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A MODEL OF STATISTICAL PROCESS CONTROL OF QUALITY AND COST OPTIMIZATION IN MILLING INDUSTRIAL PROCESSES

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Abstract

Quality control in milling industrial processes has been developed only as a technical control, so the quality control of raw materials, process parameters and the final products has been provided with a numerous defects and high cost production. The new paradigm of quality assurance is a preventive approach in quality control as a way to achieve production with zero defects.

In this paper are presented the benefits of implementation of Statistical Process Control Methods in grinding production, quality improvement and optimal cost achievement as a key of organizational success. This paper elaborate correlation models between dough extensional characteristics, relationship among extensigraph testing results of flour energy with the extensigraph measurements of wheat energy and the grinding degree, X-R quality charts for measuring process stability and cost optimization of grinding wheat process.

Based on the research results a model of statistical process control has been created, as preventive quality approach using defects prediction, and production of high quality products at minimum costs.

Key words: *Quality, Statistical Process Control, Costs, Wheat, Flour "Namensko".*

1. Introduction

The aim of every operation or production system is to generate a useful and quality product. The traditional approach which means a critical limitation of the statistical quality control is ineffective in detecting and controlling errors, the dominant source of nonconformities and waste. Statistical techniques enable preventive quality approach and help to ensure the product's quality before the final phase of production process, eliminating product's defects [1].

Flour performance depends on its composition, which in turn depends on wheat characteristics and milling. The quality of flour is determined by its ability to produce a quality baking product. Rheological characteristics of wheat flour dough, are complex and very important parameters for wheat quality evaluation and determination of end product quality. The Brabender extensigraph is empirical rheological instrument that offer a measurement of resistance to extension of a dough, extensibility of a dough, ratio between both of the parameters and area under the curve as a combination of resistance and extension, named dough energy. Result from the extensigraph test are useful in determining breadmaking performance of flour and control the flour quality for both the milling and baking industries [2, 3, 4].

The term *Statistical Process Control (SPC)* is typically used in context of manufacturing processes and it denotes statistical methods used to monitor and improve the quality of the respective operations. Correlation and regression analysis as an effective statistic tool are used to discover and characterize the relationship between a response and one or more predictors. That means it is used to establish the equation of rheological properties of wheat and flour, as a dependent variables. By measuring exactly how large and significant each independent variable has historically been in its relation to the dependent variable, the future value of the dependent variable can be predicted. These analysis attempts to measure the degree of correlation between the dependent and independent rheological properties [5]. Predicting the flour quality before the start of milling process and getting the information as soon as possible enables to meet the Miller's main need to anticipate end products quality.

The milling processes have some form of variation. Control chart is a useful tool for process monitoring which helps distinguish between normal and unusual variation in a process and provide rapid feedback on key variables of interest.

Costs are an important category for quality assurance in the milling business. Therefore, the optimal relationship quality/cost is highly important and always must be taken care of the cost's impact, productivity and customer satisfaction [1]. The aim of this research is to create a model of statistical process control in order to obtain products with high quality at minimum costs. Flour is produced in every pass and sifting in the mill. Optimizing the production, quality and cost, can be performed only if there are informations about the quality of passages flour fractions, generated during the process of wheat milling [6, 7, 8, 9].

2. Materials and Methods

The research is made in Zito Polog AD, Laboratory and Milling department. Three sets of samples were laboratory tested. Two sets of 50 samples flour "Namensko" were sampled in packing step of grinding process in different periods and set of 50 samples of mixture of different varieties of wheat used as the base for "Namensko" flour were sampled in the production step of wheat clening and conditioning in the mill. The quality parameters of the flour and wheat were measured by using Extensigraph, Brabender (Duisburg, Germany), ICC Standard no.114/1, AACC 54-10.

The mill capacity is 100t/24h flour. The grinding degree is automatically measured in the grinding process. It is a quantitative ratio of the produced flour and grinded wheat according to the required structure of the flours. The amount of grinding degree depends of many factors, primarily of wheat quality.

Both equations by which the dependent variable dough energy may be predicted from the independent variable, are created by using softver STATISTICA 8. In this multivariate case, when there is more than one independent variable, the regression line is computed via Multiple Regression just as easily. The correlation coefficient measures the degree of linear association between the variables. In Multiple Regression the coefficient can assume values between 0 and 1. It is used 3D Scatter plots to visualize the relationship between three variables using x, y and z coordinates of each point in a three-dimensional representation by selecting linear function.

In order to determine and reduce the amount of dough energy variations, by using softver Minitab Version 15 was developed a $\overline{X}-R$ control chart. A $\overline{X}-R$ chart is a type of variable control chart and it is used for quantitative measurements, such as dough energy and time. This control chart enables to monitor the deviations from target specifications of the products. In X-bar chart the sample means are plotted in order to control the mean value of a variable. In R chart the sample ranges are plotted in order to control the variability of a variable.

Before the start of grinding process, it is necessary to define the mixture of different varieties of wheat according to the expected quality of the flour types structure. Further, to achieve the high quality products at minimum costs, it is need to select and compose the appropriate passage flour fraction. The choice of the fraction is determined by required product quality which is defined in the product specification. In the observed milling process the stream are composed by 26 flour passes, so there are 26 flour fractions that differ in many quality aspects and percent of participation [6, 7, 8]. Even the smallest increase of the grinding degree on same row material has a significant importance for productivity increasing and production costs reducing because the flour "Namensko" is high quality product which is produced from high quality wheat with the high market price.

Sample preparation

For the samples preparation are used:

- AACC 26-50, Brabender Quadrumat Jr. (Duisburg, Germany)
- ICC Standard no.115/1, AACC 54-21, Farinograph, Brabender (Duisburg, Germany)

Preparation of the samples of wheat and flour for extensigraph analysis is different. Preparation of flour is made only using Farinograph to form dough. Preparation of wheat is done in two steps, first one is grinding wheat to flour on Quadromat Jr., and second one is dough forming on Farinograph.

Brabender Qudromat Jr. laboratory roller mill is used for milling grain for subsequent analysis and to indicate milling properties on small wheat samples.

The samples are prepared as follows: A 300-gram flour or grinding wheat sample on a 14 percent moisture basis is combined with a distilled water and salt and mixed in the Brabender Farinograph to form dough. After the dough is rested for 5 minutes, it is mixed to maximum consistency.

Analyses

The extensigraph determines the resistance and extensibility of dough by measuring the force required to stretch the dough with a hook until it breaks.

A 150-gram sample of prepared dough is placed on the extensograph rounder and shaped into a ball, then removed from the rounder and shaped into a cylinder. The dough cylinder is placed into the extensograph dough cradle, secured with pins, and rested for 45 minutes in a controlled environment. A hook is drawn through the dough, stretching it downwards until it breaks. The extensograph records a curve on graph paper as the test is run. The same dough is shaped and stretched two more times, at 90 minutes and at 135 minutes.

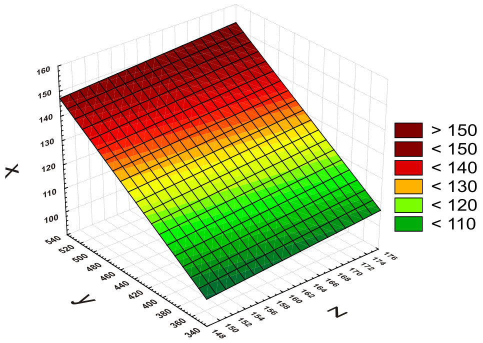
Extensigraph results include resistance to extension, extensibility, ratio of resistance to extension and area under the curve, which is combination of resistance and extensibility. Resistance to extension is expressed in Extensigraph units (EU), it is referred to as dough strength and it is indicated by the maximum height of the curve. Extensibility is indicated by the length of the curve and it is expressed in millimeters (mm). Ratio indicates the balance between dough strength (resistance) and the extent to which the dough can be stretched before breaking (extensibility). Area under the curve is a proportion of energy used for stretching a cylindrically shaped dough piece until the dough piece breaks. The dough energy value is expressed in square centimeters (cm^2) and it is obtained by calculating the surface area under the curve on the extensigram after the test in duration of 135 min. The higher values of these parameters indicate the higher flour quality.

3. Results and Discussion

3.1 Determination of the correlation among energy, extensibility and resistance of flour "Namensko"

Energy, extensibility and resistance of dough are three properties in proportion depending of wheat/flour quality, the higher are the values of these parameters the higher is the quality. If the value of resistance and extensibility is known, the value of energy can be predicted. The series of obtained results of extinsograph tests performed on 50 samples of flour "Namensko" sampled in packing step of grinding process in the period of two months are presented in Table 1.

Applying the software STATISTICA 8, is determinate quantitative equation between the energy, extensibility and resistance, presented in Figure 1.



x - flour Namensko extesibility (mm)
y - flour Namensko resistance (EU)
z - flour Namensko energy (cm^2)

Figure 1. Linear function among energy and resistance / extension of flour "Namensko"

A surface in a three-dimensional space is defined by the equation:

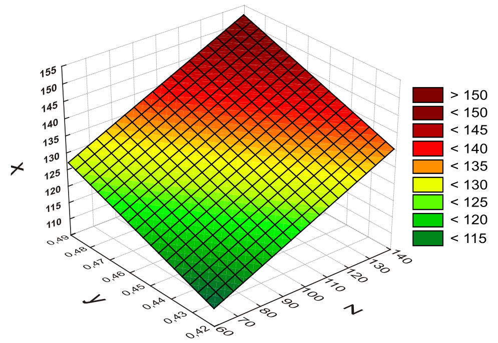
$$z = -4{,}99 + 0{,}19x + 0{,}23y \quad (1)$$

x - flour Namensko extesibility (mm)
y - flour Namensko resistance (EU)
z – flour Namensko energy (cm^2)

The constant (-4,99) is referred to as the intercept value. The coefficients (0,19 and 0,23) are positive, than the relationship of these variables with depend variable confirm that it is positive. In Table 1 are presented data values of flour "Namensko" energy (z) calculated according equation (1), the absolute value of difference between measured and predicted values and the value of the deviation ε expressed in percentages. The mean absolute value of relative error is 1.45%, so this value is in margins and it's less than 5%. The coefficient of regression is 0,243 and indicates low confidence in the correlation among energy and resistance and extension as a parameters that define the size of the area under the curve. If the duration of 135 min for usual extensigraph test and mill capacity of 100t/24h flour are considered, equation (1) enables timely information for millers to estimate the flour quality only after 45 min when the extensigraph records a first curve on graph paper, without waiting of the test completion.

3.2 Determination of the correlation among flour "Namensko" energy, wheat energy and grinding degree

A unique resource to flour production is mixture of different varieties of wheat. The quality of wheat is determined defining the correlation between flour energy, wheat energy and grinding degree enable production of milling products with quality prediction. In Table 2 are presented another data series of extinsograph tests performed on 50 samples of row material sampled in the production step of wheat cleaning and conditioning in the mill and extinsograph tests performed on 50 samples of produced flour "Namensko" sampled in the milling process in the period of three months.



x - wheat energy (cm^2)
y - flour "Namensko" grinding degree (%)
z - flour "Namensko" energy (cm^2)

Figure 2. Linear function among wheat energy, grinding degree and flour "Namensko" energy

Table 1. Measured values for extensibility, resistance and energy of flour "Namensko", predicted values of energy, occurs error and deviation values

No. sample	Resistant (EU) y	Extensibility (mm) x	Energy (cm²) measured value z	Energy (cm²) predicted value z'	z'-z (aps.)	€ (%)
1	410	150	119.5	117.7	1.8	1.51
2	430	160	126.5	124.2	2.3	1.82
3	420	160	121.5	121.9	0.4	0.33
4	350	175	112.0	108.8	3.8	2.86
5	410	155	115.5	118.7	3.2	2.77
6	410	160	113.5	119.6	6.1	5.37
7	390	160	113.0	115.1	2.1	1.86
8	500	155	137.5	139.3	1.8	1.31
9	520	160	149.0	144.8	4.2	2.82
10	460	160	129.0	131.1	2.1	1.63
11	450	160	127.0	128.8	1.8	1.42
12	460	150	125.0	129.2	4.2	3.36
13	440	160	129.0	126.5	2.5	1.94
14	470	150	132.0	131.5	0.5	0.38
15	460	155	129.0	130.1	1.1	0.85
16	470	150	130.0	131.5	1.5	1.15
17	420	150	118.5	120.0	1.5	1.27
18	420	150	119.0	120.0	1.0	0.84
19	420	155	120.0	121.0	1.0	0.83
20	430	150	122.0	122.3	0.3	0.25
21	460	160	129.0	131.1	2.1	1.63
22	470	160	133.0	133.4	0.4	0.30
23	480	150	136.0	133.8	2.2	1.62
24	470	150	132.0	131.5	0.5	0.38
25	450	150	128.5	126.9	1.6	1.25
26	450	150	130.0	126.9	3.1	2.38
27	470	160	135.0	133.4	1.6	1.19
28	460	160	132.0	131.1	0.9	0.68
29	450	150	128.0	126.9	1.1	0.86
30	450	150	127.0	126.9	0.1	0.08
31	450	150	129.0	126.9	2.1	1.63
32	420	150	119.5	120.0	0.5	0.42
33	430	150	125.0	122.3	2.7	2.16
34	440	150	127.0	124.6	2.4	1.89
35	430	150	125.0	122.3	2.7	2.16
36	430	160	127.0	124.2	2.8	2.20
37	460	150	127.0	129.2	2.2	1.73
38	460	150	131.0	129.2	1.8	1.37
39	450	150	126.0	126.9	0.9	0.71
40	430	150	124.0	122.3	1.7	1.37
41	430	160	127.0	124.2	2.8	2.20
42	450	150	128.0	126.9	1.1	0.86
43	410	160	119.0	119.6	0.6	0.50
44	430	150	123.0	122.3	0.7	0.57
45	400	160	118.0	117.4	0.6	0.51
46	420	150	120.0	120.0	0.0	0.00
47	450	160	126.0	128.8	2.8	2.22
48	460	150	128.0	129.2	1.2	0.94
49	460	150	126.0	129.2	3.2	2.54
50	470	160	131.0	133.4	2.4	1.83
Mean value						1.45

Table 2. Measured values of energy of flour "Namensko" and wheat, grinding degree, predicted values of flour "Namensko", occurs error and deviation values

No. sample	Energy of wheat (cm^2) x	Grinding degree of flour "Namensko" (%) y	Energy of flour "Namensko" (cm^2) measured value z	Energy of flour"Namensko" (cm^2) predicted value z'	z'-z (aps.)	€ (%)
1	106.0	48.00	142.0	139.3	2.6	1.83
2	95.0	48.00	130.0	135.8	5.8	4.46
3	110.0	48.00	153.0	140.5	12.4	8.10
4	100.0	47.00	138.0	134.9	3.0	2.17
5	95.0	47.50	137.6	134.6	2.9	2.11
6	98.0	46.50	120.0	133.1	13.1	10.84
7	88.5	47.00	131.0	131.3	0.3	0.23
8	99.0	47.50	131.3	135.8	4.5	3.43
9	87.0	47.00	131.3	130.9	0.3	0.23
10	72.0	47.00	120.0	126.2	6.2	5.16
11	64.0	48.00	121.0	126.1	5.1	4.21
12	79.5	48.50	126.0	132.1	6.1	4.84
13	65.5	48.00	137.5	126.5	10.9	7.93
14	76.0	48.00	152.3	129.8	22.4	14.71
15	89.5	44.50	131.3	125.6	5.6	4.26
16	74.5	46.00	122.0	124.5	2.5	2.05
17	102.0	46.00	129.0	133.1	4.1	3.18
18	109.0	45.00	134.6	132.9	1.6	1.19
19	91.5	45.50	131.3	128.6	2.6	1.98
20	101.5	46.00	118.8	133.0	14.2	11.95
21	104.0	44.50	121.3	130.1	8.8	7.25
22	78.0	44.50	117.2	122.0	4.8	4.09
23	98.0	44.50	117.5	128.3	10.8	9.19
24	100.0	45.00	131.0	130.1	0.8	0.61
25	96.0	46.00	128.5	131.3	2.8	2.18
26	131.0	44.50	138.2	138.6	0.4	0.29
27	115.0	44.50	143.2	133.6	9.5	6.63
28	86.0	44.00	113.0	123.3	10.3	9.11
29	78.0	43.00	121.0	118.3	2.6	2.15
30	86.5	46.00	126.8	128.3	1.5	1.18
31	106.5	45.00	132.7	132.1	0.5	0.37
32	89.0	45.00	127.7	126.6	1.0	0.78
33	106.0	44.50	132.7	130.8	1.8	1.36
34	100.0	43.50	126.5	126.5	0.0	0.00
35	99.0	44.00	138.5	127.4	11.0	7.94
36	69.5	44.50	110.0	119.3	9.3	8.45
37	65.0	44.50	125.5	117.9	7.5	5.97
38	68.5	44.50	123.0	119.0	3.9	3.17
39	84.0	45.00	133.0	125.1	7.8	5.86
40	85.0	45.50	131.5	126.6	4.8	3.65
41	88.0	43.50	133.5	122.7	10.7	8.01
42	78.5	45.50	129.5	124.6	4.8	3.70
43	77.0	46.50	110.5	126.5	16.0	14.47
44	95.5	47.00	135.0	133.5	1.4	1.04
45	82.0	47.00	129.5	129.3	0.1	0.08
46	70.0	46.50	121.5	124.3	2.8	2.30
47	68.5	44.00	118.0	117.8	0.1	0.08
48	71.5	44.00	121.5	118.7	2.7	2.22
49	81.0	44.00	115.5	121.7	6.2	5.36
50	81.0	44.00	122.0	121.7	0.2	0.16
Mean value						4.25

Applying the software STATISTICA 8, a diagram is determinate (Figure 2) and quantitative equation as follows:

A surface in a three-variable space is defined by the equation:

$$z = -10{,}33 + 0{,}31x + 242{,}43y \quad (2)$$

x – wheat energy (cm^2)

y – flour "Namensko" grinding degree (%)

z – flour "Namensko" energy (cm^2)

In equation (2) is confirmed positive correlation between variables. The constant (-10,33) is referred to as the intercept value. The coefficient of regression is 0,380 and compared to the previous it is higher. The absolute value of relative error is 4.25% and it is close to the upper limit. This is the way to predict the quality of flour 'Namensko" which is produced from known wheat energy value and previously defined grinding degree in the mill.

Predicting the results in terms of quality of final products is very important because it does not only allow the prediction of the quality of end products, but allows complete planning of the production capacity of the mill for an extended period of time.

The benefits from the creating of regression models to improve the quality of milling products in the production process are:

- Definition of the equation (1) among rheological properties enable calculation of dough energy directly from recorded curve on graph paper and it is used for indication the quality of flour "Namensko" only after 45 min when the extensigraph records a first curve.

- Definition of the equation (2) allows prediction of flour quality before starting of milling, by determining the quality of wheat and defined grinding degree.

<u>*3.3 Stability evaluation of technological milling process for "Namensko" flour production*</u>

For each type and brand of flour offered in the company's product line, the main task is to make sure that the composition of the flour and its performance characteristics are generally kept within narrow parameters.

The $\overline{X} - R$ Control chart is made for evaluation the stability of "Namensko" flour production process. The chart was developed based on measured values of energy of "Namensko" flour (Table 1) and is presented in Figure 3.

The measured values are within the limits defined in the Quality specification of the product, with an exception of two cases where the measured value exceeds the upper limit. However, there are recorded customer responses about quality variations in a wide interval. For these reasons, was suggested narrowing the interval of specification limits, by moving up the lower limit of flour "Namensko" energy for 5 cm^2 [10, 11].

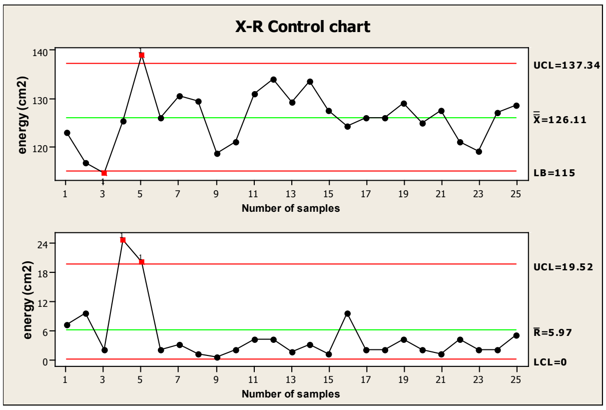


Figure 3. $\overline{X} - R$ **Control chart: energy of "Namensko" flour – existing specification limits**

A new $\overline{X} - R$ control chart was made, and is presented on Figure 4.

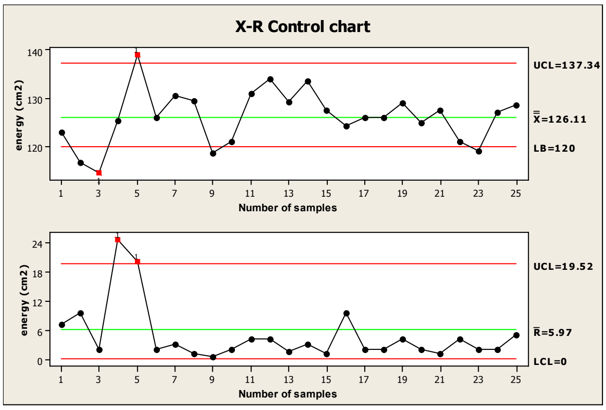


Figure 4. $\overline{X} - R$ **Control chart: energy of "Namensko" flour - narrowed specification limits**

Moving the lower limit of 5 cm^2 upper, exactly 115 cm^2 120 cm^2, the interval of variation of quality shrinks, which results in achieving a more uniform quality of flour "Namensko", market competitiveness, consequently, increasing customer satisfaction, and the same time reduction of the number of complaints [12, 13].

<u>*3.4 Optimization of the cost of the production process of wheat milling*</u>

In the production process of flours "Namensko" and T-500 usually the total grinding degree is 74.00%. The cost analysis is done at 47.70% measured grinding degree of flour "Namensko" and 26.30% grinding degree of flour T-500. The usually combination of selected fractions for each type of flour in the mill are called standard combination. The new combinations are made by addition or subtraction of two of the passage flours, M3 I and M3 II, to standard compositions of "Namensko" flour and T-500 flour. The standard and the performed combinations of passage flours are presented in Table 3:

Table 3. Combinations of passage flours

Type of flour	Selection of passages	Grinding degree (%)
Flour "Namensko"	standard	47.70
Flour "Namensko"	standard + M3 I	51.26
Flour "Namensko'	standard + M3 II	48.74
Flour T-500	standard	26.30
Flour T-500	standard - M3 I	22.74
Flour T-500	standard - M3 II	25.26

According to the presented values in the table, in the first case with adding passage flour M3 I to the flour "Namensko", the grinding degree increases from 47.70% to 51.26%, respectively the grinding degree of the flour T-500 extent decreases from 26.30% to 22.74%. In second combination by adding M3 II to the flour "Namensko", the grinding degree increases from 47.70% to 48.74%, respectively the milling degree extent decreases of the flour T-500 from 26.30% to 25.26%.

3.5 Analysis of the results according to quality

Extensograph analysis results of all 6 combinations of types of flour are presented in Table 4.

Table 4. Extensograph properties of flour passage

Type of passage flour	Resistance (EU)	Extensibility (mm)	Ratio (EU/mm)	Energy (cm^2)
Flour "Namensko" standard	440	170	2,58	144,0
Flour "Namensko" standard + M3 I	450	170	2,65	130,5
Flour "Namensko" standard + M3 II	430	170	2,53	128,5
Flour T-500 standard	250	140	1,78	57,5
Flour T-500 standard - M3 I	260	160	1,62	68,0
Flour T-500 standard - M3 II	300	140	2,14	65,0

With combination of M3 I of flour "Namensko"/T-500 can be achieved the following:

- The energy of flour "Namensko" is lower, but is within the product quality specification limits.
- Resistance and the ratio resistant/ extensibility of flour "Namensko" are increased.
- The energy of flour T-500 is increased.
- The resistance and extensibility of flour T-500 are increased, but the ratio resistant/extensibility is reduced. (theoretically there is potential danger of producing baking products with lower volume).

With combination of M3 II of flour "Namensko"/T-500 can be achieved the following:

- The energy of flour "Namensko" is almost the same as in previous case, which means the value is within the product quality specification limits.
- Resistance and ratio resistant/ extensibility of flour "Namensko" are lower and extensibility is remained unchanged.
- The energy of flour T-500 is increased.
- Resistance and ratio resistant/ extensibility of flour T-500 are increased.

There have been tests of final bakery products - industrial bread with three different types of passages flours: T-500-M3 I (1), T-500 M3-II (2) and T-500 standard (3) used as a base raw material. The result tests are presents on Figure 5 [10, 14].

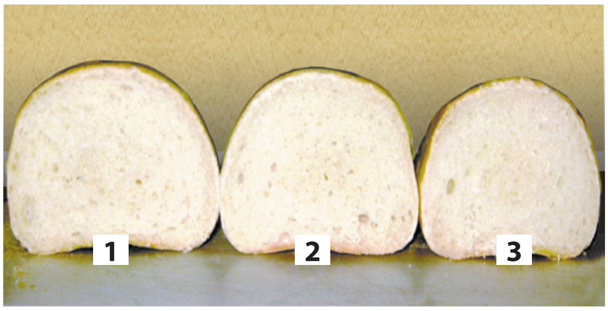


Figure 5. Cross section of the bread with three types of passages flour: T-500 -M3 I (1), T-500 -M3 (2) II и T-500 (3)

In accordance with performed tests, the highest volume of industrial bread is achieved by flour T-500-M3 I (1) and the lowest volume is achieved by flour T-500 (3).

It concludes that adding of M3 I passage flour to the "Namensko" flour will cause slight decline of flour "Namensko" quality within the specification limits and improvement of quality of flour T-500. The higher quality of T-500 flour which use as a main base in bread making processes provides high quality of bread [14, 15].

3.6 Analysis of the results according to costs

Performed optimization by M3 I passage flour transfer from the group of T-500 fractions to the flour "Namensko" fractions primarily has economic impact because the cost price of flours "Namensko" and T-500 is different (0.49 euro and 0.21 euro).

The analysis is done at following value of market prices:

Average price of wheat used for flour "Namensko" production	0.15 euro/kg
Distribution and processing costs of wheat	0.04 euro/kg
Total costs	0.19 euro/kg

The results are presented in Table 5.

The transfer of M3 I at flour Namensko / T-500 is achieved by the following:

- Saving the quantity of high quality wheat in the amount of 30 t (7.50%) per month.
- Increasing the profitability of 8.65%.

The transfer of M3 II at flour Namensko/T-500 is achieved by the following:

- Saving the quantity of high quality wheat in the amount of 9 t (2.25%) per month.
- Increasing the profitability of 2.52%.

4. Conclusions

- Correlation and regression model enable prediction of flour quality before the start of milling process, by determining the wheat quality, in accordance of extent grinding degree. Defining the linear equation with two variables among rheological parameters resistance, extensibility and energy, allows quickly calculation of flour energy directly from the registered extensogram.

- Implementing a control chart of process monitoring allow reducing variability in quality of products and enhance customer satisfaction.

- Cost optimization is achieved with increasing of grinding degree by adding the M3 I to the standard fraction group of flour "Namensko". The benefits are reduced costs through saving the quantity of high quality wheat, and increased profitability of the milling process.

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Table 5. Total income of grinded wheat per kilogram according to the grinding degree of flour types

Type of product	Sales prices VAT incl. (euro)	Sales prices VAT not incl. (euro)	Grinding degree standard combination (%)	Total income/ kg grinded wheat (euo)	Grinded quantity of wheat (t)	Grinding degree combination +/-3.56 (%)	Total income/ kg grinded wheat +/-3.56% (euro)	Grinded quantity of wheat (t)	Grinding degree combination +/-1.04 (%)	Total income / kg grinded wheat +/-1.04% (euro)	Grinded quantity of wheat (t)
"Namensko" flour	0.488	0.465	47.70	0.222	190.80	51.26	0.238	189.70	48.74	0.226	190.60
Flour T-500	0.211	0.201	26.30	0.053	105.20	22.74	0.046	84.10	25.26	0.051	98.80
Bran	0.098	0.083	25.00	0.021	100.00	25.00	0.021	92.50	25.00	0.021	97.80
Combustion	0.000	0.000	1.00	0.000	4.00	1.00	0.000	3.70	1.00	0.000	3.90
			100.00	0.295	400.00	100.00	0.305	370.00	100.00	0.298	391.00
	Gross margin (euro.):			**0.108**			**0.118**	**0.58**		**0.111**	**0.17**
	Increased profitability (%):							**8.65**			**2.52**
	Saved high quality wheat (%):							**-7.50**			**-2.25**

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