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Statistical analysis of seed oils from melon and pumpkin by using colour parameters

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Difference in colour parameters and content of the pigments chlorophyll and β-carotene for different sorts of melon and pumpkin seed oils was proved by applying mathematic statistical analysis. The significance of the different indicators for modeling the oil groups was estimated. Data on different sorts of melon and pumpkin fruit oils were processed by applying discriminant analysis to study the possibility to create discriminatory procedures for modelling the various sorts and their origin.

Keywords: pumpkin and melon seed oils, colorimetry, statistical analysis

INTRODUCTION

Various physical and chemical tests have been used to establish the authenticity of oils and to detect the level of adulterants in it. The most useful are the chromatographic methods. They offer high sensitivity and accuracy, but are time consuming and expensive. For this reason in our study we suggest three fast and cheap physical methods on the base of colorimetric techniques. Different kinds of vegetable oils can be quickly and precisely differentiated by using statistical analysis.

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

To achieve this objective the following tasks were formulated:

- obtaining and analyzing a database of colorimetric analyses of seed oils of different varieties of pumpkin and melon;
- establishing the differences in the values of the investigated indicators;
- modeling and analysis of the groups representing different varieties.

MATERIALS AND METHODS

The seeds of the pumpkin species *Cucurbita moschata*, *Cucurbita pepo* and *Cucurbita maxima*, and the melon species Honeydew, Desserten 5 and Hybrid 1 from fam. *Cucurbitaceae*, were grown and obtained from the region of South Bulgaria, crop 2013.

Isolation of glyceride oil and determination of oil content.

The seeds (50 g samples) were air-dried and ground to powder and the oil was extracted with n-hexane in a Soxhlet apparatus for 8 h. The solvent was partly removed in a rotary vacuum evaporator, the residue was transferred in a pre-weighed glass vessel and the rest of the solvent was removed under stream of nitrogen to a constant weight to determine the oil content [1].

Colour parameters in two different colorimetric systems - XYZ (for large colour differences) and CIE Lab (for small ones) were obtained using a colorimeter Lovibond PFX 880 (UK) and cuvette with a length of 10 mm [2]. All measurements were carried out at room temperature immediately after oil extraction. Colour coordinates, colour parameters a, b and brightness L of the tested samples were measured. Chlorophyll and β- carotene were calculated by using the transmission spectra in the visible region and the values of the colour parameters - by software program developed specially for Lovibond PFX 880 by the producer. Five replicates of each measurement were performed.

The programme "Statistica" was used for data processing. Data distribution was found to be normal according to the criterion of Kolmogorov - Smirnov [3-4]. To establish statistically significant differences between the characteristics of the studied varieties, the Tukey criterion for multiple comparisons was applied [5]. When modeling the groups per variety discriminant analysis with *a priori* equal probabilities for hit in groups was used [6-7]. Data about Mahalanobis distances were obtained.

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

Parameters	Variety of pumpkin seed oils					
	Cucurbita pepo		*Cucurbita moschata*		*Cucurbita maxima*	
	$\bar{x}$	**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, ppm	0.00	0.00	0.00	0.00	0.00	0.00
β - carotene, ppm	62.84	4.78	72.91	2.32	1222.33	0.72

$\bar{\mathbf{x}}$ -Average value; SD – standard deviation

RESULTS AND DISCUSSION

Colour parameters of the investigated seed oils from different melon and pumpkin varieties were obtained. Data are presented in Tables 1 and 2. Fisher's test significance is 0.00.

Unlike the other pumpkin seed oil varieties, the one for the variety *Cucurbita maxima* possesses a negative colour component a. This colour parameter means that the green component predominates over the red one in that sample, although none of the pumpkin seed oils contains chlorophyll. The mentioned variety is probably rich in pigments, different from chlorophyll. Similar observation for the same variety has been announced by Leila Rezig [8], who has obtained rather lower values for brightness (44.8) of the seed oil of the same variety of pumpkin grown in Tanzania.

The most pronounced yellow component was observed for pumpkin seed oil of the variety *Cucurbita moschata*; the lowest brightness was obtained for the seed oil of the variety *Cucurbita pepo*. The colour component b of the pumpkin seed oils is several times higher than that 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 plant oil have been obtained by Hsu and Yu [9].

The brightness for melon seed oils has the highest values for the oil of the variety Desserten 5 and the lowest one for the oil of the variety Hybrid 1. Unlike the pumpkin seed oils, melon seed oils possess a negative colour component a for all varieties, which means that in melon oils the green component prevails over the red one. The latter observation can be explained with the presence of chlorophyll in all samples of melon oils. In melon seed oils, with rising the content of β-carotene raises the colour component b. The strongest prevalence of the yellow nuance was observed in seed oils of the variety Hybrid 1 – about twice as high as that of the two other varieties.

Tests were made about the homogeneity of dispersions. Tukey test showed differences between the varieties, which were 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 were derived.

For each of the sample groups, the mahalanobis distances were calculated and canonical analysis was simultaneously performed because mahalanobis distances provide an insight on the specific features of the examined group in the original space,

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

Parameters	Variety of Melon seed oils					
	Medena rossa		*Desserten 5*		*Hybrid 1*	
	$\bar{x}$	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, ppm	0.04	0.00	0.02	0.00	0.02	0.00
β- caroten, ppm	8.73	0.71	6.58	0.03	35.97	4.31

$\bar{\mathbf{x}}$ -Average value; SD – standard deviation

whereas canonical representations are in a bidimensional space. They serve for better visualization of the particular groups since their canonic variables are linear combinations of the initial physical indices. The existence of differences in the values of the investigated parameters was statistically proven. This makes discriminant analysis an efficient tool for the qualitative distinction of natural pumpkin oil and melon oil from other oils. The models and the associated mahalanobis distances enable the classification of unknown samples.

The parameters involved in the modeling in order of their inclusion in the model for oil of pumpkin seeds are: brightness (L), colour component a and β-carotene. To illustrate the groups designating the studied pumpkin varieties, additionally canonical analysis was made. The result presented in Fig. 1 confirms the distinct varietal differences and ensures 100% recognition.

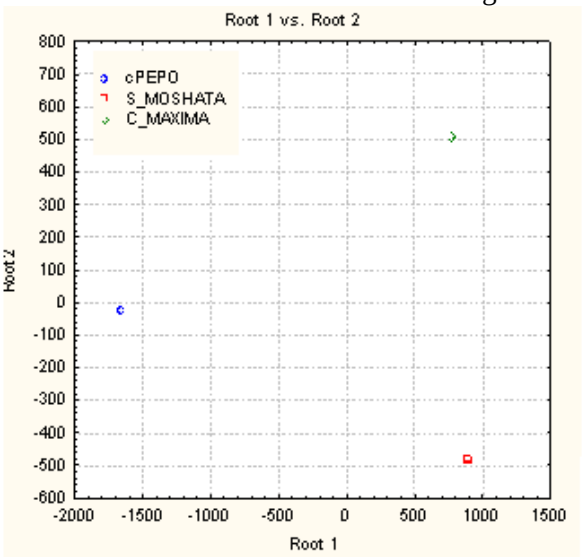

Fig. 1. Location of the varieties of pumpkin seed oil according to the first two canonical variables

For further clarification of these differences the Mahalanobis distances between centroids of the individual groups were identified as well. Results are presented in Table 3. Mahalanobis distances represent individual groups better than canonical variables because they give an idea of the dynamics of the change in the distance between the group centroids.

According to the 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 the variety *Cucurbita moschata* is most distant from the one obtained for the variety C*ucurbita 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, colour component a, β-carotene and colour component b. To illustrate the groups designating the studied melon varieties, canonical analysis was made as in the case of pumpkin varieties. Again 100% recognition of the groups was ensured. The latter fact is illustrated on Fig. 2.

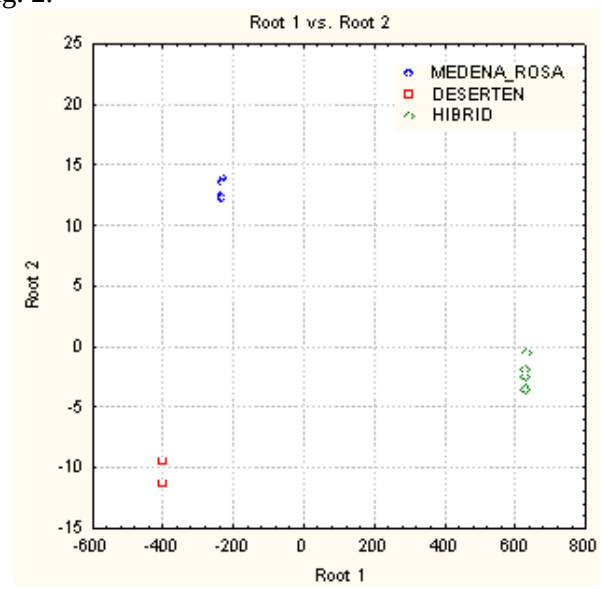

Fig.2. Location of the varieties of melon seed oil according to the first two canonical variables

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

Pumpkin variety	**Mahalanobis distances**		
	Cucurbita pepo	*Cucurbita moschata*	*Cucurbita maxima*
Cucurbita pepo	0	8966170	8205937
Cucurbita moschata	8966170	0	1332496
Cucurbita maxima	8205937	1332496	0

Table 4 Mahalanobis distances between different varieties of melon seed oils

Melon variety	**Mahalanobis distances**		
	Medena rossa	*Desserten 5*	*Hybrid 1*
Medena rossa	0	38524	985990
Desserten 5	38524.3	0	1409382
Hybrid 1	985990.1	1409382	0

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

CONCLUSIONS

The analysis of the database on colour parameters of oils from Bulgarian varieties of pumpkin and melon fruits showed the possibility to characterize certain group varieties by discriminant analysis.

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

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

In the case of melon seed oils the oil seed of variety Hybrid 1 differs most strongly in colour parameters and in the case of pumpkin oil - the one of *Cucurbita moschata*.

It was statistically shown that there are differences in the values of the considered parameters for different groups of oils - pumpkin and melon ones. This makes the use of the discriminant analysis efficient for the qualitative differentiation of various oils, non-traditional for food technologies.

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

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(Резюме)

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 при маслата. Чрез дискриминатен анализ са обработени данни за масла, получени от семки на тиква и пъпеш за да се проучи възможността за математик-статистическо моделиране на различни сортове с отделен произход.