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Cluster analysis for some different types of vegetable oils by the physicochemical characteristics

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Abstract

Vegetable oils are a class of natural products commonly used and appreciated due to their nutritional, sensorial, technological principles. Vegetable oils constitutes an important component of human diet often used in daily consumption with beneficial effects for the body balance. The aim of this study was to evaluate and compare some of the physicochemical characteristics (dynamic viscosity, refractive index, surface tension, relative density and acidity index) in case of six food consumption vegetable oils, cold pressed. The analysed oil assortments, in these work were soybean, rapeseed, corn oil, almond, sesame and pumpkin seed oil purchased from the speciality stores with natural products, having different origins. The refractive index was measured using the refractometry method, and the dynamic viscosity using the Ostwald-type viscometer. From the physicochemical analyzed characteristics, it was observed that the values differ from one category of oil to another. Oils density varies from species to species and at the same oil with the conservation conditions (conservation period, climatic conditions in which the plant has developed). Viscosity gives relevant indication of the degree of oil fluidity. The experimental results showed that the highest value for viscosity was registered in rapeseed oil (38,7088cP) and the smallest in soybean oil (34,0174cP). All the data was statistically analyzed using Statistica10. The results showed that there is statistically significant correlation between the physicochemical characteristics for the analyzed types of oils. The purpose of the statistical analysis was to highlight the analysed parameters expressed by cluster analysis.

Keywords: vegetable oils, physicochemical characteristics, statistical evaluation data.

1.Introduction

Lipids are indispensable food components which determines, besides the energy value also the nutritional and sensory qualities, of the food. Being an important source of energy for the body, considered as an "efficient fuel" to sustain physical activity, lipids play an essential role in human nutrition. The energy role consists in providing of 9.2 kcal for every gram of lipids consumed. Lipids are the main constituents of living cells, playing an essential role in functioning of organs and the entire body, being necessary in the metabolic processes [1,2]. They should not miss from the daily diet because the body is unable to synthesize a sufficient amount of essential fatty acids and liposoluble vitamins it, alone. It is estimated that lipid intake for an adult is better to be around 30% of total energy.

Numerous studies in modern human diets, revealed serious changes in terms of lipids by increasing consumption of refined products of plant lipid (vegetable oil) and animal (butter, cheese, cream) [3]. Vegetable oils are found in nature in plant tissues, inside fruit kernels, in tubers or in germs. In our country the main raw material is seed oil plants. Most plants contain oils to a greater or lesser extent, especially in seeds, fruits, kernels, germs [4,5]. The majority of variety comestible oils and fats produced globally every year come from plant sources, known as vegetable oil. Vegetable oils are not only a non-polluting renewable resource but also offer a wide diversity in the composition of the fatty acid with various applications. Oils of plant origin have been predominantly used for food-based applications [6,7].

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Rape (*Brassica napus oleifera* and *Brassica rapa oleifera*) is a plant of the Brassicaceae cruciferous family with yellow flowers and long, branched stem. Rape is grown for seeds and the oil is used in food and industry (biofuel). Nowadays, rape occupies a special place in the world economy as a source of vegetable oils for use in food and particularly in industry by creating alternative energy solutions. Due to its high erucic acid content (up to 30%) rapeseed oil has been considered to be toxic to the human body. Animal experiments have led to the conclusion that the consumption of rapeseed oil with high erucic acid content does not cause negative effects if the proportion in the diet does not exceed 5%. Its introduction into food was possible after world war II when new genetically modified varieties were created, degraded to erucic acid (less than 2%) and very low glucose (less than 30 μmol / gram) known as "canola". The oil is dark green, has no specific taste and smell and is used in refined form in food [8,9].

Soybean (*Glicina hispida Max*) is part of the Glycin family of Oriental Asian legumes. The soy is very rich in protein - 40% (while the meat has only 15-25%), carbohydrates (10-15%) minerals (calcium, iron, magnesium, phosphorus, sulfur), vitamins (A, B1, B2, D, F, E), lecithin (as well as egg yolk), waxes, resins, cellulose. Essential and non-essential amino acid content is a percentage double of meat. From this content come the general properties for which soy oil is highly recommended in food, representing a completely constructive (muscle, bones, nerves) and easily digestible food, is an energetic, remineralizing and balanced cell nutrition, preventing fattening [7,8].

The oil obtained from the corn germ, *Zea mays*, is light yellow or orange, if unrefined and almost tasteless. Corn oil is generally less expensive than most other types of vegetable oils. Corn oil is a mono and polyunsaturated oil. Percentage contains 54.7% polyunsaturated fatty acids, 27.6% monounsaturated fatty acids and 13% saturated fatty acids. Of saturated fatty acids, 80% are palmitic acid, 14% stearic acid and 3% arachidic acid [9]. Of the monounsaturated fatty acids, 99% are oleic acid. 98% of the polyunsaturated fatty acids are linoleic acid, an omega-6 and 2% linoleic acid, an omega-3. With its high smoking point, refined corn oil is a precious frying oil, the main use being cooking. Corn oil is also a raw material used for biodiesel. Other industrial uses for corn oil include soap and paint production, rust resistance to the metal surfaces, inks, textiles, nitroglycerin and insecticides. Because the sensory and chemical properties are related to the oxidative stability of the oil, it is necessary to analyze the relevant physicochemical parameters.

Pumpkin (*Cucurbita maxima*) is an annual herbaceous plant, being cultivated for the benefit of its fruits, flowers and seeds [6]. Pumpkin belong to the *Cucurbitaceae* family and is native to South America. Pumpkin seeds oil have assigned many nutritional and medicinal effects. From a nutritional point of view pumpkin seed kernels are rich in minerals especially phosphorus, magnesium, potassium, zinc. Pumpkin oil is also full of A, B, D, E, F, K vitamins, carotenoids, iodine and fat acids Omega 3, 6 and 9 [10,11,12]. From the pressed cold pumpkin oil, all these elements can be integral absorbed in a short time. This is why the World Health Organization recommends a daily consumption.

Many studies focused particularly on the composition and content of fat acids, tocopherols and sterols in pumpkin seed oil because of their positive health effects. Pumpkin has an exceptional protective effect against many diseases as hypertension and carcinogenic diseases, due to its health benefits such as antiinflammatory, antidiabetic, antioxidant and antibacterial effect [13,14]. Biochemical properties and oxidative stability of pumpkin seeds oil contribute to the valorization of this oil especially in pharmaceutical, cosmetic, and food industries.

Almond (*Prunus Dulcis*) is a Mediterranean fruit tree that is part of the Rosaceae family [7]. It is originally from Asia. Fruits are edible, ovoid, wrapped in a thick, pear-shaped shell, inside of which there is a kernel, which tastes sweet or bitter. Almonds contain vitamins A, C, E, vitamin B complex, mucilage, glycerides, proteins, enzymes, riboflavin, pantothenic acid, folic acid, thiamine, amino acids and minerals: calcium, phosphorus, potassium, magnesium, iron [4,6]. The sweet almonds are used in food industry. The bitter almond oil is extracted from the bitter almonds that contain a glycoside called amygdalin which turns into toxic hydrocyanic acid on processing. It can have fatal consequences if ingested. Bitter almond oil does have some medicinal properties, and may be pretty safe for external application, but is better avoided due to the high risk of poisoning [15]. The sweet almond oil improves the taste of food and can

also be used for salads, cereals and sandwiches. Besides the nutritional properties, almond oil has many uses in the cosmetics industry [6]. This oil is a natural emollient and is recommended for any type of skin. It is rich in vitamins, minerals and fat acids. Moisturizes and helps regenerate the skin [15]. Its toning and anti-aging properties make this oil an ideal body and face massage oil [6,15].

Sesame (Sesamum indicum) is a plant grown for oil-rich seeds. The seeds are small, brownish-yellowish. It originates in the Middle East and India. Sesame seeds abound in proteins and contain methionine, an essential amino acid. They contain unsaturated fats that together with lecithin and phytosterol make the sesame seeds a food that helps reduce blood cholesterol. The calcium, iron, zinc, selenium and copper content of sesame seeds helps the body to function normally, to form bones, teeth, metabolism of fats, carbohydrates [4,6]. Sesame seeds contain antioxidants and have anti-carcinogenic properties. Sesame oil improves hair and skin structure, helps to increase bones, reduce blood pressure, maintain heart health, improves digestive process, prevents cancer and prevents anxiety and depression. It's one of the healthiest alternatives to normal vegetable oils. Sesame oil has also been used in massages because of its beneficial effects on the body and skin. It is a highly sought after oil, even as a base oil for various cosmetics [7,16].

2. Materials and Methods

In the experimental part, it was analyzed in terms of physicochemical and nutritional characteristics six types of food vegetable oils commonly used in the food industry to prepare dishes and culinary products. The oil assortments analyzed in these works are soybean, rapeseed corn oil, almond, sesame and pumpkin seed oil purchased from the natural products department store. These are used and appreciated due to the nutritional principles in the preparation of various sauces, salads, dressings especially in the cold kitchen as they also highlight the characteristics of the other ingredients. The purpose of the study was to analyze and compare some physicochemical characteristics as dynamic viscosity (η), refractive index, superficial tension (σ), relative density (ρ_r) and acidity index in case of those natural, cold pressed vegetable food oils. The dynamic viscosity was obtained using the Ostwald-type viscometer. The refractive index were obtained using the refractometry method, with the Abbe refractometer corrected to the equivalent reading at 20°C. The use of the refractometer requires a calibration check by measuring the refractive index of distilled water, which has a value of 1.3330 at t = 20C. Relative density determination was made using the pycnometric method and for the surface tension coefficient has been used the stalagmometric method [17]. The free oils acidity is an important indicator due to the free fatty acids composition present in the product. The acidity index represents the amount of potassium hydroxide, in mg, required to neutralize free fatty acids from one gram of product [18]. The data were statistically processed using Statistica10 program. Basic descriptive statistics and cluster analysis were achieved. The purpose of the statistical analysis was to highlight the analysed parameters expressed by cluster analysis. This method using two-way cluster that groups objects based on the average distance between all parameters taken into study.

3.Results and Discussion

All the obtained results were statistically processed using the Statistica10 program. Analysis of the physicochemical parameters (n, η, σ, $\rho_{rel,}$ acidity index) are a basic indicator in investigating the nutritional, biological and sensorial properties of the natural edible food oils taken into study. Basic descriptive statistics (mean, minimum, maximum, the lower and upper quartile, standard deviation, variance, coefficient of asymmetry and flattening coefficient) for each parameter, variable, are presented in Table 1. The parameters considered as variables in the applied statistical analysis are: refractive index, n; absolute viscosity, η; superficial tension, σ, relative and absolute density, ρ_r and ρ and also acidity index.

The variable composition of the different oils and fats allows their characterization also by measuring the refractive index. These measurements can provide a perspective on their quality because any change in their optimal composition will also affect the value of the refractive index. The refractive index of animal and vegetable fats and oils is a qualitative parameter, easily identified in a short time. Pure oils have marked values of refractive index and density, so the degree of variation, of a typical oil, of its real values may indicate a relative purity [7]. Refractive index values for oil samples at 27 ° C is in the range 1.4702 -1.4754. Regarding the refractive index, the smallest value (1.4702) was obtained in case of vegetal almond oil and the

highest value (1.4754) was obtained for the natural sesame oil. The refractive index is evaluated to measure the unsaturation changes during oil or fat hydrogenation. The refractive index of oils depends on many factors such as the fatty acid chain length, molecular weight, conjugation degree and degree of unsaturation [19].

Table 1. Basic descriptive statistics for the physicochemical analyzed parameters

Parameter	Mean	Minimum	Maximum	Lower quartile	Upper quartile	Variance	Standard deviation	Skewness	Kurtosis
n	1,4724	1,4702	1,4754	1,4714	1,4733	0,0000	0,0017	0,7888	0,9325
eta	35,7406	34,0174	38,7088	34,3750	37,2518	3,3872	1,8404	1,0190	-0,4105
σ	29,1093	23,5600	34,7360	25,6700	33,8830	19,6165	4,4290	0,2576	-1,5014
ρ_{rel}	0,9166	0,9134	0,9211	0,9145	0,9183	0,0000	0,0027	0,7019	0,1319
ρ	0,9136	0,9102	0,9182	0,9113	0,9152	0,0000	0,0028	0,6729	0,2299
Acidity	0,4216	0,1100	0,8000	0,1800	0,7000	0,0830	0,2881	0,3235	-2,1441

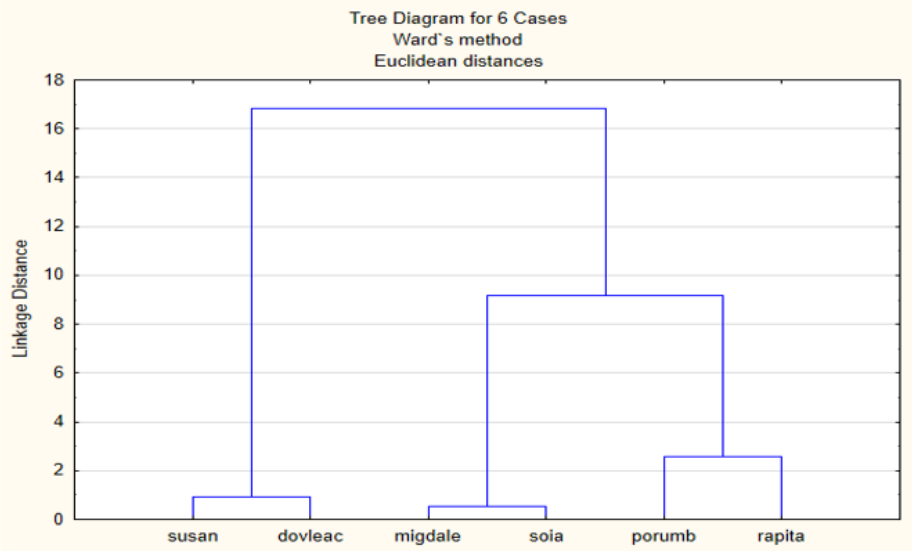

Figure 2. Cluster representation of the edible oils under study

Viscosity is considered an major characteristics for the quality and stability of a liquid food system. The investigated oil samples generally have a Newtonian fluid behavior, the saturated fatty acid content playing a major role in the viscosity size. All edible oils consist of triglycerides with a variety of fatty acids that differ depending on chain length, saturation degree and position, as well as the geometry of the double bond in the carbon chain [6]. The viscosity provides mainly indications of the degree of the oils fluidity [20].

The viscosity of edible vegetable oils increases with the chain length of triglyceride fatty acids and decreases with unsaturation. Distinctive behavior of the oils subjected to the same thermal stress is due to the composition of saturated, monounsaturated and polyunsaturated fatty acids together with the concentration of minor compounds, mainly phenols and tocopherols [7]. From table1, the minimum values of the dynamic viscosity are 34,0174 cP in case of sesame oil while the maximum viscosity values are 38,7088 cP for the rape oil.

This can be directly related to the contribution of saturated fatty acids. The viscosity of refined rapeseed oil is higher than that of soybeans.

Also, from table 1 it can see that the average relative density of the studied oils is 0.9166. The minimum of the relative density values of the studied syrups is 0.9134 in case of rapeseeds oil and the maximum values of the relative density was found 0.9211 for pumpkin seeds oil. The density of oils varies from one species to another, and in the same type of oil with conservation conditions (storage and climatic conditions in which the plant

is developed). The oils density varies according to each type of oil and also with the temperature [17]. The range is from 0.91 to 0.93 g/cm^3 between temperatures 15 °C and 25 °C. Compared to water, which has a density of 1.00 g/ml, oils are less dense [20]. The value of the relative density of the investigated oils at 27 ºC varies between 0.9134 and 0.9211.

The free acidity oils studied was determined according to STAS 145-67. Free acidity is the percentage of free fatty acids found in the analyzed oil are conventionally expressed in the most representative fatty acid [18]. For ordinary soybean oils, sunflower, peanut, pumpkin is expressed in oleic acid; for coconut and palm oil in lauric acid; for palm oil in palmitic acid for rapeseed oil in erucic acid. The free acidity values for the analyzed oils correspond to the standards in force, the values being between 0.11 - 0.8 % oleic acid [10,19].

The investigated oils samples were grouped and were obtained the Cluster representation for those six edible oils sample taken into study (Figure 2).

The cluster analysis based on Ward's method using Euclidian distances is revealing the type of similarity between the edible oils. We observe 3 clusters: one cluster formed by sesame and pumpkin oil, the second cluster formed by almond and soybean oil and the third cluster formed by the corn germ and rape oils. We can state that physicochemical characteristics have a high influence on oil quality.

4.Conclusions

Evaluations of physicochemical characteristics (refractive index, viscosity, surface tension, relative density) represents a significant indicator in the appreciation of biophysical properties.

For analyzed vegetable oils samples it was noticed that their values differ from one category to another, results being comparable to the data from the literature.

Compliance with Ethics Requirements. Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human / or animal subjects (if exist) respect the specific regulation and standards.

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