Does the Recirculating aquaculture system produce lettuce of satisfactory nutritional quality?

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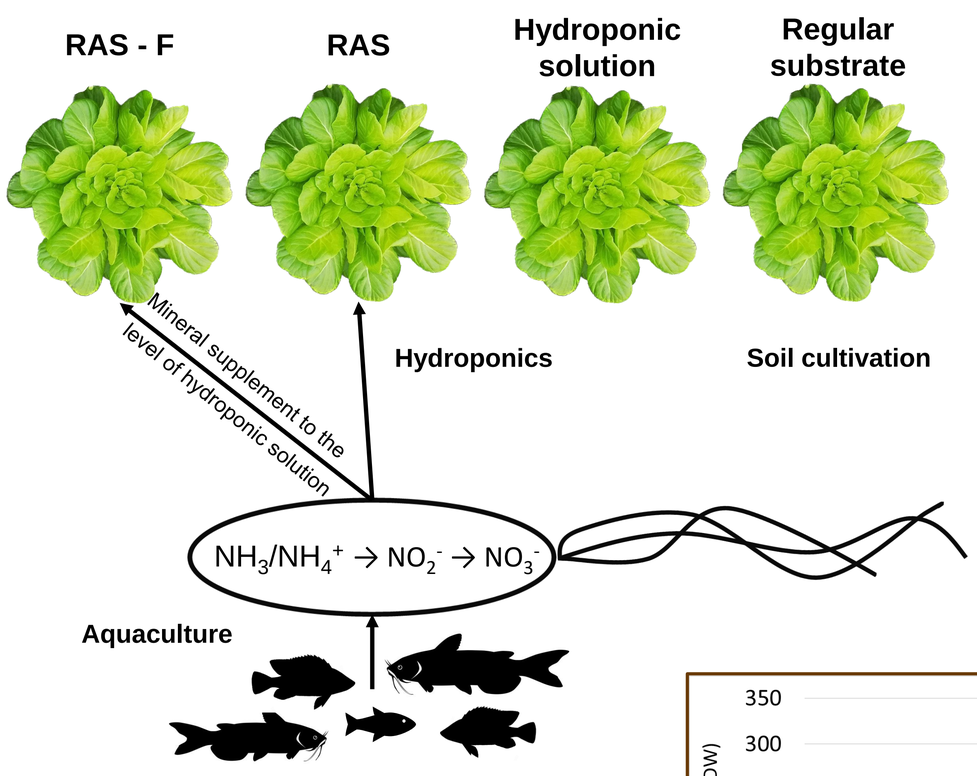
Introduction

The world is facing significant challenges including food security, global warming, and water scarcity, but modern technologies like aquaponic systems, which merge Recirculating Aquaculture System (RAS) with hydroponics, present potential solutions. However, consumer worries about the potential decline in vegetable quality from these systems also come into play.

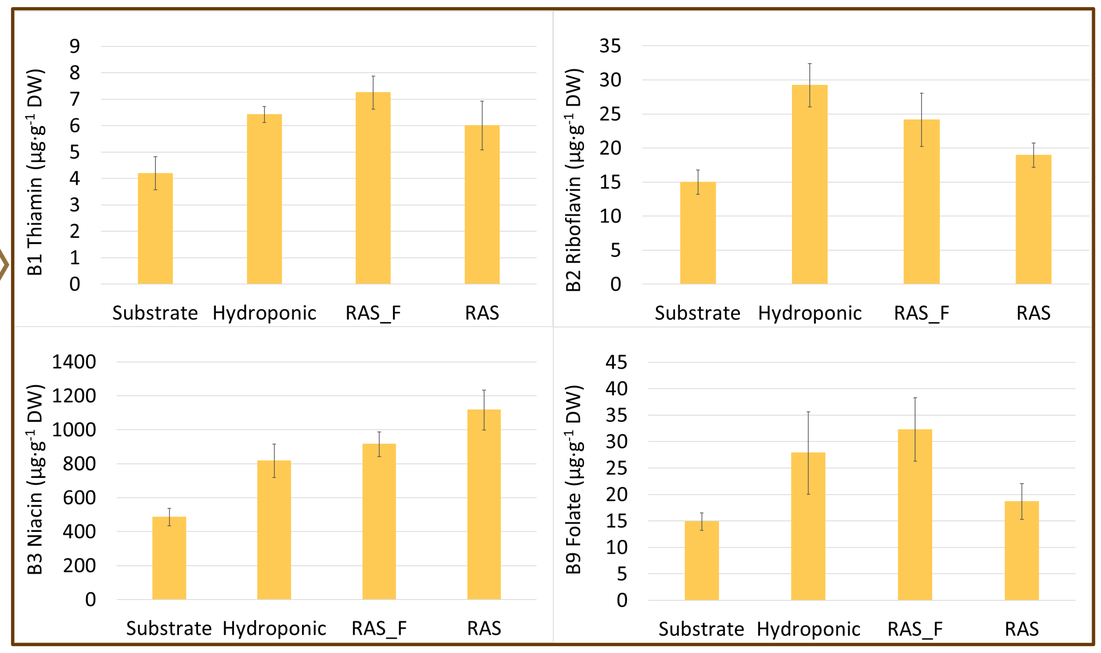
Material and Methods

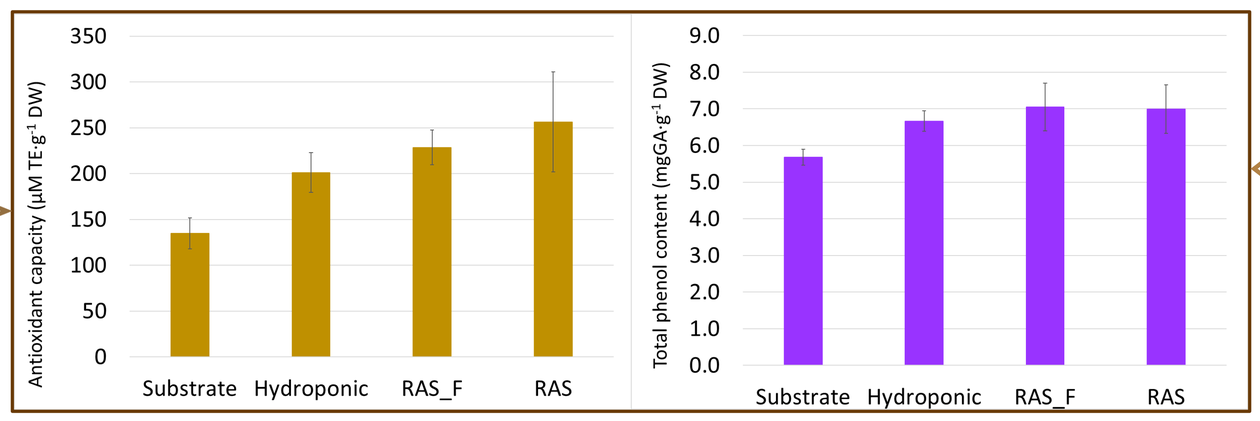


Oxygen radical absorbance capacity (ORAC) assay. Quantification was based on calibration curve constructed with Trolox (0 – 64 µM; 0.3281x + 1.7649; $R^2 \geq 0.9806$; LOD = 29.18 ± 0.38 µM; LOQ = 88.41 ± 1.20 µM). The reaction kinetics were measured at 485 nm excitation and 535 nm emission wavelength for 1 hour at 1 min intervals.

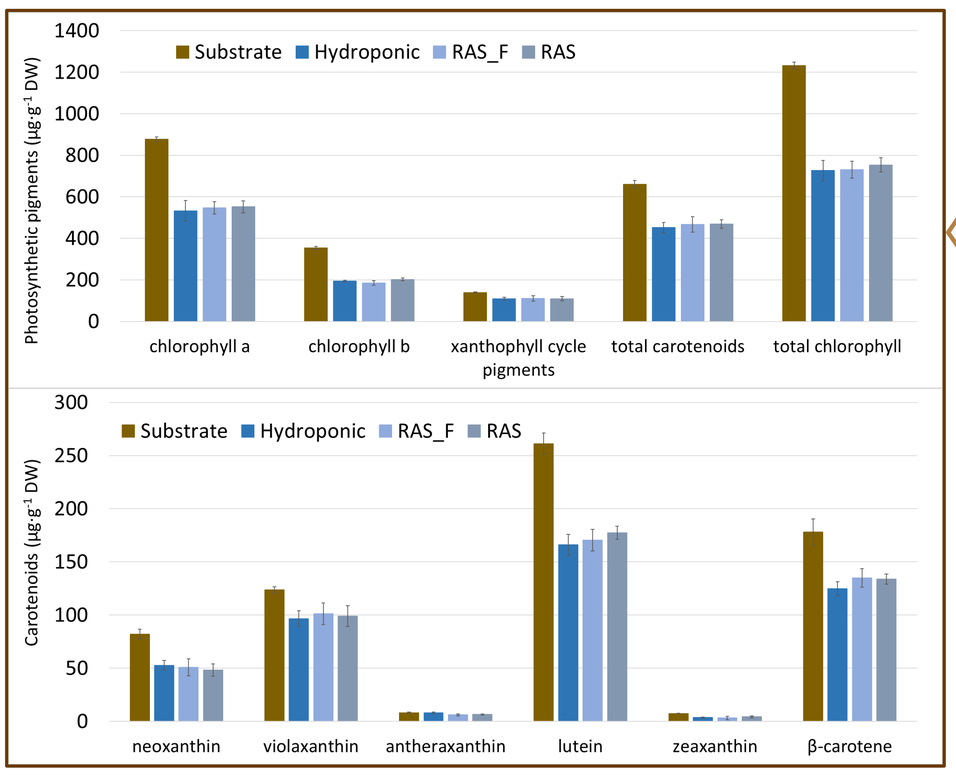
Freeze-dried homogenized lettuce leaves (0.2 g) were extracted in 2 mL of acetonitrile:acetic acid:water (5:1:94 v/v/v). HPLC Waters e2695 Separations Module, 2998 PDA Detector (Waters Alliance), Phenomenex Luna column (C18, 5 µm particle size, 250 × 4.6 mm). Gradient: A (0.1 % acetic acid), B (acetonitrile): 0-5 min. 99 %A; 6-12 min. 75 % A; 13-20 min. 55 % A; 21-30 min. 99 % A

Results

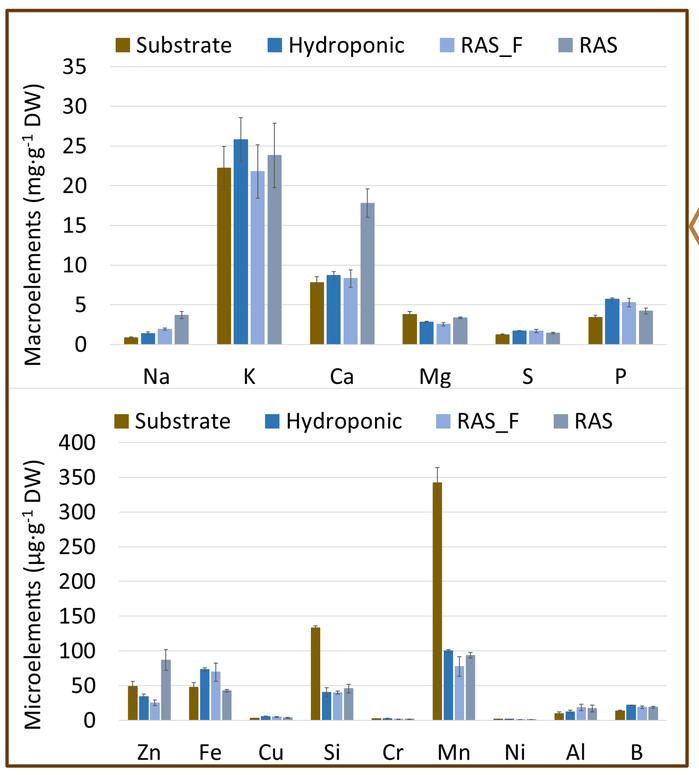




Total content of antioxidative phenolic compounds were determined using Folin-Ciocalteu reagent from methanolic extract. Quantification was based on calibration curve constructed with gallic acid (0 – 25 µg mL^{-1}; 0.0329x + 0.0411; $R^2 \geq 0.9992$; LOD = 4.15 ± 0.826 µg/mL; LOQ = 12.56 ± 2.504 µg/mL).



Freeze-dried homogenized lettuce leaves (5 mg) were extracted with 1 mL of acetone with 0.001 % of an antioxidant, butylated hydroxytoluene (BHT, 2,6-di-tert-butyl-4-methylphenol. HPLC/UV-VIS system, consisting of Gradient Pump Beta; Autosampler HTA 300; Watrex Nucleosil column (120-5-C18, 250×4 mm, 5 µm particle size); UV-VIS detector Sapphire; and Vacuum Degasser DG 3014 (ECOM, Czech Republic). Gradient: From 100% A (acetonitrile/methanol/water – 80/12/10, v/v/v), to 100 % B (methanol/ethylacetate – 95/5, v/v), both solvent mixtures contained 0.01 % of BHT.



Freeze-dried homogenized lettuce leaves (0.25 g) were digested with HNO_3 and $HClO_4$ mixture 7:1 (v/v) in microwave system Multiwave PRO (Anthon Paar GmbH, Austria). Mineral content was quantified through ICP-OES (Thermo Fisher Scientific iCAP Plus Series 7000,USA) analysis.

Summary

In lettuce grown on RAS, either with or without mineral supplementation, we found higher levels of antioxidants and increased antioxidant capacity by 70-90% compared to lettuce grown in soil. Although the vitamin C content was slightly reduced (by 6% in RAS compared to soil), the vitamin B content was 1.26 to 2.30 times higher in RAS lettuce compared to greenhouse lettuce. In all hydroponic systems, with standard or RAS solutions, we observed a reduced content of photosynthetic pigments (to 70% of carotenoids and 60% of chlorophylls) compared to soil cultivation in the greenhouse. This attribute indicates either insufficient light conditions or a reduced uptake of manganese in hydroponic systems.

Additionally, lettuce grown hydroponically exhibited a deficiency in silicon in contrast to soil cultivation. Conversely, an overabundance of calcium was detected in lettuce grown with RAS solution in the absence of mineral supplementation. While the calcium content was nearly equivalent between RAS and hydroponic solution, the increased availability could be attributed to a slightly elevated pH, which may simultaneously lead to decreased iron availability. Interestingly, lettuce grown with RAS solution demonstrated notably higher zinc uptake, even though the zinc content in hydroponic and supplemented RAS solutions was almost three times greater.

In summary, lettuce cultivated within aquaponic systems demonstrates the potential to attain satisfactory levels of vitamins, antioxidants, and minerals. However, meticulous attention is required to ensure optimal growth conditions in hydroponic setups, including careful adjustment of factors such as pH and light parameters.

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