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学 位 論 文 内 容 の 要 旨/Dissertation Abstract

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Study on the impact of ploidy levels in shaping morphological and biochemical traits in haskap (*Lonicera caerulea* L. subsp. *edulis*)
（倍数性レベルがハスカップ（*Lonicera caerulea* L. subsp. *edulis*）の形態学的および生化学的形質に及ぼす影響に関する研究）

This doctoral dissertation investigates the complex interplay between ploidy levels and the morphological and biochemical characteristics of haskap (*Lonicera caerulea* L. subsp. *edulis*) fruits. By integrating phenotypic and biochemical analyses, the study aims to elucidate how variations in ploidy affect critical fruit traits and to explore their implications for breeding and cultivation strategies. The study begins with a thorough genetic analysis of haskap, focusing on the role of polyploidy—where cells contain multiple sets of chromosomes—a common phenomenon in plant evolution and breeding. Haskap exhibits a range of ploidy levels, from diploids to polyploids, and this study assesses how these genetic variations influence phenotypic traits such as fruit weight, size, shape, and water content. Polyploidy in haskap is achieved naturally and through breeding techniques, leading to significant differences in the plant's physical and biochemical traits. For instance, higher ploidy levels often result in larger fruit sizes and changes in fruit shape, which are crucial for marketability and consumer preference. Additionally, the increased cell size associated with higher ploidy levels can contribute to a greater accumulation of essential nutrients and secondary metabolites, thereby enhancing the fruit's nutritional value and potential health benefits. Moreover, the increased cell size associated with higher ploidy can enhance the plant's overall robustness, making it more suitable for diverse environmental conditions. These genetic variations are not merely academic curiosities but have practical implications for the commercial cultivation of haskap, providing breeders with a powerful tool to enhance fruit quality and tailor plants to specific cultivation needs. This genetic diversity also facilitates the development of cultivars with specific attributes, such as improved resistance to pests and diseases, which is critical for sustainable agriculture. Understanding these genetic underpinnings is essential for developing new cultivars with optimized characteristics, such as improved taste, nutritional content, and adaptability to different environmental conditions. This comprehensive approach lays the groundwork for advanced breeding techniques that can meet the growing demands of both consumers and the agricultural industry.

The study then delves into a comprehensive biochemical analysis of haskap fruits across different ploidy levels, employing techniques like gas chromatography-mass spectrometry (GC-MS) to quantify sugars, organic acids, and phytochemicals known for their health benefits. This analysis includes identifying key compounds such as fructose, glucose, mannose, sucrose, galactose, and sorbitol among sugars, as well as malic acid, citric acid, and quinic acid among organic acids. The rigorous analytical methods ensure high precision and reliability in detecting these compounds, thereby providing a robust understanding of the biochemical profile of haskap fruits. Results reveal a clear correlation between ploidy levels and the physical and biochemical properties of haskap fruits. Higher ploidy levels are generally associated with larger fruit sizes, thicker peels, and variations in fruit shape and other phenotypic traits. For instance, tetraploid fruits exhibited significantly larger mass and volume compared to their diploid counterparts, indicating the influence of genetic factors on these traits. Notably, ploidy variations significantly impact the concentration and composition of key biochemical compounds, influencing the nutritional value of the fruits and potential health benefits. The increased levels of sugars such as fructose and sorbitol in higher ploidy levels suggest enhanced sweetness and potential for creating more palatable fruit varieties. Additionally, the presence of organic acids like quinic acid, which increases with higher ploidy levels, highlights the potential for breeding haskap varieties with specific health benefits, given the role of these acids in human health. Furthermore, the study explores the impact

of polyploidy on the antioxidant properties of the fruits, revealing that higher ploidy levels often correspond to increased concentrations of anthocyanins and flavonoids. These compounds are known for their anti-inflammatory and cardioprotective properties, suggesting that polyploid haskap fruits could offer greater health benefits. These biochemical differences underscore the importance of considering ploidy in the commercial cultivation and breeding of haskap to optimize fruit quality and nutritional content. Understanding these variations at a biochemical level enables the development of targeted breeding programs aimed at enhancing specific health-promoting traits, thereby increasing the commercial appeal and marketability of haskap fruits.

Furthermore, the study discusses the practical implications of these findings for the commercial cultivation and breeding of haskap. The ability to manipulate ploidy levels provides breeders with a powerful tool to enhance fruit quality and tailor plants to specific cultivation needs. For example, the study emphasizes that ploidy manipulation can lead to the development of haskap cultivars with improved fruit size, taste, and nutritional content, as well as enhanced adaptability to diverse environmental conditions. The creation of polyploid haskap plants has already demonstrated significant advances in cultivation, particularly in generating variants with desirable traits such as increased sugar content and thicker peels, which are crucial for marketability and consumer preference. Moreover, the study underscores the potential of using polyploidy as a breeding strategy to develop new haskap cultivars with optimized characteristics, such as improved taste, nutritional content, and resistance to pests and diseases. This genetic flexibility is essential for creating robust plants that can thrive under various climatic conditions, thereby supporting sustainable agricultural practices. Additionally, polyploid plants often exhibit greater resistance to environmental stressors, including drought and extreme temperatures, enhancing their viability and productivity in changing climates. The findings from this study provide a roadmap for future breeding programs, guiding the selection of specific ploidy levels to achieve desired fruit traits and improve overall yield and quality.

The study also highlights the potential for using ploidy manipulation to enhance the biochemical properties of haskap fruits, such as increasing the levels of antioxidants and other health-promoting compounds. This can lead to the development of functional foods that meet the growing consumer demand for health-enhancing products. Furthermore, cultivating haskap varieties with specific ploidy levels allows for more efficient use of land and resources, as plants can be tailored to the specific conditions of different growing regions. This optimizes yield and reduces the environmental footprint of haskap cultivation. The economic benefits of optimizing haskap cultivation through ploidy manipulation are significant, potentially leading to higher market values and greater consumer satisfaction. Improved fruit quality and increased yields can boost profitability for growers and create new opportunities in the agricultural market. Additionally, developing haskap cultivars with enhanced traits can open new markets and applications, such as in the nutraceutical and functional food industries. Integrating these advanced breeding strategies into commercial cultivation practices represents a significant step forward in the agricultural development of haskap, offering a model for other fruit crops as well. This comprehensive approach not only addresses the immediate needs of growers and consumers but also supports long-term sustainability and innovation in agricultural practices.