Aquaponics Food Production Systems

Simon Goddek • Alyssa Joyce • Benz Kotzen
Gavin M. Burnell
Editors

Aquaponics Food Production Systems

Combined Aquaculture and Hydroponic Production Technologies for the Future

Funded by the Horizon 2020 Framework Programme of the European Union

Editors
Simon Goddek
Mathematical and Statistical Methods
(Biometris)
Wageningen University
Wageningen, The Netherlands

Benz Kotzen
School of Design
University of Greenwich
London, UK

Alyssa Joyce
Department of Marine Science
University of Gothenburg
Gothenburg, Sweden

Gavin M. Burnell
School of Biological, Earth
and Environmental Sciences
University College Cork
Cork, Ireland

ISBN 978-3-030-15942-9 ISBN 978-3-030-15943-6 (eBook)
https://doi.org/10.1007/978-3-030-15943-6

This Springer imprint is published by the registered company Springer Nature Switzerland AG.
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

It has been more than 45 years since the science fiction film Soylent Green (1973) first appeared in cinemas. The movie was prescient for its time and predicted many of our current environmental problems, including dying oceans, the greenhouse effect, overpopulation, and loss of biodiversity. Even though we hope that humans will not serve as a future nutrient source, the scenarios laid out in the movie are not that far from being realised. As researchers and citizens, we realise our duty of care to the environment and the rest of our world's ever-growing population. We are concerned that if we stand back and ignore the current trends in exploitation of resources and methods of production that our paradise of a planet will be doomed or at least far diminished, such that living on the sterile surfaces of the Moon or Mars will seem like a pleasant alternative. Generations to come will and should hold us individually and collectively responsible for the mess that we leave. The numerous authors of this book are in a lucky as well as in an unfortunate position, in that we can either help to solve problems or be held responsible by future generations for being part of the problem. When we started the COST Action FA1305 'The EU Aquaponics Hub – Realising Sustainable Integrated Fish and Vegetable Production for the EU', aquaponics was a niche technology that, at an industrial scale, could not compete with stand-alone hydroponics and aquaculture technologies. However, aquaponics technology in the past decade has taken great leaps forward in efficiency and hence economic viability through a wide range of technological advances. As our ability to understand the environmental costs of industrial farming increases, we are more capable of developing technologies to ensure that farming is more productive and less damaging to the environment. This positive outcome should be bolstered by the very encouraging signs that although young people are statistically not interested in being the farmers of the future, they do want to be future farmers if technology is involved and they can adapt these technologies to live closer to urban environments and have a better quality of life than in the rural past. Kids of all ages are fascinated by technology, and it is no wonder as technology solves many problems. At the same time though, kids (perhaps less so with teenagers) are also environmentally conscious and understand that the future of our planet lies in the

melding of nature and technology. Technology allows us to be more productive, and although we have no certainty that we can and will effectively solve climate change, we still have hope that there will be a future where people will be healthy and fed with nutritious food. We, the authors of this book, realise that we are but small fry in a world of much bigger fish (sometimes sharks), but we are more than hopeful, indeed confident, that aquaponics has a role to play in the world's future food production.

Within the timeline of COST Action FA1305, our objective was to bring aquaponics closer to the public and to raise awareness of alternative growing methods. The Action's Management Committee had 90 experts from 28 EU countries, 2 near neighbour countries, and 2 international partner countries. We organised 7 training schools in different parts of Europe, involving 92 trainees from 21 countries, and 20 STSMs were awarded to 18 early career researchers from 12 countries. Most importantly, we published 59 videos based on the training schools, all of which are freely available on YouTube (https://www.youtube.com/EUAquaponicsHub). Action members collaborated in writing 24 papers (19 of which are open access), book chapters, monographs, and a white paper. The white paper identifies eight key recommendations based on the experience of the working group members, trends within current research and entrepreneurship, and the directions being investigated by ECIs. The recommendations are:

1. The promotion of continued research in aquaponics.
2. The development of financial incentives to enable the commercialisation of aquaponics.
3. The promotion of aquaponics as social enterprise in urban areas.
4. The promotion of aquaponics in the developing world and in refugee camps.
5. The development of EU-wide aquaponics legislation and planning guidance.
6. The development of aquaponics training courses in order to provide the necessary skilled workforce to enable aquaponics to expand in the EU.
7. The development of stricter health and safety protocols, including fish welfare.
8. The establishment of an EU Aquaponics Association, in order to promote aquaponics and aquaponics technology in the EU and to assist with knowledge transfer, and the promotion of high production and produce standards in EU aquaponics (Fig. 1).

The assembled knowledge and experience of the group is considerable, and it is therefore appropriate to take the opportunity at the end of the 4-year COST project to gather this into a book, which was originally proposed by Benz Kotzen and Gavin M. Burnell at the start and then with Simon Goddek and Alyssa Joyce. We are fortunate that Springer Nature particularly Alexandrine Cheronet has been enthusiastic about this publication and that the COST organisation has funded the book as open access so that it is available for anyone to download. We see it as part of our duty to ensure that as many people as possible can benefit from the knowledge and expertise. The book is the product of 68 researchers and practitioners from 29 countries (Australia, Austria, Belgium, Brazil, Croatia, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Malta, the

Fig. 1 Group picture of the COST group in Murcia, Spain, 2017

Netherlands, North Macedonia, Norway, Portugal, Serbia, Slovenia, South Africa, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States). When asking the members of our COST Action as well as external experts whether they were willing to contribute to this book, the response was overwhelming. Putting a book together with 24 chapters within 1 year would not have been possible without the cooperative spirit of every single lead author and coauthor. The book is testament to their knowledge and enthusiasm. We offer our warmest appreciation to our scientific review committee including Ranka Junge (aquaponics and education), Lidia Robaina (fish feed), Ragnheidur Thorarinsdottir (commercial aquaponics), Harry Palm (aquaponics and aquaculture systems), Morris Villarroel (fish welfare), Haissam Jijakli (plant pathology), Amit Gross (aquaculture and recycling), Dieter Anseeuw (hydroponics), and Charlie Shultz (aquaponics). We would also like to thank all peer reviewers of the 24 chapters who improved the content of the chapters. Finally, yet importantly, the editors would also like to thank their families and partners who have been patient in the editing a large book such as this.

Wageningen, The Netherlands — Simon Goddek
Gothenburg, Sweden — Alyssa Joyce
London, UK — Benz Kotzen
Cork, Ireland — Gavin M. Burnell
February 2019

Acknowledgements

The editors, authors, and publishers would like to acknowledge the COST (European Cooperation in Science and Technology) organisation (https://www.cost.eu) initially for funding and supporting the 4-year COST Action 1305, 'The EU Aquaponics Hub – Realising Sustainable Integrated Fish and Vegetable Production for the EU', which was conceived and chaired by Benz Kotzen, University of Greenwich, and then finally for contributing funds to this publication, making it open-source and available to all to read. Without COST, who brought almost all of the authors together, in an amazing project, this book would not have been written, and without their final dissemination contribution, this book would not be available to everyone. We also acknowledge and greatly appreciate the support of Desertfoods International GmbH (www.desertfoods-international.com) and Developonics asbl (www.developonics.com) for the additional financial support required to enable the publication to be open-source. Additionally we applaud the efforts and great skill of Aquaponik Manufaktur GmbH (www.aquaponik-manufaktur.de) for producing a cohesive and attractive set of illustrations for the book, the Netherlands Organisation for Scientific Research (NWO; project number 438-17-402) for supporting Simon Goddek in his editorial work and writing, and the Swedish Research Council FORMAS grant 2017-00242 for similarly supporting Alyssa Joyce whilst she undertook editorial work and writing on this book. Finally, the editors are indebted to the enthusiasm and diligence of its authors, especially of the 22 lead authors of the 24 chapters in their sterling efforts to get this remarkable book delivered on time. A heartfelt well-done one and all!

Wageningen University, Wageningen, The Netherlands — Simon Goddek
University of Gothenburg, Gothenburg, Sweden — Alyssa Joyce
University of Greenwich, London, UK — Benz Kotzen
University College Cork, Cork, Ireland — Gavin M. Burnell

Contents

Part V Aquaponics and Education

About the Editors

Simon Goddek Simon is an expert in the field of multi-loop aquaponics systems and an ecopreneur. In 2014, Simon started his PhD in the faculty of environmental engineering at the University of Iceland, completing it in the group Biobased Chemistry and Technology at Wageningen University & Research (the Netherlands). At the time of publication, he is a postdoc in the Mathematical and Statistical Methods group (Biometris), where he is involved in several projects in Europe (i.e. CITYFOOD) and Africa (e.g. desertfoods Namibia). His research focus in aquaponics includes numerical system simulation and modelling, decoupled multi-loop aquaponics systems, and anaerobic mineralization solutions.

Alyssa Joyce Alyssa is an assistant professor in the Department of Marine Sciences (aquaculture) at the University of Gothenburg, Sweden. In her group, several researchers are focused on the role of bacterial relationships in nutrient bioavailability and pathogen control in aquaponics systems. She was one of the Swedish representatives to the EU COST Network on aquaponics and is a partner in the CITYFOOD project developing aquaponics technology in urban environments.

Benz Kotzen Benz is an associate professor and head of Research and Enterprise in the School of Design, University of Greenwich, London, and a consultant landscape architect. He runs the rooftop Aquaponics Lab at the University. He developed and was chair of the EU Aquaponics Hub, whose remit was to raise the state of the art of aquaponics in the EU and facilitate collaborative aquaponics research. Urban agriculture including vertical aquaponic systems and growing exotic vegetables aquaponically and drylands restoration are key fields of research.

Gavin M. Burnell Gavin is an emeritus professor at the Aquaculture and Fisheries Development Centre, University College Cork, Ireland, and president of the European Aquaculture Society (2018–2020). He has been researching and promoting the concept of marine aquaponics as a contribution to the circular economy and sees an important role for this technology in outreach to urban communities. As a co-founder of AquaTT and editor of Aquaculture International, he is excited at the possibilities that aquaponics has in research, education, and training across disciplines.