International Journal for Quality Research 8(3) 323-334
ISSN 1800-6450

Ilija Djekic[1]
Nada Smigic
Nikola Tomic
Andreja Rajkovic

Article info:
Received 04.07.2014
Accepted 20.08.2014

UDC – 519.248

STATISTICAL PROCESS CONTROL IN SERBIAN FOOD PACKAGING

Abstract: *This paper gives an overview of the food packaging process in seven food companies in the dairy and confectionery sector. A total of 23 production runs have been analyzed regarding the three packers' rules outlined in the Serbian legislation and process capability tests related to statistical process control. None of the companies had any type of statistical process control in place. Results confirmed that more companies show overweight packaging compared to underfilling. Production runs are more accurate than precise, although in some cases the productions are both inaccurate and imprecise. Education / training of the new generation of food industry workers (both on operational and managerial level) with courses in the food area covering elements of quality assurance and statistical process control can help in implementing effective food packaging.*

Keywords: *weight management, statistical process control, three packers' rules*

1. Introduction

Weights control is a significant issue in consumer protection, since the consumer takes it on trust that purchased food products are of the stated weight (Grigg *et al.*, 1998). For the food producer, there are potentially significant financial considerations in case of overfilling the packages. Feigenbaum was the first to categorize quality costs into three components: prevention, appraisal and failure (PAF) (Feigenbaum, 1956). Weight control falls into two of these categories: appraisal, in terms of monitoring product and component weights during process control, and failure, in respect of product giveaway and underweight products (Grigg et al., 1998).

In the Republic of Serbia, weights of packaged goods should be aligned with the new regulation issued in 2013 (Regulation, 2013b). Consumer oriented regulation takes into account labeling of food products as well as protection of consumers with the focus on quality characteristics (Regulation, 2010a, 2013a).

Although many authors confirmed benefits of statistical process control (SPC) in terms of economic, predictive and systematic process control, not many researches confirmed successful application of SPC in the food industry (Bergquist and Albing, 2006, Djekic *et al.*, 2013b, Gauri, 2003, Grigg, 1998, Grigg *et al.*, 1998, Ittzés, 2001, Mastrangelo *et al.*, 1996, Srikaeo *et al.*, 2005).

The objective of this paper was to analyze the food packaging process in seven food companies on the sample of 23 different production runs regarding the three packers'

[1] Corresponding author: Ilija Djekic
email: idjekic@agrif.bg.ac.rs

rules outlined in the Serbian legislation and process capability tests related to statistical process control. None of the sampled companies have any type of statistical process control in place.

2. Use of statistical process control

The variation in the quality of a product in any manufacturing process results because of two main reasons: (a) chance cause and (b) assignable cause. A process that is operating with only chance causes of variation is said to be in a state of statistical control (Mahesh and Prabhuswamy, 2010). The major objective of SPC is to detect the occurrence of assignable causes, and if possible, eliminate variability in the processes. That is one the main reasons why SPC is a quality technique so widely accepted for analyzing quality problems and improving the performance of the production process (Gildeh *et al.*, 2014).

In analyzing processes, process capability indices are widely adopted in the manufacturing industry (Chao and Lin, 2006). Several authors analyzed these indices and concluded that as process performance improves, either through reductions in variation and/or moving closer to the target, these indices increase. In each case, the larger index values indicate a more capable process (Chao and Lin, 2006, Gildeh et al., 2014, Spiring, 2011). The importance of these indices is presented in work of Yum and Kim who analyzed literature on process capability indices in a ten year period. They concluded that in the period 2000 – 2009, a total of 530 journal papers and books have been published excluding conference papers, theses, technical reports, and working (Yum and Kim, 2011). This confirms the importance of these indices. The most well-known PCI is probably the Cp index and for it, two specific assumptions were made: (a) the underlying quality characteristic X is a random sample from a normal distribution $N(\mu, \sigma^2)$, and (b) the population mean μ is at the midpoint of the interval [LSL, USL]. *LSL* and *USL* are the lower and upper specification intervals, respectively (Chao and Lin, 2006). However, all these indices are used to identify the amount of product beyond the specification limits not proximity to the target and hence are 'essentially measures of process yield only' (Spiring, 2011).

Control charts are very important tools in statistical process control. The most commonly used charts are Shewhart control charts, cumulative sum (CUSUM) control charts and the exponentially weighted moving average (EWMA) (Cheng and Thaga, 2006). Most of the charts for monitor the process location and spread separately. Two control charts, one for monitoring the process center (such as the X chart) and the other for monitoring the process spread (such as an R chart or σ chart), are run concurrently. Control charts typically work in two phases: a retrospective phase and a monitoring phase. In the retrospective phase, historical data are analyzed to estimate the in-control state of the process, whereas the monitoring phase involves estimating the current state of the process by analyzing the current data (Abbasi and Miller, 2012).

A disadvantage of the individuals chart is that every departure from the in-control situation is signaled on only one chart, whereas the X –R chart monitors changes in the process mean and the process variation separately (Trip and Wieringa, 2006). Several researches discussed the necessity of introducing runs tests how to understand out of control processes and easily interpret the results by observing the chart. The most common runs test are: (i) points outside control limits; (ii) 9 points in Zone ±1σ or beyond (on one side of central line); (iii) 6 points in a row steadily increasing or decreasing; (iv) 14 points in a row alternating up and down; (v) 2 out of 3 points in a row outside 2σ; (vi) 4 out of 5 points in a row outside 1σ; (vii) 5 points in a row in Zone ±1σ (above and below the center line); (viii) 8 pts in a row more than 1σ from centerline (StatSoft, 2013).

3. Materials and methods

For the purpose of this research, the authors analyzed a total of 23 different production runs collected from seven different food companies – five dairies and two confectionery producers. Research period was from the end 2012 until mid of 2013. Three groups of products have been sampled–liquid dairy products, solid dairy products and confectionery products.

Within the liquid group of dairy products, two products have been analyzed – pasteurized milk 1L and yoghurt 1kg. Serbian dairy industry and legislation recognize yogurt as a fermented milk product which is produced by activity of symbiotic cultures such as *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *Bulgaricus* (Regulation, 2010b). Within the group of solid dairy products, kaymak was analyzed in packages of 100g, 450g, 500g and 1 kg (Table 1).

Depending on their daily processing capacities, Serbian dairies can be categorized as follows: (i) plants with capacity over 20,000 liters of milk/day, (ii) plants with capacity below 20,000 liters of milk/day and (iii) small craft dairies with daily capacity below 3,000 liters/day. Although the first group represents only 15% of total numbers of dairy plants, it contributes with more than 80% of total industrial milk processing (Analysis, 2012). Big dairy processors are oriented on production of liquid milks (pasteurized and sterilized milk) and fermented products (liquid and solid yoghurts) with approx. 45% and 37% of total production, respectively. On the other side, middle and small sized dairies are mostly focused on the production of dairy products such as cheeses, kaymak, etc. which comprise app. 50% of their production, but still with significant participation of fermented milks (15 – 20%) (Djekic *et al.*, 2013a, Popovic, 2009).

Among the confectionery group of products, five types of chocolates and five types of cereals have been analyzed. The following types of chocolates were chosen: dark chocolate (DC) 100g, dark chocolate (DC) 200g, milk chocolate with biscuits (MB) 90 g, milk chocolate (MC) 90 g, milk chocolate (MC) 200 g. Within the cereals, the following types were analyzed: wheat cereals with banana (WB) 200g, wheat cereals with apple (WA) 200g, wheat cereals with vanilla (WV) 200g, wheat groats (WG) 200g and rice crispies (RC) 40g (Table 1).

Confectionary and snacks is a food sub-sector with an overall production of 130,000 tons per year and increasing importance in the food production in Serbia. From 2010, results show that this sub-sector achieves annual revenues of over 400 million EUR and an export value of 150 million EUR (FAO, 2012). This industry recognizes ten major companies that participate in over 50% of the market share. All of these companies are big in size (over 250 employees). The food processing industry in Republic of Serbia consists of over 75% of enterprises employing less than 10 employees (micro enterprises), below 16% having between 10 and 49 employees (small enterprises), 7% being medium sized enterprises (between 50 and 249 employees), and below 2% are big enterprises (Serbia, 2011).

In order to analyze quality parameters of different dairy products, authors analyzed the results depending on dairy plant daily processing capacity or size of confectionery producer.

Table 1. Demographic structure of food companies and sampled products

Number of production runs	Daily capacities of dairies [liters of milk/day]			Size of confectionery producer [number of employees]	
	≤ 3,000 (*)	**3,001 – 19,999 (**)**	**≥ 20,000**	**≤ 50**	**≥ 50**
Liquid dairy products					
Yoghurt	2	2	1		
Pasteurized milk	2	1			
Solid dairy products					
Kaymak	2	2	1		
Confectionery products					
Chocolates					5
Breakfast cereals				5	

(*) – data from two dairies of daily capacity ≤ 5,000 liters of milk/day were used in the survey

(**) – data from two dairies of daily capacity 5,001 – 19,999 liters of milk/day were used in the survey

In order to analyze quality parameters of different dairy products, authors analyzed the results depending on dairy plant daily processing capacity or size of confectionery producer.

3.1 Methods of analysis

Weight of products has been measured directly on the production line during the production process using calibrated balances. Data were recorded on sheets and then transferred to the computer. As defined in the regulation, the declared weight or volume of package contents is known as the "nominal quantity". If the actual contents of any package are less than the stated nominal quantity, the difference is referred to as negative error. For any given weight or volume there is an associated tolerable negative error (TNE), which represents a permissible amount by which some packages may be underfilled (Grigg, 1998). The TNE values for a given quantity are presented in table 2 (Regulation, 2013b).

Table 2. Tolerable negative error values for a given quantities

Nominal quantity (Qn) (g or ml)	Tolerable negative error (TNE)	
	As percentage of Qn	**g or ml**
5 - 50	9%	--
50 - 100	--	4,5 g/ml
100 - 200	4,50%	--
200 - 300	--	9 g/ml
300 - 500	3%	--
500 - 1000	--	15 g/ml
≥ 1.000	1,50%	--

According to the Serbian regulation (Regulation, 2013b), the following 'three rules for packers', should apply:

Rule 1: The contents of the packages shall be not less on average than the nominal quantity;

Rule 2: Not more than 2.5% of the packages may be non-standard, ie have negative errors larger than the TNE specified for the nominal quantity Qn.;

Rule 3: No package shall have a negative error greater than twice the tolerable negative error.

3.2 Calculation of process characteristics

For every product, data from one production run with a sample of 200 were collected and grouped in subgroups of 5 packs, making a total of 40 subgroups. In order to analyze the packing process, statistical process control can be used to routinely monitor and control the mean and variability of package quantities (Gauri, 2003, Grigg, 1998). Assuming normal distribution of the results, the following statistical process has been performed. The overall mean "μ" fill is the average of the 40 subgroup means. The standard deviation (hereafter abbreviated to SD and denoted by the symbol 'σ'), and the range (the difference between the largest and smallest subgroup weights, and denoted 'R') have been calculated. Four process capability tests were used for detection of out-of-control situations as follows (Trip and Wieringa, 2006):

- **Test 1.** A control limit is exceeded when one or more points are outside the control limits. In order to further deploy this rule, authors calculated the percentage of packages that were out of specifications (below or above the specification limits).
- **Test 2.** A run of nine measurements above or below the central line (CL).
- **Test 3.** A run of six consecutive measurements either increasing or decreasing.
- **Test 4**. A signal is issued when two out of three measurements are in the same warning zone (the region between a warning limit—usually taken as the so-called 2σ-limits—and the corresponding control limit).

Two process capability indices **cp** and **cpk** have been calculated since they give a quick indication of the capability of a manufacturing process. Even though there are many process capability indices, these two are most commonly used indices (Gildeh *et al.*, 2014). They are designed to quantify the relation between the desired specifications and the actual performance of the process (Castagliola and Vännman, 2007).

$$Cp = (USL - LSL)/6\sigma \qquad (1.1)$$

This is a process capability index that indicates the process potential performance by relating the natural process spread to the specification spread. It indicates accuracy of the process.

$$Cpk = \min (USL - \mu;\ \mu - LSL)/3\sigma \qquad (1.2)$$

This is a process capability index that indicates the process actual performance towards either the upper or lower specification limit. It indicates precision of the process.

LSL and USL are the lower and upper specification intervals as outlined in the Serbian legislation (Regulation, 2013b). Process capability measures are used to provide insights into the number of non-conforming product, referred to as process yield. Usually practitioners cite a Cp value of „1“ as representing 2700 parts per million (ppm) non-conforming, whereas "1.33" represents 63 ppm; "1.66" corresponds to 0.6 ppm and "2" indicates <0.1ppm. Cpk has similar connotations, with a Cpk of "1.33" representing a maximum of 63 ppm non-conforming (Spiring, 2011). It is known that when the values of Cp and Cpk is "1", this is considered, as the minimum requirement of the system for some companies (Motorcu and Güllü, 2006). When we have a value of Cp and cpk = 1, it shows that the manufacturing is going on in the system specification limits staying at 99.73% level (±3σ limits) (Chao and Lin, 2006). It is preferable to have the values of both indices above "1.33".

3.3 Statistical analysis

Main statistical processing considered calculation of descriptive statistics. ANOVA and Tukey HSD test (for more than two groups of samples) was used to check the null hypothesis assuming that there is no difference between the producers categorized by their daily capacities. For all statistical tests, statistical significance was set as $\alpha=0.05$. Data were processed using © Microsoft Office Pack 2007 and SPSS 19.0.

4. Results and discussion

4.1 Liquid dairy products

Analyzing results for pasteurized milk, all three samples had average weights below the nominal quantity failing on the first of the three packers' rules (Table 3). Results show that the range of weights is much higher in small capacity dairies than in the middle size capacity diary. Statistical test show that small capacity dairies have results outside of control limits (one dairy on both sides, the other showing underfilling). As for the other three tests, only one dairy showed good results. Process capability indices are above "1" with the middle size dairy showing results above 1.33 for cp. ANOVA results show that there was no statistically significant difference between different groups of dairies producing this type of milk.

Table 3. Processed weight results for pasteurized milk

Liquid dairy products	**Declared volume**	**Daily capacities of dairies [liters of milk/day]**		
Pasteurized milk	1000 ml ± 15 ml	**≤ 3,000**		**3,001 – 19,999**
Mean values ± standard deviation (μ±σ)		999.7 ± 4.01	999.05 ± 3.93	999.75 ± 0.52
Range		9.25	9.25	1.125
Rule 1		Fail	Fail	Fail
Rule 2		Pass	Pass	Pass
Rule 3		Pass	Pass	Pass
Process capability tests				
One or more points are outside the control limits		Fail	Fail	Pass
% Above USL		0.03%	0.00%	0.00%
% Below LSL		0.05%	0.02%	0.00%
More than 9 points in a row on one side of the CL		Fail	Pass	Fail
Six points in a row increasing or decreasing		Pass	Pass	Pass
More than 2/3rd of pts outside 2 sigma		Pass	Pass	Fail
Process Capability Indices				
Cp		1.257	1.257	1.338
Cpk		1.232	1.178	1.165

Yoghurt was analyzes in five dairies (Table 4). Results show that in three of the five dairies, all three packers' rules are fulfilled. On the other side, process capability test were confirmed only in one of the five dairies, but not in any of the dairies that fulfilled packers' rules. It is interesting that the dairy with the highest capacity showed over 40% of overweight packages, although its results are in line with the three packers' rules. Also, process capability indices were better in the dairies that failed the three packers' rules. ANOVA results of yoghurt with declared weight 1000 g showed significant difference between samples produced in the big capacity dairy compared with the other dairies.

Table 4. Processed weight results for yoghurt

Liquid dairy products	**Declared weight**	**Daily capacities of dairies [liters of milk/day]**				
Yoghurt	1000 g ± 15 g	**≤ 3,000**		**3,001 – 19,999**		**≥ 20,000**
Mean values ± standard deviation (μ±σ)		1000.07±5.1[a]	999.3±3.14[b]	1001.42±5.64[c]	999.87±0.37[d]	1012.15±11.74[a,b,c,d]
Range		12.375	7.75	13.625	0.875	27.375
Rule 1		Pass	Fail	Pass	Fail	Pass
Rule 2		Pass	Pass	Pass	Pass	Pass
Rule 3		Pass	Pass	Pass	Pass	Pass
Process capability tests						
One or more points are outside the control limits		Fail	Pass	Fail	Pass	Fail
% Above USL		0.38%	0.00%	1.34%	0.00%	42.92%
% Below LSL		0.35%	0.00%	0.37%	0.00%	4.46%
More than 9 points in a row on one side of the CL		Pass	Pass	Pass	Fail	Pass
Six points in a row increasing or decreasing		Pass	Pass	Pass	Pass	Pass
More than 2/3rd of pts outside 2 sigma		Pass	Pass	Pass	Fail	Pass
Process Capability Indices						
Cp		0.940	1.501	0.854	1.291	0.425
Cpk		0.935	1.431	0.772	1.181	0.081

[a] – statistically significant difference between the two types of dairies
[b] – statistically significant difference between the two types of dairies
[c] – statistically significant difference between the two types of dairies
[d] – statistically significant difference between the two types of dairies

4.2 Solid dairy products

Analysis of kaymak as a solid dairy product shows that the dairy with the largest capacities passed all three packers' rules. One of the two dairies of middle capacity shows the most stable process capability with good results for all four statistical tests and process capability indices above 1.33 (Table 5).

Table 5. Processed weight results for kaymak

Kaymak	Daily capacities of dairies [liters of milk/day]				
	≤ 3,000		3,001 – 19,999		≥ 20,000
	500g±3%	500g±3%	100g±4.5g	1000g±15g	450 g±3%
Mean values ± standard deviation (μ±σ)	498.25±4.17	498.95±3.59	98.95±2.80	999.85±2.82	451.45±3.46
Range	9.625	8.375	6.0	6.38	8.0
Rule 1	Fail	Fail	Fail	Fail	Pass
Rule 2	Pass	Pass	Pass	Pass	Pass
Rule 3	Pass	Pass	Fail	Pass	Pass
Process capability tests					
One or more points are outside the control limits	Fail	Fail	Fail	Pass	Fail
% Above USL	0.01%	0.00%	2.80%	0.00%	0.08%
% Below LSL	0.17%	0.01%	11.75%	0.00%	0.00%
More than 9 points in a row on one side of the CL	Fail	Fail	Fail	Pass	Fail
Six points in a row increasing or decreasing	Pass	Pass	Pass	Pass	Pass
More than 2/3rd of pts outside 2 sigma	Pass	Pass	Pass	Pass	Pass
Process Capability Indices					
Cp	1.208	1.389	0.582	1.824	1.308
Cpk	1.067	1.291	0.446	1.806	1.168

4.3 Confectionery products

This big confectionery producer showed good results for all five types of chocolates regarding the three packers' rules (Table 6). Only for one of the four chocolates (MC 90g), statistical tests failed for three out of four. Process capability indices were above 1.33 for all production runs.

Table 6. Processed weight results for chocolates

Chocolates	Big confectionery producer				
	DC 100g±4.5g	DC 200g±4.5%	MB 90g±4.5g	MC 90g±4.5g	MC 200g±4.5%
Mean values ± standard deviation (μ±σ)	100.73±0.56	200.80±1.37	90.47±0.72	90.98±0.68	200.59±0.65
Range	1.357	3.34	1.747	1.657	1.515
Rule 1	Pass	Pass	Pass	Pass	Pass
Rule 2	Pass	Pass	Pass	Pass	Pass
Rule 3	Pass	Pass	Pass	Pass	Pass
Process capability tests					
One or more points are outside the control limits	Pass	Pass	Pass	Fail	Pass
% Above USL	0.00%	0.00%	0.00%	0.34%	0.00%
% Below LSL	0.00%	0.00%	0.00%	0.00%	0.00%
More than 9 points in a row on one side of the CL	Pass	Pass	Pass	Fail	Fail
Six points in a row increasing or decreasing	Pass	Pass	Pass	Fail	Pass
More than 2/3rd of pts outside 2 sigma	Pass	Pass	Pass	Pass	Pass
Process Capability Indices					
Cp	2.570	2.089	1.997	2.105	4.606
Cpk	2.152	1.902	1.789	1.643	4.300

The small confectionery producer shows good results for all five types of breakfast cereals regarding the three packers' rules (Table 7). On the other side, this producer failed for one of the four statistical tests showing overweight in four production runs and results outside of control limits for one production run. Process Capability Indices show that the results are accurate but not precise (too many results out of specification limits).

Table 7. Processed weight results for breakfast cereals

Breakfast cereals	Small confectionery producer				
	WB 200g±4.5%	WA 200g±4.5%	WV 200g±4.5%	WG 200g±4.5%	RC 40g±4.5g
Mean values ± standard deviation (μ±σ)	208.64±0.92	208.69±0.95	208.76±1.09	208.61±0.91	40.58±1.60
Range	2.2415	2.3255	2.6385	2.2995	3.992

Rule 1	Pass	Pass	Pass	Pass	Pass
Rule 2	Pass	Pass	Pass	Pass	Pass
Rule 3	Pass	Pass	Pass	Pass	Pass
Process capability tests					
One or more points are outside the control limits	Fail	Fail	Fail	Fail	Fail
% Above USL	36.34%	39.00%	42.03%	34.82%	3.80%
% Below LSL	0.00%	0.00%	0.00%	0.00%	0.69%
More than 9 points in a row on one side of the CL	Pass	Pass	Pass	Pass	Pass
Six points in a row increasing or decreasing	Pass	Pass	Pass	Pass	Pass
More than 2/3rd of pts outside 2 sigma	Pass	Pass	Pass	Pass	Pass
Process Capability Indices					
Cp	3.113	3.001	2.645	3.035	0.699
Cpk	0.125	0.102	0.071	0.132	0.586

As shown in the results above, there are less tangible, benefits associated with statistical process control (SPC) which make the investment worthwhile. Such benefits include the systematic recording of quality data, the possibility of predictive control, allowing corrective action to be taken proactively, and the provision of confidence to customers that an effective system is in place (Grigg *et al.*, 1998).

5. Conclusions

As previously mentioned, none of the companies have any SPC in place. The results above show that packaging process is more accurate than precise, although for some productions it is both inaccurate and imprecise. More companies show overweight packaging compared to underfilling packaging.

Although SPC is not a mandatory requirement in the food industry, it can provide benefits to organizations in the sector regardless of their particular specialism and size. Although many companies associate SPC with expensive statistical software, in some cases, manual control charts can be just as effective, and can enable operators and other users to understand the packing process (Grigg, 1998).

Expensive food products with a large operating cost associated with “overfilling”, recognize statistical quantity control more attractive to companies dealing with such produce than to others for whom the product is inexpensive, or easily reusable. Education / training of the new generation of food industry workers (both on operational and managerial level) with courses in the food area covering elements of quality assurance and SPC can help in implementing effective food packaging.

Limitations of the research stem from the use of a convenience sample. Since the data were collected from seven companies and 23 production runs, the current results should not be generalized. Given the differences within the food industry in relation to their size and level of automation of the packaging process as well as of food products related to their packaging size and aggregate state, more research is necessary to determine if similar results would be derived from different samples across the food industry.

Acknowledgement: Results presented in this paper have been processed from data gathered by two master and one bachelor student for the purpose of their master and bachelor thesis.

References:

Abbasi, S.A., & Miller, A. (2012). On Proper Choice of Variability Control Chart for Normal and Non-normal Processes. *Qual. Reliab. Eng. Int*. *28*(3), 279-296.

Analysis. (2012). *Sectoral Analysis of raw milk, production and processing of milk and dairy products*. Commision for protection of competition of the Republic of Serbia, Belgrade, Republic of Serbia.

Bergquist, B., & Albing, M. (2006). Statistical Methods – Does Anyone Really Use Them? *Total Qual. Manag. Bus. Excell*. *17*(8), 961-972.

Castagliola, P., & Vännman, K., (2007). Monitoring capability indices using an EWMA approach. *Qual. Reliab. Eng. Int*. *23*(7), 769-790.

Chao, M.-T. & Lin., D.K.J. (2006). Another Look at the Process Capability Index. *Qual. Reliab. Eng. Int*., *22*(2), 153-163.

Cheng, S. W. & Thaga. K., (2006). Single Variables Control Charts: an Overview. *Qual. Reliab. Eng. Int*. *22*(7), 811-820.

Djekic, I., Miocinovic, J., Pisinov, B., Ivanovic, S., & Smigic, N., (2013a). Quality characteristics of selected dairy products in Serbia. *Mljekarstvo*, *63*(4), 228-236.

Djekic, I., Tomasevic, I., Zivkovic, N., & Radovanovic, R. (2013b). Types of food control and application of seven basic quality tools in certified food companies in Serbia. *Quality Assurance and Safety of Crops & Foods*, *5*(4), 325-332.

FAO. (2012). *Eastern Europe and central Asia agro-industry development country brief. in Serbia*. Food and Agriculture Organization of the United Nations, FAO Regional Office for Europe and Central Asia.

Feigenbaum, A.V. (1956). Total Quality Control. *Harv. Bus. Rev*. *34*, 93-101.

Gauri, S.K. (2003). Statistical process control procedures for controlling the weight of packets of biscuits. *Total Qual. Manag. Bus. Excell*, *14*(5), 529-539.

Gildeh, B.S., Iziy, A., & Ghasempour, B. (2014). Estimation of Cpmk process capability index based on bootstrap method for Weibull distribution: a case study. *International Journal for Quality Research*, *8*(2), 255-264.

Grigg, N.P. (1998). Statistical process control in UK food production: an overview. I*nternational Journal of Quality & Reliability Management*, *15*(2), 223-238.

Grigg, N.P., Daly, J., & Stewart. M. (1998). Case study: the use of statistical process control in fish product packaging. *Food Control, 9*(5), 289-297.

Ittzés, A. (2001). Statistical process control with several variance components in the dairy industry. *Food Control*, *12*(2), 119-125.

Mahesh, B.P. & Prabhuswamy, M.S. (2010). Process variability reduction through statistical process control for quality improvement. *International Journal for Quality Research 4*(3), 193-203.

Mastrangelo, C.M., Runger, G.C. & Montgomery, D.C. (1996). Statistical process monitoring with principal components. *Qual. Reliab. Eng. Int*., *12*(3), 203-210.

Motorcu, A.R. & Güllü, A. (2006). Statistical process control in machining, a case study for machine tool capability and process capability. *Materials & Design*, *27*(5), 364-372.

Popovic, R. (2009). Structural changes on Serbian milk market. *Prehrambena industrija – Mleko i mlečni proizvodi*, *20*, 7-12.

Regulation. (2010a). *Consumers protection law. Vol. No. 73/2010*. Official Gazzete of the Republic of Serbia, Belgrade, Serbia.

Regulation. (2010b). *Ordinance on quality of dairy products and starter cultures. Vol. No. 33/2010 and 69/2010*. Official Gazette of the Republic of Serbia Belgrade, Serbia.

Regulation. (2013a). *Ordinance on labelling, marking and advertising of food products. Vol. No 85/2013*. Official Gazette of the Republic of Serbia, Belgrade, Serbia.

Regulation. (2013b). *Ordinance on pre-packed goods. Vol. No 43/2013*. Official Gazette of the Republic of Serbia, Belgrade, Serbia.

Serbia. (2011). *Statistical yearbook of the Republic of Serbia*. Statistical Office of the Republic of Serbia, Belgrade.

Spiring, F. (2011). Exploring process capability with Mathematica. *Qual. Reliab. Eng. Int*. *27*(3), 369-387.

Srikaeo, K., Furst, J.E., & Ashton, J. (2005). Characterization of wheat-based biscuit cooking process by statistical process control techniques. *Food Control*, *16*(4), 309-317.

StatSoft, I. (2013). *Electronic Statistics Textbook*. StatSoft, Tulsa OK 74104, USA.

Trip, A., & Wieringa. J.E. (2006). Individuals Charts and Additional Tests for Changes in Spread. *Qual. Reliab. Eng. Int. 22*(3), 239-249.

Yum, B.-J., & Kim, K.-W. (2011). A bibliography of the literature on process capability indices: 2000–2009. *Qual. Reliab. Eng. Int*. *27*(3),251-268.

Djekic Ilija
University of Belgrade
Faculty of Agriculture,
Department of Food Safety
and Quality Management
Belgrade
Serbia
idjekic@agrif.bg.ac.rs

Smigic Nada
University of Belgrade
Faculty of Agriculture,
Department of Food Safety
and Quality Management
Belgrade
Serbia

Tomic Nikola
University of Belgrade
Faculty of Agriculture,
Department of Food Safety
and Quality Management
Belgrade
Serbia

Rajkovic Andreja
Ghent University
Faculty of Bioscience
Engineering,
Department of Food Safety
and Food Quality
Ghent
Belgium