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CHEMICAL AND TECHNOLOGICAL STUDIES ON ROCKET (*Eruca sativa*) Seed Oil:

1- CHARACTERIZATION OF ROCKET (*Eruca sativa*) SEED OIL

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ABSTRACT

The present investigation was designed to study the physical and chemical properties of rocket seed oil. The obtained results indicated that rocket seed had high contents of protein (35.02%), oil (25.77%) and available carbohydrates (22.66%). Rocket seed oil had lower specific gravity, refractive index and saponification value than those of corn, sunflower and cottonseed oils. The iodine value of rocket seed oil was higher than those of corn, sunflower and cottonseed oils. The results cleared that, eleven saturated and unsaturated fatty acids were identified in rocket seed lipids, while ten only were identified in rocket seed triglycerides. Unsaturated fatty acids play an important role in rocket seed lipids (72.24%) and triglycerides (72.22%). Erucic acid was the major unsaturated fatty acid reached 46.58% and 40.11% in rocket seed lipids and triglycerides; respectively. Moderate quantities of oleic (13.19 and 22.71%) and linoleic acids (11.21 and 7.74%) were presented in rocket seed lipids and triglycerides; respectively. Arachidic acid is found to be the dominant saturated fatty acids in rocket seed lipids (21.56%) and triglycerides (15.92%). Palmitic acid was the second main saturated fatty acids in rocket seed lipids (4.83%) and triglycerides (8.59%). The individual rocket seed phospholipids fractions starting from the base line were phosphatidyl serine, lysophosphatidyl choline, phosphatidyl inositol, sphingolipids, phosphatidyl choline, phosphatidyl ethanol amine, phosphatidic acid and glycolipids.

INTRODUCTION

Taramira or Rocket (*Eruca sativa*) of the Cruciferae family, is grown in West Asia and Northern India as one of oil seed crop, because of its drought resistance. When crushed for oil, glucosinolates in the seeds are hydrolyzed by myrosinase, yielding isothiocyanates which make the oil pungent taste. The pungency of rocket seed oil is different from that of mustard oil and cake containing the unhydrolyzed glucosinolates is bitter (Kanya and Urs, 1989).

Rocket seeds contain 30–35% oil. The oil was used for edible purposes but it considered inferior to rapeseed oil for industrial purposes. The most important component of the vegetable oil is its fatty acids composition, which determines its quality for edible purposes (Harvey and Downey, 1963). Comparing with rapeseed and mustard oils, rocket seed oil is also, rich in erucic acid, which has been reported to cause harmful effects in animal, because of its possible relation with cardiac problems (Vles, 1974; Bhatia *et al.,* 1979 and Shenolikar and Tilak, 1980). Although much work has been done to improve the oil quality of *Brassica napus, Brassica campestris* and

Brassica juncea by lowering the amount of erucic acid to almost zero and enhancing the amount of linoleic acid (Kirk and Oram, 1981 and Downey, 1987), information on these aspects in rocket (*Eruca sativa* L.), which contains 35% oil is rather scanty (Yadava and Yadava, 1984).

Over 13.2% of the world's edible oil supply now come from the oilseed Brassica (*Cruciferae*), especially rapeseed and mustard. Indeed, production and using of Brassica seed oil has grown faster in the period 1975–1985 than any other oil crop, with the exception of palm oil, thus making it the third most important edible oil source after soybean and palm oils (Downey and Klassen, 1977).

Utilization of rapeseed and rocket seed oils as edible oils in Egypt are questionable because of its high content of harmful erucic acid. This oil can play a great role as substitute for different imported oils (Owon, 1991).

Low erucic acid content is desirable in edible products. If the rapeseeds or rocket seeds are used for the preparation of various industrial chemicals, the highest possible erucic acid content is required. Low erucic acid content increase the nutritional value of the rapeseed or rocket seed oils (Heneryk, 1990).

The average cultivated area of rocket plants in Egypt during year 2000 for all seasons were 3713 feddan, with an average production 28158 tons of leaves (Anon, 2001). The present work was designed to study the physical and chemical properties of rocket seed oil.

MATERIALS AND METHODS

Materials:

The materials used in this investigation were rocket (*Eruca sativa*) seeds (Balady variety). The seeds were obtained from Agricultural Research Center at Sakha (Kafr El-Sheikh, Egypt) at two seasons 2001 and 2002. The seeds were cleaned and stored at – 18 ^{0}C until used.

Methods:

Preparation of Rocket Seeds for Analysis:

Rocket seeds were ground directly before analysis in a Cycloteic Mill (cycloteic 10.93 sample Mill tecator Abbox 70, Hoganas, Sweden) until passed through a 50 mesh screen. The produced meals were stored at – 18 ^{0}C until using in the following experiments.

Gross Chemical Composition of Rocket Seeds:

Gross chemical composition of whole rocket seed and meal were analyzed. Moisture, ash, crude protein, ether extract and crude fibers were determined according to the methods of A. O. A. C. (1990).

Total carbohydrates were determined by phenol–sulphuric acid according to the method outlined by Dubois *et al*., (1956). The available carbohydrates were calculated by subtraction the percentage of crude fibers from the percentage of total carbohydrates content.

Extraction, Separation and Identification of Rocket Seed Lipids:

Total lipids of rocket seeds were extracted according to the method described by Folch *et al*., (1957). The total lipids fractions of rocket seeds were separated and identified using thin layer chromatography (TLC). Twenty µl per spot of total lipids was applied on the base line of silica gel GF 254 (0.5 mm) preparative thin-layer plate (20 x 25 cm).

The developing solvent system used was composed of petroleum ether: diethyl ether: acetic acid, 70: 30: 2, (v/v/v) as described by El- Sebaiy *et al*., (1984). The plate was dried and sprayed with the charring reagent which was 50 % sulphuric acid (Rouser *et al*., 1970).

R_f values for each fraction were calculated and each fraction was identified by comparison with the values present by El- Sebaiy *et al*., (1984)

Fractionation and Identification of Rocket Seed Phospholipids:

Rocket seed phospholipids were fractionated and identified in rocket seed lipids using thin layer chromatography (TLC) according to the methods outlined by Bunn *et al*., (1969) and modified by El- Sebaiy *et al*., (1980).

Assay of Physical and Chemical Properties of Rocket Seed Oil:

Some physical and chemical properties of rocket seed oil were determined. Those properties were also tested in corn and sunflower oils.

Physical and chemical Properties:

Specific gravity and refractive index were determined according to the A. O. A. C. (1990) methods.

Acid value (AV) and saponification value (SV) were determined according to the A. O. A. C. methods (1990). Peroxide value (PV) and iodine value were tested using the method outlined by Leonard *et al*., (1987).

Determination of Fatty Acids of Rocket Seed Oil:

Fatty acids composition of rocket seed fixed oil and triglycerides were determined by gas liquid chromatography (GLC) technique at Central Laboratory, Faculty of Agriculture, Alexandria University according to Radwam (1978) methods.

Fatty Acid Methyl Esters Analysis:

The fatty acid methyl esters were analyzed by GC Model Shimadzu – 4 CM (PFE) equipped with PID detector and glass column 2.5 m X 3 mm i.d under the following conditions:

Item	Description
Column	5 % DEGS on 80/ 100 Chromo Q.
Detector temperature	270 ^{0}C.
H_2 flow rate	75 ml /min.
Sensitivity	16 x 10^2.
Column temperature	180 ^{0}C isothermal.
N_2 flow rate	20 ml /min.
Air flow rate	0.5 ml /min.
Chart speed	2.5 ml /min.

RESULTS AND DISCUSSIONS

Gross Chemical Composition of Rocket Seeds and Meal:

The gross chemical composition of whole rocket seeds and meal (based on dry weight) are given in Table (1). The obtained results indicated that, moisture contents were 8.08 and 10.87%and the dry matters were 91.92 and 89.13%; respectively. High amounts of crude protein and ether extracts were found in whole seeds (35.02% and 25.77%; respectively). Available carbohydrates, ash and crude fiber contents of the examined whole seed were 22.66%, 8.97% and 7.58%; respectively. Extraction of oil from the seeds increased the meal constituents as follows: Protein content reached 43.77%, available carbohydrates (32.12%), crude fiber (12.45%), ash (8.58%) and ether extract (3.07%).

These results are in agreement with those reported by Flanders and Abdulkarim (1985) and Das *et al*., (2001) and Abdel Aal (2002). The percentage of ether extract (25.77%) was less than that reported by Kaushal *et al*., (1982) they found that oil content was ranged between 30 – 35% on dry weight and also lower than that published by Kanya and Urs (1989) which was 33.74% on dry weight. The differences in oil contents of the seeds may be due to date of sowing, variety, temperature, number of irrigations and days after flowering (DAF). The lipids of unirrigated seeds contained 18.50% oils, while applying of one, two and three irrigations resulted in increase of this percentage of oil to reach 25.50%, 29.30% and 33.40%; respectively. Also increases of days after flowering lead to increment in the oil percent in the seeds (Sukhija *et al*., 1976).

Table (1): Gross Chemical Composition of Rocket Seeds and Meal (on dry weight basis).

Constituents (%)	Whole Rocket Seed	Rocket Seed Meal
Moisture	8.08	10.87
Dry Matter	91.92	89.13
Crude Protein	35.02	43.77
Ether extract	25.77	3.07
Ash	8.97	8.58
Total Carbohydrates	30.24	44.58
Available Carbohydrate	22.66	32.12
Crude Fibers	7.58	12.45

*** The values are means of three determinations.**

Rocket Seed Oil:

Physical and Chemical Characteristics:

Some physical and chemical properties of the oil extracted from rocket seeds are presented in Table (2), compared with those measured of corn and sunflower oils; and cottonseed oil as published by Stevenson *et al.,* (1984).

Specific Gravity:

Specific gravity of rocket seed oil determined at 25 ^{0}C was shown in Table (2). It was lower (0.8960) than those of corn (0.9173), sunflower (0.9200) and cottonseed (0.9170) oils. Specific gravity of the examined oil is also, lower than that found by Flanders and Abdelkarim (1985) on rocket seed oil which was (0.0910) and also, lower than that reported by Abdel Aal (2002) which was ranged between 0.9090 to 0.9205 at 25 ^{0}C.

Refractive Index (RI):

Table (2) revealed that refractive index of rocket seed oil measured at 25 ^{0}C is lower (1.412) than those of corn, sunflower and cottonseed oils (1.465, 1.470 and 1.470; respectively). Flanders and Abdulkarim (1985) estimated the refractive index of rocket seed oil and they found that the value was 1.468 at 40 ^{0}C. Abdel Aal (2002) found that RI of rocket seed oil determined at 30 ^{0}C was ranged between 1.4712 to 1.4722.

Saponifcation Value (SV):

The saponification value (SV) of the rocket seed oil was 162.98 mg KOH/g as shown in Table (2), which was lower than those of corn, sunflower and cottonseed oils (191.35, 210.44 and 213.88 mg KOH/g oil; respectively).

This result reflect that the glycerides of rocket seed oil composed of high molecular weight fatty acids. These acids are relatively higher than those of cottonseeds and corn oils. The obtained results are in fair agreement with that found by Flanders and Abdulkarim (1985), who found that SV of rocket seed oil was 168.1 mg KOH/g oil.

Iodine Value (IV):

The iodine value is often the most useful figure for identifying an oil or at least placing it into a particular group. It should also be noted that the less unsaturated fats with low iodine values are solid at room temperature, or conversely, oils that are more highly unsaturated are liquid. This statement is generally in all oils. The iodine value of rocket seed oil was higher (134.35 g I/100 g oil) than those of corn, sunflower and cottonseed oils (118.40, 130.07 and 102.15 g I/100g oil; respectively) as reported by Stevenson *et al.,* (1984).

On the other hand, iodine value of the investigated oil was higher than that reported by El- Hinnawy *et al*., (1975) which was 100.10 g I/100 g oil) and that reported by Abdel Aal (2002) which ranged between 100.20 to 102.80 g I/100 g oil. While the iodine value of rocket seed oil is in agreement with that reported by Flanders and Abdulkarim (1985).

Acid Value (AV):

The acid value of the investigated rocket seed was 2.25 mg KOH/g. This value is a measure of the decomposition degree of glycerides. The results also indicated that acid value of rocket seed oil is higher than those of corn, sunflower and cottonseed oils, which were 0.28, 0.48 and 0.43 mg KOH/g oil; respectively.

Free Fatty Acids:

The free fatty acids content (as % oleic acid) detected in rocket seed oil was 1.13% (Table 2). This value was higher than those of corn, sunflower and cottonseed oils. But, this value is lower than that reported by Flanders and Abdulkarim (1985) which was found to be 2.3% (as oleic acid). While the obtained results are not far from those reported by Abdel Aal (2002) who found that acid value of rocket seed oil was ranged between 1.9 to 9.59 mg KOH/g and was lower than the permitted maximum values of virgin palm oil (10 mg KOH/g oil) and coconut oil (4 mg KOH/g oil) which were stipulated by CAC (1982).

Peroxide Value (PV):

Table (2) show that, the peroxide value of rocket seed oil was 0.71 meq. O_2/ kg oil, which is lower than that reported by El – Hinnawy *et al*., (1975) which was 1.20 meq. O_2/kg oil, and that reported by Abdel Aal, (2002) which was ranged between 1.35 to 1.67 meq. O_2/kg oil.

The peroxide value detected in rocket seed oil (Table 2) was much lower than that of the stipulated maximum level for CAC (1982) which permitted the peroxide value to be not more than 10 meq. O_2/kg oil for the edible oils.

Table (2): Some Physical and Chemical Properties of Rocket Seed Oil Compared with Sunflower, Corn and Cottonseed Oils.

Properties / Oil	Rocket Seed Oil*	Corn Oil*	Sunflower Oil*	Cottonseed Oil**
Specific gravity (25 ^{0}C)	0.8960	0.9173	0.9200	0.9170
Refractive index (25 ^{0}C)	1.412	1.465	1.470	1.470
Saponification value (mg KOH/g oil)	162.98	191.35	210.44	213.88
Iodine value (g I/100 g oil)	134.35	118.40	130.07	102.15
Acid value (mg KOH/g oil)	2.25	0.28	0.48	0.43
Free fatty acids (as % Oleic)	1.13	0.14	0.24	0.22
Peroxide value (meq. O_2 /kg oil)	0.71	0.00	0.00	-

*** The values are means of three determinations.**

Lipid Fractions:

The total lipids of rocket seed oil were separated into their fractions as shown in Figure (1) and Table (3). According to the R_f values and the reference reported by El– Sebaiy *et al*., (1984). The sequence of the ten fractions obtained from the base line to the front were: (1) phospholipids, (2, 3 and 4) unidentified compounds, (5) monoglycerides, (6) sterols, (7) diglycerides, (8) free fatty acids, (9) triglycerides and (10) hydrocarbons + sterol ester + pigments classes; respectively.

Figure (1): Thin–Layer Chromatogram of Rocket Seed Lipid Fractions.

Table (3): Fractions of Rocket Seed Lipids Separated by Thin Layer Chromatography (TLC).

Fraction No.	Lipid Fractions	R_f Values
1	Phospholipids	0.00
2	Unidentified Cpd	0.06
3	Unidentified Cpd	0.11
4	Unidentified Cpd	0.29
5	Monoglycerides	0.32
6	Sterols	0.34
7	Diglycerides	0.37
8	Free Fatty Acids	0.49
9	Triglycerides	0.66
10	Hydrocarbons + Sterol esters + Pigments.	0.97

Fatty Acids:

Fatty Acids Composition of Total Lipids and Triglycerides:

Table (4) show the fatty acids methyl esters of rocket seed lipids and triglycerides. The separated peaks were identified by external standard. Eleven saturated and unsaturated fatty acids were identified in rocket seed lipids, while ten only were identified in rocket seed triglycerides. Table (4) also documents that unsaturated fatty acids play an important role in this oil. This tested oil contained 72.24 and 72.22% unsaturated fatty acids in rocket seed lipids and triglycerides; respectively. Erucic acid ($C_{22:1}$) is the major unsaturated fatty acid was to be found (46.58 and 40.11% in rocket seed lipids and triglycerides; respectively). Moderate quantities of oleic acid (13.19 and 22.71%) and Linoleic (11.21and 7.74%) were present in rocket seed lipids and triglycerides; respectively, while trace amounts of palmitoleic ($C_{16:1}$), linolenic and ecosenoic ($C_{20:1}$), acids were detected.

Table (4): Fatty Acids Composition of Rocket Seed Lipids and Triglycerides.

Fatty Acids	Rocket Seed Lipids	Rocket Seed Triglycerides
Saturated F. A.		
Myrstic ($C_{14:0}$)	0.24	0.86
Palmatic ($C_{16:0}$)	4.83	8.59
Stearic ($C_{18:0}$)	0.62	1.67
Arachidic ($C_{20:0}$)	21.56	15.92
Behenic ($C_{22:0}$)	0.52	0.74
Total Saturated F. A.	27.77	27.78
Unsaturated F. A.		
Palmitoleic ($C_{16:1}$)	0.39	0.67
Oleic ($C_{18:1}$)	13.19	22.71
Linoleic ($C_{18:2}$)	11.21	7.74
Linolenic ($C_{18:3}$)	0.35	0.99
Eicosaenoic ($C_{20:1}$)	0.52	0.00
Erucic ($C_{22:1}$)	46.58	40.11
Total Unsaturated F. A.	72.24	72.22
Total Fatty Acids	100.00	100.00

Total saturated fatty acids content of rocket seed lipids and triglycerides are 27.77 and 27.78% of the total fatty acids; respectively. Arachidic acid is found to be the dominant saturated fatty acids in rocket seed lipids (21.56%) and triglycerides (15.92%). Palmatic acid was the second main saturated fatty acids in rocket seed lipids (4.83%) and

triglycerides (8.59%). Stearic, behenic and myrstic acids were present in trace amounts.

Flanders and Abdelkarim (1985) found that, total saturated fatty acids content in Indian rocket seeds were 10.9% and total unsaturated was 89.1%. They also reported that the oil contain high levels of linolenic acid (36.2%) and relatively low levels of erucic acid (10.3%), $C_{16:0}$ (6.9%), $C_{16:1}$ (0.2%), $C_{18:0}$ (2.3%), $C_{18:1}$ (11.9%), $C_{18:2}$ (16.3%), $C_{20:1}$ (13.0%), $C_{20:2}$ (1.2%), $C_{22:0}$ (1.7%) and $C_{24:0}$ (traces) of total fatty acids.

Yadava *et al*., (1998) studied fatty acids composition of rocket seed oil and reported large variations in erucic acid (26.7–52.4%), oleic acid (14.1–23.4%), linoleic acid (6.9 – 15.7%), linolenic acid (8.3–15.3%) and eicosaenoic acid (9.3 –18.3%).

Abdel Aal, (2002) showed that, erucic acid was 41.3% of total fatty acids, while oleic acid represented 15.2%, linoleic and linolenic acids represented 10.0 and 10.8%, respectively.

Phospholipid Fractions:

Figure (2) shows the fractionation of phospholipids of rocket seed lipids. The phospholipid fractions of rocket seed were identified using R_f values of albino rat liver phospholipids (Figure 3) Published by El–Sebaiy *et al*., (1980).

Figure (2): Thin-Layer Chromatogram of Rocket Seed Phospholipid Fractions.

The individual phospholipid fractions, starting from the base line, are shown in Table (5), the sequence of these fractions were as follows: phosphatidyl serine (PS, R_f value = 0.0), lysophosphatidyl choline (LPC, R_f value = 0.07), phosphatidyl inositol (PI, R_f value = 0.19), sphingolipids (SL, R_f value = 0.30), phosphatidyl choline (PC, R_f value = 0.44), phosphatidyl ethanol amine (PE, R_f value = 0.50), phosphatidic acid (PA, R_f value=0.53), glycolipids (R_f value = 0.59) and the fraction number nine refer to neutral lipids (R_f value = 0.89).

Table (5): Phospholipids of rocket seed lipids.

Fraction No.	Phospholipid Fractions	R_f values
1	Phosphatidyl serine (PS)	0.00
2	Lysophosphatidyl choline (LPC)	0.07
3	Phosphatidyl inositol (PI)	0.19
4	Sphingolipids (SL)	0.30
5	Phosphatidyl choline (PC)	0.44
6	Phosphatidyl ethanol amine (PE)	0.50
7	Phosphatidic acid (PA)	0.53
8	Glycolipids	0.59
9	Neutral lipids	0.89

Using buffered silica gel GF 254 plates.

Figure (3):*Thin-Layer Chromatogram of Rat Liver Phospholipids.

1= Ps, 2 = LPs, 3 = PI, 4 = SL, 5 = PS, 6 = PE, 7 = PA, 8 = Cardiolipin and 9 = Glycolipids, 10 = Sterols, 11 = Neutral Lipids.

(* As described by El-Sebaiy *et al*., 1980).

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دراسات كيماوية وتكنولوجية على زيت بذور الجرجير

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فسم الصناعات الغذائية – كلية الزراعة بكفر الشيخ – جامعة طنطا – مصر

صمم هذا البحث لدراسة الخواص الطبيعية والكيماوية لزيت بذور الجرجير وكذا مدى إمكانية استخدام هذا الزيت فى أغراض التغذية ، حيث أوضحت النتائج المتحصل عليها أن بذور الجرجير غنية بكل من البروتينات (٣٥,٠٢%) والزيوت (٢٥,٧٧%) والكربوهيدرات (٢٢,٦٦%)، كما تميز هذا الزيت بكثافته النوعية ومعامل الإنكسار ورقم التصبن أقل من تلك الزيوت المستخدمة فى تغذية الإنسان مثل زيوت كل من الذرة وعباد الشمس وبذرة القطن٠ كما تميز هذا الزيت باحتوائه على رقم يودى عالى عن هذه الزيوت مما يدل احتوائه على نسبة عالية من درجة عدم التشبع٠ أثبتت الدراسة أيضا" أن هذا الزيت غنى بالأحماض الدهنية سواء المشبعة والغير مشبعة حيث احتوت ليبيدات بذور الجرجير على إحدى عشر حامض دهنى بينما احتوت جليسريداته الثلاثية على عشرة أحماض دهنية فقط٠

لقد بينت الدراسة أن الأحماض الدهنية الغير مشبعة تلعب دورا" هاما" فى ليبيدات بذور الجرجير (٧٢,٢٤%) وكذا فى جليسريداته الثلاثية (٧٢,٢٢%)٠ أثبتت النتائج أن حامض الأيروسيك هو أكثر الأحماض الدهنية الغير مشبعة انتشارا" فى هذا الزيت حيث يصل إلى ٤٦,٥٨% ، ٤٠,١١% فى كل من الليبيدات والجليسريدات الثلاثية لزيت بذور الجرجير، كما احتوى هذا الزيت على كميات متوسطة من الأوليك (١٣,١٩ ، ٢٢,٧١%) واللينوليك (١١,٢١ ، ٧,٧٤%) فى كل من الليبيدات والجليسريدات الثلاثية لزيت بذور الجرجير على التوالى٠ بينت الدراسة أيضا" أن حامض الأراشيديك يعتبر هو الحامض الدهنى المشبع السائد فى الليبيدات (٢١,٥٦%) والجليسريدات الثلاثية (١٥,٩٢%) لزيت بذور الجرجير ، كما أن حامض البالمتيك يوجد أيضا" بكميات عالية فى كل من الليبيدات (٤,٨٣%) والجليسريدات الثلاثية (٨,٥٩%) لزيت بذور الجرجير٠

أثبتت الدراسة أيضا" أن بذور الجرجير غنية بالفوسفوليبيدات حيث تم فصلها وتفريدها والتعرف عليها وكانت على الترتيب من خط الأساس كما يلى: الفوسفاتيديل سيرين وليزوالفوسفاتيديل كولين والفوسفاتيديل إينوسيتول والأسفنجولييدات والفوسفاتيديل كولين والفوسفاتيديل إيثانول أمين وحمض الفوسفاتيديك والجليكوليبيدات٠