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A MATHEMATICAL STATISTICAL ANALYSIS OF SEED OILS FROM MELON AND PUMPKIN BY USING COLOR PARAMETERS*

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A difference in color parameters and the content of the pigments chlorophyll and beta carotene for oils from seeds of different sorts of melon and pumpkin has been proved by applying mathematic statistical analysis. The significance of the different indicators for modeling groups of oils has been estimated. Data on different sorts of melon and pumpkin fruit oils have been processed by applying discriminant analysis to study the possibility to create discriminatory procedures for modeling the various sorts and their origin.

1. Introduction. The study aims to analyze a database of color parameters of seeds oils obtained from of different varieties of pumpkin and melon grown in Bulgaria, and to explore the possibility of application of mathematical and statistical modeling to varieties of different origin.

To achieve this objective the following tasks have been formulated:

– Obtaining and analyzing a database of colorimetric analysis of seed oils of different varieties of pumpkin and melon.

– Establishing significant differences in the values of investigated indicators.

– Modeling and analysis of the groups representing different varieties.

2. Materials and methods. Seed oils from three pumpkin varieties (Cucurbita moschata, Cucurbita pepo and Cucurbita maxima) and three melon varieties (Desserten 5, Medena rossa and Hybrid 1) have been investigated. Seed oil for investigation has been obtained through extraction with an organic solvent (hexane) in a Soxhlet extractor for 8 hours and subsequently removing the solvent in a rotary evaporator under nitrogen atmosphere [1].

Color parameters in two different colorimetric systems – XYZ (for large color differences) and CIE Lab (for small ones) have been obtained using the colorimeter Lovibond PFX 880 (UK) and a cuvette with length 10 mm [2]. All measurements have been carried out at room temperature immediately after oil extraction. The color coordinates, color

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Key words: seed oils of melon and pumpkin, color parameters, discriminant analysis Mahalanobis distance.

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Table 1. Color parameters and pigments in seed oils of different pumpkin varieties

Cucurbita	Pepo		Moschata		Maxima	
parameters	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
X	4.64	0.07	34.09	2.56	26.02	1.18
Y	3.54	0.12	34.58	2.73	28.36	1.23
Z	0.18	0.02	4.90	0.53	8.32	0.61
Brightness L	22.31	0.02	66.42	0.02	60.80	0.001
a	16.49	0.02	0.61	0.00	−7.31	0.01
b	35.69	0.05	71.63	0.05	48.18	0.02
Chlorophyll	0.00	0.00	0.00	0.00	0.00	0.00
β-carotene	62.84	4.78	72.91	2.32	1222	0.72

$\bar{x}$ – average value; SD – standard deviation

parameters a, b and brightness L of tested samples have been measured. A software program developed specially for the equipment allowed evaluation of chlorophyll and β-carotene.

All results have been measured in five replicates of the experiments. The "Statistica" program has been used for data processing. Data distribution has been found to be normal according to the criterion of Kolmogorov–Smirnov [3–4]. To establish statistically significant differences between the characteristics for the studied varieties, the Tukey criterion for multiple comparisons was applied [5]. When modeling the groups per varieties discriminant analysis with a priori equal probabilities of hit in the groups has been used [6–7].

3. Results. Color parameters of investigated seed-oils from different melon and pumpkin varieties have been obtained. The data are presented in tables 1 and 2. Fisher's test significance is 0.001. Unlike the other pumpkin seed oil varieties, the one for variety Cucurbita maxima possesses a negative color component a. This color parameter means that the green component predominates over the red in that sample, although none of the pumpkin seed oil contains chlorophyll. The said variety probably is rich in pigments different from chlorophyll. A similar observation for the same variety has been announced by Leila Rezig [8], who has obtained rather lower values for brightness (44.8) of seed oil of the same variety of pumpkin grown in Tanzania.

The most pronounced yellow component has been observed for pumpkin seed oil of variety Cucurbita moschata, the lowest brightness has been obtained for the seed oil of variety Cucurbita pepo. The color component b of pumpkin seed oils is several times higher than the one measured in other vegetable oils such as soybean, sunflower, rapeseed etc. For the listed vegetable oils this parameter changes from 9.2 to 10.4 while for pumpkin seed-oils it lies between 35 and 72. Similar data for seed oil of Cucurbita maxima have been obtained by Hsu and Yu [9]

The brightness for melon seed oils has the highest values for the oil of variety Desserten 5 and the lowest one for the oil of variety Hybrid 1. Unlike the pumpkin seed oils, melon seed oils possess a negative color component a for all the varieties, which means, that in melon oils the green component prevails over the red one. The last observation can be explained by the presence of chlorophyll in all samples of melon oils. In melon seed oils raising the content of β-carotene raises the color component b.

Table 2. Color parameters and pigments in seed oils of different melon varieties

Melon seed	Medena rossa		Desserten 5		Hybrid 1	
parameters	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
X	53.17	10.02	75.78	0.50	19.47	0.25
Y	56.74	10.64	80.12	0.43	20.88	0.21
Z	40.88	9.44	64.72	0.37	4.17	0.02
Brightness L	76.70	0.94	91.78	0.06	48.29	1.83
a	−4.04	0.10	−5.21	0.01	−3.51	0.21
b	25.44	0.05	22.05	0.05	49.44	1.22
Chlorophyll	0.04	0.00	0.02	0.00	0.02	0.00
β-carotene	8.73	0.71	6.58	0.03	35.97	4.31

$\bar{x}$ – average value; SD – standard deviation

Table 3. Mahalanobis distances between different varieties of pumpkin seed oils

variety	Mahalanobis distances		
Pumpkin sorts	Cucurbita pepo	Cucurbita moschata	Cucurbita maxima
Cucurbita pepo	–	8 966 170	8 205 937
Cucurbita moschata	8 966 170	–	1 332 496
Cucurbita maxima	8 205 937	1 332 496	–

Table 4. Mahalanobis distances between different varieties of melon seed oils

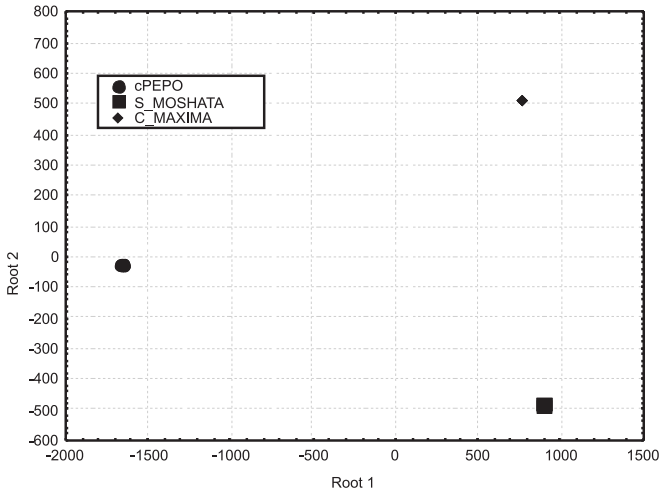
variety	Mahalanobis distances		
Melon sorts	Medena rossa	Desserten 5	Hybrid 1
Medena rossa	–	38 524	985 990
Desserten 5	38 524	–	1 409 382
Hybrid 1	985 990	1 409 382	–

The strongest prevalence of yellow nuance has been observed in seed oils of the variety Hybrid 1 – about twice as high as the one of two other varieties.

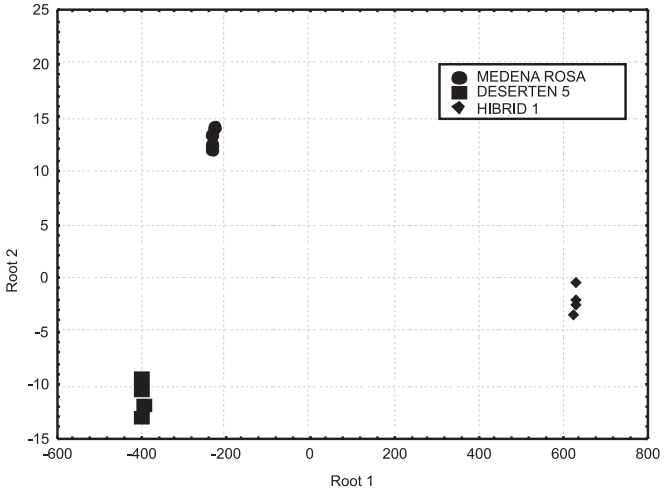
Tests have been made for the homogeneity of dispersions. The Tukey test has showed differences between the varieties, which is sufficient for modeling. After applying the incremental discriminant analysis with grouping variable "variety of pumpkin or melon" the discriminant functions ensuring 100% recognition of the different varieties have been derived.

The parameters involved in the modeling in order of their inclusion in the model for oil of pumpkin seeds are: brightness (L), color component a and β-carotene. To illustrate the groups designating the studied pumpkin varieties, additional canonical analysis has been made. The result presented in Figure 1 (a) confirm the distinct differences in varieties and ensures 100% recognition.

For each sample group the Mahalanobis distances have been calculated and at the same time canonical analysis has been performed, because Mahalanobis distances give an idea about the peculiarities of the observed group in the original area, while the canonic presentations serve for better visualization of different groups, since their canon-



(a)



(b)

Fig. 1. Location of the varieties of pumpkin (a) and melon (b) seed oil according to the first two canonical variables

ical variables represent linear combinations of the primary color indicators. Mahalanobis distances reveal the dynamics of changing the distance between the centroids of the individual groups.

The results for pumpkin seed oils are presented in the Table 4. According to data on the distances between the centroids of the individual groups, pumpkin oil from the variety Cucurbita pepo is relatively equidistant from the varieties Cucurbita moschata and Cucurbita maxima. Pumpkin seed oil of variety Cucurbita moschata is most distant from the one obtained for the variety Cucurbita maxima.

The parameters involved in the modeling of melon seed oils in order of their inclusion in the model for oils of melon seeds are: chlorophyll, color component a, β-carotene and color components b. To illustrate the groups designating the studied melon varieties as well, canonical analysis has been made as in the case of pumpkin varieties. Again a 100% recognition of the groups has been ensured. The latter fact is illustrated in Figure 1 (b).

According to the distances between the centroids of the individual groups the melon seed oil (Table 4) of the variety Medena rossa is closest to that of Desserten 5 and most distant from the oil from variety Hybrid 1. The melon seed oil of the variety Hybrid 1 differs most strongly from the melon seeds oils of the other two melon varieties.

4. Conclusions.

1. The analysis of the database on color parameters of oils from Bulgarian varieties of pumpkin and melon showed the possibility of characterizing certain groups of varieties by discriminant analysis.

2. The color parameters in the CIE Lab colorimetric system and pigments (chlorophyll and β-carotene) determine the specificity of oils of different varieties.

3. The color indicators in the XYZ colorimetric system are not important in distinguishing oils from pumpkin and melon.

4. In the case of melon seed oils the oil seed of the variety Hybrid 1 differs the most strongly by color parameters, and in the case of pumpkin oil, the one of *Cucurbita moschata*.

5. It has been statistically shown that there are differences in the values of the considered parameters for different groups of oils – pumpkin and melon ones. This makes efficient the use of discriminant analysis to qualitatively differentiate various oils which are not traditional in food technologies.

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МАТЕМАТИКО СТАТИСТИЧЕСКО МОДЕЛИРАНЕ ПО ЦВЕТОВИ ПАРАМЕТРИ НА МАСЛА ОТ СЕМЕ НА ПЪПЕШ И ТИКВА

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Чрез прилагане на математико-статистически анализ на масла от семена на различни сортове тиква и пъпеш е доказано различие в цветовите параметри и съдържанието на пигменти като хлорофил и β-каротен. Оценена е значимостта на отделните показатели при моделирането на групите от масла. Чрез приложение на дискриминантен анализ са обработени данни за масла, получени от семена на различни сортове тиква и пъпеш, за да се изследва възможността за приложение на математико-статистическо моделиране при отделните сортове.