# Economics and environmental impact of water lentil protein for human consumption

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Duckweed or water lentils are a source of plant-based protein producing up to 45% of protein in the dry matter (Men, et al., 1995). Plant-based proteins generally result in lower environmental impact compared to animal-based protein. In many Western countries there is a lot of effort aimed at transitioning from animal-based to plant-based protein in human diets. Producing high value protein from water lentils, therefore, is interesting from an economic as well as environmental perspective. Currently, novel food procedures for admitting water lentils as food are underway in the EU and insight is needed in how water lentil value chains perform economically and environmentally. We provide an overview of the economics and environmental impact, based on life cycle assessment, of water lentil value chains (Figure 1). We use data from practice to assess and estimate: fixed and variable costs, climate change, water use, land use and energy use. Outcomes show that production costs in greenhouses vary between 33 and 82 dollars per kg of protein. Revenues varied between 16 and 134 dollars depending on the market and application, e.g. high-end food products or bulk protein. Greenhouse gas emissions were mainly determined by high electricity consumption and use of gas for heating during production in greenhouses (50 to 92%). This led to relatively higher emissions compared to other protein sources (Table 1). Water and land use were lower for lentil protein (-2.8 to 1.3 $m^3$ and -8.0 to 1.5 $m^2$ per kg of protein, respectively). In future value chains, energy reduction and sustainable energy use, low cost harvesting techniques and targeting complete nutrition sales routes will be relevant for improving economic returns and for reducing environmental impact of water lentil protein for human consumption.

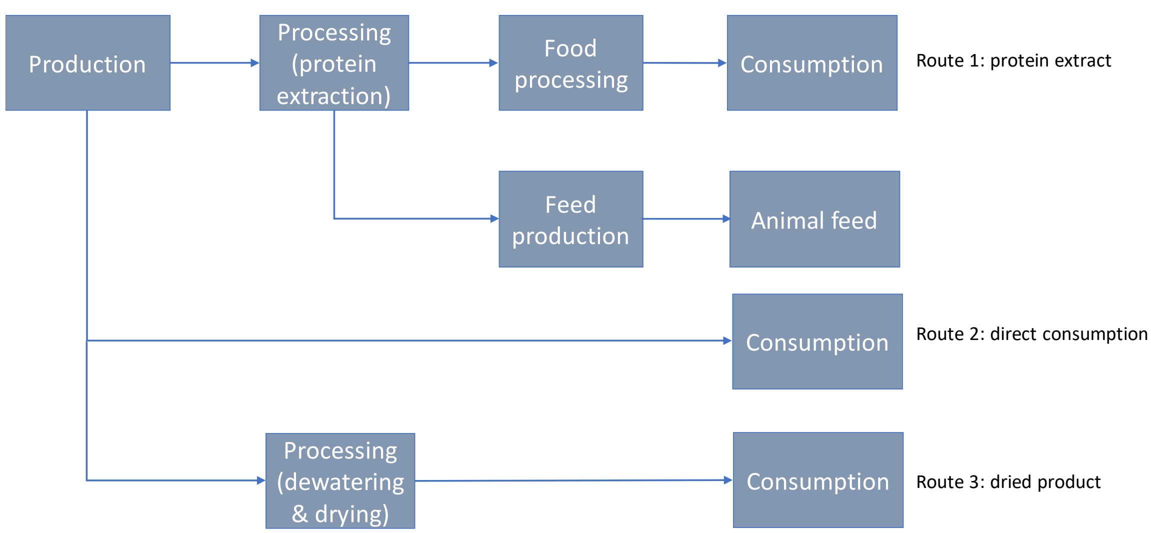


Figure 1. Production routes and value chains for using water lentils and its derived products: Route 1 protein extract, Route 2 direct consumption and Route 3 dried product.

Table 1. Ranges of economics and environmental impact of water lentil value chains and other protein sources, expressed per kg of protein

| Product | Economics | Environmental impact | | | |
|---|---|---|---|---|---|
| | Estimated production costs ($USD) | Climate change (kg $CO_2$-eq) | Land use ($m^2$) | Water use ($m^3$) | Energy use (GJ) |
| 1. protein extract** | 50 – 82 | 151 – 179 | -8.0 – -1.3 | -2.8 – 0.4 | ~2.3 |
| 2. direct consumption** | 38 – 47 | 133 – 163 | 1.4 – 1.7 | 1.2 – 1.5 | 1.7 – 2.1 |
| 3. dried product** | 30 – 37 | 105 – 129 | 1.1 – 1.3 | 0.9 – 1.1 | 1.4 – 1.7 |
| Chicken egg protein# | 9 – 12 | 35 – 77* | 45 – 58 | ~7.9 | 0.1 – 269 |
| Algal protein# | 27 – 144 | 16 – 263 | 1.8 – 5.8 | 0.3 – 4.2 | 2.3 – 3.6 |
| Soy protein# | ~2.19 | 1.7 – 2.2* | ~3.6 | ~3.6 | ~0.01 |

* Including land use and land use change
** Own calculations based on production scales of 150 t/ha $yr^{-1}$ and 1000 t/ha $yr^{-1}$
# Williams et al. (2006); Baumgartner et al. (2008); Smetana et al. (2017)

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