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A Comprehensive Study of Duckweed for NASA/Hudson Alpha Proposal

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ABSTRACT

Duckweed is a type of small aquatic plant, which is starting to be investigated for human consumption. In particular, the unique properties of this plant make it suitable for growing in outer space, where it can be used to feed astronauts. The plant-omics company Growmics plans to partner with NASA and Hudson Alpha to study and engineer duckweed for this purpose, but first it needs a basic understanding of both the plants themselves and the industry surrounding them. This project is a comprehensive survey of the available literature on duckweed biology, genetics, and cultivation methods, as well as an outline of the economic landscape, including the research and products of the major companies in the space and projections for the future of the duckweed market. The findings of this survey show that the nutritional density, hardiness, genetic malleability, and low resource requirements of duckweed, as well as its tolerance of microgravity, make it a promising subject of study for space agriculture, and economic projections show that the duckweed market is expected to grow significantly. This study will help Growmics both in their anticipated collaboration with NASA and Hudson Alpha and in any other duckweed-related ventures they choose to undertake in the future.

INTRODUCTION

Nutrition is an essential consideration in planning off-Earth missions for astronauts. Growing food in space is an appealing alternative to shipping it from Earth, but as space agriculture is a relatively new field, more research is needed to determine optimal strategies and long-term viability.

Growmics, an Illinois-based plant-omics startup, plans to collaborate with NASA and HudsonAlpha on researching duckweed, a type of small aquatic plant (above) for this purpose.



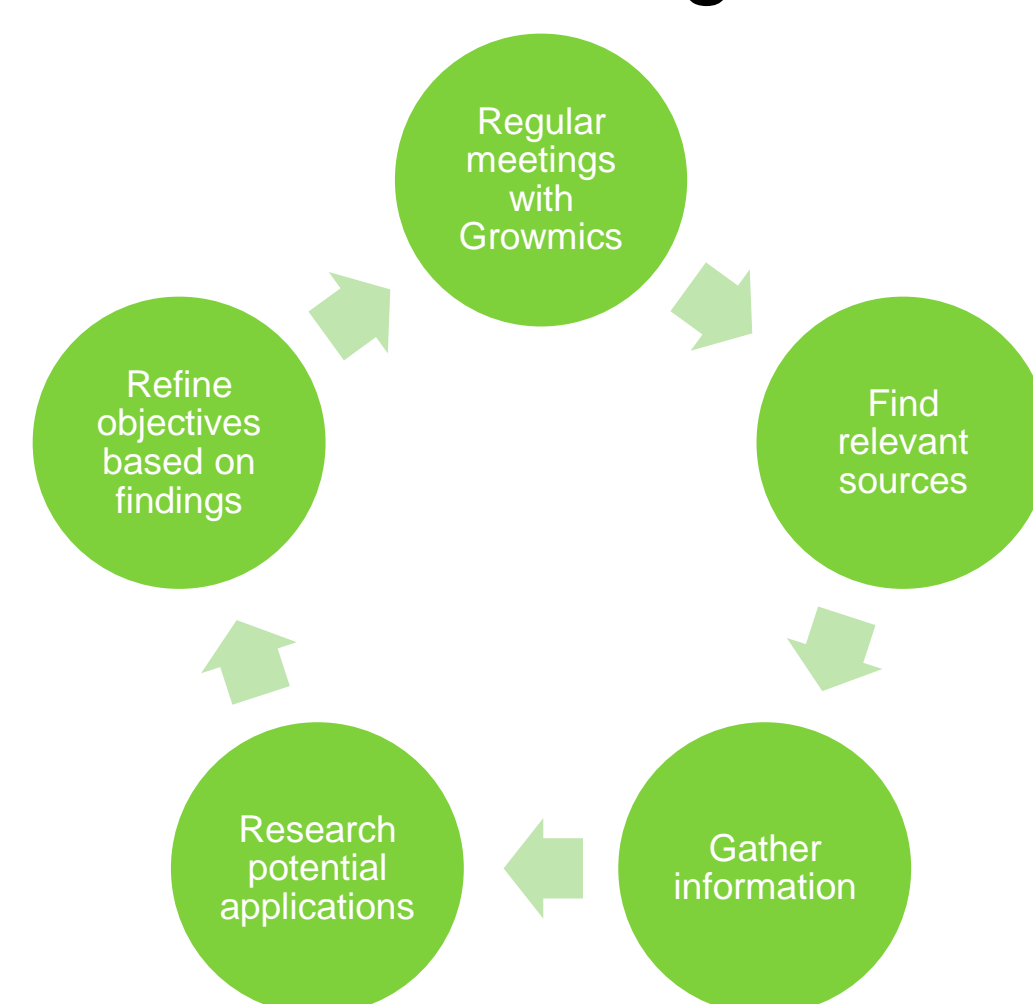
To enter the duckweed agritech field, Growmics needs a sufficient technical and economic knowledge base. The goal is for Growmics to be able to develop a workable proposal regarding duckweed specially engineered for space farming to potential partners and investors.

The project has three main objectives:

1. to research the biology, genetics and genomics of duckweed
2. to learn about current practices in duckweed farming
3. to outline the economic landscape of the duckweed industry and investigate the major companies in the space.

APPROACH

The chart below shows the process of completing the project. Objectives were defined through meetings with Growmics, and the requisite information was collected from the relevant sources. The objectives were then refined based on the findings.



Literature Survey (objectives 1 and 2): Information on general biology, genetics and epigenetics, nutritional value, and cultivation was collected. Studies from the past 5 years were preferred, but some information was only available from earlier works. Special attention was given to studies on novel farm designs for different environments, including outer space.

Market Research (objectives 2 and 3): Details on farming methods, target markets, business strategies, and product concepts were collected from company websites. Survey focused on companies active in duckweed research and farming, and preferably late-stage enough to have a product on the market.

FINDINGS

Duckweeds are simple aquatic plants that mainly reproduce through budding, doubling in mass in a few days (Baek et al., 2021). Their genomes are also very simple, lacking many genes found in other plants. This allows them to hybridize readily and even express introduced genes (Fourounjian et al., 2020).

Of note is their high protein content, which ranges between 20-40% dry mass. The nutritional profile of duckweed protein resembles that of animal proteins, which are more bioavailable than most plant proteins (Yahaya et al., 2022). The growing popularity of veganism will likely drive near-future growth of the duckweed market. Selected startups in this market are described in the table below.

Company	Main Product	Target Market	Notes
GreenOnyx	Wanna Greens (fresh duckweed)	End consumers	Has sent duckweed to space in special closed farms
Hinoman	Mankai (frozen duckweed)	End consumers	Engineered strain for large-scale production
Plantible Foods	Rubi Protein (duckweed-derived food additive)	Chefs and manufacturers	Developing methods of processing plants after harvest
Pontus Water Lentils	Closed Environment Vertical Aquaponic System (CEVAS)	Manufacturers and researchers	Creating novel farming methods

Duckweed has been shown to be tolerant of microgravity, and thus would be suited for conditions in space. Fully-closed modular farms, such as those used by GreenOnyx, have been developed to precisely control growing conditions and maximize space efficiency, and can be engineered for space-based farming.

CONCLUSIONS & RECOMMENDATIONS

The research has identified and detailed the properties of duckweed that make it suitable for space agriculture, as well as multiple ways to grow and prepare the plants for human consumption. It has also shown that there is a growing interest in duckweed as a food.

This project focused on topics relevant for space travel, as Growmics intends to collaborate with NASA and Hudson Alpha for a specific grant regarding duckweed in space. However, future works on duckweed may involve broader applications, such as health and wellness, sustainable food production, and non-agriculture applications.

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