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Original Scientific paper

STATISTICAL MODELLING AND ANALYSIS OF NATURAL FERMENTATION PROCESS OF BULGARIAN ORIENTAL TOBACCO VARIETIES BASMI

Maria Kasheva

Tobacco and Tobacco Products Institute – Markovo, 4108, maria_kasheva@abv.bg

ABSTRACT

The tobacco production has a significant impact on economic, demographic and social problems in Bulgaria and other Balkan countries. The quality of the produced fine, light and aromatic oriental tobacco requires studying of the natural fermentation process. The current article presents regression model of the natural fermentation process in seven varieties of oriental tobacco Basmi in Bulgaria, first and second class. This model shows the relationship between tobacco temperature, relative humidity of the environment and time. The three stages of the natural fermentation process: pre-fermentation, active fermentation and "attenuation of the fermentation" are analyzed.

Keywords: oriental tobacco, natural fermentation, correlation, regression model

СТАТИСТИЧКО МОДЕЛИРАЊЕ И АНАЛИЗА НА ПРОЦЕСОТ НА ПРИРОДНА ФЕРМЕНТАЦИЈА НА БУГАРСКИТЕ ОРИЕНТАЛСКИ СОРТИ ТУТУН ОД ТИПОТ БАСМА

Производството на тутун има значајно влијание врз економскиот, демографскиот и социјалниот развој на Бугарија и другите држави на Балканот. Квалитетот на произведените нежни, светли и ароматични ориенталски тутуни бара проучување на процесот на природна ферментација. Во овој труд е прикажан регресиониот модел на процесот на природна ферментација кај седум сорти ориенталски тутун од типот басма во Бугарија, прва и втора класа. Овој модел укажува на врската меѓу температурата на тутунот, релативната влажност на надворешната околина и времето. Анализирани са трите фази на процесот на природна фермантација: предферментација, активна ферментација и „слабеење“ на ферментацијата.

Клучни зборови: ориенталски тутун, природна ферментација, корелација, регресионен модел

INTRODUCTION

Despite of decreasing production quantity in the last 10-15 years tobacco represents more than 12 % from the agrarian export of Bulgaria (Agrarian Academy-Sofia, 2011). In addition, the tobacco production has significant impact on demographic and social problems in some compact regions in the country. Bulgarian oriental tobacco is exported in EC and USA whose markets are very strict to quality issues. This requires scientific research on the technologies for processing oriental tobacco. Natural fermentation generally gives tobacco a more uniform color and a milder taste (Geiss al., 2007). The natural fermentation is being used more frequently for light, fine and aromatic oriental tobacco in order to achieve the balance between its aromatic and taste qualities (Гюзелев, 1978; Мохначев al., 1983).

The current article presents regression model building and analysis of the natural fermentation process of seven Bulgarian varieties of oriental tobacco Basmi.

MATERIAL AND METHOD

Experimental studies are carried out on the natural fermentation process of seven varieties of oriental tobacco Basmi in Bulgaria: Perustitsa-Ustina, Krumovgrad 90, Nevrokop 1146, Nevrokop 261, Melnik 812, Melnik 294 and Djebel 576. The temperature of tobacco y (^{o}C) and relative humidity of the environment φ (%) are measured in time t (days). Table 1 presents the obtained experimental data on the natural fermentation of oriental tobacco Nevrokop 1146, first class.

Table 1. Experimental data on the natural fermentation of tobacco Nevrokop 1146, first class

y (^{o}C)	φ (%)	t (days)	y (^{o}C)	φ (%)	t (days)
6.0	73.0	0	24.0	67.2	101
10.0	76.9	16	25.8	66.6	108
13.2	72.2	31	26.6	65.8	115
14.5	77.5	38	25.3	61.2	122
19.3	68.3	43	26.8	66.2	129
17.2	76.0	52	23.6	73.6	136
17.5	76.5	60	27.2	71.6	143
18.4	80.2	69	26.0	69.2	150
22.8	68.7	73	24.0	62.8	157
22.6	67.0	80	22.6	63.8	164
24.0	70.0	87	21.8	65.0	171
21.6	69.0	94	22.0	63.5	182

Correlation coefficients between temperature of tobacco **y** and time **t** as well as temperature of tobacco **y** and relative humidity of the environment **φ** are estimated (table 2).

Table 2. Correlation coefficients

Variety	Class	Correlation (y, t)	Correlation (y, φ)
Perustitsa-Ustina	I	0,699	-0,540
	II	0,670	-0,523
Krumovgrad 90	I	0,775	-0,610
	II	0,734	-0,582
Nevrokop-1146	I	0,851	-0,633
	II	0,791	-0,616
Nevrokop-261	I	0,768	-0,629
	II	0,723	-0,641
Melnik-812	I	0,762	-0,623
	II	0,796	-0,597
Melnik-294	I	0,782	-0,559
	II	0,784	-0,608
Djebel 576	I	0,675	-0,482
	II	0,683	-0,516

From the obtained results it is evident that:

- There are not significant differences in the values of correlation coefficient regarding varieties and classes as well;
- The effect of time **t** and relative humidity of the environment **φ** on the temperature of tobacco **y** is significant with an opposite sign.

The aim of statistical data processing is to establish the adequate model $y = F(t, \varphi)$ in order to learn more about the relationship between independent variables (**t, φ**) and dependent variable **y**. Besides, the model will give opportunity to study precisely the dynamic of natural fermentation process of the Bulgarian oriental tobacco varieties. The general stepwise regression procedure (Fowler et al., 2000) includes studying **t**, **φ,** $\mathbf{t^2}$, $\mathbf{t^3}$, **φ, t.φ,** $\boldsymbol{\varphi^2}$. The regression model (1) is the best fit for all seven varieties of oriental tobacco Basmi. The software system SPSS is used for experimental data processing (Field, 2003).

$$y = a_0 + a_1 t + a_2 t^2 + b\varphi \ , \qquad \text{Model (1)}$$

where a_0, a_1, a_2 and b are model coefficients.

The adequacy of the regression model (1) is proved by using F-test at level of significance α = 0.05. This model explains the dynamic of the studied natural fermentation process in all seven varieties of Basmi tobacco in Bulgaria. Table 3 presents obtained R^2 values corresponding to the model (1) for varieties and classes of Basmi tobacco in Bulgaria. The R^2 values range from 0.912 for Melnik 812, II class to 0.962 for Nevrokop 1146, I class.

Table 3. R^2 values and coefficients of the the regression model

Variety	Class	R^2	a_0	a_1	a_2	b
Perustitsa-Ustina	I	0,940	21,9276	0,3650	-0,0017	-0,2255
	II	0,960	21,9895	0,4070	-0,0019	-0,2431
Krumovgrad 90	I	0,936	26,0865	0,2527	-0,0009	-0,2567
	II	0,928	26,3675	0,2643	-0,0011	-0,2628
Nevrokop 1146	I	0,962	19,8991	0,2300	-0,0008	-0,1837
	II	0,962	24,7199	0,2651	-0,0010	-0,2417
Nevrokop 261	I	0,917	30,2143	0,1325	-0,0003	-0,2520
	II	0,923	30,7023	0,1304	-0,0003	-0,2580
Melnik 812	I	0,923	25,7559	0,1746	-0,0007	-0,1787
	II	0,912	20,9945	0,1594	-0,0006	-0,1053
Melnik 294	I	0,932	17,9208	0,1684	-0,0006	-0,060
	II	0,919	25,1069	0,1461	-0,0004	-0,1603
Djebel 576	I	0,948	15,4784	0,4510	-0,0025	-0,1376
	II	0,948	20,5287	0,4170	-0,0023	-0,2020

The model coefficients a_0, a_1, a_2 *and* b as well as R^2 are different for the varieties and classes because of their specific biological features and the following technological factors: initial humidity of the tobacco, bale density and homogeneity of the tobacco class for natural fermentation. It is important that the structure of the regression model is the same for entire varieties and classes.

The effectiveness of the factor "time", based on the regression model of the fermentation process for Nevrokop 1146, I class can be computed as follows:

$$\frac{y}{t} = \frac{19{,}899 + 0{,}23 * t - 0{,}0008 * t^2 - 0{,}184 * \varphi}{t}$$

This estimation shows the effectiveness of the factor “time” during the natural fermentation process. It is calculated for constant value of **φ.** Figure 1 shows that the effectiveness of this factor is declining during the studying period of time. The results of estimations of other varieties and classes of the studied oriental tobacco varieties are similar.

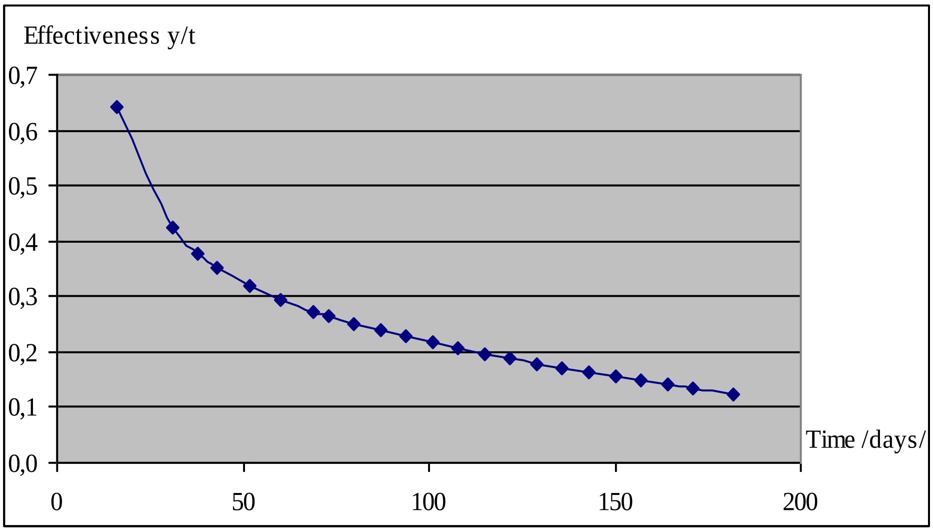

Figure 1. Effectiveness of the factor “time” during natural fermentation of tobacco Nevrokop-1146, I class

Fig. 2 shows the tobacco temperature y (^{o}C) during natural fermentation of tobacco Nevrokop-1146, I class under the regression model. It describes the three stages of the natural fermentation process: pre-fermentation (60-70 days), active fermentation (70-80 days) and “attenuation of the fermentation” (20-30 days). It should be noted that:

- The specific characteristics of all varieties of oriental tobacco affect the duration of the fermentation stages. The studied process is natural, therefore the real climate conditions also affect the duration of fermentation;
- The expert activities continue after the stage “attenuation of the fermentation” with the stage “watching the tobacco”. It is necessary because of two main reasons: a risk of pests and the probability of deformation of the bales. The stage “watching the tobacco” is important in order to save the tobacco quality.

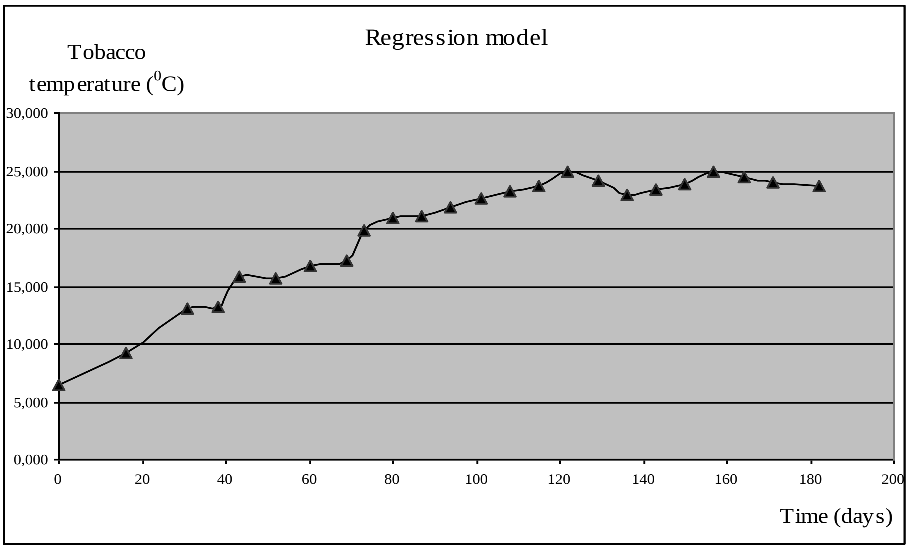

Figure 2. Tobacco temperature (^{0}C) during natural fermentation of tobacco Nevrokop-1146, I class

CONCLUSIONS

The developed regression model explains the relationship between tobacco temperature, time and relative humidity of the environment for the process of natural fermentation of seven oriental varieties Basmi of tobacco in Bulgaria. It describes the three stages of the natural fermentation process: pre-fermentation, active fermentation and “attenuation of the fermentation”. The current tendency for applying natural fermentation of oriental tobacco has a positive impact on the development of small and medium tobacco enterprises in Bulgaria and other Balkan countries. The aim of the future scientific work is to assess precisely the effect of natural fermentation on the quality of the cigarettes and last but not least on the health of large group of people.

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