

USE OF STATISTICAL CONTROL CHARTS FOR MONITORING THE QUALITY OF FLOUR

KORIŠĆENJE STATISTIČKIH KONTROLNIH KARATA U OCENI KVALITETA BRAŠNA

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ABSTRACT

The use of statistical quality control in the production and storage processes significantly enhances the overall quality of products. Although various techniques are used for quality monitoring purposes, control charts are considered of paramount importance. In this paper, the ash and moisture contents of the wheat flour type 500 were analyzed using descriptive statistics. Consequently, the control charts for the variations in and the mean values of the parameters considered were created. The control charts obtained for the mean parameter values show that the flour production process was in control relative to both parameters considered, exhibiting only random variations. However, the control charts obtained for the variability in the parameter values considered show special variations, the causes of which require further research in order to maintain the satisfactory quality of flour production.

Key words: quality, quality control, control charts, flour.

REZIME

Primena statističke kontrole kvaliteta proizvodnog procesa i procesa skladištenja u velikoj meri doprinosi povećanju kvaliteta samog proizvoda. U svrhu praćenja kvaliteta koriste se razne tehnike, od kojih se kao najznačajnija izdvajaju kontrolne karte. Osnovna svrha primene statističkih kontrolnih karata jeste otkrivanje specijalnih uzroka varijacije. Ukoliko se utvrdi postojanje specijalnih uzroka varijacije može se konstatovati da je proces proizvodnje ili skladištenja van kontrole. U radu su analizirani podaci koji se odnose na sadržaj vlage i pepela u brašnu. Analiza podataka o sadržaju pepela i vlage u brašnu izvedena je na osnovu pokazatelja deskriptivne statistike. Osnovni predušlovi za primenu kontrolnih karata jeste da su podaci raspoređeni po zakonima normalne distribucije, nekolinernost opservacija, homogenost varijansi i aritmetičkih sredina, s toga su u radu najpre testirane ove pretpostavke, a zatim su na bazi izračunatih aritmetičkih sredina i intervala varijacije konstruisane kontrolne karte za srednju vrednost i varijabilitet posmatranih obeležja, tj. sadržaja pepela i vlage u brašnu tipa 500. Na bazi formiranih kontrolnih karata za srednje vrednosti uočeno je da je proces proizvodnje brašna pod kontrolom za oba posmatrana parametra. Utvrđeno je postojanje samo slučajnih uzroka varijacije, a analizom kontrolnih karata za varijabilitet posmatranih obeležja, uočeno je postojanje specijalnih uzroka varijacija koje treba dodatno ispitati kako bi kvalitet proizvodnje ostao na zadovoljavajućem nivou.

Ključne reči: kvalitet, kontrola kvaliteta, kontrolne karte, brašno.

INTRODUCTION

The finalization of agricultural production requires adequate quality control, implemented to the greatest extent possible (Đević and Dimitrijević, 2005). Quality represents the totality of characteristics that meet the users' needs and/or demands, whereas functioning security is a unified feature of maintaining the quality within the set limits of time, working mode and conditions (Filipović and Đurić, 2009).

The application of statistical methods, with precisely and clearly defined parameters, provides the basis for consistent implementation of the quality policy. Statistical methods are considered suitable for defining the standards of production and services, which ensure high levels of quality and better business results (Drenovac A., et al, 2013). Statistical quality control is a set of methods and procedures for collecting, processing, analyzing, interpreting and presenting data. It is used to ensure the quality of production processes and final products. The proper implementation of statistical quality control can reduce production costs (Horvat et al, 2006). A number of different types of diagrams serve as the basic tools for statistical quality control: control charts, the Pareto diagrams, histograms, scatter diagrams and the Ishikawa diagrams (Hadživuković, 1989).

Control charts are the basic instrument for controlling the quality of production processes and final products. The control chart is a statistical technique used to differentiate between

common and special variations in a given process. It represents a graphical analysis of the process stability and instability over time, which is performed in order to ensure and maintain the stability of the process considered (Okwonu and Ogini, 2017).

There are a number of different versions of control charts that can be used to detect process irregularities. However, the Shewhart control chart (\bar{X} chart) is considered the most common and easily interpretable of them all. It was based on the assumption that the variations which occur in every process can be understood and statistically monitored (Savić, 2006). The control chart consists of a center line, which represents the mean value of the in-control process, and two horizontal lines (namely the upper control limit (UCL) and the lower control limit (LCL)) (Muhammad R and Muhammad, 2012). The center line represents the mean value of the observed feature, whereas the upper and lower limits represent the range in which almost all feature values should be found if the process is in control. Control limits indicate the qualitative movement of a process, i.e. the stability and capability of a process. Moreover, they represent the possibilities of a process and normal process variations that can be expected (Drenovac et al., 2013).

Wheat is one of the most important cereals in the world, and wheat bread is one of the global staple foods (Tarjan et al., 2009). The properties of flour reflect its condition and quality. Various changes occur in flour during processing, which greatly affect its technological quality. Therefore, the production and storage of flour must be strictly controlled. The purpose of this

paper is to examine the use of control charts for monitoring the quality of wheat flour (namely the wheat flour type 500) according to the contents of ash and moisture of the flour type considered.

MATERIAL AND METHOD

In order to be properly created, control charts must contain the following entries: uncorrelated measurements, the normality of data, the homogeneity of variance and means. The Kolmogorov-Smirnov and Shapiro-Wilks normality tests, autocorrelation coefficients, the Levene's homogeneity tests and the analysis of variance (ANOVA) were used to test all the control chart considerations stated above.

The control chart used for monitoring changes in the average parameter values was based on the arithmetic mean and standard deviation calculations for the parameters considered. The estimate of the parameter μ equals the overall average of the m sample means. It was assumed that each sample contains the n observations. The average of the sample arithmetic means was computed using the following equation:

$$\mu = \frac{\sum \bar{x}_j}{m} \quad (1)$$

The estimate of σ equals \bar{S} , which is computed using the following equation:

$$\bar{S} = \bar{I}/d_n \quad (2)$$

The range I represents the difference between the maximum and minimum values of the sample, and d_n denotes the coefficient by which \bar{I} is transformed into \bar{S} .

The lower and upper control limits are calculated using the following equation:

$$\mu \pm 3 \frac{\bar{I}/d_n}{\sqrt{n}} \quad (3)$$

The \bar{X} charts are usually accompanied by the process variability R charts. In the R chart, the center line is the average range of the m samples observed, whereas the lower and upper control limits are expressed using the transformation coefficient (f_n).

The lower and upper control limits of the process variability chart are calculated using the following equation:

$$\bar{I} \pm 3f_n \bar{I}/d_n \quad (4)$$

In the present study, the moisture and ash contents of the wheat flour type 500 were observed relative to the monitoring standards as defined in the HACCP plan. A flour mill in Novi Sad, used for the experimental purposes in this study, was monitored during July and August in 2018. The capacity of the mill is 100 tons per 24 hours, whereas its silo capacity approximates to 35,000 tons. The moisture and ash contents of the flour considered were measured over a 50-day period. Based on the data obtained for 250 observation units, a total of 50 groups of five units each were formed. Mill products that meet the quality requirements have a maximum moisture content of 15 % and a maximum ash content of 0.6 % (Sl. Glasnik RS 56/2018). The IBM SPSS 21.0 software was used for statistical data processing.

RESULTS AND DISCUSSION

The descriptive statistics results for the moisture and ash contents of the wheat flour type 500 are presented in Table 1. The results obtained indicate that the average moisture content of the wheat flour

type 500 was 14.03 %, with a minimum moisture content of 3.13 % and a maximum moisture content of 1.67 % (a coefficient of variation of 5.61 %). Furthermore, the average ash content of the wheat flour type 500 was 0.49 %, with a minimum ash content of 0.36 % and a maximum ash content of 0.57 % (a coefficient of variation of 6.84 %).

Table 1. Descriptive indicators of the quality properties of the wheat flour type 500

	Mean	Range		Coefficient of variation (%)
		Minimum	Maximum	
Moisture content (%)	14.03	10.90	15.70	5.61
Ash content (%)	0.49	0.36	0.57	6.84

The data normality was tested using the Kolmogorov-Smirnov and Shapiro-Wilk tests. The tests performed indicate that the parameter values examined had a normal probability distribution (Sig. > 0.05). The autocorrelation coefficients computed suggest that no autocorrelation of the data was found. The Levene's test results show the homogeneity of variance for both parameters considered (Sig. > 0.05), whereas the ANOVA results indicate the homogeneity of their means (Sig. < 0.05) (Table 2). The tests performed confirmed that the basic assumption about the use of control charts in the process considered was fully met. Upon the basic assumption testing, the control charts for the variations in and the arithmetic means of the parameter values considered were created. Fig. 1 shows the control chart for the average moisture content of the wheat flour type 500. The value of the center line on this chart is 14.03 %, whereas the lower and upper limit values are 12.95 % and 15.12 %, respectively. All the control points are located within the control limits, indicating the stability of the process.

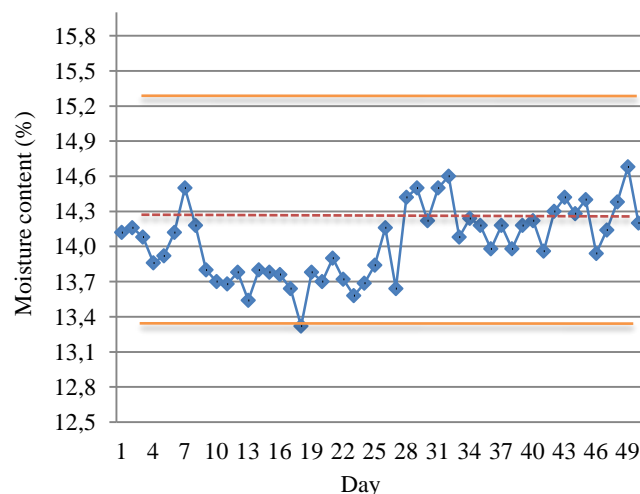


Fig. 1. Control chart for the average flour moisture content

Table 2. Basic assumption tests for the use of control charts

	Kolmogorov-Smirnov		Shapiro-Wilk		Levene's test		ANOVA	
	Statistic	Sig.	Statistic	Sig.	Statistic	Sig.	Statistic	Sig.
Moisture content (%)	0.096	0.200	0.980	0.543	0.453	0.532	24.627	0.003
Ash content (%)	0.108	0.200	0.963	0.121	0.875	0.467	11.729	0.001

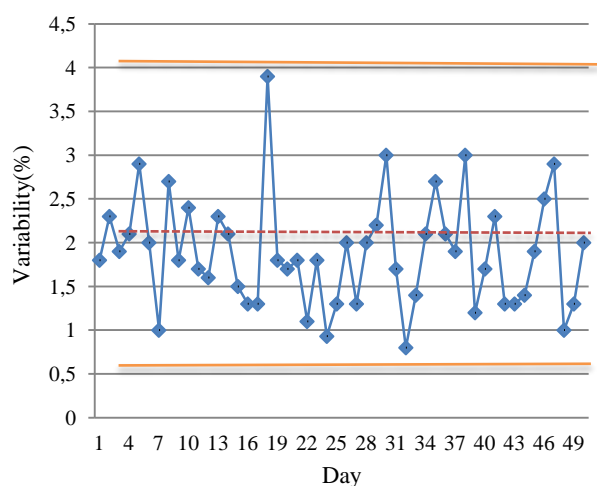


Fig. 2. Control chart for variations in the flour moisture content

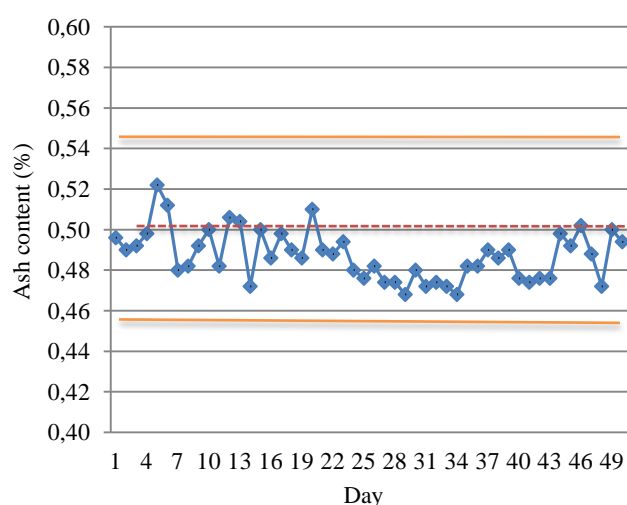


Fig. 3. Control chart for the average flour ash content

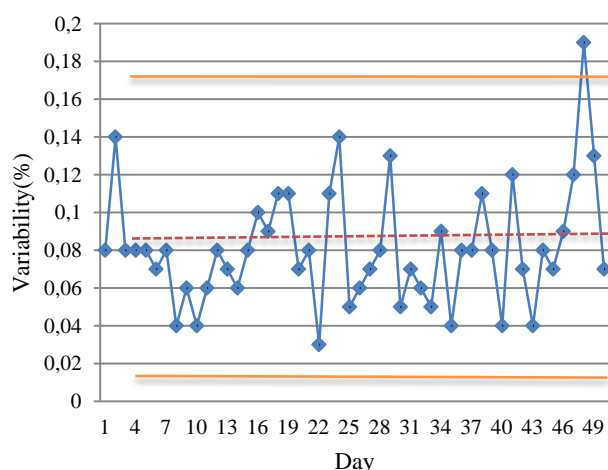


Fig. 4. Control chart for variations in the flour ash content

The control chart for variations in the flour moisture content (Fig. 2.) shows an average center line value of 1.88 % and control limit values of 0.00 % and 3.97 %, respectively. Although all the control points are within the control limits, a variability increase in this parameter value was recorded in the sample 18. Such occurrence should be further examined, as well as the quality of raw material used in the flour production

considered. The control chart for the average ash content of the wheat flour type 500 (Fig. 3.) shows a center line value of 0.49 % and lower and upper limit values of 0.44 % and 0.53 %, respectively. The process was found to be stable with an acceptable content of flour ash. The control chart for variations in the flour ash content (Fig. 4) shows an average center line value of 0.08 %, and control limit values of 0.00 % and 0.17 %, respectively. A variability increase in this parameter value was recorded in the sample 48, indicating special variations and the need for further research. Special variations are most often caused by human errors or the use of poor quality raw material

CONCLUSION

In this study, the average moisture and ash contents of the wheat flour type 500 were 14.03 % and 0.49 %, respectively. On the basis of the calculated central line values and the lower and upper limit values, control charts for variations in and mean values of the parameters considered were created.

The control charts created for the mean parameter values indicate that the process of storing flour is in control, with acceptable contents of flour moisture and ash. However, the control charts for the variability in the parameter values considered show special variations, the causes of which require further research in order to eliminate them and thus render the flour storage process more stable in the future.

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