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Journal of Nutrition and Food Processing
Asomiba Rita Abaajeh *

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Research Article

A Review of the Global Microgreens' Market by most Popular Species Grown, Farming types and Practices, end users, Revenue Generated: Opportunity Analysis, and Industry Forecast

Asomiba Rita Abaajeh*

Coudrin House 27 Northbrook Road Ireland.

***Corresponding author:** Asomiba Rita Abaajeh, Coudrin House 27 Northbrook Road Ireland.

Received date: March 21, 2023; **Accepted date:** April 03, 2023; **Published date:** April 10, 2023

Citation: Asomiba R. Abaajeh., (2023), A Review of the Global Microgreens' Market by most popular Species Grown, Farming Types and Practices, end users, Revenue Generated: Opportunity Analysis, and Industry Forecast. *J. Nutrition and Food Processing,* 6(2); DOI:10.31579/2637-8914/134

Abstract:

Background: Alcoholic liver damage is caused by long-term and heavy alcohol consumption, which leads to many diseases and even cancer. α-Pinene has been shown to have antioxidant and anti-inflammatory activity, however, it is still unclear the relationship between α-Pinene and alcohol-induced liver injury. The potential molecular mechanisms of α-pinene in reducing alcohol-induced liver injury in mice were investigated in this study.

Materials and methods: The C57BL/6 mice were randomly divided into five groups, which were the control groups (physiological saline, 0.2mL per days), alcohol group (50% alcohol, 5 mL/kg bw/day), alcohol with low/medium/high dosage α-pinene treatment group ((7.2 mg/kg bw, 14.4 mg/kg bw, 28.8 mg/kg bw, dissolved in 50% alcohol, Separately). The dosing method for mice is via oral gavage. After 8 weeks of experimentation, mouse serum and liver were collected for further testing.

Result: The increased antioxidant enzyme activities demonstrated the alleviated effect of α-pinene against alcohol-induced mouse liver injury. Moreover, in liver tissues, α-pinene promoted nucleus translocation of nuclear factor-erythroid-2-related factor 2 (NRF2) and transcription of antioxidant target genes, including heme oxygenase 1 (HMOX-1 / HO-1), NAD[P]H quinone dehydrogenase 1 (NQO-1), and glutathione S-transferase alpha 1 (Gsta-1). Meanwhile, α-pinene promoted the protein expression of autophagy-related proteins and inhibited the increase of inflammatory factors caused by chronic alcohol intake. Furthermore, α-pinene partially inhibited the activation of apoptotic signaling pathways by increasing the expression of Bcl-2 and decreasing Bax and cleaved caspase-3 proteins.

Conclusion: Taken together, our results indicated that α-pinene might alleviate alcoholic liver injury by reducing lipid accumulation, enhancing anti-oxidative stress and anti-inflammatory, activating autophagy, and inhibiting cell apoptosis.

Key words: alcoholic liver injury; α-pinene; antioxidation; autophagy; inflammatory

Introduction

Microgreens are a new type of edible seedlings that are grown from the seeds of various herb, vegetable, and wild species (Di Gioia *et al*., 2015a). They represent potential regenerative functional foods that can enhance general health through dietary augmentation (Sharma *et al*., 2022). They are characterised by delicate distinctive flavors, high levels of different nutrients, and more health benefits than some of their mature counterparts. Di Gioia *et al*. (2015): Sharma *et al*. (2022). The cotyledonary leaves and stems of microgreens are typically harvested 7 to 21 days after germination, with or without the appearance of a small pair of genuine leaves (Treadwell *et al*., 2010; Xiao *et al*., 2012). They are also becoming more often used by chefs as an edible garnish. Microgreens are growing in popularity due to their high bioactive chemical concentration (Treadwell *et al*., 2010; Xiao *et al*., 2012). In addition, interest in their commercial production is rising as the urban agricultural sector develops (Di Gioia *et al*., 2015b).

Microgreens can be cultivated in soil or, more frequently, in soil-less systems (Di Gioia, *et al*., 2015c; Murphy *et al*., 2010) using organic or inorganic solid growing media or hydroponics, as well as in greenhouses or vertical farms with artificial light sources (Choi *et al*., 2015). Microgreens have a short production cycle, but they still need special care, and one of the most important steps in the process is choosing the right growing medium (Di Gioia, *et al*., 2015c). The manufacturing process's environmental sustainability, as well as the yield and quality of the microgreens, are both significantly influenced by the growing medium, which is one of the primary production costs (Di Gioia, *et al*., 2015c).

The optimal growing medium should be easily accessible, reasonably priced, made from renewable resources, have a suitable capacity to hold water (55–70% of the total volume), and enable adequate aeration [(20–30% of the total volume) Murphy *et al*., 2010]. It must be microbiologically safe, have a pH of between 5.5 and 6.5, and have an electrical conductivity of less than 0.5 dS m-1 (Di Gioia, *et al*., 2015c). Evidently, the growing medium, seed quality, and growing environment parameters have a significant impact on the yield and quality of microgreens, particularly their microbiological quality (Di Gioia, *et al*., 2016).

According to market research by Allied Market Research published in 2022, the most popular species are broccoli and arugula, both of which belong to the brassica family and are stuffed with lots of bioactive chemicals that promote good health.

Main text

Microgreens are edible vegetable seedlings that are one to three inches tall at the time of the first two leaves' emergence (Treadwell et al., 2010; Xiao et al., 2012). Depending on the species, plants are harvested 7–21 days after germination, and they are frequently referred to as "vegetable confetti (Di Gioia et al., 2015a; Sharma et al., 2022)." They contain higher levels of numerous health-promoting minerals, vitamins, and antioxidants than some of their more developed counterpart (Sharma et al., 2022). The risk of xenobiotics pollution in microgreens in minimal considering that little or no fertilisers are used in their production. More so, when consumed, microgreens are packed with antioxidant that metabolize xenobiotics in human (Ali & Alsayeqh, 2022). The global market for microgreens is being driven by factors like increased spending on nutrient-dense meals and the rising adoption of indoor vertical and greenhouse farming (Allied Market Research, 2022). The Allied Market Research 2022 also noted that since microgreens require a lot of care and a controlled environment, they are typically grown inside greenhouses and vertical farms. It is also projected that growth in the cosmetics and personal care industry would further boost the product market because microgreens-based oils and components are highly sought after to produce consumer goods like shampoo and skin care products (Allied Market Research, 2022).

Market size

The global microgreens market has experienced rapid expansion due to changes in lifestyle, the health advantages of microgreens, and an increase in the popularity of rooftop and windowsill gardens (Allied Market Research, 2022). Furthermore, the Covid-19 pandemic changed people's perspectives on their food-buying behaviors, and microgreens provide a sustainable alternative. Microgreen demand was boosted by the pandemic's rise in health consciousness among individuals. The world is slowly recovering from the pandemic, and the need for microgreens is anticipated to increase soon (Allied Market Research, 2022). Even though the pandemic slowed down the markets in 2019 due to the closure of major restaurants, the demand is projected to increase drastically by 2030as predicted in the Allied market research published in 2022.

According to a study by Raju Kale and Roshan Deshmukh, published in the May 2022 issue of Allied Market Research, the global microgreens market generated $1.3 billion in revenue in 2019 and is anticipated to grow by 11.1% CAGR to reach $2.2 billion by 2028. By 2030, it is anticipated to increase from a projected value of USD 1.62 billion to USD 3.49 billion (Market Data Centre, 2022). The Allied survey included participants from the following regions: North America (U.S., Canada, Mexico), Europe (Russia, Spain, Italy, France, Germany, UK, and the rest of Europe), Asia-Pacific (China, Japan, India, South Korea, Australia, Rest of Asia-Pacific), LAMEA (Latin America, Middle East, and Africa), and Africa.

It is forecasted that the global microgreens market across Asia-Pacific may see a rise in the CAGR of 14.1% by 2028 because of the huge demand for organic vegetables (Allied Market Research, 2022). Furthermore, in an earlier report published by Allied Market Research, titled, "Canada Microgreens Market by Type, Farming and End User: opportunity analysis and industry forecast, 2021–2028," the Canadian microgreens market alone was valued at $99.3 million in 2019, and is projected to reach $168.6 million by 2028, registering a CAGR of 10.9% from 2021 to 2028 while Europe was valued at $415.5 million in 2019, and is expected to reach $596.8 million by 2028, registering a CAGR of 9.7% from 2021 to 2028 with broccoli being the most popular species.

Most cultivated species

Sunflower (28%), peas (27%), and radish (29%) were the most widely grown microgreen types in a study that was conducted on farms that began operating before 2010 (75%) and farms that began operating after 2011 (Gina &Kristen 2021). Consumers have become more aware of the nutritional value of the many species being grown because of the growing study in microgreen nutrition. Considering this, people's preferences for species have changed (Allied Market Research, 2022). Broccoli, arugula, cabbage, cauliflower, peas, basil, radish, and cress were the most popularly cultivated species, according to a more current poll by Allied Market Research in 2022, as seen in figure 1 below.

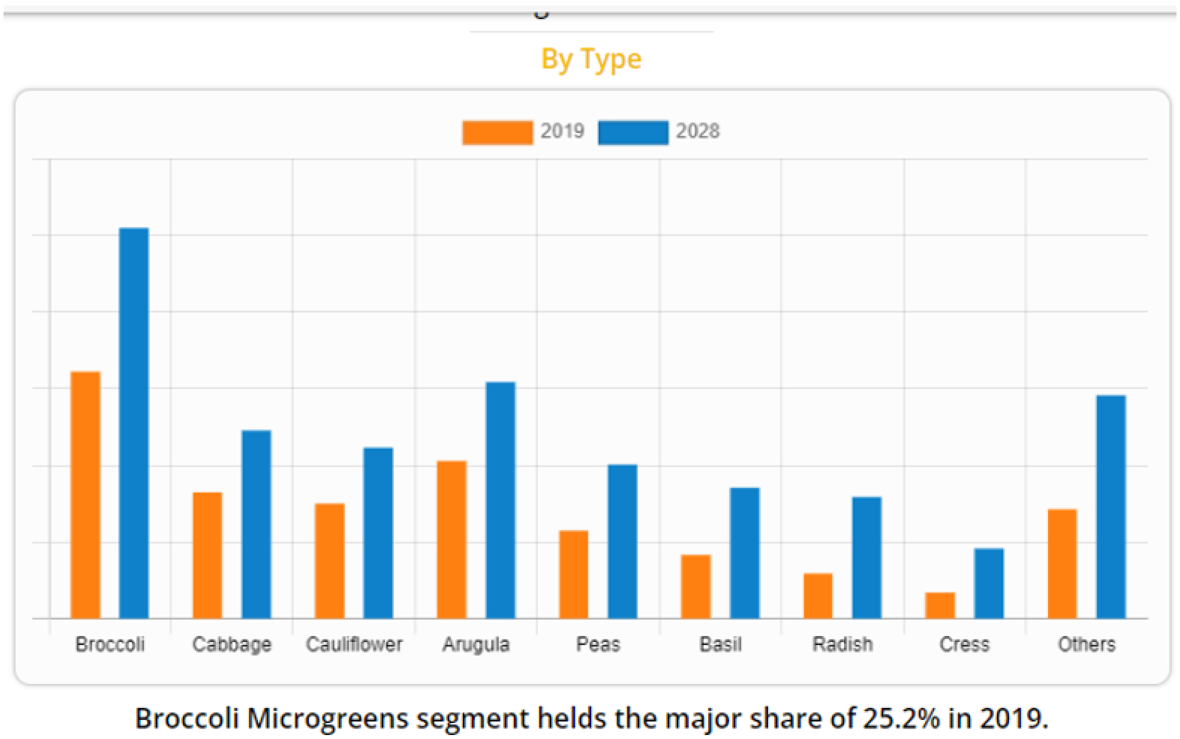

Figure 1: *Microgreens market by type (Allied market research 2022)*

According to Allied Market Research, (2022), broccoli was the most popular species, holding a fourth (24.6%), and arugula held second place in the global market in 2019. However, radish is projected to manifest the highest CAGR of 16.5% by 2028. Broccoli and arugula microgreens are members of the brassica family which are abundant in all health-promoting nutrients such as vitamins A, B, C, E, and K (USDA, 2011; Kyriakou *et al*., 2016; Xiao *et al*., 2012, 2019; Liu *et al*., 2012). Broccoli (Wild cabbage, brassica, and algentem) has been pursued due to its high nutritional value and functionality nowadays (Fahey *et al*., 2019). The sprouts of broccoli have been recognized as nutritious food because it is rich in bioactive compounds, including polyphenols, carotenoids, minerals, vitamins, and especially glucosinolates [(GLS) Fahey *et al*., 2019; Lu *et al*., 2018; Tian *et al*., 2017], with concentrations higher than those of the adult plant. GLS can be hydrolyzed into isothiocyanates (ITCs) and furthermore hydrolysed into sulforaphane (SFN), which is an inducer of nuclear factor E2-related factor 2 (Nrf2) (Liou *et al*., 2020).

They also contain large quantities of essential minerals such as manganese, zinc, copper, magnesium, sulforaphane, nitrates, and calcium which are deficient in most people and are also rich in polyphenols (Di Gioia *et al*. (2015): Sharma *et al*. (2022). Further, broccoli microgreens have a tangy taste, mild peppery aroma, and crunchy texture, which makes them a great addition to dishes such as tofu scramble, salads, sandwiches, soups, and cooked grains (Di Gioia *et al*., 2015; Sharma *et al*., 2022), gaining them popularity in the food service sector. These characteristics also propel their popularity in the Canadian microgreens market growth.

The nutrition and aesthetical characteristics of the members of the brassicas were earlier reported by Xiao *et al*. (2012), Kou *et al*. (2014), and many more.

End Users

Microgreens are frequently used in restaurants to enhance the color, texture, or flavor of various foods such as pasta, pizza, omelettes, and salads because of their variety of colors and textures and rich fragrant flavor (Kou et al., 2014). Microgreens were initially discovered in upmarket restaurants in the USA in the 1980s and 1990s, when they were utilized as food garnishes in an earlier report, according to the United States Department of Agriculture (2014). This pattern has been getting stronger since then (Mir et al, 2016). Recently, Allied Market Research 2022 discovered that the primary end users comprised the retail and food service industries (figure 2).

In 2019, the food service industry held the highest share (72.5%) and accounted for over three-quarters of the worldwide microgreens market higher than the retail industry. However, the retail sector in 2021 was higher and they forecasted it to rise to a CAGR of 12.0% by 2028 because of new storage technologies that would prolong the shelf-life of microgreens (Allied market research 2022). The market was dominated by North America dominated which generated 41.2%, accounting for more than one-third of the market (Allied market research 2022).

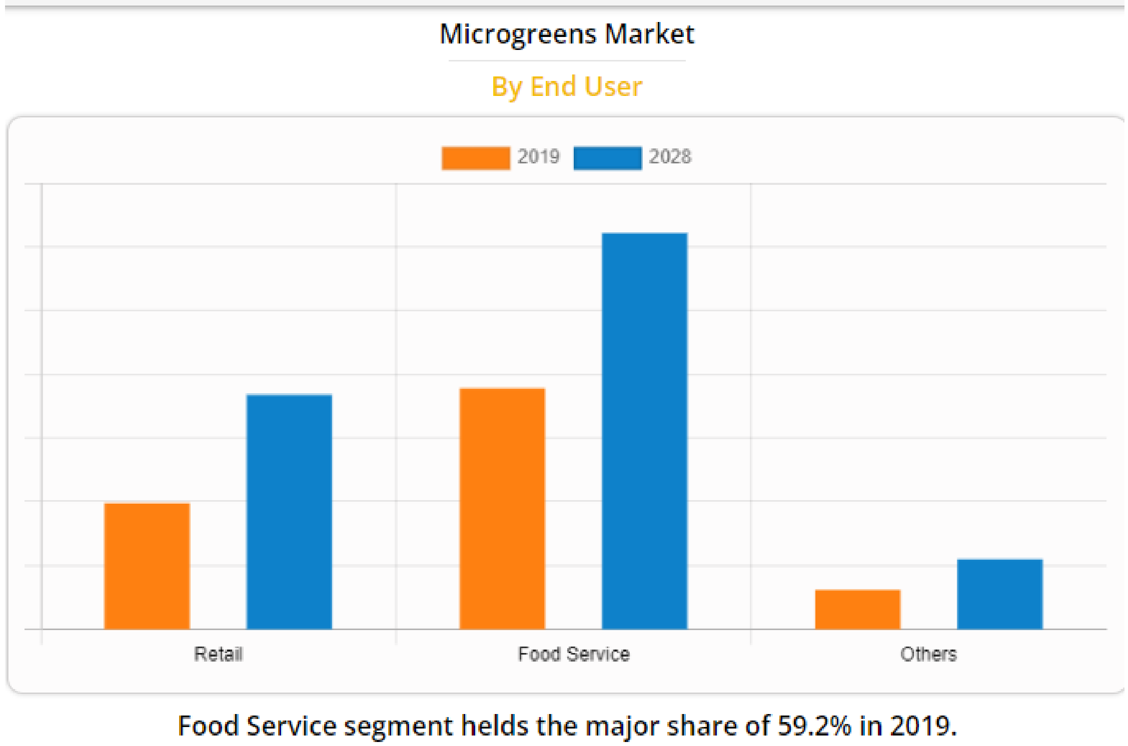

Figure 2: *Microgreens market by end-user (Allied market research 2022)*

Vertical farming was the best farming practice in 2019, and it's predicted to continue expanding (figure3). Contrary to a report released in Portland, Oregon, on July 6, 2021, by MarketersMedia, it is predicted that the commercial greenhouse farming sector would reach $625.1 million by 2028, at a CAGR of 10.1%. The greenhouse is an appropriate farming method to produce microgreens, according to this article, because microgreens require a particular temperature and humidity for the best harvests. Furthermore, by offering subsidies and technical assistance, the American government helps greenhouse farmers make money. This predicted a bright future for growing microgreens in greenhouses, which is projected to result in a rise in the amount of space dedicated to this practice (MarketersMedia, 2021).

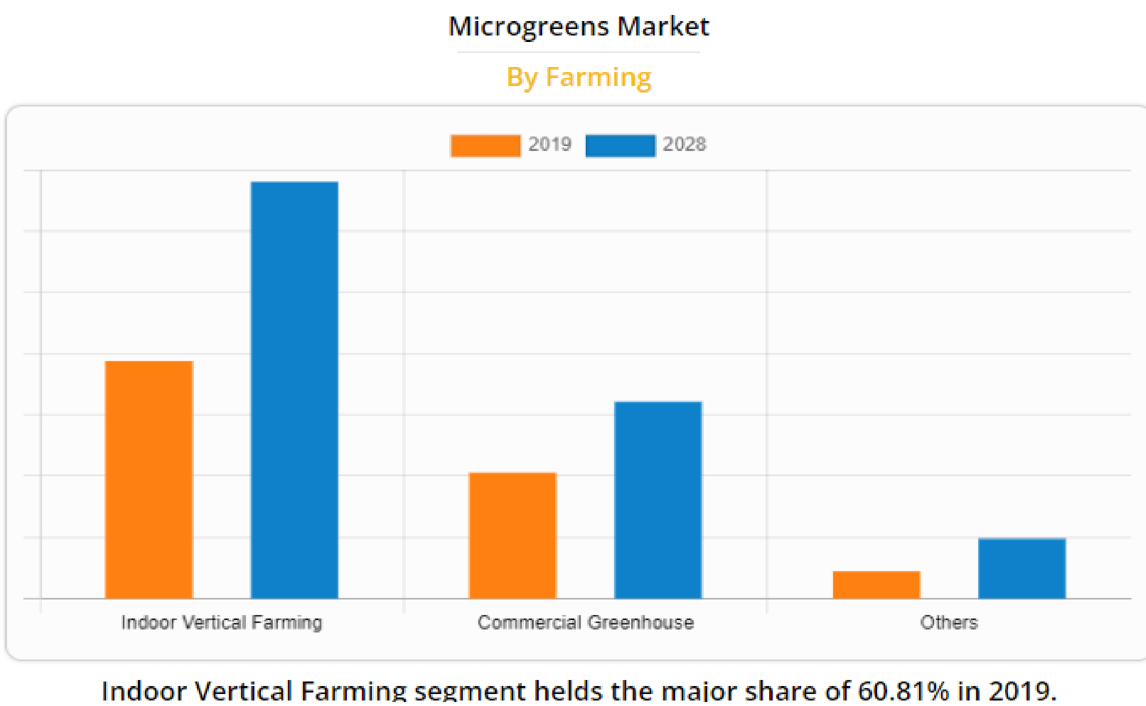

Figure 3: *Microgreens market by Farming type (Allied market research 2022)*

Conclusion and suggestions

Generally, the growing conditions reported are generic. Microgreens are mostly grown at a temperature of between18 to 24°C and relative humidity (RH) of between 40 to 60% (Misra & Gibson 2021). In this study, carried out on farms that started before 2010 (75%) and farms that started after 2021, Sunflower (28%), peas (27%), and radish (29%) were the most popular microgreen varieties produced (Misra & Gibson 2021). These farms primarily grow microgreens using peat (17.6%), coco coir (14.2%), or soil (15.3%), with the most used additives being perlite (31%) and vermiculite (19.3%).

Microgreens can be watered with underground or overhead spray irrigation (Misra & Kristen, 2021). Further, Işk *et al*. (2019); Xiao *et al*. (2014) in their studies to determine whether watering strategy may affect pathogen dispersal in microgreens reported that there were no significant changes in the transfer of pathogens such as *Escherichia coli* O157:H7 to microgreens through the two watering strategies mentioned above in the production of microgreens. The range of the average relative humidity in the microgreen production systems examined here was 50 to 65%. Relative humidity, on the other hand, is typically close to 70% in sprouted seed production conditions (Xiao *et al*., 2014), which may promote the growth of microorganisms when pathogens are present.

like sprouts, they are harvested at a young age after germinating in a warm, moist environment (Kyriacou *et al*., 2016; Xiao *et al*., 2014). These characteristics of microgreens make them a useful crop for studying food safety ((Kyriacou *et al*., 2016). Although there are no known outbreaks associated with microgreens yet, there have been multiple products recalls related to contamination with *Salmonella enterica* subsp. enterica and *Listeria monocytogenes* since 2016 in the United States (U.S. Food and Drug Administration. 2016; 2019) and Canada Canadian Food Inspection Agency. (2018; 2020). This recent trend highlights an urgent need to examine the potential risk factors within microgreen growing operations that may render these products susceptible to contamination and possible foodborne pathogen transmission as the industry grows (Olaimat *et al*., 2012). 3. However, microgreens may need to be checked for gram negative bacteria contamination that may generate the very toxic bacterial lipopolysaccharides [LPS (Martins, 2018; Ali & Alsayeqh, 2022)].

The evaluation of environmental factors for yield improvement and reduction of the pathogenic microbial load for specific species has been under-looked. However, the effect of light quantity on the yield and nutrient content of brassicas has been reported by Samuoliené et al. (2013) who recorded optimum growth, yield, and nutritional quality of brassica at 320-440 μmol cm $^{-2}$ s^{-1}. In the case of 545 μmol cm $^{-2}$s $^{-1}$ light intensities. Another study by Kamal *et al*. (2020) indicated that supplemental lighting with green LEDs (R_{70}: G_{10}: B_{20}) enhanced vegetative growth and morphology, while blue LEDs (R_{20}:B_{80}) increased the mineral and vitamin contents in five brassica species including broccoli. In a more recent study, two brassica species' dry and fresh weight was maximized with a 14-h·d^{-1} photoperiod. The chlorophyll, carotenoid, and soluble protein content were highest for a 16-h·d^{-1} photoperiod (Lui *et al*., 2022).

But other abiotic factors surrounding the production of microgreens need attention to produce high-quality microgreens. For instance, the effect of photoperiod on microgreen growth, irrigation regime, growing media, Temperature, etc for the growth and yield of microgreens, specifically broccoli and arugula has received little attention. Furthermore, there is no literature on the sensitization of the public to the health benefits of microgreens. If the public becomes more aware of the benefits of consuming microgreens, the microgreens global market will expand further than predicted in 2028. We, therefore, propose a public awareness campaign on the benefits of consuming microgreens as well as the safety precautions to consider. We also propose a comprehensive study to assess the microbial load of the popularly used growing media for these species as well as that of their seed; and establish the optimum growing conditions for each species, especially the most popular (broccoli and arugula) such that would increase yield and reduce microbial contamination of microgreens.

Declarations

Availability of data and materials – not applicable

Funding – University College Dublin (UCD) foundation for fees payment

Authors' contribution – corresponding author contributed to 100% of the manuscript preparation

Acknowledgment: A special thank you to DR. Suinyuiy Terence for his mentorship.

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DOI: **10.31579/2637-8914/134**