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The Agronomical Characteristics, Nutritional and Technological Quality of Sunflower (*Helianthus annuus*) Seeds as Affected by Response to Foliar Spray with Zinc Oxide Nanoparticles

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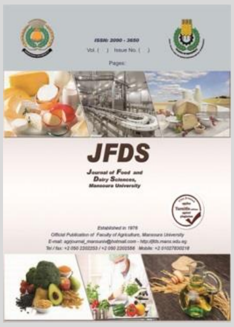

ABSTRACT

The current investigation were to study the effect of foliar spray by different zinc oxide nanoparticles concentrations (0, 100, 200, 300, 400 and 500 ppm) of two sunflower cultivars on agronomical characteristics (seasons 2017, 2018) and nutritional composition (season 2018). The tested sunflower cultivars had a highly significant influence Seed yield/fed., husking percentage, oil percentage and seed oil, G 102 variety gave the highest values in the both seasons. Chemical composition (g/100g D.W) of sunflower seeds kernels results showed that the S 400ppm, G 400ppm samples was significantly ($P<0.05$) the highest in oil content 61.75 and 60.19, respectively, comparing with the other studied samples. The G 200ppm was higher in protein content with value 23.12% when comparing with the other samples which ranging from 20.52 to 22.95%. For minerals composition (mg/100g D.W) Zn content was decreased significantly ($P<0.05$) as a result of foliar spray by ZnO in treated samples when compared with control one. The Mg content was found in higher values ranging from 3471.36 to 4020.05 mg/100g DW. The major fatty acids in sunflower kernel oil were oleic and linoleic make up more than 90 % of the total fatty acids. For defatted sunflower kernels samples the protein, crude fiber content were found in a higher contents ranging 49.29–52.95, 7.11–15.22, respectively. Defatted meal or cake was found as a nutritional material, good source of minerals, convenient for human nutrition which produces high acceptability bread comparable to control for 5, 10 and 15% replacement ratio.

Keywords: ZnO, nanoparticles, fatty acids, Crude fiber, minerals, ball bread.

INTRODUCTION

Nanotechnology offers an expanding research in the medicine, energy and life sciences fields, such as, conversion of food wastes to energy, reproductive science and technology. Nano fertilizers might have an important role for enhancement target activity; regulate plant growth by controlling release nutrients and chemical fertilizers. The using of nanoparticles metal oxides (ZnO, TiO_2, CeO_2, CuO, Fe_3O_4, Fe_2O_3, …) on plants resulting many physiological and morphological changes which depend on their properties as reactivity, chemical composition, surface covering and its effective used dose in nano form. On the other hand some studies in this field suggested both negative, positive effects on development and plant growth when NPs was used with some plant species (Giraldo *et al.,* 2014, Ditta and Arshad 2016).

Zinc ions (Zn2+) belong to micronutrients and conventional fertilizers (not only) of zinc are faced with poor bioavailability problem, which due to conversion of the zinc to insoluble compounds in the soil. Zinc has been considered as an important micronutrient for metabolic activities in plants These ZnO nanoscale particles proved effective in enhancing crop yield, development and plant growth. A lower dose of foliar application is proved to be significantly productive. The foliar application of ZnO nanoparticles showed an increasing in the kernel yield as compared to seed treatment with ZnO nanoparticles. The foliar application of ZnO nanoparticles at 500 ppm significantly increased the kernel yield (Laware and Shilpa 2014, Torabian and Khoshgoftar 2016).

The addition of zinc sprayed on the sunflower plant leaves with concentration 7.5 $mg.l^{-1}$ led to a significant increase in characteristics: seed yield per plant, total seed yield, seed oil content and oil yield, while increasing concentration of zinc to 15 $mg.l^{-1}$caused a significant decrease in that characteristics in the two growing seasons. The interaction between zinc foliar application and genotypes for seed yield, oil percent and oil yield were not statistically significant in both seasons (Al-Doori 2013).

Recently the response of seed yield and fatty acid compositions for some sunflower genotypes to plant spacing and nitrogen fertilization was studied. The results stated that Sakha 53 sunflower cultivar was ranked in the first order in stem diameter, head diameter, 100-seed weight, seed weight plant−1 and seed yield fad.−1 as well as seed oil content whereas, Giza 102 characterized with its contained the highest proportion of oleic and linoleic unsaturated fatty acids (Abd El-Satar *et al.*, 2017).

According to worldwide production sunflower plant (*Helianthus annuus*) which is ranking fourth between the major oilseeds crops. Its seeds considered an excellent source of unsaturated fatty acids, proteins, minerals (P, Zn, Cu, Fe, Mg, Ca, Se, Na), vitamins (folic acid, pyridoxine, pantothenic), phytochemicals such as phenolic acids and tocopherols. The seeds also have a beneficial role against

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cardiovascular diseases, bacterial, fungal infections and chronic inflammatory conditions. 100g of sunflower seeds contain moisture 5.50%, ash 3.02g, protein 19.80-20.78g, fat 51.46-52.10g, fiber 8.6g, carbohydrate 17.9-20.00g and energy 620kcal. The composition for mineral contents in sunflower seeds as per 100 g seeds containing calcium 78, iron 5.25mg, magnesium 325mg, phosphorus 660mg, potassium 645mg, sodium 9mg, zinc 5 mg, copper 1.80mg, manganese 1.9 mg, and selenium 53.0mg (Nadeem *et al.*, 2010, Aishwarya and Anisha 2014, Nandha *et al.*, 2014).

Whole sunflower cake (defatted whole meal) contain moisture 5.80%, crude fat 11.01%, protein 23.60%, crude fiber 30.18%, ash 5.66% and carbohydrates 23.75%, while partially dehulled sunflower cake comprises of 5.60 % moisture, 25.28 % protein, 21.38 % crude fiber, 6.89 % ash and 19.34 % carbohydrate. Similarly, dehulled sunflower cake contain moisture, crude protein, crude fat, crude fiber, ash and carbohydrate contents as 7.59 %, 29.00 %, 30.25 %, 8.60 %,7.50 %, and 11.17 %, respectively (Srilatha and Krishnakumari, 2003).

Whole sunflower seeds are characterized by high levels of fat (380-540g kg^{-1}) and fiber (120-200g kg^{-1}). Palmitic acid was found in the range of 3 to 35.5 percent for whole seeds and 3.9 to 35.8 percent for dehulled seeds. Palmitoleic acid was observed in the range of 0.0 to 8.6 percent and 0.0 to 9 percent, Stearic acid in the range of 1.4 to 30.3 percent and 1.7 to 28.5 percent, oleic acid in the range of 7.7 to 90.7 and 9.1 to 90.5 percent and linoleic acid was observed in the range of 1.8 to 74.5 and 1.9 to 64.4 percent (Canibe *et al.*, 2007, Aishwarya and Anisha 2014).

A mechanical or solvent-based method is used to extract the oil from whole sunflower seeds or both of them. After extraction, the remaining part called meal or cake is used to feeding animal. When hull is removed the oil extracted from seed kernel has more oil quantity and the cake quality was improved. Studies have shown that the percentage of oil extracted from sunflower seeds without hull is more than 93.6% compared to 86% for whole seeds.This technique also lowered the crude fiber content of the cake up to 13%, thereby increasing its nutrient value and marketability as livestock feed Sunflower cake (left after the oil extracted) contains high level of crude protein 15-45 percent, and ether extract 3.5-38 percent (Pradhan *et al*., 2011, Lomascolo *et al*., 2012).

The oil yield could be improved up to 15.4 % when sunflower seeds are dehulled. The physicochemical properties of oil and the cake quality (high crude protein content and low crude fibre content) from dehulled seeds were also significantly improved (Lazaro *et al*., 2014).

From a nutritionist's point of view, bakery products made from refined flour do not meet the nutritional requirements of some nutrients In addition, the balance of essential amino acids- lysine, threonine and valine are lack in wheat protein. Nutrition scientists are realizing that more attention should be paid to one’s daily intake of complex plant foods like seeds, nuts and whole grains. Therefore, from consumer point of view there is a need to supplement wheat flour with other materials that are nutritionally rich, such as cotton seeds, sunflower seeds and other oil seeds (Meilgard *et al*., 2007; Sabitha and Puraikalan, 2014).

Supplementation of wheat flour with different levels of sunflower seeds in bakery products especially bread improve the flavor, taste and the nutrient profile of the breads but negatively affected the volume. Sunflower seeds can be successfully replacing wheat flour up to 16 percent. There is a significant increase in fiber, fat and protein values when recipes (for biscuits) containing sunflower cake at 10 and 20 percent levels were analyzed. The importance to utilize sunflower kernels is to supplement it with wheat flour because wheat is the staple food all over the world (Skrbic and Filipcev, 2008; Anjum *et al*., 2012). The aim of this investigation is to study the effect of foliar spray by different zinc oxide nanoparticles concentrations (0, 100, 200, 300, 400 and 500ppm) of two sunflower cultivars (Giza 102, Sakha 53) on agronomical characteristics and nutritional composition, as well as processing of ball bread supplemented with 5, 10, 15, 20% of defatted sunflower seeds kernel.

MATERIALS AND METHODS

Materials

The present investigation was laid out at the Agronomy Department Farm, Faculty of Agriculture, Assiut Univ, Assiut Governorate, Egypt; during 2017 and 2018 seasons to study the response of two sunflower cultivars to foliar spray by zinc oxide nanoparticles. In addition the nutritional part of this work was done in Food Science and Technology Department laboratories, Faculty of Agriculture, Assiut Univ.

A randomized complete block design (RCBD) using a strip plot arrangement with three replications was used in the field experiment. The cultivars Sakha-53 and Giza-102 were a signed vertically, while, zinc oxide nanoparticles concentrations were allotted horizontally. The experimental unit area was 10.5 m^2 (3×3.5 m), including 5 ridges of 60 cm apart at spacing 25 cm between hills, leaving one plant / hill at thinning time (21 days after sowing). Seeds were sown on May 25th in the first and second seasons.

Using zinc oxide nano particles in plants

The ZnO in nano form was obtained from Agricultural Research Center-Giza Governorate-Egypt. The inorganic compound Zinc oxide (nano ZnO) appears as a white powder, it is nearly insoluble in water, so the required weight of zinc oxide was dissolved in hydrochloric acid and added to ten liters of water to obtain the specific concentration and spray on the plant.

Levels of zinc oxide nanoparticles (0, 100, 200 300,400 and 500 ppm) sprayed on the plant leaves one dose on July 4th.

At heading from the heads of two central rows, heads of five plants were chosen at random from external ridges of each plot and bagged at early seed development (by using craft paper) to avoid a bird's damage until maturity.

Methods

Agronomical measured traits

Husking percentage% was determined by hulling about 3 g of whole seeds and was calculated using the following formula:

$$\frac{\textbf{Seed husk weight} \times \textbf{100}}{\textbf{Whole seeds weight}}$$

Seed yield (kg $fed.^{-1}$): Heads of two bagged inner ridges of each plot were harvested and left two weeks until fully air dried and seeds were manually separated then weighted and transferred into kg fed.$^{-1}$.

Oil percentage (%): oil percentage in whole sunflower seeds was estimated by extraction using Soxhlet apparatus and petroleum ether (Bp40-60°C) as solvent (AOAC 2000)

Oil yield (kg fed.$^{-1}$): Oil yield = Seed yield fed.$^{-1}$ × oil percentage.

The nutritional properties

Sample preparation:

Sunflower seeds from season 2018 were cleaned manually by removing all the foreign matter such as stones, dirt and broken seeds. Cleaned seeds washed in abundant water before being drained on a sieve; husk removed and then treated as follow:

1-Sunflower kernel meal (SKM): Sunflower kernel meal refers as such without defatting, which crushed in a pestle and mortar then stored in a freezer (–20°C) until time for analysis.

2-Defatted sunflower kernel meal (DSKM): The sunflower kernels were crushed in a pestle and mortar before defatting. Cold extraction method with n hexane for 72 hours was used to extract the oil from the sunflower samples. The ratio of sample to solvent was 1g: 5 ml. The extracts were undergone evaporation using a rotary evaporator at 40°C to obtain the oil and the residue (Defatted sunflower kernel meal, DSKM) was collected and dried at room temperature then stored in a freezer (–20°C) until time for analysis. Ice cold acetone was used in defatting or extracts the oil from samples (Giza control and Giza 200ppm) to obtain the DSKM which used in ball bread supplementation.

Proximate composition

Moisture, crude protein, crude oil, crude fiber and ash were determined as described in the AOAC methods (2000). The total carbohydrates content was determined by difference according to Pellet and Sossy (1970) as follows:

Carbohydrate % = 100 – (protein% + ash% + lipid% + crude fiber%).

The energy (caloric value) was calculated using value of 4 k.cal/g for protein, carbohydrates and 9 k.cal/g for fat according to Livesy (1995). The contents of Zn, Mg, Fe, Cu and Mn in the studied samples were determined by iCAP6200 (ICP-OES) Inductively Coupled Plasma Emission Spectrometry (Isaac and Johnson, 1985). Total phosphorus content was determined by spectrophotometer (Jackson, 1967) after wet ashing following method described in AOAC (2000). Triplicate determinations were carried out for each sample and the means were reported.

Fatty acid composition:

The methyl esters of fatty acids were prepared from oil samples using 5ml 3% H_2So_4 in absolute methanol and 2ml benzene (Rossel 1983) after that it identified by gas liquid chromatography.

Calculated oxidizability value (Cox): The oxidative stability of the extracted oils based on unsaturated fatty acids (USFAs) content was calculated according to Fatemi and Hammond (1980) as follows:

Cox = [1(18:1%) + 10.3(18:2%) + 21.6(18:3%)]/100.

Preparation, sensory evaluation and physical characteristics of ball bread

The bread dough ingredients were wheat flour (refined) (100%), compressed yeast (2%), salt (2%), sugar (3%), shortening (3%) and defatted sunflower kernel meal at 5, 10, 15, 20% levels (Table 1). Percentages are based on flour weight. Giza 200 ppm was selected on the basis of high protein (52.95) content to making the ball bread and its control sample (G control). The bread-making performances of flours (control WF and blends) were determined using straight dough AACC method (2000). The subjective evaluation of bread samples was carried out sensory characteristics that is, color of crust (10), color of crumb (10), graining of crumb (10), texture (10), taste (10), odor (10) and total score (60) . The products were scored by the judges according to the method described by AACC (2000).

Table 1. Formulation of ball bread containing defatted sunflower kernel meal.

Ingredients	Control	5%	10%	15%	20%
White fine wheat flour (g)	100	95	90	85	80
Defatted sunflower kernel meal (g)	--	5	10	15	20
Water (ml)	60	60	60	60	60
Salt (g)	2.00	2.00	2.00	2.00	2.00
Sugar (g)	3.00	3.00	3.00	3.00	3.00
Yeast (g)	2.00	2.00	2.00	2.00	2.00
Shortening (g)	3.00	3.00	3.00	3.00	3.00

The weight (g) for bread was determined individually within two hours after baking the average was recorded, while the volume (cm3) was determined by displacement method with clover seeds. Specific volume (cm^3/g) was calculated using the following Equation: Specific loaf volume (cm^3/g) = Volume (cm3)/Weight (g) (AACC 2000).

Statistical analysis:

All collected data were analyzed with analysis of variance (ANOVA) Procedures, using the SAS Statistical Software Package v.9.2, 2008**.** Differences between means were compared by revised least significant difference (RLSD) at 5% level of significant (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Agronomical traits

Seed yield (kg/ fed.) and husking percentage (%).

Seed yield (kg/fed) trait reacted significantly ($P \leq 0.01$) to the tested zinc oxide nanoparticles concentrations (ZnO NPs) in the two growing seasons (Table 2). Thus, the highest mean values of seed yield (1751.99 and 1515.18 kg/fed in the first and second seasons, respectively) were obtained from 200 ppm of ZnO NPs concentration. Also, the recorded data in Table 2 denote that the tested sunflower cultivars had a significant influence on seed yield trait in the second season only while, sunflower cultivars failed to reach a significant level at 5% level of probability in the first season. Whatever, Giza 102 sunflower cultivar superior Sakha 53 one in this respect and gave the highest mean values of seed yield (1441.62 and 1483.55 kg/fed in the two respective seasons). Our results are in accordance with the previous studies (Abd El-Satar *et al.*, 2017, Nasim *et al.*, 2017).

Concerning the interaction effect on seed yield trait, the exhibited data in Table 2 reveal that the interaction between ZnO NPs concentrations and sunflower cultivars had a significant effect in this respect in the two successive seasons. The highest values of seed yield (1767.62 and 1665.04 kg/fed in the first and second seasons, respectively) were obtained from Giza 102 cultivar which was sprayed by ZnO NPs at 200 ppm. Similar trend was observed by Al-Doori (2013). Regarding the tested zinc oxide nanoparticles (ZnO NPs) concentrations effect on husking percentage, the illustrated data in Table (2) show that zinc oxide nanoparticles concentrations had a highly significant ($P\leq0.01$) effect on husking percentage in the two growing seasons. Thus, the highest mean values of husking percentage 69.77and 69.71% in the first and second seasons, respectively, were obtained from 300 ppm ZnO NPs concentration. This may be due to zinc oxide nanoparticles enhanced the dry matter partitioning towards of seed kernel more than towards the seed husk. In addition, the presented data in Table (2) prove that the studied sunflower cultivars had a highly significant influence on husking percentage in the second season only while, sunflower cultivars failed to reach a significant level at 5% level of probability in the first season. Giza 102 sunflower cultivar superior Sakha 53 one in this respect and gave the maximum mean values of husking percentage (67.12 and 70.22 % in the two respective seasons). These results may be due to the differences between the two tested cultivars in growth habit and response of each one to environmental conditions during the growing seasons, which was controlled by genetically factors. Our results are in agreement with data reported by Al-Doori (2013).

Table 2. Effect of zinc oxide nanoparticles concentrations, two sunflower cultivars and their interaction on seed yield (kg/fed.) and husking percentage % during 2017, 2018 seasons.

Zinc oxide nanoparticles (ppm)	Seed yield						Husking percentage %					
	First season (2017)			Second season (2018)			First season (2017)			Second season (2018)		
	Giza 102	Sakha 53	Mean	Giza 102	Sakha 53	Mean	Giza 102	Sakha 53	Mean	Giza 102	Sakha 53	Mean
Control	1274.28	1182.77	1228.53	1380.77	1139.72	1260.25	63.66	62.99	63.325	62.39	63.67	63.97
100	1348.82	1248.38	1298.60	1407.81	1308.57	1358.19	67.16	69.25	68.205	72.83	57.67	63.58
200	1767.62	1736.35	1751.99	1665.04	1365.31	1515.18	62.20	69.64	65.92	73.92	63.75	68.8
300	1379.79	1295.96	1337.88	1471.37	1243.76	1357.57	70.71	68.83	69.77	70.75	68.66	69.71
400	1262.3	1289.93	1276.12	1507.68	1194.67	1351.18	68.00	57.61	62.805	71.67	54.92	63.29
500	1616.91	1099.98	1358.45	1468.6	1277.92	1373.26	70.91	64.00	67.455	69.75	56.42	63.08
Mean	1441.62	1308.895	---	1483.55	1254.99	---	67.12	65.39	---	70.22	60.85	---
F test R. LSD 0.05	F test	R. LSD 0.05		F test	R. LSD 0.05		F test	R. LSD 0.05		F test	R. LSD 0.05	
ZnO NPs	**	126.65		*	126.83		**	0.65		**	1.36	
Cultivars	NS	--------		*	-------		NS	------		**	-----	
Interaction	*	190.32		*	88.80		**	1.22		**	2.13	

Where * and ** mean significant 5 and 1% at level of probability, respectively. NS mean non-significant.

Also, the exhibited data in Table (2) denote that the interaction between ZnO NPs concentrations and sunflower cultivars had a highly significant effect on husking percentage in both seasons. The highest values of husking percentage in the first season (70.91%) was obtained from Giza 102 cultivar which was sprayed by ZnO NPs at 500 ppm while, the highest mean value in the second season (73.92%) was registered from Giza 102 cultivar which was sprayed by ZnO NPs at 200 ppm.

Oil percentage (%) of whole seeds and oil yield.

Illustrated data in Table (3) state that the studied zinc oxide nanoparticles (ZnO NPs) concentrations had a highly significant ($P\leq0.01$) effect on oil percentage in the two growing seasons. Thus, the highest mean values of oil percentage: 41.67 and 42.09 % in the first and second seasons, respectively, were obtained from 300 ppm ZnO NPs concentration. Also, the recorded data in Table (3) denote that the tested sunflower cultivars had a highly significant influence on oil percentage in the both seasons. Whatever, Giza 102 sunflower cultivar superior Sakha 53 one in this respect and gave the highest mean values of oil percentage (41.71 and 41.16% in the first and second seasons, respectively). This is may be ascribed to the superiority of its capability in transformation of sugar to fat in seed tissue.

Table 3. Effect of zinc oxide nanoparticles concentrations, two sunflower cultivars and their interaction on oil percentage % and oil yield (kg/fed.) during 2017, 2018 seasons.

Zinc oxide nanoparticles (ppm)	Oil percentage %						Oil yield (kg/fed.)					
	First season (2017)			Second season (2018)			First season (2017)			Second season (2018)		
	Giza102	Sakha 53	Mean	Giza 102	Sakha 53	Mean	Giza 102	Sakha 53	Mean	Giza 102	Sakha 53	Mean
Control	38.50	38.05	38.28	37.21	36.88	37.05	489.75	450.02	469.89	513.78	420.22	467.00
100	45.40	34.81	40.11	41.09	39.38	40.24	612.29	432.01	522.15	578.52	515.44	546.98
200	40.92	36.27	38.60	42.12	36.63	39.38	723.61	629.97	676.79	701.37	500.25	600.81
300	41.88	41.46	41.67	42.51	41.66	42.09	577.26	537.75	557.51	625.52	518.02	571.77
400	42.08	31.78	36.93	42.49	40.95	41.72	531.09	407.84	469.47	640.37	489.19	564.78
500	41.46	33.78	37.62	41.53	37.68	37.05	669.98	373.06	521.52	610.18	481.77	545.97
Mean	41.71	36.03	-----	41.16	38.86	-----	600.66	471.78	----	611.62	487.48	----
F test R. LSD 0.05	F test	R. LSD 0.05		F test	R. LSD 0.05		F test	R. LSD 0.05		F test	R. LSD 0.05	
ZnO NPs	*	2.37		**	0.49		**	74.96		**	52.65	
Cultivars	*	-----		**	----		*	----		**	----	
Interaction	**	2.98		**	0.85		**	57.11		**	33.90	

Where * and ** mean significant 5 and 1% at level of probability, respectively.

The interaction between ZnO NPs concentrations and sunflower cultivars had a highly significant effect on oil percentage in both seasons. The highest values of oil percentage in the first season (45.40%) was obtained from Giza 102 cultivar which was sprayed by ZnO NPs at 100 ppm, while the highest mean value in the second season (42.51%) was registered from Giza 102 cultivar which was sprayed by ZnO NPs at 300 ppm. The previous results are in accordance with those obtained by Al-Doori (2013).

It is clear from the data in Table (3) that had a highly significant ($P \leq 0.01$) effect on oil yield. Where, the heaviest mean of values of oil yield 676.79 and 600.81 kg/fed in the first and second seasons, respectively, were obtained from 200 ppm ZnO NPs concentration. Data in the same table exhibited that the studied sunflower cultivars had a highly significant influence on oil yield trait. Giza 102 sunflower cultivar superior Sakha 53 one in this respect and gave the highest mean values of oil yield (600.66 and 611.62 kg/fed in the two respective seasons). This is to be logic since the same trend was observed with regard to seed yield and oil percentage traits as mentioned before (Tables 2 and 3). These results are in agreement with those reported by Al-Doori and Al-Dulaimy (2012).

Also, the obtained data in Table (3) revealed that the interaction between ZnO NPs concentrations and sunflower cultivars had a highly significant effect on oil yield. The highest values of oil yield (723.61 and 701.37 kg/fed in the two respective seasons) were obtained from Giza 102 cultivar which was sprayed by ZnO NPs at 200 ppm.

The nutritional characteristics

Chemical composition of sunflower seeds kernels

Chemical composition (g/100g D.W.) of sunflower seeds kernels as affected by foliar spray with zinc oxide nanoparticles are shown in Table (4). The moisture content was ranged from 1.05 for G 500ppm to 5.72% for S 100ppm and S 300ppm samples. The S 400ppm, G 400ppm samples was significantly ($P<0.05$) the highest in oil content (61.75 and 60.19), respectively, comparing with the other studied samples. As sunflower oil seed so using foliar spray caused increasing in oil content until concentration of 400 ppm for two cultivars, which encouraged this treatment. The G 200ppm was higher in protein content with value 23.12% when comparing with the other samples which ranging from 20.52 to 22.95%. Analysis of variance showed that the crude fiber content was increased in treated samples with ZnO concentrations increment, which reached to 12.19, 9.65 for maximum concentration G 500ppm, S 500ppm, respectively, when comparing with its control samples with values 9.09 and 4.78 for G control and S control.

On the other hand the ash content was variable via increase or decrease significantly ($P<0.05$) as affected by foliar spray (Table 4). The ash content was ranged from 3.63 to 4.11 for Giza 102 samples when compared with Sakha 53 samples which ranging from 3.73 to 4.22%. It is clear that Sakha 53 cultivar showed a gradually decreasing in the ash content from S 100ppm (4.22) to S 500ppm (3.84) sample when compared with S control (3.73%).

Table 4. Chemical composition (g/100g D.W.)* of sunflower seeds kernels as affected by foliar spray with zinc oxide nanoparticles (season 2018).

Sample	Moisture	Ash*	Oil*	Protein*	Crude fiber*	Total carbohydrates*	Energy (caloric value) Kcal/100g D.W*
G control	2.32	4.11	58.44	22.79	9.09	5.57	639.40
G 100 ppm	2.28	3.91	58.61	21.61	9.63	6.24	638.89
G 200 ppm	1.99	3.63	58.90	23.12	10.09	4.26	639.62
G 300 ppm	2.58	4.02	60.01	22.59	10.84	2.54	640.61
G 400 ppm	1.92	3.59	60.19	22.43	11.62	2.17	640.11
G 500 ppm	1.05	3.89	58.62	21.79	12.19	3.51	628.78
S control	5.46	3.73	58.49	22.95	4.78	10.05	658.41
S 100 ppm	5.72	4.22	59.27	21.04	5.33	10.14	658.15
S 200 ppm	5.68	4.17	60.40	21.58	6.07	7.78	661.04
S 300 ppm	5.72	4.14	60.43	20.89	7.15	7.39	656.99
S 400 ppm	5.12	4.03	61.75	21.17	8.40	4.65	659.03
S 500 ppm	5.56	3.84	58.89	20.52	9.65	7.10	640.49
LSD 0.05	0.4794	0.0738	0.2745	0.0818	0.0616	0.0336	0.0611

G: Giza 102. S: Sakha 53

There were significant ($P<0.05$) differences in the contents of total carbohydrates (g/100g D.W.), energy (kcal/100g D.W.) with values ranging from 2.17–10.14 and 628.78–661.04, respectively, for the studied cultivars. As a result of changes in oil, protein and total carbohydrates contents the caloric value was decreased or increased in samples under study. The chemical composition results were in accordance with Nadeem *et al*., (2010).

Minerals composition of sunflower kernels

Minerals composition (mg/100g D.W.) of sunflower kernels as affected by foliar spray with zinc oxide nanoparticles are shown in Table (5). The results revealed that Zn content was ranging from 56.92 to 65.36 for G 102 treated samples comparing with 70.34 for G control and the same for Sakha 53 samples. So, Zn content was decreased significantly ($P<0.05$) as a result of foliar spray by ZnO in treated samples when compared with control one. The Mg content was found in higher values ranging from 3471.36 to 4020.05 mg/100g D.W. In Giza 102 samples the Mg amount was significantly ($P<0.05$) decreased gradually in treated samples with range 3471.36 – 3700.10 when compared with 3870.19 mg/100g DW for G control. On the other hand, Sakha 53 treated samples did not follow the same for Mg content which decreased in S 100ppm (3967.20), S 200ppm (3799.54) then increased in S 300ppm (4020.05) and decreased for S 400ppm

(3860.21), S 500ppm (3850.22) when compared with S control (3984.48 mg/100g D.W.).

Table 5. Minerals composition (mg/100g D.W.) of sunflower kernels as affected by foliar spray with zinc oxide nanoparticles (season 2018).

Sample	Zn	Mg	P	Fe	Cu	Mn
G control	70.34	3870.19	1235.90	187.46	28.48	25.90
G 100 ppm	56.92	3700.10	1229.47	174.20	25.70	24.62
G 200 ppm	59.37	3691.52	1230.56	154.24	26.68	24.07
G 300 ppm	62.82	3544.20	1246.04	175.77	24.45	22.45
G 400 ppm	64.35	3522.32	1302.36	190.21	27.12	23.14
G 500 ppm	65.36	3471.36	1295.84	201.36	26.34	24.03
S control	78.55	3984.48	1397.52	175.91	28.71	24.40
S 100 ppm	65.46	3967.20	1258.69	218.38	26.45	22.69
S 200 ppm	65.38	3799.54	1195.73	233.14	27.81	25.40
S 300 ppm	63.07	4020.05	1262.47	181.18	25.01	22.97
S 400 ppm	63.23	3860.21	1306.98	205.41	24.92	23.45
S 500 ppm	64.41	3850.22	1284.36	219.58	26.31	23.68
LSD 0.05	0.133	281.33	0.0897	0.0753	0.0993	0.2527

G: Giza 102. S: Sakha 53

The P content was found to be 1235.90, 1397.52 for G control and S control, respectively. These values are decreased or increased significantly ($P<0.05$) as a result of treatment with ZnO. The same trend was recorded for Fe content which found with range from 154.24 to 233.14 in the studied samples. The Cu content which ranged from 24.45 to 28.71 mg/100g DW was decreased significantly ($P<0.05$) in treated samples when compared with control one for each cultivar. The Mn content was found in range 22.45-25.90 mg/100 g D.W. for the samples under study.

From the above mentioned data we can concluded that the treated samples by ZnO had a reasonable amounts of minerals via increased or decreased comparing with untreated samples and this is good from the nutritional point of view, where these amounts was increased the health benefits of sunflower seeds and encouraged using this treatment. Consequently, the amounts of mineral contents in sunflower seeds kernel under study providing a good percent of the Daily Value requirements for each element. Our results were in agreement with previous studies (Aishwarya and Anisha 2014).

Fatty acid composition of sunflower kernel meal oil.

Fatty acid composition and calculated oxidizability of sunflower kernel meal oil (g/100g oil) are illustrated in Table (6). It could be noticed that the major fatty acids were oleic and linoleic make up more than 90% of the total fatty acids in oil samples under study. The oleic acid content was ranging from 45.34 to 50.16 for G 102 treated samples comparing with 45.22 for G control and the same trend for Sakha 53 samples. So, oleic content was increased as results of foliar spray by ZnO in treated samples when compared with control one. The linoleic acid content was found in higher values ranging from 40.05 to 45.29% mg/100g. Palmitic, stearic as saturated acids were found in lower contents with range 5.17–5.99 and 2.38–2.76%, respectively, for the studied oils (Table 6).

The recorded results showed that the saturated fatty acid content decreased from 9.19% in Giza control to 8.85, 8.87 and 8.96% in Giza 102 cultivar, which was sprayed by ZnO NPs at 300, 400 and 500 ppm, respectively. While the total unsaturated fatty acid content increased from 90.77% in Giza control to 91.15, 90.06 and 90.99% in Giza 102 cultivar which was sprayed by ZnO NPs at 300, 400 and 500ppm, respectively. By the same trend, the saturated fatty acid content decreased from 9.67% in sakha-53 control to 9.02, 8.79and 8.95% in sakha-53 cultivar which was sprayed by ZnO NPs at 300, 400and 500ppm, respectively. Main while, the total unsaturated fatty acid content increased from 90.33% to 90.67, 91.17 and 91.179 and 90.85% in sakha-53 cultivar which was sprayed by ZnO NPs at 300, 400 and 500ppm, respectively. From these data, it could be observed that the rate of decrease in saturated fatty acid content and corresponding increase in unsaturated fatty acid content were markedly in sakha-53 cultivar which was sprayed by ZnO NPs at 300, 400and 500ppm.

Table 6. Fatty acid composition (g fatty acid/100g oil) of sunflower kernel meal (SKM) (season 2018).

Fatty acid (F.A)	Carbon: chain	G Control	G 100ppm	G 200ppm	G 300ppm	G 400ppm	G 500ppm	S Control	S 100ppm	S 200ppm	S 300ppm	S 400ppm	S 500ppm
Palmitic	16:0	5.90	5.81	5.81	5.17	5.56	5.19	5.99	5.81	5.80	5.29	5.51	5.26
Heptadecanoic	17:0	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.06	0.09	0.08	0.06	0.06
Stearic	18:0	2.53	2.58	2.65	2.56	2.38	2.62	2.76	2.49	2.61	2.60	2.44	2.55
Arachidic	20:0	0.19	0.19	0.21	0.22	0.19	0.21	0.19	0.20	0.22	0.22	0.20	0.21
Behenic	22:0	0.53	0.58	0.52	0.73	0.59	0.63	0.60	0.64	0.53	0.71	0.58	0.62
Lignoceric	24:0	ND	0.08	0.11	0.13	0.11	0.27	0.09	0.11	0.09	0.12	ND	0.25
Total saturated		9.19	9.28	9.34	8.85	8.87	8.96	9.67	9.31	9.34	9.02	8.79	8.95
Plmitoleic	16:1	0.16	0.16	0.17	0.17	0.16	0.16	0.15	0.16	0.17	0.19	0.20	0.19
Heptadecenoic	17:1	0.05	0.04	0.05	0.04	0.04	0.05	0.05	0.05	0.06	0.05	0.06	0.06
Oleic	18:1	45.22	48.46	50.14	50.16	45.34	49.52	44.89	48.21	49.69	50.15	45.56	50.12
Linoleic	18:2	45.14	41.79	40.05	40.54	45.29	40.99	45.03	41.10	40.18	40.05	45.12	40.23
Linolenic	18:3	0.05	0.03	0.04	0.03	0.04	0.07	0.04	0.03	0.04	0.03	0.04	0.05
Gadoleic	20:1	0.15	0.17	0.16	0.21	0.19	0.20	0.17	0.17	0.18	0.20	0.19	0.20
Total uns.		90.77	90.65	90.61	91.15	91.06	90.99	90.33	89.72	90.32	90.67	91.17	90.85
T.s./ T. uns		0.101	0.102	0.103	0.097	0.097	0.098	0.107	0.104	0.103	0.099	0.096	0.099
Cox		5.11	4.80	4.64	4.68	5.13	4.73	5.10	4.72	4.64	4.63	5.11	4.66

G: Giza 102. S: Sakha 53. Cox: Calculated oxidizability value.

The data in the same Table (6) illustrated the calculated oxidizability of sunflower kernel meal oil owing to the high proportion of unsaturated fatty acids in sunflower kernel meal oil, it could be noticed that the concentration of 400 ppm had the greatest calculated oxidizability in Giza and sakha cultivars. The effect of using ZnO nanoparticles resulted in a little increased or decreased Cox, which is calculated based on USFAs percentages, so the sunflower oil samples is almost stable against rancidity and it could be used for protection of vegetable oils against oxidative deterioration. The results are in accordance with previous studies (Canibe *et al.,* 2007, and Aishwarya and Anisha 2014).

Chemical composition and cake yield of defatted sunflower kernels (cake) treated by foliar spray with zinc oxide nanoparticles.

The chemical composition and cake yield of defatted sunflower seeds are illustrated in Table (7). From these results it could be noticed that the ash, oil contents were ranging 7.10–8.59 and 2.68–3.91, respectively, for the studied samples. The protein, crude fiber content were found in a higher contents ranging 49.29–52.95, 7.11–15.22, respectively, for defatted samples.

The G 200ppm recorded the highest value of protein (52.95%) among the other samples, while the G 500ppm was the highest in crude fiber content (15.22%). Total carbohydrates and caloric value were found in reasonable contents with ranging 22.22–29.74 g/100g D.W. and 329.84–355.34 kcal/100g D.W., respectively, for studied samples. Defatted sunflower seeds kernel meal or cake obtained from oil extraction are mainly used as a feed ingredient for domestic animals or is composted. The cake yield for the studied samples was found to be decreased in treated samples comparing with control for both two cultivars Giza 102 and Sakha 53. It ranged from 38.25 to 41.56 for all the samples. From the above mentioned data in Table (7), besides comparing it with data in Table (4) it could be concluded that there was a highly significant difference ($P<0.05$) in the crude protein, crude lipid, caloric value contents of the undefattted and defatted sample of sunflower seed kernel via increase or decrease. Also, defatting the sunflower seed kernel increased the crude fiber, ash, carbohydrates with reasonable amounts when compared with undefatted samples.

Table 7. Chemical composition (g/100g D.W.) of defatted sunflower kernels (meal) as affected by foliar spray with zinc oxide nanoparticles (season 2018).

Sample	Ash	Oil	Protein	Crude fiber	Total carbohydrates	Energy (caloric value) Kcal/100g D.W)	Cake yield
G control	8.23	2.68	51.89	12.75	24.45	329.84	41.56
G 100 ppm	7.77	2.97	50.41	12.96	25.89	331.93	41.39
G 200 ppm	7.10	2.86	52.95	13.42	23.67	332.22	41.10
G 300 ppm	8.47	3.68	51.46	13.59	22.80	330.16	39.99
G 400 ppm	7.27	3.91	51.92	14.68	22.22	331.75	39.81
G 500 ppm	7.54	2.85	50.96	15.22	23.43	323.21	41.38
S control	7.78	2.98	52.57	7.11	29.56	355.34	41.51
S 100 ppm	8.37	3.12	50.62	8.15	29.74	349.52	40.73
S 200 ppm	8.59	3.36	50.39	8.97	28.69	346.56	39.60
S 300 ppm	8.53	3.56	49.92	9.42	28.57	346.00	39.57
S 400 ppm	8.22	3.75	50.96	10.38	26.69	344.35	38.25
S 500 ppm	7.62	3.19	49.29	12.49	27.41	335.51	41.11
LSD 0.05	0.0773	0.2841	0.2736	0.0717	0.1576	0.1038	0.29

G: Giza 102. S: Sakha 53

Minerals composition of defatted sunflower kernels (cake) treated by foliar spray with zinc oxide nanoparticles.

The mineral composition of defatted control and treated samples with ZnO nanoparticles are shown in Table (8). It is clear that between the treated samples and control there were significant differences ($P<0.05$) in the mineral composition. The magnesium and phosphorus were the most abundant minerals in defatted sunflower kernels meal with the highest concentration comparing with other studied minerals. The defatted sunflower kernels meal or cake contained significant amounts of important minerals (Table 8). The Magnesium concentration (8318.27; 7957.38) was the highest, followed in descending order by Phosphorus (5959.00; 6529.88), Iron (295.12; 239.06), Zinc (145.36; 151.41), Cupper (57.43; 56.16) Manganese (53.97; 48.65 mg/100g dry weight) for the G control and S control samples, respectively. Although, there is almost a decrease in minerals contents in defatted treated samples comparing with control, it still has a superior source for these minerals.

Table 8. Minerals composition (mg/100g D.W.) of defatted sunflower kernels (cake) as affected by foliar spray with zinc oxide nanoparticles (season 2018).

Sample	Zn	Mg	P	Fe	Cu	Mn
G control	145.36	8318.27	5959.00	295.12	57.43	53.97
G 100 ppm	131.01	8296.35	4930.11	293.31	51.39	49.54
G 200 ppm	120.13	8201.54	4884.43	286.94	44.75	41.75
G 300 ppm	104.43	8105.12	5505.60	272.56	40.15	35.90
G 400 ppm	112.36	8076.98	5827.34	300.14	43.27	42.79
G 500 ppm	120.36	7805.34	5494.69	304.71	45.96	44.68
S control	151.41	7957.38	6529.88	329.06	56.16	48.65
S 100 ppm	145.69	7861.14	3601.29	334.24	53.21	47.78
S 200 ppm	128.83	7770.14	4471.98	337.56	50.84	48.96
S 300 ppm	112.25	7882.56	4019.08	326.35	48.47	46.32
S 400 ppm	120.78	7995.64	4392.28	330.98	52.32	45.12
S 500 ppm	136.42	7870.12	4508.40	336.32	50.85	46.50
LSD 0.05	0.0418	0.0288	18.648	0.0728	0.0574	0.5924

G: Giza 102. S: Sakha 53

Sensory attributes and physical evaluation of ball bread made from wheat flour and its mixtures with defatted sunflower kernel meal (DSKM)

Table (9) illustrated that ball bread made from sunflower meal gave good results in terms of color weight and volume at a replacement ratio of 5% comparing to the control bread. In 5% bread the volume was increased, after that it decreased with increment of the substitution ratio until 20% bread. In supplemented bread the loaf weight was increased with range 138.46–147.83 g when compared with control 137.84g. The taste appears clear in 20% bread but is somewhat acceptable. Loaf volumes of ball breads fortified with 10 %, 15 and 20 % were significantly ($P<0.05$) decreased with range 346.00-398.00 when comparing to control with value 406.00 ml. consequently specific volume was increased in 5% DSKM bread then decreased in other replacement ratio 10, 15and 20% comparing to control bread. Decreasing of volume because of gluten network structure was mechanically disrupted by the DSKM particles or fiber and gluten was diluted (Petterson and Crosbie 1989). Crust color, crumb color, taste and texture were found to be appealing by most people who tried DSKMG-wheat breads. The mean score for these characteristics show that the protein sources are favorable supplements especially at 5 percent level. In the end, there is general acceptance of all samples of the bread under study.

Chemical composition of ball bread made from wheat flour and its mixtures with defatted sunflower kernel meal (DSKM)

The chemical composition of the supplemented ball bread is presented in Table (10). From these data it is obviously that the protein, crude fiber and ash contents increased significantly ($P<0.05$) in replacement bread when compared with WF100% bread. In Addition the bread made from treated sample with ZnO 400ppm showed higher contents in the above components comparing with counterparts in bread made with replacement with untreated sample, which confirm the importance of using ZnO nanoparticles treatment. The crude protein, crude fiber, ash contents in replacement breads were ranging 13.92-20.05%, 1.56-3.67%, 1.68-2.71% comparing with 13.13, 0.93 and 1.42%, respectively, for control. Total carbohydrates, energy contents were decreased significantly ($P<0.05$) in all supplemented bread with range 70.03-79.43, 393.30-405.62 when compared to control with values 81.05% and 407.95 kcal/100 g D.W., respectively. So, increasing defatted sunflower kernel meal ratio can be good for improving the nutritional quality of ball bread.

Table 9. Sensory properties and physical evaluation of ball bread made from wheat flour and its mixtures with defatted sunflower kernel meal (DSKM) (season 2018).

Bread sample	Crust color	Crumb		Texture	Taste	Odor	Total score	Physical evaluation		
		Color	Graining					Volume (ml)	Weight (g)	Specific volume (ml/g)
	(10)	(10)	(10)	(10)	(10)	(10)	(60)			
WF100% (Control)	9.00	9.00	9.30	9.20	9.20	9.00	54.70	406.00	137.84	2.95
WF 95% + 5%DSKMG	9.20	8.90	9.30	9.20	9.00	8.80	54.40	413.00	138.46	2.98
WF 90% + 10%DSKMG	9.00	8.70	8.60	9.00	8.60	8.40	52.30	390.00	140.01	2.79
WF 85% + 15%DSKMG	8.40	8.20	8.40	8.40	8.20	8.00	49.60	376.00	145.81	2.58
WF 80% + 20%DSKMG	8.00	8.00	8.00	8.00	7.50	7.40	46.90	346.00	146.92	2.36
WF 95% + 5%DSKMG400	9.20	8.80	9.30	9.10	9.00	8.70	54.10	415.00	139.83	2.97
WF 90% + 10%DSKMG400	9.00	8.50	8.50	9.00	8.50	8.50	52.00	398.00	141.50	2.81
WF 85% + 15%DSKMG400	8.5	8.20	8.20	8.20	8.00	8.00	49.10	386.00	143.06	2.70
WF 80% + 20%DSKMG400	8.00	8.00	8.00	8.00	7.30	7.50	46.80	350.00	147.83	2.37
LSD 0.05	0.2369	0.0519	0.0587	0.0547	0.0635	0.0977	0.104	2.9985	0.0666	0.174

WF: Wheat flour. DSKMG: Defatted sunflower kernel meal Giza 102. DSKMG400: Defatted sunflower kernel meal Giza 400ppm.

Table 10. Chemical composition (g/100g D.W.)* of ball bread made from wheat flour (72% extraction) and its mixtures with defatted sunflower kernel meal (DSKM) (season 2018).

Bread samples	Moisture	Ash*	Oil*	Protein*	Crude fiber*	Total carbohydrates*	Energy* (Kcal/100 g)
WF100% (Control)	33.60	1.42	3.47	13.13	0.93	81.05	407.95
WF 95% + 5%DSKMG	33.99	1.73	3.36	13.92	1.56	79.43	403.64
WF 90% + 10%DSKMG	34.00	2.08	3.58	15.07	2.10	77.17	401.18
WF 85% + 15%DSKMG	33.04	2.27	3.69	17.81	2.86	73.37	397.93
WF 80% + 20%DSKMG	35.64	2.71	3.50	20.05	3.34	70.40	393.30
WF 95% + 5%DSKMG400	31.95	1.68	3.74	13.95	1.59	79.04	405.62
WF 90% + 10%DSKMG400	33.31	1.95	3.72	15.82	2.30	76.21	401.60
WF 85% + 15%DSKMG400	34.11	2.26	4.06	17.92	2.89	72.87	399.70
WF 80% + 20%DSKMG400	35.88	2.46	3.97	19.87	3.67	70.03	395.33
LSD 0.05	0.0813	0.0755	0.0836	0.0586	0.3835	17.644	0.3131

WF: Wheat flour. DSKMG: Defatted sunflower kernel meal Giza 102. DSKMG400: Defatted sunflower kernel meal Giza 400ppm.

Mineral composition of ball bread made from wheat flour and its mixtures with defatted sunflower kernel meal (DSKM)

The mineral composition of studied bread samples are shown in Table (11). There were significant differences ($P<0.05$) in the mineral composition between the replacement breads and control. The magnesium and phosphorus concentrations were higher in sunflower breads with ranging 466.07-1427.70, 374.01-1073.17 comparing to 33.58 and 138.66 for control one, respectively. By the way for other studied minerals (Fe, Zn, Cu, Mn) in Table (13) the replacement breads contained higher amounts when compared with WF100% bread. This increase in minerals content in the replacement bread by DSKM due to that defatted sunflower kernels meal or cake contained significant amounts of important minerals as previously shown in Table (10). So, defatted meal or cake was found as a nutritional material, good source of minerals, convenient for human nutrition which produces high acceptability bread comparable to control for 5, 10 and 15% replacement ratio. Our results for sensory properties, chemical and minerals composition of resulted bread are comparable with some previous studies in this field (Skrbic and Filipcev 2008, Anjum *et al.,* 2012).

Table 11. Mineral composition (mg/100 D.W.) of ball bread made from wheat flour (72% extraction) and its mixtures with defatted sunflower kernel meal (DSKM) (season 2018).

Bread samples	Zn	Mg	Fe	P	Cu	Mn
WF100% (Control)	1.32	33.58	2.75	138.66	0.70	0.44
WF 95% + 5%DSKMG	6.96	476.91	13.98	379.94	2.86	2.84
WF 90% + 10%DSKMG	11.98	751.86	23.92	570.85	5.28	5.66
WF 85% + 15%DSKMG	18.87	1179.78	36.97	840.10	7.11	6.81
WF 80% + 20%DSKMG	24.85	1427.70	47.74	1073.17	9.39	9.04
WF 95% + 5%DSKMG400	5.48	466.07	14.20	374.01	2.22	2.30
WF 90% + 10%DSKMG400	9.34	732.56	24.60	560.31	3.97	4.16
WF 85% + 15%DSKMG400	14.28	950.84	38.76	878.82	5.42	5.46
WF 80% + 20%DSKMG400	18.31	1312.69	48.55	1016.10	7.13	7.15
LSD 0.05	0.0589	0.0675	0.0973	99.933	0.0962	0.3589

DSKMG: Defatted sunflower kernel meal Giza 102. DSKMS: Defatted sunflower kernel meal Giza 400 ppm

CONCLUSION

From the study results it could be noticed that the zinc oxide nanoparticles (ZnO NPs) concentrations had a significant and highly significant effect on all mentioned traits in the two growing seasons. Giza 102 sunflower cultivar superior Sakha 53 one, this is may be due to the genetic behavior in combination with the environmental conditions which was suitable for Giza 102 cultivar than Sakha 53 one. The concentration of 200 ppm zinc oxide nanoparticles the highest values of seed yield (1751.99 and 1515.18 kg/fed.) and oil yield (676.79 and 600.81 kg/fed.) in the two seasons, respectively. On the other hand 300 ppm concentration gave the highest husking percentage (69.77 and 69.71%), and oil percentage (41.67 and 42.09%) and seed oil/fed. As a sunflower oilseed so using foliar spray caused increasing in oil content until concentration 400 ppm for two cultivars. The treated samples by ZnO had a reasonable amounts of minerals via increased or decreased comparing with untreated samples and this is good from the nutritional point of view, where these amounts was increased the health benefits of sunflower seeds and encouraged using this treatment. The defatted sunflower kernels meal or cake contained significant amounts of important minerals. Consequently, the amounts of mineral contents in sunflower seeds kernel or cake under study providing a good percent of the Daily Value requirements for each element. Defatted sunflower seeds kernel meal or cake obtained from oil extraction are mainly used as a feed ingredient for domestic animals or is composted. The bread made from treated sample with ZnO 400ppm showed higher contents in the nutritional components comparing with counterparts in bread made with replacement with untreated sample, which confirm the importance of using ZnO nanoparticles treatment. Crust color, crumb color, taste and texture were found to be appealing by most people who tried supplemented wheat breads. The mean score for these characteristics show that the protein sources are favorable supplements especially at 5 percent level. In the end, there is general acceptance of all samples of the bread under study. In addition, increasing defatted sunflower kernel meal ratio can be good for improving the nutritional quality of ball bread.

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الخصائص المحصولية والجودة الغذائية والتكنولوجية لبذور عباد الشمس ومدى تأثرها بالرش الورقي بواسطة جزيئات أكسيد الزنك النانومترية

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البحث الحالي يهدف الى دراسة تأثير الرش الورقي بتركيزات مختلفة من جزيئات أكسيد الزنك النانومترية (0 ، 100 ، 200 ، 300 ، 400 و 500 جزء في المليون) من صنفين من عباد الشمس على الخصائص الزراعية (مواسم 2017 ، 2018) والتركيب الغذائي (موسم 2018) . أعطى تركيز 200 جزء فى المليون من جزيئات أكسيد الزنك النانومترية أعلى محصول بذور (1751.99 و 1515.18 كجم/فدان) ومحصول الزيت (676.79 و 600.81%). وقد أعطى تركيز 300 جزء فى المليون أعلى قيمة لصفة التقشير (69.77 و 69.71%) وصفة النسبة المئوية للزيت بالبذور (41.67 و 42.09%) فى موسمى التجربة على التوالى. كان لأصناف عباد الشمس المختبرة تأثير كبير على محصول البذور للفدان ونسبة التقشير ونسبة الزيت ومحصول الزيت وقد أعطى الصنف جيزة 102 أعلى القيم في الموسمين. أظهرت نتائج التركيب الكيميائي (جرام لكل 100 جرام وزن جاف) لبذور عباد الشمس أن عينات S 400ppm ، G 400ppm كانت أعلى فى محتوى الزيت بنسب 61.75٪ و 60.19٪، على التوالي مقارنة مع العينات الأخرى المدروسة. كان G 200ppm أعلى في محتوى البروتين بقيمة 23.12 ٪ عند مقارنته مع العينات الأخرى التي تتراوح بين 20.52 إلى 22.95 ٪. بالنسبة لتركيب المعادن (ملليجرام لكل 100 جرام وزن جاف) انخفض محتوى الزنك بشكل معنوى ملحوظ نتيجة للرش الورقي بواسطة أكسيد الزنك في العينات المعاملة عند مقارنتها مع العينة الكنترول. ولقد تواجد الماغنسيوم بقيم مرتفعة تتراوح بين 3471.36 إلى 4020.05 ملغم / 100 جم وزن جاف. كانت الأحماض الدهنية الرئيسية في زيت نواة عباد الشمس الأوليك واللينوليك حيث تشكل أكثر من 90 ٪ من إجمالي الأحماض الدهنية. بالنسبة لعينات نواة عباد الشمس منزوعة الدهن ، تواجدت فيها نسب مرتفعة من كلا البروتين والالياف بنسب تتراوح بين 49.29 - 52.95٪ ، 7.11 - 15.22٪، على التوالي. ولقد تواجد الماغنيسيوم والفوسفور بكميات كبيرة فى نواة بذرة عباد الشمس المنزوعة الدهن مقارنة بالمعادن الاخرى التى شملتها الدراسة. أعطى الخبز الكروي المصنوع من دقيق القمح مع نواة عباد الشمس منزوعة الدهن نتائج جيدة بشكل عام. ولذلك تعتبر مطحون البذور منزوع الدهن كمادة غذائية ذات مصدر جيد للمعادن ، ومناسبة لتغذية الإنسان حيث نتج عنها خبز ذو قابلية عالية عند نسب الاستبدال 5 و 10 و 15 ٪ وذلك بالمقارنة بالخبز الكنترول.