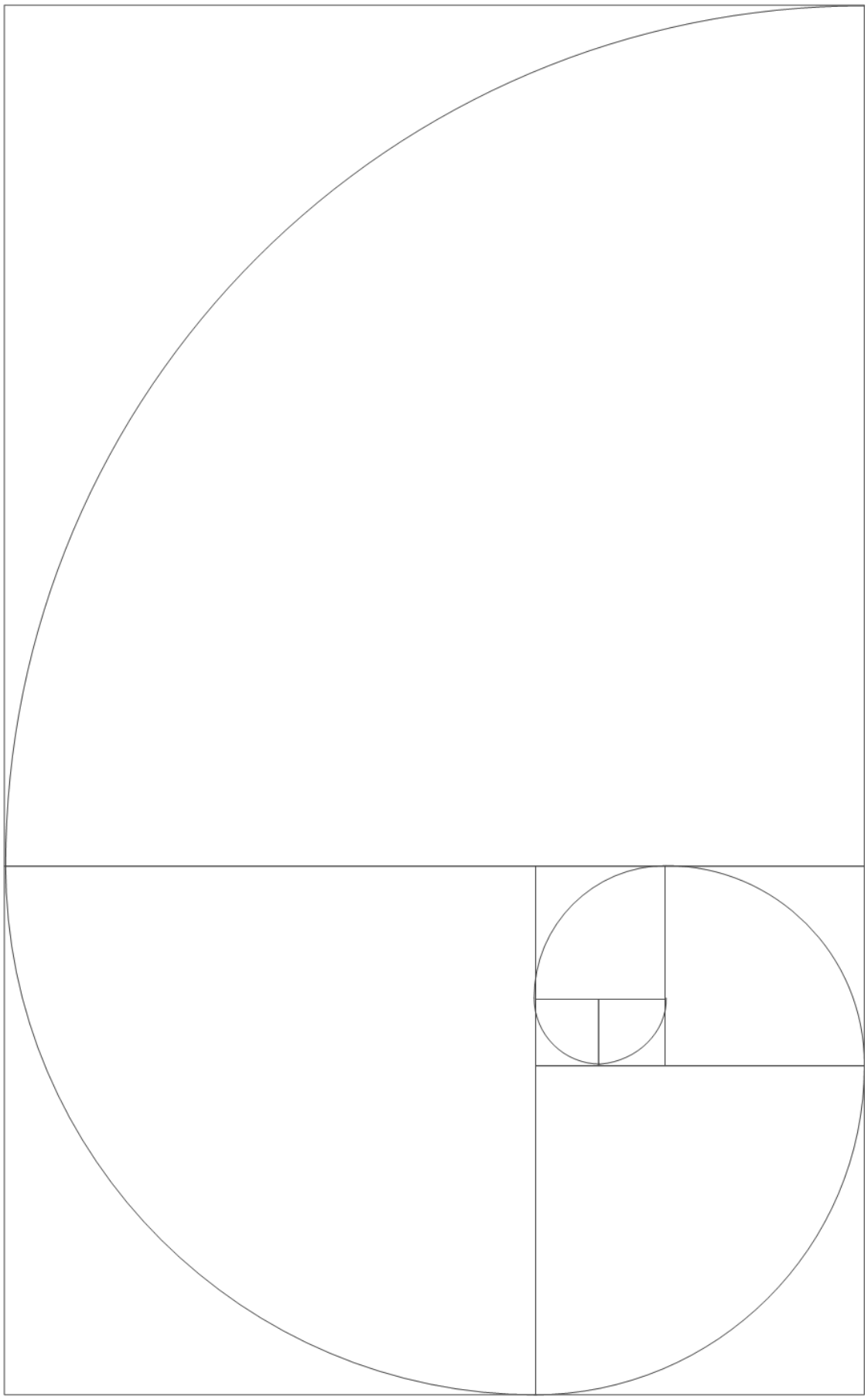

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ANALYSIS OF NON-WORKING MOVES PERFORMED BY SEMI-MOUNTED REVERSIBLE PLOUGH IN A HEADLAND

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Abstract: *When working with semi-mounted reversible plough non-working moves are turns made at the end of the field when changing the direction of movement. The choice of a turn with the smallest length and duration of performance is hampered significantly when processing fields with irregular shape.*
Three types of turns are compared in the article – oblong pear-shaped, shortened pear-shaped and eight-shaped when the angle between the direction of movement and the border of the field ranged from 20 to 90°. It is assumed that the angle is positive when it is on the right side of the unit when it enters into the turn, and negative – on the left side. The lengths of the curvilinear and the rectilinear part of the turn and the width of the headlands have been determined.
It was found that when the angle is positive the left turns have smaller length than the right turns, while when the angle is negative – vice versa. The shortened pear-shaped turns are the shortest followed by the oblong pear-shaped turns and the eight-shaped turns, but require greater headland than them. For small values of the angle the shortened and the oblong pear-shaped turns have similar lengths and widths of headlands.
Keywords: *semi-mounted reversible plough; non-working move; field with irregular shape; pear-shaped turn; eight-shaped turn; length of turn; width of headland.*

1. INTRODUCTION

When plowing with reversible plough shuttle movement is made, i.e. the working moves are performed immediately next to each other. Nonworking moves are performed by the plough in headlands in the transition between the working moves. The turns can be with a different form. Most common in shuttle movement of trailed and semi-mounted units the regular pear-shaped turn (Ω-turn) is used, but when the form of the field is not correct (other than rectangular) the shape of the turn is changing. In fields with irregular shape other types of turns can be used when plowing with semi-mounted reversible plough [1, 2]. The length of the turns and the width of the headland depend on the form of the field. When the field is with irregular shape, the angle between the direction of movement of the unit and the border of the field has a major influence on these parameters.
Dependencies to determine the length of three types of turns and the width of the headland in ploughing in a field with irregular shapes are referred in [1, 2]. They can be used to perform a comparative analysis of the different ways of movement and the study of the impact of the shape of the field on the length of the turn and width of the headland in ploughing with different units. The length of the turns has influence on the time for its performance, and it is the basis for the determination of effectiveness of the units. The width of the headland should be minimal. It is processed last and is associated with the additional expense of time.
The objective of this work is to make a comparative analysis of the non-working moves when ploughing with semi-mounted reversible plough and to determine the influence of the shape of the field on the length of the turn and the width of the headlands.

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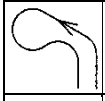
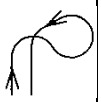
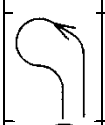
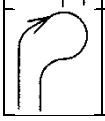
2. METODS

To determine the length of the turns of the units and the width of the headland the dependencies specified in [1, 2] are used. They are processed and summarized in Table 1.

Table 1. Analytical dependences for determining the length of the turn and the width of headland when ploughing with semi-mounted reversible ploughs in a field with irregular shape.

Shape of turn	Name	Direction of performance	α	Width of headland	Length of turn
1	2	3	4	5	6
	Oblong pear-shaped	Left	+	$E_c = (g-R)\cos\alpha + l_a.\sin\alpha + R + 0{,}5M$	$l_t = \left(2\pi + \frac{\pi.\beta}{90}\right)R + \frac{2R.\sin\beta + B}{\sin\alpha}$ $\beta = \alpha - \arcsin\left[\frac{B.\cos\alpha + (l_a + l_n)\sin\alpha}{2R}\right]$
	Oblong pear-shaped	Right	-		
	Eight-shaped	Left	+		If $\alpha < \arcsin\left(\frac{B}{2R}\right)$ $l_t = \left(2\pi + \frac{\pi.\alpha}{90}\right)R - 2R + \frac{B}{\sin\alpha} + 2l_a$ when $\alpha < arctg\left(\frac{B}{l_a - l_n}\right)$ $l_t = \left(2\pi + \frac{\pi.\alpha}{90}\right)R - 2R + \frac{B}{\sin\alpha} + \frac{B}{tg\alpha} + l_a + l_n$ when $\alpha > arctg\left(\frac{B}{l_a - l_n}\right)$
	Eight-shaped	Right	-		If $\alpha > \arcsin\left(\frac{B}{2R}\right)$ $l_t = \left(2\pi + \frac{\pi.\alpha}{90}\right)R + 2R - \frac{B}{\sin\alpha} + 2l_a$ when $\alpha < arctg\left(\frac{B}{l_a - l_n}\right)$ $l_t = \left(2\pi + \frac{\pi.\alpha}{90}\right)R + 2R - \frac{B}{\sin\alpha} + \frac{B}{tg\alpha} + l_a + l_n$ when $\alpha > arctg\left(\frac{B}{l_a - l_n}\right)$
	Shortened pear-shaped	Left	+	$E_c = (2R - l_n)\sin\alpha + (g - B - R).\cos\alpha + R + 0{,}5M$	$l_t = 2\pi R + \frac{B}{\sin\alpha} + 2R - \frac{B}{tg\alpha} - l_a - l_n$
	Shortened pear-shaped	Right	-		

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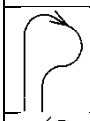
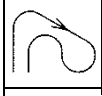
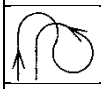
1	2	3	4	5	6
	Shortened pear-shaped	Right	+	$E_c = (B + R - g)\cos\alpha + (2R - l_n)\sin\alpha + R + 0{,}5M$	$l_t = 2\pi R + \frac{B}{\sin\alpha} + 2R + \frac{B}{tg\alpha} - l_a - l_n$
	Shortened pear-shaped	Left	-		
	Oblong pear-shaped	Right	+	$E_c = (R - g)\cos\alpha + l_a.\sin\alpha + R + 0{,}5M$	$l_t = \left(3\pi + \frac{\pi.\beta}{90}\right)R + \frac{2R.\cos\beta + B}{\sin\alpha}$ $\beta = \arccos\left[\frac{(l_a + l_n)\sin\alpha}{2R} - \frac{B.\cos\alpha}{2R}\right] - \alpha$
	Oblong pear-shaped	Left	-		
	Eight-shaped	Right	+		If $\alpha < \arcsin\left(\frac{B}{2R}\right)$ $l_t = \left(2\pi - \frac{\pi.\alpha}{90}\right)R - 2R + \frac{B}{\sin\alpha} + l_n$ when $\alpha < arctg\left(\frac{B}{l_a - l_n}\right)$ $l_t = \left(2\pi - \frac{\pi.\alpha}{90}\right)R - 2R + \frac{B}{\sin\alpha} - \frac{B}{tg\alpha} + l_a + l_n$ when $\alpha > arctg\left(\frac{B}{l_a - l_n}\right)$
	Eight-shaped	Left	-		If $\alpha > \arcsin\left(\frac{B}{2R}\right)$ $l_t = \left(4\pi - \frac{\pi.\alpha}{90}\right)R + 2R - \frac{B}{\sin\alpha} + 2l_n$ when $\alpha < arctg\left(\frac{B}{l_a - l_n}\right)$ $l_t = \left(4\pi - \frac{\pi.\alpha}{90}\right)R + 2R - \frac{B}{\sin\alpha} - \frac{B}{tg\alpha} + l_a + l_n$ when $\alpha > arctg\left(\frac{B}{l_a - l_n}\right)$

In [1] the length of the turn is calculated from the point of include or exclude of the machine inside the headland by not take into consideration rectilinear area which the unit covers between this point and the border of the headland. When system for precision agriculture is used, inclusion and exclusion of the unit can be performed exactly on the border of headland. In the dependencies listed in Table 1, the length of the turn is the distance covered by the unit from exclusion the machine when the last ploughshare reaches the border of the headland to the its inclusion for the next move when the first ploughshare again reaches on the border of the headland. In the dependencies for the calculation of the length of the turns (l_t) the first member represents the length of the curvilinear part of the turn (l_c), the rest addends form the length of the rectilinear part of the turn (l_r). Three types of turns are discussed - oblong pear-shaped, shortened pear-shaped and eight-shaped. The symbols in Table 1 have the following meanings:

E_c – the required minimum width of headland;
l_t – the length of the turn;
α – the angle between the direction of movement of the unit and the border of the field. It is assumed that the angle is positive when it is on the right side of the unit when it enters into the turn, and negative – on the left side (Figure 1). For this study is accepted that the angle is positive and it is in the range of 20˚ to 90°. In the calculations the angle is always with positive sign. When the angle is negative same dependencies are valid, but the names of turns are changed according to Table 1, and the direction of making the turns must be reversed;
β – angle from geometric construction of the turn required for the calculation of the length of the individual parts of the turn. It depends on the angle α;
B – the working width of the unit;
l_a – the kinematic length of the unit;
l_n – the distance from the center of the unit (the middle of the rear axle of the tractor) to at front point of the first ploughshare;
g – the distance from the axis of symmetry of the tractor to at front point of the last ploughshare;
R – the radius of the turn of the unit;
M – the distance between the outer boards of the rear tires of the tractor.
The actual width of the headland E must be exact multiples of the working width of the unit

$$E = k.B, \tag{1}$$

where k is the number of moves of the unit for processing of headland.
The number of moves for the processing of headland will depend on angle α. In equalizing dependence (1) with dependencies Ec in Table 1 is determined the number of the moves k and the value of angle α, where the width of the headland is changed. The result obtained for k is rounded up to the higher whole number and is replaced in (1).
On the basis of the dependencies graphics have built for the influence of angle α on the width of the headland and the length of the turns. The calculations are made for the unit with the following parameters: *B*=2,4 *m*; l_a=6,5 *m*; *g*=1,75 *m*; l_n=2 *m*; *R*=7,2 *m*; *M*=2,1 *m*.

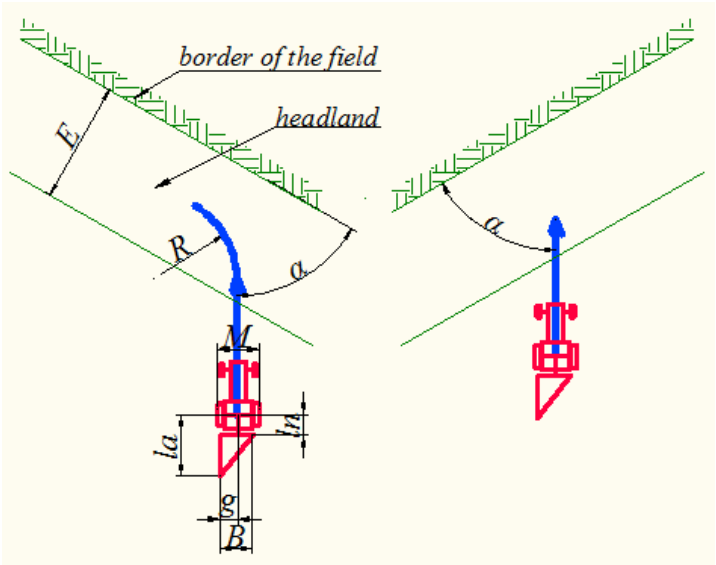


Figure 1. Movement of the unit in a field with irregular shape:
a) in a positive angle between the direction of movement of the unit and the border of the field
b) in a negative angle between the direction of movement of the unit and the border of the field

3. RESULTS

In Figure 2 the results of the calculations of the length of the turns and the width of the headland are shown. It can be seen that with increasing angle α, the length of the oblong pear-shaped turn (Figure 2a) increases, as the length of the curvilinear part of the turn grows faster. The width of the headland also grows. If the turn is on the right (Figure 2b) its length decreases with increasing α, which is also due to the more rapid change of the curvilinear part of the turn. In this case, the width of the headland remains constant regardless of the form of the field. The length of the right turn is greater than the length of the left turn, but when α = 90°, i.e. at the correct form of the field, the lengths of the turns are equal. The widths of the headlands are also equal.
In Figure 2c and Figure 2d are shown graphs for shortened pear-shaped left and right turns. It is seen that the length of the left turn is less than the length of the right turn as they are equal at α = 90˚. With the increasing of the angle α, the length of the curvilinear part of the turn does not change regardless of the direction of performance. The length of the rectilinear

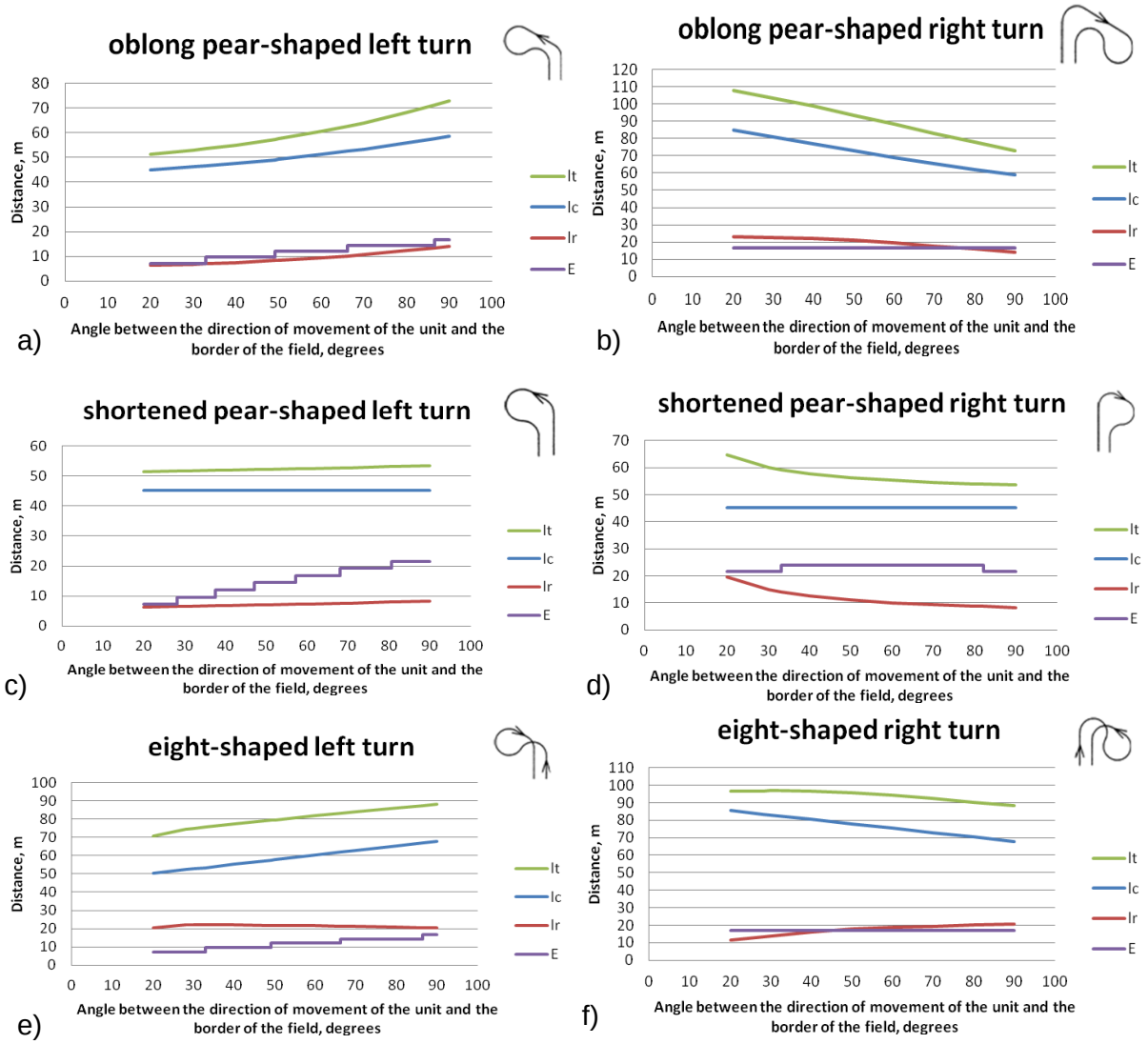


Figure 2. Length of the turns and width of the headland

part of the turn increases significantly at the left turn and decreases faster at the right turn. The width of the headland is smaller in the left turn and increases with increasing the angle α and in the great value of the angle is equal to the width of the headland in the right turn.
In Figure 2e and Figure 2f the results for eight-shaped turns are shown. They have the same character of change of the total length of the turn and the width of the headland as the other turns. The difference compared to the other turns is the change in the length of the rectilinear part of the turn. In the eight-shaped left turn with increasing the angle α, the length of the rectilinear part of the turn initially increases slightly until the boundary condition $\alpha = arctg\left(\frac{B}{l_a - l_n}\right)$, then decreases, while on the remaining left turns the length of the rectilinear part is increases. In the eight-shaped right turn the length of the rectilinear part increases, while in the other right turns decreases.
From the results it can be seen that the eight-shaped turns are with the greatest length. They are followed by the oblong pear-shaped turns. The shortened pear-shaped turns are with the smallest length. The width of the headland is the same for the eight-shaped turns and the oblong pear-shaped turns. It is smaller than the width of the headland of the shortened pear-shaped turns. The left turns have less length and narrower headland in comparison with the right turns. For small values of angle α, the oblong pear-shaped turns and the shortened pear-shaped turns have equal lengths and widths of headlands.

4. CONCLUSIONS

- When the angle between the direction of movement and the border of the field is positive the left turns are shorter than the right turns, when the angle is negative – vice versa.
- The shortened pear-shaped turns have the shortest length, followed by the oblong pear-shaped turns and the eight-shaped turns, but require wider headland than them.
- For small values of the angle the shortened pear-shaped turns and the oblong pear-shaped turns have similar lengths and widths of the headlands.

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[1] Trendafilov K. (2011). Theoretical determination of the length of turn when ploughing with a trailed and semi-mounted reversible ploughs in a field with irregular shape. Agricultural engineering, 2011, № 3, 23-29.
[2] Trendafilov K. (2010). Theoretical determination of the width of strip for turning when ploughing with trailed and semi-mounted reversible ploughs in a field with irregular shape, Agricultural science and technology, Volume 2, Number 4, December 2010.

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AN INVESTIGATION OF PATTERN MAKING OF TWISTED DRAPERIES

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Abstract: *One of the ways of design of draperies in clothing is by twisting of a piece. Usually patterns of that type of draperies are a result of moulage or draping method. A study of pattern making systems shows only one way for constructing of twisted draperies, which area result of transformation of bust darts. But this type of draperies can be situated in different areas of the clothing, not only in the bust area. Therefore it could be developed a systematic way for pattern making of twisted draperies without transformation of darts. Development of a system of pattern making of twisted draperies without transformation of darts is the aim of the paper. After the twisting, the draperied piece changed its sizes. Its width and height become smaller. If dependences between sizes of pieces before and after twisting will be found, the methodology of pattern making of twisted draperies would be full systematized. On the base of the measurements two linear regressions are realized for determination of the shortening by the width and height. The measures of the width and height shortening have to be added to the width and height of the pieces, which will be twisted. With the help of dependences for calculating of the additional width and height of the draped piece, which are results of presented regression analysis a system of pattern making of twisted draperies is developed. The developed system gives possibility for easy and correct pattern making of twisted draperies. The system facilitates the process of fashion design and pattern making especially on ready-to-wear industry and gives opportunity for variety of models with twisted draperies.*
Keywords: *fashion design, pattern making, drapery, twisted draperies, linear regression.*

1. INTRODUCTION

One of the ways of design of draperies in clothing is by twisting of a piece. Usually patterns of that type of draperies are a result of moulage or draping method. A study of pattern making systems shows only one way for constructing of twisted draperies [1], which area result of transformation of bust darts. But this type of draperies can be situated in different areas of the clothing, not only in the bust area. Figure 1 presents two models of ladies dresses with twisted draperies in the waist and in the bust. Therefore it could be developed a systematic way for pattern making of twisted draperies without transformation of darts.
Development of a system of pattern making of twisted draperies without transformation of darts is the aim of the paper.

2. METHODOLOGY

After the twisting, the draperied piece changed its sizes. Its width and height become smaller. If dependences between sizes of pieces before and after twisting will be found, the methodology of pattern making of twisted draperies would be full systematized. The dependences will be searched with the help of two-variable linear regressions. [2]

Figure 1. Ladies' dresses with twisted draperies in the waist and in the bust

Mathematical dependences are searched for the full systemized methodology of pattern making of twisted draperies. The problem is solved with the help of linear regression – formula (1):

$$Y = a + b_1 . X_1 + b_2 . X_2, \quad (1)$$

where Y is the dependent variable; X_1 and X_2 – independent variables; a – constant; b_1 and b_2 – coefficients of regressions.
The systemized mythology has to be suitable for different fabrics with good drapability. By this reason three fabrics with good drapability but in different structures are chosen. From the three fabrics rectangles in skew direction are cut in the sizes by width and height: 40,0 x 30,0 cm, 40,0 x 25,0 cm, 40,0 x 20,0 cm, 40,0 x 15,0 cm, 35,0 x 20,0 cm, 35,0 x 15,0 cm, 30,0 x 20,0 cm, 30,0 x 15,0 cm. All pieces are twisted in the way, presented in Figures 2 without additional effort as result of the skew direction and gravity.

Figure 2. Measurement of the width and height after twisting

After the twisting the pieces are shortened in width and height directions. For every rectangle three time the shortened width and height are measured.
On the base of the measurements two linear regressions are realized for determination of the shortening by the width and height. The measures of the width and height shortening have to be added to the width and height of the pieces, which will be twisted.

3. EXPERIMENTAL

For the determination of the additional width of the twisted piece formula (1) acquires mode (2):

$$Wadd = a + b_1 . Wp + b_2 . Hp, \quad (2)$$

where Wadd is additional width; Wp – primary width of the piece; Hp – primary height of the piece; a – constant; b_1 and b_2 – coefficients of regression.
For the determination of the additional height of the twisted piece formula (1) acquires mode (3):

$$Hadd = c + d_1 . Wp + d_2 . Hp, \quad (3)$$

where Hadd is additional height; Wp – primary width of the piece; Hp – primary height of the piece; c – constant; d_1 and d_2 – coefficients of regression.
The regressions are made with the help of the software STATISTICA 7.0. [3]

4. RESULTS

4.1. Additional width - Wadd

The linear regression results are a = -3,14722, b_1 = -0,03667, b_2 = 0,5144. The accuracy of the regression model is provided by the values of p < 0,0000, R-square = 0,90227262, and Std. Error of estimate = 0,84287..On the base of the statistical analysis formula (2) assumes form (4):

$$Wadd = -3,15 – 0,037 . Wp + 0,5 . Hp \quad (4)$$

The linear interaction between dependent and independent variables is shown in Figure 3.

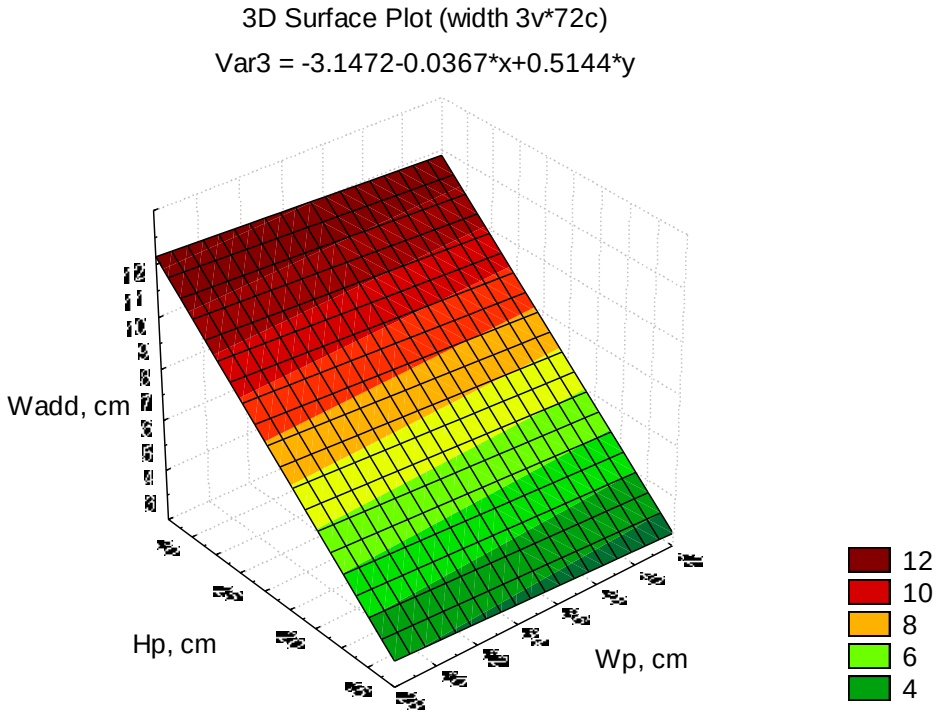

Figure 3. Linear interaction between dependent and independent variables

After the two-variable regression analysis it is seen that the value of b_1 = -0,03667 is minor and therefore an dependence between the dependent variable Wadd and the independent variable Hp without Wp can be searched. And formula (2) is transformed in (5):

$$Wadd = a + b \,.\, Hp \quad (5)$$

After the regression analysis the results are: a = -4,20139, and b = 0,50069. The accuracy of the regression model is provided by the values of p < 0,0000, R-square = 0,899634, and Std. Error of estimate = 0,84805. After the regression analysis formula (5) assumes form (6):

$$Wadd = -4,2 + 0,5 \,.\, Hp \quad (6)$$

4.2. Additional height - Hadd

The linear regression results are c = -2,63671, d_1 = -0,03667, d_2 = 0,5144. The accuracy of the regression model is provided by the values of p < 0,0000, R-square = 0,90227262, and Std. Error of estimate = 0,84287..On the base of the statistical analysis formula (3) assumes form (7):

$$Hadd = -2,6 – 0,037 \,.\, Wp + 0,5 \,.\, Hp \quad (7)$$

The linear interaction between dependent and independent variables is shown in Figure 4.

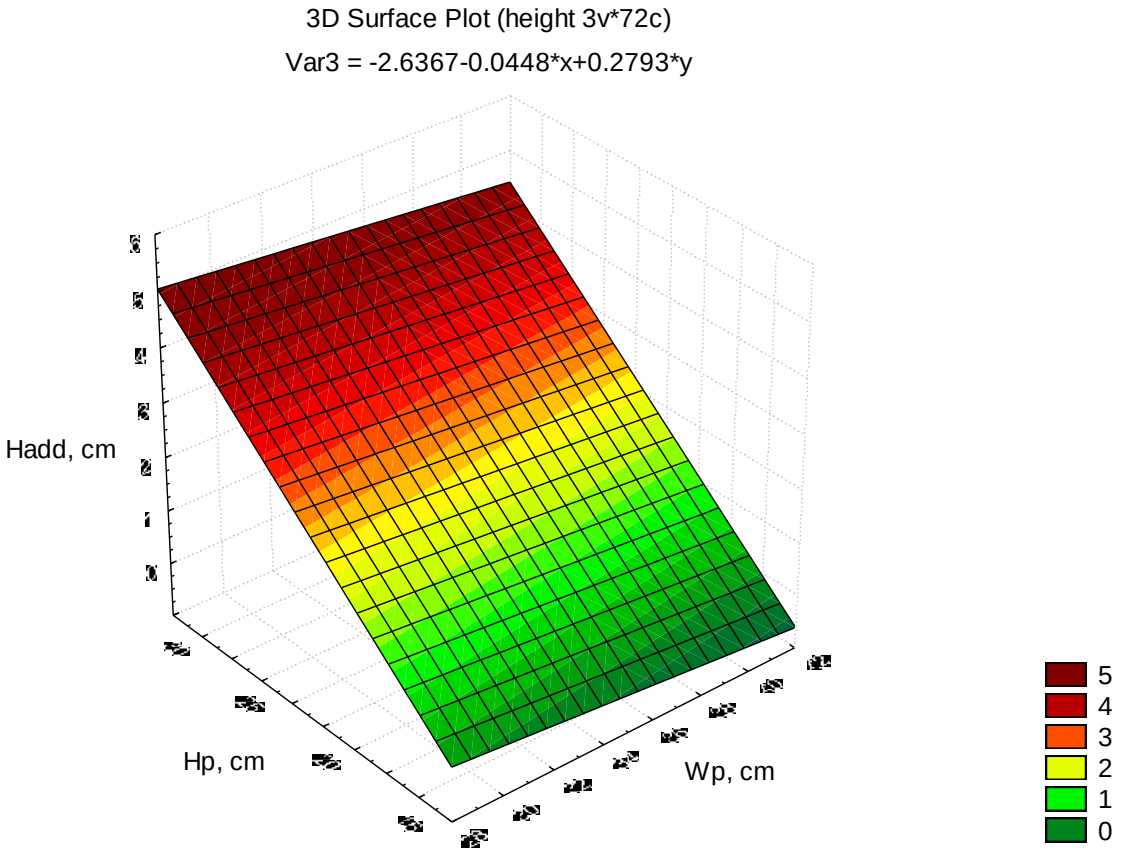

Figure 4. Linear interaction between dependent and independent variables

After the two-variable regression analysis it is seen that the value of d_1 = -0,03667 is minor and therefore an dependence between the dependent variable Hadd and the independent variable Hp without Wp can be searched. And formula (3) is transformed in (8):

$$Hadd = c + d \,.\, Hp \quad (8)$$

After the regression analysis the results are: c = -3,92361, and d = 0,26250. The accuracy of the regression model is provided by the values of p < 0,0000, R-square = 0,89680388, and Std. Error of estimate = 0,44799. After the regression analysis formula (8) assumes form (9):

$$Hadd = -3,9 + 0,26 \,.\, Hp \quad (9)$$

5. DEVELOPMENT OF A PATTERN MAKIG SYSTEM

The system of pattern making of twisted draperies is presented with a design of a lady's blouse with a piece with twisted draperies in the neck opening. The same pattern making system can be used for different location of the draped piece in different types of clothing. The pattern making of the draped detail is presented in Figures 5 and 6.

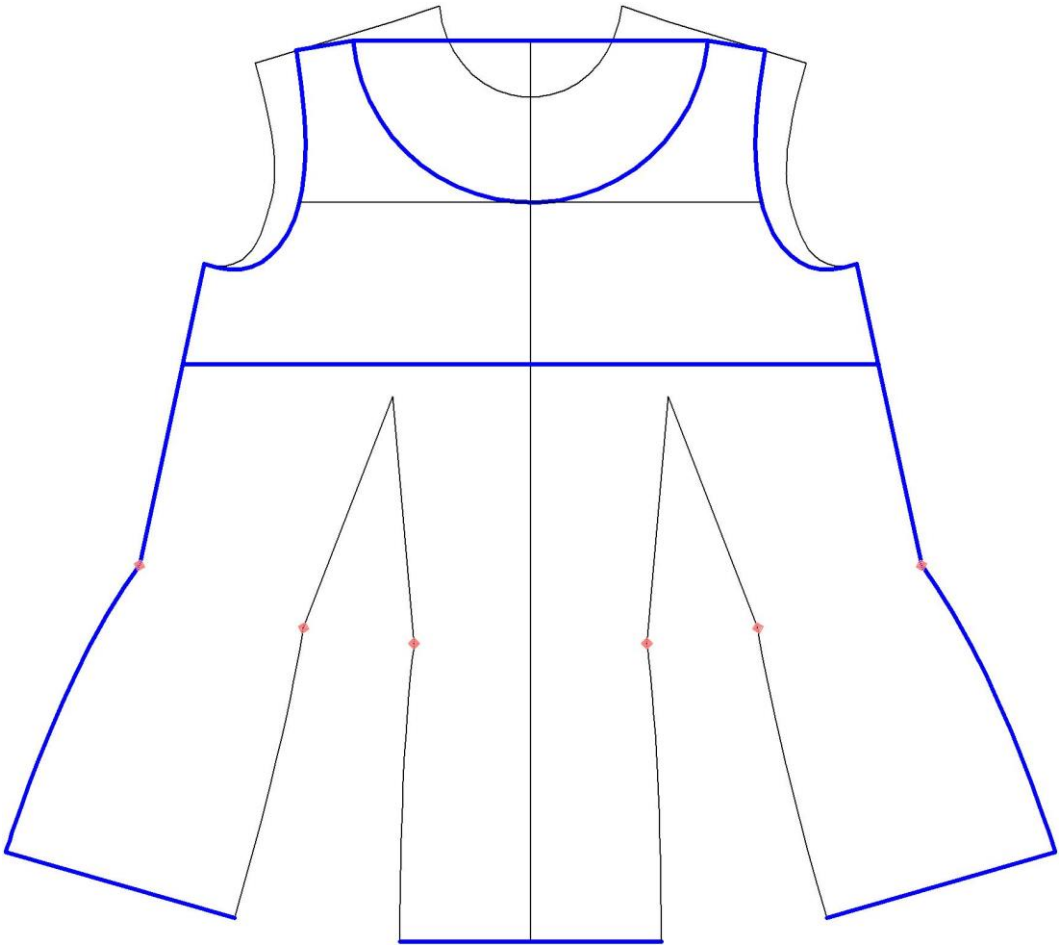

Figure 5. Pattern making of the twisted piece

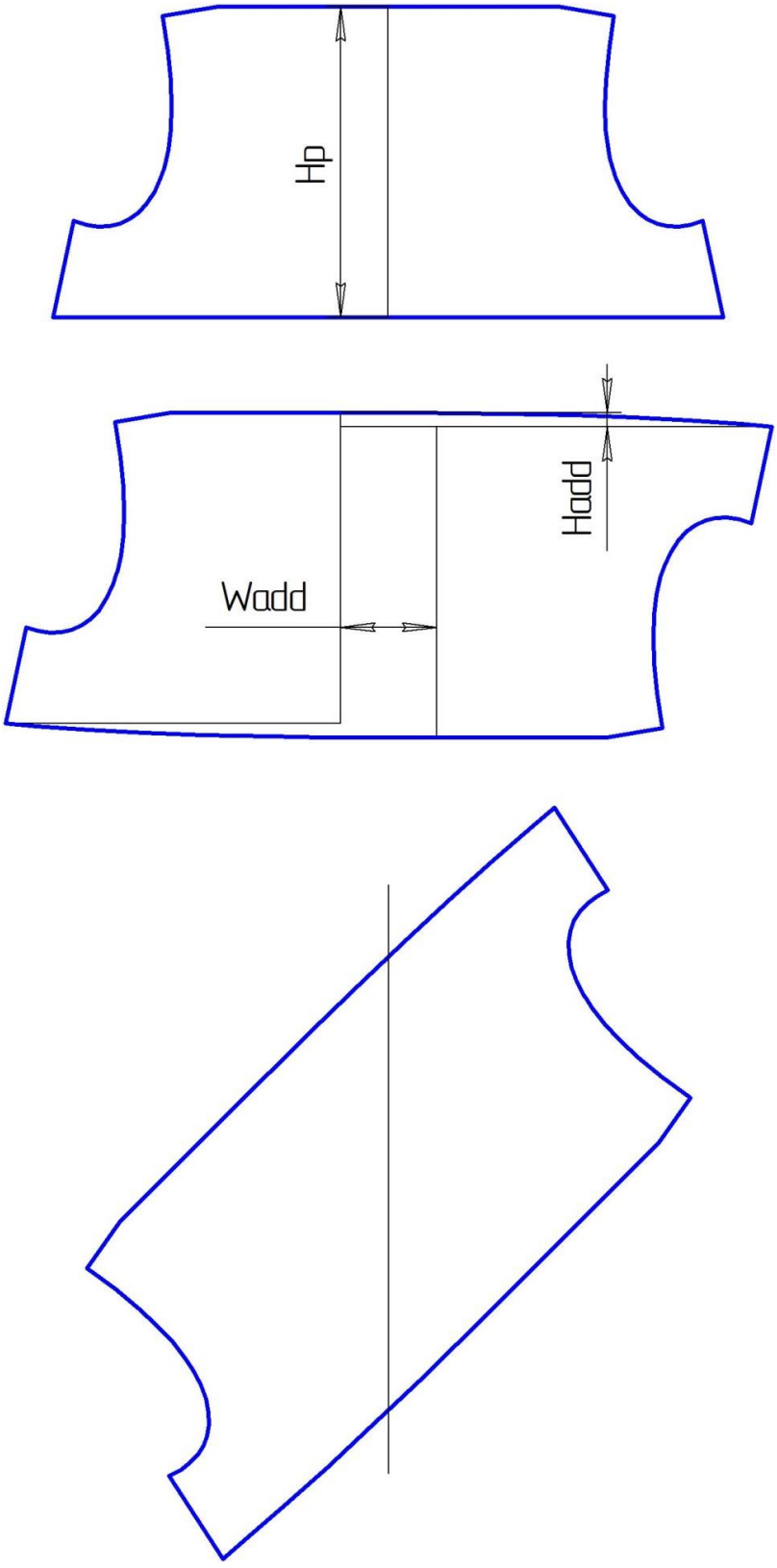

Figure 6. Pattern making of the twisted piece

In Figure 5 the twisted piece is dawn on the front with two horizontal lines. A first line is situated between the points of intersection of shoulders and neckline. The second horizontal one is located between the contours of the side seams over the bust points. The piece is situated between the both horizontal lines, shoulders, arms holes, and the parts of the side seams contours which are located over the down horizontal line, The neckline of the front is formed with arc of a circle or with a similar curved line with depth to the middle of the height of the draped piece.
In Figure 6 the draped piece is divided in two halves into the middle vertical line. In horizontal direction the both halves are set on distance, which is equal to the additional width Wadd, calculated by formula (6) as the one of the halves is turned in its mirror image. In vertical direction the both halves are set on distance, which is equal to the additional height Hadd, calculated by formula (9). Than the both halves are connected with light curved lines and the piece is turned into 45 degrees for the skew direction cutting.
An experienced model is presented in Figure 7.

Figure 7. An experienced model with twisted draperies

6. CONCLUSION

- With the help of dependences for calculating of the additional width and height of the draped piece, which are results of presented regression analysis a system of pattern making of twisted draperies is developed.
- The developed system gives possibility for easy and correct pattern making of twisted draperies.
- The system facilitates the process of fashion design and pattern making especially on ready-to-wear industry and gives opportunity for variety of models with twisted draperies.

7. ACKNOWLEDGEMENTS

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SELECTION OF INFORMATIVE COLOR FEATURES FOR CLASSIFICATION OF OBJECT AREAS OF WHITE BRINED CHEESE AND MOLD

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Abstract: *The dairy product white brined cheese is made from cows, sheep's milk or a mixture of them, which is traditional for Bulgaria. Important from a practical point of view to provide objective information about the changes occurring in the product during storage. On the contemporary level of development of science few are the publications related to changes in the surface characteristics of this product when stored under conditions not corresponding to those specified by the manufacturer. The aim of the report is to present a selection of complex color informative features describing the change of object areas of white brined cheese in storage period. Descriptive statistics is presented for 16 color components of five color models (RGB, HSV, Lab, LCH, CMYK), obtained by processing color digital images of the product. The selection of color features is made by the method "Correspondence analysis" applied to the results obtained with the distance functions. A comparative analysis of methods for classification is made. Used methods are "Cluster analysis" and "Discriminant function analysis". A set of informative color features suitable for classification is proposed.*
Keywords: *White brined cheese, Color features, Distance functions, Correspondence analysis, Cluster analysis, Discriminant function analysis.*

1. INTRODUCTION

White brined cheese is a product made from cows, sheep's milk or a mixture of them, which is traditional for Bulgaria. It has undergone a physicochemical and biochemical changes due to rennet and enzymes of lactic acid organisms. Ripened cheese has moderate salinity and pronounced acidity. It is widely spread both in Bulgaria and in the culinary region of our neighboring countries [3,8].
Important from a practical point of view to provide objective information about the changes occurring in the product during storage. These changes are related to the change in its surface characteristics and its physico-chemical properties.
In recent years, these changes in the properties and composition of the cheese in storage have been the subject of scientific researches [3,8,10]. Few are the publications related to changes in the surface characteristics of this product when stored under conditions not corresponding to those specified by the manufacturer.
Grading the cheese by its color features requires the use of precise and rapid procedures for obtaining, processing and interpreting the most informative set of features relating to the quality characteristics of the object areas on its surface. The formal representation of the object areas studied by a set of physical properties derived from the source data is used to classify their study into one of the predefined classes. Since the output data for the surface characteristics of the product being studied is formed by a system for obtaining, processing and analyzing images, the data is highly dimensional and the first phase is particularly important for the efficiency of the overall procedure and for the quality of the results obtained.

The first condition in the grading of features is to find a minimal description of the feature space, and the second condition is to find features that are as little as possible dependent on each other [1,5,8].
The main **purpose** of this article is to determine the information value of color features from color models, to recognize the object areas on the surface of white brined cheese and to determine the accuracy of the classification.

2. MATERIAL AND METHODS

The material used in the study is white brined cheese, purchased commercially. The parameters of the cheese are:
- ✓ Manufactured by BNS 15:2010, Amendment 1:2014 [2,3];
- ✓ Partied: L04130217;
- ✓ Content by label: Cow milk, Cheesy enzyme, Calcium dichloride, Salt, yeast;
- ✓ Storage conditions by label: from -2°C to 4°C.

Samples of 10,5x7,5cm and 1cm thick were prepared.
A Digimax 250 digital camera with serial number 34603308 was used. Digital images with resolution 1600x1200 pixels were obtained. Device settings are “default”. A flash is used.
The measurement were conducted for 12 days in conditions not corresponding to those specified by the manufacturer. The storage conditions were: room temperature 20-22°C; relative humidity 40-42% RH. The resulting images of changes in surface characteristics of chees during storage are presented on figure 1. Values of 16 color components of five color models RGB, HSV, Lab, LCH, CMYK are obtained.

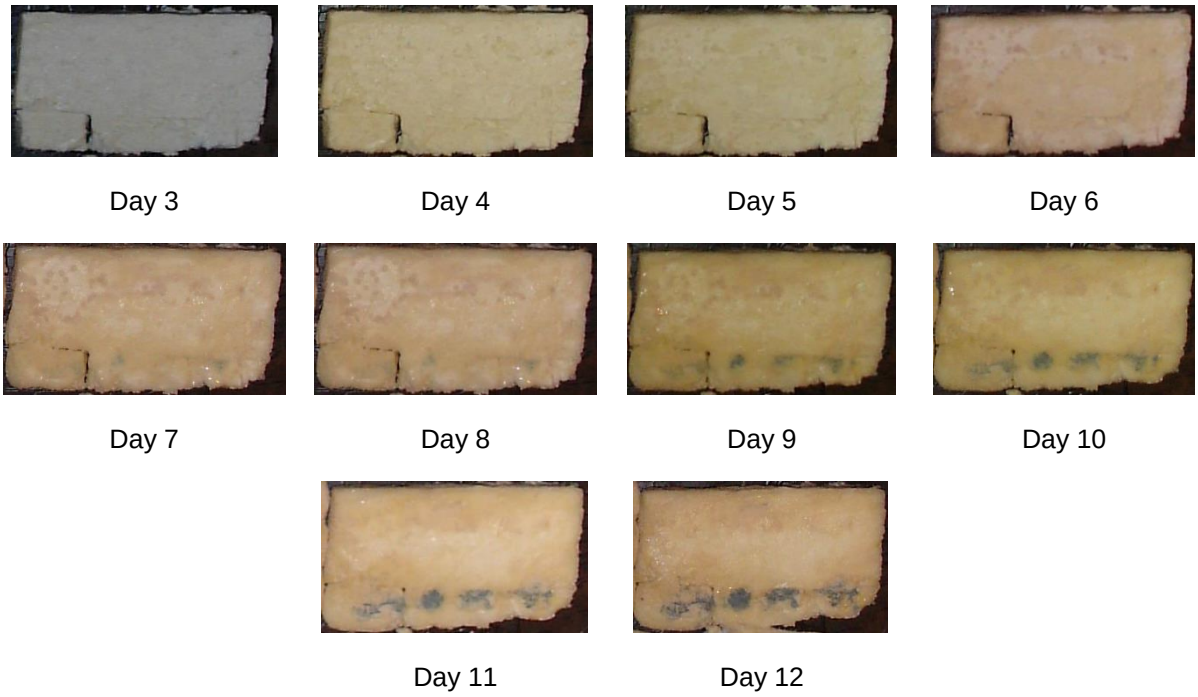

Figure 1. Changes of the surface of cheese in storage period

In Table 1 is a description of the investigated functions of the distances between the color components. The distances used are: Mahalanobis distance, Euclidean distance, Minkowski distance, a distance of Manhattan (Cityblock), Chebyshev distance and Fisher discriminant ratio.

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The obtained data for the change of the color components during the cheese storage period represent a three-dimensional matrix of the $n_x k_x j$ type, where DF=1...n are the values of the distances determined by the represented functions; CC=1...k are the color components; Day=1...i are the days of storage. Data for each day of storage can be considered as a separate two-dimensional matrix $n_x k$. Figure 2 represents the used data as three dimensional matrix.

Table 1. Distance functions used in the study

Function	Mathematical formula	Description
Mahalanobis	$d_{st}^{\ 2} = (x_s - y_t)C^{-1}(x_s - y_t)'$	C – covariance matrix
Euclidean	$d_{st}^{\ 2} = (x_s - y_t)(x_s - y_t)'$	x and y – the compared vectors
Cityblock	$d_{st} = \sum_{j=1}^{n} \lvert x_{sj} - y_{tj} \rvert$	
Chebychev	$d_{st} = max_j\{\lvert x_{sj} - y_{tj} \rvert\}$	max – maximum
Fisher discriminant ratio	$d_{st} = \frac{(\bar{x} - \bar{y})^2}{SD_x^{\ 2} + SD_y^{\ 2}}$	SD – standard deviation

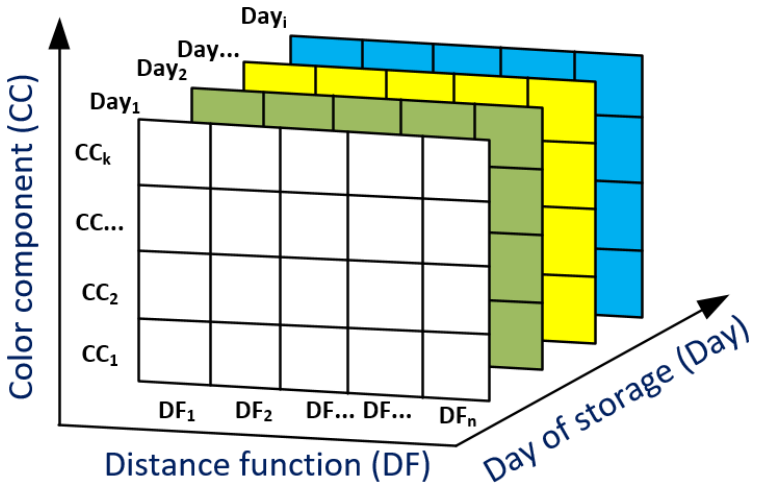

Figure 2. Three dimensional matrix of used data for color components, distance functions and days of storage

The "Correspondence analysis" method, available in the Statistica software, has been used. This analysis is a multidimensional method that enables data to be tabled by graphical interpretation, and the columns in the table can be represented as points in a small dimension space with a subsequent interpretation called the "Correspondence map" [6,9].
The classification of object areas is made by two classifiers.

✓ **Discriminant function analysis** [4] which is a statistical analysis to predict a categorical dependent variable, called a grouping variable by one or more continuous or binary independent variables, called predictor variables. The “quadratic” nonlinear discriminant function is used. This function is defined as:

$$d(x_1, x_2) = K + [x_1\ x_2]L + [x_1\ x_2]Q\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} \qquad (1)$$

where K is constant, L – linear function, Q – quadratic function;

✓ **k-means clustering.** This classification method performs k-means clustering to partition the observations of the $n_x p$ data matrix X into k clusters, and returns an $n_x 1$ vector containing cluster indices of each observation. Rows of X correspond to points and columns correspond to variables. In the study the number of replications is set to 10 replications and "sqeuclidean" separation function is used. The function Squared Euclidean distance uses each centroid as the mean of the points in cluster. It is defined by the function $d(x,c)=(x-c).(x-c)'$ [7].

3. RESULTS AND DISCUSSION

Descriptive statistics of these color components of object areas with cheese are shown in Table 2. The color components are presented with their mean value, standard deviation and coefficient of variation. It can be seen that there are small values of the coefficient of variation – under 30% for most of the color components. An analysis is made of the change in the values of the color components of the color models for object areas with mold. Changes of the values of object areas with mold are not used as the primary criterion for determining the process, as such areas on the surface of the products appear visibly after day 3. The descriptive statistics of changes of the values of color components for object areas with mold are presented on Table 3.

Table 2. Descriptive statistics of color components for object areas of white brined cheese

		RGB			HSV			Lab			LCH			CMYK			
Day		R	G	B	H	S	V	L	a	b	L	C	H	C	M	Y	K
3	mean	131,57	132,42	129,72	0,24	0,02	0,52	140,67	127,31	129,36	55,16	1,79	114,26	44,63	37,52	44,69	111,54
	SD	5,60	5,56	6,16	0,15	0,01	0,02	5,51	0,72	1,16	2,16	1,00	51,40	3,84	2,80	5,91	5,75
	CV	0,04	0,04	0,05	0,63	0,57	0,04	0,04	0,01	0,01	0,04	0,56	0,45	0,09	0,07	0,13	0,05
4	mean	166,69	153,14	119,84	0,12	0,28	0,65	162,69	129,26	147,48	63,80	19,54	86,27	27,08	42,42	100,89	81,06
	SD	9,22	8,59	8,92	0,01	0,02	0,04	8,38	0,97	1,57	3,29	1,56	2,90	3,78	4,37	8,18	8,76
	CV	0,06	0,06	0,07	0,05	0,08	0,06	0,05	0,01	0,01	0,05	0,08	0,03	0,14	0,10	0,08	0,11
5	mean	156,37	143,41	108,14	0,12	0,31	0,61	153,05	128,90	148,68	60,02	20,73	87,46	31,50	46,21	112,09	90,88
	SD	8,11	8,60	9,52	0,01	0,03	0,03	8,22	1,02	2,05	3,22	2,04	2,88	3,46	5,82	10,60	7,98
	CV	0,05	0,06	0,09	0,05	0,11	0,05	0,05	0,01	0,01	0,05	0,10	0,03	0,11	0,13	0,09	0,09
6	mean	163,28	140,42	114,49	0,09	0,30	0,64	153,00	133,97	145,27	60,00	18,34	70,56	27,07	62,21	98,10	84,50
	SD	6,96	6,95	9,45	0,01	0,04	0,03	6,69	1,31	2,93	2,63	2,81	5,06	2,89	6,32	13,31	7,13
	CV	0,04	0,05	0,08	0,10	0,14	0,04	0,04	0,01	0,02	0,04	0,15	0,07	0,11	0,10	0,14	0,08
7	mean	176,36	149,45	118,01	0,09	0,33	0,69	162,52	134,96	148,61	63,74	21,80	71,08	22,19	61,91	104,21	71,78
	SD	8,27	8,45	11,17	0,01	0,04	0,03	8,01	1,32	3,09	3,14	3,02	4,05	3,11	6,83	14,33	8,06
	CV	0,05	0,06	0,09	0,08	0,13	0,05	0,05	0,01	0,02	0,05	0,14	0,06	0,14	0,11	0,14	0,11
8	mean	175,89	149,91	117,57	0,09	0,33	0,69	162,70	134,46	148,91	63,80	21,93	72,75	22,48	60,12	105,32	72,31
	SD	7,63	7,77	9,49	0,01	0,03	0,03	7,37	1,37	2,15	2,89	2,11	3,77	2,97	6,49	10,99	7,43
	CV	0,04	0,05	0,08	0,07	0,10	0,04	0,05	0,01	0,01	0,05	0,10	0,05	0,13	0,11	0,10	0,10
9	mean	156,34	134,83	87,21	0,11	0,44	0,61	146,35	131,51	156,75	57,39	28,99	83,04	31,52	61,12	146,58	91,39
	SD	7,17	7,70	9,91	0,01	0,04	0,03	7,33	1,41	2,45	2,87	2,47	2,71	2,98	7,03	12,69	7,43
	CV	0,05	0,06	0,11	0,05	0,10	0,05	0,05	0,01	0,02	0,05	0,09	0,03	0,09	0,11	0,09	0,08
10	mean	163,75	142,62	89,79	0,12	0,46	0,64	153,63	130,83	159,13	60,25	31,30	84,88	28,91	55,92	149,41	83,83
	SD	10,47	11,93	15,65	0,01	0,06	0,04	11,21	1,62	3,25	4,40	3,30	2,83	4,20	9,52	18,74	10,38
	CV	0,06	0,08	0,17	0,05	0,14	0,06	0,07	0,01	0,02	0,07	0,11	0,03	0,15	0,17	0,13	0,12
11	mean	199,85	170,33	130,31	0,10	0,35	0,78	182,65	134,94	152,90	71,63	25,89	74,23	15,09	54,22	106,15	48,83
	SD	10,38	11,81	16,59	0,01	0,06	0,04	10,82	1,27	3,84	4,24	3,82	3,02	3,13	7,69	17,98	10,16
	CV	0,05	0,07	0,13	0,06	0,16	0,05	0,06	0,01	0,03	0,06	0,15	0,04	0,21	0,14	0,17	0,21
12	mean	174,49	142,75	100,91	0,09	0,43	0,68	156,90	136,26	155,07	61,53	28,34	72,95	23,17	71,43	132,03	74,00
	SD	12,36	14,78	19,05	0,01	0,07	0,05	13,70	1,63	3,84	5,37	3,90	3,03	4,41	12,38	22,37	12,58
	CV	0,07	0,10	0,19	0,06	0,17	0,07	0,09	0,01	0,02	0,09	0,14	0,04	0,19	0,17	0,17	0,17

Mean – average value; SD – standard deviation; CV – coefficient of variation

Table 3. Descriptive statistics of color components for object areas with mold

		RGB			HSV			Lab			LCH			CMYK			
day		R	G	B	H	S	V	L	a	b	L	C	H	C	M	Y	K
3	mean	115,20	107,36	67,64	0,14	0,42	0,45	115,35	126,48	151,39	45,24	23,47	93,63	56,15	59,81	156,71	129,36
	SD	20,94	18,60	16,91	0,01	0,06	0,08	19,54	1,39	3,29	7,66	3,31	3,33	13,30	9,21	19,68	20,16
	CV	0,18	0,17	0,25	0,07	0,14	0,18	0,17	0,01	0,02	0,17	0,14	0,04	0,24	0,15	0,13	0,16
4	mean	106,85	106,37	76,58	0,17	0,30	0,42	112,62	124,30	144,83	44,16	17,32	103,01	68,38	55,01	136,00	132,18
	SD	26,99	25,04	23,21	0,02	0,10	0,10	26,75	1,60	4,24	10,49	4,17	6,21	20,28	15,44	27,03	26,35
	CV	0,25	0,24	0,30	0,12	0,33	0,24	0,24	0,01	0,03	0,24	0,24	0,06	0,30	0,28	0,20	0,20
5	mean	99,97	99,17	70,89	0,17	0,32	0,40	105,31	124,87	144,12	41,30	16,71	103,56	72,09	60,49	138,23	139,34
	SD	27,31	27,54	29,05	0,04	0,19	0,11	28,89	2,39	8,56	11,33	8,33	13,20	19,40	20,39	40,76	29,18
	CV	0,27	0,28	0,41	0,24	0,58	0,27	0,27	0,02	0,06	0,27	0,50	0,13	0,27	0,34	0,29	0,21
6	mean	83,62	90,03	77,82	0,30	0,18	0,36	95,14	123,69	134,19	37,31	8,54	136,83	87,70	59,16	104,72	150,33
	SD	15,77	16,77	20,29	0,11	0,15	0,06	17,72	2,16	6,61	6,95	5,70	28,03	14,05	14,69	33,50	17,61
	CV	0,19	0,19	0,26	0,35	0,83	0,18	0,19	0,02	0,05	0,19	0,67	0,20	0,16	0,25	0,32	0,12
7	mean	78,98	88,17	78,46	0,33	0,16	0,35	92,60	122,75	132,34	36,31	7,59	144,21	95,06	58,54	100,60	151,96
	SD	18,84	17,66	15,96	0,10	0,08	0,07	19,06	2,29	3,95	7,47	3,12	25,55	18,62	13,19	18,71	18,54
	CV	0,24	0,20	0,20	0,30	0,50	0,20	0,21	0,02	0,03	0,21	0,41	0,18	0,20	0,23	0,19	0,12
8	mean	74,58	81,42	72,02	0,29	0,14	0,32	85,65	123,73	132,55	33,59	6,69	132,49	95,55	65,04	105,01	159,50
	SD	20,19	21,13	19,41	0,10	0,06	0,08	22,84	2,44	2,59	8,96	2,62	26,22	18,14	17,63	18,46	22,48
	CV	0,27	0,26	0,27	0,34	0,41	0,26	0,27	0,02	0,02	0,27	0,39	0,20	0,19	0,27	0,18	0,14

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9	mean	82,36	85,07	71,89	0,21	0,16	0,34	90,70	124,89	135,33	35,57	8,16	114,78	83,16	63,77	110,20	156,33
	SD	12,38	11,76	11,20	0,05	0,05	0,05	12,73	1,48	2,73	4,99	2,54	13,83	11,96	8,46	15,25	12,11
	CV	0,15	0,14	0,16	0,26	0,33	0,14	0,14	0,01	0,02	0,14	0,31	0,12	0,14	0,13	0,14	0,08
10	mean	81,67	83,71	70,25	0,20	0,18	0,33	89,03	125,17	135,63	34,92	8,39	112,10	83,89	66,59	113,12	157,70
	SD	20,49	20,76	20,04	0,06	0,08	0,08	22,49	1,87	3,08	8,82	2,98	18,13	17,50	16,96	22,42	21,33
	CV	0,25	0,25	0,29	0,31	0,44	0,24	0,25	0,01	0,02	0,25	0,36	0,16	0,21	0,25	0,20	0,14
11	mean	88,04	90,45	75,39	0,21	0,18	0,36	96,14	124,87	136,41	37,70	9,36	114,02	80,24	61,91	111,80	150,33
	SD	20,72	21,01	20,63	0,07	0,09	0,08	22,42	2,07	4,19	8,79	3,84	17,29	16,92	16,03	23,79	22,06
	CV	0,24	0,23	0,27	0,32	0,51	0,23	0,23	0,02	0,03	0,23	0,41	0,15	0,21	0,26	0,21	0,15
12	mean	91,67	95,46	79,59	0,22	0,18	0,38	101,08	124,17	136,61	39,64	9,75	115,78	79,74	57,91	110,57	144,87
	SD	20,39	21,19	20,54	0,06	0,08	0,08	22,43	2,06	3,26	8,80	2,91	16,12	16,54	16,14	21,68	22,29
	CV	0,22	0,22	0,26	0,30	0,43	0,22	0,22	0,02	0,02	0,22	0,30	0,14	0,21	0,28	0,20	0,15

Mean – average value; SD – standard deviation; CV – coefficient of variation

Table 4. Distances between object areas with cheese and mold

		RGB			HSV			Lab			LCH			CMYK			
day		R	G	B	H	S	V	L	a	b	L	C	H	C	M	Y	K
3	Mah	1,8	1,8	1,8	1,7	1,8	1,8	1,8	1,7	1,8	1,8	1,8	1,7	1,8	1,8	1,8	1,8
	Eu	25,9	23,4	21,8	0,2	0,1	0,1	24,4	1,9	4,1	9,6	4,1	52,9	16,6	11,4	24,6	25,2
	Cb	30,4	27,7	26,3	0,2	0,1	0,1	28,7	2,3	4,9	11,3	4,8	55,7	19,5	13,5	29,1	29,6
	Mink	25,9	23,4	21,8	0,2	0,1	0,1	24,4	1,9	4,1	9,6	4,1	52,9	16,6	11,4	24,6	24,6
	Cheb	24,9	22,3	20,5	0,2	0,1	0,1	23,4	1,7	3,9	9,2	3,9	52,6	15,9	10,9	23,5	24,1
	FDR	0,6	1,7	11,9	0,5	43,8	0,6	1,6	0,3	39,9	1,6	39,4	0,2	0,7	5,4	29,7	0,7
4	Mah	1,8	1,8	1,8	1,8	1,7	1,8	1,8	1,7	1,8	1,8	1,8	1,8	1,8	1,7	1,7	1,8
	Eu	33,6	31,0	29,2	0,0	0,1	0,1	32,5	2,3	5,4	12,7	5,3	8,3	23,3	17,6	32,2	32,5
	Cb	40,5	37,4	35,5	0,0	0,1	0,2	38,8	2,8	6,5	15,2	6,4	10,1	26,6	20,8	37,9	39,0
	Mink	33,6	31,0	29,2	0,0	0,1	0,1	32,5	2,3	5,4	12,7	5,3	8,3	23,3	17,6	32,2	32,2
	Cheb	31,7	29,3	27,5	0,0	0,1	0,1	30,8	2,1	5,1	12,1	5,0	7,7	22,7	16,8	30,7	30,8
	FDR	4,4	3,1	3,0	5,0	0,0	4,5	3,2	7,0	0,3	3,2	0,2	6,0	4,0	0,6	1,5	3,4
5	Mah	1,8	1,8	1,8	1,8	1,7	1,8	1,8	1,8	1,7	1,8	1,7	1,7	1,8	1,8	1,8	1,8
	Eu	33,8	34,4	36,8	0,0	0,2	0,1	35,5	3,1	10,0	13,9	9,7	15,0	22,1	24,3	49,7	35,9
	Cb	40,0	40,9	44,0	0,1	0,2	0,2	41,8	3,8	11,6	16,4	11,3	17,2	25,0	28,6	57,8	42,1
	Mink	33,8	34,4	36,8	0,0	0,2	0,1	35,5	3,1	10,0	13,9	9,7	15,0	22,1	24,3	49,7	49,7
	Cheb	32,2	32,7	34,9	0,0	0,2	0,1	33,9	2,9	9,6	13,3	9,4	14,5	21,5	23,2	47,8	34,3
	FDR	3,9	2,4	1,5	1,4	0,0	3,5	2,5	2,4	0,3	2,5	0,2	1,4	4,2	0,5	0,4	2,6
6	Mah	1,8	1,8	1,7	1,8	1,6	1,8	1,7	1,8	1,7	1,7	1,7	1,8	1,8	1,7	1,7	1,8
	Eu	20,5	21,4	26,0	0,1	0,1	0,1	22,1	3,1	8,0	8,7	7,0	33,2	16,4	18,0	40,0	22,5
	Cb	25,0	26,2	32,1	0,1	0,2	0,1	26,7	3,8	9,8	10,5	8,6	37,5	18,7	22,1	48,6	27,3
	Mink	20,5	21,4	26,0	0,1	0,1	0,1	22,1	3,1	8,0	8,7	7,0	33,2	16,4	18,0	40,0	40,0
	Cheb	19,0	20,0	24,1	0,1	0,1	0,1	20,7	2,8	7,4	8,1	6,5	32,4	15,9	16,8	37,4	21,0
	FDR	21,4	7,7	2,7	4,0	0,7	16,4	9,3	16,6	2,3	9,3	2,4	5,4	17,9	0,0	0,0	12,0
7	Mah	1,8	1,8	1,7	1,8	1,6	1,8	1,8	1,8	1,7	1,8	1,7	1,8	1,8	1,7	1,7	1,8
	Eu	24,5	23,2	23,5	0,1	0,1	0,1	24,2	3,3	6,0	9,5	5,3	30,1	21,8	16,9	28,5	23,7
	Cb	29,9	28,5	29,5	0,1	0,1	0,1	29,5	4,0	7,5	11,6	6,6	33,6	24,6	20,9	36,1	28,9
	Mink	24,5	23,2	23,5	0,1	0,1	0,1	24,2	3,3	6,0	9,5	5,3	30,1	21,8	16,9	28,5	28,5
	Cheb	22,9	21,5	21,4	0,1	0,1	0,1	22,6	3,0	5,4	8,9	4,8	29,5	21,3	15,5	25,8	22,0
	FDR	22,4	9,8	4,1	5,8	3,8	20,5	11,4	21,3	10,5	11,4	10,7	8,0	14,9	0,1	0,0	15,7
8	Mah	1,8	1,8	1,8	1,7	1,7	1,8	1,8	1,8	1,7	1,8	1,8	1,7	1,8	1,7	1,8	1,8
	Eu	25,7	26,7	26,1	0,1	0,1	0,1	28,1	3,4	4,2	11,0	4,2	28,1	21,1	21,6	26,2	27,9
	Cb	31,2	32,3	32,3	0,1	0,1	0,1	33,6	4,2	5,2	13,2	5,3	31,3	23,7	26,0	32,9	33,4
	Mink	25,7	26,7	26,1	0,1	0,1	0,1	28,1	3,4	4,2	11,0	4,2	28,1	21,1	21,6	26,2	26,2
	Cheb	24,1	25,1	24,1	0,1	0,1	0,1	26,6	3,1	3,7	10,4	3,8	27,5	20,6	20,3	23,9	26,4
	FDR	22,0	9,3	4,4	4,0	8,8	17,8	10,3	14,7	23,6	10,3	20,5	5,1	15,8	0,1	0,0	13,6
9	Mah	1,8	1,8	1,8	1,7	1,7	1,8	1,8	1,7	1,8	1,8	1,8	1,7	1,8	1,7	1,8	1,8
	Eu	17,6	17,4	18,6	0,1	0,1	0,1	18,0	2,5	4,5	7,1	4,4	15,3	14,2	13,5	24,6	17,5
	Cb	21,9	21,8	23,7	0,1	0,1	0,1	22,5	3,1	5,7	8,8	5,6	17,5	16,6	17,1	31,2	21,9
	Mink	17,6	17,4	18,6	0,1	0,1	0,1	18,0	2,5	4,5	7,1	4,4	15,3	14,2	13,5	24,6	24,6
	Cheb	16,1	15,8	16,8	0,1	0,1	0,1	16,5	2,3	4,1	6,5	4,0	14,8	13,7	12,2	22,2	16,0
	FDR	26,7	12,5	1,0	3,0	16,3	26,1	14,4	10,6	34,1	14,4	34,6	5,1	17,6	0,1	3,4	20,9
10	Mah	1,8	1,8	1,8	1,7	1,7	1,8	1,8	1,7	1,8	1,8	1,8	1,6	1,8	1,7	1,8	1,8
	Eu	27,9	29,2	31,5	0,1	0,1	0,1	30,2	3,0	5,6	11,9	5,6	18,0	20,6	22,8	36,6	28,5
	Cb	34,5	36,2	39,8	0,1	0,2	0,1	37,2	3,8	7,1	14,6	7,1	20,3	23,9	28,2	46,5	35,0
	Mink	27,9	29,2	31,5	0,1	0,1	0,1	30,2	3,0	5,6	11,9	5,6	18,0	20,6	22,8	36,6	36,6
	Cheb	25,8	26,8	28,6	0,1	0,1	0,1	28,0	2,7	5,1	11,0	5,0	17,5	19,8	21,0	33,0	26,5
	FDR	12,7	6,1	0,6	1,7	7,5	11,8	6,6	5,2	27,5	6,6	26,6	2,2	9,3	0,3	1,5	9,7
11	Mah	1,8	1,8	1,8	1,8	1,7	1,8	1,8	1,7	1,8	1,8	1,7	1,8	1,7	1,7	1,8	1,8
	Eu	27,7	29,2	33,0	0,1	0,1	0,1	29,7	2,9	7,0	11,6	6,7	20,1	19,2	20,9	37,3	29,0
	Cb	34,4	36,7	42,1	0,1	0,2	0,1	36,9	3,6	8,9	14,5	8,5	22,7	21,8	25,9	47,2	35,8
	Mink	27,7	29,2	33,0	0,1	0,1	0,1	29,7	2,9	7,0	11,6	6,7	20,1	19,2	20,9	37,3	37,3
	Cheb	25,5	26,6	29,6	0,1	0,1	0,1	27,4	2,7	6,4	10,7	6,1	19,6	18,7	19,2	33,7	26,8
	FDR	23,3	11,0	4,3	2,9	2,4	21,1	12,1	17,2	8,4	12,1	9,3	5,1	14,3	0,2	0,0	17,5
12	Mah	1,8	1,8	1,8	1,7	1,7	1,8	1,8	1,8	1,8	1,8	1,8	1,8	1,7	1,7	1,8	1,8
	Eu	28,9	31,7	34,9	0,1	0,1	0,1	31,7	3,3	6,3	12,5	6,1	18,7	19,3	24,5	39,0	31,0
	Cb	36,3	40,2	44,5	0,1	0,2	0,1	40,0	4,1	8,0	15,7	7,6	21,2	22,7	31,0	49,6	38,9
	Mink	28,9	31,7	34,9	0,1	0,1	0,1	31,7	3,3	6,3	12,5	6,1	18,7	19,3	24,5	39,0	39,0
	Cheb	26,4	28,6	31,3	0,1	0,1	0,1	28,9	2,9	5,7	11,3	5,5	18,2	18,4	22,1	35,2	28,3
	FDR	12,1	3,3	0,6	3,5	5,2	10,3	4,5	21,2	13,4	4,5	14,6	6,8	10,9	0,4	0,5	7,7

Mah – Mahalanobis distance; Eu – Euclidean distance; Cb – distance of Manhattan; Mink – Mincowski distance; Cheb – Chebyshev distance; FDR – Fisher discriminant ratio

The results from distance functions calculated are presented in Table 4. These distances are between the values of color components of object areas with cheese and mold and their change in storage period. Changes of the distances are shown in days from 3 to 12 for every color component from 5 color models.

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The resulting distances are processed with method “Correspondence analysis. Figure 3 presents the results from correspondence analysis of the data. The influence of three parameters are present. On X axis are present distances between color components, Y axis is for color components and Z axis for days of storage. The color components have higher influence 95% on the change of data, distance functions have 5% and days of storage 0,3%.

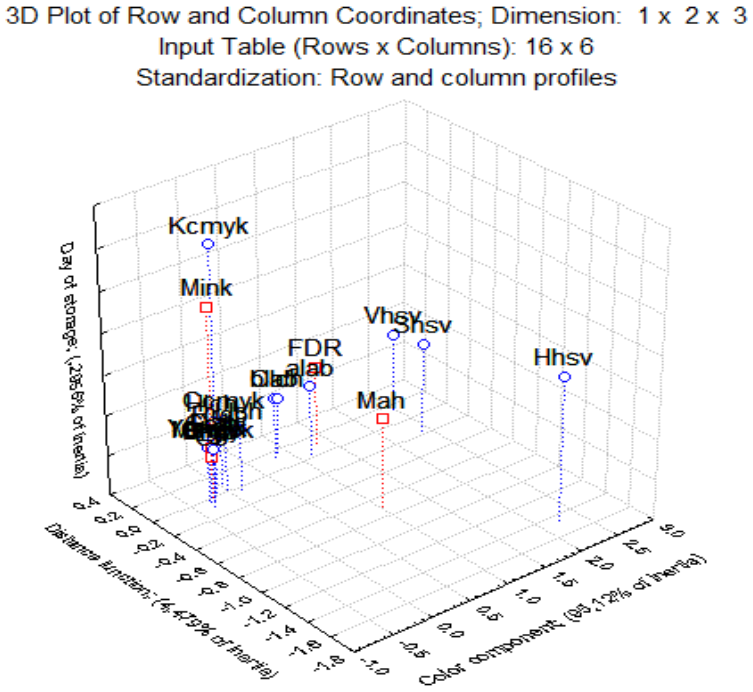

Figure 3. Results from correspondence analysis

Table 5. Results from correspondence analysis

Distance function	Mah	Eu	Cb	Mink	Cheb	FDR
Color component	H (HSV)	R (RGB) G (RGB) B (RGB) L (Lab) L (LCH) H (LCH) C (CMYK) M (CMYK) Y (CMYK)	R (RGB) G (RGB) B (RGB) L (Lab) L (LCH) H (LCH) C (CMYK) M (CMYK) Y (CMYK)	K (CMYK)	R (RGB) G (RGB) B (RGB) L (Lab) L (LCH) H (LCH) C (CMYK) M (CMYK) Y (CMYK)	S (HSV) V (HSV) a (Lab) b (Lab) C (LCH)
Mah – Mahalanobis distance; Eu – Euclidean distance; Cb – distance of Manhattan; Mink – Mincowski distance; Cheb – Chebyshev distance; FDR – Fisher discriminant ratio						

The results obtained from correspondence analysis are systematized in Table 5. By Mahalanobis and Minkowski distances the object areas with cheese and mold can be separated only with one color component H (HSV) and K (CMYK). Results for measured distances between color components by Fisher discriminant ratio show that 5 color components can be used for separation of object areas on the surface of cheese in storage period. Most of the color components – 9 can be used to separate object areas by Euclidean, Chebyshev and Manhattan distances.

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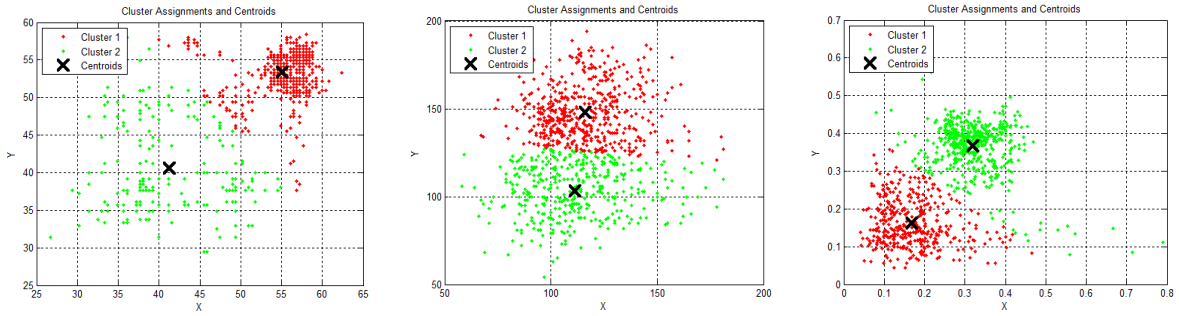
The results from analysis of distances between color components are used for classification. Four of the color components with higher distances are used – S (HSV), V (HSV), L (LCH) and Y (CMYK).

Figure 4 represents examples of classification of object area with cheese and mold with cluster classifier. Figure 5 represents examples of classification of object area with cheese and mold by non-linear discriminant analysis. On figures are shown used color components, day of storage and classification error.

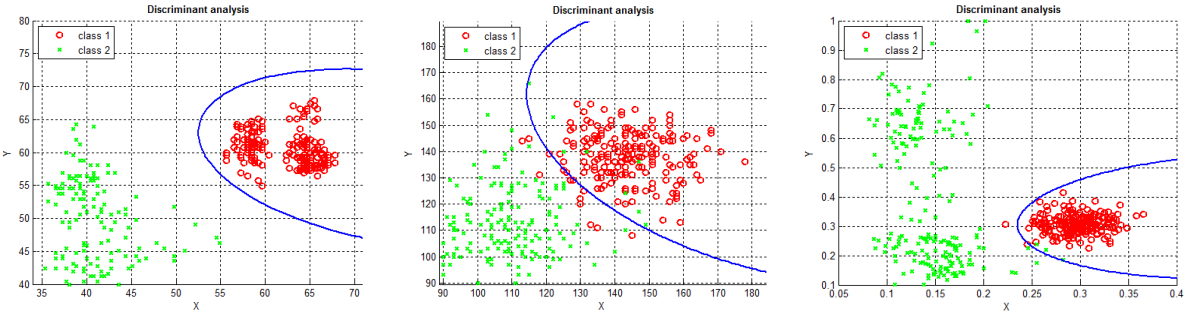


a) Day 3, L (LCH), e=40%

b) Day 12, Y (CMYK), e=12%

c) Day 11, S (HSV), e=14%

Figure 4.
Examples of classification with Cluster analysis by color components of object areas



a) Day 5, L (LCH), e=1%

b) Day 9, Y (CMYK), e=6%

c) Day 5, S (HSV), e=1%

Figure 5. Examples of classification with discriminant analysis by color components of object areas

Table 6. Results from classification

	Cluster analysis				Discriminant analysis			
Day	**S (HSV)**	**V (HSV)**	**L (LCH)**	**Y (CMYK)**	**S (HSV)**	**V (HSV)**	**L (LCH)**	**Y (CMYK)**
3	1%	44%	39%	1%	1%	13%	6%	1%
4	80%	5%	20%	60%	17%	1%	1%	2%
5	79%	12%	21%	78%	1%	1%	1%	21%
6	20%	1%	1%	88%	1%	1%	1%	29%
7	5%	1%	1%	48%	1%	1%	1%	28%
8	2%	1%	1%	42%	1%	1%	1%	32%
9	1%	1%	1%	3%	1%	1%	1%	6%
10	2%	1%	1%	17%	1%	1%	1%	19%
11	14%	1%	1%	31%	6%	1%	1%	21%
12	3%	1%	1%	12%	2%	1%	1%	29%
min	1%	1%	1%	1%	1%	1%	1%	1%
max	80%	44%	39%	88%	17%	13%	6%	32%

The results of analysis of classification errors for the two compared classifiers are presented on Table 6. Cluster analysis show higher classification errors reaching 80%. Only by V (HSV) color component the error is under 5% for values of this color component in 6 to 11 day of storage. Lower classification error is observed for non-linear discriminant classifier. The maximum error is 32% for Y (CMYK) color component. For other color components the classification error is 6-13% using S (HSV), V (HSV) and L (LCH). These results show that non-linear discriminant analysis is suitable for separation of object areas with cheese and mold by color features in storage period.

4. CONCLUSION

The article offers a comparative analysis of criteria for determining the informability of color features for separating object areas on the surface of white brined cheese during the storage period. The color characteristics of the object areas depend on a great many factors. Even within the field of a certain type, for example an area of mold, even within a sample, the color characteristics noticeably vary in non-small range. In addition, they vary depending on the duration of sample storage, storage conditions, and other factors such as ambient temperature and humidity. Compared to the refrigeration conditions prescribed by the manufacturer where these changes occur after the expiry date of the product at room temperature, these changes occur on the third and fourth day of storage of the product.
Established is the possibility of reducing the number of features through distance functions. In practice, it can be reduced, depending on the function being applied.
Four color components S (HSV), V (HSV), L (LCH) and Y (CMYK) are defined as informative by Euclidean, Chebyshev and Manhattan distances. These color components are used for assessment of the classification error of two classifiers – cluster analysis and discriminant function analysis. The results from analysis show that color components S (HSV), V (HSV) and L (LCH) are suitable for separation of object areas with white brined cheese and mold in storage period.

5. ACKNOWLEDGMENTS

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MODELING OF CHANGES IN SPECTRAL CHARACTERISTICS OF BREAD CRUST DURING BAKING

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Abstract: *The color of the crust is a significant feature of bread and bakery products. The formation of the color of bread crust depends on the physical and chemical characteristics of the raw materials used in the dough. The presentation of images of bread crust during baking by color models such as RGB or Lab has many limitations, making it difficult to track its change. This paper describes experimental system for tracking change the color of the bread crust during baking. Four mathematical models are studied of change of coefficient area under curve of spectral characteristics of bread crust. An exponential model is fitted to the experimental data. The effects of the model parameters were also studied by sensitivity. It was proved that the obtained exponential mathematical model is adequate.*
Keywords: *Bread baking, Bread crust, Mathematical model, Spectral characteristics.*

1.I NTRODUCTION

The color of the crust is a significant feature of bread and bakery products because, like other organoleptic characteristics – texture, aroma, taste, it influences consumer preferences [13,14,15,16]. The formation of the color of bread crust depends on the physical and chemical characteristics of the raw materials used in the dough such as water, active acidity (pH), sugars and amino acids, and the baking conditions such as the relative humidity of the baking chamber, temperature, speed of Air, heat and mass exchange processes [7,12,17,18].
From the point of view of bread making technology, the formation of a uniformly baked and pleasant appearance of bread crust is one of the goals in the automation of the bread baking process. It follows that control of the formation of the bread crust can be considered as an important stage of the bread making technology.
More commonly used techniques in assessing the surface characteristics of bread crust are the obtaining, processing and analysis of images, spectral and hyperspectral characteristics.
The purpose of the report is to trace the change in the color of the bread crust during baking using techniques to obtain its optical characteristics.

2. RELATED WORKS

Current studies are related to the use of offline and on-line systems [2,5,6,14] for measuring the color of various agricultural and food products, as well as for measuring the color of the bread crust during baking.
Zanoni et al. [17] suggests that traceability of the color formation of bread crust is realized through the color difference ΔE. The authors create a mathematical model that describes the change in color difference in function of the temperature of the crust. The results are compared with studies on the heat and mass transfer processes reported by other authors.
Purlis et al. [12] apply a computer vision system to track the formation of the bread crust during baking. The authors point out that the use of spectral characteristics in the UV, VIS, IR

range is not an appropriate tool for tracking the baking process. In this study, the authors applied image analysis by using the XYZ color model components and described the process as a function of baking temperature and water activity.
Castro et al. [3] apply a system for obtaining, processing and analyzing images for tracking the baking process. Measurements are in the Lab color model. Models in function of temperature, flour/sugar ratio and consumer acceptability were obtained. The authors state that the use of spectral characteristics in the UV, VIS, IR range are suitable for monitoring changes in water activity, active acidity, metal cations, sugars during baking, but can not be directly applied to trace alteration The color of the baking crust.
The review of publications related to the follow-up of bread crust color changes indicates that colorimetric methods using colorimeters and image acquisition, processing, and analysis systems are used in the known studies.
The spectral characteristics are more suitable for tracking the changes of physico-chemical parameters.
The presentation of images of bread crust during baking by color models such as RGB or Lab has many limitations, making it difficult to track its change.
The literature states that in this type of complex images it is convenient to use the full spectrum of the image [8,19]. Using the full spectrum of image requires converting RGB values into spectral characteristics in the visible range [9,11].

3. MATERIAL AND METHODS

3.1. Object of the study

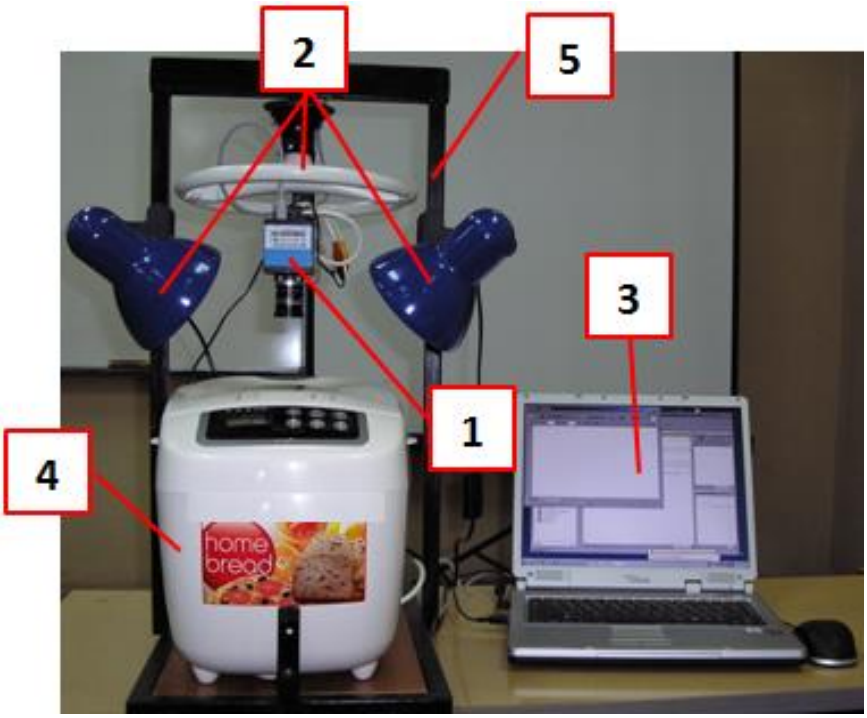
The object of the study are spectral characteristics of bread crust during baking. An automated bread making machine is set to program 1, 1000g and baking rate "High". Program with duration of 2h and 58min was used.
Pictures are taken during the baking period in the machine from 53 min to 2h and 58 min at an interval of 8 min for 5 loaves. Bread is prepared according to the requirements presented in [1]. The following ingredients are used to prepare the dough: flour 100%, water 56%, yeast 2%, salt 1,5%.

3.2. Experimental setup

The general appearance of the laboratory equipment used is shown in Figure 1. A color digital camera DFK41AU02 with ½ "CCD, 1280x960 pixels is used for capturing. The illumination is provided by a round luminescent lamp above the operating stage. A software application for image processing and analysis is enabled on the personal computer. The bread is baked in an automated machine [20] Moulinex Home Bread. The whole set is mounted on a stand with a shoulder strap, providing a change in the shooting height of the video camera.

3.3. Convertion of color components to spectra

A method is used to represent the values of the RGB color model in the form of reflectance spectra from the visible spectral range. The techniques for convertion of RGB values into spectra presented in [8,9].



1-Video camera
2-Light system
3-Personal computer with software
4-Automated bread machine
5-Mounting stand

Figure 1. Laboratory stand – general view

3.4. Area under curve

The area under curve (AUC) is used in the identification of processes for their comparison. To calculate this criterion, a function is used:

$$AUC = \int_a^b f(x)dx \qquad (1)$$

The coefficients of the models used for the evaluation of the output data to the AUC are determined by autoregression model in Matlab [4].

3.5. Models of the change for area under the curve

The CurveFitting Toolbox in Matlab was used to obtain the models.

3.6. Sensitivity analysis of models

The sensitivity analysis is designed to determine the extent to which model output variables are affected by moderate changes to the model input. The sensitivity test can provide a general assessment of the accuracy of the model when used to evaluate alternative models as well as detailed information to overcome the errors at different parameter values [10]. A simplified deterministic approach was used in which the model parameters obtained were set by ±10% of their values. Charts of the error module are analyzed at elevated and decreased values of the model parameters. If the output variables of the model differ significantly, then the output is sensitive to the specification of the input distributions and therefore they must be precisely defined.

4. RESULTS AND DISCUSSION

Figure 2 shows the spectral characteristics of bread crust during baking. The characteristics are obtained by converting the RGB color components into spectral characteristics. The graphs show that in certain spectral ranges there are overlapping characteristics, while in others they are too close to each other, which would make it difficult to distinguish them and track their change.
Figure 3 is a graph showing the change in AUC during the baking period. There is a decrease in the values of this coefficient during the baking period.

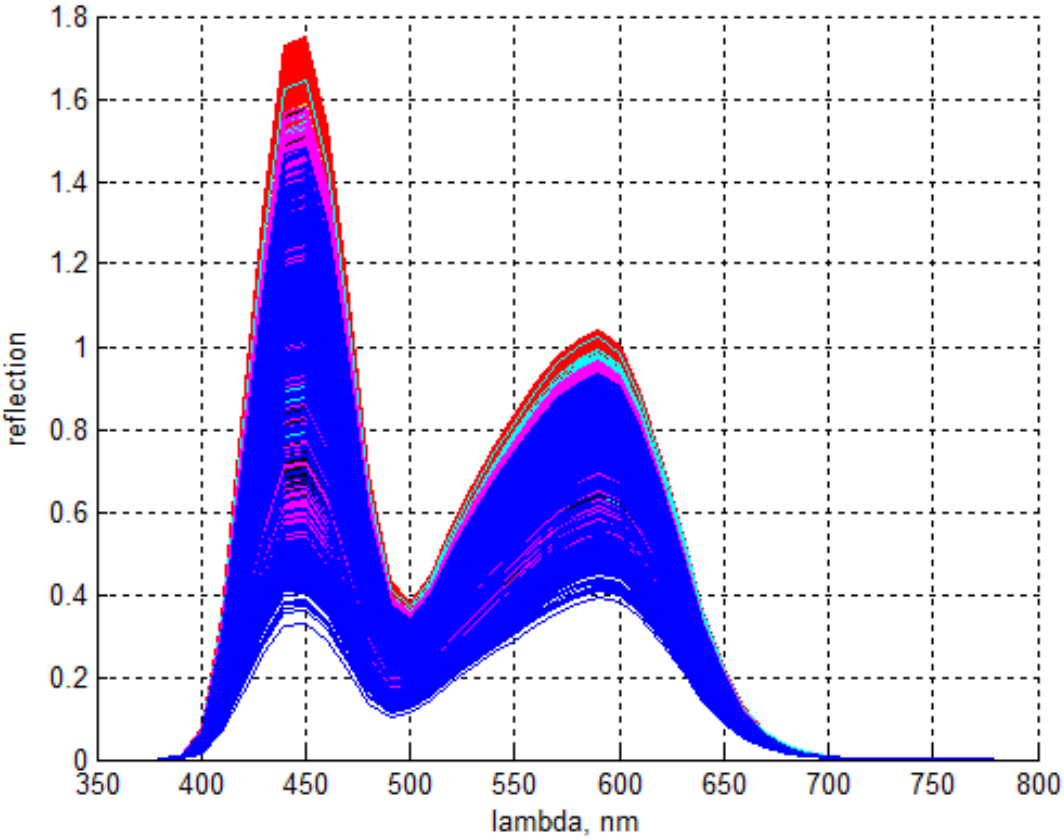


Figure 2. Spectral characteristics of bread crust during baking

Figure 3. Changes in the coefficient AUC of spectral characteristics

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For modeling the curve of bread crust spectral characteristics changes, experimentally captured data and calculations the variance of the area under curve (AUC) were used. Figure 4 shows the change in the mean values of AUC.

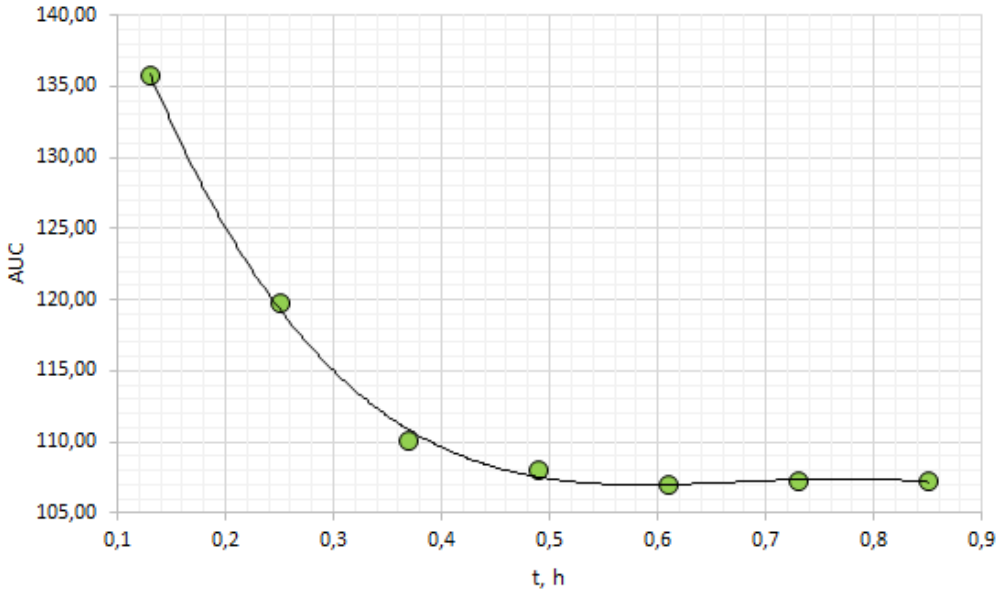

Figure 4. Changes in mean values of AUC coefficient

Table 1 shows the four models used. Parameters of coefficient of determination (R^2), sum of squired (SSE) and root mean squired error (RMSE) are specified. The coefficients of the models used and the range of their variation are given in brackets.
The coefficient of determination for all models is R^2=0,98-0,99. SSE and RMSE error values are used as criteria for model selection.

Table 1. Models used for representation of the changes of mean values of AUC

Model	Formula	Coefficients	R^2	SSE	RMSE
Exponential	$y = ae^{bx} + ce^{dx}$	a = 76,73 (63,75, 89,71) b = -5,732 (-9,153, -2,312) c = 98,27 (79,15, 117,4) d = 0,09952 (-0,1283, 0,3273)	0,997	2,034	0,823
Power	$y = ax^b + c$	a = 2,749 (-2,473, 7,971) b = -1,226 (-2,06, -0,3929) c = 102,6 (94,19, 111)	0,983	11,710	1,711
Polynomial	$y = a_3x^3 + a_2x^2 + a_1x + a_0$	a_0 = 164,3 (158, 170,6) a_1 = -269,4 (-320,6, -218,1) a_2 = 414,1 (296,9, 531,2) a_3 = -207,5 (-286,5, -128,5)	0,998	1,192	0,630
Rational	$y = \frac{a_2x^2 + a_1x + a_0}{x + b_1}$	a_1 = 31,5 (-16,56, 79,56) a_2 = 65,16 (7,488, 122,8) a_3 = 31,33 (-21,6, 84,25) b_1 = 0,1667 (-0,1762, 0,5095)	0,996	2,808	0,968

The lowest values of these errors are the exponential and the polynomial model, which describe the experimental data with sufficient precision.
The polynomial model, although having a high coefficient of determination and low error rates, has the disadvantage that oscillation of the resulting curve pattern occurs when increasing its order.
An exponential model is chosen because many of the biotech processes have an exponential character of changing their metrics [16,18].
The sensitivity analysis of the exponential model shows that the smallest sensitivity in the initial point of the baking process.
The sensitivity of the tested parameter is greatest in the middle and at the end of the process.
Figure 5 shows a sensitivity chart of the selected model when changing its parameter values within a range of ±10%. The output values of the model differ significantly when changing the parameters within this range, indicating that the output is sensitive to the specification of the input distributions and therefore they must be precisely defined.

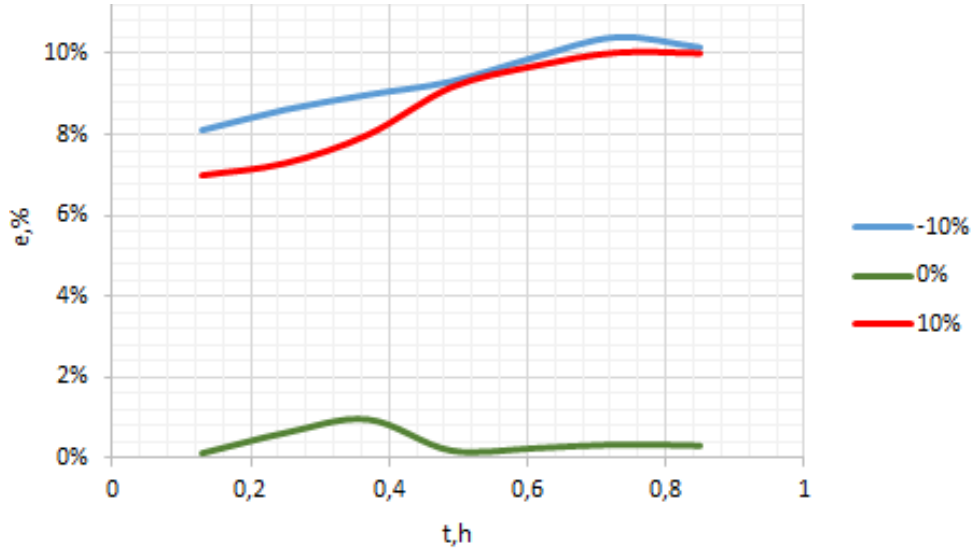

Figure 5. Error changes in decreasing and increasing the values of parameters of the model

In order to assess the extent to which the exponential model describes the baking roast color process, the results for this process and the Student criterion method are used, which at the available data have degrees of freedom k=n-1, where n is The number of experimental data. Data was used to track the changes of the AUC coefficients of spectral characteristics that were not applied when searching for a suitable model to describe the experimental data.
The calculated value of the Student's criterion is $t_{calculated}$=0,89, the critical value at degrees of freedom k=624 is $t_{critical}$=1,96.
Because the calculated value of the criterion is less than the critical, the exponential model is adequate and can be used to track the change of the bread crust during baking.

5. CONCLUSION

The proposed experimental setup for tracking the bread baking process for can be used to create kinetic curves for this process.

An analysis of errors SSE and RMSE determines that the experimental data is described with sufficient precision with a third-order polynomial model and an exponential model. For these models a generalized curve of the bread crust spectral characteristics was obtained.
The exponential model was selected and its sensitivity is assessed. The results of this assessment show that the model is sensitive to the change in its parameters and depends on the change in the other factors involved in the change in the surface features of the bread crust. Measuring these parameters and finding their relationship with the color change of the bread crust during baking will be the subject of further research.
The adequacy of the exponential model, which determines the possibility to use it to analyze the bread baking process, has been proven.

6. ACKNOWLEDGMENTS

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THE ROLE OF ENERGY MANAGEMENT FOR THE IMPLEMENTATION OF SUSTAINABLE AND EFFECTIVE HEAT PROCESSES
I. OPTIMAL ENERGY CONTROL OF HEAT PROCESSES IN THE CONDITIONS OF ANTIBIOTIC PROCESSING

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Abstract: *In this paper is described the developed by us method for optimal energy control in real production systems. The heat management role for the realization of sustainable and effective heating/cooling processes in the antibiotic production is evaluated. It was made and detailed energy – technology analysis of antibiotic production, guaranteeing flawless and quality production. Adaptive software was developed based on the MATLAB programming environment, offering an optimal management solution to energy-related problems in certain production. The specific production criteria are taken into account by formulation a complex multi parametric optimization task. The approach can be applied to other productions (operating or designing) to optimal energy consumption management and energy efficiency.*
Keywords: *energy management, sustainable heat processes, antibiotic production.*

1. INTRODUCTION

The ongoing global socio-economic crisis is putting global industry at risk. This makes the environment more vulnerable to pollution. Therefore, the minimization of energy consumption is called the sixth principle of "green chemistry", Anastas & Warner (1998) [1]. The use of energy and raw materials in different batch systems requires improved efficiency in process management and waste minimization to meet environmental requirements, Thevendiraraj et al. (2003) [13], Kim JK, Smith R. (2004) [8].
On the other hand, good economic development, and employment and, last but not least, the competitiveness of the production unit must be ensured. This requires the development of a sustainable manufacturing. It is very difficult to achieve such steady growth in batch industries such as pharmaceutical, cosmetics, paint, food production, etc. There are a number of developments that suggest different methodologies for the energy management of batch productions. These approaches include: reducing the duration and increasing productivity Koulouris A. et al. (2000) [9], [7], Burkard R. E., Hatzl J. (2005) [2]; Wastewater reduction by reuse, timing optimization and / or purification Foo C. Y. et al. (2005) [5]; Majozi T. et al. (2006) [11], Cheng K. F., Chang C. T. (2007) [3], Waste Reduction Gyeongbeom Y., Reklaitis G. V. (2007) [6]; Reducing the need for resources C. Y. et al. (2005) [4]; Environmental impact assessment, Stefanis S. K. et al. (1997) [12]; Recovery of waste heat and / or integration of some of these approaches. Linainger et al. (1995) [10] create a package that integrates environmental and economic issues.
This work presents a method for optimal energy control developed by us in a real production system. A detailed technological analysis and monitoring of heating / cooling processes in antibiotic production has been carried out. On the basis of the audit, the application software

has been developed (in MATLAB's programming environment). An optimal management solution for the problems associated with energy consumption in particular antibiotic production is proposed. Specific features have been taken into account and a complex multiparametric optimization task has been formulated. The developed approach can also be applied to other productions (working or in the design stage) to optimize energy management and energy efficiency.

2. AIM

The aim of this work is to provide optimal energy control of heating processes in conditions of antibiotic production by minimizing energy consumption.

3. MANAGEMENT OF ENERGY AND ENERGY CONSUMPTION

The energy management has its permanent role in the modern industrial world in the implementation of sustainable and efficient technological processes. The energy management, respectively energy consumption includes a rich set of comprehensive measures aimed at minimizing energy costs while respecting the maximum profit condition. This set of measures covers several important strands. Some of which are:

- **Searching for and introducing new and unconventional energy sources that do not pollute the environment and are also calorific enough.** The need to find and properly use for alternative energy sources is not new. Along with widely applied "green" energy sources are being studied and introduced into use and non-standard. For example, plans have already been developed for the world's first thorium nuclear reactor, it is proposed to place solar panels in space, to use salt water (osmotic energy or blue energy), etc .;
- **Optimising the use for secondary raw materials;**
- **Increasing the percentage of waste (secondary) heat use.** Waste heat that has been successfully recycled can greatly reduce the amount of purchased energy. It can be used directly in production or stored in heat tanks and used at a later time. Secondary energy can also be successfully used for a number of side-processing, , such as washing, packing, drying, etc. It is also possible to use as solve household energy problems, which are also in the cost of production.
- **Conducting energy - technological audit and analysis the possibilities for energy flows managing.**

This paper presents a detailed technological analysis of an antibiotic production and focuses on the management, resp. optimizing heat energy from heating / cooling processes.

4. PROBLEM DESCRIPTION

One of the most common methods used for the production of antibiotics is the preparation of the substrate by fermentation. The fermentation is performed after cooling the sterilized nutrient to working temperature of 30°C. Technical and cooled water is used for this process. The idea for managing energy consumption is in the unification of the heating / cooling processes. If a certain reactor is in a regime of cooling, then the released energy could be stored in a heat reservoir to use it for the preparation of nutrients in another reactor. This would save energy in the second reactor, and also reduce the technical water required for these processes. The idea can be implemented by designing a proper scheme. In addition, the control variables to ensure optimal energy managing in the two reactors should be identified.

The technological process of antibiotic production includes the following stages:

Stage 1: *Nutrient preparation*

1. This process is carried out by mixing micelles and nutrient in a subsidiary reactor.

Stage 2: *Fermentation components*

1. Mixing of component V_1 from Tank A with $V_{2.1.}$ with water at 20^oC ($CW20$) by stirring for 1 hour until nutrition medium NMA is obtained.
2. Mixing of component V_2 from Tank B with $V_{2.2.}$ $CW20$ by stirring for certain time until nutrition medium NMB is obtained.

Stage 3: *Fermentation process*

1. Transfer of NMA to reactor F_C and heat from 20^oC to 55^oC.
2. Heat NMA from 55° to 100°C using Steam.
3. Sterilization of NMA with 100°C steam for about 0.5 h.
4. Transfer of NMB to F_C and mixing it with NMA to obtain AB_IAB.
5. Addition of $V_{3.5.}$ $CW20$.
6. Heat the mixture V_C with vapour to $T = 55^oC$ to obtain medium $NMAB$.
7. Heat the mixture $NMAB$ with water vapour from 55^oC to 120^oC.
8. Sterilization of $NMAB$ with water vapour at temperature of 120^oC.
9. Cooling $NMAB$ from 120^oC to 45^oC using $CW20$.
10. Cooling of $NMAB$ from 45^oC to 30^oC using 5^oC cooled water ($CW5$).
11. Addition of IMX to $NMAB$ up to volume $V_{\max}$ to obtain FM.
12. Cooling the medium FM to $T_{fer.}$ using $CW5$ and carry out fermentation for $120h-150h$ until the product FB is obtained.

Stage 4: *Dilution*

1. Transfer FB to an intermediate reservoir.
2. Addition of V_d with water $CW20$ for deactivation to obtain the product DFB.

Stage 5: *Filtration*

1. Filtering the DFB to obtain concentrated material DSC.

Stage 6: *Sterilization* of the empty fermenter

1. Washing the empty fermenter with $CW20$.
2. Sterilization of the washed fermenter with water vapour with temperature of 130^oC.

On the basis of the detailed en-technologist monitoring, a scheme for performing the heating/ cooling processes using heat tanks (Figure 1) is proposed.

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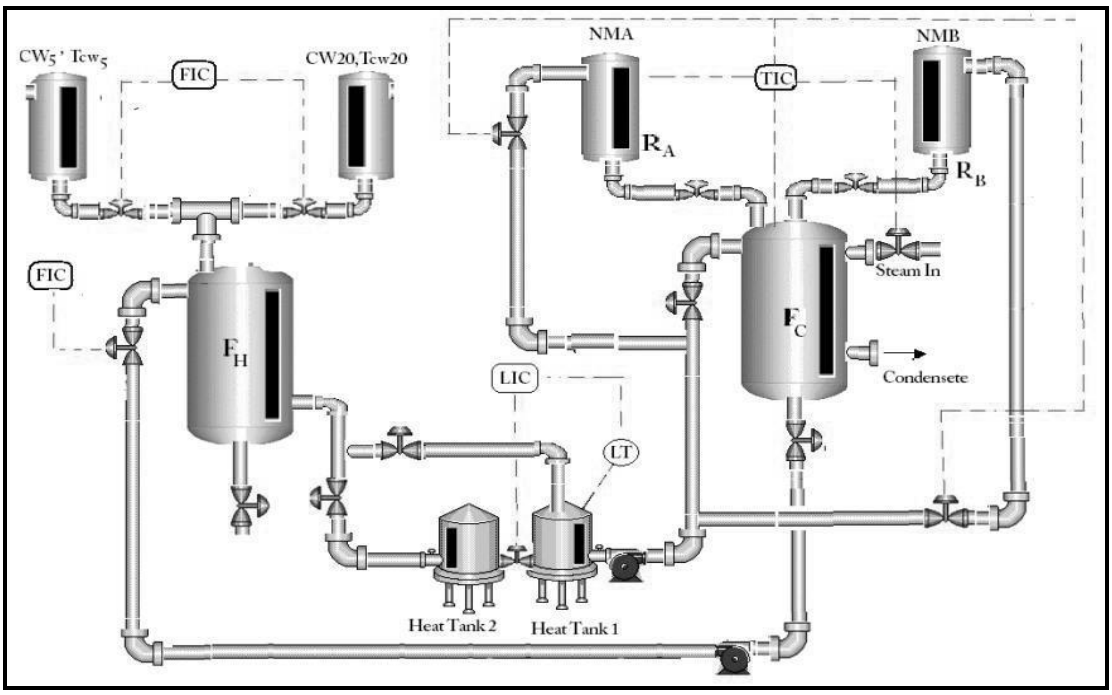

Figure 1. Technological scheme with heat reservoirs

The proposed management solution consists in the fact that water after serpentine is stored in two reservoirs, which perform the functions of heat reservoirs. The purpose is to be used the heated water after the coil, which is stored in the heat reservoirs to carry out nutrient preparation processes in another reactor.

A hot reactor is the fermenter F_H where the processes of feeding the raw materials and sterilization. (3.1-3.7). At the end of the process (3.7) the mixture in the fermenter has a temperature 120^oC.It should be cooled down to temperature of 30^oC to carry out fermentation.

In this case, it is not necessary to observe a specific schedule of reactors work in the manufacture. This leads to a reduction in the amount of wastewater and the water vapors used to heat/ cool the processes.

It is proposed that management of energy consumption by formulating complex multi-parameter optimization task. To solve it, the MATLAB program environment is used. Software for managing the heat processes in the production of antibiotics has been developed.

The management essence output is the use of a minimal resource to carry out the heating processes.

$$Cost_{INT} = MIN\left\{Cost^*_{Steam} + Cost^*_{W5} + Cost^*_{Water}\right\} \quad (1)$$

Where:

$Cost^*_{Steam}$ - Steam expenses;

$Cost^*_{W5}$ - cooling water expenses $CW5$;

$Cost^*_{Water}$ - Expenses of water used to carry out the processes in the cases when heat reservoirs are used.

These components can be found using the following expressions:

$$\left.\begin{aligned} Cost^{*}_{Steam} &= C_{Steam} Cp_W V^{*}_{S1}\left(T^{*}_{St} - T^{*}_{S1}\right) + \\ &\quad C_{Steam} Cp_W \left(V_F - V^{*}_{S1}\right)\left(T^{*}_{St} - T_{W20}\right), \\ Cost^{*}_{W5} &= C_{W5} Cp_F V_F \left(T_{F3} - T_{F4}\right), \\ Cost^{*}_{Water} &= C_{W20}\left(\begin{aligned}&\left(V_{Water} - V^{*}_{S1}\right) + \\ &\left(V_{4.2.} - V^{*}_{S2}\right) + V^{*}_{SW}\end{aligned}\right) \end{aligned}\right\} \quad (2)$$

Where:

$V_{Water} = V_{2.1.} + V_{2.2.} + V_{3.5.}$;

C_{W5} - Expenses of unit energy from $CW5$, $[lv/kJ]$;

C_{Steam} - Expenses of unit energy from steam, $[lv/kJ]$;

C_{Water} - used water expenses, $[lv./m^3]$.

This can be achieved by creating conditions for rate maximizing use of waste (second) heat energy. The search variables that can minimize the means used to carry out the heat processes are:

$$\{A_i, B_i, C_i, t_i\}, \quad \forall i \in \overline{1,4} \quad (3)$$

$$x_i = \{0 \vee 1\}, \; y_i^{S1} = \{0 \vee 1\}, \; y_i^{S2} = \{0 \vee 1\}, \; y_i^{SW} = \{0 \vee 1\}\}, \quad \forall i \in \overline{1,4} \quad (4)$$

The constraints are related to the requirements of the technology towards the duration of the processes and the technical limitations of the cooling devices (serpentine).

$$\left.\begin{aligned} &\sum_{i=1}^{i=4} t_i \le t_f \\ &V^{*}_{S1} \le V_{2.1} + V_{2.2} + V_{3.5} \\ &V^{*}_{S2} \le V_{Waste} \\ &\sum\left(y_i^{S1} + y_i^{S2} + y_i^{SW}\right) \le 1 \\ &\left(y_i^{S1} + y_i^{S2} + y_i^{SW}\right) = x_i, \forall i \in \overline{1,4} \\ &Cost_{INT} < Cost_{NO\_INT} \\ &T_{F4} \le T_{fer} \end{aligned}\right\} \quad (5)$$

$Cost_{NO\_INT}$ - Energy and water expenses, when the processes are carried out without energy management.

For the control, the variables (3) and (4) should be determined. These variables should give a minimum of the goal function (1) under the limitations posed by (5). The task is formulated

in the terms of Mixed Nonlinear Programming (MINLP) and is solved with the MATLAB programming environment.
The obtained results are summarized in Table 1. As a management result, there is a significant reduction in the cooling water $CW20$ (65%) and the water $CW5$ - increase by 3%. At the same time, the steam amount is reduced at 35%. Total energy savings (cooling water and steam) are approximately 29%. The application of this type of energy managing eliminating the need for coordination of processes in time.

Table 1. Expenses of energy resource

Expenses	Expenses for a system without applied energy management $lw.$	Expenses for a system with applied energy management $lw.$
$Cost_{STEAM}$	1168.40	720.84
$Cost_{W20}$	377.15	161.24
$Cost_{W5}$	389.89	527.95
$Cost_{SUM}$	1935.50	1410.00

5. CONCLUSION

The presented study shows the energy - technological study of the heating processes in specific antibiotic production. Based on the audit, the application software was developed with MATLAB programming environment. Some specific features of production are defined and a complex multiparametric optimization task is formulated. The developed approach can also be applied to other industries (operating or designing) in order to optimally manage energy consumption and energy efficiency.

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THE ROLE OF ENERGY MANAGEMENT FOR THE IMPLEMENTATION OF SUSTAINABLE AND EFFECTIVE HEAT PROCESSES
II. OPTIMAL ENERGY CONTROL OF HEAT PROCESSES IN THE CONDITIONS OF BREWING

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Abstract: *In this paper is described the developed by us method for optimal energy control in real production systems. The heat management role for the realization of sustainable and effective heating/cooling processes in the beer production is evaluated. It was made and detailed energy – technology analysis of beer production, guaranteeing flawless and quality production. Adaptive software was developed based on the GAMS programming environment, offering an optimal management solution to energy-related problems in certain production. The specific production criteria are taken into account by formulation a complex multi parametric optimization task. The approach can be applied to other productions (operating or designing) to optimal energy consumption management and energy efficiency.*
Keywords: *energy management, sustainable heat processes, brewing.*

1. INTRODUCTION

In industrial production systems, the realization of sustainable and efficient heat processes is of particular importance in our time. This is extremely important for production processes that are heavily influenced by market requirements, such as the pharmaceutical, food and brewery industries. Managing the energy consumption of these productions is related to the resources reduction needed to carry out the heat processes. Such optimal energy control was considered in 1986 by Vaselenak, J.A., Grossmann I.E [4]. Subsequently, Boyadjiev Ch. B., and others. (1996), [1] and further on by A. Pozna et al. (1998), [3] develop the issues of energy saving.
This work presents the method,developed by us,of optimal energy management in real production system. The role of heat energy management in the realization of sustainable and efficient heating / cooling processes in beer production is appreciated. An interesting development in this direction is the work of the team Monika Dumbliauskaite, Helen Becker, François Mar'echal (2010) [2], who propose splitting beer production into two parts.
A detailed technological analysis and monitoring of heating / cooling processes in antibiotic production has been carried out. On the basis of the audit, the application software has been developed (in GAMS's programming environment). An optimal management solution for the problems associated with energy consumption in particular beer production is proposed. Specific features have been taken into account and a complex multiparametric optimization task has been formulated. The developed approach can also be applied to other productions (working or in the design stage) to optimize energy management and energy efficiency.

2. AIM

The aim of this work is to provide optimal energy control of heating processes in conditions of brewing by minimizing energy consumption.

3. PROBLEM DESCRIPTION

There is a detailed technology analysis of conventional beer production, which is focused on management, respectively optimizing heat energy from heating / cooling processes.
The production process is in line with conventional brewing and includes the following steps:

Stage 1: **Milling**

Stage 2: **Mashing** - Mashing is carried out after mixing of the malt with water $45^{\circ}C$ in apparatus 1 (figure 1.). This process forms a so-called malt mash. A special feature here is that the temperature during the mashing is raised in steps and then kept constant for a while at different mashing rests;

Stage 3: Mash Filtration - During mash filtration, the wort is separated from the spent grains with filter bags. The wort is with temperature of $78^{\circ}C$. From wort subsequently is obtained beer. Filtration is carried out in an apparatus 2 (figure 1.);

Stage 4: **Boiling** - After mash filtration, the wort is boiled together with hops to add bitterness to the taste of the beer. The boiling takes roughly an hour and the boiler is heated with steam. This stage is carries out in apparatus 3 (figure.1.). After the brewing the wort's temperature is $98^{\circ}C$;

Stage 5: **Hot separation of hops and malt residues** - During this stage, is formed a sludge as a result of the boiling. The process is carried out in an apparatus 4 (figure 1.), at temperature $98-99^{\circ}C$;

Stage 6: **Cold separation** - Cold sludge is formed after cooling the hopped wort. Cooling is carried out in two sections. In the first section, wort is cooled with water with a temperature of $16^{\circ}C$. The second section cools with water with a temperature of $2^{\circ}C$. At the end of the process the wort is with temperature $12^{\circ}C$.

Stage 7: **Adding of yeast**
Main-alcoholic fermentation performed by yeast;
Post-fermentation and maturation - two interrelated processes that naturally follow the main alcoholic fermentation;

Stage 9: Bottling, packaging and pasteurization
The so called "Calming" of beer is mandatory operation that occurs immediately after its filtration. Then beer is fed for bottling.

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The production process of beer is presented as composed of two parts - hot (production of wort Stage 2 - Stage 6) and cold (fermentation, maturing and beer processing Stage 6 - Stage 9).
A comparison is made between a scheme without energy management and the optimized technological scheme proposed by us.
Figure 1 shows the hot part of a scheme without energy control.

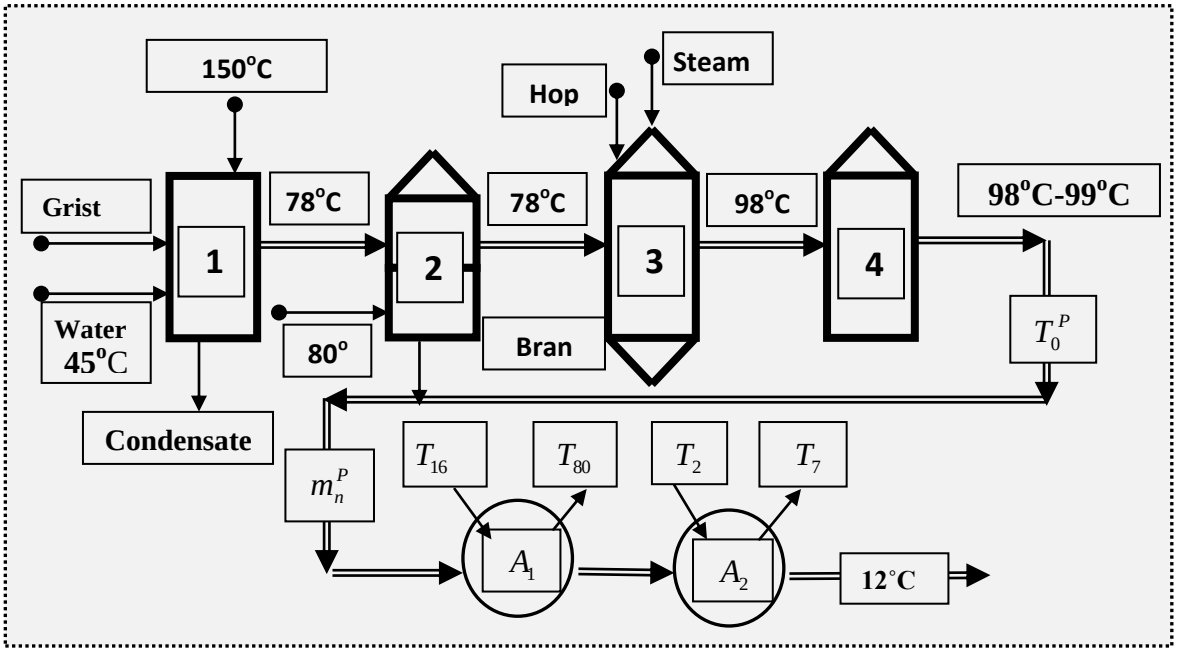

Figure 1. Scheme of hot part – without energy management

The energy audit of the technological scheme shown in Figure 1 was carried out. A mathematical description of the heating / cooling systems was also analyzed. Based on this, a new scheme is proposed to bring together these processes in a special section, including a system of specialized reservoirs (Figure 2).
The characteristic feature of the proposed scheme shown in Figure 1 is *the system of specialized reservoirs*. Wort with temperature T_0^P and debit m_n^P enters for cooling in heat exchangers A_1, A_2, A_3, A_4. The waste water after the heat exchangers is stored in four reservoirs V_{80}^*, V_{45}^*, $V_{Washing}^*$, V_{Waste}^*. The idea of this operation is that the heated water stored in the heat reservoirs is used to carry out the processes for the production and filtration of the malt mash, and also to wash the dishes.
The task of management of the process is limited to the determination of multitude independent variables which to minimize the money spent to conduct processes. Restrictions of the task are related to the technological requirements for carrying out the processes, and also with the demands to the technical equipment for performing coolin. To solve it, the GAMS program environment is used.
Software for managing the heat processes in the production of antibiotics has been developed.
In this type of energy control it is not necessary to observe a certain operation schedule of the apparatus in the workshop. This reduces the amount of wastewater and steam.

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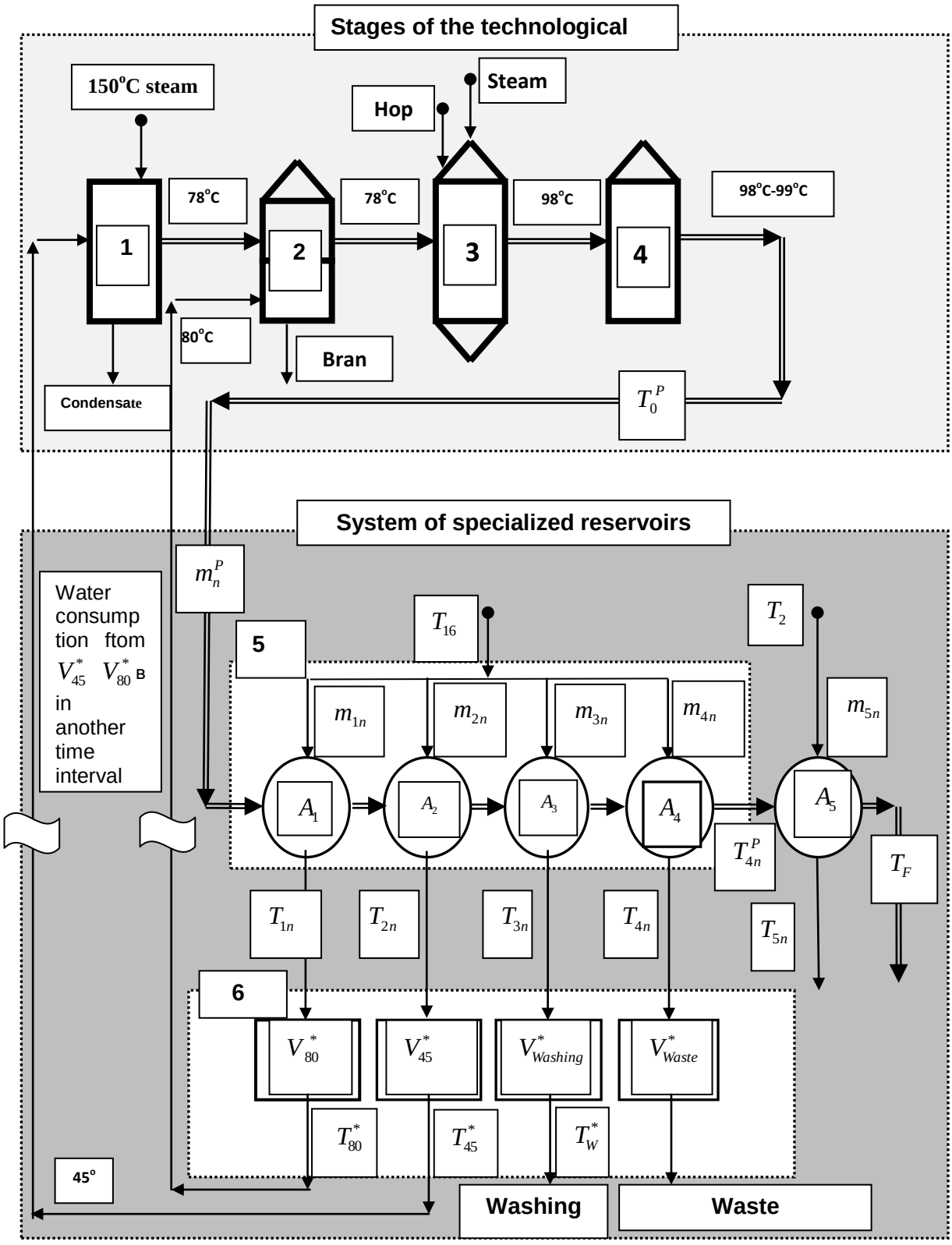

Figure 2. Scheme of hot part – with energy management

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The management essence output is the use of a minimal resource to carry out the heating processes.

$$\left\{\begin{array}{l} Find: X_t\left[\begin{array}{l} m_{in}, \quad \forall n \in (1,N), \forall i \in (1,5) \\ A_n, m_n^P, t_n, \quad \forall n \in (1,N) \end{array}\right\}^T \\ MINIMIZE\{Cost(X_t)\} \rightarrow (Cost) \\ s.t.: \{Eq.8 - Eq.14\} \end{array}\right\} \quad (1)$$

Where:

$Cost$ - an energy expenses needed to provide the processes, $[lv.]$

$$Cost = (E_{45} + E_{80} + E_{Washing})Cost_{16} + E_2 Cost_2 \quad (2)$$

$$E_{45} = (T_{45} - T_{45}^*)V_{45}^* Cp_{16} + (T_{45} - T_{16})(V_{45} - V_{45}^*)Cp_{16} \quad (3)$$

$$E_{80} = (T_{80} - T_{80}^*)V_{80}^* Cp_{16} + (T_{80} - T_{16})(V_{80} - V_{80}^*)Cp_{16} \quad (4)$$

$$E_{Washing} = (T_{Washing} - T_{Washing}^*)V_{Washing}^* Cp_{16} + (T_{Washing} - T_{16})(V_{Washing} - V_{Washing}^*)Cp_{16} \quad (5)$$

$$E_2 = \sum_{n=1}^{n=5}\left(Cp_2 m_{5n} t_n (T_{5n} - T_2)\right) \quad (6)$$

$E_{45}, E_{80}, E_{Washing}, E_2$ - the energy needed to ensure the technological processes, $[kJ]$

$Cost_{16}$ - Cost per unit of energy consumed for heating water $16^\circ C$ for technological needs, $[lv.]$

$Cost_2$ - Cost per unit of energy consumed for beer cooling with water $2^\circ C$, $[lv.]$

This can be achieved by creating conditions for rate maximizing use of waste (second) heat energy. The search variables that can minimize the means used to carry out the heat processes are:

$$\left.\begin{array}{l} m_{in}, \quad \forall n \in (1,N), \forall i \in (1,5) \\ A_n, m_n^P, t_n, \quad \forall n \in (1,N) \end{array}\right\} \quad (7)$$

Task restrictions are related to the technological requirements for carrying out the processes, and also with requirements for the technical equipment for carrying out of the cooling. In this case, the pluralities of task restrictions are:

$$\left.\begin{aligned} T_{45}^{*} &\le T_{45} \\ V_{45}^{*} &= V_{45} \end{aligned}\right\} \quad (8)$$

$$\left.\begin{aligned} T_{80}^{*} &\le T_{80} \\ V_{80}^{*} &= V_{80} \end{aligned}\right\} \quad (9)$$

$$\left.\begin{aligned} T_{Washing}^{*} &\le T_{Washing} \\ V_{Washing}^{*} &\le V_{Washing} \end{aligned}\right\} \quad (10)$$

$$V_{Beer} = \sum_{n=1}^{n=5} \left(t_n m_n^P \right) \quad (11)$$

$$A_i \le A_i^{MAX}, \ \forall i \in (1,5) \quad (12)$$

$$\sum_{n=1}^{n=5} t_n \le t_{cold} \quad (13)$$

$$T_{5n}^{P} \le T_F \quad (14)$$

The presented task is formulated in terms of the mathematical nonlinear programming MNLP and it is solved with programming package GAMS.
As a result of applying the method of energy management in the process of brewing were achieved results presented in the following tables:

Table 1. Energy needed to ensure the technological processes

Resource	Energy needed for a system without applied energy management $[kJ]$	Energy needed for a system with applied energy management $[kJ]$
E_2	1432469.724	1432469.724
E_{45}	4131340.000	1.944
E_{80}	9385600.000	2.145
E_{Wash}	5719350.000	2927238.395
Total	**20 668 759.72**	**4 359 712.208**

From the table above it is clear that during the implementation of energy control scheme with usage of specialized heat reservoirs (fig.2) the energy needed to obtain water with temperature $45^{\circ}C$ and water with temperature $80^{\circ}C$ is minimized.

Table 2. Expenses of energy resource

Expenses	Expenses for a system without applied energy management [$lw.$]	Expenses for a system with applied energy management [$lw.$]
$Cost_2$	232.060	232.060
$Cost_{45}$	311.916	1.467841E-4
$Cost_{80}$	708.613	1.619686E-4
$Cost_{Wash}$	431.811	221.006
Total	**1684.400**	**453.067**

From table 2 is clear that the optimal process management leads to significant expenses reductions for the used water with temperature $45^{\circ}C$ and $80^{\circ}C$. The overall economy of the energy resources (cooling water and steam) is approximately 3 times the energy consumption in the case without applied energy management. The advantage of this energy management is the elimination of the need to coordinate processes over time. It is not necessary to observe a certain schedule of operating devices.

4. CONCLUSION

The presented study shows the energy - technological study of the heating processes in conventional beer production. Based on the audit, the application software was developed with GAMS programming environment. Some specific features of production are defined and a complex multiparametric optimization task is formulated. The developed approach can also be applied to other industries (operating or designing) in order to optimally manage energy consumption and energy efficiency.

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ANALYSIS OF THE RENEWABLE ENERGY POTENTIAL IN YAMBOL REGION

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Abstract: *Implementation of the European policy on renewable energy sources according new aspects which are presented also in new Sustainable Development Program in 2030 is very important respect for ecology and environmental protection. The European Union (EU) has set ambitious climate and energy targets for 2030, including an EU-wide target for renewable energy of at least 27% of final energy consumption. As a member of the European Union, Bulgaria is committed to maintaining and implementing European policies. The aim of this report is to make a profound overview study of the installed capacity of renewable energy on the territory of Bulgaria and the Yambol region.*
Keywords: *Renewable energy, sources, ecology.*

1. INTRODUCTION

The global energy crisis will develop and deepen over the coming decades. Key factors in this process are increased energy consumption and the gradual depletion of nonrenewable energy sources (oil, gas, coal, etc.). Analysis of the world's leading experts indicate that even with decreased consumption, the known deposits of oil will be exhausted to 2045, and natural gas - to 2075. Over the past few years, European legislators have faced a number of challenges in energy policy.
The consequences of climate change for the environment and economies are unavoidable, energy security in Europe being jeopardized due to the high dependence on energy imports. Moreover, the current financial and economic crisis is threatening economic growth and employment. In this context, the Directive on the promotion of the use of energy from renewable sources (RES) (2009/28/EC) [1] is an important event in European legislation. By setting a common target for a 20% share of renewable energies in the final energy consumption of the 27 EU Member States by 2020, the directive provides the necessary political support for the renewable energy market, which has huge potential for growth and creating new jobs. The directive obliges each of the 27 Member States to develop a National Renewable Energy Action Plan (NREAP) on the basis of the model provided by the European Commission, creating preconditions for the harmonization of their national laws [2, 3]. The European Union could achieve the overall objective for 2020 only through the development of ambitious and concerted national action plans.
The target for Bulgaria, proposed by the European Commission, is 16% of the total final energy consumption in the country in 2020 to be from renewable energy sources, as the country receives the lowest additional increase (6.6%) from the rest of the Member States. At present, the National Energy Strategy of the Republic of Bulgaria until 2020 places priority on all possible sources of energy, which at best is unrealistic. An analysis of the possibilities shows that Bulgaria has the greatest potential for wind [4, 5], biomass and hydropower. In practice, however, Observ'ER [6] statistics for 2016 indicate that the largest installed capacity of RES in Bulgaria is from photovoltaic installations. It's still fairly expensive technologies,

leading to increased costs of green energy supplement in the monthly energy bills of consumers and incite them pessimistic towards the use of renewable energy sources.
The aim of the report is to establish the state of the installed capacity of RES in Bulgaria and the share of the Yambol region to implement the policy for wider use of green energy to meet the objectives set in the 2030 Agenda for Sustainable Development [7] and the European program "A sustainable European future: The EU response to the 2030 Agenda for Sustainable Development" [8].

2. EXPOSE

According to the annual report of Observ'ER [6, 9] on the state of renewable energy in Europe for 2015 and 2016, the situation in Bulgaria is as follows (Table 1) and graphically presented in Figure 1:

Table 1. Installed capacity in Bulgaria for some RES for the period 2013-2015

Type of RES	2013	2014	2015
Wind Installations, MW	676	686,8	700
Photovoltaic installations, MW	1018,2	1020,4	1 026
Small hydropower, MW	283	283	331
Thermal energy for direct use, MWth	83,1	83,1	83,1
Solar installations, MWth	5 600	5 600	5 600
Geothermal Energy, MWth	83,1	83,1	105,6
Heat pumps, the number	366	532	532
Biogas, ktoe	12	20	27

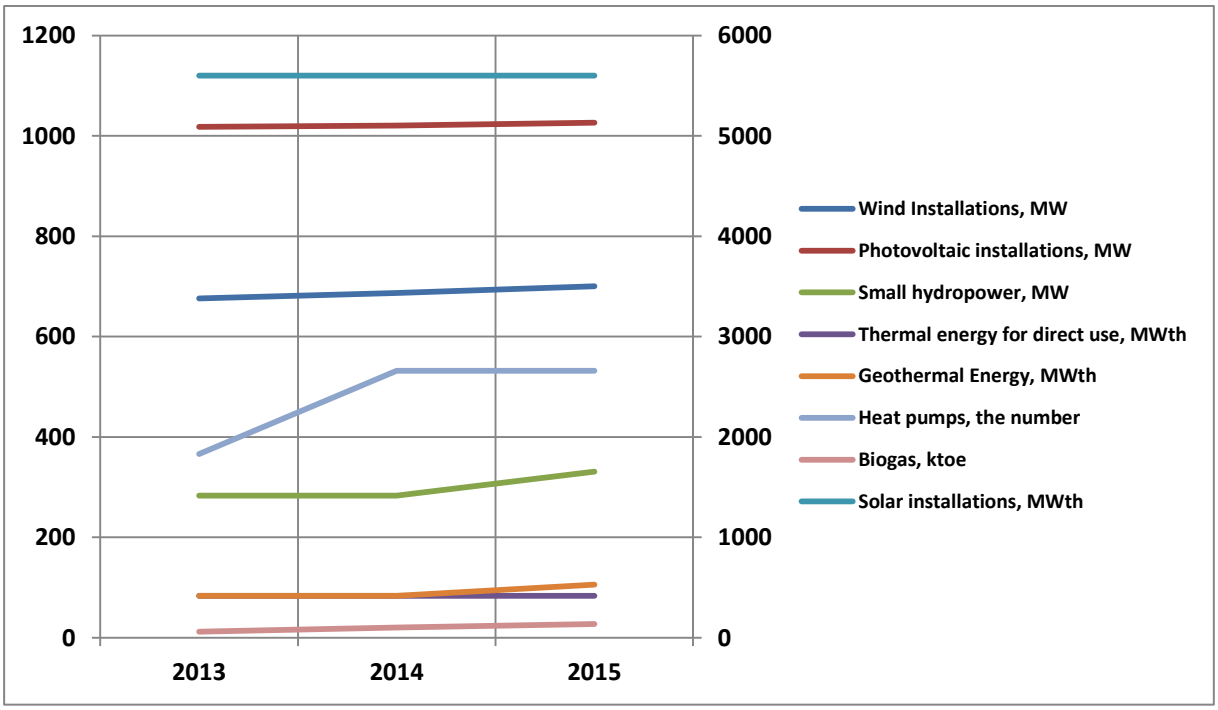

Figure 1. Installed capacity in Bulgaria for some RES for the period 2013-2015

From the provided information, the installed capacity of certain types of RES - wind installations, geothermal energy, heat pumps, small hydropower plants, and photovoltaic plant biogas plants can be monitored. There is no increase in installed capacity for thermal energy for direct use and solar installations over the period considered. It should be noted that for some types of RES the installed capacity in Bulgaria is very small, e.g. energy from the processing of solid and household waste, there aren't installed power from concentrated solar installations and ocean / marine energy. A survey of the installed RES in the three municipalities of the Yambol region for the period 2005 - 2016 was made, according to data from the National Statistical Institute [10]. The available information is only for part of Observ'ER types of RES - photovoltaic, wind, biogas and water installations. The collected information includes data on the type, size and location of installed power, year of commissioning. Figure 2 presents information on the number of installed RES in the three municipalities of the Yambol region - Yambol, Tundja and Straldja.

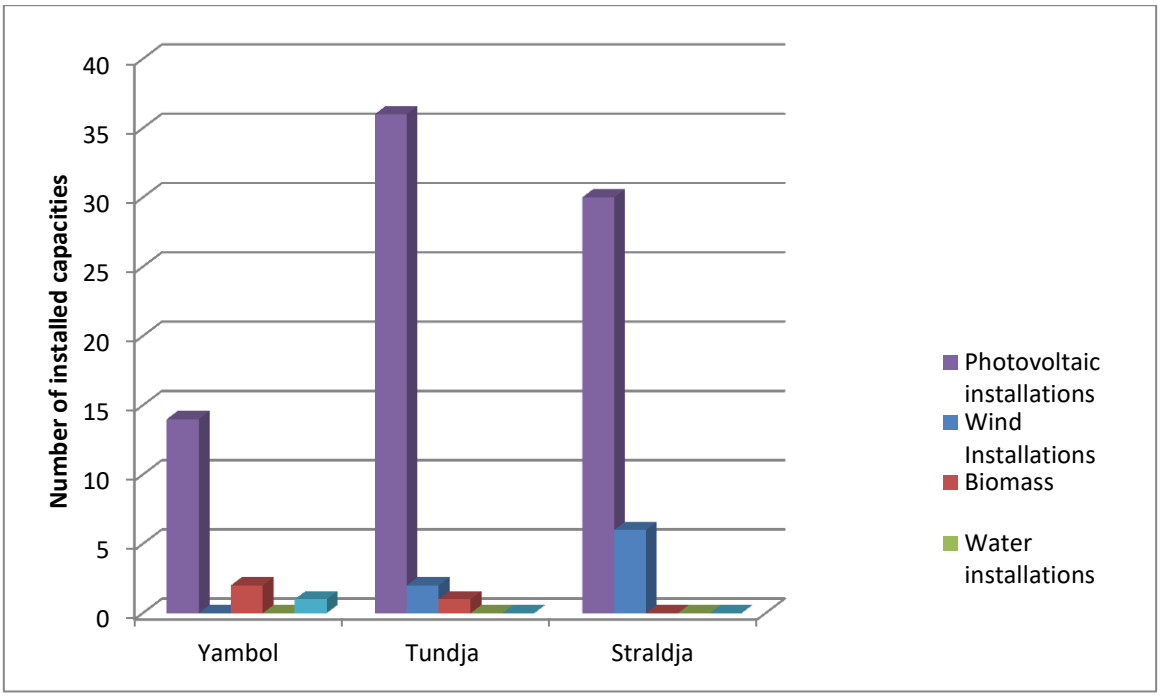

Figure 2. Number of installed RES capacities in the Yambol region

From the analysis it was found that there are no installed water capacities in the Yambol region, which is explicable according to the geographical location. With the same consideration, it can be commented on the fact that the most installed capacities are photovoltaic installations. The wind farms are mainly concentrated in the municipality of Straldja, which is closest to Stara Planina, and part of the air currents in the Balkan Mountains are captured on its territory.

The greater number of installed RES capacities are located in Tundja Municipality, except for wind farms.

The still installed biomass processing capacities in the Yambol region are very small. The region has a predominantly agricultural production whose waste could be successfully used to obtain heat or electricity power.

Table 2 gives data on the total capacity of the installed RES installations in the Yambol region for the period 2005-2016. The municipality with the most installed RES capacities is Straldja, mainly due to the photovoltaic systems. They are least in Yambol Municipality, but here, besides photovoltaics, there is a biodiesel installation, the only one on the territory of the district and the main part of installations for biogas.

Table 2. Installed RES in municipalities in Yambol region for the period 2005-2016

RES / municipality	Photovoltaic installations, kW	Wind Installations, kW	Biomass, kW	Water installations	Biodiesel, kW	Total, kW
Yambol	12249,34	0	1900	0	1050	15 199,34
Tundja	58872,77	2200	330	0	0	61 402,77
Straldja	82524	3600	0	0	0	86 124

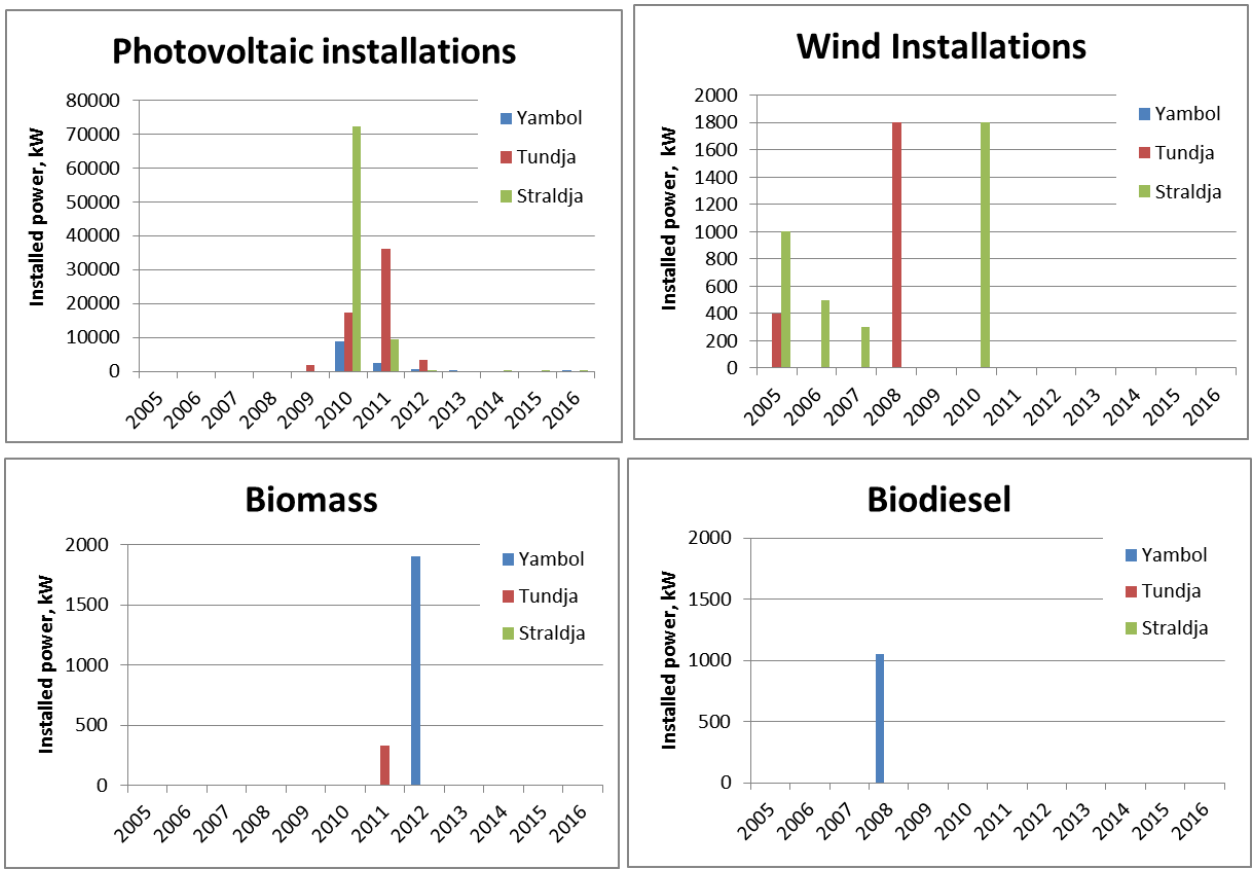

Figure 3. Dynamics of installed renewable energy capacity in the Yambol region

The total installed capacity of photovoltaics in the Yambol region is 153646,11 kW, which is 15% of the installed capacity in Bulgaria. This is mainly due to photovoltaic installations. The relatively high percentage for Bulgaria is due to the good geographic location of the region in terms of number of sunny days. In Figure 3 is presented information about the size of the installed RES capacities in years in the three municipalities.
The information provided shows that the most renewable capacities have been built in 2008-2012, after which there is a stagnation. This is probably due to the fact that European funding is usually used to finance such projects, as are the various incentives when buy up green energy from producers. It can be expected that with the start of the new programming period new RES capacities will be built.

3. CONCLUSION

The following conclusions can be drawn from the study and analysis of the results obtained:

- In general, both for Bulgaria and Yambol region, the largest share of renewable energy is from photovoltaic installations. This technology is still relatively expensive and this leads to an increase in the price of the green supplement, which is paid by the consumers of the National Electricity Company.
- There are no suitable conditions in Yambol for the use of certain RES, such as water, as the area is poor for this resource.
- Yambol is predominantly an agricultural region, many biological waste remain after the processing of the agricultural areas. In Yambol municipality there are a number of canning and food industry companies that dispose of organic waste. This shows that the Yambol area has a significant biomass potential. There are some projects that aim to build small bioreactors for the respective companies emitting bio-waste. It is necessary to carry out in-depth studies in this area of absorption of the potential raw materials for the production of green energy.
- With regard to government policy to support different types of RES, an in-depth analysis of their potential needs to be made and appropriate incentive measures should be put in place for those RESs that are profitable, for example increasing capacity to produce biodiesel has no positive effect, which has been established globally. This suggests limiting investment in this direction.

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POSSIBILITIES OF WHEAT FARMING ON SOILS CONTAMINATED WITH HEAVY METALS IN THE REGION OF NFMW – PLOVDIV, BULGARIA

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Abstract: *The subject of present comparative study in the region of the NFMW Plovdiv, Bulgaria, was to evaluate the amounts and depots of accumulated Pb, Cu, Zn and Cd in vegetative and reproductive organs of the cereal crop wheat, as well as to determine the possibilities for wheat farming on soils contaminated with heavy metals. The highest heavy metal concentrations were established in the grain of wheat farmed at a distance of 100 m from NFMW where Pb attained up to 10.689 mg.kg^{-1}, Zn – up to 71.458 mg.kg^{-1}, Cu – up to 4.583 mg.kg^{-1} and Cd – up to 1.211 mg.kg^{-1}. As the distance from the plant increased, a very marked trend to reduction of heavy metal contents in wheat grain was observed. In grains of wheat reared 7000 m away from NFMW, Pb decreased up to 0.008 mg.kg^{-1}, Zn – up to 29.265 mg.kg^{-1}, Cu up to 3.986 mg.kg^{-1} and Cd up to 0.021 mg.kg^{-1}. The strongest relationship among the total amount of studied metals in the soil and their respective contents in roots, stems, leaves, bracts and grain was established for Zn (0.998). The distribution of heavy metals in the organs of the studied cereal crop was selective in the following descending order: root > leaves > stem > bracts > grain. It was found out that the grain and aerial parts of wheat could not be used for food by humans and animals. Also, wheat could be farmed in industrially polluted areas only if intended for seed production or processing – the grain could be used in ethanol production, and straw – for production of cellulose.*
Keywords: *heavy metals, polluted soils, intake, wheat, NFMW – Plovdiv, Bulgaria.*

1. INTRODUCTION

Cadmium (Cd) and lead (Pb) are nonessential elements that are toxic to plants and animals, while zinc (Zn) and copper (Cu) play essential metabolic roles in plants and animals [1,2]. It is known that only a small amount of the total Pb in soils may be taken up by plants, and the translocation of Pb from roots to tops is greatly limited [3-5]. Cd, Zn, and Cu can be more readily taken up by plants and relatively high concentrations may occur in crops for human consumption. The amount of Pb, Cd, and Zn taken up by plants depends on the total amounts in the soil and their availability [6,7]. The availability of heavy metals is influenced by a wide range of factors, including soil pH, organic matter, carbonates, clay minerals, and oxides [2,8-10].
Toxic metals are accumulated in plants, and animals fed with these plants will tend to accumulate toxic metals themselves. Although contamination of animal feed by toxic metals cannot be entirely avoided given the prevalence of these pollutants in the environment, there is a clear need for such contamination to be minimized, with the aim of reducing both direct effects on animal health and indirect effects on human health. Toxic effects of metals have been described in animals under relatively low levels of metal exposure [11,12] and one of

the earliest effects is the disruption of trace element metabolism [13,14]. Pb interacts with calcium (Ca) in the nervous system to impair cognitive development. Cd interacts with Ca in the skeletal system to produce osteodystrophies. Pb replaces Zn on heme enzymes and Cd replaces Zn on metallothionein.

The need to reduce toxic metal contamination in animal feed in fact poses a significant problem for agricultural regions located in more-or-less industrialized areas in which animals are reared on locally produced feed. There are many such regions worldwide, including in Bulgaria. The district near the Rhodopi Mountain and the Plovdiv Field has been exposed to the influence of the Non-ferrous Metal Works (NFMW) for a long period of time. In the vicinity of the NFMW near Plovdiv, more than 2,100 ha have been polluted by heavy metals. It is estimated that approximately 460 tons of dust, containing mainly Pb, with less Zn and Cd, have been annually released into the atmosphere for more than 40 years [15,18]. As a result of the new cleansing facilities built in the NFMW, however, the aerosol pollution in the district has been reduced to a minimum. This makes it extremely appropriate to examine the connection between soil and plants regarding the assimilation of heavy metals. This area possesses high levels of heavy metals in soils and in vegetation [19-23].

The aim of the present work was to evaluate the bioavailability of heavy metals in the soil-plant system. This involved an investigation of the connection between the total quantity and the mobile forms of Pb, Cd, Zn, and Cu in soils of varying levels of contamination; the transition of these metals into wheat.

2. METHODS

2.1. Soils

Soils used in this experiment were sampled from the vicinity of the area contaminated by the NFMW near Plovdiv, Bulgaria. Soils were collected from the surface (0 to 30 cm depth) of fields located at different distances (100, 400, 800, 2000 and 7000 m) from the NFMW. The investigated soils are characterized by alkaline reaction, moderate $CaCO_3$ content, loamy texture, and moderate content of organic matter (Table 1). The soil samples were air dried, homogenized in an agitate mortar, and sieved. A fraction with particle size < 1 mm was taken for analysis.

Table 1. Soil Properties for Soil Sampled from the NFMW near Plovdiv

Distance from NFMW (m)	pH (H_2O)	$CaCO_3$ (%)	Humus (%)	Ill (%)	Clay (%)
100	7.2	3.7	2.12	16.85	36.52
400	7.8	8.2	1.21	25.64	42.75
800	7.6	3.8	1.10	14.92	26.31
2000	7.5	5.6	1.31	12.21	24.75
7000	7.9	6.2	2.41	27.81	48.13

2.2. Plants

The wheat was grown in the same regions situated at different distances (100, 400, 800, 2000 and 7000 m) from the NFMW - Plovdiv. On reaching the “blossoming” stage, the wheat was gathered, and the content of Pb, Cd, Zn, and Cu in the different parts (stems, leaves, and inflorescences) was quantitatively determined. The samples were treated by the method of dry ashing.

2.3. Heavy Metal Analysis

2.3.1. Sample Preparation

2.3.1.1. Soils

Total content of heavy metals in soils was determined in accordance with the international standard for extraction of trace elements soluble in aqua regia ISO 11466, 1995. Three grams of soil sample were decomposed on a sand bath heater for 3 h with 21 ml of concentrated hydrochloric acid (HCl) + 7 ml of concentrated nitric acid (HNO_3). After cooling the sample, the residue was transferred into a 50-ml flask and water was added up to the mark.
Fractionation studies — The distribution of heavy metals in the different forms and phases in which they occur in soil can be determined using sequential extraction procedures. Sequentialextraction procedures provide information about the determination of the relative binding strength of the metal on various solid phases and about their potential reactivity under physicochemical environmental conditions. In the present study, a five-step Tessier sequential extraction scheme [24], separating exchangeable metals, metals bound to carbonates, metals bound to Fe-Mn oxides, metals bound to organic matter, and residual metals, was applied for the extraction of metals in soil samples for assessing the mobility of the metals.

2.4. Plants

A 1 - g. sample was weighed into a quartz crucible and put into a furnace (525°C) until ashing occurred. After cooling to room temperature, 1 ml HNO_3 (1:1) was added, evaporated in a sand bath, and put again into the furnace (525°C). The procedures were repeated until the ash was white. It was finally dissolved in 2 ml 20% HCl (v/v), transferred into a graduated 25-ml flask, and brought to volume with doubly distilled water.

2.5. Equipment

In the determination of heavy metals in the soils and plants samples Atomno absorption spectrometer "AAnalyst 800 with graphite furnace HGA" Company "Perkin Elmer", at wavelengths: Pb - 217.0 nm, Cd - 228.8 nm, Cu - 324.8 nm and Zn - 213.9 nm was used.

3. EXPERIMENTAL

3.1. Soils

3.1.1. Total content

According to the results, the content of Pb, Cd and Zn in soils was considerably higher than the background levels of these heavy metals in the natural type of soil in the region.
Lead: The total Pb content in analysed soils varied from 27.3 $mg.kg^{-1}$to 913.2 $mg.kg^{-1}$. The maximum permissible limit (MPL) for Pb as per Ordinance 3/2008 stipulating norms for permissible content of harmful substances in soils is 120 $mg.kg^{-1}$.

Zinc: The total Zn content in analysed soils varied from 36.8 mg.kg^{-1} to 1928.2 mg.kg^{-1}. The maximum permissible limit (MPL) for Zn as per Ordinance 3/2008 stipulating norms for permissible content of harmful substances in soils is 400 mg.kg^{-1}.
Cadmium: The total Cd content in analysed soils varied from 2.8 mg.kg^{-1}to 27.9 mg.kg^{-1}. The maximum permissible limit (MPL) for Cd as per Ordinance 3/2008 stipulating norms for permissible content of harmful substances in soils is 3.0 mg.kg^{-1}.
Copper (Cu): The total Cu content in analysed soils varied from 17.66 mg.kg^{-1} to 172.43 mg.kg^{-1}. The maximum permissible limit (MPL) for Cu as per Ordinance 3/2008 stipulating norms for permissible content of harmful substances in soils is 300 mg.kg^{-1}.

3.1.2. Fractionation of Soil

Figure 1, Figure 2, Figure 3 and Figure 4 presents mean values (in %) of metal associated with different fractions (exchangeable metals, metals bound to carbonates, metals bound to Fe-Mn oxides, metals bound to organic matter, and residual metals).

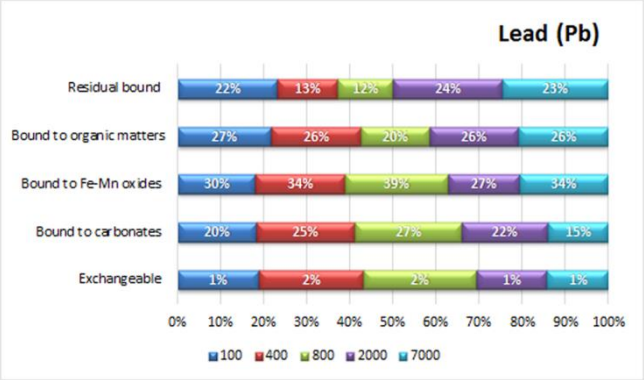

Figure 1.
Association of Pb with different fractions of soils of the study area

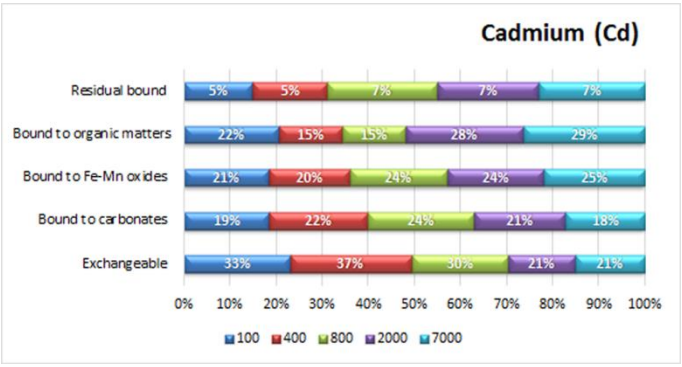

Figure 2.
Association of Cd with different fractions of soils of the study area

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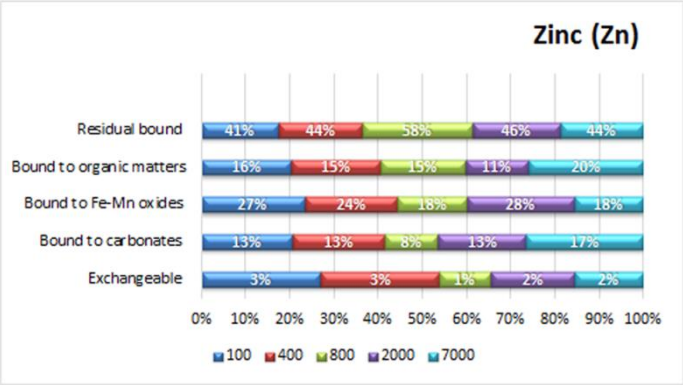

Figure 3. Association of Zn with different fractions of soils of the study area

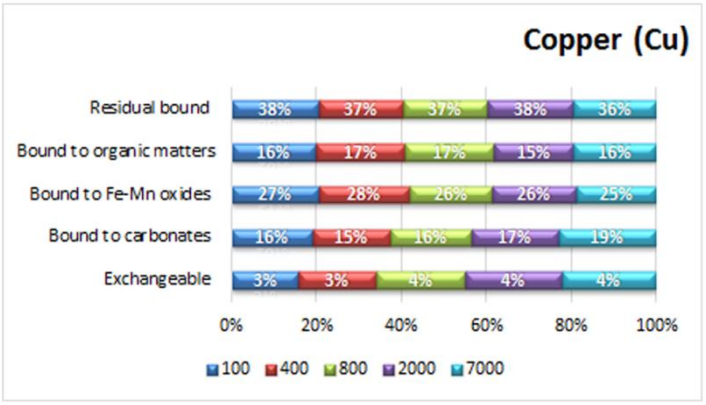

Figure 4. Association of Cu with different fractions of soils of the study area

3.2. Plants

3.2.1. Content of Pb, Zn, Cu and Cd in vegetative and reproductive organs of wheat

For elucidation of issues related to absorption, distribution and accumulation of heavy metals in vegetative and reproductive organs of wheat, samples collected from roots, stems, leaves, bracts and grain were analysed.The data from the analysis of Pb, Zn, Cu and Cd in wheat are presented in Tables 2, 3, 4 and 5.

Table 2. Contents of Pb (mg.kg^{-1}) in wheat

Distance from NFMW (m)	Roots	Stems	Leaves	Bracts	Grain
		MPL for Pb – 0.5 mg.kg^{-1}			
100	81.357	0.362	92.421	28.965	10.689
400	52.485	0.132	56.205	16.432	3.745
800	20.354	0.096	28.362	4.853	0.636
2000	8.415	0.061	7.875	0.754	0.241
7000	5.467	0.046	1.946	0.012	0.008

MPL - Maximum permissible limit (Ordinance № 31/2004; Directive 99/29/EC)
* Average value (mg.kg^{-1}) from five repetitions

Table 3. Contents of Zn (mg.kg^{-1}) in wheat

Distance from NFMW (m)	Roots	Stems	Leaves	Bracts	Grain
		MPL for Zn – 40 mg.kg^{-1}			
100	172.185	29.426	228.329	118.345	71.458
400	96.542	16.069	165.529	74.730	52.364
800	81.165	14.685	108.104	45.206	35.167
2000	63.542	13.745	47.026	34.543	31.491
7000	59.862	11.325	27.192	23.574	29.265

MPL - Maximum permissible limit (Ordinance № 31/2004; Directive 99/29/EC).
* Average value (mg.kg^{-1}) from five repetitions

Table 4. Contents of Cu (mg.kg^{-1}) in wheat

Distance from NFMW (m)	Roots	Stems	Leaves	Bracts	Grain
		MPL for Cu – 10 mg.kg^{-1}			
100	12.147	2.548	12.957	4.843	4.583
400	10.874	2.565	8.321	4.591	4.416
800	10.168	2.692	4.832	4.364	4.285
2000	8.365	2.645	3.109	3.211	4.065
7000	7.538	2.625	2.746	3.574	3.986

MPL - Maximum permissible limit (Ordinance № 31/2004; Directive 99/29/EC).
* Average value (mg.kg^{-1}) from five repetitions

Table 5. Contents of Cd (mg.kg^{-1}) in wheat

Distance from NFMW (m)	Roots	Stems	Leaves	Bracts	Grain
		MPL for Cd – 0.1 mg.kg^{-1}			
100	4.834	0.626	10.326	22.717	1.211
400	2.854	0.375	6.351	9.864	0.932
800	1.365	0.252	3.437	4.721	0.543
2000	0.921	0.161	1.254	1.524	0.073
7000	0.635	0.124	0.567	0.421	0.021

MPL - Maximum permissible limit (Ordinance № 31/2004; Directive 99/29/EC).
* Average value (mg.kg^{-1}) from five repetitions

3.3. Statistical analysis of results

The statistical analysis of results was done with SPSS for Windows software.
The results presented in Tables 6, 7 and 8 demonstrated positive correlation ($r > 0$) and a strong linear relationship between variables ($r > 0.8$). Table 9 shows a negative relationship ($r < 0$) between soil Cu content and its content in leaves.

Table 6. Relationships between the total Pb content in soil vs its content in roots, stems, leaves, bracts and grain

	The total Pb content in soil	Roots	Stems	Leaves	Bracts	Grain
The total Pb content in soil	1					
Roots	0.924	1				
Stems	0.997	0.934	1			
Leaves	0.924	0.995	0.941	1		
Bracts	0.942	0.999	0.950	0.993	1	
Grain	0.992	0.962	0.989	0.955	0.974	1

Table 7. Relationships between the total Zn content in soil vs its content in roots, stems, leaves, bracts and grain

	The total Zn content in soil	Roots	Stems	Leaves	Bracts	Grain
The total Zn content in soil	1					
Roots	0.998	1				
Stems	0.994	0.990	1			
Leaves	0.906	0.927	0.882	1		
Bracts	0.961	0.976	0.952	0.975	1	
Grain	0.950	0.969	0.939	0.964	0.996	1

Table 8. Relationships between the total Cd content in soil vs its content in roots, stems, leaves, bracts and grain

	The total Cd content in soil	Roots	Stems	Leaves	Bracts	Grain
The total Cd content in soil	1					
Roots	0.996	1				
Stems	0.990	0.995	1			
Leaves	0.979	0.992	0.995	1		
Bracts	0.995	0.993	0.996	0.983	1	
Grain	0.920	0.946	0.954	0.978	0.926	1

Table 9. Relationships between the total Cu content in soil vs its content in roots, stems, leaves, bracts and grain

	The total Cu content in soil	Roots	Stems	Leaves	Bracts	Grain
The total Cu content in soil	1					
Roots	0.968	1				
Stems	-0.671	-0.563	1			
Leaves	0.985	0.933	-0.783	1		
Bracts	0.871	0.931	-0.525	0.862	1	
Grain	0.976	0.997	-0.622	0.954	0.937	1

4. RESULTS

4.1. Soils

4.1.1. Fractionation of Soil

Any metals derived from an anthropogenic source are strongly influenced by their form, phase, and oxidation state, and hence, bioavailability. Chemical soil tests are designed to extract a quantity ofelements from the soil solids that correlate statistically to the size of the "available pool" in the soil defined by the quantity of elements taken by the plants [2,8]. Chemical extraction techniques provide a wellestablished means of identifying and characterizing different fractions of heavy metals in the soil [25].
Results of the geochemical partitioning using the Tessier scheme revealed high concentrations of Cd to be associated with the mobile fraction of the soil. Most of the Pb, Cu, and Zn were bound with forms largely unavailable for plants, i.e., Fe-Mn oxides and residual fraction.
Because Pb binds strongly with organic matter and chemisorbs on oxides of Fe, Mn, and Al, it is a low-mobility metal in soil. Studies have reported that accumulation of Pb in plants occurs only with high concentration of Pb in soils [6,26]. As the soil Pb concentration was high, the vegetation is prone to accumulate Pb [2,8].

4.2. Plants

4.2.1. Pb, Zn, Cu and Cd content in the root system

The root system is the main pathway for occurrence of heavy metals in plants. Once in roots, they could be either stored or transported to stems.
There were significant differences in the distribution of studied metals in the different parts of the plants. A substantial part of all four heavy metals was accumulated in roots, as also reported by other researchers [26-30]. This is attributed to the fact that after penetration in the plasma, the occurring inactivation and accumulation of important amounts of heavy metals was probably a result from formation of less mobile chelation compounds with organic matter.
The highest concentrations were established in wheat farmed at a distance of 100 m from NFMW where Pb attained up to 81.357 $mg.kg^{-1}$, Zn – 172.185 $mg.kg^{-1}$, Cu – 12.147 $mg.kg^{-1}$ and Cd – 4.834 $mg.kg^{-1}$. As the distance from the NGMW increased, a clear tendency for reduction of heavy metal contents in wheat roots was observed. Seven thousand meters away from the NFMW, wheat roots Pb content was reduced up 5.467 $mg.kg^{-1}$, Zn content – up to 59.862 $mg.kg^{-1}$, Cu – up to 7.538 $mg.kg^{-1}$ and Cd – up to 0.635 $mg.kg^{-1}$.

4.2.2. Pb, Zn, Cu and Cd content in stems

The content of heavy metals in the stems of studied cereal crop was considerably lesser than in roots, indicating that their transport via the vascular tissue system was very restricted. According to Wagner [31], the roots of wheat control the amount of cadmium translocated from plant roots to stems and hence, the amount of metal accumulated in leaves. The translocation mechanisms of heavy metals from roots to stems are still unclear for most plants, including wheat.
It was demonstrated that the root-to-shoot translocation of metals occurs primarily via the xylem. It is reported that Cd could also occur in the xylem through symplastic transport, but the apoplastic pathway is also probable, especially when cadmium contamination levels are high [32]
After the metals' uptake in stems, a part of them could be redistributed again in plants through the phloem as could be presumed from data reported for zinc in wheat [33] and data for cadmium [34].
The highest concentrations in wheat stems were established in plants farmed 100 m away from the NFMW where Pb attained up to 0.362 $mg.kg^{-1}$, Zn – up to 29.426 $mg.kg^{-1}$, Cu – up to 2.548 $mg.kg^{-1}$ and Cd – up to 0.626 $mg.kg^{-1}$. With shortening of the distance from the NGMW, heavy metal content in wheat stems showed a clear tendency towards reduction. In plants farmed 7000 m away from the NFMW, Pb decreased up to 0.046 $mg.kg^{-1}$, Zn – up to 11.325 $mg.kg^{-1}$, Cu – up to 2.625 $mg.kg^{-1}$and Cd – up to 0.124 $mg.kg^{-1}$.

4.2.3. Pb, Zn, Cu and Cd content in leaves

The content of heavy metals in wheat leaves was higher than in roots and stems, in agreement with other data reported [35,36]. The greater extent of accumulation in the leaves of wheat was probably due both to the uptake of metals from soil through the root system and their translocation through the vascular tissue system, and to particulate matter pollution.
The highest concentrations were established in the leaves of wheat farmed 100 m away from the NFMW with Pb levels up to 92.421 $mg.kg^{-1}$, Zn levels up to 228.329 $mg.kg^{-1}$, Cu up to 12.957 $mg.kg^{-1}$ and Cd up to 10.326 $mg.kg^{-1}$. Although the heavy metal contents in what leaves was high, there were no symptoms of toxicity. As the distance from the NFMW increased, the leaf metal concentrations tended obviously to decrease – in wheat which was 7000 m away from the NFMW, Pb decreased up to 1.946 $mg.kg^{-1}$, Zn – up to 0.547 $mg.kg^{-1}$, Cu – up to 27.192 $mg.kg^{-1}$ and Cd – up to 2.746 $mg.kg^{-1}$.

4.2.4. Pb, Zn, Cu and Cd content in bracts

The concentrations of studied heavy metals in bracts of the cereal crop was lower than respective levels in leaves, in support to findings of Zupan et al. [37] who also found out lower content of Cd, Pb and Zn in bracts and grain than in leaves.
The accumulation of heavy metals in bracts is airborne and dependent mainly on the type of bracts and the specific heavy metal.
The highest concentrations in bracts were established in wheat located 100 m away from the от NFMW: Pb up to 28.965 $mg.kg^{-1}$, Zn up to 118.345 $mg.kg^{-1}$, Cu up to 4.834 $mg.kg^{-1}$ and Cd up to 22.717 $mg.kg^{-1}$. Regardless of the fact that the levels of heavy metals in wheat bracts was high, no toxicity signs were present. With increase of distance from the NFMW heavy metal contents in bracts have markedly declined and in crops 7000 m away from the NFMW Pb was reduced up to 0.012 $mg.kg^{-1}$, Zn u to 23.574 $mg.kg^{-1}$, Cu up to 3.574 $mg.kg^{-1}$ and Cd up to 0.421 $mg.kg^{-1}$.

4.2.5. Pb, Zn, Cu and Cd content in grain

The content of heavy metals in grain was lower than in bracts. The results evidenced that bracts are a sort of obstacle to the pathway of heavy metals to the grain. Heavy metals accumulation in grain occurs probably via the vascular tissue system and depends mainly on the crop species and the specific heavy metal element. As the distance from the NFMW increased, the pollutants' content in the grain of the studied cereal crop was reduced. The highest values were found out in wheat farmed 100 m away from NFMW, where Pb attained up to 10.689 $mg.kg^{-1}$, Zn – up to 71.458 $mg.kg^{-1}$, Cu – up to 4.583 $mg.kg^{-1}$ and Cd – up to 1.211 $mg.kg^{-1}$. Heavy metal contents in wheat grain declined markedly as the distance from the NFMW increased: in grain farmed 7000 m away from the NFMW Pb decreased up to 0.008 $mg.kg^{-1}$, Zn - up to 29.265 $mg.kg^{-1}$, Cu - up to 3.986 $mg.kg^{-1}$ and Cd - up to 0.021 $mg.kg^{-1}$.
According to the results, 100 m away from NFMW wheat grains accumulated Pb, Zn and Cd in amounts higher than the permissible concentrations while in grains 7000 m away from the NFMW the concentrations were below the MPL.

4.3. Statistical analysis of results

The statistical analysis of results was done with SPSS for Windows software.
Correlation analysis between the content of studied elements in the soil and respective concentrations in roots, stems, leaves, bracts and grain was performed.
The results presented in Tables 6, 7 and 8 demonstrated positive correlation ($r > 0$) and a strong linear relationship between variables ($r > 0.8$). The strongest correlation was observed between the total soil content of zinc and its levels in roots, stems, leaves, bracts and grain ($r = 0.998$).
Table 9 shows a negative relationship ($r < 0$) between soil Cu content and its content in leaves. This is the lowest established numerical value of the correlation coefficient ($r = -0.671$), indicating a moderate strength of the relationship.

5. CONCLUSIONS

- The presented results for heavy metals' content in wheat allowing concluding that there was a clear species-specific pattern of accumulation of heavy metals in vegetative and reproductive organs of the cereal crop. With this regard, wheat belongs to the group of moderate accumulators.
- In industrially polluted regions, wheat farming for consumption is unacceptable. This is supported by the fact that grains accumulate Pb, Zn and Cd in amounts exceeding the maximum permissible limits and could pose a risk for human health.
- Also, wheat could be farmed in industrially polluted areas only if intended for seed production or processing – the grain could be used in ethanol production, and straw – for production of cellulose.

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CHEMICAL COMPOSITION AND TRACE ELEMENT ANALYSIS OF *TRICHOLOMA EQUESTRE* COLLECTED FROM BATAK MOUNTAIN IN BULGARIA

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Abstract: *Tricholoma equestre was rich in carbohydrates (88.03g 100^{-1} g^{-1} dw), followed by proteins (5.65 g 100^{-1} g^{-1} dw), ash (4.57 g 100^{-1} g^{-1} dw) and fat (1.75 g 100^{-1} g^{-1} dw). Moisture (88.31%) and Energy (390.49 kcal 100^{-1} g^{-1} dw) were also calculated. The concentrations of trace elements : Fe (12.85 ± 0.68 mg kg^{-1}), Zn (8.63 ± 0.19 mg kg^{-1}), Cu (1.16 ± 0.14 mg kg^{-1}) and Mn (0.85 ± 0.13 mg kg^{-1}), were assayed. Trace elements content of samples indicated that the Batak mountain was an ecologically pure region in Bulgaria, and therefore the mushrooms collected from this location could be consumed without any risk for human health. According to this study, the edible wild mushroom Tricholoma equestre could be used in human nutrition due to its good properties.*
Keywords: *Chemical Composition, Trace elements, Tricholoma equestre, Batak mountain, Bulgaria.*

1. INTRODUCTION

Mushrooms have been exploited in human diet for centuries because of their specific taste and flavour. Nowadays, they attract attention because of their beneficial effects and possible use in the prevention or treatment of diseases [1]. Numerous reports demonstrate beneficial in vivo effects of cultivated and wild edible mushrooms. It has been proven that the polysaccharide extract of Pleurotus pulmonarius delays the progression of hepatocellular carcinoma [2]; polysaccharide from Pholiota nameko has anti-inflammatory properties in rodents [3]; Agaricus bisporus inhibits prostate tumor growth in mice [4]; Pleurotus eryngii, Grifola frondosa, and Hypsizygus marmoreus protect apolipoproteinE deficient mice from development of atherosclerosis [5]. Simultaneously, edible mushrooms are regarded as an important dietary supplement for people interested in calorie restriction, because of the low amount of fat, cholesterol, and calories in their bodies and high concentration of fiber [1, 6–8]. The therapeutic action of mushrooms is attributed to the presence of bioactive compounds such as vitamins, polysaccharides, and secondary metabolites in their fruiting bodies. Some of them have antioxidant properties which are referred repeatedly to be the key aspect of their observed beneficial effects. Polyphenols and carotenoids, abundant in the fruiting bodies of mushrooms, are antioxidants efficient in biological systems [9]. Polyphenols have been reported to interfere with the initiation and progression of cancer [10, 11], to act as antiageing [12], anti-inflammatory [13, 14], and brain-protective factors [15] and to protect against cardiovascular diseases [16, 17]. Apart from provitamin A properties, carotenoids are known as singlet oxygen quenchers [18, 19] and lipid peroxidation chain breakers [20]. They have been reported to reduce the risk of prostate cancer [21, 22], digestive tract cancers [23, 24], and chronic diseases [25–27].
Herein, we report the chemical compositions and trace element analysis (Fe, Zn, Cu and Mn) of *Tricholoma equestre* (Fig.1) wild edible mushroom collected from Batak mountain in

Bulgaria, with reference to the content (as d.w. basis) of ash, moisture, carbohydrate, fat, protein and energy. To our knowledge, no data have previously been reported on the chemical compositions and trace element analysis of *Tricholoma equestre* which are examined from a different habitat in the same region.

Figure 1. Tricholoma equestre

2. METHODS

2.1. Mushroom Samples

Fifteen mushroom samples were collected in 2014 and 2015 from the Batak mountain by the authors themselves.
The Batak mountain is located in western Rhodopes. Its western border is defined by the Chepinska river, the southern border – by Dospatska river and Dospat dam, the eastern border – by Vacha river and the northern border – by the Thracian Plane (GPS41°46'02.6"N 24°08'48.4"E). The regions is industry-free and is characterised with forests, land and low buildings.

2.2. Reagents

All chemicals were at least of analytical-reagent grade. Water was de-ionized in a Milli-Q system (Millipore, Bedford, MA, USA) to a resistivity of 18.2 MΩ cm.
All plastic and glassware were cleaned by soaking in diluted HNO_3 (1/9, v/v) and were rinsed with distilled water prior to use.

2.3. Sample preparation for nutritional analysis

The whole macrofungal samples were used in this study. Fresh samples, after the removal of extraneous material such as mud, bush, soil, plant, etc. by washing with demineralized water, were air-dried in between Whatman's filter papers. Approximately 5 g of each sample was taken immediately for the determination of moisture. Remaining samples were stored in deep-freezer until use. While examining the nutritional composition of mushroom samples, the maturation stage of them was not considered.

2.4. Chemical analysis

The following components were determined on airdried material: moisture, by drying in a moisture determination apparatus at 110 ºC until circulation was completed; ash, from the incinerated residue obtained at 550°C after 3 h; crude protein, by the Kjeldahl method with a conversion factor of 6.25; crude fat, gravimetrically determined after Soxhlet extraction with petroleum ether. Total energy values were calculated by multiplying the amounts of protein and carbohydrate by the factor of 4 kcal/g and lipid by the factor of 9 kcal/g. In all tables, data points represent mean of three determinations.

2.5. Trace Element analysis

Fresh mushrooms, after removal of external material, were dried in an oven at 105 °C for 24 h after airdried for several days. Dried samples were homogenized, using an agate homogenizer, and stored in pre-cleaned polyethylene bottles until analysis. 1 g of sample was placed in a porcelain crucible and ashed at 450 °C for 20 h; then the ash was dissolved in 1 ml concentrated HNO_3, evaporated to dryness, heated again at 450 °C for 4 h, treated with 1 ml concentrated H_2SO_4, 1 ml HNO_3 and 1 ml H_2O_2, and then diluted with double deionized water up to a volume of 10 ml. The blank samples were treated in the same way. For the determination of metal contents, an *Varian Spectra AA 220 model Atomic Absorption Spectrometer (AAS)* was used. The determination of all metal contents was carried out in an air/acetylene flame. The maximum absorbance was obtained by adjusting the hallow cathode lamps at the operation conditions.

2.6. Statistical

SPSS (Statistical Package for Social Science) program for Windows was used for statistical data processing.

3. EXPERIMENTAL

3.1. Chemical Composition

Chemical composition of *Tricholoma equestre* are presented in Table 1. *Tricholoma equestre* showed to be rich in carbohydrates (88.03 g 100^{-1} g^{-1} dw), which were the most abundant macronutrients. Proteins were present at (5.65 g 100^{-1} g^{-1} dw), ash (4.57 g 100^{-1} g^{-1} dw) and fat (1.75 g 100^{-1} g^{-1} dw). Moisture (88.31%) and Energy (390.49 kcal 100^{-1} g^{-1} dw) were also calculated.
Despite some similarities in the composition of mushroom samples, it is known that the chemical composition of mushrooms are affected by a number of factors, namely, mushroom strain/type, composition of growth media, time of harvest, management techniques, handling conditions and preparation of the substrates. This situation, they are diversity in antimicrobial activity of mushrooms at different cultivation status of same species. It can change the content and amount of active compounds according to growth media of mushroom. Therefore chemical contents and antimicrobial substances of mushroom species naturally grown in different geographic locations of world must be analyzed and comparison of this analysis is very important [28].

Table 1. Moisture (g 100^{-1} g^{-1} of fresh weight), macronutrients (g 100^{-1} g^{-1} of dry weight) and total energy (kcal 100^{-1} g^{-1} of dry weight) in the wild edible mushrooms.

Components	$\bar{X}$ mg kg^{-1}	SD mg kg^{-1}	-95% Confid.	+95% Confid.
Moisture	88.31 %	0.89	87.82	88.81
Ash	4.57	0.16	4.48	4.66
Crude protein	5.65	0.12	5.58	5.72
Crude fat	1.75	0.20	1.64	1.86
Total carbohydrates	88.03	0.26	87.89	88.18
Energy (kcal)	390.49	1.45	389.69	391.29

A Each value is expressed as mean ± SD (n = 15). Means with different letters within a row are significantly different ($p < 0.05$).

Table 2. Trace metal concentrations (mg kg^{-1}, dry weight basis) in mushroom samples (n=15).

Fungal species	Fe	Zn	Cu	Mn
Tricholoma equestre	12.85 ± 0.68	8.63 ± 0.19	1.16 ± 0.14	0.85 ± 0.13

4. RESULTS

In this study, Fe, Zn, Cu and Mn concentrations as micronutrients in dry matter basis of *Tricholoma equestre* were analyzed (Table 2).

The micronutrient metal composition of wild edible mushrooms used in this study were investigated [29-32]. The observation of different results can be attributed that the trace element profile of mushrooms has been affected by environmental factors such as climate, growing conditions, region and soil content.

Minimum and maximum Fe levels, in the present study, were 11.84 mg kg^{-1} d.w. and 13.85 mg kg^{-1} d.w. for *Tricholoma equestre*. Higher Fe levels were reported for *C. cornucopioides, A. mellea, S. imbricatus, R. flava, H. repandum and C. cibarius* [29-32].

In this study, the highest (8.36 mg kg^{-1} d.w.) and the lowest (8.97 mg kg^{-1} d.w.) Zn content was found in *Tricholoma equestre*, respectively. Zinc is widespread among living organisms due to its biological significance [30].

The Cu contents of *Tricholoma equestre* changed from 0.92 mg kg^{-1} d.w. to 1.34 mg kg^{-1} d.w. These Cu levels for the same species were in accordance with Sesli and Tüzen [30], Mendil et al. [31] and Ouzouni et al. [32]. C. Cibarius Cu level (1.16 mg kg^{-1} d.w.) was considerably lower than reported Sesli and Tüzen [30]. The Recommended Dietary Allowances (RDA) for adults is 0.90 mg copper/ day [34]. Present concentrations of copper in mushrooms are not considered a health risk [33]. In general, copper contents in mushrooms are higher than those in green plant and vegetables and should be considered as a nutritional source of this element [35].

In this study, Mn contents of *Tricholoma equestre* were measured in the range of 0.64 – 1.06 mg kg^{-1} d.w. Higher Mn levels of *C. cornucopioides, L. volemus, A. mellea, C. cibarius, S. Imbircatus* were reported [29-32]. Whereas higher Mn levels of *L. perlatum* and *L. volemus* were found [29,30]. However, similar Mn levels for *L. perlatum* and *H. Repandum* were reported [29-32].

5. CONCLUSIONS

It can be concluded that the investigated wild edible mushroom *Tricholoma equestre* is good food sources in terms of protein, carbohydrate, crude fat, and energy values and may be cultivated. Our micronutrient values are in agreement with reports in the literature. So, it can be said that these determinations make the investigated wild edible mushroom popular and easily able to consume.

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APPLICATION AND TRANSFORMATION OF TRADITIONAL FORMS IN CONTEMPORARY INTERIORS

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Abstract: *The fence that was placed on the verandas in rural and urban houses had mainly functional implementation and then it satisfies the aesthetic criteria. Earth as a field of development in which all the primary forms - primitives reorganized in different compositions, which have application in modern interiors and exteriors. Design is used in every area of human life and creation. The things that surround us in every part of our life apart from performing a function they also have a high aesthetic and decorative part. In interior and interior decoration there is an important role which is the main factor to develop a strong emotional impact in space. Different designs in open and closed spaces could be on the floor, as wall decorations, ceilings and many additional elements that complement the space.*
Keywords: *rhythm, powerful position, interior, exterior.*

1. TRADITION

Tradition is an important segment within the needs of each individual in modern oriented society, including construction activity or designing the interior and exterior, as its integral part. The presence of traditional ornaments and stylized traditional elements are always present to meet the individual needs of each individual identification of the space in which he lives. Local habits and needs are an integral element to implement the special aspect of design. So, the application of traditional local functions in shaping the physical environment of a person has significant impact on contemporary design, in its surroundings or interior design and exterior.
Analysis of the traditional elements used in the design which make a leave a mark of tradition of a nation. Analysis of the connection between ornamentation and technology, with its application. the ability to combine tradition as symbols and decorations with their international classification and meaning in conjunction with the contemporary trends.
In the long development path, in the constant process of supporting the old traditions by entering the elements of popular taste and understanding, the application of traditional elements are formed as a specific ethnic differentiated branch of tradition. These are complex shaped sections in which the harmonious blend of individual objects of everyday life is noticeable, both in terms of decoration, colour and ornamentation. And overall composition of objects is tailored not only to its practical function, but it also serves to satisfy the aesthetic conceptions of its creator.
The subject of analysis is traditional wooden fences which were placed on the verandas and external and internal stairs, had primarily functional purpose and the function was supplemented with the aesthetic elements. Always made of wood which makes the authentic, lifestyle habits and choice of material handled. One element which is composed of geometric forms and his rhythmic repetition is made for functional composition application.

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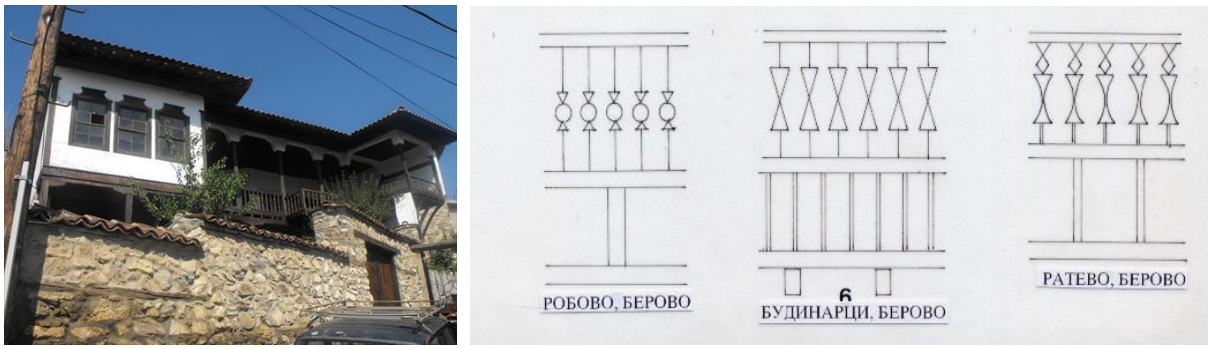

Figure 1. Traditional wooden fences

The regular repeating pattern is when one form or line is repeated many times without any changes, because the visual elements are the simplest relations. To perform this kind of repetition, previously is done an ancillary network which serves to uniformly repeating motive. The network should be made of equal fields. They are usually squares, rectangles or other geometric figures. They may be different in form fields, in condition the repetition to have a certain order. Regular repetition can be simple and alternative. Simple is when there is just one repeat motive, and alternatively when there are alternately repeated two or more motives. In repetition the leading role is carried by rhythm and form, then the other elements. Mere repetition is correct, strictly, unified, templated, because it gives the impression of uniformity. The viewer gets tired quickly and loses interest and motive for further viewing.
Alternative repetition is also right, strict and templated, only it involves many artistic elements. The more artistic elements involved, the more the composition is vivid, rich and dynamic, because that way more changes are brought. So from, one iteration to the gradual inclusion of more items, the composition invigorates and energises.
Based on these principles countless compositions can be created. Macedonian folklore abounds with them. In all these examples, it is important that repetition is strictly regular, can be developed in a sequence (frieze), in a circle or unlimited on all four sides. Such a composition is used in craft or industrial artistic production where a pattern is repeated indefinitely, usually found in the design for textiles, wallpaper and interior architecture to decorate large surfaces, especially facades, walls, floors, ceilings. Regular (simple and alternative) repeating synonymous with rhythm. They are simply inseparable. There is no rhythm without repetition, and no repetition without any rhythm. So if repetition is regular, regular rhythm is back ao repetition is free, free is the rhythm.
In the system of regular repetition, rhythm brings order in the movement, unity and beauty. The rhythm owed to the popularity of this type of decoration, because the rhythm is present in the overall art work from the beginnings to the present, as in the most primitive and the most developed civilizations.
The transformation of forms takes place when an analysis of selected frieze, their interrelationship in the placement of elements and their regrouping all so they could obtain an elastic connection between the elements in but in an expressed concept or an elastic opinion. The need of the designer is to nature and change the environment all so he could achieve a higher aesthetic value aka make various attempts at solving the design problem until they find a suitable solution that meets its design idea.

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Figure 2. Transformation of forms

2. STRUCTURAL COMBINATORICS

Structural combinatorics is a very important part of the design, the architecture because it deals solely with the use of the profession.
Without a basic understanding of the purpose, principles and methods of combinatorial creation of form is not possible, the creation, implementation and operation of any kind of nomenclature of construction elements produced industrial time. The only way to prevail first and striving for commercial production of monotonous elements in large batches (which provide more income for the manufacturer) in favour of the necessary maximum versatility in the realization of the end product - a family of products, buildings and facilities.
Each product consists of building blocks whose permanent propagated makes unified ie typed. The building blocks that belong to a particular family of combined forms are sorted by nomenclature, as designers strive to develop optimal nomenclature is most effective in terms of production.
The obligatory need for industrially manufactured objects typified elements united in some sign so they could be designed on a modular principle.
The combinatory principle used in all tasks that are scheduled for installation construction. When an object is an individual residential environment it should simplest be prepared following to verify the specific features of mass living on most economical solutions to be created for maximum flexibility in the exploitation and transformation of space, to develop a constructive solution with minimal elements to achieve simplicity and convenience of transportation and installation of typified elements in place. These requirements may come to approach, in which the dimensions of different products or groups of products are unified, it refers to the functional areas that are also unified. So it developed two main modules can easily merge into different functional blocks, whose variability is determined through the principles of combinatorial form-making usual plastic achieved interesting results. Mastery of combinatory way of educating format helps designers in their quest towards improving and optimizing the nomenclature of industrial products, which undoubtedly brings up a more moderate and effective intervention by addressing the problems of the system offers the possibility of variability and multifunctional application.
It can easily be checked when using means of combinatorial form-making.
The significance of combinatory way of the form-making in the aesthetic relationship consists of the ability to create products whose diversity is caused by the interplay of structural and stylistic unity. Regardless of the claims (which naturally contain some restrictive conditions) for unification and merging of typified elements of architectural practice giving numerous

examples of the implementation of the modular principle with very good functional and visual result.
Combinatory way of construction of the form is not a cure for any design architecture. In practice it is known that it is particularly effective in larger sizes.
Amazing results are achieved with the construction of forms of decorative and functional items. It requires a good knowledge of form-making properties of the type of elements (type, combinatorial and connection between them) and the types of creating a format which usually are base for the design process related to full alignment of the figures (in the case - typified elements) also gets a kind of mosaic or as accepted in the design grid.
Combinational form of creation is indispensable a means of planning, design and implementation of sustainable structure character whose effectiveness is checked at the time and is of great importance to harmony in the interior.

3. CONCLUSION

Use of traditional local features has a significant impact on the modern design of its proximity or design furniture. This contributes to the continuation of some national characteristics, habits, lifestyle, and environmental improvement with environmental standards, while local resources are used, and the types of development of energy technology, solving specific social problems and so on. There are several ways to use elements of tradition in modern interior design space, which can be interpreted by taking their direct form or motive that can cause some positive messages regarding their use of visual and decorative aspect.
Future concept of modern designer needed to use the experiences of previous models using modern tradition, where it needs a new innovative approach and look of the design to create new models using traditional matrix elements that will carry systems symbolic value and also for the development of contemporary thought about the need to apply the tradition in this area.
Of course, while it is true that rules are made to be broken, until you have a solid understanding of what those rules are and why they exist, will never understand the best way to cite them and how to use them.

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GRAPHIC LINE AS COMPOSER OF FORMS IN INTERIOR AND EXTERIOR DESIGN

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Abstract: *The line is an essential tool in fine and applied arts.The definition saying that the line is a continuous movement of a point in space at one, two or three dimensions (length, height and width) or that the line is connected in two distant points. However, there is also a view that the line is an abstract concept, because it as such does not exist. Its application in interior and exterior transformation and change the line of art in design and after its functional application. Application of old graphics technique in modern spaces. No boundary line between what is art and what is not applied arts in interior design and exterior design. It all starts on the skill of the designer in the creation of good composition and then must create the structure.*
Keywords: *line, graphics, composition, interior, exterior.*

1. INTRODUCTION

Line form for its distribution and intensity creates certain spatial characteristics. There are two important principles that prove that the line is the adjustable visual factor in the volume of space.

1. All open lines inclination rights.
2. All loops tend to round.

It follows that there is open and closed forms of space and, therefore, once again, that open shapes belonging to two-dimensional space for the closed forms of three-dimensional space. The meaning of certain visual information received line up of underline, i.e. when a stream or meeting with other lines creates a loop of some sort. Dense placement of the line next to one another or above one another creating repair area whose density is to transparent film to the end of the linear structure. It now opens the way to the idea of making the surface table.

In contemporary art this problem is well known. Numerous lines of the same size to that extent smother their material traces and create a layer with a palpable energy put into these movements. This creates a new problem.

The effect of multiple lines on the surface although obviously created layer and introduced energy created and energized zone - tensions that produced the effect of linear organization afloat.

This brings us to the idea that its line of action can achieve for itself an element that does not analyse anything except very existence. With these theses about the ability of the line come in two basic types of expression of the line can persist in some segments of art.

The first types are linear flow to the space as the line "wrapped" around a space as an offer volume. Here is dominant curvilinear move. The second type occurs when introduced energy matter (which leaves traces) is identified with the straight and speed implementation of such a linear structure. We call this creative gesture.

The definition saying that the line is a continuous movement of a point in space at one, two or three dimensions (length, height and width), or that the line is connected in two distant

points. However, there is also a view that the line is an abstract concept, because it as such does not exist. What is called line, although the length has known even minimum height and is actually just very elongated area.
In further exposure line we will treat it as an independent artistic element used in graphics and all his subtlety, as portrayed by printing paint because as such it has specificity in art and in practice.
To be clear, we will disregard, i.e. they will stand out from the picture, with which it is associated most often because the drawing are other artistic elements. In isolated line easily discern its essential characteristics.

2. TYPES OF LINES AND THEIR FUNCTION

It is wrong to believe that there are a number of different lines. In fact there are only two types of lines: straight and curved. Other types of lines no. But these two lines make the contents of all graphics are distinguished by energy and tenderness of the author, as it is presented.
The straight line is one. It is always just right, no matter how long, wide, whether vertical or horizontal, dark or light coloured, smooth or rough, if only drawn or deduced with any material. It is constantly moving in the same direction and does not change the angle.
Together with the line moving and the eye and attention of the viewer, it just pulls behind. As is longer, the more uninteresting, in featureless and monotonous. This is due to the repetition of the point without changes in direction, i.e., sole rhythm.
Curve. Unlike rights curved line has a lot of options. They may be very little to very strongly curved, i.e. have very small to very large bending angle. By switching angles can create multiple variations of curved lines that do not really have anything else, but only segments of circles of various sizes.
The chart is used much more straight line from simple reason that it is higher in nature, but also because it provides an opportunity to express different and complex content and messages. In the aesthetics of the past, it was thought that the straight line does not express anything, looking like a secondary line and avoided where not needed, but in modern life is much represented the straight line as an expression of coldness rigor emotional impact.
The line performed aesthetic and practical function. It very easy and quick way to describe, register or define a character or object; to announce thought, intention or information; marked and maintained an idea or a vision; to suggest movement or direction of movement; to express the structure of the object or creature to design or decorate objects and premises; to express different feelings, characters, and many other topics in the field of art.
The lines carry a certain content that shows the viewer.
For example, a clean, sharp line involves accuracy, precision, hardness, cold, oblong rights - weakness, tenderness, light; curve - softness, tenderness, warmth, femininity, many curve - excitement, strong emotion, strong movement; shrink down - laziness, fatigue; shrink up - energy sustainability; wavy - elasticity, laziness, passivity, peace, gentleness and others.

3. NATURE OF LINE

The most characteristic feature of the line made in fine arts - graphic and from here the whole eligibility analysis of the line in the graph, combined with interior and exterior, because it is one of the middle, so that the most effective means of expression.
The line is actually visualized recording state of mind of the artist, his sensibility, character and aesthetics. Depending on the nature of the artist's feelings and visions line in its appearance varies from artist to artist.

In one she is thin and soft, others hard and firm, with a third and a wide collar or heavy; some is sharp and cold, others warm, lyrical, dramatic. These features mean the very quality of the line.
Spontaneity the occurrence of line and allowing speaks more directly to the author than the subject matter that may be described. It follows that artistic expression is more important that the line is contained in itself than what it describes. For the look of the line have an important role and the means by which it is performed, tools and materials.
Same line displayed with different materials change their appearance (pencil, pen, brush). So every artist requires adequate material for its expression.
From the wide palette of lines that express different states of mind and qualities will mention some that are often found in the drawings: gentle, soft, warm, calm, lyrical, playful, hard, heavy, hard, rough, heavy, nervous, alert, tired cumbersome, vivid, dramatic, bold, masculine, monumental this is just the total content.
The same motive various artists will express any "their" line in each of them has a peculiar character. This is the road that takes place instantly understanding of the work of art before you understand thematic content.
Today has not attempted to consciousness that it depends on the sense of the direction and forms of what visually supports the head of the background colour to the type of materials that line is drawn.
Thus example the same line will also mean regardless of its same length and width, if withdrawn with shower, the other with a pencil.

4. DESCRIPTION OF THE LINE GRAPHICS

linocut technique known users of linocut Henry Matisse, Pablo Picasso. Original graphics by Alexander Jing made in technology linocut. Chief inspirational segment structure of nature with its virtues presented by the author's fingerprints.

Figure 1. Line graphics

The line in the graphs is the most special place for expression that modelled a variety of ways inserted special expression. Choosing a topic that is processed in the engineering as the topic itself offers its transformation to the degree of realization of the idea, the concept art. Remind one approach used long schedule, access, which uses is in celebration of nature, to be displayed in graphic technique which carving in modern time changes with linocut the same effects (Figure 1).
Maximum simplification of line, colour, shape and colour and three-dimensional risk that the case be thrown out of range of criteria Fine viability, but with a strong attribute of the criteria used in the design viability.
Schematically display does that sort of yielding in cases qualify desire line to be illuminated and healthy and whole, graphical be released of unnecessary information per tonne explanation in order to escape the complexity of painting effects and treated topic to be within a simple content .
Line as an expression to be the main carrier in the simple construction of composition number and be faithful to the story-entered in each chart. The act in the treatment of colour-tone is to say colour is used Valero. Nature is in flat surfaces space associative landscape or other abstract setting that closes the composition on the one hand as a justified case, on the other hand spread in imaginary space outside the frame (Figure 2).
The graphics are complemented by a colour that will function rendering artistic effect and the area and usually makes graphic ton.

Figure 2. Print

5. PRINT

Art print has a long history, its beginning and for making books can be found in Egypt, where they used wooden boards for printing. Yet the earliest printed object originated in China in the 9th century BC, and already the 13th century this technique was brought to the Western world.
A printing is particularly widespread in the 16th century in Europe Albert works of Durer, Cranach Luke, and Hans Balding Green. Young, later artists have used their skills valuable reproductions of old photos, for propaganda purposes, social satire ITN.

Even in the 20th century, printing was adopted as a technique, which is valuable in itself and as an artistic expression that has values by the effect of highlighting subtle prosthetics thread, soft texture of fine lines linocut.
Art print today is very similar to that of a few centuries ago. As with photomechanical reproduction can be grouped into three broad categories: relief, intaglio/offset and planography.
Chart as a visual technique opportunity for creative motion which extends into the interior and exterior

5.1. The impact of the line of graphics as a composer as interior design

Without colour - where you need to create and implement - in a decision called in only its dramatic to move the entire interior, the selected graph linocut if the basic technique with its concave and bruises closes entire floor. Of its outgoing lines are placed all functional forms in space. To meet the requirement should apply the same principles that apply to any good design and the only way to attract more attention and maintain interest.
Principle is to focus on the floor, highlighting which also has many examples. Here is very important to respect the hierarchy of importance of used items at the heart will be on the floor and that we have sent the message.
Graphics – linocut technique that can be implemented in the exterior.

5.2. The impact of the line of graphics as a composer of form exterior design

The impact of the line of graphics as a composer of form exterior design is placed on the floor, where the composition is seating - holiday and where start all moving lines.
The first of these principles in the creation of the idea is balance. The elements in shaping the space can be arranged to achieve harmony and balance that will allow the observer immediately notices and quick to react.
When this balance can be symmetrical, as in countless examples, but once established, it will be experimented in several versions. In its most typical form it already represents the quality of the material from which it is made, transforming them into an artistic expression.

6. CONCLUSION

The graph meets the requirements of interior and exterior.
Decisions are better when the selected subject on the chart merges with all requirements and criteria for the interior.
As the main recommendation we suggest trends always lead forward, provide the opportunities for shaping and space exploration, but putting such an approach in interior and exterior makes another dimension of space.
Storage and composed elements combined with the amount of space attach harmony, beauty of simplicity and avidity of space.
The essence of the furniture is in the structure, union, common function, but the end result is synthesis - aesthetic rationale and vision, not monotonous lightweight and celery. The most outrageous recognizable elements of modern design style of the interior and exterior of the line. The line is a brain start, definition, root from which further develops the fruit of the design itself.
The line is everywhere in design and all its details and elements of the main constructions maximum use in aesthetic purposes.

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