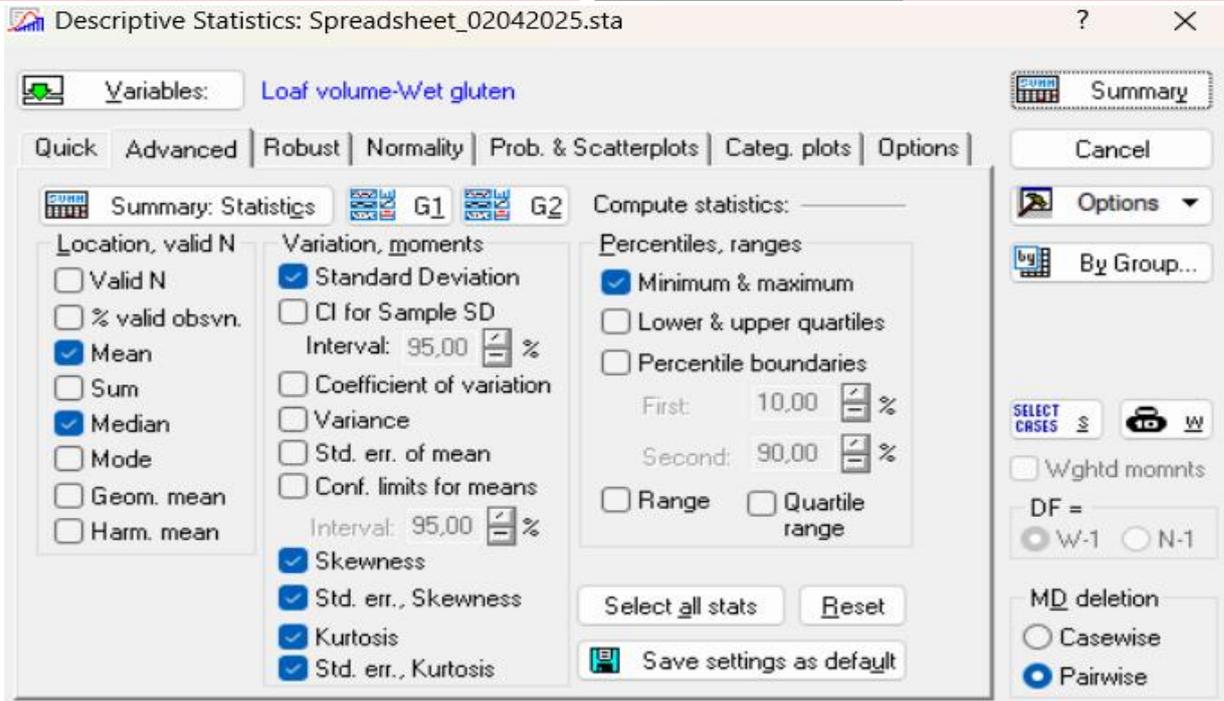


Figure 3. The window for specifying the settings required to check for normal distribution in the Statistica program.

Descriptive Statistics (Spreadsheet_02042025.sta)									
Variable	Mean	Median	Minimum	Maximum	Std.Dev.	Skewness	Std.Err. Skewness	Kurtosis	Std.Err. Kurtosis
Loaf volume	2165,528	2050,000	1650,000	2970,000	312,0923	0,28674	0,173210	-1,22841	0,344735
Water content	14,574	14,700	12,600	16,500	0,7999	-0,28209	0,173210	-0,31683	0,344735
Ash	0,597	0,595	0,480	0,720	0,0509	0,18622	0,173644	-0,56256	0,345592
Protein	12,497	12,400	10,500	16,200	1,1453	0,28503	0,173210	-0,76755	0,344735
Falling number	394,990	397,000	304,000	471,000	29,2106	-0,28256	0,173644	0,22864	0,345592
Gluten index	90,950	92,750	62,250	99,600	6,9685	-1,52079	0,175416	2,74986	0,349085
Wet gluten	34,117	34,355	26,600	46,200	2,8443	0,31896	0,175416	1,97749	0,349085

Picture-4. Normal distribution results in Statistica.

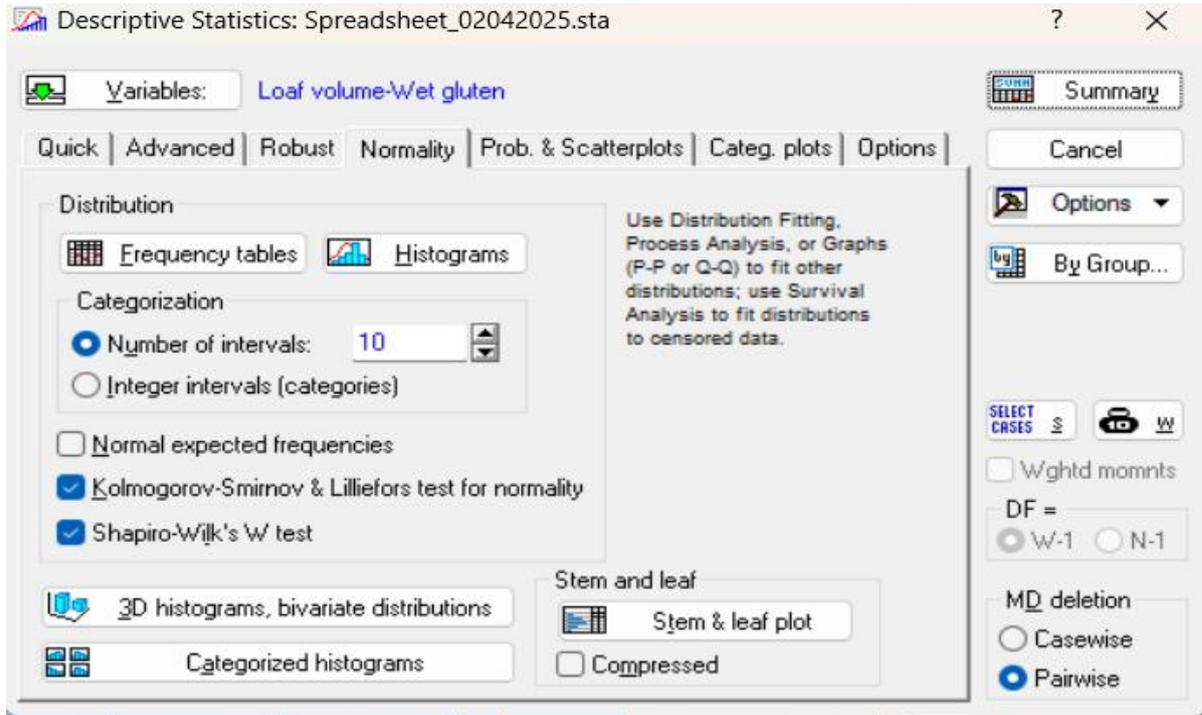


Figure 4. The window for specifying the settings required to check for normal distribution in the Statistica program.

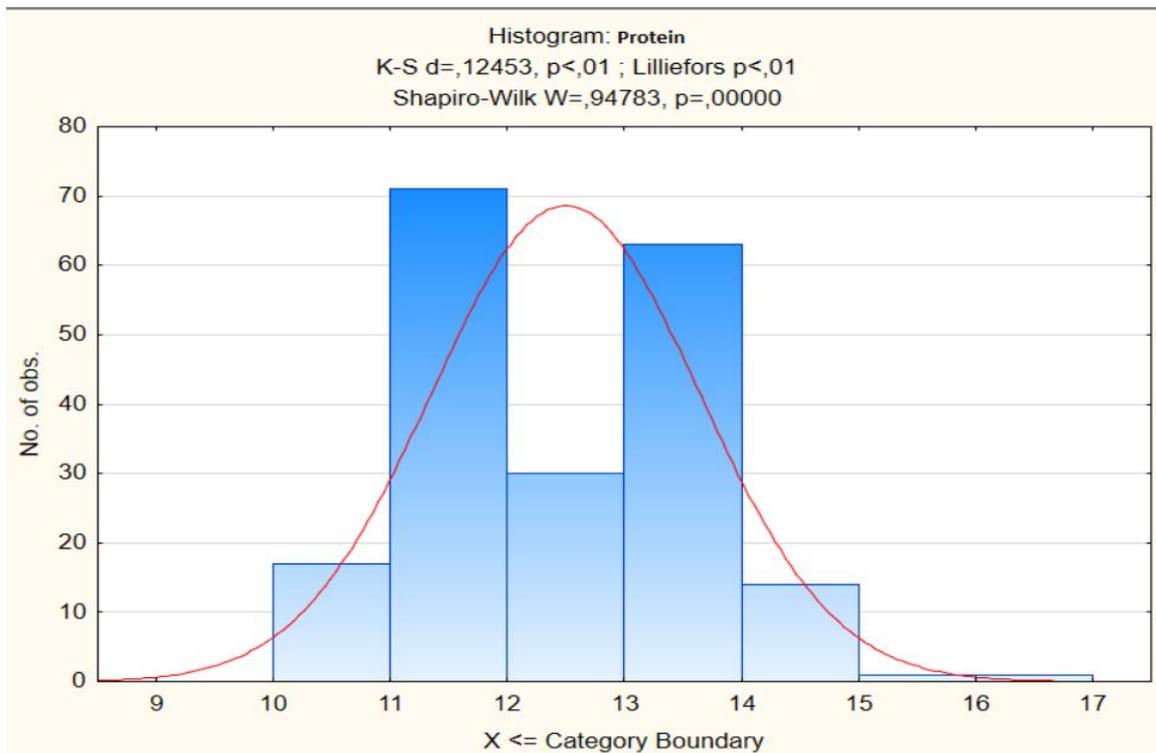


Figure 5. Histogram (Gaussian line) tested for normal distribution in the Statistica program.

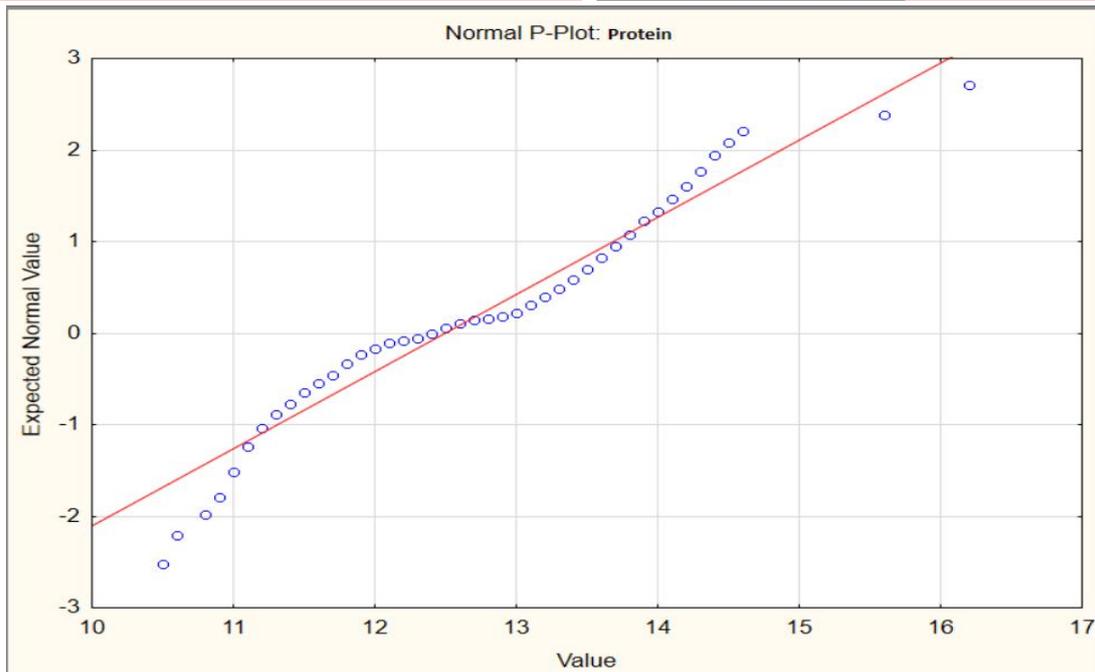


Figure 6. The distance between the points along the line when testing for normal distribution in the Statistica program.

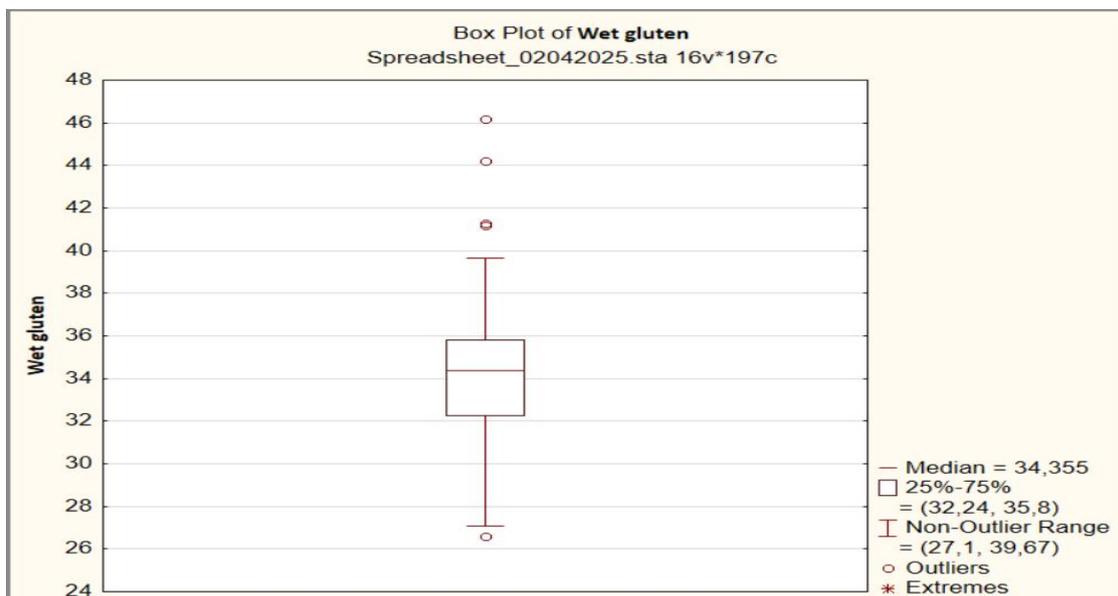


Figure 7. Box plot of the data points tested for normal distribution in the Statistica program.

Conclusion

The normal distribution is one of the fundamental concepts of statistical analysis and probability theory. Literature analysis shows that it is widely used in theoretical and practical fields. In sources ranging from classical works to modern data science books, the normal distribution plays an important role in topics such as the Central Limit Theorem, regression analysis, hypothesis testing, and quality control. Textbooks in the Uzbek language explain this

concept in an easy and understandable way. A deep knowledge of the normal distribution is important for every statistician.

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