

Identifying and Comparing the Benefits of High Oleic Soybeans and DHA Canola on Combating Global Food Insecurity

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Abstract

This paper evaluates the use of genetically modified organisms (GMOs) to alleviate global hunger. Traditional agricultural technologies alone cannot solve issues related to food security, hence the use of GMOs to increase nutritional values and yield. This paper compares two prominent GMOs, Docosahexaenoic acid (DHA) canola and high oleic soybeans, by researching previous scientific literature to assess their ability to withstand limiting conditions such as disease, drought, climate, and other environmental stressors. DHA canola is modified to contain supplemental omega-3 fatty acids commonly found in fish oil. High oleic soybeans, on the other hand, have been modified to maintain higher concentrations of oleic acid, a monounsaturated acid that increases stability and longevity compared to regular canola. To conduct this literature review, Virginia Tech Library databases such as Google Scholar, Gale, and EBSCOhost were used to find previous research. The main keywords used include high oleic soybean, DHA canola, advantages of soybeans or canola, disadvantages of soybeans or canola, and genetically modified organisms. The findings from the studies reviewed found that high oleic soybeans can resist certain herbicides while also reducing the risk for certain cardiovascular diseases, due to their lowered saturated contents. As for DHA canola, it has been proven to be an effective plant-based source of omega-3, thus reducing negative implications on the environment, such as overfishing, while ensuring the consumption of omega-3 supplements in the human diet.

Introduction

With over 820 million people suffering from hunger and malnutrition each year, it's evident that food insecurity is a prevalent issue in today's society (Food and Agriculture Organization, 2019). In particular, areas more vulnerable to environmental distress, such as disease and natural disasters, are significantly affected by this issue. To combat this problem, a solution researchers have identified is the usage and adoption of genetically modified organisms (GMOs). The original deoxyribonucleic acid (DNA) in organisms is altered with biotechnology, also known as genetic engineering, to achieve desirable traits (Food and Drug Administration, 2023). GMOs present a viable pathway to reducing global hunger, showing benefits such as increased production and nutrition in crops. In 1997, an outbreak of the Papaya Ringspot Virus (PRSV) wiped out more than 50% of papayas in Hawaii (Gonsalves et al, 2004). While this originally led to a range of negative implications on the papaya plants, this resulted in the creation of the rainbow papaya which is resistant to PRSV. However, even with these advantages, there is still contemplation among consumers about the use of GMOs in their

food (Desaint et al, 2013).

The main GMOs being evaluated throughout this paper include docosahexaenoic acid (DHA) canola and high oleic acid soybeans. DHA canola is engineered to produce more seed oil than regular canola, while also incorporating omega-3 fatty acids (MacIntosh et al., 2021). This can help conserve fish populations by providing a plant-based source of omega-3, instead of sourcing the acid from fish. High oleic acid soybeans, on the other hand, produce less saturated and more stable oil than standard soybeans (Indiana Soybean Alliance, n.d.).

Alongside those benefits, genetic modification technology allows for the development of crops with better resistance to environmental challenges, such as natural disasters, disease, and infestation of pests. High oleic soybeans have been modified to resist herbicides, which reduces the need for destructive soil tillage, thus increasing yield (Powles, 2010). Similarly, DHA canola has been modified to tolerate drought conditions, ensuring stable yields even in adverse environments (Whelan et al., 2013).

This research paper will address the primary topic of comparison between DHA canola and high oleic soybean by breaking it down into multiple objectives. Each objective will be further researched using evidence from the scientific literature. After analyzing the collected results from different studies, the two genetically modified crops being studied will be compared for similarities and advantages over each other. Finally, the paper will conclude with a summary of all the main findings and important takeaways.

Problem Statement

The primary problem being addressed in this paper is the use of genetically modified crops to alleviate hunger. There are many controversies around the world surrounding the implementation of genetically modified crops, such as allergies, cross-contamination, and other potential health effects. Hence, this paper aims to analyze the benefits and risks associated with developing genetically advanced foods by comparing two commonly used crops: high oleic acid soybeans and DHA canola. Methods of genetically enhancing these crops to withstand limiting conditions such as disease, drought, and other factors will be evaluated with the use of previously conducted research.

The research in this paper is primarily related to the USDA-NIFA research area of food security since the paper aims to evaluate GMOs with the intent to use them to alleviate hunger (National Institute of Food and Agriculture, n.d.). For the United Nations Sustainable Development Goals, three main categories that the research and issues aligned with were identified: Zero Hunger, Good Health, and Responsible Consumption and Production (Department of Economic and Social Affairs, n.d.). As previously stated in the research question, the paper aims to study the benefits and risks associated with developing genetically enhancing to alleviate hunger, supporting the UN's goal of reaching Zero Hunger. Though it's improbable that Zero Hunger will ever be reached, GMOs can still play a role in significantly reducing hunger rates globally if they are truly as effective as studies claim them to be. This leads to the next goal, Good Health and Well-Being. If food can become more accessible with the use of GMOs, reducing starvation rates, then the well-being and health of the people will naturally increase. The third goal of Responsible Consumption and Production relates to GMOs

as the focus is on the effects of genetically modified crops on the surrounding environment and the nutritional intake from consuming GMOs. Specific production-related issues could include labor input, machinery/materials, space, as well as costs needed to grow GMOs. Consumption concerns may include allergens, nutritional value, company ingredient transparency, as well as other unknown health effects. Overall, the topic of GMOs can help solve some of the United Nations Sustainability Goals.

Methods

The first step of starting the analytical study was examining the research problem provided. From there, the research problem was broken down into the comparison of soybeans and canola. These grains were picked through an algorithm of sorting based on popularity, nutrition, and specific genetic modification. These crops were also picked because they both fall under the same category, which is nutrition. For example, one can't effectively compare a GMO that is meant to increase nutrition value compared to a GMO that focuses on increasing yield since they don't serve the same purpose. While doing this research, the genetically modified crops were compared to their non-modified counterparts. Next, research was conducted by analyzing both quantitative and qualitative information from various databases on the Virginia Tech Library website, such as Google Scholar, EBSCOhost, and Gale. These sources were picked because they provide reliable information, specializing in scholarly articles that have been peer-reviewed. Keywords such as biofortified, genetically modified, soybean, canola, global security, biotech, gene editing, nutrient enhancement, and pest resistance were applied.

Additionally, information sources that were published after 2000 were prioritized to keep the information up to date. This led to reading over 40 articles and using 45 reports for data and information. When deciding the initial opinion on genetically modified foods, bias was limited by looking at specific statistics that GMOs produce, such as yield, health benefits and harms. Surveys, news articles, and blogs were also reviewed to understand the whole scope of public controversy around GMOs, and the beliefs of people in the food production process including farmers, manufacturers, distributors, policymakers, and consumers.

To continue the research, a few guiding questions were constructed. One of the major questions considered was how GMOs would be implemented globally to reduce food insecurity. Many countries currently limit the use of, or even entirely ban, certain GMO products, such as the European Union. This would make it difficult to alleviate hunger in certain countries, even if GMOs are safe and capable of doing so. Since GMOs are somewhat relatively new, there is a lack of proper education about them. This often results in common misconceptions, and thus reluctance to incorporate GMOs into a nation's diet. This leads to the next major question: the cost of implementing GMOs.

Even if countries are willing to expand their production of GMOs, they might not have the funds to do so. GMOs may not necessarily require the same care and processing as compared to growing non-genetically modified crops, meaning many producers would have to change their systems to adapt to GMOs. This could include things such as different pesticides, machinery, and other equipment that would end up amounting to hefty costs. There is also the issue that many GMO seeds are unable to be reused or replanted for future harvests, such as

with Monsanto food seeds. Monsanto, an international seed company, has incorporated a certain technology known as dubbed Terminator into their seeds (Yoder, 1999). It works by attaching a promoter from a gene called Late Embryogenesis Abundant (LEA) to a gene that stops germination. The gene is then inserted into a seed. When the seed grows into a plant, the promoter triggers the terminator gene, which sterilizes the plant's maturing seeds. This prevents producers from keeping seeds from their last crop to reuse the following year (Yoder, 1999).

These effects can be seen with examples such as the 2013 Supreme Court case *Bowman v. Monsanto*. Monsanto patented Roundup Ready soybean seeds, which contain a genetic alteration that allows them to survive exposure to the herbicide glyphosate (Justia, n.d.). In the licensing agreement, farmers are only permitted to plant the purchased seeds for one growing season. This means they may consume or sell the resulting crops, but may not save any of the harvested soybeans for replanting. To reduce costs for late-season planting, farmer Vernon Bowman purchased soybeans, planted them, and treated the plants with glyphosate. This killed all plants without the Roundup Ready trait, leaving only the soybeans that contained that trait. Bowman saved some of these harvested seeds to use in his planting the next season. After discovering this practice, Monsanto sued for patent infringement. In a unanimous decision, the Supreme Court rejected Bowman's defense. They made their decision on the basis that by planting and harvesting patented seeds, Bowman made additional copies of Monsanto's patented invention, which falls outside the protections of patent exhaustion. Patent exhaustion does not permit a farmer to reproduce patented seeds through planting and harvesting without permission. The court determined if Bowman were granted an exception, patents on seeds would retain little value (Justia, n.d.). As shown in the case mentioned above, these regulations would not only add to production costs but would also lead to excess environmental waste.

This leads to one of the last major considerations in the research: environmental impacts. A majority of genetically modified crops are known to contain herbicide-resistant and pesticide ingredients, causing the weeds and pests around them to be killed. While this allows for better crop growth, this means that certain insects and other plants may be harmed in the process.

With all these issues in mind, it questions whether the implementation of GMOs worldwide is even viable in the near future. Since GMOs are still somewhat of a relatively new concept, it becomes difficult to set "realistic" global goals concerning the use of GMOs since each country has varying amounts of information surrounding GMOs as well as different intent regarding whether they want to use GMOs.

Background

DHA canola is a genetically modified crop aimed at improving nutritional deficiencies and increasing oil yield since canola is mostly used in an oil form (MacIntosh et al., 2021).

Traditional canola oil, which is already considered healthy due to its high levels of monounsaturated fats, was modified to contain DHA, an omega-3 fatty acid. Omega-3 is typically sourced from marine sources, mainly fatty fish such as salmon, mackerel, and sardines, along with marine microorganisms (MacIntosh et al., 2021).

Benefits of Docosahexaenoic acid (DHA) Canola

The creation of DHA canola was influenced by the increased demand for sustainable sources of DHA (Nuseed, 2023). Traditional sources of DHA are affected by overfishing and environmental contaminants, making them an unsustainable source of DHA. By adding genes from DHA-containing organisms, such as microalgae and yeast, into the canola plant, scientists have been able to make canola produce DHA in their seeds. One to two acres of DHA canola can produce the same amount of DHA as ten thousand two-pound fish (Nuseed United States, 2023). The production of DHA canola can reduce dependency on marine sources for omega-3 fatty acids, contributing to the conservation of fish stock and building marine biodiversity (Ward, 2016). Additionally, canola-sourced DHA can further decrease the carbon footprint associated with fish oil production by up to 30% per unit of DHA produced (Ruyter et al., 2022).

Omega-3 fatty acids have many health benefits which consist of supporting heart health by triglyceride reduction, blood pressure, prevention of arterial plaque buildup, and overall improved heart function (National Institutes of Health, 2022). In a 5-period crossover trial involving 130 participants, the only diet significantly increasing "good" HDL cholesterol was through DHA canola (Jones et al., 2014). This significantly reduced triglycerides and systolic blood pressure and showed the largest reduction in cardiovascular risk scores compared to other diets. These measurements suggest the inclusion of DHA canola in the diet to be of critical importance in the protection of the risk for coronary heart disease (CHD), showing its inclusion in heart-healthy diets is important (Jones et al., 2014). It's especially helpful towards brain health, promoting cognitive function, improving memory, and reducing the risk of neurodegenerative diseases like Alzheimer's disease (National Institutes of Health, 2022). Along with this, omega-3s serve anti-inflammatory properties to relieve symptoms of arthritis, inflammatory bowel disease, and other inflammatory conditions. They also contribute to the health of vision, specifically toward preventing age-related macular degeneration, and support good vision. Omega-3s have also been linked to improved mood, reduced symptoms of depression and anxiety, and may also have benefits for joint health through reduced inflammation and related pain. Under skin health, these unsaturated fatty acids aid in the maintenance of the integrity, hydration, and elasticity of the skin, possibly reducing the incidence of skin disorders like acne and psoriasis (National Institutes of Health, 2022).

Furthermore, the commercialization of DHA canola has been supported by federal approvals, such as the U.S. Department of Agriculture's Animal and Plant Health Inspection Service (APHIS), and advancements in agricultural biotechnology (International Service for the Acquisition of Agri-biotech Applications, 2018). With this, many producers benefit from DHA canola, such as Aquaterra and Nutriterra. Both used it for aquafeed, food for aquatic animals, and human nutrition. Statistics show that the global market for omega-3 fatty acids, including plant-based sources like DHA canola, is projected to reach \$4.50 billion by 2028, growing at a compound annual growth rate (CAGR) of 7.2% from 2021 to 2028 (Gorade, 2024). This emphasizes the crop's commercial viability and health benefits.

Farmers growing DHA canola can benefit from the high market demand for omega-3-enriched products. This crop can potentially increase farm income and contribute to economic growth in agricultural communities, especially if the market for plant-based omega-3s

continues to expand. Additionally, this is a crop that can be grown in various climates, therefore, increasing its marketability (Ward, 2016).

Negatives of DHA Canola

Although there are many benefits of DHA canola, there is a significant amount of doubt concerning its use as well. Critics have argued that the long-term impacts of consuming GMOs are not fully understood yet, hence there is a fear of unintended health consequences (Norris, 2021). Furthermore, environmentalists worry about the ecological effects of growing genetically modified crops, including the potential for gene flow to wild relatives and the disruption of local ecosystems (Ward, 2016). Though most agencies take precautions with their GMO safety testing, public doubt will continue to linger regardless. Furthermore, the commercialization of genetically modified crops, including DHA canola, is usually connected with patenting and property rights to corporate ownership of seeds and farming practices. This raises ethical concerns such as farmer exploitation and increased prices of seeds, hence reducing accessibility to small and resource-poor farmers (Greenpeace USA, 2015).

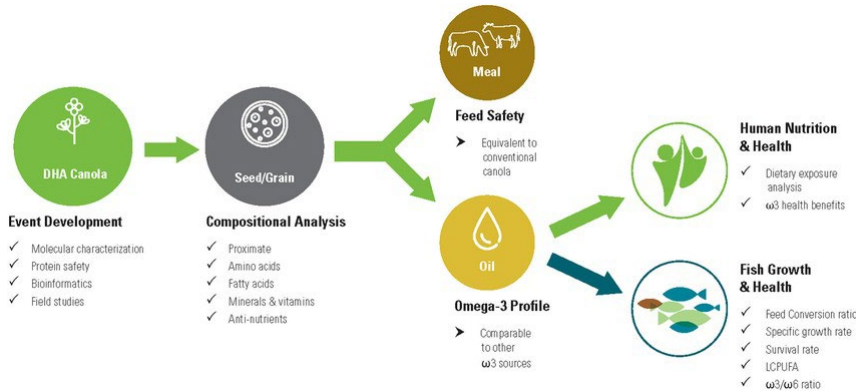
The distrust of DHA canola is similar to the resistance faced by golden rice, another genetically modified crop designed to address nutritional deficiencies (Earth Island Journal, 2020). While DHA canola produces omega-3 fatty acids, golden rice contains beta-carotene, a source of vitamin A essential for vision and immune function (Tang et al., 2009). Both crops aim to enhance nutritional value but face skepticism regarding their environmental impact and cultural acceptance. For instance, when golden rice was first introduced in Germany, there was significant resistance despite its safety, as abrupt changes to traditional diets were seen as a threat to cultural heritage. Similarly, critics of DHA canola worry about gene flow to wild relatives and potential ecological consequences. These concerns must be balanced against the potential public health benefits, such as reducing malnutrition, and the risk of corporate control over food supplies. The debate highlights the complexity of implementing GMOs globally, requiring careful consideration of both benefits and drawbacks (Earth Island Journal, 2020).

Scientific Process

DHA canola is genetically altered through the insertion of genes containing omega-3 fatty acids into canola plant genomes (International Service for the Acquisition of Agri-biotech Applications, 2024). The modification derives genes from marine microorganisms, particularly the microalgae that inherently produce high levels of DHA and yeast. Scientists isolate the key genes responsible for DHA in the microorganisms and implement those genes into the canola plant through a process called *Agrobacterium-mediated transformation*. This methodology uses the help of a soil bacterium, specifically *Agrobacterium tumefaciens*, to transfer DNA to plant cells and eventually into the plant's DNA (International Service for the Acquisition of Agri-biotech Applications, 2024).

Figure 1

DHA Canola Food and Feed Safety



Note. This flowchart illustrates DHA canola's main benefits and advantageous traits (MacIntosh, 2021).

Soybeans are a major legume crop, valued for oil and protein content. The worldwide soybean production in 2014 and 2015 was over 319 million metric tons, with 108 million metric tons produced in the United States (Demorest et al., 2016). Soybeans accounted for 57% of U.S. vegetable oil consumption in 2016 (Bachleda et al, 2017). This widely consumed oil is made up of five major fatty acids: palmitic, stearic, oleic, linoleic, and linolenic acids (Bachleda et al, 2017). Soybean oil is often used in applications ranging from cooking and baking to biofuels.

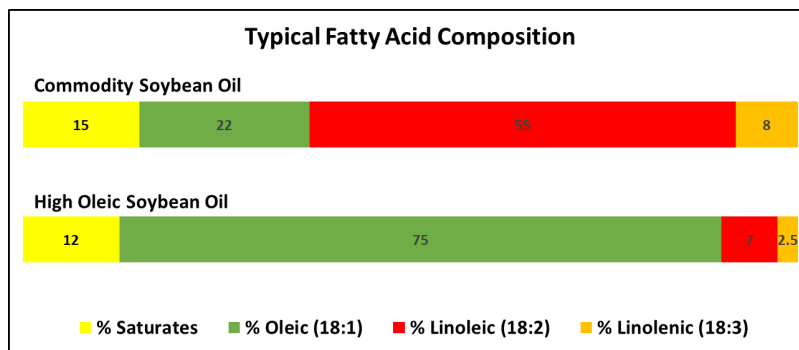
However, its natural seed oil content is much lower than most oil crops, not meeting the specifications for certain food and industrial applications (Song et al., 2023). Due to high levels of polyunsaturated and linolenic fatty acids, soybean oil has poor oxidative and frying stability (Bachleda et al., 2017). However, its ability to modulate levels of individual fatty acids within soybean oil has the potential to increase shelf-life and frying stability and to improve nutritional characteristics.

To improve shelf life and cooking characteristics by lowering levels of polyunsaturated fatty acids, soybean oil is partially hydrogenated. Partial hydrogenation is the process of adding hydrogen to unsaturated fats to convert its double bonds into single bonds (Arellano et al., 2015). However, partial hydrogenation results in increased levels of trans-fatty acids, which have been associated with coronary heart disease and buildup of plaque in arteries (Demorest et al., 2016). The Food and Drug Administration (FDA) announced that partially hydrogenated oils are no longer recognized as safe, and they are actively trying to remove artificial trans-fats from human foods. To combat this problem, researchers have altered the composition of soybean oil by lowering levels of polyunsaturated fatty acids, which enhances shelf life and heat stability while mitigating the need for hydrogenation (Demorest et al., 2016). Hence,

developments such as high-oleic acid soybean oil were created to increase its monounsaturated fat concentration by limiting the amount of linoleic acid. Oleic acid is a monounsaturated fatty acid with a naturally occurring carbon double bond and is found in most plant and animal oils, including soybean seeds (Bachleda et al., 2017). However, these genetic modifications can negatively impact soybean production, including impaired germination, reduced protein content, and many other factors. For example, the modification of the fatty acid composition or lipid content can lead to declined yields or low-quality seed products (Gaffield et al., 2022).

Figure 2

High Oleic Soybean Fatty Acid Composition



Note. This graph compares the fatty acid composition between typical soybean oil and high oleic soybean oil. As seen above, commodity soybean oil contains higher concentrations of saturated fatty acids (Hubbard Feeds, n.d.).

Benefits of Soybean

Soybeans are a highly versatile crop with many desirable traits that make them ideal for supporting global food security. Soybeans are made up of a high protein content, essential amino acids, and a rich nutrient profile, all contributing to significant health benefits (Nguyen et al., 2016). Furthermore, genetic modification can enhance these traits, improving soybeans' nutritional value and agricultural productivity. Soybeans are naturally extremely nutritious. They contain a high protein content, which ranges from 37% to 42%, making them a great source of non-meat protein (O'Keefe, n.d.).

Additionally, they contain all essential amino acids, which are valine, isoleucine, leucine, methionine, phenylalanine, tryptophan, threonine, histidine, and lysine. These amino acids do a multitude of functions including breaking down food, growing and repairing body tissue, making hormones and neurotransmitters, providing an energy source, maintaining healthy skin, hair, and nails, building muscle, boosting your immune system, and sustaining a normal digestive system. Since humans cannot synthesize these naturally, they increase soybean's nutritional profile.

Furthermore, soybeans are rich in important nutrients, including vitamins, such as B1,

B2, E, C, and beta-carotene, minerals, and healthy fats. Vitamin B1 is important for energy metabolism and nerves. Vitamin B2 is essential for growth, red blood cell production, and energy release from carbohydrates. Vitamin E acts as an antioxidant, protecting cells from damage caused by free radicals and supporting immune function. Vitamin C is crucial for immune function, skin health, and collagen production. Beta-carotene is essential for vision health, immune function, and skin health. Overall, this shows that soybeans are an extremely nutritious crop (Cleveland Clinic, 2021).

Looking at genetically modified soybeans, high oleic acid soybeans are created by the usage of the bacteria *Agrobacterium tumefaciens* to introduce the traits *fatb1-A* and *fad2-1A*. These traits not only produce herbicide resistance but also change the composition of soybeans (International Service for the Acquisition of Agri-biotech Applications, 2023).

The *fad2-1A* trait has been modified to reduce the amount of polyunsaturated fatty acids and increase the amount of monounsaturated fatty acids, or oleic acid. Researchers added *fad2-1A* because an increase in oleic acid has been linked to an increase in soybean quality and an increase in human health (Fu, 2022). Oleic acid is beneficial to human health because it has been linked to a reduction in LDL cholesterol which can help reduce risk for cardiovascular diseases. Additionally, oleic acid's anti-metastatic properties play a role in cancer prevention including colorectal, breast, and prostate cancers (Whelan, n.d.).

Weed damage is one of the most challenging difficulties to overcome in crop production. In the past, farmers tried to combat weed damage through means of mutagenesis and transgenic breeding, which is when farmers cross-bred organisms to get a desired trait, this was very time consuming and very hard to create the specific changes needed, while also having the potential to breed out important traits because of the inability to see the genome (Dong et al., 2021).

Therefore, genetically modified soybeans demonstrate agricultural benefits because they can target specific genes. For example, the trait *cp4 epsps* is used to make soybeans resistant to glyphosate herbicides such as Roundup weed control. This allows farmers to control weeds more adequately without damaging the soybean, therefore, reducing the need for tillage while preserving soil health (Hoidal, 2020).

Risks of Soybean

One of the first studies reviewed found that increasing the oleic acid content in crops could potentially negatively impact agronomic performance, such as plant height and seed germination, resulting in lower quality or yields (Gaffield et al., 2022). For instance, a mutant line of rapeseed with over 80% oleic acid content exhibited delayed plant development and a 7–11% reduction in seed oil content (Gaffield et al., 2022). In soybeans, high-oleic acid near-isogenic lines (NILs) had significantly lower germination rates in soil compared to regular NILs. For reference, near-isogenic lines are defined as strains whose genetic makeups are identical except for a few specific locations (Yuan et al., 2017). This shows how increasing the amount of oleic acid can affect both the soybean's growth and the germination rates.

Furthermore, to extend the shelf life of soybean seeds, some researchers have targeted

the reduction of FAD3 to control α -linolenic acid levels. The enzyme FAD3 (fatty acid desaturase 3), which is created by a group of genes consisting of FAD3A, FAD3B, and FAD3C, is responsible for converting linoleic acid to linolenic acid. Researchers predict that decreasing the levels of linolenic acid, a polyunsaturated fatty acid, can improve soybean oil characteristics such as oxidative stability and shelf life (Demorest et al., 2016).

Going back to the original study, researchers found that silencing GmFAD3E led to a decrease in seed oil content, as well as weakened heat stress tolerance. However, soybeans displayed desirable agronomic traits, such as high seed yields, without compromising protein and lipid content. Additionally, GmFAD3A in soybeans enhanced drought and salinity stress tolerances. In short, silencing GmFAD3s to lower linolenic acid content may adversely affect physiological processes, such as photosynthesis, transpiration, and phytohormone signaling (Demorest et al., 2016).

The researchers in the next study (Demorest et al., 2016) previously generated soybean lines with knockout mutations within fatty acid desaturase genes (FAD2-1A and FAD2-1B), resulting in oil with increased levels of monounsaturated oleic acid and decreased levels of linoleic and linolenic acid. In their new experiment, they stacked mutations within FAD2-1A and FAD2-1B with mutations in fatty acid desaturase 3A (FAD3A) to further decrease levels of linolenic and linoleic acid to below 3 percent. The conversion of oleic to linoleic acid is catalyzed by fatty acid desaturase 2 (FAD2) proteins. Both *FAD2-1A* and *FAD2-1B* are highly expressed during peak oil synthesis and are the primary genetic determinants of oleic and linoleic acid levels in soybean seeds. Disruption or decreased expression of *FAD2-1* genes results in oil with elevated oleic acid and decreased linoleic and linolenic acid. Additionally, as previously mentioned, the gene FAD3A is responsible for converting linoleic acid to linolenic acid. Hence researchers predicted by knocking out the FAD3 linoleate desaturase genes as well, levels of linolenic acid would further decrease. Researchers initially observed lower levels of linoleic acid and higher levels of oleic acid within oil from *fad2-1a fad2-1b fad3a* (soybean with FAD3A mutation) plants, when compared to oil from *fad2-1a fad2-1b* plants (soybean plants without FAD3A mutation). When they introduced FAD3A mutations within *fad2-1a fad2-1b* soybeans, the level of linoleic acid decreased and the levels of oleic acid increased. This trend was also observed in high oleic and low linolenic soybean plants generated after combining different sources of mutant FAD2-1A, FAD2-1B, and FAD3A genes. However, it was noted that fatty acid levels were also significantly affected by environmental conditions (Demorest et al., 2016).

It has been previously studied that environmental conditions influence crop yield and seed composition, such as seed fatty acids (Bachleda et al., 2017). Several studies have found that temperature affects fatty acid concentrations, particularly unsaturated fatty acids, including oleic acid in soybean oil (Kim et al., 2015) reported that there was a significant location effect for oleic acid and that the oleic acid concentration in soybean oil was more sensitive to environmental changes than the other fatty acids. It was found that soybeans grown in warmer climates produce more oleic acid, hence there is a positive correlation between high oleic acid in soybean seeds and higher temperatures.

Another study (Bachleda et al., 2017) found that the high oleic NILs averaged 806 g/kg oleic acid, whereas the normal oleic NILs averaged 252 g/kg oleic acid in the seed oil. This

indicates that mutant alleles of both *FAD2-1A* and *FAD2-1B* loci significantly increased oleic acid content in the seed oil. In general, the average oleic acid content across all oleic NILs in Plains, GA (831 g/kg) was significantly higher than that in Athens, GA (785 g/kg). The increase in oleic acid content was likely due to the higher temperature in Plains, GA than in Athens, GA, in September and October when the soybean plants were at the seed-filling stage. Researchers also observed a decrease in linolenic acid content among the oleic NIL groups in Plains, GA (Bachleda et al., 2017).

Current Implementation

Many major companies have already implemented high-oleic soybeans into their products, such as Monsanto and DuPont. Monsanto's Vistive Gold high oleic acid soybean oil utilizes naturally occurring mutations in *FAD3* genes and has oleic, linoleic, linolenic, and saturated fatty acids levels of 71.7, 16.9, 2.9 and 6.8 %, respectively (United States Department of Agriculture, 2011). Further, DuPont's Plenish® high oleic soybean oil has oleic, linoleic, linolenic, and saturated fatty acids levels of 70.6, 5.5, 7.2, and 14.3 % respectively (Delaney et al., 2008). Variations in fatty acid levels may be due to differences in gene targets, genetic background, growth conditions, and technology methods (Demorest et al., 2016).

Solutions

To address global food security through genetically modified crops, this paper combines information on the benefits and risks of genetically enhanced foods, compares genetically modified soybeans and canola, and relates these findings to the United Nations Sustainable Development Goals of Zero Hunger, Good Health and Well Being, and Responsible Consumption and production by exploring what researchers have proposed.

Genetically modified foods provide many benefits. For the farmers, GMOs create higher yields while reducing the amount of labor needed. This is the result of common traits that combat environmental risks such as pests, weeds, disease, and droughts. Therefore, farmers don't have to spray as much pesticide and water. Which is a reduction in both labor and materials. Additionally, GMOs benefit consumers with traits such as increased nutritional value while reducing the cost of produce (Smyth, 2019). Nevertheless, using and creating genetically modified crops has some risks such as environmental concerns including the potential for gene flow to non-GMOs, therefore, impacting biodiversity. Other issues, such as socio-economic issues including corporate control over genetically modified seeds and the effects on small-scale farmers, also need to be addressed. Combining all these concludes that public acceptance remains a significant challenge, influenced by cultural attitudes, misinformation, and distrust of biotechnology companies (Greenpeace USA, 2015).

Considering genetically modified crops such as DHA canola and high oleic soybeans, the soybeans developed resistance to herbicides and increased oleic acid content, which makes this food healthier in the aspects of less saturated fat and more monounsaturated fat (Bawa et al., 2013). This would reduce chemical herbicide use and ensure healthier cooking oils. However, even with the greater nutritional value, there are limitations to weed control that occur from this modification. On the other hand, DHA canola is modified for increased levels of omega-3 fatty acids, making up the supply chain demand for fish oils and helping to avoid

overfishing and reduce ecosystem damage. However, there are also environmental concerns regarding the spread of wild gene flow in other crops (MacIntosh et al., 2021). In the ways mentioned above, both high oleic soybean and DHA canola contribute to the United Nations Sustainable Development Goals of Zero Hunger, Good Health and Well-Being, and Responsible Consumption and Production previously mentioned, though there are still previous concerns that need to be addressed.

Since this paper aims to evaluate the use of GMOs to alleviate global food insecurity, it's important to consider how certain countries would react to the use of GMOs in their diet. This issue was previously mentioned with the European Union severely restricting the use of GMOs, as well as many other countries. One possible solution to this concern is demonstrating the benefits of GMOs in countries where they are less restricted (ie. the US). To elaborate, one country could host an assembly between multiple countries and have different researchers present their research and answer questions about GMOs. There is often false or exaggerated information about GMOs, which then results in misunderstandings about their use and benefits. Conferences such as the one mentioned above would allow representatives from different countries to gain accurate information as well as have their questions answered by professionals. By providing nations with the opportunity to list out their concerns, it will be easier to pinpoint specific solutions and clear up false perceptions.

In the future, further research into GMO technologies should continue to develop and improve them. Policymakers should make regulations based on evidence rather than perception to both encourage genetically modified innovations while alleviating public concerns. Finally, researchers and educators ought to partner in educating the public about the benefits and the safety of GMOs in regions characterized by food insecurity.

Conclusion

The implementation of genetically modified crops is significant because of its potential to increase global food security. Both DHA canola and high oleic soybeans have many beneficial traits, providing reason to implement them globally to alleviate global hunger. Though GMO use has constantly been debated, there is increasing research on the benefits they bring, as shown in this study. GMOs can reduce hunger by producing a stable food system through the supply of higher yields, better nutrition, and increasing resistance to environmental stresses, such as pests and diseases (Whelan et al., 2013). Further advancements in biotechnology could create more efficient and effective solutions, encouraging the case for integrating GMOs into current farming practices (Klümper & Qaim, 2014). In conclusion, GMOs in agriculture are promising for promoting human health.

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