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PHYSICO-CHEMICAL PROPERTIES OF BLENDS OF CORN OIL WITH CORIANDER SEED OIL

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Abstract: *The effects of different additions of coriander seed oil (10%, 20% and 30%) in the corn oil on the physico-chemical parameters like refractive index (RI), iodine value (IV), saponification value (SV), peroxid value (PV), acid value (AV) and oil viscosity were investigated. It was found that the presence of coriander seed oil up to 30% in corn oil had an improving effect on quality parameters of the oil blends. The addition of coriander seed oil in corn oil caused a decrease in the refractive index, iodine value, saponification value and peroxid value with the increased mixing ratios (proportion) in the oil blends formulation. The viscosity of all oil samples analyzed by Brookfield viscometer appeared to remain constant regardless of the shear rates tested. The results suggest that coriander seed oil can contribute to improving quality of corn oil.*

Keywords: *oil blends, corn oil, coriander seed oil*

1. Introduction

Coriander (*Coriandrum sativum L.*) is an herbal plant of a high economic interest for the food and other industries. Cultivated for both leaves and seeds, coriander is highly appreciated not only for the nutritional point of view [1, 2], but also for some medicinal benefits like hepatoprotective [3] antioxidant [4], antimutagenic [5], antianxiety [6], antidepresive [7] antitumor [8], antihyperlipidemic [9], against worms, rheumatism [10], for ameliorate insomnia, anxiety, convulsion [11], digestive stimulant [12] e.g. Due to its bioactive components [13, 14], different parts of coriander plant can be used to develop new formulations as a promising functional foods.

The coriander seeds are the most widely used components of the plant due to its many important constituents. It contains high levels of bioactive lipids [15] such as essential oil (linalool) and fatty oil. The content of fatty oil is around 25% of the seed while the essential oil content is usually less than 1% [16].

Coriander seed oil is a triglyceride oil extracted from seeds of *Coriandrum sativum L.* using various technique such as expelling or pressing, organic solvents extraction, supercritical fluid extraction [17], e.g. This vegetable oil, considered as a novel food ingredient, is a triglyceride oil in which the monounsaturated fatty acid - petroselinic acid (cis-C18:1(n-12)) is the main fatty acid (60-75 % of coriander seed oil) [18]. Some researchers have reported that this major fatty acid is ranging from 65.7% to 84.2% and is followed by linoleic acid (C18:2) which is accounting for 12–19%, and small quantities of oleic acid (cis-C18:1(n-9)) (8-15 %), palmitic acid (C16:0) (2-5 %) and stearic acid (C18:0) (< 1.5 %) [18, 19, 20]. The coriander seed oil is a highly promising edible oil with a high antioxidant potential [4, 21], due to it higher radical scavenging activity that has been partly attributed to its unsaponifiables (21.8 g/kg) and phospholipids (1.57%) content. In addition, coriander oil is a good source of tocols (327.47 mg/g) and tocotrienol (275.87 mg/g) [16] which inhibit the lipid peroxidation. The variations in oil composition and fatty acids of the coriander oil can be due to the geographic divergence and ecological conditions [16].

Therefore, among newer sources of edible oils, the coriander seed oil may be used as potent source of valuable amounts of bioactive compounds in order to improve the quality of vegetable oils, like corn oil. Oil quality is very important for both the consumers and well as an application in different industries.

Corn oil is extracted from the corn germ by a combination of expelling in continuous screw presses and solvent extraction of the press cake. Then, crude corn oil is subject to the refining process in order to remove it free fatty acids and phospholipids content and to retain the tocopherols in the refined corn oil. The main fatty acids in corn oil is linoleic acid (C18:2) (54-60%), oleic acid (C18:1) (25-31%), palmitic acid (C16:0) (11-13%), followed by stearic acid (C18:0) 2-3% [22]. Corn oil is recognized as a healthy edible oil due to its high content of the fatty acids, having beneficial effects on blood pressure, platelet aggregation, diabetes [23], atherosclerosis by prevention of the oxidation of low-density lipoproteins due to the antioxidant properties of tocopherols [24] and cholesterol-lowering properties [23, 25] due to its highest levels of unsaponifiables and phytosterols. The corn oil has wide application in food industry where this is used in frying, salad dressing, shortening, cooking, e.g. Corn oil composition can affect its behaviour during frying and processing. Due to it high content of polyunsaturated fatty acid (56%) [18], is not quite stable at high temperatures. Also, a disadvantage of corn oil is the high linoleic acid content (40-70%) [26]. The high level of this polyunsaturated fatty acid can cause a high degree of oxidation at high temperature [27]. Also, during storage the quality of corn oil decreased because it undergoes hydrolysis, oxidation and polymerization [28]. Therefore, the development of a more stable high product, more stable to frying and storage, with the increase of the quality parameters at a low price would be desirable. On the other hand, the demand for edible oil with a improve quality is in continually increasing due to the increased concern of the population regarding to the healthy eating. Nutritional quality has been recognized for oils rich in monounsaturated fatty acids with the reducing of its polyunsaturated (like, linolenic acid) and saturated contents [29]. One way to improve the quality of corn oil is by blending with oils of high monounsaturated fatty acids contents and high antioxidants' levels.

During last years, blending of two or more vegetable oils with different characteristics have been a common permitted practice in the many countries and aiming an improving of the physicochemical parameters of the new specific products with a better quality and nutritional value at procurable prices [27, 28]. Blending different types of vegetable oils lead not only to a change in fatty acids profile, but also increase the levels of bioactive lipids and natural antioxidants in the blends and change the physico-chemical oil parameters. The refractive index, iodine value, peroxide value, saponification value and acid value can be improved in this way to get good and desirable blends. Viscosity of the oil is another important parameter that must be considered for example in chemical engineering design. The rheological behaviour and flow properties of edible oils have a significant role in the food industry for the evaluation process of the equipments such as pumps, piping, e.g. [30]. The viscosity of the oil has a direct relationship with the physico-chemical oil composition, respectively with the nature of the triglycerides presents in the oil. In this way, viscosity is related to some chemical properties of the oils, such as the degree of unsaturation and the chain length of the fatty acids [31]. It has been reported that oil viscosity increased with the increased degree of saturation and decreased with the increased of the degree of unsaturation [32].

The blending of vegetable oils with various characteristics to make new products has been investigated by various researchers [15, 27, 33, 34] but, to our knowledge, the physicochemical properties of corn/ coriander oil blends in mixing ratios of 9/1, 8/2 and 7/3 have not been evaluated yet. Therefore, corn oil mixed with coriander seed oil could give new oil formulation with improved characteristics.

In this study the effect of blending corn oil with coriander seed oil in different mixing ratios on the physico-chemical parameters of the blends oil samples has been investigated. The studies have conducted on the following parameters: refractive index, iodine value, peroxide value, saponification value, acid value and viscosity. This research can contribute to the development of healthy blended oils with an improved quality.

2. Experimental

2.1 Materials

Corn oil and coriander seed oil were purchased from local market (Suceava, Romania). Corn oil (CO) was blended with coriander seed oil (CSO) in varying proportions. The following CO:CSO (% w/w) blends were formulated: 100:0, 90:10, 80:20, 70:30 and 0:100. The oil blends were thoroughly mixed to form uniform blends at room temperature. All solvents and reagents used in this work were of the highest purity needed for each application.the samples was subsequently analysed.

2.2 Methods of analysis

The following physico-chemical parameters were carried out according to the Romanian or international standard methods. All tests were performed in duplicate.

Refractive index

The refractive index (RI) of the oil samples was determined with a *Abbé* refractometer at 20°C by the measurement of the angle of total reflection [SR EN ISO 6320:2002/AC:2006].

Iodine value

Iodine value (IV), expressed of the number of g of iodine absorbed by 100 parts by weight of the oil (g I_2/100 g sample) (SR EN ISO 3961:2013), was determined using the Hanus method. A blank was also prepared alongside the oil samples.

Saponification value

Saponification value (SV) which represents the amount of the potassium hydroxide, in mg, required for saponification of the free fatty acids and the esterified one from of a 1 g of oil sample (mg KOH/g sample) was determined according to the SR EN ISO 3657 : 2013. A blank was also prepared alongside the oil samples.

Peroxide value

The peroxide value (PV) (meq/kg) was determined according to SR EN ISO 3960:2010, by the reaction of 2 g oil in 25 mL solvent mixture of glacial acetic acid: chloroform (3:2, v/v) with freshly prepared potassium iodide solution. The solution was placed in darkness for 5 min and was titrated with sodium thiosulfate solution (0.01N) after addition of soluble starch (1%) as indicator. The titration continued till until the blue color had just disappeared. A blank was also prepared alongside the oil samples.

Acid value
The acid value (AV), expressed in mg KOH/g sample, was determined by titration with the potassium hydroxide (0.1N) of a solution of oil (10 g) in a previously neutralized solvent mixture of ethanol–ethyl ether (1:1) with phenolphthalein indicator (1% in ethanol) added [SR EN ISO 660 : 2009]. The titration continued until the pink coloration persists for at 1 min.

Viscosity
A Brookfield rotational viscometer (Model RVDV-I Prime, Brookfield Engineering Laboratories) was used to measure the oil samples viscosity (Pa·s) at the speed of 2.5, 5, 10, 20 and 50 rpm.
A fixed volume of oil in a 600 mL beaker was used to immerse the groove on the spindle and the spindle depth was kept constant throughout the measurements. Two readings were taken per sample at 30 s intervals.

2.3. Statistical analysis

The experimental results were expressed as means ± standard deviation (SD) of duplicate measurements. Differences between means were evaluated by the analysis of variance (ANOVA) using SPSS v.16.0 software. Statistical significant difference was considered at $p < 0.05$.

3. Results and discusion

Physicochemical characteristics
Refractive index (RI)
Refractive index of corn oil, coriander seed oil and oil blends is shown in Fig. 1. The RI values for CO and CSO is in agreement with the values reported by different researches [18, 22, 35]. Blending of CSO with CO has changed significantly ($p < 0.5$) the value of RI in CO:CSO blends. This decreased of RI value with the increased of the mixing ratio may be due to the decreased of the unsaturation acid content in the blends knowing that the the refractive index is the physical parameter that dependent on degree of unsaturation acid content [36]. Also, the decrease of RI in the blends can be due to the increased of the monounsaturated fatty acids of blends formulation, according to Ramadan and Wahdan (2012) or may be due to molecular weigh, fatty acid chain length, or the degree of conjugation [37].

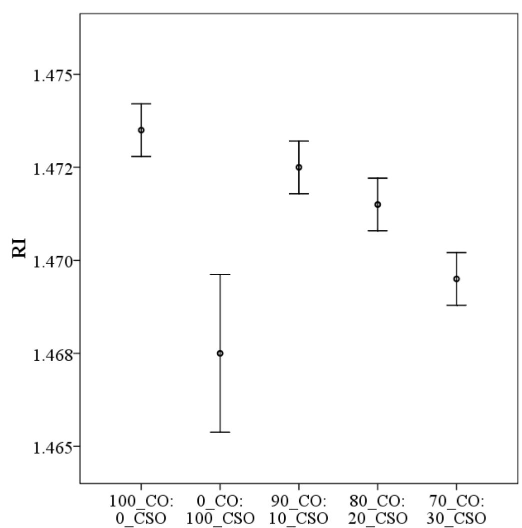

Fig. 1. Variation of Refractive index (RI) in oil samples formulation: CO –corn oil; CSO – coriander seed oil. Error bars show the variations of two determinations in terms of standard deviation.

Iodine value (IV)

Comparatively with the iodine value of coriander seed oil (CSO), the iodine value of corn oil (CO) was higher (Fig. 2) probably due to a high degree of unsaturated fatty acids from oil corn and a degree of heat treatment during corm oil processing [38]. Because the IV is a measure of the degree of lipid unsaturation in oil, this high value may be an indication of a high saturation in corn oil and therefore may become more vulnerable to oxidation, influencing therefore the stability during storage. By blending CO with CSO in different mixing ratio was obtained a decrease in the IV with the increased ratio of coriander oil in blends, probably due to the increased content of unsaturation acid in oil samples formulation. The phenomenon of a decreased trend in IV indicates an increased in unsaturation content this fact leading to no risk on the consumer health.

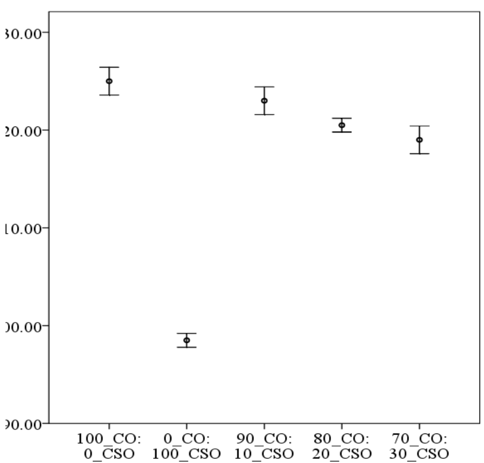

Fig. 2. Variation of Iodine value (IV) in oil samples formulation: CO –corn oil; CSO – coriander seed oil. Error bars show the variations of two determinations in terms of standard deviation.

The results obtained for IV gives a reasonable quantitation of lipid unsaturation if the double bonds are not conjugated with each other or with carbonyl oxygen [39].

Saponification values (SV)

The SV of CSO is insignificance lower comparable with the CO, probably due to a high molecular weight lipids from coriander oil. The SV of the binary blends were found to be in decrease as shown in Fig. 3. This trend explains the fact that with the increase level of CSO ratio in formulated blends the fatty acids are not likely to formed, therefore the SV will decrease. This also indicates that, comparatively with the pure CO, these blends can be stored for a long time.

Peroxide value (PV)

The PV calculated for pure corn oil, coriander seed oil, and binary oil blends are shown in Fig. 4.

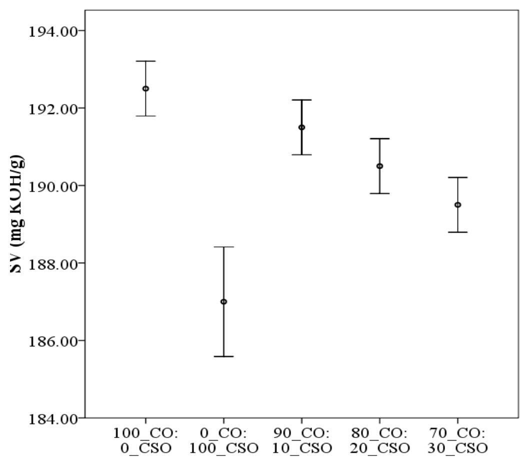

Fig. 3. Variation of Saponification value (SV) in oil samples formulation: CO – corn oil; CSO – coriander seed oil. Error bars show the variations of two determinations in terms of standard deviation.

CSO indicates a relatively good quality of this oil compared to the CO. The PV obtained indicates an early lipid phase peroxidation probably due to the fact that peroxides are the first components of lipid oxidation. The addition of CSO to the CO significantly decreases ($p < 0.05$) the PV, this showing an enhancement of the oxidative stability of oil blends. Because the hydroperoxide is the primary product of lipid oxidation, the PV can be used as oxidative index during the early stage of lipid oxidation. The decrease of PV with the increase level of SCO from blends may be due to the changes in the fatty acids profile, and some bioactive lipid's such as sterols and phenolics from the seeds coriander, in agreement with other results [28] as a consequence of the changes in fatty acids and tocopherols' profile, and minor bioactive lipids (e.g., sterols and phenolics) founded in coriander and black cumin oils. The PV of CO and oil blends varied significantly ($p < 0.05$) with the increase level of CSO (90:10, 80:20 and 70:30, w/w) for the high level of CSO being the most stable from the point of view of oxidation.

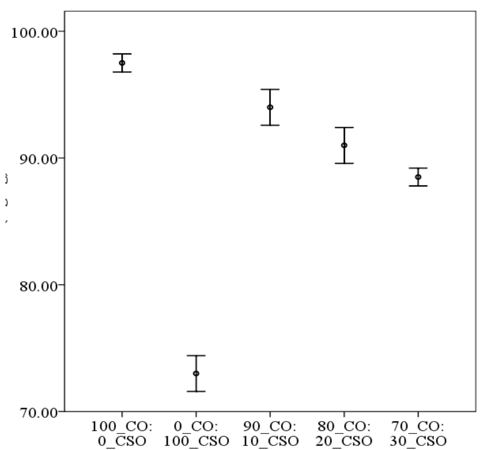

Fig. 4. Variation of peroxide value (PV) in oil samples formulation: CO –corn oil; CSO – coriander seed oil. Error bars show the variations of two determinations in terms of standard deviation.

These results indicated that the natural antioxidants from coriander seed oil hindered considerably the oxidation process in oil blends formulation.

Acid value (AV)

AV is a very important parameter for the assessment of oils quality, because it represents free fatty acid content due to it enzymatic activity. This parameter can be used to check the level of oxidative deterioration of the oil by enzymatic or chemical oxidation. The experimental results showed a significant decrease ($p < 0.05$) in the AV of the CO when it is blended with CSO (Fig. 5). The greater proportion of CSO from the oil blend showed the lowest AV value. The higher AV in CO is due to the free fatty acids present in the oil and the lower level of AV in CSO indicating lowers levels of hydrolytic and lipolytic activities. The higher ratio of the CSO blended with CO led to a further decrease in the AV values in the blends. By blending with coriander oil the portion of the unsaturated fatty acids increased in the blends formulated. These is probably due to the fact that these fatty acids do not take part in any chemical changes in the oil and do not interact with triacylglycerol even if they are of similar chemical composition [40].

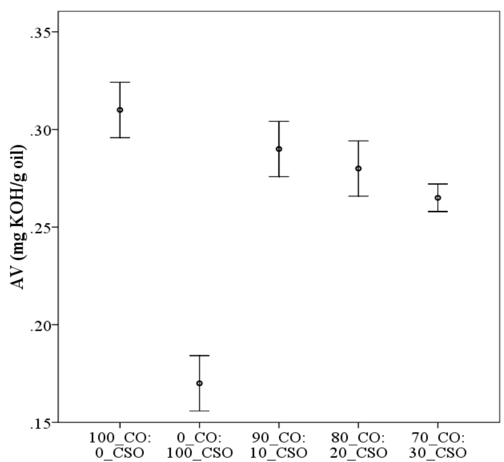

Fig. 5. Variation of Acid value (AV) in oil samples formulation: CO - corn oil; CSO – coriander seed oil. Error bars show the variations of two determinations in terms of standard deviation.

Viscosity

The oil samples viscosity is influenced by the triglycerides present in the pure oil, oils blends, respectively. The various arrangements of the fatty acids on the glycerol backbone of the triglyceride molecule changed the viscosity. Therefore, this parameter is related to the chemical properties like the chain length and saturation/unsaturation [41].

The rheological behaviour of oil samples analyzed can be explained by empirical relationship of power law model (Eq.1)

$$\sigma = k \cdot \gamma^{n} \quad (1)$$

where, σ - is the shear stress (Pa), k is the consistency coefficient (Pa · s^n), γ is the shear rate (1/s) and exponent n is the flow behavior index (dimensionless).

The empirical data obtained for oil sample formulation were converted to shear stress and shear rate followed the method described by Briggs and Steffe [42]. Average shear stress and shear rate was calculated using Eqs. 2 and 3, respectively:

$$\sigma_a = k_{\alpha\sigma} \cdot (C \cdot \alpha) \quad (2)$$

$$\gamma_a = k_{N\gamma} \cdot N \quad (3)$$

where, σ_a is the average shear stress (Pa), k_∞ is the shear stress conversion factor (Pa), C is the spring constant that depend on Brookfield viscosimeter model used and α is the torque value read for the viscosimeter (%). The $k_\infty$is a function of the spindle number, γ_a is the shear rate (1/s), k_{N_γ}- the shear rate conversion factor and N is the rotational speed in rpm. Values of$k_{N_\gamma}$are as function of the spindle number and the flow behaviour index [43].

The apparent viscosity (η_a) (Eq. 4) was calculated dividing Eq.2 by Eq. 3:

$$\eta_a = \frac{\sigma_a}{\gamma_a} \quad (4)$$

The results obtained for all oil samples showed a similar flow trend in which the shear stress is directly proportional to the shear rate (Fig. 6) having flow indices very close to 1.

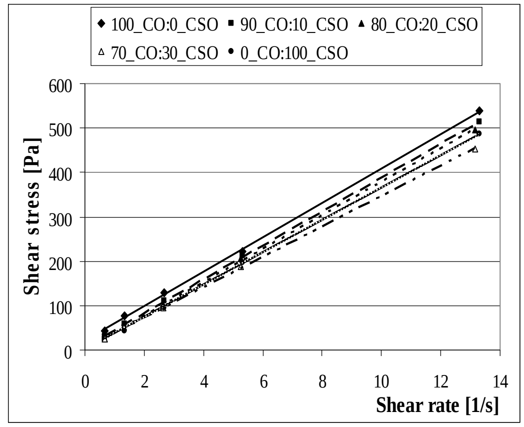

Fig. 6. Curves of shear stress vs. shear rate of oil samples formulation at 23°C.

The characteristics of the oil samples showed a Newtonian flow behaviour which was adequately described by the Eq. 4, indicating high determination coefficients (R^2). The R^2 values ranged from 0.985 to 0.0.998 for all oil samples. This behaviour can be due to their long chain molecules [44] and to the ratio saturation/unsaturation. The values of pure and oils blends viscosity is shown by the slope of each curve, varying distinctly as function on the each type of the oil samples.

4. Conclusion

The quality characteristics of the pure corn oil, coriander seed oils and formulated blends were evaluated through this study by different characteristics.

For oil blends the physical and chemical parameters have the same tendency to decrease with the increased of mixing ratio of coriander seed oil in corn oil. The viscosity of oil blends decreased insignificantly with an increase in proportion of coriander seed oil in corn oil probably due to change of the fatty acid profile of oil blends.

This study shows that blending is a good choice by which we can obtain edible oils with desirable physico-chemical parameters, improved from the point of view nutritional and qualitative. The coriander seed oil was found to be the vegetable oil with high qualitative properties that can be use to improving quality of corn oil and may bring functional benefits to food systems.

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