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Evaluation of Physicochemical Properties of Iranian Tomato Seed Oil

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Abstract

The major components of tomato processing industry wastes are seed that is not edible. The physicochemical properties and chemical composition of oil from tomato seed were studied by established methods. The oil yield of tomato seeds is about 35% on a dry weight basis. This vegetable oil has low sulphur (0.04 wt%), low ash content (0.034%), and high viscosity (51.5 mPa.s at 50°C). The fatty acid profile of tomato seed oil shows that there is a predominance of compounds containing an even number of carbon atoms, especially C_{16} and C_{18}. The total saturated and unsaturated fatty acid composition is 18.28% and 81.72%, respectively, and the most abundant fatty acid is linoleic acid (56.12%). This study indicates that tomato seed wastes are a potential source of edible oil.

Keywords: Tomato seed oil; Physicochemical characteristics; Fatty acid composition; Total oil yield

Introduction

Tomato (*Lycopersicon esculentum* L.) is the second most important vegetable crop next to potato worldwide, with annual production at 100 million tons fresh fruit produced in 144 countries [1]. Tomatoes are processed in manufactories to obtain products like puree, juices, ketchup, sauce, and paste and tomato powder. The solid waste that remains after the juice/pulp extraction process consists of skin, seeds, fibrous matter and cull tomato that are not suitable for human consumption and usually used as the animal feed but processing of these by-products generates substantial benefits [1]. Seeds of tomatoes have in composition essential fatty acids, vitamins (A, D, E and K), Phytosterols and other components with an important role in nutrients that play an important role in the human health and diet [2].

Tomato seed is the major by-product of the tomato paste manufacturing industry that produce is about 71%-72% from total waste production [3,4]. Tomato pulp primarily consists of skin and seeds. It is a lignocellulosic based that often creates disposal difficulty [5]. Several unit operations such as drying, grinding, squeezing and filtrating were used to obtain tomato seed oil from tomato seeds [6]. Tomato oil was extracted from the seeds with hexane as a solvent. The extraction rate increased as solvent flow rate increased. Tomato seed meal, the main by product during tomato oil production, could be used as animal food [6,7].

The purpose of this work is to determine the fatty acid composition and some physicochemical characteristics of the oil extracted from industrial tomato seed wastes and evaluate its potential for human consumption.

Materials and Methods

Material

Tomato seeds oil extraction: Three sample of 10 kg tomato pomace were obtained from one of the tomato processing plants in Tehran. Tomato seeds were separated and cleaned from pulp with water and then were dried in a desiccator for 3 days by silica gel. Dried seeds were milled and tomato oil was extracted from the seeds with hexane for 6 hr at 70-80°C in soxhlet extractor.

Methods

Total oils present: The solvent was evaporated using rotary system. Purified oil was calculated on a dry weight basis and stored in sealed bottles under refrigeration (0-4°C) for further processing and analysis.

Fatty acid composition: Fatty acid composition of tomato seed oil was identified by gas chromatography (Hewlett-Packard 5790) on a 12 m, 0.2 mm capillary column coated with Carbowax PEG20 accompanied by flame ionization (FID) detector and helium as mobile phase [8]. The sample was injected into the system at 230°C injector temperatures and the oven temperature was adjusted at 175°C for 30 min. Oven temperature was slowly increased with 3°C/min up to 220°C for 60 min.

For identification peaks the methyl esters for fatty acids were used. For preparation of fatty acid methyl esters, the samples containing fatty acids were esterified to the more volatile methyl esters by methanol-BF3 method. 100 mg tomato seed oil or 5 mL hexane solution obtained from the extraction of complexes was treated with 5 mL methanol-BF3 solution and refluxed for 2 min on a water bath, and then 5 mL hexane was added; after another one minute of reflux, the solution was treated with 15 mL saturated NaCl solution under vigorous stirring. The organic layer was separated and dried over anhydrous $CaCl_2$ [6,8].

Physico-chemical properties: The saponification value of the sample is a measure of the total fatty acids, bonded and not, in oils. The analyses have been conducted according to ISO 3657 standard [9]. Samples are dissolved in solvent and a defined amount of potassium hydroxide is added. After a certain reaction time, the residual potassium hydroxide is titrated with a hydrochloric acid solution (phenolphthalein as indicator). Results are then expressed in milligrams of potassium hydroxide used for the saponification of a gram of sample.

The iodine value of the oil or fat sample indicates the degree of unsaturation. The analyses have been conducted according to ISO 3961 standard. Samples are dissolved in solvent and added with Wijs

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reagent. After a defined time, potassium iodide and water are added and the liberated iodine is titrated with a sodium thiosulfate solution (starch as indicator). Results are then expressed in grams of iodine absorbed by 100 g of sample [10].

Ash and sulphur contents of the tomato seed oils were evaluated according to calcination method [11] and about density ASTM D4052-91 standard method were used [12]. All data were statistically analyzed using general linear model and tests were performed in triplicate.

Results and Discussion

Oil content and fatty acid composition

The oil yield of tomato seeds ranged from 33.6% to 37.4% on a dry weight basis that are similar to those of other investigators [4,11,13-17]. The seed oil was a red-yellowish liquid at ambient temperature and had a pleasant tomato fruit-like odor**.**

The chemical compositions of fatty acids of tomato seed oil from Soxhlet extraction are presented in table 2. Mrystic (C14:0), palmitic (C16:0), stearic (C18:0), arachidic (C20:0), myristoleic (C14:1), palmitoleic (C16:1), oleic (9c-C18:1), linoleic (9c, 12c-C18:2) and 8 other fatty acids that present in small amount were observed in the oil samples. Unsaturated fatty acid as myristoleic acid, palmitoleic acid, oleic acid, linoleic acid and linolenic (9c, 12c, 15c-C18:3) acid totally reach as high as 81.27% in extraction. The fatty acid profile of tomato seed oil is shown in figure 1. Result shows that palmitic acid was the major saturated fatty acid (12.26%) and was found to be dominant saturated fatty acid followed by stearic acid (5.15%) but higher palmitic acid concentrations (20.28%, 17.18%) have been reported by El-Tamimi et al. [4] and Botinestean et al. [11]. The same authors have also reported lower concentrations for stearic acid (2.36-2.96%), and relatively high concentrations of arachidic acid (1.93-2.20%). Linoleic acid was the major unsaturated fatty acid (56.12%) followed by oleic acid (22.17%). Tomato seed oil is an excellent source of essential fatty acids omega-6 (linoleic acid) and omega-9 (oleic acid). The differences in individual contents of fatty acids when compared to the bibliographic references may be due to the cultivars used and to the cultivation or environmental factors (Table 1) [13-18].

Physicochemical properties

The physico-chemical properties of the tomato seed oils are given in table 2. The physical and chemical parameters are very important because they are giving information about the composition of tomato seed oil, for example the density and viscosity are very important parameters, because tomato seed oil can be used as fuel after transesterification that has the purpose to decrease viscosity of it to not damage the engine [19].

The saponification value is the milligrams of KOH necessary to saponify 1 g of oil sample and shows the capacity of forming soaps of oil. Tomato seed oil shows a relatively high saponification value of 195 mg-KOH/g.

The iodine value (IV) is the amount of iodine (in grams) necessary to saturate 100 g of oil sample and is a measure of the amount of unsaturation in fats and oils [20]. The value of it is high (124 g/100 g) and that means that tomato seed oil has a high content of unsaturated fatty acids and this was also shown in the present study by determination of fatty acid composition using gas chromatography.

The peroxide value (PV) is a measure of the extent of oxidation of a fat or oil. The value indicates the quantity of oxidized substances, normally hydroperoxides that liberate iodine from potassium iodide under specified conditions [21]. The PV is expressed in milliequivalents of active oxygen per kg fat that level were measured in tomato seed oil was 15 mmol/kg oil [4,11,13,17]. Oxidation of fatty acids might be causing the formation of hydroperoxides. Many of the vegetable oils contain

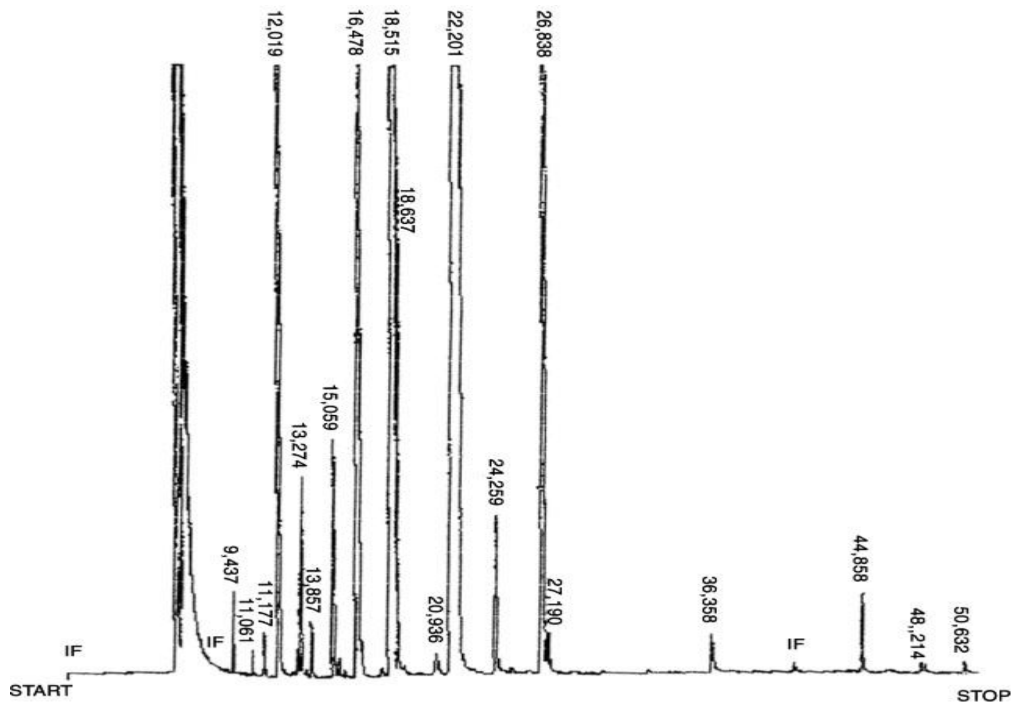

Figure 1: GC chromatogram of tomato seed oil.

Fatty acid	wt%
Myristic (C14:0)	0.1
Palmitic (C16:0)	12.26
Palmitoleic (C16:1)	0.08
Heptadecanoic (C17:0)	0.1
Heptadecenoic (C17:1-9c)	0.04
Stearic (C18:0)	5.15
Arachidic (C20:0)	0.41
Oleic (C18:1-9c)	22.17
Linoleic (C18:2-9c,12c)	56.12
Linolenic (C18:3-9c,12c,15c)	2.77
Ecosenoic (C20:1-10c)	0.12
Eladic (C18:1-9t)	0.03
C18:2 (C9t,12t)	0.08
C18:3(C9t,12t,15t)	0.04
Behinic (C22:0)	0.09
Lignoceric (C24:0)	0.08

Table 1: Fatty acid profile.

Vegetable oil	Density (Kg/m^3)	Sulphur (wt%)	Saponification value (mg-KOH/g)	Iodin number (1 g/100 g oil)	Ash (%)
Com	0.9095	0.01	187-195	122.6	0.01
Cottonseed	0.9148	0.01	189-198	105.7	0.01
Peanut	0.9026	0.01	187-196	101	0.005
Rapeseed	0.9115	0.01	168-181	130	0.054
Sesame	0.9133	0.01	187-195	106.6	<0.01
Soya bean	0.9138	0.01	189-195	112.5	<0.01
Sunflower	0.9161	0.01	188-194	125.5	<0.01
Tomato seed oil	0.9151	0.004	195	124	0.034

Table 2: Properties of tomato oil and other vegetable oils.

polyunsaturated fatty acid chains and their double bonds are very reactive. Abstraction of a proton from neighbouring polyunsaturated fatty acids produces a lipid hydroperoxide (LOOH) and regeneration of a carbon-centered lipid radical, thereby propagating the radical reaction.

Ash content is important to determine the concentration of heavy metals and expresses the degree of impurification [4,9,11]. Tomato seed oil exists in the low sulphur content (0.004wt %) or sulphur free compared with corn (0.01%), cottonseed (0.01%) and other vegetable oils so it was suitable for edible consumption. In a general manner, ash content of tomato oil is very low. The evaluated values for density are in line with those reported by other scholars [2-4,9,11,13,14,].

The levels and values found for the most important physico-chemical indicators of tomato seed oil were in agreement with other authors [4,13-17,19].

Conclusion

The present work indicates that tomato seed wastes were a potential source of edible oil. Tomato seeds by-product give a report nearly 10% of the fruit and 60% of the total tomato industry waste. The oil yield of tomato seeds was about 35% on a dry weight basis. Tomato seed oil contains a healthy mixture of fatty acids saturated and unsaturated. The result showed that palmitic acid (12.26%) was the major saturated fatty acid, followed by stearic acid (5.15%) in tomato seed samples. Linoleic acid (56.12%) was the major unsaturated fatty acid followed by oleic acid (22.17%). The study shows that tomato seed oil is an excellent source of essential fatty acids such as linoleic acid and oleic acid. The fatty acid profile plays an important role to the chemical properties therefore, this is useful knowledge for further researches.

Physico-chemical properties of triglyceride and its applications depend upon fatty acid constituents in molecule and are very important in the determination of the composition of tomato seed oil. The levels and values of the parameters that were determinate showed that this oil is rich in unsaturated fatty acids. The high value of total fat substance, low value of ash and sulphur content shows that tomato seed oil is an oil with superior quality and a very low degree of impurification. Other investigations show that tomato seed oil can be used as renewable energy source and a potential feedstock for the substitution of diesel fuel [19,21] because tomato seed oil exhibit low sulphur and ash content, high density and high iodine value compared to diesel fuels.

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