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. 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).

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 [1].

Keywords—quality parameters, mustard, viscosity

I. INTRODUCTION

THE name "mustard" is used to describe seeds from a group of plants that are used in the preparation of condiments in a process that consists of mixing the sweet "must" of old wine with crushed seeds to form a paste, "hot must" or "mustum ardens" [2]. Apart from the use of mustard in the preparation of condiments, the seeds have considerable potential as sources of edible oil and protein [3]. Since the residual meal remaining after oil extraction is rich in proteins (30–48%, dry weight basis), mustard seeds could serve as suitable raw materials in the manufacture of protein ingredients for the food and nonfood industrial sectors [4]. The balance of amino acids found within the seed of these crops compares favorably with that required for human nutrition [5]. Unfortunately, seeds from the Brassicaceae contain several antinutritional and flavor components that tend to bind to the protein and are carried to the isolate. These components include glucosinolates and their toxic breakdown products, phenolics and phytates, which hinder bioavailability of amino acids and minerals (1–3).

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These components are also largely responsible for the dark color and strong, astringent flavor of the products; therefore, they must be substantially removed.

Brassica juncea (L.) – brown mustard is grown extensively for oil in India, Pakistan and China [6]. In Poland this species is cultivated mainly for seeds used in medicine and mustard production. *Sinapis alba L.* – white mustard – a rapidly growing species with short vegetation period is cultivated for seeds or as a second crop. In apiculture, *Sinapis alba* is recommended as a good melliferous plant [7].

The mustard crops *Brassica juncea* and *B. hirta* are important condiment crops which have considerable potential as edible oil sources [8].

Mustard (Brassica juncea) is an important crop in both ancient and modern world. It has a broad resource of genetic diversity that is used primarily as oilseed but as vegetables, condiment and medicines also [9].

It was shown that aqueous extracts of sunflower leaves completely inhibited the germination of mustard seeds [10]. Allelopathy is a direct or indirect influence of chemical compounds (allelochemicals) released from one living plant on the growth and development of another plant [11]. Many allelochemicals can be toxic to higher plants and for this reason they can be used as a natural herbicide. Nowadays, a new method of weed control is searched for and allelochemicals are considered to be environmentally friendly herbicides [12].

Helianthus annus L. is a well-known plant which contains a lot of allelopathic components [13].

The nitrogen mustards are an important group of alkylating agents that have been commonly used in clinical cancer chemotherapy for more than 30 years [14]. Like almost all other anticancer drugs, their clinical efficacy has been limited by their toxicity to normal tissues [15]. Thus, it is important for pharmacochemists to reduce their side effects and prolong their duration of activity [16, 17]. Many works have reported that it is possible to improve their targeting of tumor cells by linking them with different drug carriers such as lectins, glycoproteins, and lipids [18].

Mustard seed like other oil seeds are rich source of phenolic compounds [19], and mustard seed flour has also anti-microbial property.

The aim of this work was the determination of physico-chemical properties of mustards from the Romanian market and to reveal differences among these samples.

II. MATERIALS AND METHODS

A. 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.

B. Methods

1. Dry matter content

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

2. Extract content

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

3. Proteins content

The protein content of mustards was measured by Kjeldahl method, using the multiply factor of 6.25

4. Lipids content

Lipid extraction was carried out with a Soxhlet extractor with 250 mL of petroleum ether and then the solvent was removed by evaporation.

5. Ash content

To remove carbon, about 2 g sample in a porcelain container was ignited and incinerated in a muffle furnace at about 530^0C for 5 h. Ash content were expressed as percent of dry weight.

6. Instrumental colour analysis

The colour of the samples was measured using a Hunter-Lab colour meter. The instrument was calibrated using the black and white tiled provided. Colour was expressed in Hunter Lab units L^*, a^* and b^*. Samples of purée were filled into plastic Petri dishes (i.d. 50 mm) taking care to exclude air bubbles and placed under the aperture of the colour meter. Five replicate measurements were performed and results were averaged. In addition, hue angle and chroma were calculated by the following equations:

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

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

7. Statistics

Samples were assayed in triplicate and results are given as averages ± SD. To find relationships between the physic-chemical and the rheological parameters of mustards [1], the values of linear correlation coefficient were calculated. Student's t – test was used for the statistical evaluation and $p<0.05$ was considered statistically significant.

Data analysis was performed using partial least squares method of regression (PLS) which determines the relationship of the physic-chemical characteristics of the product quality and strength of the bonds between these features [20]. 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).

III. RESULTS AND DISCUSSION

3.1. Physico-chemical properties

The results of the physico-chemical analysis of mustards samples are shown in Table 1. The ash content are presented in Figure 1. The mustards had a 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 the 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.

Table 1
Physico-chemical properties of samples of mustard

Mustard 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 the traditional mustard varieties, on the basis of three measurement, ± S.D.

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

Table 2. Colour parameters of mustards

Samples	L^*	a^*	Colour 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±0.11	-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 are means ± standard deviation, $n = 3$

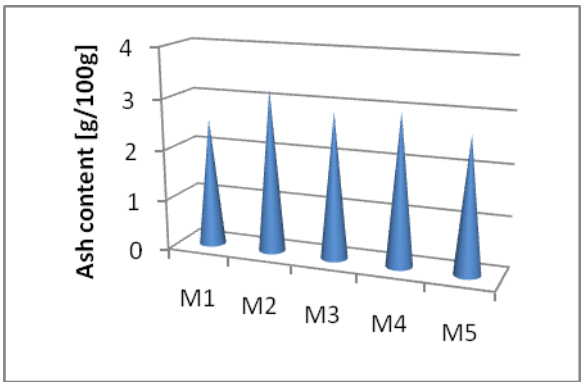

Fig. 1. Ash content of mustard

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. Strong positive correlation (r = 0.986) between the stands and the content of dry substance extract.Formarea 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).

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.

The evaluation of the emulsion characteristics was determined based on the analysis of the principal components between the physico-chemical characteristics of the 5 mustard samples and the emulsion stability emulsion, emulsion activity 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 (Fig. 4, Fig. 5 and Fig. 6).

Table 3. Pearson correlation matrix for the dependent variables

Variables	Dry matter	Extract content	Protein content	Fat content	Ash content	Water holding capacity	holding capacity	Emulsion activity	Emulsion stability	k [Pa,sn]
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	0.230	-0.308
Protein content	0.644	0.552	**1**	0.967	0.947	0.008	0.160	-0.742	0.158	0.203
Fat content	0.788	0.721	0.967	**1**	0.837	-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	0.160	-0.066	0.387	0.969	**1**	0.163	-0.273	0.530
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	0.230	0.158	0.291	-0.058	**-0.375**	-0.273	-0.311	**1**	**-0.692**
k [Pa.sn]	-0.205	-0.308	0.203	-0.015	0.493	0.445	0.530	0.407	-0.692	**1**

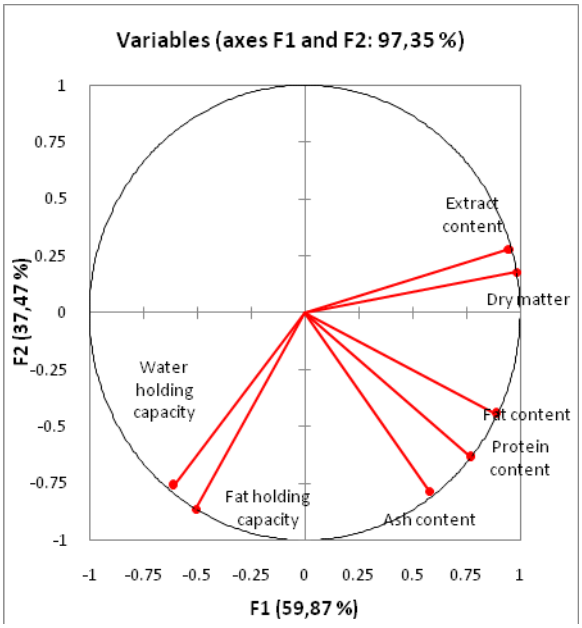

Figure 2. Analysis of the dependent variables PLS

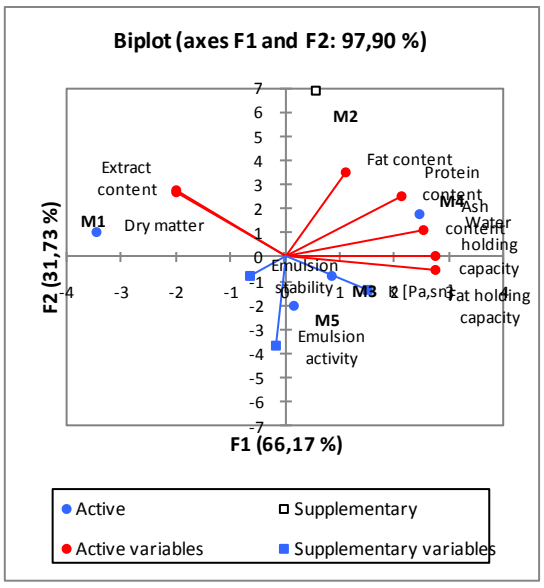

Figure 3. Principal components analysis

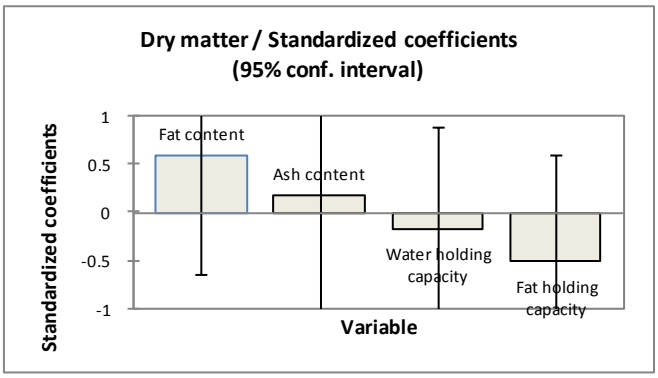

Figure 4

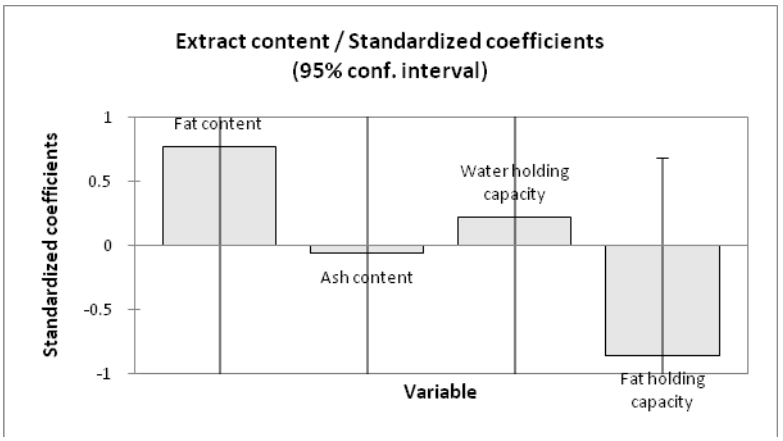

Figure 5

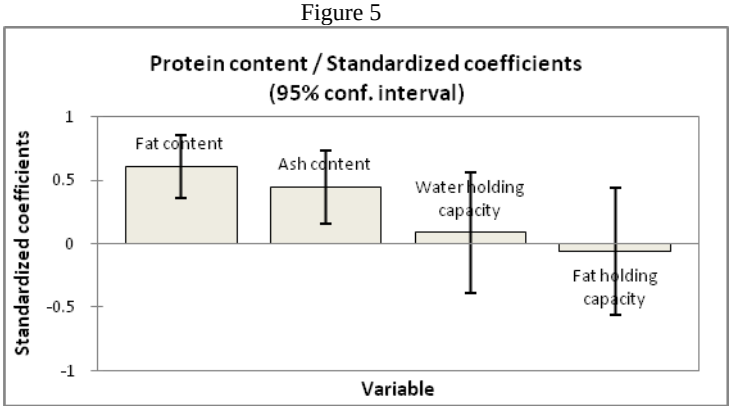

Figure 6

3.2. Correlation between physico-chemical and rheological properties

A relatively high coefficients of linear correlation between the physico-chemical and rheological [1] properties of mustards (0.76; $p < 0.05$) were found for the dry matter content and the viscosity as well as the flow behavior index (0.6252). However, at the number of the degrees of freedom used in this study they were statistically non-significant. In contrast, Bhattacharya (1999) [22] found an increase in the values of yield stress, consistency coefficient and apparent viscosity of model mustard samples with decreasing water content. In the present study the extract content significantly correlated solely with the flow behavior index. The ash content correlated only with flow behavior index (0.9252) and consistency coefficient (0.70), while the protein contents correlated with flow behavior index (0.8152) and fat contents correlated with consistency coefficient (0.9009) and flow behavior index (0.6876) [1].

IV. CONCLUSION

Summarizing these results it seems that on the basis of chemical composition (advantageous protein and essential amino acid content) mustards may be used for human consumption as additive.

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 that there are significant linear correlations between some physico-chemical properties and some parameters describing rheological properties of mustards [1]. 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.

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