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Full Length Article

The Impact of Gamma Radiation on Crude Oil Yield and Chemical Composition of *Simmondsia chinensis* (Jojoba)-Arizona A42 Seeds

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Abstract

This study was carried out to investigate the physiological effects of gamma radiation on Jojoba (*Simmondsia chinensis*) Arizona A42 variety seeds. The seeds were irradiated with doses of 0 (control), 100, 200, 300, 400 and 500 Gy gamma radiation using cesium (Cs^{137}) source. After irradiation; crude oil yield, antimicrobial activity and chemical composition were determined. Extraction of the seeds was done with soxhlet apparatus using petroleum ether. The result showed that the highest crude oil yield was obtained from 500 Gy. Compared to reference antibiotics, seed extracts applied with 500 Gy of the *S.chinensis*-Arizona A42 had a strong antibacterial activities against the *Escherichia coli* ATCC 25922 and *P. aeruginosa* ATCC 27853. Gamma radiation had no significant effect on oil composition of *S. chinensis*-Arizona A42 seed extracts. The chemical composition of the all extracts elucidated presence of average in major oleic acid (65%) and linoliec acid (15%) at 500 Gy, respectively.

Keywords: Gamma Rays; Jojoba (*Simmondsia chinensis);* Oil yield; Chemical composition

Introduction

Simmondsia chinensis, known as jojoba, is the unique species in the Simmonsiaceae family (Mills *et al*., 1997). Jojoba is an important plant with a long-lived (100–200 years) and drought-enduring plant. Jojoba plants improve air quality and prevent soil erosion and is a renewable energy resource.

Jojoba is used by many people for medicinal purposes for cold, cancer, parturition and skin diseases (Bloomfield and Bernardi, 1985; Ranzato *et al*., 2011). The Jojoba oil from its seeds can be used in cooking, as fuel for tank, automobiles and planes and in treatment for several diseases such as cancer, kidney disorders, hair loss, skin protection against sun and wind and in addition to oil from seeds in various industrial areas such as drug industry, cosmetic and fuel industry are huge (Leoni *et al*., 1988).

Radiation are used on plants in developing varieties with high productivity potential (Jain *et al.*, 1998). Seed irridation is one of the most effective methods to improve plant production, yield components and chemical composition (Selenia and Stepanenko, 1979). Some studies have investigated the effects of gamma radiation on plants, including changes at the morphological, physiological and biochemical levels. These effects include changes in the plant photosynthetic pigments, composition of chemical, cellular structure and crude oil yield (Wi *et al.*, 2005).

In the present study, *S. chinensis* Arizona A42 seeds were exposed to the effects of gamma radiation on crude oil yield, antimicrobial activity and chemical composition. Furthermore, *in vitro* antimicrobial activity depend on radiation of *S. chinensis* Arizona A42 has not been reported earlier. In this study, our result will provide a starting point for discovering effects of gamma radiation on antibacterial activity in seeds of *S. chinensis*.

Materials And Methods

Plant Materials

The original Jojoba seeds were brought from Arizona, USA, in 1991 and transplanted to Sarıcasu town, Kumluca, Turkey in 1994. The jojoba seeds variety of Arizona A42 were used for experiments. The seeds of *S. chinensis*-Arizona A42 were collected Sarıcasu town, Kumluca in 2013. Kumluca is located 102 km to the west of Antalya 10 km from the editerranean Sea and at an altitude of 55 m. The irradiated and un-irradiated seeds in sealed bags were stored at room temperature without exposure to direct sunlight.

Gamma Radiation

The different radiation doses (0, 100, 200, 300, 400 and 500 Gy) were applied to the jojoba seeds. Irradiation was

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performed in a cesium (Cs^{137}) Gammacell 3000 Elan source, dose rate ~9.75 Gy/min (2900 Ci) at the Pamukkale University Faculty of Medicine in the Department of the Radiology. Irradiated and non-irradiated samples were stored at room temperature. Non-irradiated samples served as control.

Crude Oil Yield

After gamma radiation application, about 4 g of crushed seeds were extracted to Soxhlet apparatus using petroleum ether as solvent. The extraction was executed for 6 h with 250 mL of solvent. The extracts were concentrated and the solvent was then evaporated. The extracted oil yield was calculated as percentage, which is defined as weight of oil extracted over weight of the sample taken (Sabzalian *et al*., 2008).

Statistical Analysis

The experimental data were subjected to analysis of variance (ANOVA) using the software SAS (Inc. Chicago.IL., USA, 1988) for Windows. Significant differences between a values were calculated using Duncan's Multiple Range test ($P<0.05$).

Antimicrobial Activity

Mueller Hinton Agar (Oxoid) for bacteria were used as medium. *Micrococcus luteus* NCIMB 13267, *Stapyhlococcus aureus* ATCC 25923, *Escherichia coli* ATCC 25922 and *Pseudomonas aeruginosa* ATCC 27853 were used as strains. The strains of ATCC coded were obtained from American Type Culture Collection and the strain of NRRL coded was obtained from Northern Regional Research Laboratory. The antimicrobial effect of all extracts were assayed by the standard disc diffusion method (Collins, 1995). Ten µL of extract (25 mg/100 mL) were injected sterile discs (Schleicher and Schuell). Antimicrobial activity was calculated by measuring the zone of inhibition. Discs of petroleum ether (Merck) were used as negative controls. Discs of antibiotics were used as positive controls.

Determination of Fatty Acid Composition

The oil of *S. chinensis* Arizona-A42 seeds were analyzed by GS-MS. GS-MS analyses were carried out on an Agilent 7890 A GS-MS equipped with a HP-88 silica column (100 m × 0.250 mm i.d., film thickness 0.20 µm); oven temperature was held at 60ºC for 1 min. Then programmed to 175ºC at 13ºC and programmed their temperature to 215ºC at 4ºC/min (Bardakçı and Canbay, 2011). The percentage oil composition of the extracts was determined with MSDChem computer program.

Results

Crude Oil Yield

The effects of gamma radiation on crude oil yield of *S. chinensis* Arizona-A42 seeds. Showed that highest crude oil yield was recorded in the 500 Gy. The crude oil yields of *S.chinensis* Arizona-A42 were determined between 27.56 and 46.84% compared to control (Fig. 1).

Antimicrobial Activity

Antimicrobial activity of *S. chinensis* Arizona-A42 seed extracts was determined two Gr(+) and two Gr(-) bacteria (Table 1). Compared to reference antibiotics, extracts of the *S. chinensis* Arizona-A42 showed significant antibacterial activities against the *P. aeruginosa ATCC 27853.*

Fatty Acid Composition

Fifteen components of the extract were obtained by soxhlet extraction and detected by using GC-MS analytical methods. It was determined that, oleic acid (C18:1n9) and linoliec acid (C18:2n6) were the major compounds with average 61% and 18%, respectively (Table 2).

The percentage of fatty acids in *S. chinensis*-Arizona A42 extract changed in oleic acid at 500 Gy and the highest oleic acid was obtained in 500 Gy gamma irradiation with 65.12%. Oleic acid and cis 11,14-eicosadienoic acid were raised with increasing in gamma irradition. Conversely, linoliec acid, g-linolenic acid and stearic acid were decreased with increasing in gamma irradition.

Discussion

The effects of gamma radiation on some properties of many plants and seeds were investigated by researchers (Mahmoud, 2002; Wi *et al*., 2005; Rahimi and Bahrani, 2011). In our study, the crude oil yield of *S. chinensis* Arizona-A42 seeds was affected by gamma rays in a significantly positive way. Gamma rays belong to interact molecules and atoms to produce free radicals in cells. These free radicals can damage or modify important ingredients of plant cells. These components can effect the physiology and biochemistry of plants depending on the radiation level. These effects include changes in the plant metabolism and cellular structure (Rahimi and Bahrani, 2011).

Mahmoud (2002) reported an increase in sugar and carbohydrates in response to seed irradiation. In this study, the stimulation of oil yield may be due to radiation of highest doses of gamma rays on carbohydrates and sugar metobolism of *S. chinensis* Arizona-A42 seeds. Our results are supported that an increase in oil production by gamma radiation in several plant species (Youssef *et al*., 2000).

Table 1: Antimicrobial activity of *S. chinensis* Arizona-A42 extracts

Extracts		Inhibition zone diameter (mm)			
		Microorganisms			
		Gr (+)		Gr(-)	
	Concentrations (µL/disc)	*M. luteus* NRLL B-4375	*S. aureus* ATCC 25923	*E. coli* ATCC 25922	*P. aeruginosa* ATCC 27853
S. chinensis Arizona-A42 extract control	10 µL	8	11	-	-
S. chinensis Arizona-A42 extract applied 100 Gy	10 µL	8	12	8	9
S. chinensis Arizona-A42 extract applied 200 Gy	10 µL	9	12	8	9
S. chinensis Arizona-A42 extract applied 300 Gy	10 µL	10	13	10	13
S. chinensis Arizona-A42 extract applied 400 Gy	10 µL	10	13	12	13
S. chinensis Arizona-A42 extract applied 500 Gy	10 µL	11	15	15	16
References Antibiotics					
Ampicillin	10 µg	28	NT	21	NT
Penicilin	10 U	29	30	18	NT
Oxacillin	1 µg	20	19	NT	NT
Gentamicin	10 µg	NT	NT	NT	15

NT: Not tested

Table 2: Chemical compositions of *S. chinensis* Arizona-A42 extracts in GC-MS methods

		Compound	Structure	Rt	C (%)	E1 (%)	E2 (%)	E3 (%)	E4 (%)	E5 (%)
Saturated fatty acids	1	Lauric acid ME*	(C12:0)	27,3	-	-	-	-	-	-
	2	Myristic Acid ME*	(C14:0)	30,4	0,10	0,10	0,10	0,09	0,09	0,09
	3	Palmitic acid ME*	(C16:0)	34,5	12,38	12,30	12,34	12,95	13,18	12,34
	4	Heptadecanoic (Margaric) acid ME*	(C17:0)	36,5	0,12	0,12	0,11	0,10	0,09	0,10
	5	Stearic Acid ME*	(C18:0)	39,1	4,19	4,02	3,96	3,88	3,62	3,64
	6	Arachidic Acid ME*	(C20:0)	43,3	0,90	0,91	0,90	0,90	0,86	0,93
	7	Pentadecanoic (Pentadecyclic) Acid ME*	(C15:0)	32,3	-	-	-	-	-	-
Unsaturated fatty acids	8	Myristoleic Acid ME*	(C14:1)	31,8	-	-	-	-	-	-
	9	Palmitoleic acid ME*	(C16:1)	35,5	0,07	0,07	0,06	0,06	0,06	0,07
	10	Oleic acid ME*	(C18:1n9)	40,3	61,16	61,11	61,10	61,02	61,67	65,12
	11	cis-11eicosenoic acid ME*	(C20:1)	44,9	0,44	0,44	0,42	0,41	0,65	0,46
	12	Linoliec Acid ME*	(C18:2n6)	42,1	19,37	19,11	19,04	18,90	18,54	15,88
	13	g-linolenic acid ME*	(C18:3n6)	44,2	0,11	0,10	0,09	0,09	0,08	0,06
	14	cis 11,14-eicosadienoic acid ME*	(C20:2)	48,3	0,70	0,69	0,65	0,66	0,66	0,98
	15	EPA (Eicosapentaenoic acid) ME*	(C20:5n3)	53,3	-	-	-	-	-	-

ME:Methyl Ester, Rt: Retention time, C (%): Control extract (not irradiated), E1 (%): Applied 100 Gy dose extract, E2 (%): Applied 200 Gy dose extract, E3 (%): Applied 300 Gy dose extract, E4 (%): Applied 400 Gy dose extract, E5 (%): Applied 500 Gy dose extract

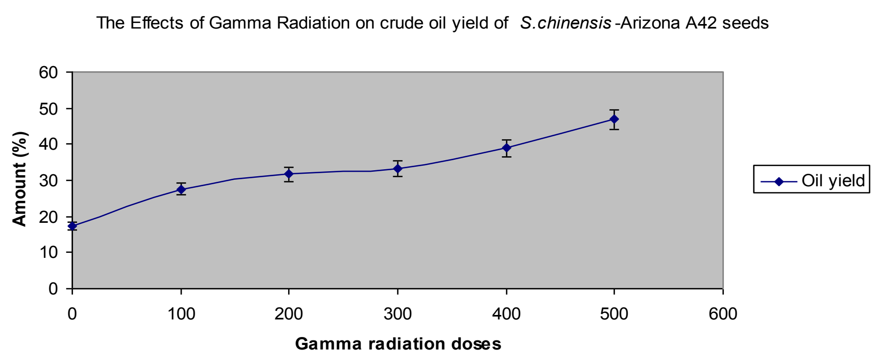

Fig. 1: The effects of gamma radiation on crude oil yield of *S. chinensis*-Arizona A42 seeds (Dry matter, %)
Differences are not significantly different (p> 0.05)

Jojoba seeds were used for medicinal purpose in many countries for decades. The literature reports showed many health benefits associated with the consumption of Jojoba seeds; for instance, cold, cancer, obesity, dysuria, and wounds (Yaron *et al.*, 1982; Bloomfield, 1985; Ranzato *et al.*, 2011). In our study, the extracts of the *S. chinensis* Arizona-A42 seeds showed significant antibacterial activities against the *P. aeruginosa* ATCC 27853 after gamma radiation application.

Jojoba is unique in terms of lipid characteristic of the seeds (45–55 wt%), is in the form of long-chain esters of FA (fatty acids) and alcohols (Weiss, 1971;

Elleuch *et al.,* 2007). The fatty acid element of jojoba oil primarily consists of eiconenoic, oleic and erucic acids with alcoholcomponent (Elleuch *et al.,* 2007).

The fatty acid combination was not markedly changed by irradiating of the 100 Gy dose. However, irradiating at 400 and 500 Gy significantly increased the percentage of oleic acid (C18:1n9), cis 11, 14-eicosadienoic acid (C20:2) and cis 11-eicosenoic acid (C20:1). These results indicate that irradiating seeds at higher dose excited decomposition of the polyunsaturated fatty acids. This was probably because, *S. chinensis* contains important antioxidant compounds such as tocopherols and carotenoids which can scavenge the radicals by gamma radiation (El-Shamy *et al.,* 2001; Ibrahim *et al.,* 2011).

Ionizing radiation might affect the quality of oils by increasing oxidation rate. Irradiation may also produce free radicals, which start chemical reactions that might also result in the rancidity of oil and fats (Victroria *et al.,* 1992). Irradiation of lipid increased the production of free radical which reacts with oxygen, leading to the formation of carbonyls, responsible for the food spoilage (Brito *et al.,* 2002).

Ionizing radiations affects the fatty acid combination of fats and the lipid peroxide synthesis as a result indicates that the peroxide value of fats and oils would increase with radiation (Handel and Nawar, 1981). A study on the effect of radiation with gamma radiation of 0.5, 1.0 and 1.5 kGy, on the lipids present in different plant nuts revealed that the lipid extracted from the seeds have peroxide, anisidine and free fatty acid values higher than in their non-irradiated samples (Sattar *et al.,* 1989).

Conclusion

Our results suggested that certain 500 Gy radiation doses positively effect crude oil yield and antimicrobial activity of *S. chinensis* Arizona-A42 variety seeds. Therefore, that gamma radiation can be used in both in increasing the oil yield and shelf life of seeds and field trials are suggested for further elucidation of effects of gamma radiation on seeds and their biological activities.

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