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Enhancing Tomato Plants with Lysozyme Proteins for Gut Health

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ABSTRACT

Within the past decades, there has been a noticeable decrease in the microbiome of the population, which corresponds to probiotic intake and the production of bifidobacterium in the human body. 020402_LYZ M1, a lysozyme-like protein which is produced by Bifidobacterium longum (B. Longum), would hypothetically increase the nutritional value of a tomato when genetically engineering a tomato plant with this protein. This research review explores the main reasons this GMO would succeed in the real world and describes its other effects on plants, immunity, the biochemical pathways of the plants, and human gut health. The main hypothesis of this paper is to state that the 020402_LYZ M1 protein can make a tomato plant produce more B. longum in the tomato to increase the growth of good bacteria in the human gut while also reducing gut inflammation.

Introduction

The human gut microbiome is a complicated ecosystem that influences what we eat and how the microbes interact (Cleveland Clinic). One of the essential microbes is the Bifidobacterium longum which supports gut health by digesting fiber, preventing infections, and producing important compounds (Wong & Ruriai, year). Tomatoes, rich in vitamins, minerals, and antioxidants such as lycopene, also contribute to the growth of good gut bacteria (Researchers Have Discovered That Tomatoes Are Healthy for Gut Bacteria). By restraining pathogenic bacteria, the 020402_LYZ M1 protein helps maintain a healthy balance between good and bad bacteria, which is important for proper digestion and overall health. This research review will elucidate what the 020402_LYZ M1 protein will do to a tomato plant and a human gut if the produce from the plant is consumed.

We can strengthen plant and human gut health by inserting lysozyme-like proteins from beneficial gut bacteria into tomato plants. This protein is looked at mainly for its trait of mimicking lysozyme, an enzyme that can corrode bacterial cell walls (Nawaz, 2022). By inserting this protein in the DNA sequence of a tomato plant, we can investigate how much capacity the protein has to trigger genetic and biochemical changes. A study by Kumar and colleagues showed significant improvement in genetically modified rice's resistance to bacterial blight, which increased the level of essential nutrients in it, such as iron and zinc (2018).

The rice had a lysozyme-like protein inserted into it which can lead us to believe that lysozyme-like proteins can contribute to the nutritional enrichment of crops. It is also possible that the protein will improve the plant's adaptability to microbial threats and enhance the integration of bioactive compounds such as antioxidants. By looking at the predicted effects, this research can help scientists increase the certainty that this experiment will turn out a certain way. It can show scientists that enhancing crop production and promoting health through these GMOs can be more innovative and time-efficient.

Pathogen Resistance in Tomato Plants

One of the benefits of lysozyme-like proteins is their ability to mimic enzymes that can decay bacterial cell walls. As a result, refining plant immunity (Ferraboschi). Lysozymes, known for their antibacterial properties can amplify their endurance to microbial threats (Nawaz). Inserting these proteins into tomato plants could increase their immune response, leading to increased resistance against other pathogens. Genetically modified tobacco plants demonstrated that a lysozyme gene from chicken showed a faster activation of defense-related pathways, which then led to an increase in the production of antimicrobial compounds. (Wei, 2019)

Plants have an intricate system that will respond to microbial intrusion (Nishad). Genetically modifying the tomato plants would strengthen the plant walls and produce more antimicrobial compounds. Accordingly, it would make the plant more durable and less prone to invading pathogens. For example, having the proteins could directly constrain the growth of pathogenic bacteria on the surface of the plants and within the plant tissues. Implementing this method would reduce the number of cases of bacterial infections, which are more likely to cause the loss of crops. Other effects of the protein could be that it would increase beneficial microorganisms' growth while decreasing harmful ones' growth. Overall, the hypothesis of this GMO is displaying a potential increase in resistance, which could lead to healthier plants, improved produce, and increased nutritional value.

Genetic Modifications to the Plant

Researchers can track plant defense mechanism changes by introducing the 020402_LYZ M1 protein into tomato plants. Different techniques may be capable of triggering genetic changes in tomato plants via lysozyme-type proteins. Studies on tobacco plants with lysozyme genes have previously revealed heightened activation of defense-related pathways, leading to enhanced production of antimicrobial compounds (Wei, Fan, & Zhu, 2017). The system will protect against bacteria, fungi, and viruses in tomato plants. Communication between a lysozyme-like protein and plant cells may activate signal transduction pathways, leading to the increased expression of genes associated with plant defense (Andersen). Antimicrobial peptides and secondary metabolites can be produced by these genes.

In addition, the insertion of the proteins can stimulate systemic acquired resistance, more commonly known as SAR, in plants. SAR is a plant resistance response that equips long-lasting protection against pathogens (Shine, year). “Lysozyme is a protein of approximately 14 kDa found in the fluids and tissues of both animals and plants. It plays a key role in innate immunity by defending against bacteria, viruses, and fungi. Additionally, it can act as a trigger, activating systemic acquired resistance (SAR) pathways and boosting the overall immune response of the plant. (Shine, 2019). This process would include the production of pathogenesis-related (PR) proteins and the growth of signaling molecules such as salicylic acid, which will further strengthen the plant’s defense mechanisms (Cristiane dos Santos, year).

Plants can detect microbial intrusion using pattern recognition receptors (PRRs) on plant cells' surfaces (Zipfel). These PRRs detect hidden microbial features, also known as pathogen-associated molecular patterns (PAMPs) (Zipfel, year). PAMPs are molecules that are commonly found in pathogens but not in host organisms such as bacterial flagellin (Pathogen-Associated Molecular Pattern). When this protein interacts with the tomato plants, it may expedite the exposure or recognition of PAMPs, activating the PRRs. The tying of PAMPs to PRRs instigates the plant's immune response, starting with the activation of signal transduction pathways (Mogensen, year).

The protein might affect gene expression connected to nutrient biosynthesis in other situations (Kimball). For example, it could affect the expression of genes involved in synthesizing vitamins and minerals, making tomatoes with a higher nutritional value. 16. This GMO could make the protein's ability to interact with transcription factors and other regulating proteins differ, letting it manipulate the plant's metabolic pathways (National Academies of Sciences).

Biochemical Changes

Another reason for the effects of the results is epigenetics. Epigenetics refers to genetic changes in gene expression that do not involve changes to the underlying DNA sequence (Hamilton). The lysozyme-like protein can affect epigenetic transformations such as DNA methylation, histone modification, and RNA interference (Handy, year). These changes can alter the attainability of specific genes to the transcriptional machinery, which then regulates their expression (Handy, year). Epigenetic transformations can have long-lasting effects on the plant's phenotype, which include increased resistance to pathogens and improved nutrient content (Handy, year).

In addition, the lysozyme-like proteins can generate beneficial changes in the plant's biochemical pathways, increasing the production of medicinal properties (Nawaz, year). Research suggests that these proteins can stimulate the biosynthetic pathways responsible for these antioxidants. For example, in genetically modified rice, proteins similar to these have been shown to involve enzymes in antioxidant production. It was proven that lysozyme-like proteins may affect specific pathways like carotenoid biosynthesis and enzymes such as phytoene synthase and lycopene cyclase (Kumar et al., 2018). Moreover, these proteins may turn on regulatory mechanisms that better the expression of genes responsible for antioxidant biosynthesis (Ferraboschi). This includes interaction with transcription factors and other regulatory proteins that control metabolic pathways connected to antioxidant production.

On a biochemical level, we can look at the possibility of modification of secondary metabolites. Secondary metabolites contribute to plant defense and health improvement (Jurić, year). Inserting the 020402_LYZ M1 protein could stimulate the production of beneficial secondary metabolites such as flavonoids, phenolic acids, and alkaloids in the tomato plant. Research indicated that lysozymes-like proteins can control the biosynthesis pathways of secondary metabolites in plants. For instance, researchers who produced genetically modified crops showed increased concentrations of flavonoids and phenolic acids due to the introduction of similar plants (Zhang et al., 2019). These compounds were shown to improve plant resistance to environmental stress and enhance the produce's nutritional quality and health benefits.

Additionally, lysozyme-like proteins may activate enzymes and mechanisms that produce beneficial secondary metabolites (Ferraboschi, year). This includes interactions with key metabolic pathways and transcription factors that govern the production of these bioactive compounds (Ferraboschi, year). It's possible that the lysozyme-like protein could influence the enzymes and pathways involved in consolidating these metabolites, increasing their concentrations in the tomatoes.

Impact on Gut Health

The combined nutritional contents, as well as bioactive compounds, are what foster a healthier gut microbiome (Zheng, year). Lysozyme-like proteins have antibacterial properties that selectively target harmful bacteria while leaving beneficial ones in the gut microbiome (Nawaz, year). The tomatoes' original antioxidants and bioactive compounds contribute to reducing gut inflammation (Karem, year). Consuming tomatoes with the 020402_LYZ M1 protein is more hypothetical and not proven directly from any source. However, we can support this hypothesis with many studies similar to this project and studies that used identical components from this project. Based on the evidence from studies such as one by Hosseinian in 2020, we can understand that dietary lysozymes can regulate the gut microbiota and improve the strength of an intestinal barrier. These findings suggest that lysozyme-like proteins in tomatoes could similarly promote gut health by supporting a stronger gut microbiome.

Prebiotics are food components important for stimulating beneficial gut bacteria and microorganisms in the gut (Davani-Davari). Non-digestible food components such as probiotics stimulate bacteria such as bifidobacterium and other lactobacillus species in the gut (Gul). The curated environment that the beneficial traits of the protein and the tomato provide is what stimulates probiotics in the tomatoes (Gul). The lysozyme-like protein can also directly affect the harmful bacteria in the gut when ingested by exerting antibacterial properties on the gut microbiome

(Ferraboschi). Therefore, the insertion of the lysozyme-like protein is crucial for curating better digestive health. The increased antioxidants in the tomatoes are also helpful for decreasing gut inflammation.

Conclusion

In conclusion, inserting lysozyme-like proteins, such as the 020402_LYZ M1 protein, into tomato plants represents a futuristic apportion for agricultural biotechnology. This genetic modification demonstrates hopeful results in modifying the plant's resistance to pathogens and boosting its nutritional content and medicinal properties. Through mechanisms involving the activation of plant defense genes, stimulation of antioxidant biosynthesis, and potential epigenetic transformation, these genetically modified tomatoes offer a more sensible solution for the future of tomatoes and other GMOs.

Moreover, the consumption of these modified tomatoes holds potential benefits for gut health, primarily due to the presence of bioactive compounds and the selective antibacterial effects of the lysozyme-like protein. These tomatoes have overall digestive and immune function by stimulating the growth of beneficial gut bacteria and reducing GI inflammation.

Looking forward, further research is necessary to fully clarify the mechanisms underlying these benefits and validate their safety and potency in human populations through rigorous clinical trials. Such advancements not only pave the way for innovative approaches in agriculture but also hold promise for improving public health through nutritionally enhanced, genetically modified foods. As our understanding of plant-microbe interactions and human health continues to evolve, integrating lysozyme-like proteins into tomato plants stands at the forefront of sustainable agricultural practices and personalized nutrition strategies.

Future Applications

Future research should focus on deciphering the mechanisms by which lysozymes and related proteins interact with the gut microbiota and host immune system. In addition, clinical trials are required to validate the hypothesis of the different effects of long-term consumption. Future studies should focus on finding the specific methods the proteins use to interact with the gut microbiota. Looking for microbial gene expression, metabolic pathways, and the production of beneficial metabolites such as short-chain fatty acids could give us a deeper understanding of how these proteins affect gut health.

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