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Establishment of Effective Callus Induction in the Economically Important Brown Seaweed *Ecklonia cava*

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Abstract: The edible brown seaweed, *Ecklonia cava*, is highly valued for its bioactive compounds, and is widely used in food supplements and functional foods. The increasing demand for this seaweed in the food industry emphasizes the necessity for sustainable cultivation practices. This study focused on inducing callus in the meristem and stipe of *E. cava* using different culture media: Provasoli's enriched seawater medium (PESI), enriched artificial seawater medium (ESAW), artificial enriched seawater medium (ASP2), or Von Stosch's enriched seawater medium (VS). Various abiotic stress factors (photoperiod, agar concentration, and temperature), growth regulators, carbon sources, polyamines, and plasma treatments were explored for their impact on callus induction. Both stipe and meristem explants developed callus within three to six weeks across all media except ASP2. Callus development was favored at temperatures between 8 to 13 °C and in the absence of light. Stipe explants showed a higher callus induction rate (up to 65.59 ± 6.24%) compared to meristem (up to 57.53 ± 8.32%). Meristem explants showed optimal callus induction in PESI medium with a low concentration of indole-3-acetic acid (IAA; 40.93 ± 8.65%). However, higher concentrations of IAA and 1-naphthaleneacetic acid (NAA) reduced meristem callus induction. Stipe showed high induced-callus (up to 50.37 ± 5.17%) in PESI medium with low concentrations of IAA, NAA, and 6-benzylaminopurine (BAP). Both stipe and meristem explants induced largest callus at 2% sucrose, but higher carbon source concentrations reduced callus induction. Spermine (Spm) at 1 μM resulted in high induced calluses; however, increasing Spm concentrations decreased callus induction. This tissue culture technique not only supports mass cultivation of *E. cava*, but also holds potential for extending to other seaweed species, contributing to the sustainability of seaweed stocks for the food industry.

Keywords: abiotic stresses; callus; functional food material; laminariales; phaeophyta; seaweed; tissue culture

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1. Introduction

Seaweeds encompass a diverse array of marine species [1,2], showing remarkable adoptability to challenging environmental conditions. In response to these adversities, seaweeds produce allelochemicals which contribute to their ability to compete for space, resist

pathogenic microorganisms and predators, and hinder the establishment of epiphytes [3,4]. Notably, seaweeds have been associated with various biological activities that offer health-promoting benefits related to human skin, immunity, and growth [5–8]. These attributes position seaweed as a valuable source for pharmaceuticals, nutraceuticals, and cosmeceuticals [5,9,10]. The seaweed market is expected to undergo significant growth, with projections indicating a 39.8% increase, reaching USD 24.98 billion from 2021 to 2028 [11]. Recognizing the potential of seaweed as a source of biomass in the pharmaceutical, food, and chemical industries, there is pressing need to adopt sustainable seaweed cultivation practices, with tissue culture emerging as a key strategy.

Seaweeds can undergo in vitro cultivation through various methods, including (1) micropropagation, (2) protoplast isolation and regeneration, or (3) callus induction [12]. Among these techniques, micropropagation, which involves meristem or somatic embryogenesis, stands out as one of the most commonly employed methods for in vitro propagation of macroalgae [12,13]. Tissue culture presents a sustainable approach for fostering tissue development and enhancing quality in seaweeds. The controlled cultivation of seaweed tissues has the potential to maximize biomass production and stimulate the synthesis of desired compounds [14]. Particularly vital for species like *Ecklonia cava*, characterized by limited wild stocks, tissue culture serves as a strategic response to challenges posed by climate change, pollution, and escalating demand, ensuring the availability of stocks. Tissue culture of seaweeds can be achieved through direct regeneration from explant tissues or indirectly through callus induction. While callus culture is a well-established technique in tissue culture engineering for terrestrial plants, its application in seaweed culture remains underdeveloped, despite the recognition of seaweeds for various applications such as functional foods, nutraceuticals, and pharmaceuticals.

The brown seaweed, *E. cava*, found only in Japan, Korea's Jeju Island, and Busan [15–17], has been associated with various physiological benefits, including antioxidant, antibacterial, anti-thrombotic, anti-diabetic, anti-hypertensive, anti-obesity, and anti-inflammatory properties, making it a potential raw material for functional foods [18–23]. However, industrialization has been limited to a few seaweed species from various genera that are suitable for cultivation and harvesting. The cultivation of *E. cava* is particularly challenging due to farming difficulties and environmental issues such as microplastic and radioactive pollution, ocean desertification, and resource depletion. Countermeasures are essential, especially considering that Korea's Incheon-Gyeonggi coast and the Nakdong river estuary rank second to third globally in microplastic concentration [24,25]. While indoor culture technology has advanced for land crops and mushrooms, tissue culture research for seaweeds, especially *E. cava*, is limited, with only the report on callus culture by Kawashima and Tokuda [26], examining the impact of collection time on callus development. The limited research on this species may be attributed to the restricted distribution of *E. cava* resources, mainly in Korea and Japan. Considering the escalating marine pollution and global interest in the safety of marine resources, we aim to develop callus culture for *E. cava* as a natural, year-round, and cost-effective food and pharmaceutical material, safe from marine pollution.

Callus induction, a critical initial stage of proliferation and growth, is influenced by various abiotic factors. Seaweed callus induction is triggered by tissue wounding and changes in the physical environment [27], with different seaweed groups displaying varied responses to abiotic conditions [14,28]. Factors such as light irradiance, temperature, media composition, growth regulators, CO_2 levels, temperature, nutrient absorption, osmolarity, nutrient absorption, salinity, photosynthesis, and culture medium composition influence callus induction [14,29–51]. Earlier studies have investigated the effects of different abiotic parameters on various marine algae species, including red algae like *Gracilariopsis* and *Gelidium*, brown algae such as *Dictyota* and *Undaria*, and green algae like *Cladophora* and *Ulva* [29–51]. Additionally, studies have examined the effects of radiation, carposporophyte culture, protoplast isolation, callus ontogeny, tissue culture, gametogenesis induction, clonal propagation, and epigenetic variations [52–56].

Despite the importance of abiotic factors in callus induction, research on this aspect in seaweed culture is limited. While some studies have explored the influence of abiotic factors on seaweed callus induction [14,57,58], to the best of our knowledge, except one study focusing on the impact of collection time [26], no other studies have reported their impact on tissue culture or callus induction in *E. cava*. Therefore, in this study, we not only focused on callus induction in *E. cava*, but also investigated the impact of abiotic stresses on callus development. This study would provide basis for establishing the liquid suspension culture of *E. cava* to mass-produce the secondary metabolites, mainly phlorotannins, which have been proven for their antibacterial, antioxidant, anti-inflammatory, anti-proliferative, anti-tumor, anti-diabetic, anti-adipogenic, anti-allergic, and radio-protective effects [59].

2. Materials and Methods

2.1. Sample Collection

Fresh and dark brown thalli of *Ecklonia cava* were collected from Gijang, Busan, Republic of Korea (GPS coordinates: 35°15′34″ N 129°15′02″ E). Thalli were transported in a portable icebox to Tongyeong, Republic of Korea, and pre-processed on the same day.

2.2. Pre-Processing of E. cava Thalli

Fresh and dark brown thalli of *E. cava* were selected for the tissue culture experiment. Thalli were wiped with sterile paper towels (Wypall, Yuhan-Kimberly Co., Ltd., Seoul, Republic of Korea), washed twice with autoclaved seawater, and immersed sequentially in autoclaved seawater containing 1% povidone-iodine (Green Pharmaceutical Co., Ltd., Jincheon, Republic of Korea) and 2% triton X-100 (Samchun Pure Chemical Co., Ltd., Pyeongtaek, Republic of Korea) for 3 min each. After rinsing and washing, thalli were treated with an antibiotic mixture: Kanamycin (0.1 g L^{-1}; K1377; Sigma-Aldrich, St. Louis, MO, USA), Ampicillin (0.1 g L^{-1}; A9518; Sigma), Streptomycin (0.2 g L^{-1}; S9137; Sigma), Neomycin (20 mg L^{-1}; N1876; Sigma), and Nystatin (1.5 mg L^{-1}; N4014; Sigma) for 30 min at 12 °C to prevent contamination.

2.3. Experimental Conditions

Four culture media were employed: Provasoli's enriched seawater medium (PESI) [60], enriched artificial seawater medium (ESAW) [61], artificial enriched seawater medium (ASP-2) [62], and Von Stosch's enriched seawater medium (VS) [63]. Meristem and stipe were used for callus induction. Each section was cut into 1 × 1 cm^2 (L × W) pieces, treated with a 10× antibiotics mixture for 30 min at 12 °C, and placed on agar media in a growth chamber (Multi-Room Incubator; LMI-3004PL, Daihan Labtech Co., Ltd., Namyangju, Republic of Korea) for callus development. Six to eight explants were inoculated on each agar plate, and callus formation was confirmed under a microscope (Routine Microscopes; CX33; Evident Co., Ltd., Shinjuku-ku, Tokyo, Japan). Various treatments to optimize callus induction were performed as described in Table 1. The plant growth regulators, carbon sources, and polyamines were purchased from Sigma-Aldrich, St. Louis, MO, USA.

Table 1. Experimental conditions for callus induction in explants from *E. cava* meristem and stipe.

Parameter	Experimental Conditions
Effect of culture medium	• Explants were cultured on PESI, ESAW, ASP2, or VS solid medium supplemented with 1.5% agar. • Growth was monitored at 12 °C with a light period of 12 h for eight weeks.
Effect of agar concentration	• Explants were cultured on PESI solid medium containing 1.2% or 1.5% agar. • Growth was monitored at 12 °C for eight weeks.
Effect of photoperiod and temperature	• Explants were cultured on PESI solid medium containing 1.5% agar. Varying photoperiods (0 h or 12 h light period at a light intensity of 160 µmol m^{-2} s^{-1} using a fluorescent lamp; 36 W; FPL36EX-D/C, Ilshin Vitson Co., Ltd., Namyangju, Republic of Korea) and temperatures (12 °C or 18 °C) were tested. • Growth was monitored for eight weeks.

Table 1. *Cont.*

Parameter	Experimental Conditions
Effect of growth regulator	• Explants were cultured on PESI solid medium containing 1.5% agar. Different plant growth regulators: IAA (1003530010), IBA (I5386), NAA (N0640), BAP (B3408), 2,4-D (D70724) or KIN (48130), were added at concentrations up to 5 mg L^{-1}. • Growth was monitored at 12 °C in the dark for eight weeks.
Effect of carbon source	• Explants were cultured on PESI solid medium containing 1.5% agar. • Different carbon sources: glucose (PHR1000), lactose (PHR1025), galactose (PHR1206), fructose (F0127), sucrose (S0389), or sorbitol (PHR1006), were added at concentrations up to 5%. • The medium for meristem explants was supplemented with 1 mg L^{-1} IAA. • Growth was monitored at 12 °C in the dark for eight weeks.
Effect of polyamine	• Explants were cultured on PESI solid medium containing 1.5% agar and 2% sucrose. Different polyamines: Spm (85590), Put (51799), or Spd (S0266), were added at concentrations up to 1000 μM. • The medium for meristem explants was supplemented with 1 mg L^{-1} IAA. • Growth was monitored at 12 °C in the dark for eight weeks.
Effect of plasma treatment	• Explants were directly or indirectly treated with plasma. • Explants were cultured on PESI solid medium containing 1.5% agar and 2% sucrose. The medium for meristem explants was supplemented with 1 mg L^{-1} IAA and 1 μM Spm. • Growth was monitored at 12 °C in the dark for eight weeks.

PESI: Provasoli's enriched seawater medium; ESAW: Enriched artificial seawater medium; ASP2: Artificial enriched seawater medium; VS: Von Stosch's enriched seawater medium; IAA: Indole-3-acetic acid; IBA: Indole-3-butyric acid; NAA: 1-naphthaleneacetic acid; BAP: 6-benzylaminopurine; 2,4-D: 2,4-dichlorophenoxyacetic acid; KIN: Kinetin; Spm: Spermine; Put: Putrescine; Spd: Spermidine.

2.4. Plasma Treatment

Meristem and stipe explants were prepared as discussed in Sections 2.2 and 2.3, and then subjected to plasma treatment.

2.4.1. Indirect Plasma Treatment

A 40 mL autoclaved seawater in a Petri dish was treated with a plasma generator provided by KRIBB (Korea Research Institute of Bioscience and Biotechnology, Daejeon, Republic of Korea) for 5, 10, 40, or 60 s, respectively, following the procedure by Bian et al. [64]. Prepared explants were socked in plasma–treated autoclaved seawater for 20–22 h and then cultured on agar PESI medium in a growth chamber (LMI-3004PL; Daihan Labtech) for eight weeks at 12 °C in the dark.

2.4.2. Direct Plasma Treatment

Explants were placed in a beaker filled with autoclaved seawater and incubated for 20–22 h, and then cultured on agar PESI medium. Plasma treatment durations were 5, 10, 30, or 60 s, followed by incubation in a growth chamber (LMI-3004PL; Daihan Labtech) for eight weeks at 12 °C in the dark.

2.5. Statistical Analysis

Ten different replicates were utilized per experiment (n = 10). Initially, the percentage values underwent arcsin-square root transformation prior to statistical analysis. Subsequently, statistical significance was assessed using a one-way or multiple-way analysis of variance (ANOVA) conducted with IBM SPSS Statistics version 29.0 (IBM Corp., Armonk, NY, USA). Post hoc tests were conducted using Tukey's Honestly Significant Difference (HSD) test. Statistical significance was set at $p \leq 0.05$. The experimental results were presented as percentage values in the figures.

3. Results and Discussion

During preliminary experiments, poor callus development was observed in liquid media. Therefore, only agar media were used for callus induction and subsequent cultures, aligning with the findings of Kawashima and Tokuda [26]. Callus growth was monitored

for up to eight weeks, and both stipe and meristem explants displayed callus development within three to six weeks. The calluses, appearing light brown, exhibited gradual volume increases over the inoculation period and featured rod-shaped filamentous structures (Figures 1 and 2), reminiscent of those observed by Kawashima and Tokuda [26]. The optimal callus induction parameters were determined under various conditions, and the impact of abiotic factors on callus development was explored. Callus induction rate (%) was calculated based on the total number of induced calluses per total number of explants multiplied by 100.

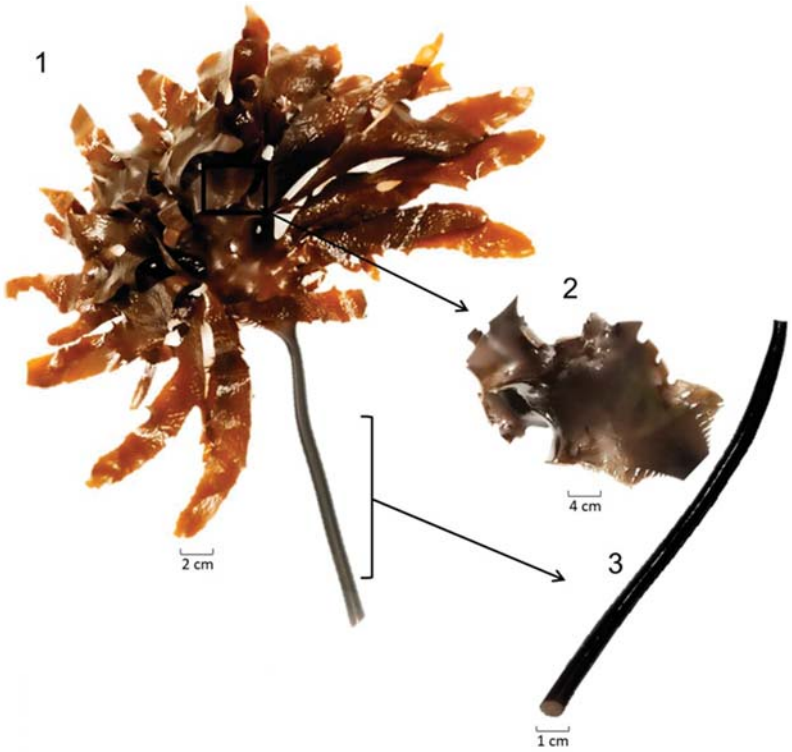

Figure 1. Preparation of *E. cava* for callus induction. (**1**) Collected *E. cava*, (**2**) *E. cava* meristem, (**3**) *E. cava* stipe.

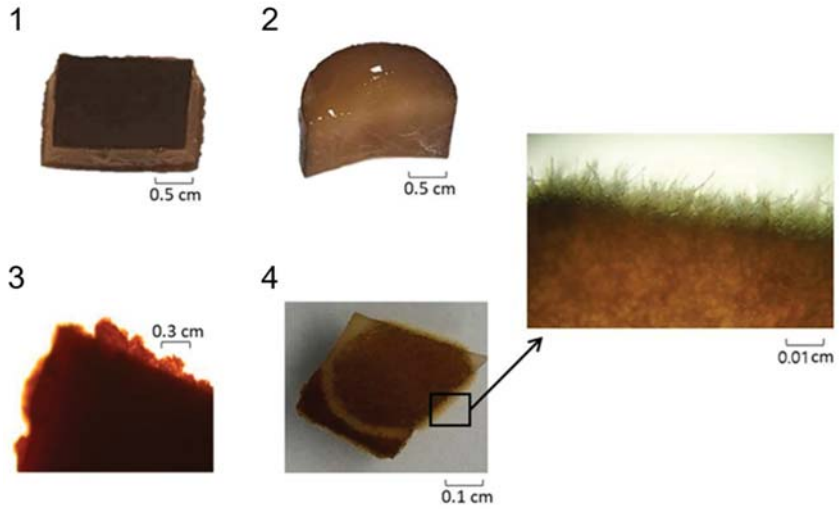

Figure 2. Callus induction in *E. cava* on PESI solid medium. (**1**) Meristem explant (1 × 1 cm^2), (**2**) Stipe explant (1 × 1 cm^2), (**3**) induced meristem callus under microscope (4×), (**4**) induced meristem fibrous callus under microscope (4×).

3.1. Effect of Media Type

Figure 3 presents the callus induction rates (%) observed with different culture media, and Figure 4 illustrates selected calluses induced from meristem and stipe explants of *E. cava*. The highest callus induction (31.73 ± 4.41% in stipe tissue and 38.28 ± 8.37% in meristem tissue) was observed on PESI medium, leading to its selection for subsequent experiments. The addition of potassium iodide in PESI medium [60] may have enhanced callus formation, aligning with the findings of Kawashima and Tokuda [26]. No callus growth was observed on ASP2 medium, possibly due to the presence of nitrilotriacetic acid and mannitol, acting as potential toxins [26,65] and increasing osmotic pressure of media [66], respectively.

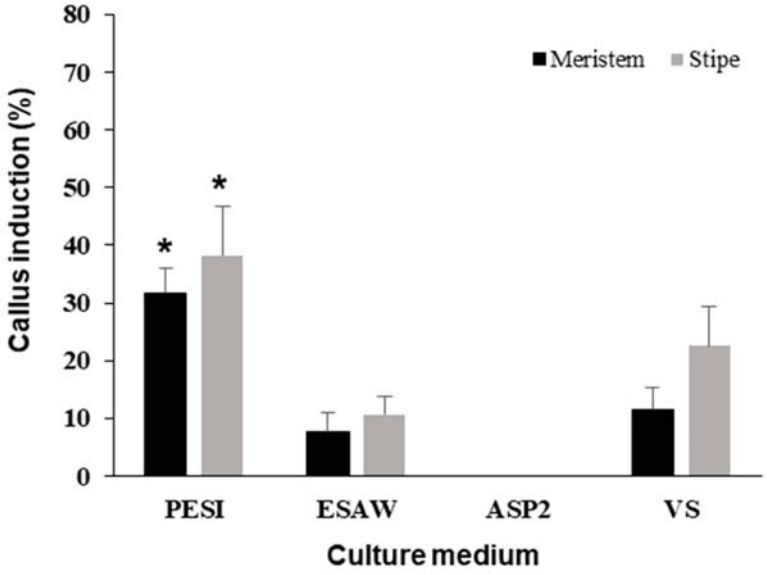

Figure 3. Effect of media type on callus induction. Values are means ± standard errors (S.E.) of 10 individual replicates per experiment (n = 10). PESI: Provasoli´s enriched seawater medium; ESAW: Enriched artificial seawater medium; ASP2: Artificial enriched seawater medium; VS: Von Stosch's enriched seawater medium. *: Indicates significant differences using Tukey's HSD test using a one-way ANOVA test at $p < 0.05$.

Figure 4. Callus induction in meristem (**a**) and stipe (**b**,**c**) on PESI solid medium supplemented with 1.5% agar.

3.2. Effect of Agar Concentration

Figure 5 shows the results of callus induction in meristem and stipe using PESI solid medium with different agar concentrations (1.2% and 1.5%). The highest callus induction rate (39.85 ± 8.27%) was observed in stipe at 1.5% agar concentration, followed by meristem (33.44 ± 6.50%) at 1.5% agar and 18 °C. Subsequent experiments utilized 1.5% agar concentration.

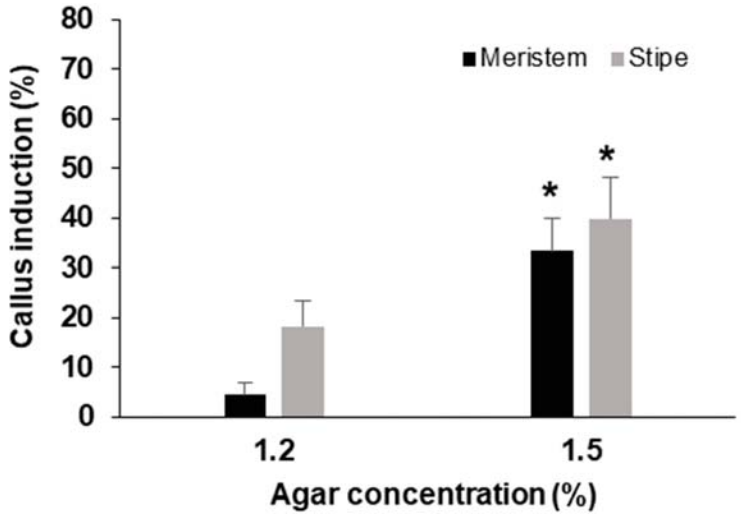

Figure 5. Effect of agar concentration on callus induction. Values are means ± standard errors (S.E.) of 10 individual replicates per experiment (n = 10). *: Indicates significant differences using Tukey's HSD test using a one-way ANOVA test at $p < 0.05$.

3.3. Effect of Photoperiod and Temperature

Environmental elements, including factors like photoperiod and light intensity, play a crucial role in the growth of algae. However, their influence varies among species and is contingent upon the specific product under investigation [67,68]. Additionally, light significantly impacts the growth and morphogenesis of callus by influencing the rate of cell division in various plants, directly regulating plant growth and development [69]. The impact of photoperiod (0 h and 12 h light) and temperatures (12 °C and 18 °C) on callus induction in meristem and stipe is shown in Figure 6. The highest callus induction (44.30 ± 6.28%) occurred in stipe at 0 h photoperiod and 12 °C. Optimal development of *E. cava* callus was observed at 12 °C, consistent with the findings of Kawashima and Tokuda [26]. Higher callus development was observed in complete darkness (0 h provision of light), possibly due to heterotrophic culture conditions overcoming growth inhibition challenges in light and aeration-dependent algal growth [70]. Subsequent experiments were conducted at 12 °C in dark.

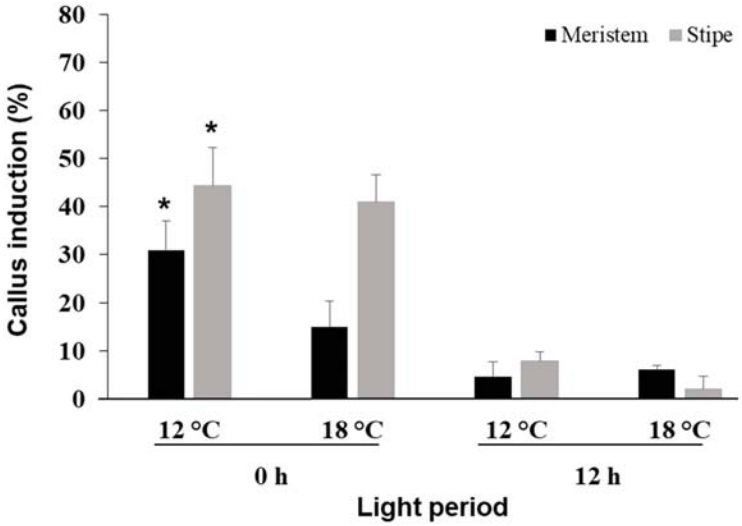

Figure 6. Effect of photoperiod and temperature on callus induction. Values are means ± standard errors (S.E.) of 10 individual replicates per experiment (n = 10). *: Indicates significant differences using

Tukey's HSD test using a multiple-way ANOVA test at $p < 0.05$. The temperature alone had no statistically significant effect ($p = 0.089$) on callus induction in stipe explant. However, the photoperiod alone ($p = 0.002$) and the interaction between photoperiod (0 h) and temperature (12 °C) showed a significant effect ($p = 0.049$) on callus induction in meristem when checked using a multiple-way ANOVA test using SPSS.

3.4. Effect of Growth Regulator

Plant growth regulators (PGRs) are incorporated into the basal growth medium of cell cultures to stimulate and regulate plant development [71–73]. These PGRs govern cell division in undifferentiated cells [74] and prompt callogenesis, leading to subsequent callus proliferation. Callus induction in meristem and stipe was observed in PESI solid medium with different growth regulators: indole-3-acetic acid (IAA), indole-3-butyric acid (IBA), 1-naphthaleneacetic acid (NAA), 6-benzylaminopurine (BAP), 2,4-dichlorophenoxyacetic acid (2,4-D), and kinetin (KIN) at concentrations of 1 or 5 mg L^{-1} at 12 °C (Figure 7). The selected calluses developed from meristem and stipe tissues are shown in Figure 8. The highest callus induction (50.37 ± 5.17%) in stipe occurred in standard PESI solid medium without growth regulators. Meanwhile, the highest callus induction rate (40.93 ± 8.65%) in meristem tissue was observed in PESI medium containing 1 mg L^{-1} IAA. Further experiments for meristem calluses were performed in PESI agar medium containing IAA, while stipe explants were cultured on standard PESI solid medium.

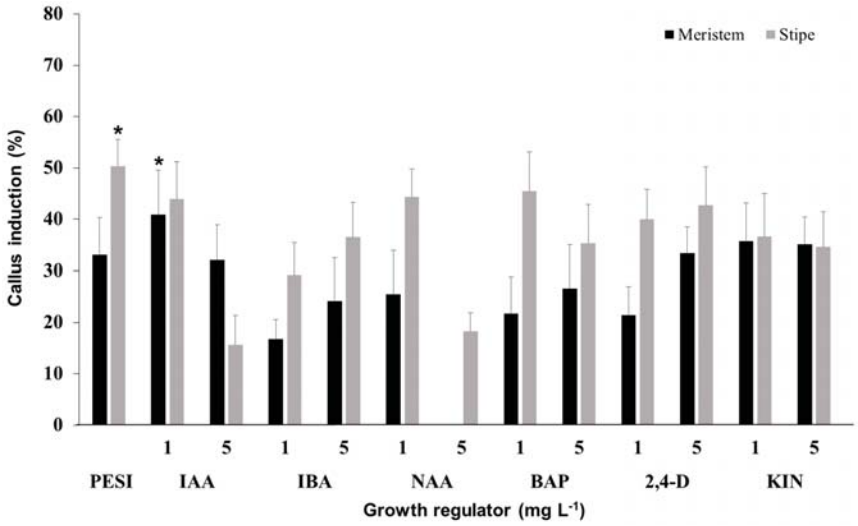

Figure 7. Effect of growth regulators on callus induction. Values are means ± standard errors (S.E.) of 10 individual replicates per experiment ($n = 10$). IAA: Indole-3-acetic acid; IBA: Indole-3-butyric acid; NAA: 1-naphthaleneacetic acid; BAP: 6-benzylaminopurine; 2,4-D: 2,4-dichlorophenoxyacetic acid; KIN: Kinetin. *: Indicates significant differences using Tukey's HSD test using a multiple-way ANOVA test at $p = 0.0312$ for stipe and $p = 0.047$ for meristem.

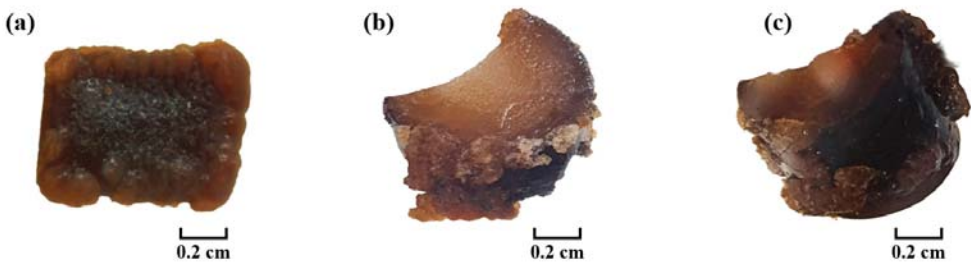

Figure 8. Callus induction in meristem (**a**) on PESI medium supplemented with 1 mg L^{-1} of IAA, and stipe (**b**,**c**) on standard PESI solid medium without containing growth regulators.

3.5. Effect of Carbon Source

Sugars are essential for biomass accumulation, serving as a vital energy source due to typically diminished photosynthetic activity in in vitro growing tissues. They also contribute to supply of carbon for biosynthetic processes and cell wall synthesis [75]. Moreover, sugars function as signal molecules that can either repress or activate plant genes, as noted by Tognetti et al. [76]. Callus induction in meristem and stipe was observed in PESI solid medium with different carbon sources (glucose, lactose, galactose, fructose, sucrose, or sorbitol) at 12 °C in dark (Figure 9). The selected calluses induced from meristem and stipe tissues are shown in Figure 10. Meristem tissue exhibited higher callus induction rates in PESI medium containing sucrose (51.42 ± 5.05%) or glucose (43.60 ± 7.88%) compared to standard PESI medium (40.31 ± 17.41%). Stipe tissue displayed an overall higher rate of callus induction in PESI medium supplemented with 2% sucrose (58.48 ± 5.66%) or glucose (53.10 ± 7.15%). It could be due to the factor that the inclusion of organic carbon sources may alleviate stresses arising from heterotrophic conditions in algal growth [40]. Furthermore, sucrose proves to be a relatively economic choice compared to other carbon sources. Consequently, subsequent experiments were performed in PESI medium containing 2% sucrose at 12 °C in the dark.

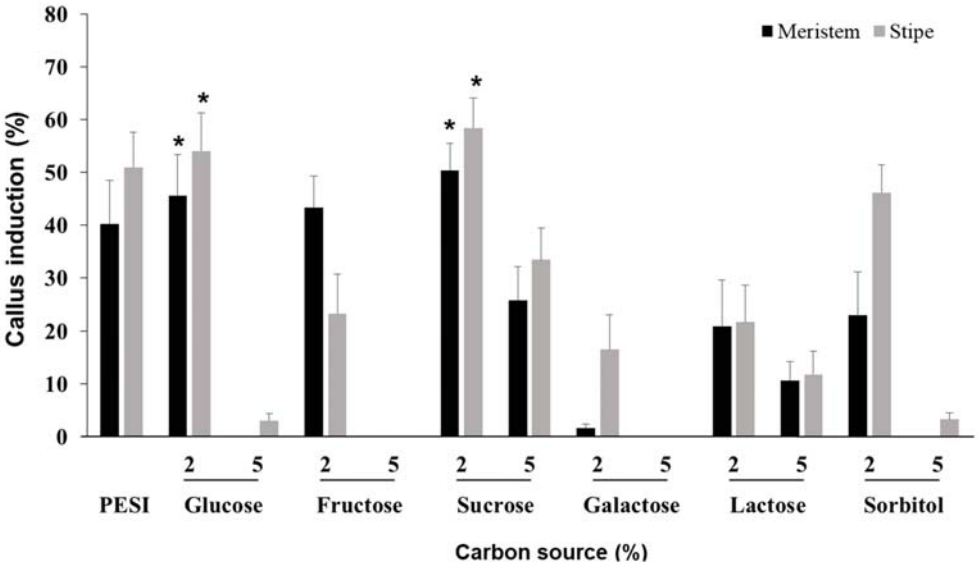

Figure 9. Effect of carbon sources on callus induction. Values are means ± standard errors (S.E.) of 10 individual replicates per experiment (n = 10). *: Indicates significant differences using Tukey's HSD test using a multiple-way ANOVA test at $p < 0.05$.

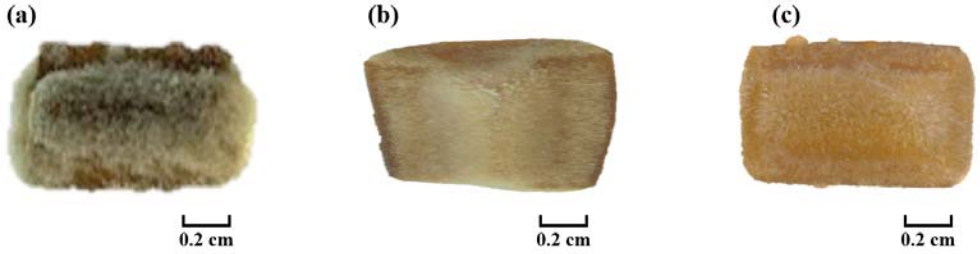

Figure 10. Callus induction in meristem (**a**) and stipe (**b**,**c**) on PESI solid medium supplemented with 2% sucrose.

3.6. Effect of Polyamine

Polyamines, including spermine (Spm), putrescine (Put), and spermidine (Spd), represent a category of low molecular weight aliphatic nitrogenous organic compounds containing two or more amino groups [77]. These compounds are associated with various biological processes, including tissue growth, cell division, and cell differentiation [78]. Polyamines have been linked to higher callus induction and growth [79], while also playing a significant role in responding to both biotic and abiotic stresses [80]. Previous studies have indicated an increase in arginine decarboxylase (ADC) activity in rice seedlings when exposed to salinity [81]. Similarly, Wang and Liu [82] observed an increase in ADC and S-adenosylmethionine decarboxylase (SAMDC) expression in citrus embryogenic callus under high salinity and both low and high temperatures. Furthermore, various abiotic stresses have been shown to trigger the up regulation of SAMDC expression at the transcriptional level in transgenic tobacco plants [83]. Moreover, Zhou et al. [78] observed higher free polyamine levels and the expression of polyamine biosynthesis enzyme genes in young rice spikelets under heat stress, thereby increasing endogenous Spd and Spm levels. This correlation was associated with higher yield and resistance to heat stress, providing insights for rice production under high temperatures. This involvement in stress response is just one aspect of their intricate physiological functions.

Callus induction in meristem and stipe was monitored in PESI solid medium with different polyamines (Spm, Put, Spd) at 12 °C in dark (Figure 11). The selected calluses are shown in Figure 12. Overall, an increase in callus induction was observed in meristem tissue when culture medium was supplemented with 1 µM Spm (60.55 ± 3.05%). Except for this, all other conditions did not show a favorable impact on callus induction in meristem and stipe of *E. cava* compared to the callus development in standard PESI medium.

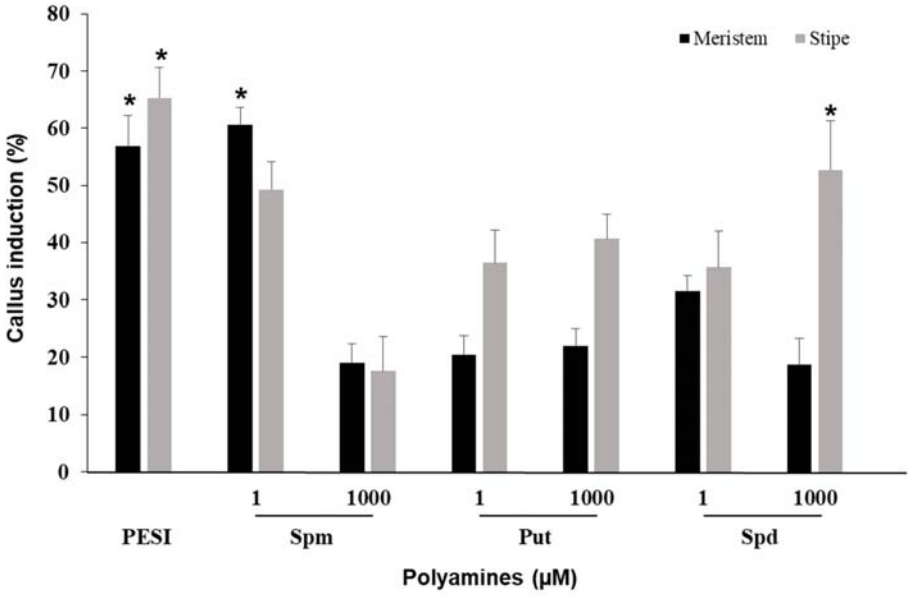

Figure 11. Callus induction in PESI medium supplemented with different polyamines. Values are means ± standard errors (S.E.) of 10 individual replicates per experiment (n = 10). Spm: Spermine; Put: Putrescine; Spd: Spermidine. *: Indicates significant differences using Tukey's HSD test using a multiple-way ANOVA test at $p < 0.05$.

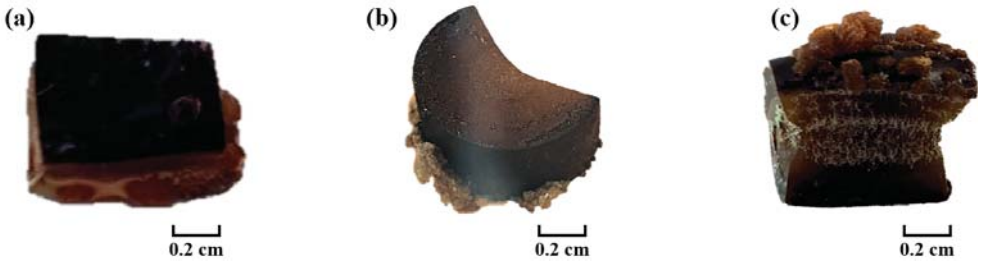

Figure 12. Callus induction in meristem (**a**) on PESI solid medium supplemented 1 µM SPM, and in stipe (**b**,**c**) on standard PESI solid medium without containing polyamines.

3.7. Effect of Plasma Treatment

The impact of plasma treatment on callus induction in meristem and stipe is shown in Figure 13. The selected calluses are shown in Figure 14. Indirect plasma treatment showed callus induction in both meristem and stipe, while direct plasma treatment on meristem explants did not yield callus induction. Indirect or direct plasma treatment failed to enhance callus induction rate, as the highest development occurred at 0 s plasma treatment in both meristem (57.53 ± 5.19%) and stipe (65.59 ± 6.24%). Therefore, based on the findings of this study, plasma treatment is not recommended for callus development in *E. cava*. However, further research exploring alternative plasma techniques may reveal different outcomes.

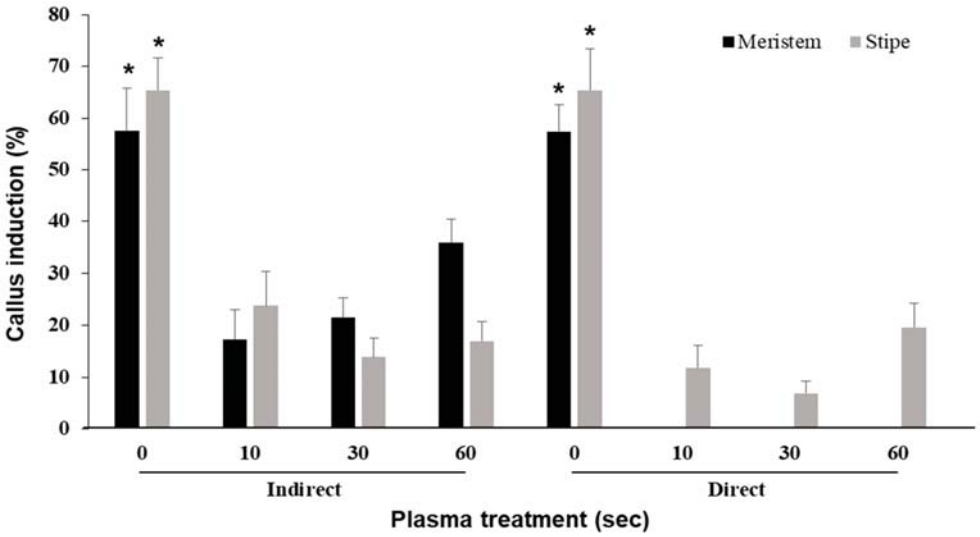

Figure 13. Effect of plasma treatment on callus induction on PESI medium. Values are means ± standard errors (S.E.) of 10 individual replicates per experiment (n = 10). *: Indicates significant differences using Tukey's HSD test using a multiple-way ANOVA test at $p < 0.05$.

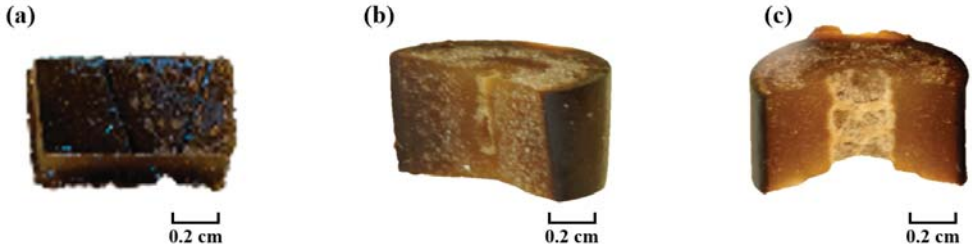

Figure 14. Callus induction in direct (**a**) for 5 s and indirect for 60 s, (**b**,**c**) plasma treated stipe explants cultured on standard PESI solid medium.

4. Conclusions

Callus, often referred to as the stem cell of a plant, represents an undifferentiated cell mass capable of unlimited proliferation and re-differentiation under favorable conditions. The establishment of callus-based seaweed culture technology holds the key to the mass production and industrialization of seaweeds that pose challenges in cultivation or collection, such as *E. cava*. The improved method for callus induction in *E. cava* involves culturing in PESI solid medium with 1.5% agar and 2% sucrose at 12 °C in the dark. Specifically for stipe explants, it is recommended to omit growth regulators, while for meristem, the use of 1 mg L^{-1} IAA and 1 μM Spm is advisable. Although plasma treatment did not yield favorable results in our study, exploring different plasma techniques may offer alternative outcomes. The establishment of *E. cava* callus cultures holds significant promise for research purposes and for addressing seed stock supply for mariculture and bioactive compound production. The callus induction technique developed in this study could streamline the mass cultivation of *E. cava* and other beneficial seaweed species, paving the way for the development of a callus-based smart farming technology. This advancement contributes to the cultivation of *E. cava* and other commercially valuable seaweed species for functional food and pharmaceutical materials.

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Abbreviations

2,4-D: 2,4-dichlorophenoxyacetic acid; ANOVA: Analysis of variance; ASP2: Artificial enriched seawater medium; BAP: 6-benzylaminopurine; ESAW: Enriched artificial seawater medium; IAA: Indole-3-acetic acid; IBA: Indole-3-butyric acid; KIN: Kinetin; KRIBB: Korea Research Institute of Bioscience and Biotechnology; NAA: 1-naphthaleneacetic acid; PESI: Provasoli´s enriched seawater medium; PGRs: Plant growth regulators; Put: Putrescine; S.E.: Standard error; Spd: Spermidine; Spm: Spermine; VS: Von Stosch's enriched seawater medium.

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Department of Mechanics of Materials and Constructions, Vrije Universiteit Brussel, Pleinlaan 2, 1050 Brussels, Belgium

Interests: nondestructive testing; acoustic emission; ultrasonic testing; ultrasound; concrete; structural health monitoring

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Institut de Recherche Dupuy de Lôme (UMR CNRS 6027 IRDL), University of Brest, 29238 Brest, France

Interests: fault detection and diagnosis; failure prognosis; cyberattack detection; fault-resilient control; machine learning

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Department of Cancer Biology, University of Kansas Medical Center, Kansas City, KS, USA

Interests: protease signatures for early cancer diagnostics and cancer therapy decisions; imaging of biophysical barriers in cancer/spectral imaging/micrometastases; advanced drug delivery and drug delivery materials

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Optical Sciences Centre and ARC Training Centre in Surface Engineering for Advanced Materials (SEAM), School of Science, Swinburne University of Technology, Melbourne, VIC 3122, Australia

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Advanced Ultrafast Laser Research Center, The University of Electro-Communications, 1-5-1, Chofugaoka, Chofu, Tokyo 182-8585, Japan

Interests: ultrafast and nonlinear optical processes; quantum optics; quantum photobiology

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School of Mechanical Engineering, Shanghai Jiao Tong University, Shanghai 200240, China

Interests: carbon-neutral energy and power technologies; low-carbon combustion technologies; combustion kinetics and dynamics; novel combustion technologies, such as flame synthesis and plasma-assisted combustion; spray, atomization and evaporation

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Department of Agroindustry and Food Quality, Andalusian Institute of Agricultural and Fisheries Research and Training (IFAPA), Avenida Menendez-Pidal, SN, 14004 Córdoba, Spain

Interests: food quality and traceability; specifically on the characterization of sensory; bioactive compounds of different food matrixes using several techniques (e.g., GC-MS/GC-FID, UHPLC-HRMS and EA(GC)-C-IRMS)

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Interests: biosensors; electrochemical sensors; electrochemistry

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Section Editor-in-Chief

School of Civil Engineering, University College Dublin, D04 V1W8 Dublin, Ireland

Interests: bridge health monitoring and assessments; weigh-in-motion; sensor-based monitoring; structural dynamics

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2. Department of Electronic and Biomedical Engineering, University of Barcelona, Barcelona, Spain

Interests: inorganic thin film photovoltaic technologies; chalcogenide based solar cells; advanced device concepts for very high efficiency photovoltaics; emerging photovoltaic technologies; advanced PV integration concepts (BIPV, AIPC, PIPV…)

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Department of Earth and Environmental Sciences (DISAT), University of Milano-Bicocca, Piazza della Scienza 4, 20126 Milano, Italy

Interests: isotope geochemistry (mainly light noble gas and CO_2) in gases, waters, minerals/rocks (fluid inclusions) from volcanic/geothermal areas and lithospheric mantle; application of isotope geochemistry to volcano monitoring

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Section of Condensed Matter Physics and Solid Earth Physics Institute, Department of Physics, National and Kapodistrian University of Athens, Panepistimiopolis Zografos, 157 84 Athens, Greece

Interests: earthquake precursory phenomena; physics of earthquakes; earthquake prediction; natural time analysis; thermodynamics of point defects; complex systems physics; nonlinear dynamics

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Department of Solid Mechanics, Mechanical Engineering and Civil Engineering, Ecole Centrale de Lyon, 69134 Ecully, France

Interests: nonlinear vibration; friction-induced vibration; uncertainties; structural health monitoring; rotordynamics

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Section Editor-in-Chief

Department of Neurosciences, Reproductive and Odontostomatological Sciences, University of Naples "Federico II", 80131 Naples, Italy

Interests: oral medicine; dental materials; operative dentistry; oral health

* Section: Applied Dentistry and Oral Sciences

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Department of Experimental Biomedicine and Clinical Neuroscience, University of Palermo, via del Vespro 129, 90127 Palermo, Italy

Interests: medicine; biochemistry, genetics, and molecular biology; agricultural and biological sciences; baropodometry

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Associate Editor

Department of Engineering, University of Campania Luigi Vanvitelli, Via Roma 29, 81031 Aversa, Italy

Interests: optical sensors; biosensors and chemical sensors; optical fiber sensors and optoelectronic devices

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Associate Editor

School of Environmental Science and Engineering, Tianjin University, Tianjin 300072, China

Interests: biomass energy utilization; combustion reaction kinetics; pyrolysis; combustion; gasification; reaction mechanism; catalytic thermal conversion

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Associate Editor

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Interests: structural engineering; impact dynamics; discrete element modeling; concrete; timber

* Section: Civil Engineering

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Associate Editor

European Laboratory for Non-Linear Spectroscopy, Department of Physics and Astronomy, University of Firenze, Via N. Carrara 1, 50019 Sesto Fiorentino, Italy

Interests: nanophotonics; photonic bandgap materials; mie resonators; semiconductor nanostructures; high spatial resolution imaging; scanning near-field optical microscopy

* Section: Optics and Lasers

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Institut National des Sciences Appliquées de Lyon (INSA-Lyon), 20 Avenue Albert Einstein, 69100 Villeurbanne, France

Interests: multiphysic coupling; electroactive conversion and device; energy harvesting; self-powered devices; vibration control

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Associate Editor

Department of Mechanical Engineering and Aeronautics, University of Patras, 26504 Patras, Greece

Interests: robotic systems; automation; augmented, mixed, and virtual reality in manufacturing; manufacturing process modeling; cloud technologies; Internet of Things (IoT); digital twin; 5G; artificial intelligence; product–service systems (PSS); Industry 4.0; Industry 5.0

* Section: Robotics and Automation

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Appl. Sci., Volume 14, Issue 8 (April-2 2024) – 402 articles

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Factors Affecting Radial Increment Dynamics in Lithuanian Populations of Common Juniper (*Juniperus communis* L.)

by Rasa Vaitkevičiūtė, Ekaterina Makrickiene and Edgaras Linkevičius

Appl. Sci. 2024, *14*(8), 3536; https://doi.org/10.3390/app14083536 - 22 Apr 2024

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Abstract Although common juniper (*Juniperus communis* L.) is a widely spread species and important for the forest biodiversity and economy in many European countries, it remains one of the least studied coniferous species. This research is the first attempt to evaluate the factors [...] Read more.

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by Baptiste Chanel, Nicolas Babault and Carole Cornelli

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by Ezgi Gurgenc, Osman Altay and Elif Varol Altay

Appl. Sci. 2024, *14*(8), 3534; https://doi.org/10.3390/app14083534 - 22 Apr 2024

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Abstract To ascertain the optimal and most efficient reservoir temperature of a geothermal source, long-term field studies and analyses utilizing specialized devices are essential. Although these requirements increase project costs and induce delays, utilizing machine learning techniques based on hydrogeochemical data can minimize losses [...] Read more.

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by **Libo Zhang**, **Bing Duan**, **Jinlong Li**, **Zhan'gang Ma** and **Xixin Cao**

Appl. Sci. 2024, *14*(8), 3533; **https://doi.org/10.3390/app14083533** - 22 Apr 2024

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Abstract With the continuous enhancement of privacy protection globally, there is a problem for the traditional machine learning paradigm, which is that training data cannot be obtained from a single place. Federated learning is considered a viable technique for preserving privacy that can train [...] Read more.

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Appl. Sci. 2024, *14*(8), 3532; **https://doi.org/10.3390/app14083532** - 22 Apr 2024

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Abstract With the rapid development of the Internet and social media, false information, rumors, and misleading content have become pervasive, posing significant threats to public opinion and social stability, and even causing serious societal harm. This paper introduces a novel solution to address the [...] Read more.

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by **Shekhar Suman Borah**, **Aaditya Khanal** and **Prabha Sundaravadivel**

Appl. Sci. 2024, *14*(8), 3531; **https://doi.org/10.3390/app14083531** - 22 Apr 2024

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Abstract This article explores the impact of automation on environmental sensing, focusing on advanced technologies that revolutionize data collection analysis and monitoring. The International Union of Pure and Applied Chemistry (IUPAC) defines automation as integrating hardware and software components into modern analytical systems. Advancements [...] Read more.

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by **Paulius Ragauskas**, **Ina Tetsmann** and **Raimondas Jasevičius**

Appl. Sci. 2024, *14*(8), 3530; **https://doi.org/10.3390/app14083530** - 22 Apr 2024

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Abstract The optimization of the geometry of a centrifugal fan is performed at maximum power and high-efficiency design points (DPs) to improve impeller efficiency. Two design variables defining the shape of fan blade are selected for the optimization. The optimal values of the geometry [...] Read more.

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by **Monica Macrì**, **Abdulaziz Alhotan**, **Gabriella Galluccio**, **Ersilia Barbato** and **Felice Festa**

Appl. Sci. **2024**, *14*(8), 3529; **https://doi.org/10.3390/app14083529** - 22 Apr 2024

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Abstract (•) Orthognathic surgery is a necessary procedure for the correction of severe skeletal discrepancies, among which are skeletal Class III malocclusions. Currently, both conventional fixed braces and clear aligners can be used in orthognathic surgery. However, the use of clear aligners remains a [...] **Read more.**

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by **Sofianos Panagiotis Fotias**, **Ismail Ismail** and **Vassilis Gaganis**

Appl. Sci. **2024**, *14*(8), 3528; **https://doi.org/10.3390/app14083528** - 22 Apr 2024

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by **Konstantin Kebkal**, **Aleksey Kabanov**, **Oleg Kramar**, **Maksim Dimin**, **Timur Abkerimov**, **Vadim Kramar** and **Veronika Kebkal-Akbari**

Appl. Sci. **2024**, *14*(8), 3527; **https://doi.org/10.3390/app14083527** - 22 Apr 2024

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Abstract When several hydroacoustic modems operate simultaneously in an area of mutual coverage, collisions of data packets received from several sources may occur, which lead to information loss. With an increase in the number of simultaneously operating hydroacoustic modems, physical layer algorithms do not [...] **Read more.**

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Hypergraph Position Attention Convolution Networks for 3D Point Cloud Segmentation

by **Yanpeng Rong**, **Liping Nong**, **Zichen Liang**, **Zhuocheng Huang**, **Jie Peng** and **Yiping Huang**

Appl. Sci. **2024**, *14*(8), 3526; **https://doi.org/10.3390/app14083526** - 22 Apr 2024

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Abstract Point cloud segmentation, as the basis for 3D scene understanding and analysis, has made significant progress in recent years. Graph-based modeling and learning methods have played an important role in point cloud segmentation. However, due to the inherent complexity of point cloud data, [...] **Read more.**

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by **Qi Yi**, **Zhen Shen**, **Guanhua Sun**, **Shan Lin** and **Hongming Luo**

Appl. Sci. **2024**, *14*(8), 3525; **https://doi.org/10.3390/app14083525** - 22 Apr 2024

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Abstract Lined rock caverns (LRCs) are becoming the preferred option for air storage at sites where there are no natural cavities, such as salt caverns, and this storage technology is being developed and utilized in markets around the world. The stability of the overlying [...] Read more.

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Text Triplet Extraction Algorithm with Fused Graph Neural Networks and Improved Biaffine Attention Mechanism

by **Yinghao Piao** and **Jin-Xi Zhang**

Appl. Sci. **2024**, *14*(8), 3524; **https://doi.org/10.3390/app14083524** - 22 Apr 2024

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Abstract In the realm of aspect-based sentiment analysis (ABSA), a paramount task is the extraction of triplets, which define aspect terms, opinion terms, and their respective sentiment orientations within text. This study introduces a novel extraction model, BiLSTM-BGAT-GCN, which seamlessly integrates graph neural networks [...] Read more.

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Structural and Tribological Analysis of Brake Disc–Pad Pair Material for Cars

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Appl. Sci. **2024**, *14*(8), 3523; **https://doi.org/10.3390/app14083523** - 22 Apr 2024

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Abstract The study of the tribological behavior of the braking system in auto vehicles requires knowing the characteristics of the material in contact and, in the work process, the friction pair brake disc pads. Material structural analysis is necessary because the wear process depends [...] Read more.

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Encapsulation of Fennel Essential Oil in Calcium Alginate Microbeads via Electrostatic Extrusion

by **Erika Dobroslavić**, **Ena Cegledi**, **Katarina Robić**, **Ivona Elez Garofulić**, **Verica Dragović-Uzelac** and **Maja Repajić**

Appl. Sci. **2024**, *14*(8), 3522; **https://doi.org/10.3390/app14083522** - 22 Apr 2024

Cited by 3 | Viewed by 1637

Abstract Fennel essential oil (EO) is well known for its biological activities and wide potential for use in the food, cosmetic, and pharmaceutical industries, where the main challenge is to achieve higher stability of EO. This study aimed to evaluate the potential of electrostatic [...] Read more.

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Automatic Object Detection in Radargrams of Multi-Antenna GPR Systems Based on Simulation Data for Railway Infrastructure Analysis

by **Lukas Lahnsteiner**, **David Größbacher**, **Martin Bürger** and **Gerald Zauner**

Appl. Sci. **2024**, *14*(8), 3521; **https://doi.org/10.3390/app14083521** - 22 Apr 2024

Cited by 1 | Viewed by 1652

Abstract Ground-penetrating radar (GPR) is a non-invasive technology that uses electromagnetic pulses for subsurface exploration. In the railroad sector, it is crucial to assessing soil layers and infrastructure, offering insights into soil stratification and geological features and aiding in identifying subsurface hazards. However, the [...] Read more.

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by **Yousef Mahmoud Al-Awadi**, **Ali Baydoun** and **Hafeez Ur Rehman**

Appl. Sci. **2024**, *14*(8), 3520; **https://doi.org/10.3390/app14083520** - 22 Apr 2024

Cited by 1 | Viewed by 2790

Abstract The ever-evolving landscape of cyber threats, with ransomware at its forefront, poses significant challenges to the digital world. Windows 11 Pro, Microsoft's latest operating system, claims to offer enhanced security features designed to tackle such threats. This paper aims to comprehensively evaluate the [...] Read more.

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Stability Analysis in Multi-VSC (Voltage Source Converter) Systems of Wind Turbines

by **Dimitrios Dimitropoulos**, **Xiongfei Wang** and **Frede Blaabjerg**

Appl. Sci. **2024**, *14*(8), 3519; **https://doi.org/10.3390/app14083519** - 22 Apr 2024

Cited by 2 | Viewed by 1444

Abstract In this paper, a holistic nonlinear state-space model of a system with multiple converters is developed, where the converters correspond to the wind turbines in a wind farm and are equipped with grid-following control. A novel generalized methodology is developed, based on the [...] Read more.

(This article belongs to the Section Energy Science and Technology)

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Users' Expectations of Smart Devices during Physical Activity—A Literature Review

by **Kitti Tóth**, **Péter Takács** and **Ildikó Balatoni**

Appl. Sci. **2024**, *14*(8), 3518; **https://doi.org/10.3390/app14083518** - 22 Apr 2024

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Abstract Background: The field of smart devices and physical activity is evolving rapidly, with a wide range of devices measuring a wide range of parameters. Scientific articles look at very different populations in terms of the impact of smart devices but do not take [...] Read more.

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Soil and Sediments in Natural Underground Ecosystems as a Source of Culturable Micromycetes: A Case Study of the Brestovská Cave (Western Tatras, Slovakia)

by **Rafał Ogórek**, **Justyna Borzęcka**, **Klaudyna Spychała**, **Agata Piecuch** and **Jakub Suchodolski**

Appl. Sci. **2024**, *14*(8), 3517; **https://doi.org/10.3390/app14083517** - 22 Apr 2024

Cited by 1 | Viewed by 1214

Abstract Soil and sediment host microorganisms are able to survive in extremely resource-limited environments. Therefore, more and more attention is being paid to cave sediments as a reservoir of microbiota. The aim of this study is the speleomycological evaluation of the culturable soil and [...] Read more.

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Exploring the Performance of Continuous-Time Dynamic Link Prediction Algorithms

by **Raphaël Romero**, **Maarten Buyl**, **Tijl De Bie** and **Jefrey Lijffijt**

Appl. Sci. **2024**, *14*(8), 3516; **https://doi.org/10.3390/app14083516** - 22 Apr 2024

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Abstract Dynamic Link Prediction (DLP) addresses the prediction of future links in evolving networks. However, accurately portraying the performance of DLP algorithms poses challenges that might impede progress in the field. Importantly, common evaluation pipelines usually calculate ranking or binary classification metrics, where the [...] Read more.

(This article belongs to the Special Issue Data Mining and Machine Learning in Social Network Analysis)

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Comparison of the Operator and Surrounding Dose When Using Portable Intraoral X-ray Devices

by **Mehrdad Abdinian**, **Maedeh Aminian**, **Forouzan Keymasi**, **Parisa Soltani**, **Mariangela Cernera**, **Niccolo Giuseppe Armogida** and **Gianrico Spagnuolo**

Appl. Sci. **2024**, *14*(8), 3515; **https://doi.org/10.3390/app14083515** - 22 Apr 2024

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Abstract This study aimed to investigate the scattered radiation dose using three portable dental radiographic units: iRay D3, EZRay Air, and Epix. The absorbed dose was measured at 0.5 and 1 m distances, every 15° in the horizontal plane, using an ionization chamber. The [...] Read more.

(This article belongs to the Section Applied Dentistry and Oral Sciences)

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Research on Optimization of an Open-Bench Deep-Hole Blasting Parameter Using an Improved Gray Wolf Algorithm

by **Li Zhao**, **Dengfeng Su**, **Zhengguo Li**, **Banghong Chen**, **Rui Wang** and **Rongkai Chen**

Appl. Sci. **2024**, *14*(8), 3514; **https://doi.org/10.3390/app14083514** - 22 Apr 2024

Cited by 2 | Viewed by 1547

Abstract The blasting quality of open-pit mining can be enhanced and the production cost of stope reduced by establishing a mathematical model for step drilling and blasting costs based on stope consumption. By enhancing the Gray Wolf algorithm, the parameters for step drilling and [...] Read more.

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Enhanced Visual Performance for In–Vehicle Reading Task Evaluated by Preferences, Emotions and Sustained Attention

by **Yichen Ni**, **Christopher Weirich** and **Yandan Lin**

Appl. Sci. **2024**, *14*(8), 3513; **https://doi.org/10.3390/app14083513** - 22 Apr 2024

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Abstract The proliferation of electric and hybrid vehicles has made it possible for people to read and work in a stationary vehicle for extended periods. However, the current commonly used in–vehicle lighting design is still centered around driving and driving safety. Following recommendations from [...] Read more.

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A Meta-Analysis of the Effect of Moisture Content of Recycled Concrete Aggregate on the Compressive Strength of Concrete

by **Sung-Won Cho**, **Sung Eun Cho** and **Alexander S. Brand**

Appl. Sci. **2024**, *14*(8), 3512; **https://doi.org/10.3390/app14083512** - 22 Apr 2024

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Abstract To reduce the environmental impact of concrete, recycled aggregates are of significant interest. Recycled concrete aggregate (RCA) presents a significant resource opportunity, although its performance as an aggregate in concrete is variable. This study presents a meta-analysis of the published literature to refine [...] Read more.

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by **Abdel Boughriet**, **Gildas Doyemet**, **Nicole Poumaye**, **Oscar Allahdin** and **Michel Wartel**

Appl. Sci. **2024**, *14*(8), 3511; **https://doi.org/10.3390/app14083511** - 22 Apr 2024

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Abstract Kaolinite-rich soils were used to prepare zeolite-based composites via alkaline activation. The porous material was characterized by conducting XRD and microporosity measurements, as well as ESEM microscopy. The Weber and Morris (W-M) model was used for studying adsorption kinetics of radioactive cations on [...] Read more.

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Appl. Sci. **2024**, *14*(8), 3510; **https://doi.org/10.3390/app14083510** - 22 Apr 2024

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Abstract Consensus protocols, as crucial components of blockchain technology, play a vital role in ensuring data consistency among distributed nodes. However, the existing voting-based and proof-based consensus protocols encounter scalability issues within the blockchain system. Moreover, most consensus protocols are serialized, which further limits [...] Read more.

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P D N: A Priori Dictionary Network for Fashion Parsing

by **Jue Hou**, **Yinwen Lu**, **Yang Yang** and **Zheng Liu**

Appl. Sci. **2024**, *14*(8), 3509; **https://doi.org/10.3390/app14083509** - 22 Apr 2024

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Abstract The task of fashion parsing aims to assign pixel-level labels to clothing targets; thereby, parsing models are required to have good contextual recognition ability. However, the shapes of clothing components are complex, and the types are difficult to distinguish. Recent solutions focus on [...] Read more.

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The Quality of Goose Breast Muscle Products Depending on the Cooking Method Used

by **Adam Więk**, **Wacław Mozolewski**, **Sylwester Rybaczek** and **Monika Modzelewska-Kapituła**

Appl. Sci. **2024**, *14*(8), 3508; **https://doi.org/10.3390/app14083508** - 22 Apr 2024

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Abstract This study was conducted to compare the quality characteristics of White Kołuda goose breast muscle products, heated using the sous vide (SV) and the convection–steam oven (OV) methods. The qualitative analysis included instrumental evaluation of texture and colour parameters and the content of [...] Read more.

(This article belongs to the Section Food Science and Technology)

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Chosen Biochemical and Physical Properties of Beetroot Treated with Ultrasound and Dried with Infrared–Hot Air Method

by **Malgorzata Nowacka**, **Katarzyna Rybak**, **Magdalena Trusinska**, **Magdalena Karwacka**, **Aleksandra Matys**, **Katarzyna Pobiega** and **Dorota Witrowa-Rajchert**

Appl. Sci. **2024**, *14*(8), 3507; **https://doi.org/10.3390/app14083507** - 22 Apr 2024

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Abstract Beetroots are sources of bioactive compounds and valued pigments such as betalains. The purpose of this study was to determine the influence of ultrasound pretreatment on the beetroot infrared–hot air drying process and the functional properties of the obtained product. In this study, [...] Read more.

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by **Tomasz Kozior**, **Jerzy Bochnia**, **Aleksandra Bochenek**, **Dominik Malara**, **Michal Nawotka**, **Jan Jansa**, **Jiri Hajnys**, **Adam Wojtowicz** and **Jakub Mesicek**

Appl. Sci. **2024**, *14*(8), 3506; **https://doi.org/10.3390/app14083506** - 21 Apr 2024

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Abstract This paper presents the results of a study on the dimensional accuracy analysis of models produced by 3D printing technology—Fused Filament Fabrication (FFF). Geometric measurements were conducted using a dial caliper, a 3D scanner and a coordinate measuring machine. In addition, a statistical [...] Read more.

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by **M. Lourdes Mourelle**, **Carmen P. Gómez**, **José L. Legido** and **Leonel Pereira**

Appl. Sci. **2024**, *14*(8), 3505; **https://doi.org/10.3390/app14083505** - 21 Apr 2024

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by **Takudzwa Martin Mashamba**, **Jiale Wen**, **Catalina Spataru**, **Yiwu Weng** and **Xiaojing Lv**

Appl. Sci. **2024**, *14*(8), 3504; **https://doi.org/10.3390/app14083504** - 21 Apr 2024

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Abstract In this study, the implementation of a solid oxide fuel cell–gas turbine hybrid engine for primary propulsion and electric power generation in aircraft is investigated. The following three parameters, which are crucial in attaining optimal performance at any point in the flight profile, [...] Read more.

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Appl. Sci. **2024**, *14*(8), 3503; **https://doi.org/10.3390/app14083503** - 21 Apr 2024

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Appl. Sci. **2024**, *14*(8), 3502; **https://doi.org/10.3390/app14083502** - 21 Apr 2024

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The Effect of Laser Settings and Ureteral Access Sheath Size on Intrapelvic Temperature during Holmium Laser Lithotripsy

by **Krzysztof Balawender** and **Bartosz Dybowski**

Appl. Sci. **2024**, *14*(8), 3501; **https://doi.org/10.3390/app14083501** - 21 Apr 2024

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Abstract Introduction: Thermal damage to the kidney during holmium laser lithotripsy is a serious complication, which cannot always be prevented considering the diversity of conditions in the kidney and the lack of technical capability to measure intrarenal temperature in real-time. The aim of this [...] Read more.

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Appl. Sci. **2024**, *14*(8), 3500; **https://doi.org/10.3390/app14083500** - 21 Apr 2024

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Abstract Hub airports typically have multiple parallel runways, requiring aircraft to transfer between them. This increases the risk of runway incursions. End-around taxiways (EATs) mitigate such risk by enabling bypassing without runway crossings. This review summarizes 15 EAT layouts worldwide and presents two classification [...] Read more.

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Appl. Sci. **2024**, *14*(8), 3499; **https://doi.org/10.3390/app14083499** - 21 Apr 2024

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Abstract Currently, the cultivation and harvesting of mollusks is a crucial activity worldwide. However, this industry generates a large amount of mollusk shell waste disposed of in landfills, causing environmental pollution. In addition, the companies linked to this item allocate large sums of money [...] Read more.

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by **Jian Gao**, **Jin Tian**, **Li Gong** and **Yujin Zhang**

Appl. Sci. **2024**, *14*(8), 3498; **https://doi.org/10.3390/app14083498** - 21 Apr 2024

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Abstract We present an innovative cooperative driving strategy known as Dynamic Resequencing and Platooning (DRP) designed to ensure the safe and efficient traversal of Connected and Automated Vehicles (CAVs) through signal-free intersections. By employing a Resequencing and Platooning Algorithm (RPA) grounded in state transition [...] Read more.

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by **Gwo-Ching Chang**, **Bo-Han Zeng** and **Shih-Chiang Lin**

Appl. Sci. **2024**, *14*(8), 3497; **https://doi.org/10.3390/app14083497** - 21 Apr 2024

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Abstract This study refines the YOLOv7-tiny model through structured pruning and architectural fine-tuning, specifically for real-time eye state detection. By focusing on enhancing the model's efficiency, particularly in environments with limited computational resources, this research contributes significantly to advancing driver monitoring systems, where timely [...] Read more.

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Abstract The performance of a retaining wall is dependent on multiple factors including lateral earth pressure, which results from backfill soils and adjacent footings located behind a retaining wall. The prediction of a retaining wall's performance in a footing–soil–wall system (FSPS) must incorporate the [...] Read more.

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by **Marek Belda** and **Tomáš Hyhlík**

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by **Ali Osman Topal**, **Enea Mancellari**, **Franck Leprévost**, **Elmir Avdusinovic** and **Thomas Gillet**

Appl. Sci. **2024**, *14*(8), 3493; **https://doi.org/10.3390/app14083493** - 21 Apr 2024

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Abstract Convolutional neural networks (CNNs) serve as powerful tools in computer vision tasks with extensive applications in daily life. However, they are susceptible to adversarial attacks. Still, attacks can be positive for at least two reasons. Firstly, revealing CNNs vulnerabilities prompts efforts to enhance [...] Read more.

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by Jin-Hwa Lee, Khawaja Muhammad Imran Bashir, Gabriel Tirtawijaya, Bertoka Fajar Surya Perwira Negara and Jae-Suk Choi

Appl. Sci. 2024, *14*(8), 3480; https://doi.org/10.3390/app14083480 - 20 Apr 2024

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Abstract The edible brown seaweed, *Ecklonia cava*, is highly valued for its bioactive compounds, and is widely used in food supplements and functional foods. The increasing demand for this seaweed in the food industry emphasizes the necessity for sustainable cultivation practices. This study [...] Read more.

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by Iuliana Banu and Iuliana Aprodu

Appl. Sci. 2024, *14*(8), 3479; https://doi.org/10.3390/app14083479 - 20 Apr 2024

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Abstract The performance of oat flake flour and pumpkin seed protein powder in gluten-free dough and bread based on rice flours was assessed in this study. After studying the thermo-mechanical properties of the rice and oat flake flours at different water absorption capacities, two [...] Read more.

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by Zhengjiang Long, Xushuang Zhu, Junqiao Liao, Dingnan Ye and Run Chen

Appl. Sci. 2024, *14*(8), 3478; https://doi.org/10.3390/app14083478 - 20 Apr 2024

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by Roman Trochimczuk, Andriy Zdobytskyi and Piotr Borkowski

Appl. Sci. 2024, *14*(8), 3477; https://doi.org/10.3390/app14083477 - 20 Apr 2024

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Abstract This paper presents the results of a computer optimising a multibody system using Generative Design methods to select a lower-cost actuator that meets process requirements with its parameters. Optimisation was performed to reduce the mass of the motion apparatus components of the author's [...] Read more.

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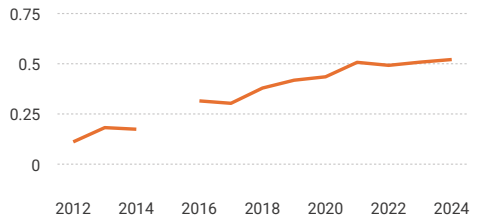

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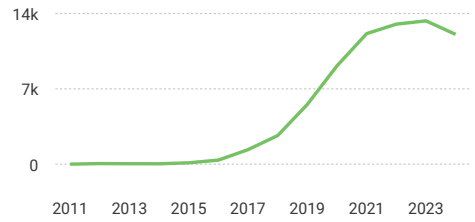

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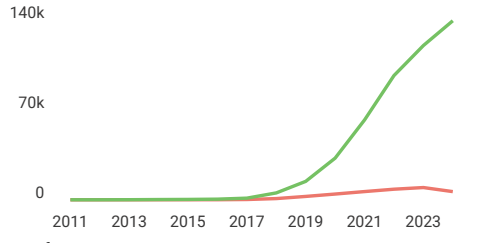

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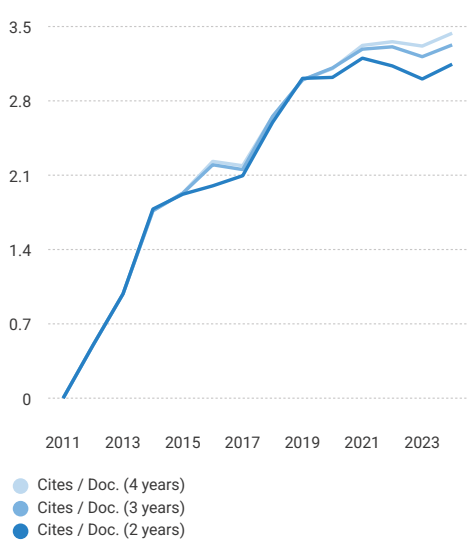

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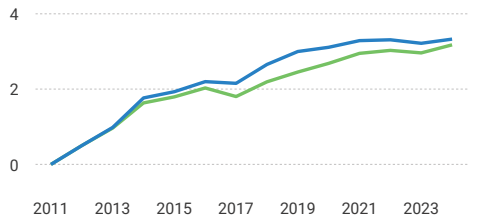

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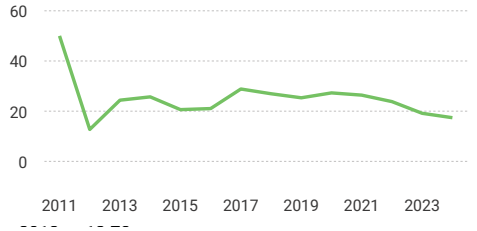

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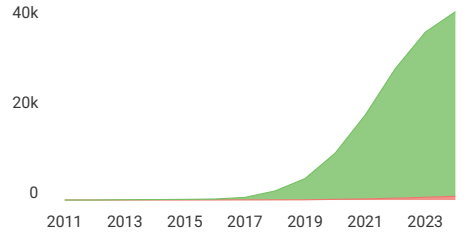

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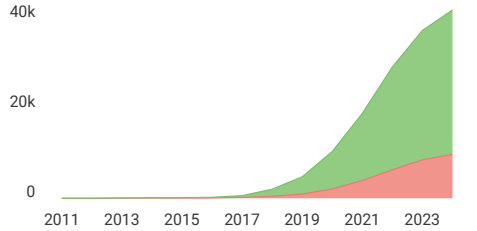

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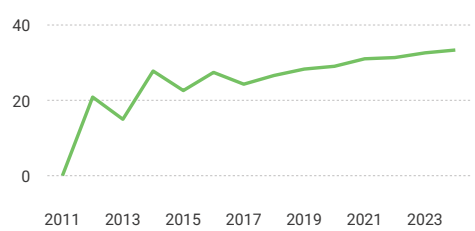

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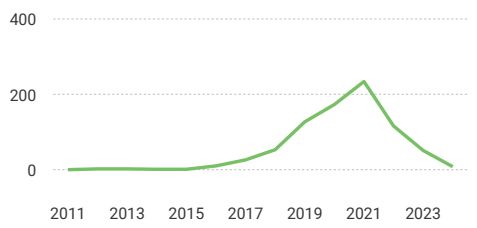

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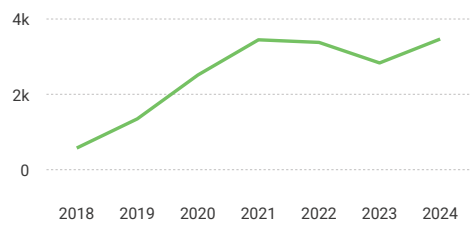

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C **CHIARA DEANGELI** 2 years ago

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Could you explain please what happens and why?
Thank you
Best Regards

reply

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Dear Noor,
Thank you for contacting us.
We suggest you visit the journal's homepage or contact the journal's editorial staff , so they could inform you more deeply.
Best Regards, SCImago Team

N **nand kumar Tiwari** 4 years ago

Sir
Most humbly, I submit that is the applied Sciences (Switzerland) paid journal? How much processing charges needed for publication in the journal.

reply

SCImago Team

Melanie Ortiz 4 years ago

Dear Nand,
thank you for contacting us.
Unfortunately, we cannot help you with your request, we suggest you visit the journal's homepage or contact the journal's editorial staff , so they could inform you more deeply.
Best Regards, SCImago Team

T **tairo henry** 4 years ago

here, in scimago journal is shown as Q1 but in the journal official website it is shown as Q2. Please clarify the same

reply

SCImago Team

Melanie Ortiz 4 years ago

Dear Tairo, thank you for contacting us.
For every journal, the annual value of the SJR is integrated into the distribution of SJR values of all the subject categories to which the journal belongs. There are more than 300 subject categories. The position of each journal is different in any category and depends on the performance of the category, in general, and the journal, in particular . Best Regards, SCImago Team

M **Mladen** 4 years ago

I published an article in a special issue that is said to belong to the Energy section.

The article is called Perspective of large scale production of algae-biodiesel.

In which Subject Area and Category article belong?
Which quartile?

reply

M **Mladen Bošnjaković** 4 years ago

Is that mean that can be applied section Engineering (Q1)?

SCImago Team

Melanie Ortiz 4 years ago

Dear Mladen,

Thank you for contacting us. All the articles published in a journal that has been listed in different categories and has different quartile data inherit all the Subject Categories of the

journal.

Best Regards, SCImago Team

A **ankit singh** 4 years ago

I would like to know how much time does the SN journal of applied sciences take to give its first decision its been around a month now and the status of my manuscript is still New submission.

reply

SCImago Team

Melanie Ortiz 4 years ago

Dear Ankit,
thank you for contacting us.
Unfortunately, we cannot help you with your request, we suggest you contact the journal's editorial staff , so they could inform you more deeply.
Best Regards, SCImago Team

L **Lu Phi** 5 years ago

why this journal is not ranked as a Chemistry (miscellaneous) journal? It published several important articles in the field in last years!

reply

SCImago Team

Melanie Ortiz 5 years ago

Dear Lu Phi,
Thank you for contacting us. Our data come from Elsevier, which offers an annual copy of their database. Scopus provides us the category for a journal. So, it is Scopus who should proceed to make the necessary changes. If they let us know, we can modify it in the SJCR.
Greetings from Spain and thank you for using the SCImago products, SCImago Team

soundos 5 years ago

I really enjoy reading this post.
Thank you.

reply

SCImago Team

Melanie Ortiz 5 years ago

Dear Soundos, thanks for your participation! Best Regards, SCImago Team

J **Jon** 5 years ago

Why is plotted as a Q1 when the official data states it is a Q2 in General Engineering??

https://www.mdpi.com/journal/applsci

reply

SCImago Team

Melanie Ortiz 5 years ago

Dear Jon,
thank you for contacting us. This journal is Q1 only in Engineering (misc.) category.
For every journal, the annual value of the SJR is integrated into the distribution of SJR values of all the thematic categories to which the journal belongs. There are more than 300 thematic categories. The position of each journal is different in any category and depends on the performance of the category, in general, and the journal, in particular .
Best Regards, SCImago Team

A **ASHRAF HENIEGAL** 5 years ago

Is SN Applied Science Journal Has SJR and in scoups

reply

A **abdullah** 5 years ago

Hello
I want to publish my paper in a short time! could you please let me know the process and payment!!

Best regards
Haidari

SCImago Team

Melanie Ortiz 5 years ago

Dear Abdullah, thank you very much for your comment, we suggest you look for author's instructions/submission guidelines in the journal's website. Best Regards, SCImago Team

SCImago Team

Melanie Ortiz 5 years ago

Dear Ashraf, thank you very much for your comment.
The SJR's data is available above.
We suggest you to consult the Scopus database to see the current index status of this journal. Keep in mind that the SJR is a static image (the update is made one time per year) of a database (Scopus) which is changing every day.
Best Regards, SCImago Team

A **Aistis** 5 years ago

Hello. I need to know how to understand the comments of reviewers? For example:
Reviews after submissions are different;
Even good comments of reviewers have been ended in negative decisions;
Reviewers write comments almost without confirmations. (One reference was about a soft robot, when a described robot in my article consists of rigid parts-links.)

reply

SCImago Team

Melanie Ortiz 5 years ago

Dear Aistis,
thank you for contacting us.
We are sorry to tell you that SCImago Journal & Country Rank is not a journal. SJR is a portal with scientometric indicators of journals indexed in Elsevier/Scopus.
Unfortunately, we cannot help you with your request, we suggest you to contact the journal's editorial staff , so they could inform you more deeply. Best Regards, SCImago Team

Z **zayed** 5 years ago

i want to now the quartile of SN Applied Sciences

reply

SCImago Team

Melanie Ortiz 5 years ago

Dear Zayed, thank you very much for your request. You can consult that information in SJR website. Best Regards, SCImago Tea

W **Win Pa Pa San** 5 years ago

Dear Sir,

Please,I want to know the ranking of "A Novel Approach for Outdoor Fall Detection Using Multidimensional Features from a Single Camera".

Kindly,
Win PaPa San

reply

SCImago Team

Melanie Ortiz 5 years ago

Dear user, thank you very much for your comment, unfortunately we cannot help you with your request. Best regards, SCImago Team

E **El sayed Mohamed Ahmed Abedelaal** 7 years ago

I need to know if Applied sciences journal is ISI or not.

reply

SCImago Team

Elena Corera 7 years ago

Dear El Sayed, SCImago Journal and Country Rank uses Scopus data, our impact indicator is the SJR. Check our page to locate the journal. We suggest you consult the Journal Citation Report for other indicators (like Impact Factor) with a Web of Science data source. Best Regards, SCImago Team

Leave a comment

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(will not be published)

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The users of Scimago Journal & Country Rank have the possibility to dialogue through comments linked to a specific journal. The purpose is to have a forum in which general doubts about the processes of publication in the journal, experiences and other issues derived from the publication of papers are resolved. For topics on particular articles, maintain the dialogue through the usual channels with your editor.

Source details

Applied Sciences (Switzerland)

Open Access

Years currently covered by Scopus: from 2011 to 2025

Publisher: Multidisciplinary Digital Publishing Institute (MDPI)

E-ISSN: 2076-3417

Subject area: Engineering: General Engineering | Physics and Astronomy: Instrumentation | Chemical Engineering: Fluid Flow and Transfer Processes | Computer Science: Computer Science Applications | Materials Science: General Materials Science | View all

Source type: Journal

CiteScore 2023
5.3

SJR 2023
0.508

SNIP 2023
0.924

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CiteScore | CiteScore rank & trend | Scopus content coverage

CiteScore 2023

$$5.3 = \frac{237{,}130 \text{ Citations } 2020 - 2023}{44{,}530 \text{ Documents } 2020 - 2023}$$

Calculated on 05 May, 2024

CiteScoreTracker 2024

$$5.5 = \frac{273{,}516 \text{ Citations to date}}{49{,}647 \text{ Documents to date}}$$

Last updated on 05 April, 2025 • Updated monthly

CiteScore rank 2023

Category	Rank	Percentile
Engineering		
General Engineering	#62/307	79th
Physics and Astronomy		
Instrumentation	#42/141	70th
Chemical Engineering		
[illegible]	#29/96	70th

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