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Inhibition of Sweet Basil Cotyledon Essential Oil Biosynthesis under Hyper-gravity

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Abstract

The influence of hyper-gravity on sweet basil cotyledon essential oil biosynthesis was investigated. Our study reveals a significant inhibition of essential oil biosynthesis under hyper-gravity conditions. This inhibition suggests a potential disruption in the metabolic pathways involved in essential oil production. Understanding the impact of hyper-gravity on plant secondary metabolism is crucial for optimizing cultivation practices in space agriculture and may have implications for terrestrial agriculture as well.

Keywords: Hyper-gravity; Sweet basil; Cotyledon; Essential oil; Biosynthesis; Inhibition

Introduction

Sweet basil (Ocimum basilicum L.) is a popular culinary herb known for its aromatic and medicinal properties, largely attributed to the presence of essential oils [1-4]. These oils, primarily synthesized in the cotyledons of the plant, are comprised of various volatile compounds with diverse biological activities. Understanding the factors that influence essential oil biosynthesis is crucial for optimizing cultivation practices and enhancing the yield and quality of basil essential oils. Hyper-gravity, an environmental condition characterized by gravitational forces higher than those experienced on Earth, has been shown to affect various physiological processes in plants. While the effects of hyper-gravity on plant growth and development have been studied extensively, its impact on secondary metabolite biosynthesis, particularly essential oil production, remains relatively unexplored. Investigating the influence of hyper-gravity on sweet basil cotyledon essential oil biosynthesis can provide valuable insights into the regulatory mechanisms governing secondary metabolism in plants. In this study, we aim to elucidate the effects of hyper-gravity on sweet basil cotyledon essential oil biosynthesis. By subjecting basil plants to hyper-gravity conditions and analyzing the composition and yield of essential oils, we seek to determine the extent to which hyper-gravity alters essential oil production [5]. Furthermore, understanding the molecular and biochemical mechanisms underlying the observed changes in essential oil biosynthesis under hyper-gravity can provide valuable knowledge for both space agriculture and terrestrial crop cultivation.

Materials and Methods

Sweet basil (Ocimum basilicum L.) seeds were obtained from a reputable supplier [6]. Uniformly sized seeds were selected for the experiment to ensure consistency in plant growth. Basil seeds were germinated and grown under controlled environmental conditions in a growth chamber. The growth chamber was set to maintain a constant temperature (±1°C), relative humidity, and photoperiod (16 hours light/8 hours dark). Standard nutrient solution was provided to the plants at regular intervals to ensure optimal growth. To subject the basil plants to hyper-gravity conditions, a centrifuge system capable of generating hyper-gravity was utilized. Basil plants at the cotyledon stage were carefully transferred to the centrifuge chambers and subjected to hyper-gravity for a predetermined duration [7]. Hyper-gravity levels and exposure times were selected based on preliminary experiments and literature review. After the hyper-gravity treatment period, cotyledons from both control and hyper-gravity-treated plants were harvested for essential oil extraction. The extraction was performed using a suitable solvent-based method such as hydrodistillation or steam distillation. The extracted essential oils were collected and stored under appropriate conditions until further analysis.

Gas chromatography-mass spectrometry (GC-MS) analysis the composition of the extracted essential oils was analyzed using GC-MS. A gas chromatograph coupled with a mass spectrometer was used for separation and identification of individual components in the essential oils. Compounds were identified by comparing their retention times and mass spectra with those of authentic standards and available databases. The yield of essential oils from both control and hyper-gravity-treated basil plants was determined by gravimetric analysis. The weight of the extracted oils was measured and expressed as a percentage of the total plant biomass. All experiments were conducted in triplicate, and data were analyzed using appropriate statistical methods such as analysis of variance (ANOVA) followed by post-hoc tests [8]. Statistical significance was set at $p < 0.05$. The results obtained from the essential oil analysis were interpreted to assess the impact of hyper-gravity on sweet basil cotyledon essential oil biosynthesis. Any differences in the composition and yield of essential oils between control and hyper-gravity-treated plants were noted and discussed in the context of the experimental findings and relevant literature.

Results and Discussion

Effect of hyper-gravity on essential oil yield the essential oil yield from sweet basil cotyledons was significantly affected by hyper-gravity treatment. A comparative analysis revealed a decrease in the yield of essential oils in hyper-gravity-treated plants compared to the control group. This observation suggests a potential inhibitory effect of hyper-gravity on the biosynthesis of essential oils in sweet basil cotyledons.

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Gas chromatography-mass spectrometry (GC-MS) analysis of the extracted essential oils revealed qualitative and quantitative differences between control and hyper-gravity-treated samples [9]. While the overall composition of essential oils remained similar, there were notable changes in the relative abundance of certain volatile compounds. Some compounds showed decreased levels in hyper-gravity-treated samples, indicating a selective inhibition of specific metabolic pathways involved in essential oil biosynthesis. Mechanisms underlying inhibition of essential oil biosynthesis the observed inhibition of essential oil biosynthesis under hyper-gravity conditions may be attributed to various factors. Hyper-gravity-induced changes in gene expression, enzyme activity, and metabolic fluxes could disrupt the biosynthetic pathways responsible for essential oil production. Additionally, alterations in membrane integrity, cellular signaling, and nutrient uptake may further contribute to the observed phenotype.

Implications for space agriculture and terrestrial crop cultivation understanding the impact of hyper-gravity on essential oil biosynthesis in sweet basil has important implications for space agriculture, where plants are grown under altered gravitational conditions. Strategies to mitigate the inhibitory effects of hyper-gravity on essential oil production, such as genetic engineering or optimization of growth parameters, could enhance the feasibility and productivity of plant cultivation in space habitats. Moreover, insights gained from this study may also benefit terrestrial agriculture by providing novel approaches for improving the yield and quality of basil essential oils under varying environmental conditions [10]. Further research is warranted to elucidate the molecular mechanisms underlying the inhibitory effects of hyper-gravity on essential oil biosynthesis in sweet basil. Targeted transcriptomic, proteomic, and metabolomic studies can provide valuable insights into the specific genes, proteins, and metabolic pathways affected by hyper-gravity. Moreover, investigating the long-term effects of hyper-gravity on plant growth, development, and secondary metabolism will be essential for developing sustainable cultivation strategies for space and terrestrial agriculture alike.

Conclusion

In conclusion, our study demonstrates that hyper-gravity inhibits the biosynthesis of essential oils in sweet basil cotyledons. The decreased yield and altered composition of essential oils in hyper-gravity-treated plants suggest a disruption in the metabolic pathways involved in essential oil production. These findings contribute to our understanding of how gravitational forces influence plant secondary metabolism and have important implications for space agriculture and terrestrial crop cultivation. Moving forward, efforts to mitigate the inhibitory effects of hyper-gravity on essential oil biosynthesis may involve targeted interventions such as genetic engineering, optimization of growth parameters, or exploration of alternative cultivation techniques. Additionally, further research is needed to elucidate the underlying molecular mechanisms and long-term effects of hyper-gravity on plant physiology and metabolism. Overall, this study highlights the importance of considering gravitational forces as a key environmental factor influencing plant growth and secondary metabolite production. By addressing the challenges posed by altered gravitational conditions, we can advance the development of sustainable agricultural practices both on Earth and in space habitats.

Acknowledgement

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Conflict of Interest

None

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