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EFFECT OF SOME MICRONUTRIENTS ON THE CHEMICAL COMPOSITION OF SESAME SEEDS

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Abstract

Seame seeds (*Sesamum indicum* L. Giza 32 variety) were cultivated at Bahtim, Agric. Res. Station, during two successive seasons 1995 and 1996. After germination, the seedlings were sprayed with some micronutrients, i.e., Zn, Mn, Fe in the form of EDTA compound and Cobalt nitrate at the concentration of 0.06% (w/v). The sesame seeds were evaluated through testing their chemical composition and oil quality. The results revealed that foliar spraying with Fe caused a significant decrease in protein content compared to the control, other treatments resulted in nonsignificant differences. Total carbohydrates were significantly increased in all treatments in comparison to the untreated plants. Oil content showed insignificant differences after the Cobalt treatment, while significant increase was observed for the Fe treatment, while Zn and Mn treatments resulted in significant decrease, in the oil content. Concerning mineral content, sesame plant sprayed with Zn produced seeds with highest amounts of Zn, K and Mg. The Mn application resulted in an increase in Mn, Mg, K, Ca and Zn. While Fe treatment showed highest amounts of Fe, Na and Ca. Sesame seed proteins either treated or untreated with micronutrients were fractionated into fractions according to their solubilities in H2O, NaCi, Et-OH and NaOH. The obtained data showed highest amounts in proteins fraction due to Zn treatment. Sesame fatty acids were fractionated by GLC and the the data showed that the levels of C18: 1 and C18:2 were increased and decreased respectively due to the application of the aformentioned mineral treatments.

In conclusion, it is evident that sprayed micronutrients maintain or improve most of the chemical components and nutritive value of the produced sesame seeds, as well as the oil quality and its stability.

INTRODUCTION

In Egypt, the cultivated area with sesame (*Sesamum indicum* L.) is around 20,000 Feddans which yield about 6, 400 tons of the seeds per year. Most of the produced sesame seeds are consumed locally in preparing home foods, bakery products and edible sesame oils. Also sesame seeds are pressed to produce sesame paste (Tahina) which is used in foods and salads.

Sesame is one of the most important oil seed crops in the world. Not only due as a source of edible oil, but also the seeds provide nutritious elements for humans. Yen *et al.* (1986). Nagaral (1991) found that the protein and oil contents of 10 sesame varieties ranged from 21.71 to 30.28% and from 46.30 to 56.60%, respectively. Srenvivas *et al.*, (1991) studied the biochemical constituents and nutrient uptake of sesame grown in Vertisol. They found that the protein, fiber and oil contents of seeds were 20. 43, 3.80 and 50.09% respectively. Dashak and Fali, (1993) showed that sesame seeds, specially the yellow variety, are rich in lysine, methionine and cystein. Therefore, when eaten together with the careals, helps supplementing the deficiency of these amino acids in the meals. Egyptian Ministry of Agriculture (1968) demonstrated that sesame seeds contents of ash, proteins, fiber, soluble carebohydrates and ether extract ranged from 3.51 to 13.56; 16.12 to 23.65; 3.28 to 6.80; 9.88 to 16.42 and 47.10 to 62.30% while Ca and P were found in the range of 0.42-0.54 and 0.51-0.71% respectively. The oil contents of the seeds of 42 strains of sesame plant ranged from 43.4 to 58.8% (Tashiro *et al.*, 1990). The Food and Agriculture Organization of the United Nations World Organization Codex Alimentarius mentioned the ranges of fatty acids of sesame oil as follows: palmitic (7-12%); stearic (3.5-6%); oleic (35-50%) and linoleic acid (35-50%) Spencer *et al.*, (1976).

Micro nutrients are required in small quantities for normal plant nutrition, their role is important and their deficiencies lead to severe depression in plant nutrition, growth and yield. The present investigation was designed to inspect the effect of foliar spray of micronutrients on the nutritive value of the produced sesame seeds.

MATERIALS AND METHODS

Materials

Sesame seeds (*Sesamum indicum* L. Giza 32 variety) was cultivated at Bahtim

Agricultural Research Station during two successive seasons (1995 and 1996). Soil samples were analyzed for controlling of available nutrients according to Jackson (1973) and Lindsay and Norvell (1969). The levels of available N, P, K, Zn, Mn and Fe were found to be 45.9, 17.0, 234.5, 0.62, 3.74 and 6.32 ppm, respectively. After germination, the seedlings were thined to two plants in every hill and sprayed separately with some micronutrients in the forms of EDTA compounds, i.e. Zn-EDTA (14% Zn), Mn, EDTA (13% Mn), Fe-EDTA (6% Fe) and cobalt nitrate.

Each element was sprayed after 40 days from sowing at the rate of 200 L/ Fed at the concentration of 0.06% (w/v). The randomized block design with four replicates was used. Nitrogen was applied at the rate of 30 unit N/Fed as urea (46.5% N) and phosphorous was appied at the rate of30 unit as supper phosphate (15.5 P2O5). After maturation, sesame seeds were collected and a representative samples of the treated and untreated sesame of the two seasons were mixed to gether for analysis.

Methods :

General chemical analysis: Moisture, ash, oil, crude protein, and crude fiber were determined according to the methods outlined in A.O.A.C. (1990). Total carbohydrates were determined by difference.

Determination of minerals : Sodium, potassium calcium, magnesium, zinc, iron, manganese and copper of sesame seeds were measured after ashing using a Pye Unicam Sp. 1900 Atomic Absorption Spectrophotometer. The metals were determined according to the AOAC. (1990).

Protein Fractions: The proteins were fractionated according to their solubilities in water (separated albumins faction); ethanol 80% (separated gliadin fraction) and sodium hydroxide 0.4%, w/v (separated glutelin fraction) according to the method described by Ma and Nelson (1973).

Oil extraction: The seeds yield of each treatment for each season were mixed together and a representative sample was taken for oil analysis. Oils were extracted three times using hexane in a Waring blender.

Physical and chemical properties of sesame seed oil: Refractive index, acid value, iodine value, peroxide value were determined according to the methods described by the A.O.A.C. (1990).

Separation, identification and determination of fatty acid methyl esters of sesame oil: The oil was saponified with KOH (20%, w/v) at room temp. overnight. The unsaponifiable matter was extracted three times with ether. The aqueous layer was acidified with sulphuric acid (20%, v/v) and the liberated fatty acids were extracted three times with ether and washed several times with distilled water, then dried over anhydrous sodium sulphate. The fatty acids were methylated with diazomethane (Vogel, 1975) and were analyzed using gas-liquid chromatography. The separation conditions were exactly as described by Ashoub *et al.*, (1989).

Statistical analysis: The obtained data were statistically analyzed and the mean values were compared using the least significant difference (L.S.D.) at 0.05% level according to the methods described by Steel and Torri (1980).

RESULTS AND DISCUSSION

Table 1 shows the chemical composition of sesame seeds as affected by foliar fertilizer. The data illustrate that foliar fertilizer resulted in an increments or decrements in the chemical constituents of sesame seeds. Statistical analysis were performed to elucidate the effect of the sprayed minerals compared to the control. The results reveal that Fe treatment caused a significant decrease in protein content (22.19%) compared to the control (23.48%). Other treatments resulted in nonsignificant differences. Total carbohydrates were significantly increaased in all treatments (13.80%, 14.33%, 17.50% and 19.85% For Zn, Mn, Fe, and Co respectively) compared to the control (13.53%). Oil content showed non significant differences due to Cobalt treatment (56.29%, while significant increase was observed for the Fe treatment (57.15%), Also, Zn and Mn treatments resulted in significant decrease in oil contrent (56.24% and 56.04%), respectively. The ash content significantly decreased due to the foliar application compared to the control except when sprayed, with Cobalt which showed non significant differences compared to the control. The obtained data were in line with the findings of Dhindesa and Gupta (1976) and Basyony (1984) who found that the protein content ranged from 18 to 28% and 22.11%, respectively. Also Muralidharudu and Mev (1990) found that the oil content was increased when the sesame plants were treated with 5 and 10 ppm Zn and with 20 ppm Fe. Seed yield showed non significant differences except that of Co treatment which showed significant decrease compared with all treatments.

Table 1. Chemical composition of sesame seeds (on dry weight basis) and seed yield as affected by foliar fertilizer (micronutrients).

Treatment	Protein %	Oil %	Ash %	Fiber %	T.C. %	Seed yield (kg/fed)
Control	23.48	56.24	4.54	2.10	13.53	481.39
Zn	23.17	56.24	4.25	2.00	13.80	499.12
Mn	23.55	56.04	4.20	1.88	14.33	489.49
Fe	22.19	57.15	4.31	1.90	17.50	493.69
Co	23.36	56.29	4.50	2.00	19.85	388.26
L.S.D. 0.05%	0.36	0.11	0.06	N.S.	0.04	89.53

* T.C. = Total carbohydrates were calculated by differemce.

Table 2 illutrates the effect of foliar application of Zn, Mn, Fe and Co on some mineral contents of the produced sesame seeds. The data revealed that treatment with Zn significantly increased Mg (274.0 mg/100 g), K (487.5 mg/100 g) and Zn (1.03 mg/100g) compared to the control (240.67, 343.0 and 0.7 mg/100 g respectively). The Mn application produced seeds containing Mn, Mg, K, Ca and Zn of 4.90, 248.5, 344.5, 648.5 and 0.95 mg/100 g respectively) compared to the control which had (2.95, 240.67, 343.0, 612.5 and 0.7 mg/100g) for the some minerals respectively. Fe treatment caused significant increase in Na (47.80), Ca (617.0) and Fe (306, 0) in comparison to the control (35.53; 612.5; 180.5 mg/100g), respectively. On the other hand, treatment with Co showed a significant decrease in all determined minerals. It seams that there is a relationship between the sprayed element and its level in the seeds. In other words, the application of Zn, Mn and Fe led to increased their levels in the seeds.

Table 2. Mineral content (mg/100 g. on dry weight basis) of sesame seeds as affected by foliar fertilizer.

Treatment	Mn	Mg	Na	K	Ca	Zn	Cu	Fe
Control	2.95	240.67	35.53	343.0	612.5	0.70	7.05	180.5
Zn	2.77	274.0	33.03	487.5	566.0	1.03	3.55	116.3
Mn	4.90	284.5	21.20	344.5	648.5	0.95	2.14	34.5
Fe	1.40	188.0	47.80	256.0	617.0	0.65	5.30	306.0
Co	0.70	23.97	23.55	338.0	576.5	0.75	1.75	60.5
L.S.D. 0.05%	0.03	0.78	0.25	0.37	0.37	0.06	0.20	2.13

From the above mentioned data, it could be concluded that Zn and Fe application increased the amounts of K and Na besides Zn and Fe contents of the produced sesame seeds. This means that Zn and Fe encourage the absorption of K and Na from the soil to the seeds which have an affect on human blood pressure. On the other hand, Zn and Fe can play an important role in anemic deseases. Mn application resulted in significant increase in the levels of Mn, Mg, K, Ca and Zn compared to the control, which is important in human metabolism. The variation in mineral composition could be due to differences in variety, location, element interaction in the soil. In this respect, Dashak and Fali (1993) found that four varieties of Nigerian (sesamum indicum) have high values of K, Ca and P.

Sesame seed protein fraction as affected by foliar fertilizer: Sesame seed proteins either treated or untreated with micronutrients were fractionated into fractions according to their solubilities in water (H2O), salt (NaCl), alcohol (EtOH) or alkali (NaOH). The obtained data presented in Table 3 showed that there were no appreciable differences between the protein fractions due to foliar

Table 3. Sesame seed protein fractions (on dry weight basis as affected by foliar fertilizer.

Treatment	Water soluble protein %	Salt soluble protein %	Alcohol soluble protein %	Alkali solube protein %	Insoluble Protein %
Control	5.28	4.45	4.22	7.91	1.42
Zn	5.33	4.63	4.26	7.95	1.44
Mn	5.24	4.65	4.23	7.94	1.43
Fe	4.94	4.36	3.98	7.48	1.35
Co	5.25	4.62	4.21	7.90	1.40
L.S.D. 0.05%	0.04	N.S.	0.18	0.037	0.056

application. However, statistical analysis revealed distinctly the effect of foliar fertilizer on the protein fractions. Water soluble protein significantly increased due to the Zn treatment, while Mn and Fe treatments resulted in significant decrease in water soluble proteins. On the other hand, salt soluble protein showed non significant difference due to all mineral treatment. Alcohol soluble protein also, showed insignificant differences due to all treatments except that of Fe treatment which showed significant decrease compared to the control. Concerning alkali soluble protein, it was significantly increased and decreased due to Zn and Fe treatments, respectively, while other treatments showed non significant differences. Insoluble protein showed non significant differences except for Fe treatment which resulted in significant decrease compared to the control. From the above mentioned data, it could be concluded that foliar application affected protein solubility except that of the Co-treatment .

The effect of foliar fertilizer on some physicla and chemical characteristics of sesame seed oil: Table 4 shows the effect of foliar application with micronutrients on some physical and chemical properties of the extracted sesame oil. The refractive index (R.I.) was 1.4698 for the oil of the untreated sesame seeds. Significant decrease in R.I was observed due to all foliar application treatments. The most effect was found under Mn treatment (1.4671) followed by Co, Fe and Zn (1.4678, 1.4680 and 1.4690) respectively. Acid value of the control was 0.32 while treatments showed a remarkable increase in the acid value ranged from 5.39 to 7.96. This may be due to the action of lipase enzyme which play an important role in the hydrolysis of glycerides. Peroxide value showed also a significant increase due to Fe and Mn treatments (4.41 and 4.36 mg/Kg oil), respectively, while other treatments showed insignificant differences. This increment can perhaps be attributed to Mn and Fe encourage the peroxidase enzyme. On the other hand, iodine value significantly decreased (103.71, 93.46, 103.07 and 101.61) for Zn, Mn, Fe and Co treatments respectively, compared to the control (105.75). The decrease in iodine value may be due to the enhancement of mono-unsaturated fatty acids and the decrease in the polyunsaturated ones due to foliar application. The obtained data of all treated sesame were in agreement with that of Dashak and Foli, 1993.

Table 4. Some physical and chemical properties of sesame seed oil as affected by foliar fertilizer.

Treatment	Refractive index at 25oC	Acid value (mg KOH/g oil)	Peroxide number (meq/Kg oil)	Iodine value (Hanus)
Control	1.4698	0.32	2.42	105.75
Zn	1.4690	5.39	2.82	103.71
Mn	1.4671	7.96	4.36	93.46
Fe	1.4680	5.44	4.41	103.07
Co	1.4687	7.82	3.67	101.61
L.S.D. 0.05%	0.0006	0.04	0.85	0.12

Effect of some micronutrients on fatty acid composition of sesame seed oil: The results in Table 5 illustrate the fatty acid composition of the oils extracted from treated and untreated sesame seeds. The untreated control oil was characterized by palmitic (C16:0); stearic (C18.0); oleic (C18:1) and linoleic (C18:1); and *linoleic* (C18:2) acids in the amounts of 20:45%, 1.48%, 28.7% and 49.37% respectively. Treatment with Mn increased C16:0 (23.07) compared to the control (20.45%), while it decreased with Zn, Fe and Co (17.95%, 16.28% and 16.68% respectively). As for the unsaturated fatty acids in all treatments there was an increase in the level of C18: 1, which ranged from 40.80% in Zn treatment to 50.95% in Co treatment. On the contrary C18:2 decreased, and ranged from 28.22% in Mn treatment to 40.00% on the Zn treatment. The low linoleic acid percentages in all treatments were accompanied by noticable relative increase in the percentage of oleic acid. These data were in agreement with the findings of (Codex Committee on fats and oils 1979; Kamal Eldin and Appelqvist 1994; Sato 1994 and Kamal-Eldin *et al.*, 1995). The oleic to linoleic (O/L) ratio and iodine value (IV) are important indicators of oil stability and quality. Higher O/L ratios and lower Ivs would suggest better oil which has good stability and longer shelf like (Ahmed and Young 1982). Accordingly, the oil from sesame seed treated with micronutrients (Mn, Co, Fe and Zn), had higher oleic acid contents and, correspondingly, exhibits good stability and long shelf life (Table 5 and 6).

In conclusion, it is evident that the sprayed micronutrients maintain or improve most of the chemical component and help to enhance the nutritive value of the produced sesame seeds and also improve oil quality and increase its stability.

Table 5. Fatty acid composition of sesame seed oil as affected by foliar fertilizer

Treatment	Fatty acids composition (%)				TS	TU
	$C_{16:0}$	$C_{18:0}$	$C_{18:0}$	$C_{18:0}$		
Control	20.45	1.48	28.70	49.37	21.93	78.07
Zn	17.95	1.25	40.80	40.00	19.20	80.80
Mn	23.07	1.15	47.56	28.22	24.22	75.78
Fe	16.28	2.24	48.35	33.13	18.52	81.48
Co	16.68	1.40	50.95	30.97	18.08	81.92

Table 6. Total unsaturated-to-total saturated fatty acid ratios (TU/TS). degree of unsaturation (DU), oleic-to-linoleic fatty acid (O/L)* and iodine value (IV) of sesame seed oil.

Treatment	TU/TS	DU	O/L	IV
Control	3.56	1.27	0.58	105.75
Zn	4.21	1.21	1.02	103.71
Mn	3.13	1.04	1.68	93.46
Fe	4.40	1.15	1.45	103.07
Co	4.53	1.13	1.64	101.61

* TU/TS, and O/L were calculated from fatty acid composition of Table (5)
DU = The degree of unsaturation = (Monoene x 1 / 100) + (Diene x 2 /100).

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تأثير بعض العناصر الصغرى على التركيب الكيماوى لبذور السمسم

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أجريت تجربتان حقليتان بمحطة البحوث الزراعية ببهتيم لموسمين متتاليين ١٩٩٥ ١٩٩٦ لدراسة تأثير الرش بالعناصر الصغرى مثل الزنك ، المنجنيز ، الحديد على الصورة المخلبية. بينما كان الكوبالت على صورة نترات بتركيز ٠,٠٦ ٪ (وزنية / حجمية) لكل منهم على التركيب الكيماوى وجودة الزيت لبذور السمسم (صنف جيزة ٣٢).

وقد أظهرت النتائج انخفاضا معنويا فى محتوى البروتين عند الرش بالحديد مقارنة بالكونترول بينما لم يحدث أى تغير معنوى للمعاملات الاخرى. وقد وجدت زيادة معنوية فى محتوى الكربوهيدرات الكلية لكل المعاملات بالمقارنة بالبذور غير المعاملة. وقد أظهر الرش بالكوبلت فروقا غير معنوية فى محتوى الزيت ولوحظ زيادة معنوية عند الرش بالحديد بينما الرش بالزنك والمنجنيز أدى الى انخفاض معنوى فى نسبة الزيت.

وفيما يتعلق بمحتوى البذور من المعادن وجد أن رش نبات السمسم بالزنك انتج بذورا ذات محتوى عالى من الزنك والبوتاسيوم والماغنسيوم. كذلك الرش بالمنجنيز أدى الى زيادة فى كل من المنجنيز والماغنسيوم والبوتاسيوم والكالسيوم والزنك بينما الرش بالحديد أظهر زيادة فى الحديد والصوديوم والكالسيوم.

وعند تفريد البروتين تبعا لاذابته فى كل من الماء والكحول والملح والقلوى وجد ارتفاعا فى نسبة ذوبانه فى كل منهم عند الرش بالزنك بالمقارنة بالبذور غير المعاملة.

وعند تفريد الأحماض الدهنية بجهاز التحليل الكروماتوجرافى الغازى السائل اوضحت النتائج زيادة فى الحامض الدهنى الاوليك بينما حدث نقص فى حامض اللينوليك بالرش بالمعادن المذكورة سابقا.

مما سبق يتضح أن رش بذور السمسم ببعض العناصر الصغرى أدى الى الحفاظ وتحسين التركيب الكيماوى للبذور كذلك تحسين جودة الزيت وارتفاع درجة ثباته الأكسيدى.