Smart Wolffia Farming With Internet of Things technology (IoT) to promote Superfood Production

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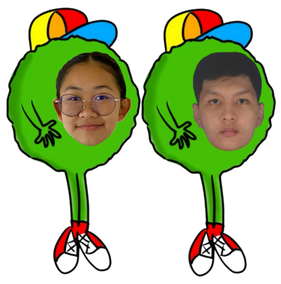
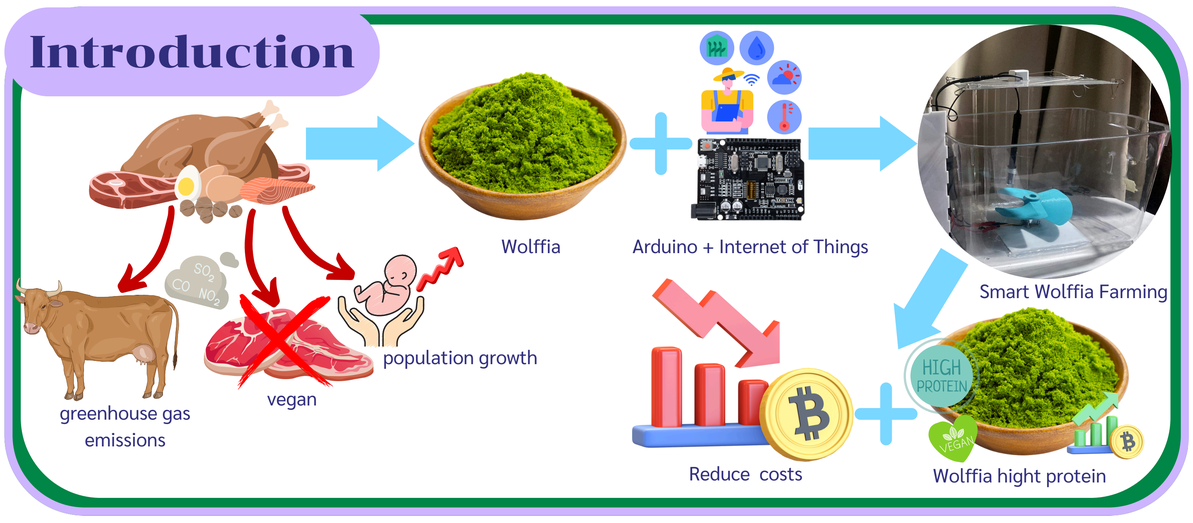


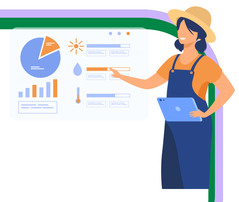
Abstract

Smart farms represent a new agricultural approach that promotes sustainable agricultural production by reducing unnecessary costs, increasing productivity, controlling and minimizing losses, and addressing environmental issues. Wolffia, a plant with high nutritional value, is primarily harvested from natural water sources. However, this has led to insufficient and inconsistent production throughout the year due to unsuitable environmental conditions. Therefore, a study was conducted to design a system for cultivating Wolffia, determine the optimal conditions for its cultivation, and analyze the nutritional value of Wolffia grown using an intelligent farm system. The system controlled various factors by receiving data from sensors and then instructing the motors to adjust the inputs to maintain optimal conditions. A fan was used to ensure even distribution of nutrients. Protein content was measured using the spectrophotometric biuret method. The results indicated that Wolffia grown using the automated system had a higher protein content compared to the controlled system, with the automatic system yielding 59.33±0.44% protein and the controlled system yielding 43.54±0.33% protein, under the same cultivation period. The use of smart farm technology reduced cultivation costs, increased yields, decreased maintenance burdens, and provided year-round production. It promoted the cultivation of Wolffia as a superfood, generated income, and supported the sustainable development of community-level agriculture.

Introduction



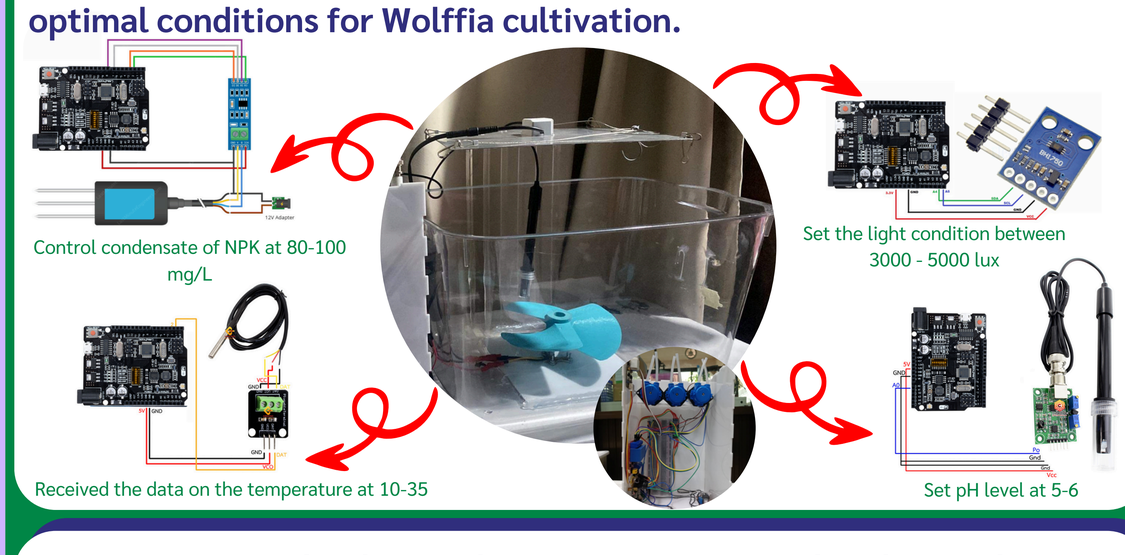
Purpose



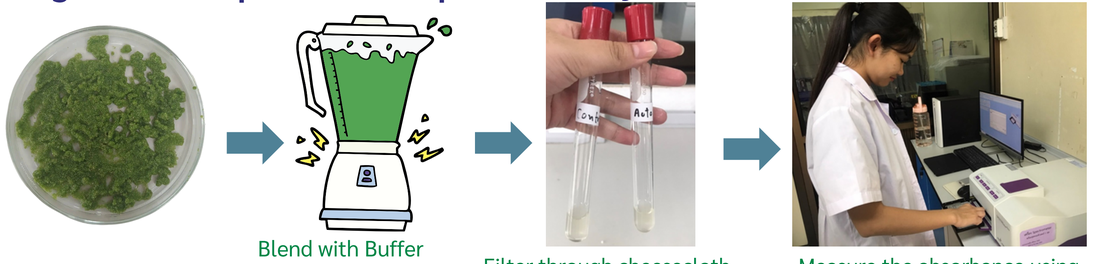
1.Design a system for cultivating Wolffia and study the optimal conditions for its cultivation.
2.Analyze the nutritional value of Wolffia grown using the developed smart Wolffia farming system.

Methodology

Part 1:Design of the Wolffia cultivation system and study of the optimal conditions for Wolffia cultivation.



Part 2: Nutritional Value Analysis of Water Hyacinth Cultivated Usingthe Developed Smart Aquaculture System



Drying Wolffia Cultivated Using Automated and Controlled Systems

Blend with Buffer Solution at a Concentration of 50 Millimolar, pH 5.5, and Add 2% PVPP Solution.

Filter through cheesecloth, then mix 1 ml of the resulting solution with 4 ml of Biuret reagent.

Measure the absorbance using a spectrophotometer and calculate the protein concentration using a standard BSA calibration curve.

Benefit and suggestion

1. It is possible to increase the protein content in Wolffia to enhance it as an alternative protein source.
2. Cultivation costs of Wolffia can be reduced, enabling farmers to increase their income.
3. The system can be controlled via mobile devices, offering ease of use and convenience.
4. The automated farm system can be applied to other plant species.

Results

Part 1: Education and Development of Intelligent Systems for Smart Wolffia Farming System

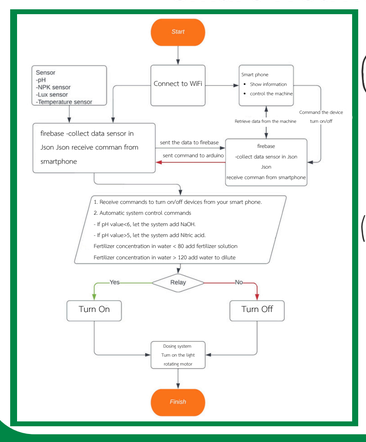


Diagram showing work of automation

Example screen format Mobile display

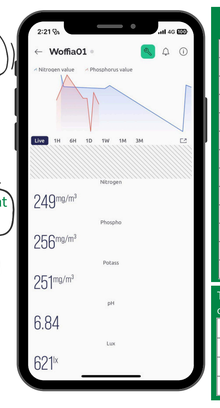


Table 1 shows the results of performance testing of the sensors compared to standard instruments (n=5)

The tools used for measurement	The measured value
Temperature sensor	$25.60^{a} \pm 0.93$
Thermometer	$25.40^{a} \pm 0.44$
pH sensor	$5.66^{b} \pm 0.34$
pH meter	$5.60^{a} \pm 0.38$
sensor N	$105.20^{c} \pm 0.34$
sensor P	$104.20^{c} \pm 7.08$
sensor K	$106.20^{d} \pm 5.34$
Rapitest 3in1 gen 181 : N	$105.20^{d} \pm 10.02$
Rapitest 3in1 gen 181 : P	$104.40^{e} \pm 6.55$
Rapitest 3in1 gen 181 : K	$106.00^{c} \pm 4.89$
lux sensor	$4465^{f} \pm 470$
digital lux meter	$4400^{f} \pm 567$

Table 2 shows the measurement results of the response time for the operation of the chemical dosing pump, propeller, and UV light (n=5)

Equipment	Average working time (s)
Chemical dosing pump	5.60 ± 0.93
Fan	4.40 ± 0.93
UV light	6.60 ± 0.93

Part 2: Nutritional Value Analysis of Wolffia Cultivated Using the Developed Smart Wolffia Farming System

Table 3 shows the UV absorption values at 298 nanometers and the concentration of the BSA standard solution.

BSA (mg/ml)	Absorbance (Wavelength = 298 nanometers)
0	0.00
1	0.84
2.5	1.07
5	1.23
7.5	1.50

Graph 1 shows the standard curve illustrating the relationship between UV absorption at a wavelength of 298 nm and the concentration of BSA.

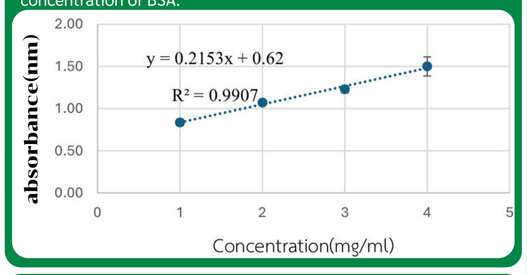


Table 4 shows the protein content of wolffia from the automated system and the system mimicking natural conditions (n = 5).

Data collection	Percentage of grams per dry weight of wolffia cultivated in a natural-like environment	Percentage of grams per dry weight of wolffia in Smart Farming system
day 1	$31.44^{a} \pm 0.79$	$31.44^{a} \pm 0.79$
day 3	$35.13^{a} \pm 0.68$	$45.40^{b} \pm 1.07$
Da' 5	$43.66^{a} \pm 0.86$	$50.86^{b} \pm 0.72$
day 7	$45.56^{a} \pm 0.33$	$58.65^{b} \pm 0.44$
day 9	$50.32^{a} \pm 0.33$	$68.32^{b} \pm 0.43$
day 12	$55.12^{a} \pm 0.33$	$81.32^{b} \pm 0.33$
Average	**43.54**	**59.33**

Graph 2 shows the percentage of protein content in Wolffia (grams per dry weight) cultivated using the automated system and the system mimicking natural conditions.

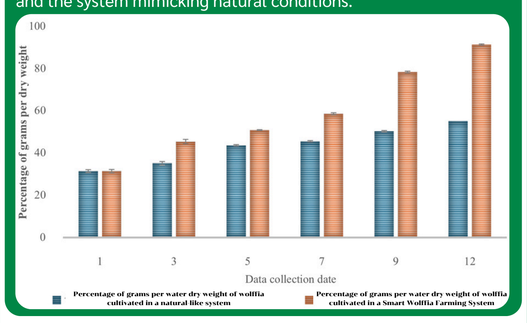


Table 5 shows the biomass production results of Wolffia after 12 days of cultivation (n = 3).

System of farming	Average biomass production of wolffia (grams)	Average yield in crease (grams)
Smart Farming System	$85.00^{a} \pm 2.64$	$70.91^{a} \pm 2.64$
Cultivated in a natural like	$85.00^{b} \pm 3.42$	$51.02^{b} \pm 3.42$

Conclusion

From the study and development of the smart farming system, it was found that using the intelligent system and Internet of Things (IoT) technology can increase the protein content in Wolffia daily. Wolffia cultivated in the automated system had a higher protein content than that grown in the controlled system. The average protein content in Wolffia grown in the automated system was 59.33±0.44%, compared to 43.54±0.33% in the controlled system.

Reference

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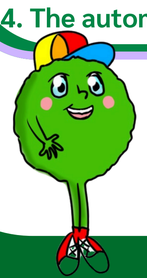

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