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Ultrasonic Assisted Optimal Oil Extraction of *Prunus Arminica* Seeds: An Approach towards the Production of Bioactive and Nutritional Oil

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Abstract

Bioactive and nutritional enrich *Prunus arminica* oil was extracted first time with ultrasonic assisted procedure. Process was optimized by central composite model based on independent variables :solvent seed ratio, sonic power and three levels. Time, temperature and particle size were the dependent variables. Actual and predicted yields differences <1, multiple regression 0.941 showed the adequacy of the model. The sonic power 300W and 10/1mL g^{-1} solvent seed ratio were found significant variables according to P value. The results of the yield 54.0%, dominancy of oleic acid, scanning microscopic images of seeds, IC_{50} value 25.1µg μL^{-1} and the inhibition against gram positive and negative microorganisms revealed the ultrasonic extraction technique more efficient compared to Soxhlet extraction with 51.73% yield and 27.4µg μL^{-1} IC_{50}. 10mL g^{-1} solvent, 300W sonication, 50°C and 30min makes the extraction cost effective and environment friendly and can step ahead to replace conventional methods for edible oils commercial production.

***Key words*:** *Prunus arminica*; composite model; ultrasonic assisted; scanning electron Microscope; yield.

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1. Introduction

Ever growing demand of edible oil and the formation of undesired compounds on the cost of essential components during the extraction processes have urged the researchers to explore low temperature, pressure and solvent free extraction techniques, importantly: cost effective, advanced and environmentally benign [1-4]. Recently, the 182 million metric tons oils produced yearly from the major oil-bearing seeds crops namely olive, palm, corn, soybean, rape, canola and sunflower, but the raise in demand due to over paced growth of population makes the situation alarming especially for the developing countries of Asian pacific region because of their tremendous demand for edible oils as food [5]. Further, the supplies of the edible oils are decreased day by day due to the utilization of edible oils as the bio fuel production in the advanced countries [6]. Unfortunately, the limited modern resources of farming, seeds quality, restrictions of soil nature, ripening time duration and free space of cultivation in developing countries are the main barriers to increase the main crop production for edible oils. Moreover, the reluctance to use of the commercial extraction plants for oil production from non- conventional oil-bearing seeds, as well as the shortcomings of the extraction processes like control of extracting parameters (adjustable), selection of organic solvent, seeds handlings prior extraction) in already existed extraction units are the barrier to utilize the non-conventional oil-bearing crops for oil production. However, the long extracting time at high temperature with organic solvents on conventional Soxhlet extracting plants is against the environmental safety regulations and the reason to increase the public health risk factor[7]. Therefore, introducing the new extraction techniques is necessitating the oil industry to consider alternative of Soxhlet extraction. Some of the extraction techniques like supercritical extraction with carbon dioxide (SC-CO_2) is already used for extracting components as well as the oil but majority of SC-CO_2 extraction based published work has focussed on laboratory scale oil extraction rather on commercial grounds[8]. Moreover, the ethno pharmacology surveys on plants revealed the medicinal important components in plants along with oil which demand low heat, low pressure extraction procedures for extracting the essential components along with the oil[9]. So, it is not surprising to use the radiation techniques for extraction of the oil and other biocomponents of the plants because of cost effectiveness, short time of extraction and high efficiency.

Collection of agro waste material, selection of seeds having oil content, the evaluation and characterization of the extracted oil, and bioactive materials are other areas of interest to choose the seeds for edible oil production with the appropriate use of their meal as well to get rid the dumping excersie of the waste as the meal of conventional crops are in the used of some valuable food products [10-12]. In the last decade, most of the issues regarding selection of oil bearing seeds crops, characterization of their oils, traditional use of the oils has been addressed[13] but no solution has yet been presented regarding unanimously cost-effective extraction procedure for all the seeds.

Prunus genus is one amongst the 85 genera of *Rosaceae* family and is explored widely by the scientists regarding oil characterization and medicinal importance of the fruits[14]. *Arminica.L* known as apricot is well known *prunus* specie famous due to its delicious, juicy fruit. Despite of the pleasant taste, the fruit used as the treatment of nervous system disorder, fight against anemia, relieve constipation, prevent cancer whereas, the leaves in crude forms are the remedy for cough, asthema, bronchitis and fever. In Pakistan, the evergreen *P. arminica* fruit tree is the main fruit crop of all the provinces namely, Punjab, Gilgit Balitistan, Khyber

Pakhtoon Khan, Sindh and Blochistan and more than 80 % of this crop production consumed by the local food and beverage industries .Seeds of the fruit – the agro waste can be the potential option to the production of the oil. Furthermore, the production of the *P. arminica* can increase easily because the country soil and the climate are suitable for its growth and enough place is available at some province for crop further plantation. Nevertheless, apricot ripening time comes earlier than other summer fruit crops so provides enough time to the growers for the preparation of their land for next crops.

The main purpose of this study was the exploration of the *P. arminica* seeds as a commercial product – an edible grade *P. arminica* oil, using latest ultrasonic assisted extraction technology. Since ultrasonic extraction has not been introduced previously for the fixed oil extraction so, obligation is required to optimize the process and its comparison with the conventional technique (Soxhlet method). Full factorial central composite design has been employed with two factors and three levels for maximum apricot oil fraction. Efficacy of the extraction process is determined in term of oil characterization, fatty acid profiling of oil and its lipid classes, scanning electron microscopic images of extracted seeds, total phenolic content of the oil, antioxidant and antimicrobial activities of the extracted oil.

2. Experimental

2.1. Extraction of lipids

2.1.1. Soxhlet extraction

Fully grounded 25 g apricot seeds were extracted with 150 ml 2:1 v v^{-1} chloroform and methanol with Soxhlet apparatus on water bath. The extraction time was 6-8 hours. Filter the material and remove the excess solvent by means of rotary evaporator under vacuum. Rotary was used for this purpose. Extracted oil was then stored under inert atmosphere [15].

2.1.2. Ultrasonic extraction

Fine grounded 25 g *P. arminica* seeds with the extracting solvents put in the beakers for the sonication with Hielscher ultrasonic UP 400S.Sonic powers and solvent to seed ratios were the independent variables while other factors namely extraction time, extraction temperature, particle size and extracting solvent were the dependent variable in the present study. After 30 minutes the sonicated mixtures were centrifuged for 10 minutes at 4000 rpm with the help of centrifuge. Both Solid and liquid layers separated and treated separately. 10 mL extracting solvent added in solid layer and centrifuged for 10 minutes to get the complete oil content. All the liquid layers combined and put in rotary evaporator to get rid of excess solvent. Oil thus obtained stored in an inert atmosphere for further studies[15].

2.1.3. Design of experiments for Ultrasonic extraction (Optimization studies)

Taguchi method was employed as the advanced statistical technique for design the experiments (DOE) for optimization of ultrasonic assisted extraction of *P. arminica*. Nine experiments were designed with the variation

of two independent variable parameters (sonic power, solvent seed ratio) and their three levels in orthogonal array L9. Fine grounded 100 mesh sized of 25 g weight of *P. arminica* seeds were used for each experiment. The three levels of sonication power were 300, 200 and 100 W, while Solvent and seed ratio kept 10 mL g^{-1}, 5 mL g^{-1} and 2.5 mL g^{-1} (table-1)

2.1.4. Statistical analysis

Statistica 7.0 software used for statistical analysis of the extraction yield of *P. arminica* seeds. General regression model applied for predicted and residual values. Tests of SS whole model vs ss residual showed the closeness of residual values with the observed values. Univariate test of significance and parameter estimate sigma restricted parameterization predicted the significance of the experiments.

2.2. Scanning electron microscopic (SEM) images of seed powder

To observe the change on the surface of seeds after extraction the oils with ultrasonic assisted extraction (UAE) and Soxhlet extraction (SE), the images were taken at the magnification power of 100 x. The meals were dried prior and Hitachi S3700N scanning electron microscope used for SEM images.

2.3. Chemical characterization of seed meal and oils (UAE and SE)

Arminica oil extracted by ultrasonic assistance method and Soxhlet technique were analysed physicochemically. AOCS methods were adopted to evaluate moisture, colour index refractive index, unsoponifiable matter, peroxide value, saponification value and free fatty acids[16]. Whereas, Protein, carbohydrate, ash and fibre determined from the defatted seeds (meal) by following the International Standard Organization testing methods [17].

2.4. Fatty acid profiles of P. arminica oils of UAE and SE procedures

Fatty acids methyl esters of ultrasonic extracted and Soxhlet extracted *P. arminica* oils with 2:1 v v^{-1} chloroform, methanol solvent was prepared by using BF3- metanol reagent used Hussain and his colleagues [18] and analysed by Gas chromatograph (shimadzu 14A) on FID (Flame Ionization Detector). The analysis conditions were set as 180^{o}C as initial temperature with 4 ^{o}C min^{-1} rise of column oven temperature and 215 ^{o}C fixed as the final temperature. Injector and detector temperature were set at 255 ^{o}C and 285 ^{o}C respectively. The freshly prepared 0.1 µL methyl esters of the oils and the standards were injected in capillary column (25 m length, width of 0.22 mm (i.d.) and internally coated with CBP 20, Polyethylene glycol). Helium gas with flow rate of 2.5 mL min^{-1} used as carrier gas. Peaks of methyl esters of each fatty acids with different retention times correspondent to their respective standards were recorded on chromatopac CR4A – Shimadzu.

2.5. Antimicrobial activity

Agar disc diffusion method employed for the determination of antimicrobial activity of the extracted oils and their extracted fatty acids [19]. Streptomycin; a broad-spectrum synthetic antibiotic used as the control. The

inhibition power of microbial activity of oils were examined against selected micro-organisms.

Microbial activity examined after 24 hours for clear zone of inhibition. The zones were measured in mm after using zone reader.

2.6. DPPH Scavenging Assay

DPPH assay were performed as described by Brand William method. The scavenging activity of antioxidant compounds present in the oils were measured by taking 0.006% DPPH solution in hexane. UAE and SE extracted apricot oils (12 µg μL^{-1} – 60 µg μL^{-1}) were used for the antioxidant assays. A potent synthetic antioxidant (α-D-tocopherol) with the concentration of 0.077 - 0.20 µg μL^{-1} were used as the reference values. Absorbance of colour complex formed after vortexed the DPPH and oil after incubation of 30 minutes in dark at 517 nm indicated the inhibition value of oxidation. Control was run parallel to nullify the effect of the solvent. The %age of radical scavenging activity was calculated using the following equation

DPPH Scavenging affect (%) = (abs. of control at 30 min/abs. of sample at 30 min)] x 100

2.7. Total Phenolic Contents

Folin Ciocalteu reagent used to determine the total phenolic content in *P. arminica* oils extracted by UAE and SE. 1.0 g oils and 1.25 mL Folin – Ciocalteu reagent used for the analysis. The mixture was diluted further with 20.0 mL deionized water and left for 10 minutes. Mixture was further incubated at 40 ^{o}C for 20 minutes after the addition of 20 % aqueous sodium carbonate (w v^{-1} 3.75 mL). The colour complex was developed and its absorbance were measured at 755 nm on spectrophotometer. Gallic acid used for standard curve to evaluate the total phenolic contents.

3. Result and Discussion

3.1. Extraction of oil and process optimization

The *P. arminica* seeds of Gilgit (Pakistan) region were selected to study the extraction efficiency of two different extraction procedures (UAE and SE) with respect to yield analysis and the bioactivity of the extracted lipid. For optimal conditions of UAE studies an orthogonal array design (OAD) with two independent and three dependent variables was developed. As the technique behind the extraction is the mass transport phenomenon so extracting temperature, time and solvent were dependent variables and their selection based on the previous work[20]. Solvent concentration and intensity can play a significant role in the extraction of the oil as well as the functional components of the oil, so these are the independent variables in the present study. Table-1 shows all the experimental runs their observed, predicted and residual values. The minute differences between experimental based observed and statistical analysis based predicted values showed the fitness adequacy of the selected model. The studied independent variables were three levelled sonic power and solvent to seed ratios. Seed particle size, extraction temperature and extraction time were the dependent variables. These variables were used by most of the researchers in their studies[15].

Table 1: Observed and predicted oil yields(%),residual values of Prunus Arminica seeds as designed of experiments with different sonic power(W) and solvent seed ratio (mL g^{-1})

Sr No	Sonic Power (variable 1)	Solvent to seed ratio (variable2)	Observed experimental values	Predicted values	Residual values
1	300	10/1	54.0	53.60	0.39
2	300	5/1	45.3	44.61	0.688
3	300	2.5/1	35.7	40.11	-4.41
4	200	10/1	45.0	44.61	0.688
5	200	5/1	38.60	34.17	0.688
6	200	2.5/1	30.1	29.68	0.41
7	100	10/1	28.9	32.74	-3.84
8	100	5/1	23.5	23.7	-0.2
9	100	2.5/1	20.0	19.24	0.75

The highest oil yield was 54.0 % with UAE technique and obtained under the optimal conditions of 100-micron mesh sized seeds with 300W sonic power. The solvent seed ratio was 10:1 mL g^{-1}. The UAE oil yield of apricot seeds was 2.27 % higher than that of conventional extraction technique; Soxhlet extraction under standard procedure and method (AOCS method). The increase in yield with UAE was reported by previous worker while comparing the extraction methods [1,2].

The huge difference in extraction time (30 minutes for UAE and 6 hours for SE) made the UAE more feasible for commercial oil extraction of oil bearing seeds.

The results of ANOVA (analysis of variance), goodness of fit and adequacy of the model were summarized in table -2. The P and F values presented in the table showed the effectiveness of selected independent variables for maximum oil yield of *P. arminica* .

Table 2: Univariate tests of significance for oil yield

Effect	SS	Degree of freedom	MS	F	P
Intercept	15.9717	1	15.9717	1.63677	0.248016
Sonic power	653.12	1	653.12	66.93	0.000180
Solvent seed ratio	283.20	1	283.20	29.02	0.001684

The estimated regression coefficient presented in table -3 made the model statistically acceptable at P value 0.000204 and F value 47.97673 and adequate with significant multiple and adjusted R values.

he results presented in table-3 showed that more than 90 % yield variation attributed by the independent variable with statistically significant P value ($P < 0.05$).

Table 3: Test of SS whole model vs SS residual

Dependent variable	Multiple R^a	Multiple R^2	Adjusted R^2	SS Model	Df Model	Ms model	SS residual	Df residual	Ms residual	F value	P value
Yield	0.97	0.94	0.921533	936.32	2	468.16	58.54	6	9.758	47.97	0.000204

[a] Regression

The R, R^2 and adjusted R^2values of the model were 0.97, 0.94 and 0.92 whereas F value was 47.97 and P value 0.000204.

3.2. SEM Images of Seed Meal

Visual observations of the surfaces by SEM images of extracted seed powder also supported the effectiveness of the lipid extraction. The surfaces of ultrasonic extracted and Soxhlet technique extracted seeds powder at the magnification power of 100x shown in figure1 & 2. The difference of the surface appearance was showed the goodness of ultrasonic extraction procedures. Images showed bigger surface area of UAE seed powder which might be the reason of acceleration of the removal of more oil as compared to SE. Observations was well in accordance to the previous work [1].

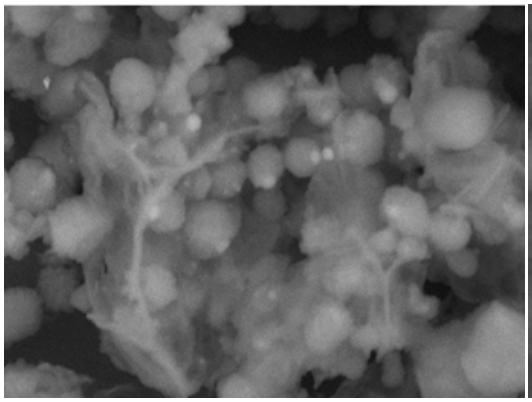

Figure 1: The SEM image of SE *P.arminica* seed powder at magnification factor of 100 X

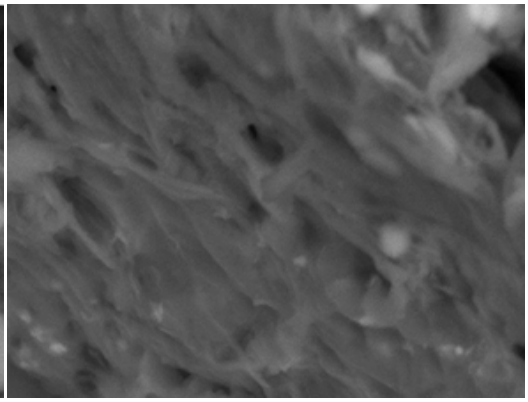

Figure 2: The SEM image of UAE *P.arminica* seed powder at magnification factor of 100 X

3.3. Chemical characterization of oils

The quality of the extracted oil is the prime objective of the present work, so the characterization of both procedures extracted oils were done by means of physical parameters (colour, refractive index) as well as chemical parameters. The analysis of the oils regarding iodine values, unsaponifiable matter, saponification value, free fatty acids, acid value and peroxide value revealed the effectiveness of the ultrasonic extraction. The

calculated values summarized in table - 4 showed that extracted oils can be used for edible purpose as the values are well accordance to previous work[20-22] and fall within range of conventional cooking oil reported earlier studies [23]. So, *P. arminica* oil source can be the new addition in the field of edible oil and fat. Amongst the two extraction procedures UAE results of physico-chemical parameters showed less degradation of oil evidenced from the less numeric value of free fatty acids and low oxidation value (Peroxide value). Furthermore, other values like unsaponifiable matter, colour index, moisture content and acid value made the ultrasonic extraction procedure hustle free from extra refining process.

Table 4: Physical and chemical characteristics of *P. arminica* oils

Parameters	Soxhelt Extracted (SE) Oil	Ultrasonic Extracted (UAE) Oil
Refractive index at 40°C	1.4726	1.4720
Colour index Lovibond scale in 1" cell	Y=1.8, R=0.2	Y=1.2, R=0.1
Moisture content %age	0.25	0.09
Unsaponifiable matter %age	0.35	0.20
Free fatty acid (as oleic acid %age)	2.3	0.7
Saponification value	189	194
Acid value	4.6	1.4
Iodine Value wiji solution	98	103
Peroxide value	3.98	2.7
Neutral lipids % age	96.5	97.3
Polar lipids% age	3.5	2.7

Currently, the leftover material after the oil extraction (seed meal) used as the fuel by the local population but present study on seed meal explored the hidden potential of the meal. The results of meal approximate analysis showed the enrichment of micro and macro nutrients which make the meal commercially important as a feed for animals and the source for food grade nutrients as well. Varying the extraction methodology brought the changes in values of the observing parameters. The ultrasonic procedure meal of *P. arminica* contained 7.30 % fibre, 1.10 % ash , 16.30 % protein and 20.21 % carbohydrate whereas, SE meal contained 6.98 % fibre, 2.65 % ash, 21.61 % protein and 17.39 % carbohydrate. The minerals contents of UAE meal showed the goodness of UAE technique as compared to SE on basis of the values obtained by the AAS (Atomic absorption spectrophotometer). The main minerals of UAE in mg $100g^{-1}$ were found copper1.0, iron 1.1, calcium 17.4, magnesium 136, zinc1.4, phosphorus 487, potassium 669 and nickel 0.01 whereas, SE showed 1.3, 0.7, 17.9, 135, 1.5, 378, 687 and 0.07 respectively. The reason might be the temperature difference because most of the micro nutrients showed the sensitivity at elevated and prolong heating time.

3.4. Fatty acid composition of oils by GC

As dietary fat and fat containing foods are the main source of the essential fatty acids due to lacking the ability to synthesize these essential fatty acids in the body [24]. These acids not only important to maintain the hormonal balance in the body but also essential to regulate the main functions of the body [25]. Many scientists

correlate the concentration of the fatty acids of the dietary fat directly with human diseases [26]. So, the extraction procedure plays the vital role in profiling of the fatty acids. Oleic acid found the main unsaturated acid in the oils extracted by the UAE and SE followed by the linoleic acid. UAE extracted oil showed 10.633 % saturated fatty acids and 88.659 % unsaturated fatty acids, amongst them 27.181 % were polyunsaturated and 61.478 % monounsaturated fatty acids. Whereas, SE oil contained 12.672 % saturated, 25.808 % polyunsaturated and 60.238 % monounsaturated fatty acids. The values of individual fatty acids as well as the ratio of saturated and unsaturated fatty acids revealed the ultrasonic method ideal and health promoting according to conclusions of the clinical studies made on the fatty acids profile [27,28]. The table -5 showed the fatty acid profile of SE and UAE.

Table 5: Fatty acid profile of Soxhlet and ultrasonic assisted extracted P.arminica oil

Oil Description	Fatty Acids	RT Time	Peak Height	%age of Total
SE	Lauric acid	14.017	1751	1.13
	Myristic acid	14.378	1051	1.179
	Palmitic acid	15.873	53057	7.932
	Palmitoleic acid	15.901	105	0.013
	Stearic acid	20.130	1328	2.12
	Oleic acid	20.245	505282	59.401
	Linoleic acid	20.451	180716	25.088
	Linolenic acid	21.612	10230	0.72
	Ecosenoic acid	24.124	226	0.837
UAE	Lauric acid	14.109	487	0.723
	Myristic acid	14.732	1029	1.08
	Palmitic acid	15.874	102916	7.730
	Palmitoleic acid	15.894	130	0.0104
	Stearic acid	20.108	530	1.10
	Oleic acid	20.258	1280811	61.385
	Linoleic acid	20.45	436019	26.701
	Linolenic acid	21.03	102	0.48
	Ecosenoic acid	24.119	295	0.093

3.5. Antimicrobial activity of oils

Both procedures (UAE and SE) extracted oils did not show any microbial activity against selected gram positive (*Staphylococcus aureus*, *Bacillus subtilis*) and gram negative (*Escherichia coli*, *Salmonella enterica* and *Enterobacter aerogenas*) microorganisms but their fatty acids (Free) showed inhibition against selected

microorganisms. The inhibition power of the fatty acids showed variation, and this might be due to the difference in extraction techniques. The inhibition results of control, both procedures extracted fatty acids and their efficacy grading with respect to the control were mentioned in table-6

Table 6: Antimicrobial activity of *P. arminica* oils against selected microorganisms.

Material under study	Tested organism	Colony morphology	Incubation temperature °C	*Culture media oxide[i]	Inhibition zone at 24 hr of material (mm)	Inhibition zone at 24 hr of control (mm)	Efficacy grade with relevant to control
Fatty acid of SE oil	*S.Aureus*	Gram+ve cocci	37	CM 145	8 mm	15 mm	Intermediate
	B. Subtilis	Gram+ve rods	-	CM 271	10 mm	17 mm	-
	E. Coli	Gram–ve rods	-	CM 69	-	21 mm	absent
	S.Enterica	-	-	CM 201	10 mm	20 mm	Intermediate
	E. Aerogenas	-	-	CM 7	11 mm	17 mm	-
Fatty acid of UAE oil	*S.Aureus*	Gram+ve cocci	37	CM 145	12 mm	15 mm	Intermediate
	B. Subtilis	Gram+ve rods	-	CM 271	13 mm	17 mm	Sensitive
	E. Coli	Gram–ve rods	-	CM 69	17 mm	21 mm	-
	S.Enterica	-	-	CM 201	13 mm	20 mm	-
	E. Aerogenas		-	CM 7	10 mm	17 mm	Intermediate

*CM145 = Staph 110 medium, CM 27 = Blood ager base, CM 69 = Eosin methylene blue ,CM 201 = Bismith sulphite ager, CM = MacCon key's ager

The results of table-6 showed the good and positive activities of liberated fatty acids of those of extracted oils using acid hydrolysis methodology against microorganisms but the oil itself did not show any activity .The diversification of the behaviour of oil and its own fatty acids are in accordance to the previous work [29] . No much clue was found in literature about this behaviour, but the values of the ongoing study strengthened the ideas of former researchers that resistance against the microorganisms dependent on the unsaturation of fatty acids and the nature of extracting solvents[30].

3.6. Antioxidant activity of oils

The antiradical activities of the oil mainly attributed to the phenolic compounds[31], so total phenolic content was assessed prior to evaluate the antioxidant activity of both procedures extracted oils. Folin- ciocalean method due to the reliability and reproducibility was used to ensure the phenolic content in the oil[32]. The measured intensity of blue colour formed due to the transfer of electrons from the extracted oil to folin- ciocalean alkaline reagent showed 2.98 mg gallic acid equivalent (GAE) to 100 g SE armerica oil, whereas 100g UAE armerica oil showed 3.05 mg GAE. Previous workers reported different values of total phenolic contents (TPC) in their studies on arminica oil (Erdugan, and his colleagues *Sultana Bushra*). Ongoing comparative study of two

different techniques revealed the fact why the previous reported values showed deviations. The antioxidant of SE and UAE apricort oil was determined by DPPH free radical assay. α- D-tocophenol used as a control. The figure-3 showed the ability of scavenge the oxygen increased with the increase in the concentration of oil.

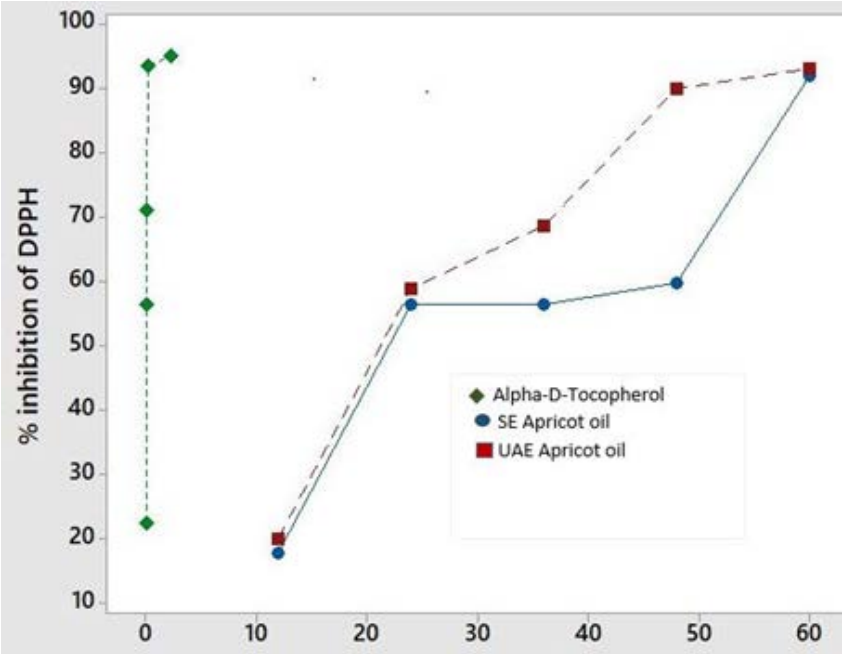

Figure 3: DPPH Radical Scavenging Activity of Fixed Oil of Arminica Seeds Extracted using Soxhlet, Ultrasonic technique and α-D-tocopherol.

Concentration of the oil in µg µL^{-1}

IC_{50} calculated of oils as well as the control (α- D-tocopherol). IC_{50} for SE oil was 27.4 µg µL^{-1} whereas, 25.1 µg µL^{-1} was calculated for UAE. Although, these values did not have any match with IC_{50} value of alpha -D-tocopherol (0.109 µg µL^{-1}) a potent antioxidant.

But the presence of antioxidant properties in the oils made the worth of the oil as an essential bioactive enrich oil and a protective significant agent against lethal diseases like cancer, atherosclerosis, diabetes, cerebrovascular disorder and inhibitor of initiation, promotion and progression stages of different chronic diseases[33,34]. Amongst both extraction technique UAE found good candidate for enriched antioxidant agent.

4. Conclusion

Ultrasonic technique at optimal conditions (300 W sonic power and 10 mL g^{-1}) was found excellent to release the lipid content from the *Arminica* seeds in comparison to Soxhlet extraction procedure.

The UAE procedure was simple and gave high yield (54 %) at low temperature (50 °C) in short time (30 mins) with no change in oil constituents (value Refractive index). The good performance to scavenge the free radical (DPPH H^{+}), inhabitation characteristic against growth of experimental microorganisms (gram positive and gram

negative) and retainment of essential fatty acids made UAE technique more effective for the production of nutritional enrich oil fit for human consumption as well as for value addition of cosmetic products.

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