Siberian elm samaras: a natural source with potential for sustainable aviation fuel

A lipidomics study revealing the presence of medium-chain triglycerides

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Abstract

Sustainable aviation fuel (SAF) is being developed as a way to reduce the aviation industry's large impact on global greenhouse gas emissions. SAF is made from renewable sources and can lower total emissions by as much as 80% compared to regular jet fuel. One promising group of materials for making SAF is plant seed oils, especially those high in medium-chain triglycerides (MCTs), because of their good chemical properties for fuel use. This study looks at the potential of Siberian elm (*Ulmus pumila*) samaras as a new source of MCTs. While most research focuses on genetically modified oilseed plants, the Siberian elm has not been studied for this purpose. Since it's an invasive species that produces lots of seeds with a high MCT content, it could be both a useful and sustainable fuel source. We analyzed samaras at different stages of growth to find the best time to collect seeds with the most MCTs. Our results show that Siberian elm samaras may have MCT levels equal to or even higher than other commonly used oilseeds. Using them for fuel could also help manage the spread of this invasive tree, offering both energy and environmental benefits. This study highlights the potential of Siberian elm as a dual-purpose solution—for cleaner aviation fuel and better ecological control.

1. Introduction

1.1 Sustainable aviation fuel (SAF): what is it and why we need it.

Sustainable aviation fuel (SAF) represents a transformative solution in the global effort to decarbonize the aviation sector, which currently accounts for approximately 2-3% of global CO_2 emissions. SAF is produced from renewable biomass and waste resources, offering a lifecycle greenhouse gas (GHG) emissions reduction of up to 80% compared to conventional jet fuel (Rosales Calderon et al., 2024).

The urgency to adopt SAF is underscored by the aviation industry's commitment to achieving net-zero carbon emissions by 2050. In response, the U.S. Government launched the SAF grand challenge, aiming to produce 3 billion gallons of SAF annually by 2030 and 35 billion gallons by 2050—enough to meet 100% of projected U.S. Aviation fuel demand (*SAFGC-Progress-Report-Factsheet.Pdf*, n.d.).

As of 2024, global SAF production reached approximately 1 million tons (1.3 billion liters), doubling from 2023 levels (*Disappointingly Slow Growth in SAF Production*, n.d.). Despite this growth, SAF still constitutes less than 0.2% of total aviation fuel consumption, highlighting the need for accelerated investment and policy support.

SAF can be synthesized through various pathways, including hydroprocessed esters and fatty acids (HEFA), fischer-tropsch synthesis, and alcohol-to-jet (ATJ) processes. Feedstocks range from used cooking oil and agricultural residues, plant seed oil to municipal solid waste, making SAF a versatile and scalable solution *(Rosales Calderon et al., 2024).*

The national renewable energy laboratory (NREL) emphasizes that scaling SAF production will require overcoming technical, economic, and infrastructure challenges. Their 2024 report outlines strategies such as expanding feedstock supply chains, improving conversion technologies, and fostering public-private partnerships *(Rosales Calderon et al., 2024).*

SAF is not just a technological innovation but a critical enabler of sustainable air travel. With coordinated global action, SAF can significantly reduce aviation's climate impact while supporting energy security and rural economic development.

1.2 Plant seed oil as sustainable aviation fuel (SAF)

Sustainable aviation fuel (SAF) derived from plant seed oils is a promising pathway to reduce the aviation sector's carbon footprint. Oils extracted from crops such as camelina, jatropha, and algae are renewable, energy-dense, and can be cultivated on marginal lands, making them ideal feedstocks for SAF. These oils are rich in triglycerides, which can be refined into hydrocarbons that closely mimic the properties of conventional jet fuel (*Alternative Fuels Data Center*, n.d.).

The environmental benefits of SAF from plant seed oils are substantial. Depending on the feedstock and production pathway, SAF can reduce lifecycle GHG emissions by up to 94% compared to petroleum-based jet fuel (*Alternative Fuels Data Center*, n.d.). This makes SAF a critical component of the aviation industry's strategy to achieve net-zero carbon emissions by 2050. The U.S. Department of Energy (DOE) emphasizes that SAF offers a near-term solution for decarbonizing aviation without requiring changes to existing aircraft or fueling infrastructure *(Sustainable Aviation Fuels, n.d.).*

The production process of SAF from plant seed oils involves several stages. First, oilseed crops, usually as cover crops, are cultivated, often in areas unsuitable for food production. The seeds are then harvested and processed to extract the oil, typically through mechanical pressing or solvent extraction. This crude oil undergoes hydroprocessing—a refining technique that removes oxygen and other impurities—to produce a clean, energy-dense fuel. Finally, the refined SAF is blended with conventional jet fuel to meet aviation standards and ensure compatibility with current engines and distribution systems (*Alternative Fuels Data Center*, n.d.).

Beyond environmental benefits, SAF production from plant seed oils also supports energy security and rural economic development. By utilizing domestic agricultural resources, countries can reduce their reliance on imported fossil fuels. Moreover, the SAF supply chain—from farming to refining—can stimulate job creation in agriculture, logistics, and biofuel processing. According to the DOE's 2023 billion-ton report, the U.S. Has the potential to produce over 1 billion tons of biomass annually, enough to generate 60 billion gallons of low-emission liquid fuels, including SAF (*Sustainable Aviation Fuels*, n.d.).

Plant seed oil-based SAF is a viable and scalable solution for sustainable aviation. With continued investment in research, infrastructure, and supportive policies, this technology can play a pivotal role in transforming the aviation industry into a low-carbon future.

1.3 Medium-chain triglycerides (MCTs) in SAF and other industry applications

Medium-chain triglycerides (MCTs) are a class of triglycerides composed of fatty acids with aliphatic tails of 8–14 carbon atoms. Commonly found in coconut oil, palm kernel oil, and certain dairy products, MCTs are known for their high energy density, rapid metabolism, and chemical stability. These properties make them valuable not only in nutrition and pharmaceuticals but also as promising feedstocks for biofuel production, particularly sustainable aviation fuel (SAF).

In the context of SAF, MCTs offer several advantages. Their relatively short carbon chains make them easier to process through hydrodeoxygenation and hydroisomerization—key steps in converting triglycerides into jet-range hydrocarbons. Recent research has demonstrated that MCTs can be efficiently upgraded into SAF using bifunctional catalysts such as IR-REOX/SAPO-11, which enable high yields of iso-alkanes under milder conditions compared to traditional long-chain triglycerides (Praikaew et al., 2024). These iso-alkanes meet the stringent freezing point and energy density requirements of aviation fuels, making MCTs a viable and efficient SAF precursor.

Beyond aviation, MCTs are widely used in the food and health industries due to their rapid digestibility and potential benefits in weight management and cognitive function. In cosmetics, MCTs serve as emollients and carriers for active ingredients. Their chemical stability and low viscosity also make them suitable for industrial lubricants and solvents.

The dual-use potential of MCTs—both as a high-value nutritional supplement and a renewable energy source—positions them uniquely in bioeconomy. However, large-scale use of MCTs for SAF requires sustainable sourcing strategies to avoid competition with food uses. Algae and engineered oilseed crops are being explored as scalable, non-food sources of MCTs, aligning with the goals of the circular bioeconomy and the SAF grand challenge (Rosales Calderon et al., 2024).

1.4 Introduction to Medium-Chain Triglycerides (MCTs)

Medium-chain triglycerides (MCTs) are a class of triglycerides composed of a glycerol backbone and at least one medium-chain fatty acid (MCFA), typically containing 8 to 14 carbon atoms. MCFAs have a carbon chain with 8-14 carbons attached to a carboxylic group at one end (Table 1).

Table 1: introducing medium-chain fatty acids. Number of carbons in the chain, scientific name, and common name.

Fatty acid notation	Number of carbons in the chain	Number of double bonds in the chain	Scientific name	Common name
FA 8:0	8	0	Octanoic acid	Caprylic acid
FA 10:0	10	0	Decanoic acid	Capric acid
FA 12:0	12	0	Dodecanoic acid	Lauric acid
FA 14:0	14	0	Tetradecanoic acid	Myristic acid

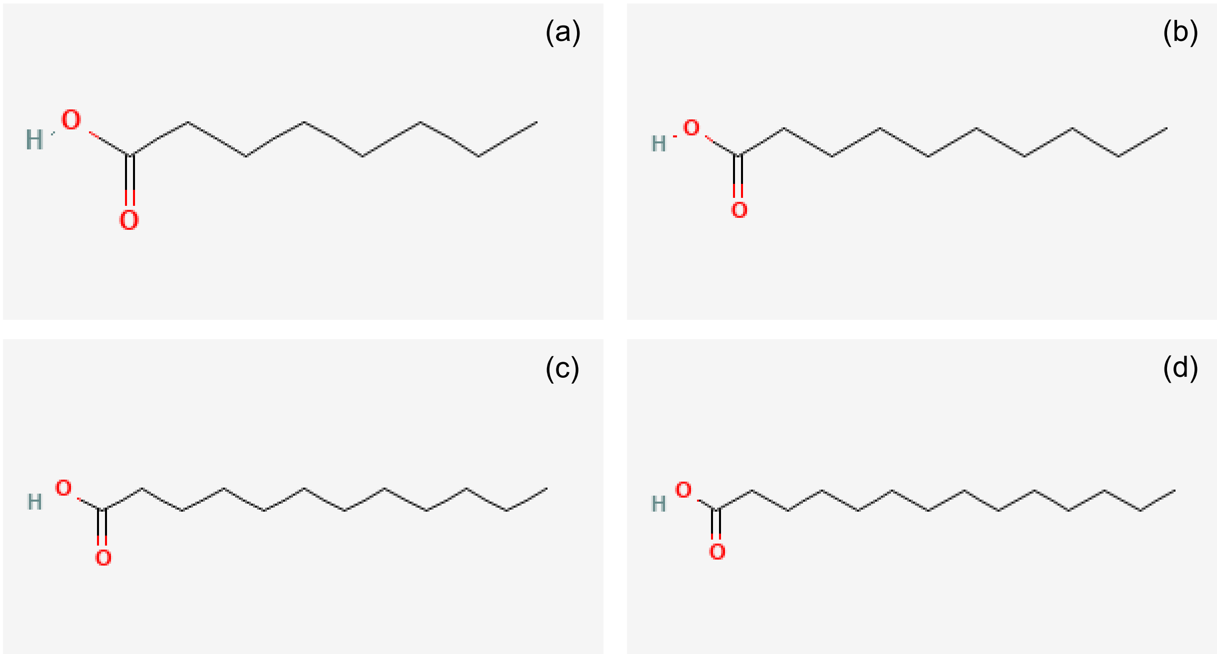

Figure 1: 2d structures of medium-chain fatty acids. (a) (downloaded from https://pubchem.ncbi.nlm.nih.gov/.) (a) FA 8:0, (b) FA 10:0, (c) FA 12:0, (d) FA 14:0

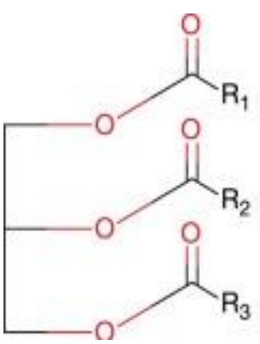

Figure 2: 2d structure of triglyceride molecule. R1, R2, R3 medium-chain fatty acids (Downloaded from https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/triglyceride.

1.5 Bioengineering advances to enhance MCT production in cover crops

To reduce reliance on tropical sources like coconut and palm kernel oil, scientists are engineering temperate cover crops—such as camelina and pennycress—to produce MCTs.

Researchers have introduced several genes from original plants that produce MCTs into cover crops to produce MCT in seed oil. These modifications redirect the plant's natural lipid metabolism toward MCT production. These engineered crops can be grown in rotation with food crops, offering environmental benefits and new revenue streams for farmers.

1.6 Challenges of bioengineered seed oil cover crops and the objectives of our study

Bioengineered seed oil cover crops often produce significantly lower levels of medium-chain triglycerides (MCTs) compared to the original donor plants from which the genes are sourced. This discrepancy suggests fundamental differences in lipid metabolism between native MCT-producing species and the engineered cover crops.

To address this bottleneck in MCT synthesis, two potential strategies have emerged:

1. **Identifying novel gene candidates** for improved MCT biosynthesis in seed oil cover crops.
2. **Directly harvesting MCTs from MCT-rich tissues** from the original plant species.

One of the most extensively studied genera for MCT production is *Cuphea*. While it has been a valuable model, researchers are increasingly exploring alternative genera. In line with this approach, our study investigates MCT accumulation in the samaras of Siberian elm (*Ulmus pumila*), aiming to provide clear evidence that these fruits contain commercially relevant levels of MCTs.

Additionally, our research indirectly supports the second strategy by evaluating the feasibility of extracting MCTs directly from samara oil. Unlike *Cuphea*, which presents several agronomic challenges—including severe seed shattering, sticky plant surfaces that hinder mechanical harvesting, unpredictable flowering, and frost sensitivity—Siberian elm offers several practical advantages.

Siberian elm is widespread across the United States, primarily due to its use as a hardy, fast-growing tree for shade and windbreaks in both urban and rural shelterbelt plantings. However, it has become invasive in many regions. Notably, these trees produce thousands of fruits (samaras) annually. Each samara contains a single seed encased in a pod that changes color from green to brown as it matures (Figure 5).

If the invasive nature of Siberian elm could be leveraged through organized harvesting programs, communities might benefit economically by collecting samaras from existing trees. Our study contributes to this by identifying the developmental stage at which samaras yield the highest MCT content, thereby supporting both ecological management and potential commercial utilization.

Questions we will address and our approach to finding answers

1. Do Siberian elm (Ulmus pumila) samaras accumulate significant levels of MCFAs?

Compare buds, and flower tissues with samara to indicate only samaras have high MCFA and MCT levels.

2. During samara development, which stage produces the highest MCT levels?

Compare MCT levels throughout the samara development to find out at which stage has high MCT levels.

2. Methods

2.1 Tree Selection and Sample Collection

We selected an *Ulmus pumila* (Siberian elm) tree located (Lat: 39.189900, Lon: -96.580985) at Kansas State University. This tree was chosen based on health, accessibility, and consistent samara production.

Buds, flowers, and samara collection began on March 6, 2025, and ended April 17, 2025, for once a week. harvest ~25 samaras per session from the tree's lower branches. Samples were placed into 50 mL tubes, at least half full, and immediately submerged in liquid nitrogen for preservation. Samples were stored in a –80 freezer until grinding.

2.2 Sample Preparation

Back in the lab, all working surfaces were sanitized with 70% ethanol. Personal protective equipment included gloves, lab coat, and cryogenic-rated gloves and eyewear.

Using mortar and pestle pre-chilled with liquid nitrogen, samples were ground into a fine powder. Clusters were ground in sets of five, Samaras were ground in sets of fifteen. Care was taken to allow slight nitrogen evaporation to prevent splashing. Ground tissue was transferred into 15 mL blue-capped tubes and stored in –80°C freezer.

2.3 Lipid Extraction

We heated isopropanol with 0.01% butylated hydroxytoluene (inactivation buffer) until it gets to 75° C. Next, we added about 20 mg of ground tissue into the 75°C isopropanol with 0.01% butylated hydroxytoluene and left for 15 minutes to inactivate enzymes. Then we let the system cool down to room temperature. Next, we added chloroform: methanol: water (30:41.5:3.5, v/v/v ratio) to extract lipids. Samples were shaken for 24 hours at 100 rotations per minute. Lipid extracts were decanted into a 4 mL glass vials, sorted in –20 freezer until use.

2.4 Sample Run for Fatty Acid Analysis

Taking 300 µL from each sample and 25 µL from internal standard (FA 15:0), put into clean, dry 15 mL glass vials with Teflon caps. Next, dry down with nitrogen gas. Then, add 0.5 mL 3 mol•dm ^-3 methanolic HCL and Bubble with liquid nitrogen. Heat at 78°C for 30 minutes. Next, we Add 1mL optima water. Then, add 250 µL saturated NaCl and Add 0.5 mL (hexane: chloroform)(4:1, v/v ratio) Then, we vortexed the mixture to make sure it is all mixed well. Next, we centrifuged the samples for eight minutes in the benchtop centrifuge machine at level five (located Ackert Hall 510). After this, we transferred about 200 microliter upper layer to mass spectrometry vial with flat bottom insert.

2.5 Sample Run for Triglyceride Analysis

To start sample run for triglyceride analysis, we diluted samples 10 times with chloroform from the diluted samples we transferred 8 μL into mass spec vials and internal standards to these vials (tri 15:0 triglyceride). Next, we added 1.2 mL of complete mass spec solvent (chloroform: (methanol + 300 mM ammonium acetate in water, 100:5.26, v/v/v ratio), 300:700, v/v ratio) to the same mass spec vials. We used SCIEX 6500+ electrospray ionization-tandem mass spectrometer to identify triglycerides in samples.

2.6 Microscopy

Microscopy was conducted in the Schrick Lab (Ackert Hall, 3rd floor) using a Leica compound microscope. Samples were viewed under different magnifications, and images were acquired using Leica software. Exposure and focus were adjusted as needed to optimize visual clarity.

3. Results and Discussion

3.1 Fatty acid analysis

The main goal of this analysis was to find out which medium-chain fatty acids were in our samples and how much of each was present. We used a method called Gas Chromatography with Flame Ionization Detection (GC-FID) to examine fatty acid methyl esters (FAMEs), focusing on identifying even numbered fatty acids from C8:0 to C20:0. To get a better idea of how fatty acid content differs between parts of the plant, we analyzed the clusters of different plant parts and samaras separately. This was important because the sample sizes were different—we only used five clusters per sample but had fifteen samaras per sample. Since this difference in sample size could affect the results, keeping the samples separate helped us get more accurate data.

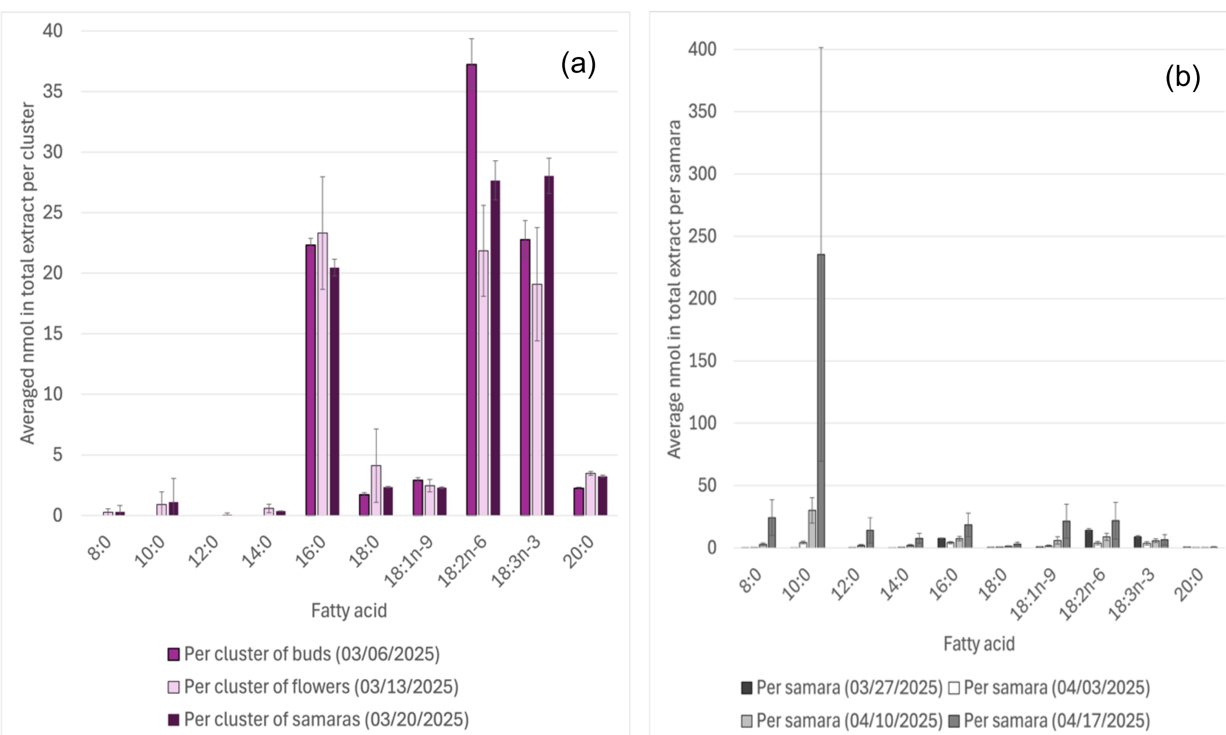

Figure 3: Fatty acid data through samara development. (a) Average nmols of fatty acids per cluster of buds (03/06/25), per cluster of flowers (03/13/25), and per cluster of young samaras (03/20/25) (b) Average nmols of fatty acids per samara (03/27/25, 04/03/25, 04/10/25, 04/17/25)

In graph Figure 1(a), we observe that the clusters of buds, flowers, and young samaras contain little to no medium-chain fatty acids. However, they exhibit relatively high levels of long-chain fatty acids, including FA 16:0, FA 18:0, FA 18:1n-9, FA 18:2n-6, FA 18:3n-3, and FA 20:0. When we compare this to the graph in Figure 1(b), which represents the final four harvests, a noticeable change is easily seen. These later-stage samples show a significant increase in medium-chain fatty acids specifically in FA 8:0 and FA 10:0, accompanied by a decrease in long-chain fatty acids. This suggests a developmental transition in fatty acid composition as the plant matures.

3.2 Triglyceride analysis

The main goal of this part of the project was to figure out when during the development of the samara the production of medium-chain triglycerides (MCTs) was at its highest. Knowing the best time to harvest the seeds is important for making biofuel production more efficient. To do this, we used a technique called electrospray ionization–tandem mass spectrometry (ESI-MS/MS), which is very sensitive and good for identifying different types of lipids. This method helped us detect and measure specific triglycerides, especially those with medium-chain fatty acids, at different stages of samara development. We also used a microscope to study the physical changes in the samaras over time. By comparing these observations with the chemical data, we were able to connect how the seeds look with how much MCT they produce, which can help improve how we choose and manage plant feedstocks in the future.

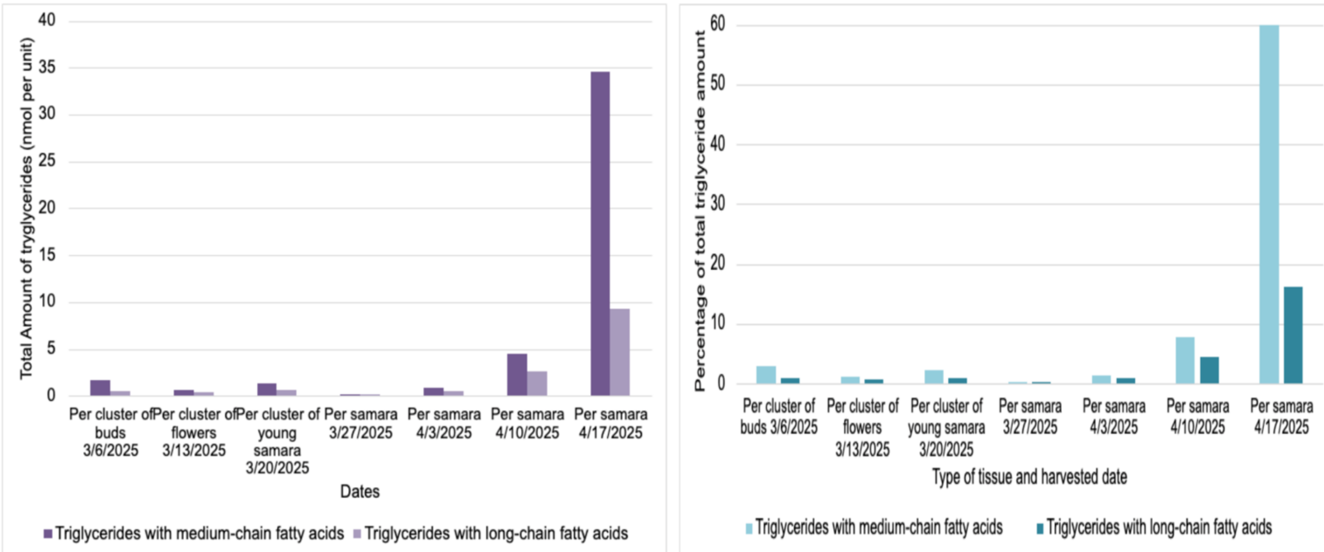

Figure 4: Triglycerides through samara development. (a) Total Average nmols of fatty acids per cluster of buds (03/06/25), flowers (03/13/25), and young samaras (03/20/25), samara (03/27/25, 04/03/25, 04/10/25, 04/17/25) (b) Percentage of the total triglyceride amount per cluster of buds (03/06/25), flowers (03/13/25), and young samaras (03/20/25), samara (03/27/25, 04/03/25, 04/10/25, 04/17/25)

The graphs display the amounts of triglycerides in the samara throughout the development. In Figure 4, the date 4/17/2025 has the highest triglyceride count, moreso than the others. This means that to gain the most MCT's, one must collect the samaras at this later stage in the development.

3.3 Microscopic imagery analysis

This part of the study focused on closely observing the development of clusters, seeds, and samaras over time to better understand their physical changes and identify the best stage for medium-chain fatty acid production. Using light microscopes, we examined the samaras in detail at several points in their development. This helped us track visible changes—such as size, color, texture, and internal structure—that may relate to shifts in lipid content. Our goal was to create a visual timeline of how the samaras develop, which can guide future efforts to collect seeds when they are most useful for making biofuels.

3.3.1 Light microscope and camera photos

To support this analysis, we used a light microscope and the camera on one of our phones to capture high-quality images of the samaras at each stage of development. These close-up photos helped us monitor seed development, document structural changes, and study features that aren't visible to the naked eye. The images provided valuable visual data for describing and possibly measuring traits like symmetry, color shifts, and shape changes, giving us a clearer picture of the plant's reproductive and dispersal processes.

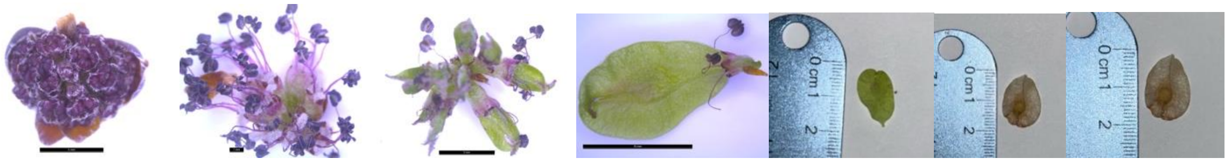

Figure 5: Timeline of samara development. (a) a cluster of buds (03/06/25), (b) a cluster of flowers (03/13/25), and (c) a cluster of young samaras (03/20/25), (d) a samara (03/27/25), (e) a samara (04/03/25), (f) a samara (04/10/25), (g) a samara (04/17/25). (a)-(d) microscopic figures (e)-(g) camera photos.

These images showcase the timeline development of the Siberian Elm samara. The last four images display the development of an individual samara, note the color change as the samara develops.

3.3.2 Scanning electron microscope

The goal of using the scanning electron microscope was to measure the size and observe the surface structure of the samaras and seeds at high resolution. SEM allowed us to capture detailed images that helped quantify key physical features, including embryo area, length and width. Additionally, SEM images helped track morphological changes during embryo development, supporting our broader aim of linking structural traits to biochemical outcomes like lipid content.

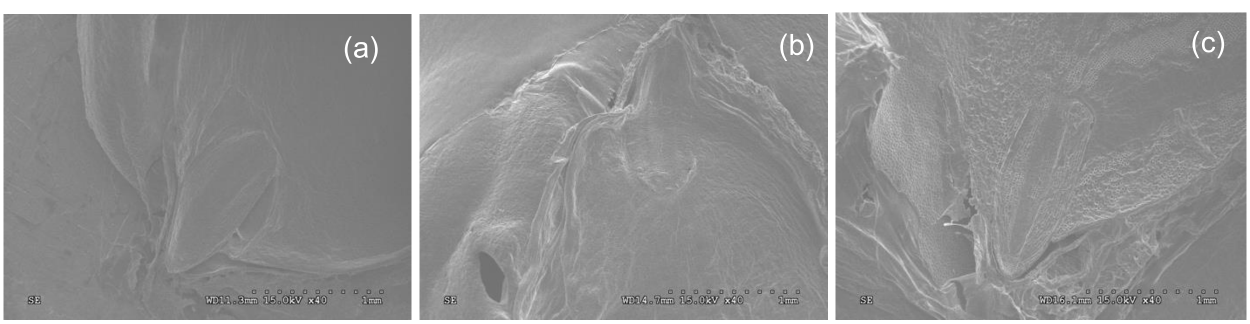

Figure 6: Scanning electron microscopic images of developing embryo of last three time points. Magnifi. (a) 4/03/2025, (b) 4/10/2025, (c) 4/17/2025.

Table 2: Area, length, and width of the embryo in the images in Figure 6.

SEM image	Harvested date	Area (μm)^2	Length (μm)	Width (μm)
Figure 6(a)	4/03/2025	83686	530	215
Figure 6(b)	4/10/2025	79778	501	220
Figure 6(c)	4/17/2025	117434	592	234

This table describes the growth of the samara seed at the respective dates. As is demonstrated there is not much difference in embryos between dates Figure 6(a) and Figure 6(b). However, the embryo in Figure 6(c) is much larger because it appears to have increased in size during its growth. Here we relate increased lipid amounts to the increase in the embryo size, assuming MCTs accumulate in embryo. This hypothesis could be tested in a future study.

Conclusion

Finding sustainable feedstocks for aviation fuel is more important than ever, as traditional jet fuel continues to be a major source of greenhouse gas emissions. While sustainable aviation fuel (SAF) offers a cleaner alternative, finding enough renewable and eco-friendly sources to make it is still a challenge. In this study, we explored the use of Siberian elm (*Ulmus pumila*) samaras as a new and mostly overlooked option for producing SAF based on medium-chain triglycerides (MCTs). Our research shows that these samaras contain a high amount of MCTs, which can be turned into bio-jet fuel.

We found that MCT levels in the samaras peak at certain stages of their development, which means we can time the harvest to get the best yield.

Using Siberian elm samaras for biofuel has a second benefit: the tree is invasive in many areas, so harvesting its seeds could help control its spread. This way, we're not just making cleaner fuel—we're also improving the environment. This study shows how biofuel production and ecological management can work together in a win-win situation.

Although more research is needed to improve the process for larger-scale use, our findings suggest that Siberian elm could become a useful and sustainable SAF feedstock. By adding this tree to the mix of biofuel sources, we can reduce our dependence on traditional oil crops and make the SAF industry more flexible and resilient. In the bigger picture, this work points to a future where we tackle energy and environmental problems at the same time—turning invasive species into part of the solution.

Acknowledgement

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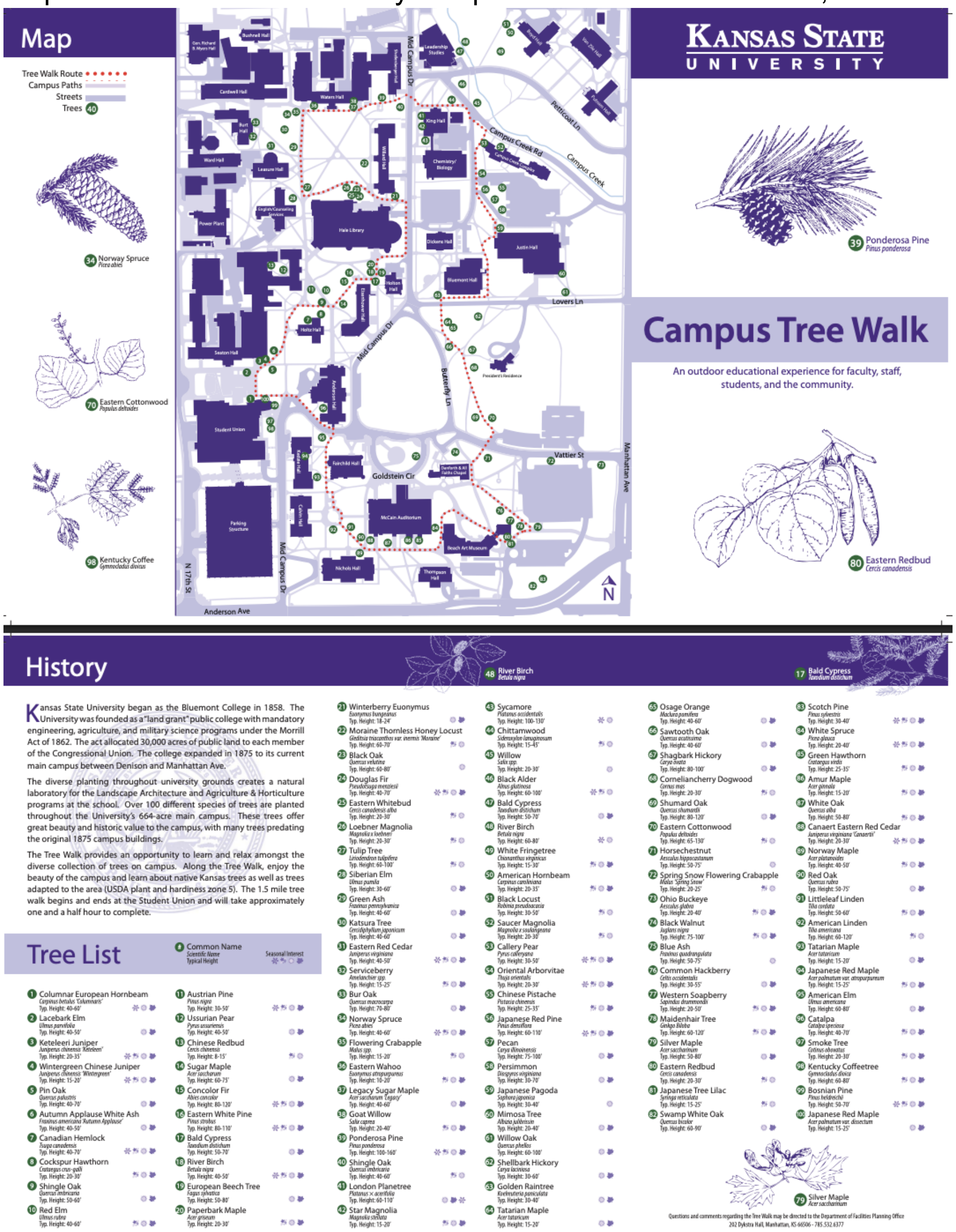
Appendix

Map of Kansas State University campus tree walk in Manhattan, Kansas.



History

Kansas State University began as the Bluemont College in 1858. The University was founded as a "land grant" public college with mandatory engineering, agriculture, and military science programs under the Morrill Act of 1862. The act allocated 30,000 acres of public land to each member of the Congressional Union. The college expanded in 1875 to its current main campus between Denison and Manhattan Ave.

The diverse planting throughout university grounds creates a natural laboratory for the Landscape Architecture and Agriculture & Horticulture programs at the school. Over 100 different species of trees are planted throughout the University's 664-acre main campus. These trees offer great beauty and historic value to the campus, with many trees predating the original 1875 campus buildings.

The Tree Walk provides an opportunity to learn and relax amongst the diverse collection of trees on campus. Along the Tree Walk, enjoy the beauty of the campus and learn about native Kansas trees as well as trees adapted to the area (USDA plant and hardiness zone 5). The 1.5 mile tree walk begins and ends at the Student Union and will take approximately one and a half hour to complete.

Tree List

Common Name / *Scientific Name* / Typical Height — Seasonal Interest

1. Columnar European Hornbeam — *Carpinus betulus 'Columnaris'* — Typ. Height: 40-60'
2. Lacebark Elm — *Ulmus parvifolia* — Typ. Height: 40-50'
3. Keteleeri Juniper — *Juniperus chinensis 'Keteleeri'* — Typ. Height: 20-35'
4. Wintergreen Chinese Juniper — *Juniperus chinensis 'Wintergreen'* — Typ. Height: 15-20'
5. Pin Oak — *Quercus palustris* — Typ. Height: 40-70'
6. Autumn Applause White Ash — *Fraxinus americana 'Autumn Applause'* — Typ. Height: 40-50'
7. Canadian Hemlock — *Tsuga canadensis* — Typ. Height: 40-70'
8. Cockspur Hawthorn — *Crataegus crus-galli* — Typ. Height: 20-30'
9. Shingle Oak — *Quercus imbricaria* — Typ. Height: 50-60'
10. Red Elm — *Ulmus rubra* — Typ. Height: 40-60'
11. Austrian Pine — *Pinus nigra* — Typ. Height: 30-50'
12. Ussurian Pear — *Pyrus ussuriensis* — Typ. Height: 40-50'
13. Chinese Redbud — *Cercis chinensis* — Typ. Height: 8-15'
14. Sugar Maple — *Acer saccharum* — Typ. Height: 60-75'
15. Concolor Fir — *Abies concolor* — Typ. Height: 80-120'
16. Eastern White Pine — *Pinus strobus* — Typ. Height: 80-110'
17. Bald Cypress — *Taxodium distichum* — Typ. Height: 50-70'
18. River Birch — *Betula nigra* — Typ. Height: 40-50'
19. European Beech Tree — *Fagus sylvatica* — Typ. Height: 50-80'
20. Paperbark Maple — *Acer griseum* — Typ. Height: 20-30'
21. Winterberry Euonymus — *Euonymus bungeanus* — Typ. Height: 18-24'
22. Moraine Thornless Honey Locust — *Gleditsia triacanthos var. inermis 'Moraine'* — Typ. Height: 60-70'
23. Black Oak — *Quercus velutina* — Typ. Height: 60-80'
24. Douglas Fir — *Pseudotsuga menziesii* — Typ. Height: 40-70'
25. Eastern Whitebud — *Cercis canadensis alba* — Typ. Height: 20-30'
26. Loebner Magnolia — *Magnolia x loebneri* — Typ. Height: 20-30'
27. Tulip Tree — *Liriodendron tulipifera* — Typ. Height: 60-100'
28. Siberian Elm — *Ulmus pumila* — Typ. Height: 30-60'
29. Green Ash — *Fraxinus pennsylvanica* — Typ. Height: 40-60'
30. Katsura Tree — *Cercidiphyllum japonicum* — Typ. Height: 40-60'
31. Eastern Red Cedar — *Juniperus virginiana* — Typ. Height: 40-50'
32. Serviceberry — *Amelanchier spp.* — Typ. Height: 15-25'
33. Bur Oak — *Quercus macrocarpa* — Typ. Height: 70-80'
34. Norway Spruce — *Picea abies* — Typ. Height: 40-60'
35. Flowering Crabapple — *Malus spp.* — Typ. Height: 15-20'
36. Eastern Wahoo — *Euonymus atropurpureus* — Typ. Height: 10-20'
37. Legacy Sugar Maple — *Acer saccharum 'Legacy'* — Typ. Height: 40-60'
38. Goat Willow — *Salix caprea* — Typ. Height: 20-40'
39. Ponderosa Pine — *Pinus ponderosa* — Typ. Height: 100-160'
40. Shingle Oak — *Quercus imbricaria* — Typ. Height: 40-60'
41. London Planetree — *Platanus × acerifolia* — Typ. Height: 60-110'
42. Star Magnolia — *Magnolia stellata* — Typ. Height: 15-20'
43. Sycamore — *Platanus occidentalis* — Typ. Height: 100-130'
44. Chittamwood — *Sideroxylon lanuginosum* — Typ. Height: 15-45'
45. Willow — *Salix spp.* — Typ. Height: 20-30'
46. Black Alder — *Alnus glutinosa* — Typ. Height: 60-100'
47. Bald Cypress — *Taxodium distichum* — Typ. Height: 50-70'
48. River Birch — *Betula nigra* — Typ. Height: 60-80'
49. White Fringetree — *Chionanthus virginicus* — Typ. Height: 15-30'
50. American Hornbeam — *Carpinus caroliniana* — Typ. Height: 20-35'
51. Black Locust — *Robinia pseudoacacia* — Typ. Height: 30-50'
52. Saucer Magnolia — *Magnolia x soulangeana* — Typ. Height: 20-30'
53. Callery Pear — *Pyrus calleryana* — Typ. Height: 30-50'
54. Oriental Arborvitae — *Thuja orientalis* — Typ. Height: 20-30'
55. Chinese Pistache — *Pistacia chinensis* — Typ. Height: 25-35'
56. Japanese Red Pine — *Pinus densiflora* — Typ. Height: 60-110'
57. Pecan — *Carya illinoinensis* — Typ. Height: 75-100'
58. Persimmon — *Diospyros virginiana* — Typ. Height: 30-70'
59. Japanese Pagoda — *Sophora japonica* — Typ. Height: 30-40'
60. Mimosa Tree — *Albizia julibrissin* — Typ. Height: 20-40'
61. Willow Oak — *Quercus phellos* — Typ. Height: 60-100'
62. Shellbark Hickory — *Carya laciniosa* — Typ. Height: 30-60'
63. Golden Raintree — *Koelreuteria paniculata* — Typ. Height: 30-40'
64. Tatarian Maple — *Acer tataricum* — Typ. Height: 15-20'
65. Osage Orange — *Maclura pomifera* — Typ. Height: 40-60'
66. Sawtooth Oak — *Quercus acutissima* — Typ. Height: 40-60'
67. Shagbark Hickory — *Carya ovata* — Typ. Height: 80-100'
68. Corneliancherry Dogwood — *Cornus mas* — Typ. Height: 20-30'
69. Shumard Oak — *Quercus shumardii* — Typ. Height: 80-120'
70. Eastern Cottonwood — *Populus deltoides* — Typ. Height: 65-130'
71. Horsechestnut — *Aesculus hippocastanum* — Typ. Height: 50-75'
72. Spring Snow Flowering Crabapple — *Malus 'Spring Snow'* — Typ. Height: 20-25'
73. Ohio Buckeye — *Aesculus glabra* — Typ. Height: 20-40'
74. Black Walnut — *Juglans nigra* — Typ. Height: 75-100'
75. Blue Ash — *Fraxinus quadrangulata* — Typ. Height: 50-75'
76. Common Hackberry — *Celtis occidentalis* — Typ. Height: 30-55'
77. Western Soapberry — *Sapindus drummondii* — Typ. Height: 20-50'
78. Maidenhair Tree — *Ginkgo Biloba* — Typ. Height: 60-120'
79. Silver Maple — *Acer saccharinum* — Typ. Height: 50-80'
80. Eastern Redbud — *Cercis canadensis* — Typ. Height: 20-30'
81. Japanese Tree Lilac — *Syringa reticulata* — Typ. Height: 15-25'
82. Swamp White Oak — *Quercus bicolor* — Typ. Height: 60-90'
83. Scotch Pine — *Pinus sylvestris* — Typ. Height: 30-40'
84. White Spruce — *Picea glauca* — Typ. Height: 20-40'
85. Green Hawthorn — *Crataegus viridis* — Typ. Height: 25-35'
86. Amur Maple — *Acer ginnala* — Typ. Height: 15-20'
87. White Oak — *Quercus alba* — Typ. Height: 50-80'
88. Canaert Eastern Red Cedar — *Juniperus virginiana 'Canaertii'* — Typ. Height: 20-30'
89. Norway Maple — *Acer platanoides* — Typ. Height: 40-50'
90. Red Oak — *Quercus rubra* — Typ. Height: 50-75'
91. Littleleaf Linden — *Tilia cordata* — Typ. Height: 50-60'
92. American Linden — *Tilia americana* — Typ. Height: 60-120'
93. Tatarian Maple — *Acer tataricum* — Typ. Height: 15-20'
94. Japanese Red Maple — *Acer palmatum var. atropurpureum* — Typ. Height: 15-25'
95. American Elm — *Ulmus americana* — Typ. Height: 60-80'
96. Catalpa — *Catalpa speciosa* — Typ. Height: 40-70'
97. Smoke Tree — *Cotinus obovatus* — Typ. Height: 20-30'
98. Kentucky Coffeetree — *Gymnocladus dioica* — Typ. Height: 60-80'
99. Bosnian Pine — *Pinus heldreichii* — Typ. Height: 50-70'
100. Japanese Red Maple — *Acer palmatum var. dissectum* — Typ. Height: 15-25'

Questions and comments regarding the Tree Walk may be directed to the Department of Facilities Planning Office
202 Dykstra Hall, Manhattan, KS 66506 - 785.532.6377