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Changes in some physiological and biochemical parameters of lupine plant via two bio-stimulant yeast extract and folic acid

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Abstract: The physiological responses of foliar spraying using yeast extract and folic acid were examined on Egyptian lupine. Foliar application with yeast extract (1%, 2%, 3%) and folic acid (1mM, 2mM, 3mM) were applied in two field experiments conducted at Nubaria research station, National Research Centre, Egypt during two growing seasons of 2020/2021 and 2021/2022. However, results indicated that all applied treatments caused significant increases in most of vegetative growth criteria, photosynthetic pigments, indole acetic acid, seed yield and its components and some nutritional value of the yielded seeds (oil content, total carbohydrate, total phenolic content, flavonoids, antioxidant activity), and fatty acid composition of the yielded lupine oils. Yeast extract at 1% and folic acid at 3mM recorded the least value of all examined parameters. It can be concluded that applied yeast extract were more effective than applied folic acid. Moreover, yeast extract at 3% (the most optimum treatments) and folic acid at 2mM resulted in the higher quality of the yielded lupine oil.

Keywords: *Lupinus termis* L; Biostimulant; Biofertilizer, Vitamins; Yeast.

1. Introduction

Lupine (*Lupinus termis* L) is developed in a wide range of environments and is utilized for human food, ruminant feed and medicinal uses. Lupine seeds include both nutritive and functional components as lipids, proteins, carbohydrates, carotenoids, tocopherols, polyphenols, and dietary fibers (Sujak et al. 2006). Recently, bio-stimulants such as yeast extract and vitamins can be utilized as a natural, simple, and inexpensive organic bio-fertilizer to boost plant efficiency and maintain its nutrients and promote plant growth, quality, and productivity.

Yeast contains significant levels of protein, carbohydrates, reducing sugars, amino acids, enzymes, mineral elements (N, P, K, Mg, Ca, Na, Mn, Zn, Cu, B, and Mo), and a natural source of many growth substances (thiamine, riboflavin, niacin, pyridoxine, and vitamins B1, B2, B3, and B12) (Marzauk *et al*. 2014; Abdelaal *et al*. 2017). Yeast extract acts as a natural biological stimulant that improves the growth and yield of different crops (Abbas 2013, Dawood *et al*. 2013; Mahmoud *et al*. 2016). The effective influence of yeast may be attributed to its effect on enzymatic activity**, i.e.** Yeo *et al*. (2000) reported that yeast extract contains trehalose-6-phosphate synthase that is considered a key enzyme in trehalose biosynthesis. They speculated that trehalose biosynthesis influences not only plant

development but also improves plant abiotic stress tolerance. Furthermore, the conversion of phosphorus from insoluble to soluble, the synthesis of numerous plant hormones, and the improvement of nutrient absorption, all of these factors boost the plants biochemical contents (Abbas 2013). Additionally, beneficial effect of yeast extract on plant growth could be related to direct or indirect capability of yeast to change the pH of the soil around the roots and thereby allow nutrients to be absorbed to enhance plant growth (Amadi 1991). Also, yeast extract exerts stimulatory impact on cell division and enlargement, and on biosynthesis of protein, nucleic acid and chlorophyll as demonstrated by Ibrahim (2014), Mahmoud *et al*. (2016).

Folic acid (vitamin B9) is one of the most prominent B complex vitamins and composed of pteridine nuclei, para-aminobenzoic acid and glutamic acid (Babarabie *et al*. 2020). Exogenous administration of vitamins had a significant impact on plant growth regulating factors, which influenced several physiological processes and protected the plant from the adverse effects of environmental stress (Sadak and Dawood 2014, El-Awadi et al. 2016).Vitamins aid in the capture of free radicals or active oxygen species that are created during photosynthesis and respiration (Fard *et al.* 2008). In addition, Smith *et al*. (2007) illustrated that most vitamins work as cofactors for a number of enzymes.

Human cells are unable to synthesize folic acid; hence it is obtained primarily from plants. Exogenous administration of folic acid, which is a natural and environmentally safe material, can enhance a variety of morphological, physiological, and biochemical processes in plants, resulting in increased energy and nutritional reserves, which improves plant growth and development (Omar *et al*., 2020). As such as, some studies recorded that growth, yield, and quality of faba beans have been improved using folic acid (Dawood *et al*. 2019 a)**,** snap beans (Ibrahim *et al*. 2021). In addition, folic acid is considered as a natural antioxidant and growth regulator in plants (Kołton *et al*. 2022, Selem *et al*. 2022).

The current investigation aimed to study the effect of two bio-stimulants yeast extract and folic acid on growth, yield and quality characters of lupine plants under sandy soil.

2. Materials and Methods

2.1. Yeast extract preparation

The yeast extract was prepared by combining 30 g of commercial yeast with one liter of warm water, two table spoons of sugar to activate the yeast, and letting it sit for 24 hours before filtering through a piece of cloth. Dilution of aqueous extract was done to obtain 1%, 2%, 3% yeast extract.

2.2. Experimental procedure

Two field experiments were carried out at Nubaria research station, National Research Centre, Egypt during two growing seasons of 2020/2021 and 2021/2022 using foliar application with yeast extract (1%, 2%, and 3%) and folic acid (1mM, 2mM, 3mM). Lupine seeds (Cultivar Giza 2) were obtained from Agriculture Research Center, Giza, Egypt. A complete randomized block design with three replicates was used. The experimental area was divided to seven plots, as one plot for each treatment. Each plot was ridged, four meters long, 50 cm apart, and hills were spaced at 20 cm distance, and three seeds were planted in each hill. At 21 DAS, the plants were reduced to one plant per hill. Preparation of soil, application of fertilizer and different cultural operations followed the usual techniques of lupine cultivation in this land area. Plants were sprayed with different concentrations of yeast extract and folic acid at 30 and 60 days after sowing (DAS).

Photo 1 : Egyptian Lupin plant and seeds

2.3. Vegetative growth parameters

In order to analyze the plant morphological characteristics at the age of 75 days after sowing, a random sample of ten plants was given for examination in each plot; a total of 30 plants were fixed for each treatment to determine shoot height, number of leaves and branches / plant, stem fresh and dry weight / plant, leaves fresh and dry weight / plant. Furthermore, photosynthetic pigments and indole acetic acid (IAA) were estimated in fresh leaf tissues.

2.4. Seed yield and yield characters

At harvest time, ten plants from each plot were chosen randomly to measure the number of pods and seeds produced per plant, the weight of the pods and seeds were expressed as g/ plant **(Table 5)**, the yield of straw produced per plant (g), and the yield of seeds (Kg/Feddan).

2.5. Biochemical studies

The method of Sumanta *et al*. (2014) method was used to measure the photosynthetic pigments in the fresh leaf tissues at 75 days after sowing. The method of Larsen *et al*. (1962) was used to extract and analyze indole acetic acid content. The process described by A.O.A.C (1990) was used to determine the oil content of the yielded seeds. The resulting defatted meal was used for determination of carbohydrates, phenolic content, flavonoide and antioxidant activity. According to DuBois *et al*. (1956), reducing sugars were estimated. The method described by Tavarini *et al*. (2008) was used to extract and measure the total phenolic content. According to Ordoez *et al*. (2006), the aluminium chloride colorimetric assay was used to estimate the total flavonoid content. According to Brand-Williams *et al*. (1995), the free radical scavenging activity was assessed using the 1.1-diphenyl-2-picrylhydrazil (DPPH) reagent. According to Harborne (1984), methyl esters of fatty acids were produced from an aliquot of total lipid. Identification and quantitative determination of fatty acid were performed using Gas Liquid Chromatography

2.5. Statistical analysis

According to Silva and Azevedo (2016), least significant differences (L.S.D.) at the 5% level of probability were used to determine the analysis of variance and differences between means.

2. Results

3.1. Vegetative growth parameters

The effect of both yeast extract (1%, 2%, 3%) and folic acid (1mM, 2 mM, 3mM) on growth criteria of lupine plants grown under sandy soil is shown in Table (1). Yeast extract and folic acid at different concentration significantly increased fresh and dry weight of stem and leaves/plant relative

to control. It was noted that the promotive effect of yeast extract was in direct proportional with the yeast concentration where 3% yeast extract was the most optimum treatment. The promotive effect of folic acid at 2mM was higher than 1mM and 3mM folic acid. Generally, yeast extract treatments were more effective than folic acid treatments.

Table (1): Effect of yeast extract and folic acid treatments on vegetative growth parameters of lupine plants

Treatments	Shoot height (cm)	Branches / plant	Leaves / plant	Stem fresh weight/ Plant (g)	Leaves fresh weight/ plant (g)	Stem dry weight/ Plant (g)	Leaves dry weight /plant (g)
Control	36.00^{e} ±1.00	3.33^{c} ±0.58	21.67^{d} ±1.53	7.86^{e} ±0.47	5.677^{e} C0.33	1.123^{e} ±0.068	0.811^{e} ±0.47
Yeast extract (1 %)	39.00^{cd} ±1.00	4.00^{bc} ±0.00	25.33^{bc} ±3.51	9.90^{cd} ±0.17	8.457^{b} ±0.60	1.414^{cd} ±0.024	1.208^{b} ±0.086
Yeast extract (2 %)	42.67^{b} ±1.53	4.33^{ab} ±0.58	26.33^{bc} ±1.53	10.86^{bc} ±0.50	9.930^{a} ±0.57	1.551^{bc} ±0.071	1.419^{a} ±0.081
Yeast extract (3 %)	45.00^{a} ±1.00	5.00^{a} ±0.00	32.67^{a} ±1.53	11.96^{a} ±0.30	10.513^{a} ±0.70	1.709^{a} ±0.042	1.502^{a} ±0.034
Folic acid (1 mM)	38.58^{cd} ±1.66	3.33^{c} ±0.58	23.00^{cd} ±2.00	10.75^{bc} ±0.24	6.473^{d} ±01.38	1.536^{bc} ±0.035	0.925^{d} ±0.054
Folic acid (2 mM)	40.33^{c} ±0.58	4.33^{ab} ±0.58	26.67^{b} ±2.08	11.57^{ab} ±0.21	7.347^{c} ±0.82	1.653^{ab} ±0.030	1.050^{c} ±0.053
Folic acid (3 mM)	37.25^{de} ±0.43	3.33^{c} ±0.58	23.00^{cd} ±1.00	9.60^{d} ±0.63	6.493^{d} ±0.22	1.372^{d} ±0.090	0.928^{d} ±0.031

3.2. Photosynthetic pigments

Table (2) shows that there were a markedly increases in all components of photosynthetic pigments achieved with all applied treatments. Yeast extract at all concentrations significantly increased total photosynthetic pigments relative to control. Since, 3% yeast extract significantly increased total photosynthetic pigments by 85.56% relative to control. On the other hand, 2mM folic acid significantly increased the total photosynthetic pigments by 25.77% relative to control. Moreover, the most optimum treatment achieved with 3% yeast extract and yeast extract was more effective than folic acid. Table (2) also, shows that all applied treatments significantly increased IAA content relative to control. Yeast extract at 3% significantly increased IAA by 54.86%, followed by folic acid at 2mM that caused significant increase in IAA by 48.31%.

Table (2): Effect of yeast extract and folic acid treatments on photosynthetic pigments and IAA of lupine leaf tissues

Treatments	Chlorophyll A	Chlorophyll B	Carotenoids	Total photosynthetic pigments	IAA
	mg/g fresh weight				Ug/g fresh weight
Control	0.649^{d} ±0.01	0.253^{d} ±0.00	0.082^{c} ±0.01	0.971^{c} ±0.02	25.79^{e} ±0.17
Yeast extract (1 %)	0.897^{bc} ±0.11	0.294^{bc} ±0.03	0.115^{b} ±0.01	1.278^{b} ±0.14	35.82^{c} ±0.20
Yeast extract (2 %)	0.920^{b} ±0.06	0.318^{b} ±0.02	0.111^{b} ±0.02	1.308^{b} ±0.11	37.87^{b} ±0.75
Yeast extract (3 %)	1.289^{a} ±0.17	0.392^{a} ±0.05	0.164^{a} ±0.02	1.802^{a} ±0.23	39.94^{a} ±0.32
Folic acid (1 mM)	0.829^{bc} ±0.04	0.252^{d} ±0.01	0.108^{b} ±0.01	1.158^{bc} ±1.05	33.73^{d} ±0.11
Folic acid (2 mM)	0.865^{bc} ±0.03	0.276^{cd} ±0.01	0.115^{b} ±0.01	1.224^{b} ±1.04	38.25^{b} ±0.40
Folic acid (3 mM)	0.777^{cd} ±0.03	0.268cd ±0.00	0.101^{bc} ±1.00	1.121^{bc} ±0.03	36.10^{c} ±0.48

3.3. Seed yield and its components

Table (3) shows that there were a markedly increases in seed yield and yield components relative to control achieved with all applied treatments. The enhancement effect of yeast extract at 2% and 3% was more pronounced than the enhancement effect of folic acid at 1 mM and 2mM. The minimum increases in seed yield and yield components were recorded due to 1%yeast extract and 3 mM folic acid. Notably, yeast extract at 2% and 3% significantly increased seed yield/feddan by 42.57% and 47.78% respectively followed by folic acid at 1 mM and 2 mM by 25.19% and 38.33% respectively relative to control. Other else, the most optimum treatment achieved with 3% yeast extract and yeast extract was more effective than folic acid.

Table (3): Effect of yeast extract and folic acid treatments on seed yield and yield components of lupine plants

Treatments	Pods / plant	Pods weight/ plant (g)	Seeds /plant	Seed yield/plant (g)	100 Seed Weight (g)	Straw weight/plant (g)	Seed yield (Kg/feddan)
Control	13.57^{d} ±0.50	17.09^{d} ±0.93	26.60^{b} ±0.70	9.22^{c} ±0.06	26.24^{b} ±0.48	3.06^{b} ±0.50	774.49^{c} ±13.03
Yeast extract (1 %)	14.12^{d} ±0.52	19.60^{cd} ±0.14	34.54^{ab} ±1.29	10.53^{bc} ±0.34	32.26^{ab} ±0.88	8.59^{ab} ±1.73	884.72^{b} ^{c}±13.88
Yeast extract (2 %)	16.70^{ab} ±0.3	24.11^{b} ±0.64	37.71^{ab} ±1.04	13.15^{a} ±0.09	41.57^{ab} ±1.61	12.43^{a} ±1.34	1104.22^{a} ±5.37
Yeast extract (3 %)	17.43^{a} ±0.7	29.31^{a} ±1.10	42.98^{a} ±0.96	13.63^{a} ±0.42	50.50^{a} ±1.54	13.78^{a} ±1.39	1144.56^{a} ±19.15
Folic acid (1 mM)	15.27^{c} ±0.63	21.89^{bc} ±0.62	30.25^{b} ±0.40	11.54^{abc} ±0.40	31.65^{ab} ±0.26	7.93^{ab} ±0.70	969.61^{abc} ±34.05
Folic acid (2 mM)	15.65^{bc} ±0.36	21.99^{bc} ±0.33	35.93^{ab} ±0.29	12.76^{ab} ±0.52	34.92^{ab} ±1.12	9.79^{ab} ±0.74	1071.39^{ab} ±28.57
Folic acid (3 mM)	13.94^{d} ±0.86	19.16^{cd} ±0.71	33.49^{ab} ±1.41	9.85^{c} ±0.12	30.57^{ab} ±0.22	3.30^{b} ±0.79	827.12 ^{c}±25.53

3.4. Biochemical composition of the yielded seeds

Table (4) shows the effect of yeast extract and folic acid treatments on the nutritive value of the yielded lupine seeds. All applied treatments caused significant increases in oil and carbohydrate content of the yielded seeds. In addition, promotive effect of yeast extract treatments was more pronounced than that of folic acid treatments. 3% yeast extract was the optimum treatment followed by 2mM folic acid. Regarding antioxidant substances, all applied treatments significantly increased total phenolic content, flavonoid and antioxidant activity of the yielded seeds. It was noted that the significant increases in phenolic content resulted from folic acid treatments were more than that due to yeast extract. Meanwhile, the promotive role of all applied treatments on flavonoid was approximately similar. The changes in antioxidant activity due to folic acid treatments at 2mM and 3mM were higher than that due to 3% yeast extract.

3.5. Fatty acid composition

Table (5) shows the changes in fatty acid composition of the yielded lupine oils due to 3% yeast extract and 2mM folic acid treatments. Results show that both treatments decreased palmitic acid, stearic acid, arachidic acid, behenic acid, lignoceric acid + eicosapentanoic acid (total saturated fatty acids) accompanied by increases in oleic acid, linoleic acid, linolenic acid (total unsaturated fatty acids). It is worthy to mention that both treatments increased essential fatty acids (linoleic acid +linolenic acid), thus improve quality of the yielded oils.

Table 4: Effect of yeast extract and folic acid treatments on some chemical composition of the yielded lupine seeds

Treatments	Oil (%)	Total carbohydrate (%)	Total phenolic content (mg/g)	Flavonoids (mg/100g)	DPPH (%)
Control	9.54^{d} ±0.09	41.34^{d} ±0.32	50.89^{f} ±0.43	35.87^{c} ±0.25	42.34^{f} ±0.19
Yeast extract (1 %)	10.47^{c} ±0.22	42.07^{c} ±0.25	60.65^{e} ±0.40	43.07^{b} ±0.55	47.50^{e} ±0.85
Yeast extract (2 %)	11.05^{b} ±0.20	42.27^{bc} ±0.45	62.80^{d} ±0.45	48.25^{a} ±0.34	53.54^{d} ±0.09
Yeast extract (3 %)	11.69a ±0.05	43.15^{a} ±0.47	65.41^{c} ±0.00	49.99^{a} ±0.40	57.15^{c} ±0.30
Folic acid (1 mM)	11.42^{ab} ±0.50	42.42^{bc} ±0.10	73.12^{b} ±0.50	48.33^{a} ±0.33	52.79^{d} ±0.45
Folic acid (2 mM)	11.49^{ab} ±0.10	42.75^{ab} ±0.10	77.90^{a} ±0.95	49.44^{a} ±1.09	59.11^{a} ±0.40
Folic acid (3 mM)	10.49^{c} ±0.47	42.00^{c} ±0.05	72.84^{b} ±0.19	47.75^{a} ±0.70	58.25^{b} ±0.43

Table 5: Effect of yeast extract and folic acid treatments on fatty acid composition of the yielded lupine oils

Fatty acids	Pamitic	Stearic	Oleic	Linoleic	Arachidic	Linolenic	Behenic	Lignoceric + Eicosapentanoic	Total fatty acids	TSA	UN	UN/TS
	C16:0	C18:0	C18:1	C18:2	C20:0	C18:3	C22:0	C24:0+C20:5				
Control	6.35	2.52	23.35	49.32	1.62	7.48	6.90	0.83	98.37	18.22	80.15	5.40
Yeast extract (3%)	6.21	2.42	24.65	50.62	1.52	8.62	4.35	0.62	99.41	15.22	83.89	5.50
Folic acid (2 mM)	5.24	2.35	24.80	52.10	1.51	8.60	4.85	0.75	99.90	14.70	85.50	5.81

(TSA) total saturated fatty acids**; (UN)** unsaturated fatty acids

4. Discussion

4.1. Vegetative growth parameters

The presence of certain macro- and micronutrients, proteins, vitamins and growth regulators as gibberellins, auxins and cytokinins in yeast extract may account for the improvement in plant's physiological processes, increase cell division and expansion, and stimulate plant to build up dry matters (Marzauk *et al*. 2014 and Abdelaal *et al*. 2017). Moreover, yeast extract has an important role in improving the efficiency of enzymes (Abbas 2013), increasing the availability of water and minerals (Marzauk *et al*. 2014), and stimulating photosynthetic processes (Mady 2009) that reflected on higher plant performance. Folic acid foliar spraying has a positive impact on plant growth characteristics (Table 1) because of folic acid plays a beneficial role in controlling the production of proteins and nucleic acids (Andrew *et al*. (2000), natural hormones, and chlorophyll, (Jabrin *et al*. 2003), increasing cell division and expansion, nutrient uptake (Kilic and Ace 2016) enhancing root development and uptake of water (Poudineh *et al*. 2015). In addition, the stimulating effect of folic acid on plant growth and development may be attributed to the increase of the mitotic division (Hillis *et al*. 2011), root elongation, germination percentage (Burguieres *et al*. 2007) and amount of chlorophyll in leaves (El Saidy *et al*. 2011). Furthermore, folic acid has an important impact on auxin activity that improves plant dry matter (Ayala-Rodríguez *et al*. 2017).

4.2. Photosynthetic pigments

Yeast extract's activity as a bio-regulator may be responsible for the enhancement of photosynthetic pigments (Table 2), because of its influences on the balance among photosynthesis and photorespiration in plants (Olaiya 2010). Furthermore, using yeast can improve chlorophyll concentrations due to its rich contents from many essential elements, vitamins, and amino acids, which (Abdelaal *et al*. 2017). At the same time, the yeast works on CO_2 release, which is positively reflected on the increase of the total production of photosynthesis (Khalil and Ismael 2010).

The increases in the chlorophyll content of leaves due to folic acid treatment may be due to the role of folic acid in activation the biosynthesis of glycine that involved in the synthesis of porphyrins and chlorophyll in chloroplast membranes (Ibrahim *et al*. 2015).

However, yeast is rich in tryptophan that is considered a precursor of IAA (Mostafa and Abou Raya 2003). Foliar application of yeast extract at 5 ml/L increased auxins level as reported by Abou EL-Yazied and Mady (2012). Folic acid has an important impact on auxin activity (Ayala-Rodríguez *et al*. 2017).

4.3. Seed yield and its components

The increments in seed yield and yield components as shown in Table (3) may be illustrated as follows: Application of yeast extract exerted beneficial role during vegetative and reproductive growth through improving flower formation and their set in some plants due to its content of biologically active substances such as phytohormones (cytokinins, gibberellins, indol acetic acid), different nutrients, protein, vitamin B and amino acids (Abdelaal *et al*. 2017 and Abdallah 2020) thus reflected on crops yield.

The increase in seed yield due to folic acid could be attributed to the increase in nutrient uptake and/or assimilation (Samiullah *et al*. 1988). Stakhova *et al*. (2000) described that folic acid application stimulates the content of chlorophyll in the leaves and the synthesis of the dependent amino acids and increases the yield and quality of the seeds of pea (*Pisum sativum* L) and barley (*Hordeum vulgare* L). These responses can be attributed to the raising in the energy and nutritional reserves of the plants as well as improving the development and production of the crops (Omar *et al*. 2020). These findings concur with those provided by Babarabie *et al*. (2020), who explained how folic acid application increased chlorophyll content, photosynthetic rate, and plant productivity.

4.4. Biochemical composition of the yielded seeds

All applied treatments improved nutritive value of the yielded seeds as shown in Table (4). The high nutritive content of yeast may have a significant impact on the direction and movement of metabolites from leaves (source) into the seeds (sink). According to Khalil and Ismael (2010), foliar application of yeast on *Lupinus termis* plants produced the greatest significant values of carbohydrate, nitrogen, and protein percentages. Moreover, Dawood *et al*. (2019 b) stated that yeast extract significantly increased the nutritive value of the yielded flax seed. Ezz *et al*. (2012) illustrated that yeast treatments had high content of various organic substances that enhance the growth and flower setting, and reflected on oil production of rue plants. Mady (2009) mentioned that the increase in the total carbohydrate may be due to the role of yeast extract in increasing the photosynthetic pigments content, which eventually leads to increase synthesis of sugars. Besides, yeast stimulates the release of Co_2 from fermentation process, which will contribute in the process of photosynthesis and increase the overall output of the process (Khalil and Ismael 2010) and consequently accelerates the biosynthesis

of carbohydrates**.** Sanchez-Sampedro *et al*. (2005) documented that yeast extract triggered the production of endogenous jasmonic acid and/or methyl jasmonate, which affect the production of secondary metabolites. Plant secondary metabolites, specifically phenolics and flavonoids have critical roles in plant growth, and contribute to the nutritional value of crops (Payyavula *et al*. 2012). They are referred to as antioxidants, because they can quench and scavenge the generation of ROS, and attenuate oxidative damage. Yeast extract augments the enzyme activities of phenylpropanoid metabolism which leads to phenolic compounds formation (Ramachandra and Ravishankar 2002). Abraham *et al*. (2011) indicated that yeast extract at optimum amount could be used for the enhancement of phenolics production.

Improving the seed biochemical constituents by the foliar application of folic acid was emphasized earlier by many researchers (Dahmardeh *et al*.2015, Dawood *et al*.2019 a). Stakhova *et al*. (2000) reported that folic acid plays an important role in the regulation of metabolism of plant cells. Folic acid treatments increased nutritive value of the yielded flax seed as stimulated oil production, and activated the antioxidative properties of flax seeds in terms of endogenous contents of total phenolics. Folic acid acts as a promoter of the secondary metabolites production with antioxidant action (Omar *et al*. 2020).

El-Metwally and Dawood (2017) stated that foliar spraying with 30 mg L^{-1} folic acid enhanced growth, yield and chemical composition of faba bean seeds and attributed these increases to the regulating role of folic acid in plant metabolism which reflected on the nutritive value of the yielded seed. Folic acid also works as a regulator in protein synthesis and participates as a coenzyme in a series of metabolic processes, which are essential to the optimum growth and development of plants (Rezaee *et al*. 2012 and Omar *et al*. 2020).

4.5. Fatty acid composition

The increments in oil quality due to yeast extract at 3% and folic acid at 2mM as shown in Table (5) may be accounted that the oil's quality is typically determined by the amount of essential fatty acids present (Johnson et al. 2008). According to Emam (2012), yeast treatment markedly reduced the levels of the saturated fatty acids palmitic acid (C 16:0) and stearic acid (C 18:0) in flax seed oil. On soybean, Dawood *et al*. (2013) confirmed that treatment with yeast extract increased the total unsaturated fatty acid content of three soybean cultivars while lowering the total saturated fatty acid content. Moreover, Dawood et al. (2019 b) stated that using organic and bio-fertilizers (i.e yeast extract) led to a change in the composition of essential oil in the flax via the increase of unsaturated fatty acids and decrease in saturated fatty acids. The observed increase in linolenic acid with vitamin treatments might be attributed to the acceleration of the biosynthetic pathway of linolenic acid (Joshi et al. 1998).

Conclusions

It can be concluded that yeast extract applications were more effective than folic acid applications. Moreover, yeast extract at 3% (the most optimum treatments) and folic acid at 2mM resulted in the higher quality of the yielded lupine oil.

Statements and Declarations

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Competing interests

The authors have no relevant financial or non-financial interests to disclose.

Data Availability

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

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