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Some quality parameters of mustards from the Romanian market

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Abstract. Five commercial mustards, made by different manufacturers, were studied to examine their physico-chemical properties and to establish relationships between those properties. Physico-chemical analysis revealed distinct differences between the mustards in the dry matter and extract contents and smaller differences in the protein, fat and ash levels. Two of the investigated mustards did not satisfy the requirements of the relevant Romanian standard regarding dry matter content. Statistical analysis of the results showed significant linear correlations between the dry matter, fat, protein and ash contents of mustards and some parameters of rheological model.

***Keywords*:** quality parameters, mustard, viscosity.

1. Introduction

The name "mustard" describes seeds from a group of plants usually used in the preparation of condiments [1]. The seeds also have significant potential as sources of edible oil and protein [2]. Due to the fact that the residual meal after oil extraction is rich in proteins (30–48%, dry weight basis), mustard seeds can be used as appropriate raw materials in the manufacturing of protein ingredients for food industrial field and more [3]. These seeds have a balance of amino acids which can be positively compared with that required for human diet [4]. Unluckily, mustard seeds contain some antinutritional and flavor constituents. These constituents disturb the bioavailability of amino acids and minerals [1, 2, 5]. These constituents must also be eliminated because they are greatly responsible for the strong, astringent flavor and the dark color of the final products.

Brassica juncea (L.) – Brown mustard is especially grown in India, Pakistan and China for oil [6]. This species is also grown in Poland especially for seeds used in mustard production and medicine. *Sinapis alba L.* is white mustard with a fast growing period. Moreover, *Sinapis alba* is mainly used in apiculture as a proper melliferous plant [7]. Mention must be made of the fact that mustard crops are used as condiments, oilseed and medicines [8, 9]. It was previously pointed out that some sunflower extracts inhibited the germination of mustard seeds [10, 11]. Nowadays new methods of weed killing are environmentally friendly [12]. *Helianthus annuus* L. is a well-known plant with many allelopathic components [13].

The nitrogen mustards have been used for more than 30 years in clinical cancer chemotherapy [14]. However, their toxicity must be taken into account [15]. Therefore, pharmacochemists must lower their side effects and extend their life [16 - 18].

Mustard seeds, as any other oil seeds, are rich sources of phenolic compounds [19], while mustard seed flour has also got an anti-microbial property.

The purpose of this paper was to establish the physicochemical properties of mustards from the Romanian market and to reveal differences among these samples.

2. Experimental

2.1. Materials

Five commercial mustards not containing mustard seeds, seed pieces or spices have been made in Romania by different manufacturers. According to the composition information from the labels, all products have been manufactured without thickening agents. Samples of mustards were marked with symbols M1 to M5. In the period of analyses the samples were stored at room temperature and prior to measurement they were gently stirred for homogenization.

The reagents (sodium hydroxide solution 32%, boric acid solution 2%, sulfuric acid solution 97%, petroleum ether) were provided by Sigma Aldrich.

2.2. Methods

2.2.1. Dry matter content. The dry matter content of mustards was determined in accordance with the relevant Romanian Standard (SR ISO 1442:2010).

2.2.2. Extract content. The extract content was determined by refractometry (SR EN 12143:2003).

2.2.3. Proteins content. The protein content of mustards was established using Kjeldahl method, with a multiply factor of 6.25.

2.2.4. Lipids content. Lipid extraction was accomplished with a Soxhlet extractor with 250 mL of petroleum ether and then the solvent was eliminated by evaporation.

2.2.5. Ash content. About 2 g sample was ignited in a porcelain container and incinerated in a muffle furnace at about 530 ºC for 5 h in order to remove carbon. The ash content was expressed as percent of dry weight.

2.2.6. Instrumental color analysis. The color of the samples was established by means of a Hunter-Lab color meter. This instrument was calibrated using the black and white tiled offered. The sample color was expressed in units L^*, a^* and b^*. Purée samples were put into Petri dishes (i.d. 50 mm) excluding air bubbles and they were placed under the aperture of the color meter. Five

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replicate measurements were done and the results were averaged. Moreover, hue angle and chroma were calculated using the following equations:

$$Hueangle = tan^{-1}(b^*/a^*) \quad (1)$$

$$\text{Chroma} = \sqrt{a^2 + b^2} \quad (2)$$

2.2.7. Determination of colloid-chemical properties. The colloid-chemical properties (the emulsion activity and emulsion stability) of mustard samples were established. The samples of mustard were homogenized with a blender (model, R 555, ROHNSON, Romania) for 2 min. Then the product obtained was divided into ten 10 mL centrifugal tubes and centrifuged at 1,500 x g for 20 min.

The emulsion activity was established as:

$$\frac{the\ height\ of\ emulsified\ layer}{the\ height\ of\ whole\ layer\ in\ the\ centrifuged\ tube} \times 100$$

To measure the emulsion stability, the emulsion prepared using the method for emulsion activity measurement was heated for 30 min, divided into ten 10 mL centrifugal tubes evenly and centrifuged at 1,500 x g for 20 min. Emulsion stability was calculated as:

$$\frac{the\ height\ of\ remaining\ emulsified\ layer}{the\ height\ of\ the\ whole\ layer\ in\ the\ tube} \times 100$$

The water and fat holding capacity was established gravimetrically.

2.2.8. Statistics. Samples were assayed in triplicate and results are given as averages ± SD. Data analysis was performed using partial least squares method of regression (PLS), which determines the relationship of the physico-chemical characteristics of the product quality and strength of the bonds between these features. The properties of the emulsion were correlated with physico-chemical characteristics of the mustard which can influence the formation and the stability of the emulsion, using principal component analysis (PCA).

3. Results and discussion

3.1. Physico-chemical properties

Table 1 contains the results of the physicochemical analysis of mustard samples. The ash content is presented in Figure 1. The mustards presented dry matter content in the range of 16.82 g /100 g (Sample M5) to 29.9 g /100 g (Sample M2). Mustards M5 and M3 failed to satisfy the requirements of Romanian Standard (SR ISO 1442:2010), which provide that the dry matter content of a mustard should not be less than 20 g/100 g, and mustard M4 had the amount of dry matter close to the minimum value specified by that standard.

The results for extract followed the same pattern: the sample which contained the smallest amount of dry matter (M5) had also the lowest extract content (Table 2). The protein content ranged from 4.37 g/100 g for sample M1 to 6.71 g/100 g for sample M2. Mustard M2, again, had the highest fat and ash contents, while M5 contained the smallest amount of fat and M1 – of ash. The differences between samples were slighter for fat and ash than for other investigated properties.

The results of the color analysis [20, 21] of mustards samples are shown in Table 2. For mustard pastes, color intensity (chroma) was higher for sample M4 ($p < 0.05$). Redness as measured using hunter a^* values was higher for sample M5. The mustards had a lightness values in the range of 89.89 (Sample M4) to 92.32 (Sample M3).

Table 1. Physicochemical properties of mustard samples

Sample	Dry matter [g/100 g]	Extract content [g/100 g]	Protein content [g/100 g]	Fat content [g/100 g]
M1	25.23 ± 0.1	20.89 ± 1.3	4.37 ± 0.2	4.42 ± 1.3
M2	29.9 ± 0.8	23.1 ± 2.2	6.71 ± 1.3	5.31 ± 2.2
M3	18.83 ± 1.2	13.21 ± 0.2	4.76 ± 1.9	4.28 ± 0.8
M4	19.97 ± 1.9	14.99 ± 2.2	5.7 ± 0.6	4.79 ± 0.7
M5	16.82 ± 2.9	11.23 ± 1.2	4.38 ± 0.3	4.23 ± 1.8

Mean value of traditional mustard varieties, on the basis of three measurements, ± S.D.

Table 2. Physicochemical properties of mustard samples

Sample	L^*	a^*	Color intensity	Hue angle
M1	91.69±0.04	23.1±0.04	50.3±1.2	-61.3±1.04
M2	90.89±0.03	24±1.02	50.9±0.1	-61.1±0.07
M3	92.32±0.04	23.9±0.04	51±0.023	-60.9±2.1
M4	89.89±1.03	24.2±1.12	54.4±0.34	-61.3±1.2
M5	92.11±1.83	26.7±2.13	53.8±1.21	-61±2.12

Values in the table are means ± standard deviation, $n = 3$

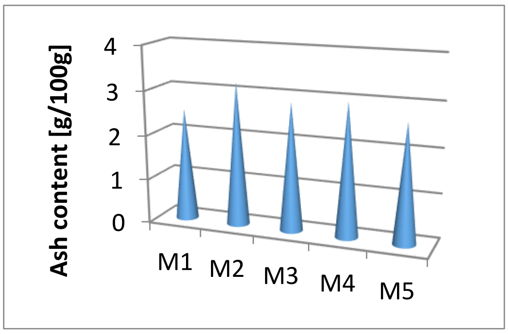

Figure 1. Ash content of mustard

3.2. Correlation between physico-chemical and rheological properties

Data analysis was performed using partial least squares method of regression (PLS), which determines the relationship of the physico-chemical characteristics of the product quality and strength of the bonds between these features [22].

The properties of the emulsion were correlated with physico-chemical characteristics of the mustard which can influence the formation and the stability of the emulsion, using principal component analysis (PCA).

The Pearson correlation matrix (Table 3) for the dependent variables, quality characteristics of mustard respectively, indicating high correlation coefficient (r = 0.947) between the ash content and protein content.

Table 3. Pearson correlation matrix for the dependent variables

Variables	Dry matter	Extract content	Protein content	Fat content	Ash content	Water holding capacity	Fat holding capacity	Emulsion activity	Emulsion stability	k [Pa·s^n]
Dry matter	1	0.986	0.644	0.788	0.439	-0.732	-0.647	-0.689	0.253	-0.205
Extract content	0.986	1	0.552	0.721	0.322	-0.763	-0.717	-0.708	0.23	-0.308
Protein content	0.644	0.552	1	0.967	0.947	0.008	0.16	-0.742	0.158	0.203
Fat content	0.788	0.721	0.721	1	0.721	-0.202	-0.066	-0.846	0.291	-0.015
Ash content	0.439	0.322	0.947	0.837	1	0.226	0.387	-0.524	-0.058	0.493
Water holding capacity	-0.732	-0.763	0.008	-0.202	0.226	1	0.969	0.178	-0.375	0.445
Fat holding capacity	-0.647	-0.717	0.16	-0.066	0.387	0.969	1	0.163	-0.273	0.53
Emulsion activity	-0.689	-0.708	-0.742	-0.846	-0.524	0.178	0.163	1	-0.311	0.407
Emulsion stability	0.253	0.23	0.158	0.291	-0.058	-0.375	-0.273	-0.311	1	-0.692
k [Pa·s^n]	-0.205	-0.308	0.203	-0.015	0.493	0.445	0.53	0.407	-0.692	1

Strong positive correlation (r = 0.986) between the stands and the content of dry substance extract. Formulation of the mustard emulsion is determined by the low content of fat (r = -0.846) and protein (r = -0.742). The emulsion stability is strongly influenced by the water binding capacity of the product (r = -0.375).

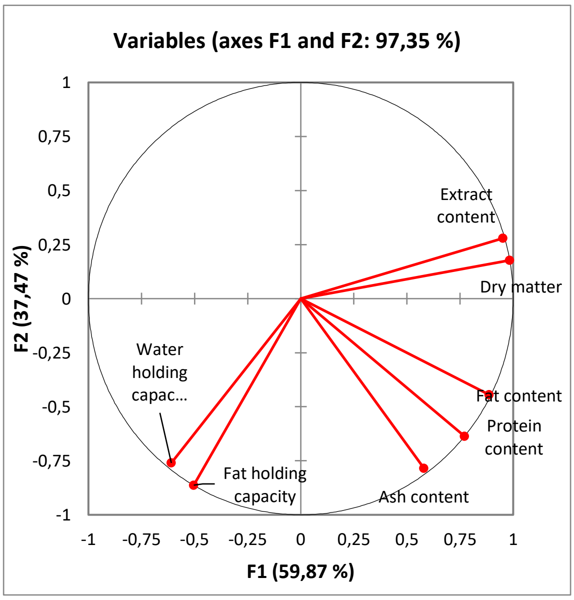

Figure 2. Analysis of the dependent variables PLS

The graphical representation of output variables which characterize mustard samples (Fig. 2) provides the possibility of grouping indicators as follows: in the first quadrant (the clockwise direction) are clustered dry substance content in the extract; quadrant 2 groups positive correlations which are established between the content of fat, protein and ash and in quadrant 3 the water retention capacity of the slurry and fat mustard are positively correlated.

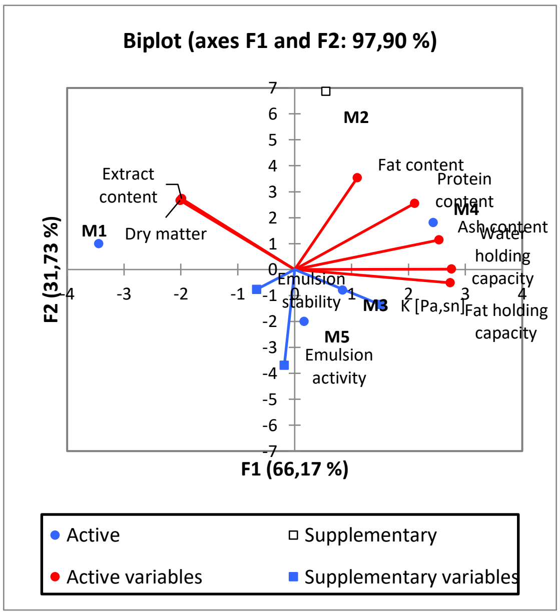

Figure 3. Principal components analysis

The evaluation of the emulsion characteristics was determined on the analysis of the principal components between the physicochemical characteristics of the 5 mustard samples and the stability of the emulsion, the activity of the emulsion and k. The analysis of the principal components highlights through graphical representation the strong negative correlation between the activity of emulsion and the content of fat, protein respectively, as recorded by the distribution of the output variables to the opposite quadrant. Also, mustard analyzed samples are different from the compositional point of view, their distribution in the different quadrants indicates weak correlation between them. An exception is samples 3 and 5 of the output variables close in value.

4. Conclusion

To sum up these results, it appears that on the basis of chemical composition (advantageous protein and essential amino acid content) mustards can be used for human consumption as additive.

Physico-chemical analysis showed distinct differences between the mustards in the dry matter and extract contents and smaller differences in the protein, fat and ash levels. Two of the investigated mustards did not satisfy the requirements of the relevant Romanian standard regarding dry matter content.

Statistical analysis of the results showed that there are significant linear correlations between some physico-chemical properties and some parameters describing rheological properties of mustards.

Conflict of interest

The authors confirm that this article content has no conflicts of interest.

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