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Growing duckweed indoors: how cultivation conditions and management strategies modulate productivity and nutritional quality - A systematic review

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Non-conventional crops with high nutritional value and efficient resource use may improve food security while reducing environmental pressures. Duckweeds are fast-growing aquatic plants with high potential as alternative protein sources. However, their ability to assimilate several compounds may impose food-safety concerns. Controlled-environment agriculture (CEA) could reduce microbiological risks and accumulation of undesirable compounds, but knowledge of indoor cultivation strategies remains fragmented. This systematic review synthesized how growing conditions and management affect duckweed growth and biochemical composition in indoor CEA. Four databases were searched for studies reporting growth and/or biochemical outcomes. Responses varied among genera, species, clones, and outcomes, preventing definition of common cultivation ranges. Most studies examined *Lemna*, particularly *Lemna minor*, in small-scale batch systems; semi-continuous, recirculating, photobioreactor, and multilayer systems were uncommon. In *Lemna*, nitrogen availability and source affected biomass and protein production, while nutrient limitation and environmental stress promoted starch or soluble sugar accumulation, often reducing growth. Light intensity influenced biomass more consistently than composition. In *Spirodela*, red light and carbon availability promoted starch accumulation, while blue light increased amino acids and photosynthetic pigments. *Landoltia* showed consistent starch accumulation under nutrient limitation, especially when combined with extended photoperiods. In *Wolffia*, nutrient availability influenced protein, starch, biomass nitrogen, and nitrate accumulation, while evidence for *Wolffiella* was limited. Minerals, undesirable compounds, and microbiological safety were occasionally assessed. Evidence supports food-oriented production and shows that cultivation conditions can direct biomass towards protein- or starch-oriented uses. Scaling up cultivation alongside comprehensive nutritional and safety assessments is needed to develop standardized production strategies.

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