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LAVANDULA DENTATA: OPTIMIZING *IN VITRO* SHOOT AND CALLUS CULTURES AND ASSESSMENT OF PHENOLIC COMPOUNDS AND ANTIOXIDANT ACTIVITY

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Lavandula dentata is a plant with potential medicinal and cosmetic applications due to its phenolic compounds and antioxidant properties. This study sought to improve our understanding of the In vitro propagation and callus induction of the plant, as well as to assess its total phenolic content and antioxidant activity. The impact of media composition on germination, plant growth, shoot induction, and callus induction was examined. The efficacy of hormone combinations comprising 6-benzyladenine and gibberellic acid was probed for shoot development. Callus generation from leaf explants was achieved using various concentrations of 2,4-dichlorophenoxyacetic acid and 6-benzyladenine. The extraction procedure for phenolic compounds was performed on wild plants, In vitro shoots, callus cultures, and vitroplants. An assessment was carried out on various extracts to determine their total phenolic content and antioxidant capacity. Our results demonstrated that the combination of 6-benzyladenine and gibberellic acid significantly promoted shoot growth at concentrations of 0.5 mg/L gibberellic acid and 0.25 mg/L 6-benzyladenine. Various hormonal treatments influenced callus induction, with a 2:1 ratio of 2,4-dichlorophenoxyacetic acid (0.5 mg/L) and 6-benzyladenine (0.25 mg/L) yielding the highest callus production rate (100%). The highest total phenolic content was observed in extracts from In vitro shoot cultures and wild plants (11.11 and 13.10 mg GAE/g of dry extract, respectively) and antioxidant capacity (322.52 and 319.71 mg GAE/g of dry extract, respectively). These findings provide insights into optimizing L. dentata micropropagation and secondary metabolite production, holding potential therapeutic and cosmetic applications

Keywords: *micropropagation, callus induction, plant growth regulators, phenolic compounds, Lavandula dentata*

INTRODUCTION

Lavandula dentata L. (Lamiaceae), also referred as French lavender, it is a flowering plant native to the Mediterranean region, valued for both its attractiveness and therapeutic properties[1]. *L. dentata* has received considerable attention in the realms of medicine and pharmacology in recent years. Several studies[2–5] have found that *L. dentata* has phenolic compounds like flavonoids, tannins, and phenolic acids, which have

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anticancer, anti-inflammatory, and antibacterial properties. These bioactive compounds are highly significant to the pharmaceutical, perfume, cosmetics, food, and flavor industries, resulting in increased customer demand for *L. dentata*.

Plant tissue culture techniques offer an alternative to traditional cultivation approaches for the controlled production of numerous economically and medically important bioactive compounds[6]. These procedures enable the mass production of *In vitro* cultivated plants without seasonal constraints, yielding compounds analogous to those found in mother plants[7,8]. Among the various tissue culture methods, callus induction stands out as a vital method for swiftly obtaining plant cells, promoting the synthesis of a wide range of secondary metabolites, including polyphenols, alkaloids, terpenoids, and other biologically active compounds[9,10]. Another critical tissue culture approach, micropropagation, plays a pivotal role in producing pathogen-free plants and generating a significant amount of both genetically and physiologically identical clones of the mother plant, ensuring genetic uniformity[11]. Furthermore, micropropagation functions as an efficient method for rapidly multiplying plants, providing a sustainable alternative to wild harvesting. This approach ensures a reliable and uninterrupted supply of bioactive compounds, thus diminishing the dependence on wild harvesting and securing a continuous source of valuable substances for applications in pharmaceutical and cosmetic products[9,12].

The *In vitro* culture of *L. dentata* to create uniform plant material by direct organogenesis has received modest consideration[13-15]. Other species of the *Lavandula* genus have demonstrated the ability to induce callogenesis[16,17] and *In vitro* regeneration by indirect organogenesis[18].

This research aims to establish a successful *In vitro* protocol for callus and shoot induction in *L. dentata*. Furthermore, we conducted a comparative analysis of the antioxidant capacity and phenolic compound composition among *In vitro* shoot cultures, callus cultures, and wild plants of *L. dentate*

MATERIALS AND METHODS

Plant material

Seeds of *L. dentata* were harvested from mature plants in the region of Beni Houa in Algeria, at the geographical coordinates of 36° 31' 45. 24"N, 1° 33' 58.10"E. The collected seeds were disinfected by individually passing them through 70% ethanol for 30 seconds before immersing them in a 12% sodium hypochlorite solution for 10 minutes. The disinfected seeds were washed with sterile distilled water and dried thoroughly on sterile filter paper. The seeds were subsequently placed into Petri dishes containing B5 medium[19] and/or MS medium[20], supplemented with 30 g/L sucrose, and solidified with 7 g/L agar. The pH was adjusted to 5.6–5.8. The Petri dishes were placed at a temperature of 25 ± 2 °C with 16 hours of light photoperiod under cool white fluorescent lamps (4000 Lux). Germination percentages were recorded over a period of 30 days. After germination, well-developed seedlings were transferred to new culture medium, including MS, half-strength MS, B5, and half-strength B5 medium, containing 30 g/L sucrose and 6 g/L agar. These culture medium were pH-adjusted at 5.6–5.8.The cultures were maintained under the same conditions as previously described.

Induction of shoots

Nodal segments measuring 2 to 3 cm in length were meticulously cut from fully matured vitroplants. These segments were subsequently placed on MS medium, supplemented with 30 g/L sucrose and 6 g/L agar. Different concentrations of 6-benzyladenine (BA) were introduced (0.5 and 0.25 mg/L), with or without gibberellic acid (GA3) at a concentration of 0.5 mg/L. The pH of the medium was set at 5.6-5.8. Following a four-week incubation period, the treated explants were assessed for several parameters, including the number of buds per shoot, the number of nodes per shoot, shoot height, and the fresh weight of plant tissues. Cultures were were kept at a constant temperature of 25 ± 2 °C and exposed to a 16-hour photoperiod under cool white fluorescent lights (4000 Lux).

Induction of callogenesis

Leaf segments (about 5 mm long) from *In vitro* plants were employed as explants in the process of inducing the callus of *L. dentata*. These segments were placed on MS medium containing 30 g/L sucrose and 6 g/L agar. Various concentrations of 2,4-dichlorophenoxyacetic acid (2,4-D) (0.25, 0.5, and 1 mg/L) were supplemented to the culture medium, either with or without 6-benzyladenine (BA) (0.125, 0.25, and 0.5 mg/L). The pH was adjusted to 5.6–5.8. The cultures were maintained at a constant temperature of 25 ± 2 °C and a 16-hour photoperiod. After one month of each culture, data regarding the frequency of callus induction, color, and appearance of the callus were recorded.

Extraction Procedure

The extraction procedure for *L. dentata* involved wild plants, *In vitro* shoots, callus cultures, and vitroplants. First, the plant was dried for 48 hours at 45 °C. A solution of 10 ml ethanol and water (7:3) was used to homogenize 500 mg of dried and powdered plant material. After that, the mixture was macerated for 48 hours at 80 rpm at room temperature. The filtrates were concentrated in a vacuum rotary evaporator at 45 °C under reduced pressure. The dried extracts were kept until used in the dark at +4 °C. This was done three times for each sample to calculate yields. After completing the extraction procedure, the yields of the extracted compounds were calculated for each sample. This calculation involved determining the mass of the final dried extract obtained from the 500 mg of powdered plant material used in the extraction. The yield data provided important insights on the efficiency of the extraction procedure and the relative abundance of phenolic compounds in *L. dentata* samples.

Measurement of Total Phenolic Content (TPC)

Total phenolic content (TPC) was measured in hydroethanolic extracts of *L. dentata* from *In vitro* shoots, callus cultures, germinated vitroplants, and wild plants using the Folin-Ciocalteu method, which was described by Singleton and Rossi[21]. In the beginning, a volume of 3.95 mL of distilled water was combined with 0.05 mL of the hydroethanolic extract, which had a concentration of 10 mg/mL. The mixture received 0.25 mL of Folin-Ciocalteu reagent. After 3 minutes of reaction, 0.75 mL of 20% sodium carbonate was supplemented. The mixture was carefully stirred before heating at 40 °C for 40 minutes to develop a blue-colored complex. Following the reaction, a spectrophotometer was used to measure the absorbance of the solution at 760 nm. Phenolic compounds were calculated using the absorbance values and the following equation, which was derived from a standard gallic acid curve: absorbance = 0.1035 gallic acid (µg/ml) + 0.1046 (R2: 0.98). Each sample was processed three times.

Assessment of Total Antioxidant Capacity (TAC)

To assess the total antioxidant capacity (TAC) of *L. dentata* extracts, we used a well-established method based on the protocol described by Prieto et al.[22]. For this test, 25 µL of each extract was mixed with 1.5 mL of a reagent solution consisting of 0.6 M sulfuric acid, 28 mM sodium phosphate, and 4 mM ammonium molybdate. The resulting mixture was incubated at 95 °C for 90 minutes to facilitate the reaction. Subsequently, the optical density of the samples was evaluated using a spectrophotometer at a wavelength of 695 nm, with a control sample included for reference purposes. We measured the total antioxidant capacity using a gallic acid calibration curve. The results can be written as milligrams of gallic acid equivalent per gram of extract (mg GAE/g MS extract). To ensure accuracy and reliability, the experiment was replicated three times for each sample. This TAC evaluation provides crucial information on the antioxidant potential of *L. dentata* extracts.

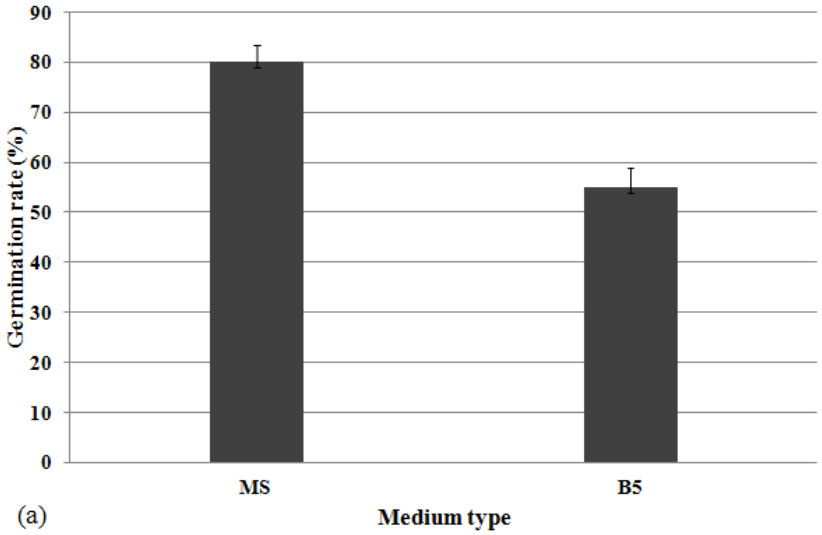
Statistical Analysis

All tests and analyses were conducted using three replicates. The mean and standard deviation were computed based on the results of each test. The data was examined using the one-way analysis of variance (ANOVA) method in the SPSS software, specifically version 22.0. The Tukey post-hoc test was used to conduct multiple comparisons.

RESULTS AND DISCUSSION

Seed germination

The results obtained revealed remarkable germination rates **(Fig. 1)** for seeds grown in medium MS, with a germination rate of 80%, while those grown in B5 medium showed a germination rate of 55%. Our findings were similar to those of Koefender et al.[23], who observed 80% germination rate for *L. dentata* seeds on MS media. According to Panizza and Tognoni[24], lavender seeds germinate slowly and have a low percentage of germination in tissue culture. Some research showed the impact of culture medium on *In vitro* enhanced germination rates. In this regard, research on *L. angustifolia* demonstrated that the germination rate was more important in full-strength medium[25].



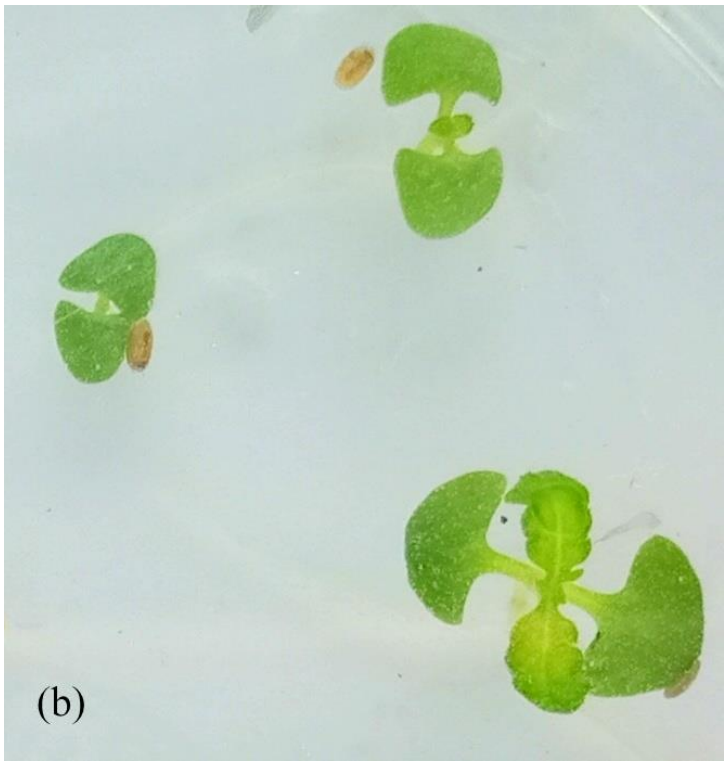


Fig. 1: Seed germination of *L. dentata*. (a) Effect of different culture media on germination rate, showing higher germination (80%) (MS) medium compared to 55% in B5 medium; (b) 10-day-old seedlings grown on MS medium.

Effect of medium composition on plant development

The results indicate that the type of culture media has a substantial impact on the number of nodes and induced axillary buds in *L. dentata* vitroplants **(Fig. 2)**. The most notable growth was seen in the MS medium, which had the largest average number of axillary buds, with 9.25 buds per explant **(Fig. 2a**). Similar to this, explants grown in the MS media displayed the largest average number of nodes per explant, with 5.125 nodes **(Fig. 2b)**. Thus, The MS culture medium appears to produce more buds and nodes per explant than other culture media (B5, half-strength B5, and half-strength MS). The popularity of the MS medium is evident in numerous studies on the influence of culture medium on the *In vitro* culture of *Lavandula* species in general[17,26] and specifically for *L. dentata* species[27]. The favorable performance of the MS medium is not limited to *Lavandula* species alone but extends to other members of the Lamiaceae family. According to Arikat et al.[28], the MS medium promoted shoot proliferation in *Salvia fruticosa* better than the B5 medium.

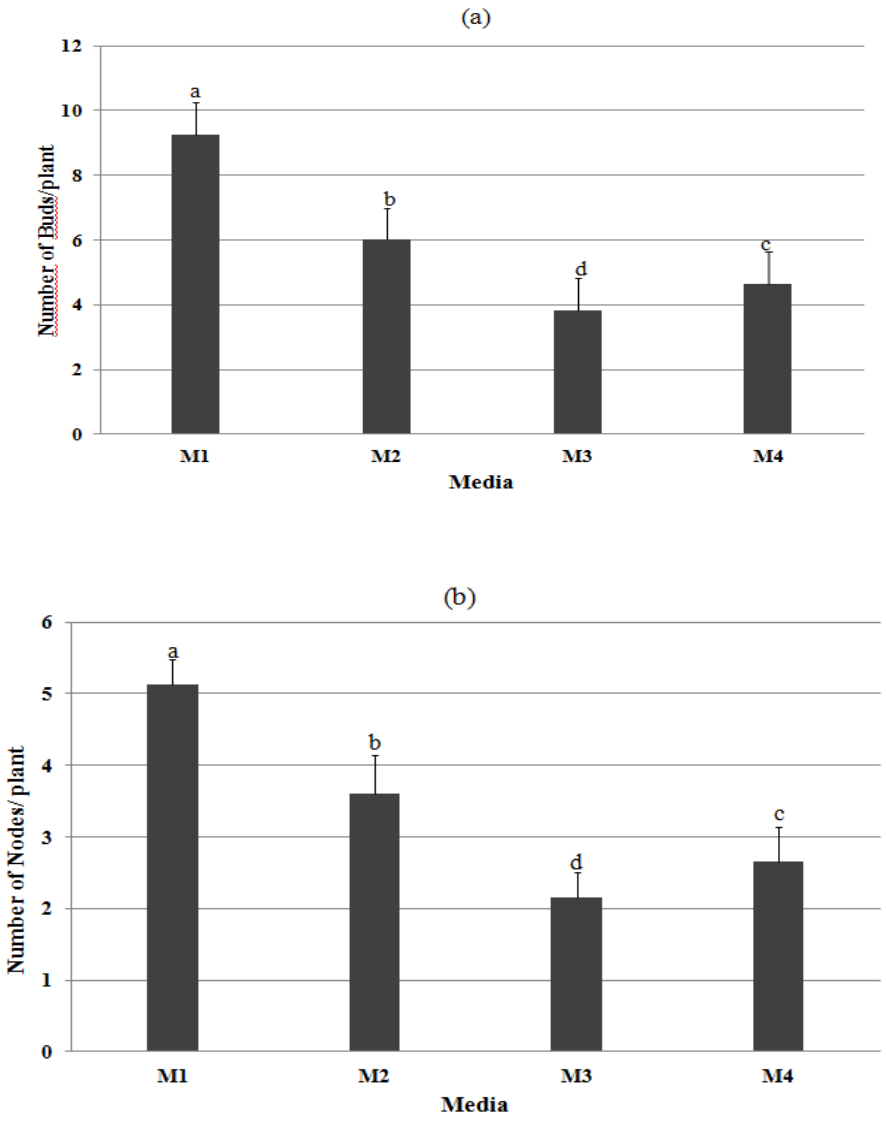


Fig. 2: Effect of culture mediums on plant development of *L. dentata*. (a) number of buds; and (b) number of nodes. M1 = full-strength MS, M2 = full-strength B5, M3 = half-strength MS, and M4 = half-strength B5. The standard error is shown by error bars (n = 3). Tukey's range test at $p < 0.05$ determines whether there are significant differences between letters.

***In vitro* propagation of *L. dentata* shoots**

Our findings regarding the induction of *L. dentata* shoots **(Fig. 3b, 3c)** indicate that by the tenth day of culture, there was a noticeable proliferation of shoots. The medium containing 0.25 mg/L of BA and 0.5 mg/L of GA3 (T2) generated the highest number of axillary buds and nodes among all the evaluated hormone treatments **(Fig. 4a, 4b)**. In comparison to the control, this hormone treatment raised axillary buds and nodes by 145.45% and 170.27%, respectively. Additionally, shoot length and biomass both significantly augmented with this hormonal treatment (T2) compared to the control, with increases of about 249.42% and 233.33%, respectively **(Fig. 4c, 4d)**. GA3 is necessary for achieving the best development and proliferation in *L. dentata* cultures, as shown by the fact that shoots grown on media with only 0.25 mg/L of BAP (T1) grew at a rate that was remarkably comparable to that of the control. Previous research have also demonstrated the synergistic effects of growth regulator combinations on the organogenesis process[29,30]. In agreement with our results, Zare Khafri et al.[31] demonstrated that the application of BAP combined with GA3 in a 1:2 (v:v) ratio significantly increases the proliferation of axillary buds. Additionally, shoot elongation and multiplication are promoted by the application of a GA3 and BA combination in *Canscora decussata*[32].

This is further substantiated by studies on *Citrus jambhiri* explants cultured *In vitro*, where a hormonal combination of GA3 and BA resulted in a high rate of shoot multiplication[33]. Numerous investigations on the *In vitro* culture of lavender species have revealed that MS media supplemented just with BA is the most successful method for shoot growth[13,34,35]. Echeverrigaray et al. (2005) proved that *L. dentata* exhibited significant shoot proliferation (18.60 buds/explant) in response to the application of 0.5 mg/L of BA combined with 0.5 mg/L of indole-3-butyric acid (IBA), although the shoot length was 2.46 times less than that observed in our study. The use of GA3 promotes the development of stem elongation and increases plant growth[30].

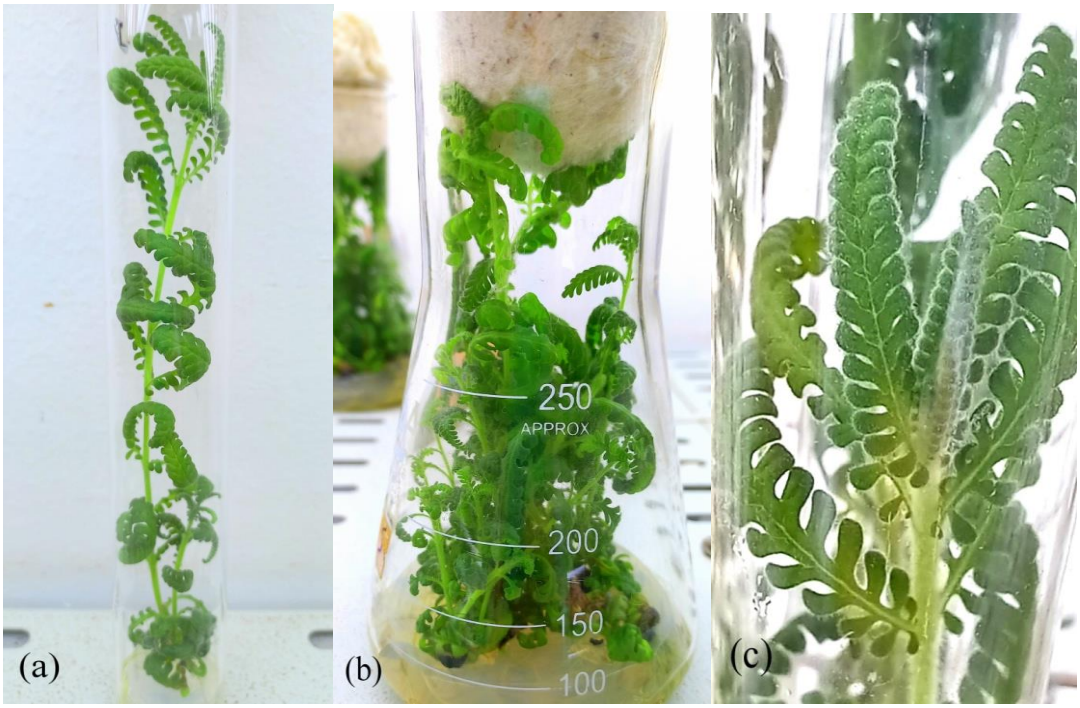
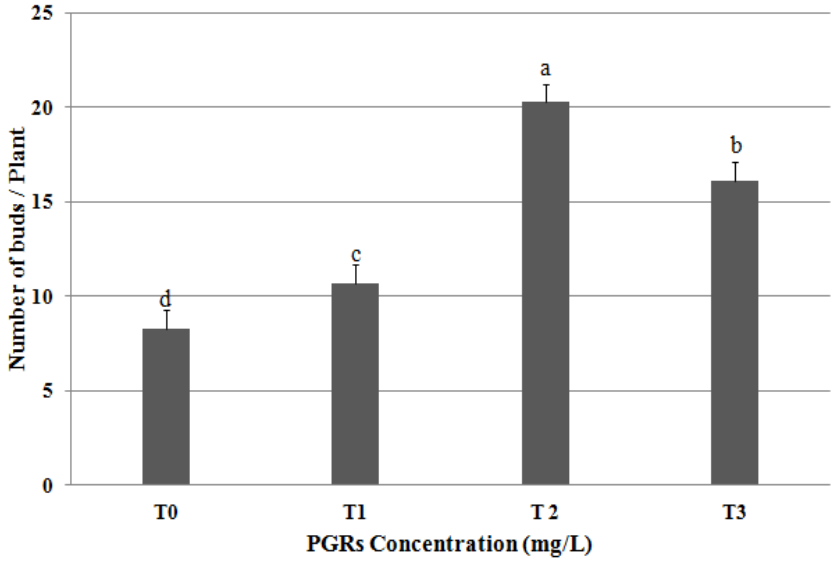


Fig. 3: Regeneration of *L. dentata* on MS medium. (a) Vitroplant after 30 days of culture; (b) 45-day culture with multiple shoots; (c) morphology of induced shoots.

(a)


25
20
15
10
5
0
Number of buds / Plant
a
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c
d
T0
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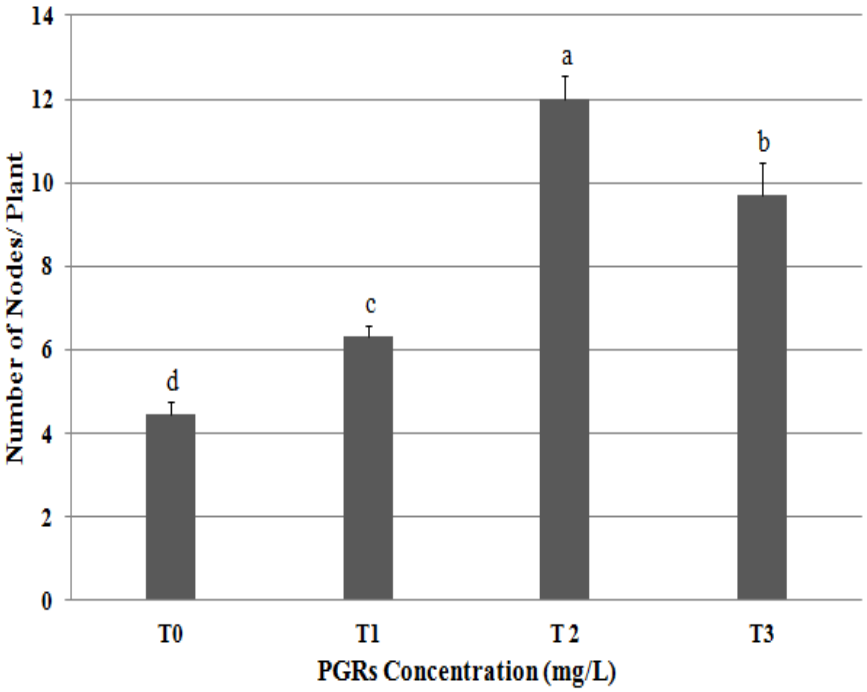
T 2
T3
PGRs Concentration (mg/L)

(b)


14
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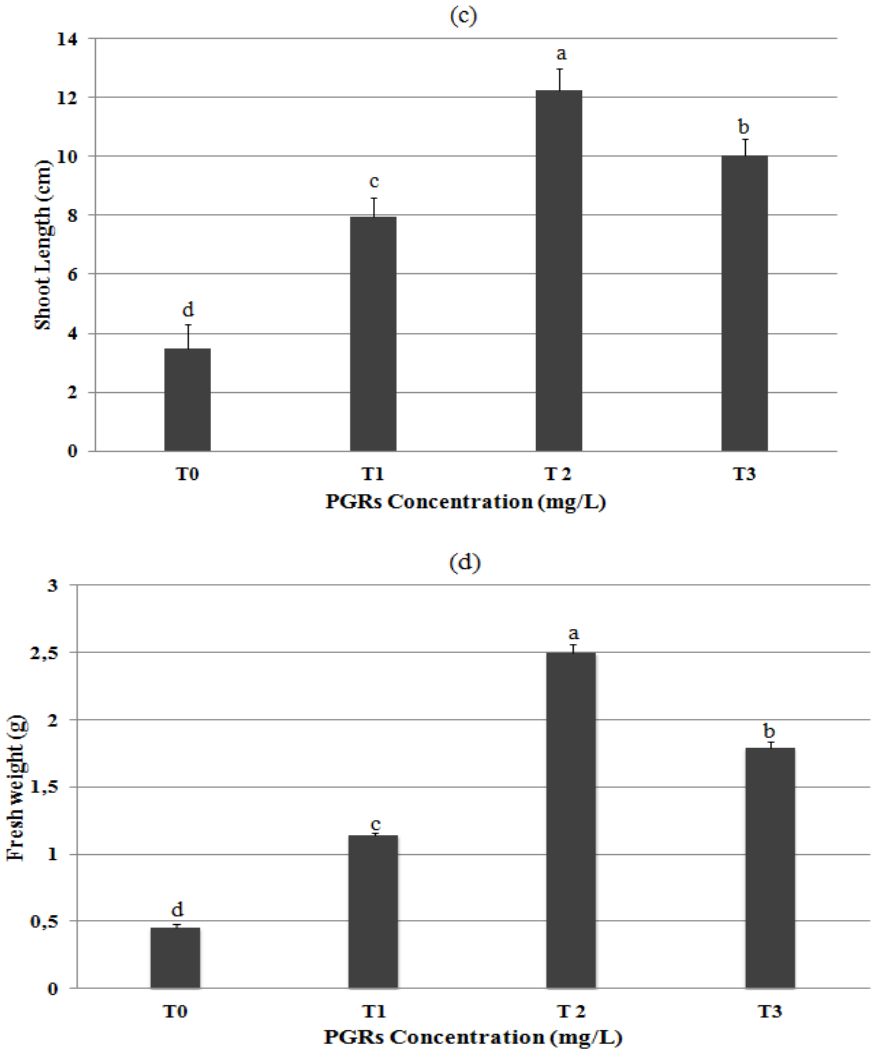

Fig. 4: Effect of different concentrations of BA and GA3 on the profilation of *L. dentata* shoots developed on MS medium. (a) number of buds in shoots; (b) number of nodes in shoots; (c) length of shoots; (d) the fresh weight of shoots. T0 = control, T1 = 0.5 mg/L BA, T2 = 0.25 mg/L BA + 0.5 mg/L GA3, and T3 = 0.5 mg/L BA + 0.5 mg/L GA3. The standard error is shown by error bars (n = 3). The Tukey's range test at $p < 0.05$ indicates that various letters are statistically different.

Induction of a callus

The induction of callus formation in *L. dentata* is a crucial step in tissue culture protocols, and the selection of an optimal hormonal treatment is essential for successful callus formation. In the present study, we employed six different hormonal combinations (auxin and/or cytokinin) to evaluate the frequency of callus induction over a 30-day culture period. Significant effects on callus formation frequency were observed among the various tested hormonal treatments ($p < 0.05$) **(Table 1)**. The leaf explants cultured on MS media containing a 2:1 (v:v) ratio of 2,4-D and BA produced the highest rates of callus development; the maximum percentage of 100% was attained when 0.25 mg/L of BA was combined with 0.5 mg/L of 2,4-D **(Table 1)**. Additionally, the surface area of the resulting callus varied according to the concentrations of 2,4-D and BA, ranging from 30.48 mm^2 to 92.39 mm^2, with the largest callus surface obtained using 0.5 mg/L of BA combined with 1 mg/L of 2,4-D. Several studies have demonstrated the success of the 2,4-D and BA combination to promote callus development when applied at a 2:1 (v:v) ratio[16,37,38]. Our research demonstrates that *L. dentata* can induce callus, which is affected by the type of explant used and the hormone treatment[39]. In

other *Lavandula* species, combinations of auxin and cytokinin have been used to stimulate the formation of calluses from leaf explants. For instance, *L. angustifolia* leaf explants cultivated on MS media added with 2 mg/L of 2,4-D and 1 mg/L of BA formed callus at a frequency of 96%[16]. Studies on *L. coronopifolia* showed that the best callus induction results were achieved using a combination of NAA (1 mg/L) and BA (0.5 mg/L)[17]. Furthermore, using the composition of auxin and cytokinin, particularly 2,4-D and BA, at a 2:1 (v:v) ratio showed in significant callus induction rates in numerous medicinal plant species of the Lamiaceae family[37,38,40].

The different hormonal treatments tested had significant effects on the morphological features of the resulting callus **(Fig. 5)**. Callus induced on a medium containing only 2,4-D exhibited a distinct morphological structure, with a predominant formation of adventitious roots **(Fig. 5a)**, particularly at concentrations of 0.25 mg/L and 0.5 mg/L of 2,4-D. However, calli produced with 1 mg/L of 2,4-D displayed a granular texture **(Fig. 5b)**, suggesting the potential for somatic embryogenic development[41]. Whereas, callus formation on a medium that included a combination of 2,4-D and BA had a compact appearance and a green color **(Fig. 5c)**. The effects of the hormonal balance being employed are consistently associated with changes in callus morphology[39]. According to De Sousa-Machado et al.[42], the presence of BA inhibits the formation of adventitious roots, while the presence of 2,4-D at low concentrations promotes the development of adventitious roots. Furthermore, the presence of BA stimulates the accumulation of chlorophyll [43], which clarifies why the induced calluses in our study exhibited a green color.

Table 1: The impact of various 2,4-D and BA concentrations on the in vitro induction of *L. dentata* callus.

PGRs Concentration (mg/L)		Calogensis induction frequency (%)	Area of callus (mm^2)	Color of callus	Texture of callus
2,4 D	BA				
0.25	0	75.1 ± 1.12^{f}	49.33 ± 3.03^{c}	Green	Compact with adventitious roots
0.5	0	82.33 ± 1.92^{e}	44.28 ± 5.66^{d}	Light green	Compact with adventitious roots
1	0	89.21 ± 1.3^{d}	30.48 ± 3.23^{f}	Light green	Compact globular
0.25	0.125	94.5 ± 1.55^{c}	38.14 ± 4.5^{e}	Green	Compact
0.5	0.25	100^{a}	92.39 ± 3.43^{a}	Green	Compact
1	0.5	96.08 ± 2.03^{b}	78.56 ± 5.23^{b}	Light green	Compact

All values were shown as mean ± standard deviation (n = 3). Tukey's range test indicates significant differences between letters in a column at $p < 0.05$.

Table 2: Total phenolic content and antioxidant activity of hydroalcoholic extracts of-wild plants, in vitro shoot cultures, callus cultures, and vitroplants of *L. dentate*.

	TPC (mg GAE/g DW)	TAC (mg GAE/g DW)	Yields %
Wild plant	13.10 ± 0.25^{a}	322.52 ± 17^{a}	98.00
Vitroplants	5.75 ± 0.62^{d}	268.21 ± 13.80^{c}	64.00
In vitro shoot culture	11.11 ± 0.38^{b}	319.71 ± 15^{b}	84.78
Callus culture	9.48 ± 0.69^{c}	256.5 ± 11.59^{d}	57.00

The values were expressed as mean ± standard deviation (n = 3), with letters indicating significant differences ($P < 0.05$). TPC was measured in mg gallic acid equivalents/g dry weight of extract, and TAC was the total antioxidant capacity.

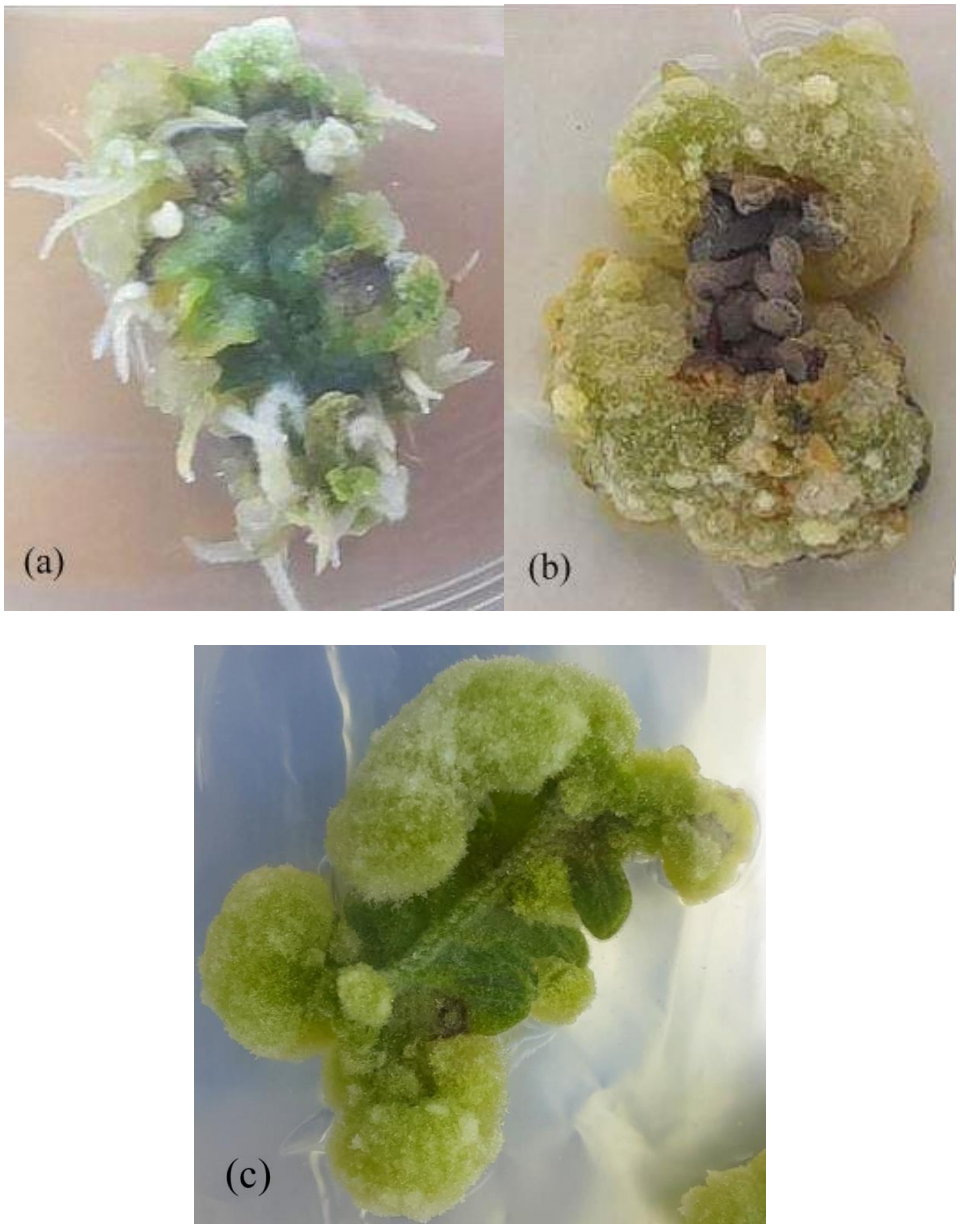

Fig. 5: Callus texture induced from *in vitro* cultured explants of *L. dentata*. (a) Callus with adventitious roots formed on MS medium with 0.25 mg/L of 2,4-D for 1 month; (b) Granular callus formed on MS medium with 1 mg/L of 2,4-D for 1 month; (c) Green compact callus on MS medium with 0.5 mg/L of 2,4-D and 0.25 mg/L BA

Total Phenolic Content and Antioxidant Activity

The total phenolic content (TPC) was measured using the Folin-Ciocalteu reagent and quantified using the gallic acid calibration curve **(Table 2)**. The extraction yields, measured as extract weight relative to plant material weight, were 57% to 98%. Wild plants exhibited the highest extraction yield at 208%, followed by *In vitro* shoot cultures with 128.26%, whereas *In vitro* plants and callus cultures had the lowest yields at 64% and 57%, respectively. The extract from wild plants included the highest quantities of phenolic compounds ($p<0.05$), with 13.10 mg GAE/g of dry extract. This was followed by *In vitro* shoot cultures, which had 11.11 mg GAE/g of dry extract, and callus cultures, which had 9.48 mg GAE/g of dry extract. In contrast, the lowest phenolic content was observed in *In vitro* plants at 5.75 mg GAE/g of dry extract **(Table 2)**. The TAC test was used to assess antioxidant activity. Results revealed that the highest antioxidant capacity ($p < 0.05$) was identified in the extract resulting from wild plants and in the extracts derived from *In vitro*

shoot cultures (322.52 and 319.71 mg GAE/g of dry extract, respectively), compared to *In vitro* plants and callus cultures (268.21 and 256.5 mg GAE/g of dry extract, respectively) **(Table 2)**. Previous research on *L. coronopifolia* indicated that the phenolic compound content in wild plants (4.9 mg GAE/g of dry extract) was twice that of shoot cultures [17]. Additionally, Costa et al.[44] reported that wild *Thymus lotocephalus* plants exhibited more significant total phenolic content and antioxidant activity than *In vitro* plants. The antioxidant activity of *Lavandula* species is significantly influenced by the phenolic compounds contained in these plants[3]. Consequently, plant extracts abundant in phenolic compounds hold great potential as antioxidants[45,46]. Our results align with previous investigations, demonstrating that both hydroethanolic extracts from wild *Lavandula* plants and those from *In vitro* cultures, with their high phenolic content, possess notable antioxidant potential[17,44]. Moreover, our findings are relatively more significant compared to previous research that examined the anti-radical power of *L. dentata* extract[5,47,48].

Conclusion

In conclusion, this study explored the *In vitro* propagation, callus development, and germination of *L. dentata*. Our findings underscore the crucial role of culture medium composition in governing plant growth and germination rates. The synergistic effect of growth regulators, particularly the combination of BA and GA3, proved pivotal in promoting shoot proliferation and development. Hormonal treatments affected the induction of callus formation, with a 2:1 ratio of 2,4-D and BA yielding the highest callus production rates. The potential health advantages of *L. dentata* extracts were demonstrated by their antioxidant activity and total phenolic content. In comparison to callus cultures and *In vitro* plants, *In vitro* shoot cultures and wild plants both exhibited the highest levels of phenolic content and antioxidant capacity. This research establishes the groundwork for future biotechnological applications of *L. dentata*, such as large-scale propagation for commercial cultivation or the development of purified extracts for therapeutic and cosmetic purposes. The chemical composition of *L. dentata* extracts, particularly those abundant in phenolic content, could be the subject of future research. Such exploration may lead to the discovery of new bioactive compounds with potential applications across various industries.

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لافاندولا دينتاتا : تحسين زراعة البراعم والكلوسات في الزراعة النسيجية وتقييم المركبات الفينولية والنشاط المضاد للأكسدة

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يعد نبات **لافاندولا دينتاتا** من النباتات التي تتمتع بإمكانيات طبية وتجميلية بفضل مركباتها الفينولية وخصائصها المضادة للأكسدة. سعى هذا البحث إلى تحسين فهمنا لتكاثر هذه النبتة في الزراعة النسيجية وتحفيز تكون الكالوس، بالإضافة إلى تقييم محتواها الكلي من المركبات الفينولية ونشاطها المضاد للأكسدة.

تمت دراسة تأثير تركيبة الأوساط الغذائية على الإنبات، نمو النبات، تحفيز البراعم، وتكوين الكالوس. كما تم اختبار فعالية تركيبات الهرمونات التي تحتوي على البنزيل أدنين وحمض الجبريليك لتطوير البراعم. تم إنتاج الكالوس من أجزاء الأوراق باستخدام تراكيز مختلفة من حمض ٢،٤–ثنائي كلورو فينوكسي أسيتيك والبنزيل أدنين.

تم استخراج المركبات الفينولية من نباتات برية وبراعم مزروعة نسيجياً , الكالوس ونباتات مزروعة مخبريًا، وتم تقييم المستخلصات المختلفة لتحديد محتواها الكلي من المركبات الفينولية ونشاطها المضاد للأكسدة.

أظهرت النتائج أن تركيبة ٠,٥ ملجم/ل من حمض الجبريليك مع ٠,٢٥ ملجم/ل من البنزيل أدنين عززت نمو البراعم بشكل ملحوظ. كما أثرت المعالجات الهرمونية المختلفة على تحفيز الكالوس، حيث كانت نسبة ٢:١ من ٢،٤–ثنائي كلورو فينوكسي أسيتيك (0.5 - ملجم/ل) والبنزيل أدنين (٠,٢٥ ملجم/ل) هي الأفضل وأدت إلى معدل إنتاج كالوس بنسبة ١٠٠%.

لوحظ أعلى محتوى كلي من المركبات الفينولية في مستخلصات البراعم المزروعة نسيجياً والنباتات البرية (١١,١١ و١٣,١٠ ملجم مكافئ حمض الجاليك/جرام من المستخلص الجاف على التوالي) وكذلك أعلى نشاط مضاد للأكسدة (٣٢٢,٥٢ و ٣١٩,٧١ ملغ مكافئ حمض الجاليك/جرام من المستخلص الجاف على التوالي).

توفر هذه النتائج رؤى قيمة لتحسين التكاثر الدقيق لـ **لافاندولا دينتاتا** وإنتاج مركباتها الثانوية، مما يحمل إمكانات تطبيقية في المجالات الطبية والتجميلية.