AI in the Food Industry

The Next Industrial Revolution from Farm to Fork

AIFST Webinar 2024

Dr Jordan Pennells | Dr Kai Knoerzer
CSIRO Food Innovation Centre

Presentation Outline

Time	Topic
~ 5 mins	Introductions
~ 15 mins	AI Fundamentals
~20 mins	Case Studies for AI in Food Manufacturing
~15 mins	Q&A Discussion

Introductions

Dr Jordan Pennells
Postdoctoral Researcher
CSIRO Food Innovation Centre

Current focus:
Developing a digital platform for prediction of the food extrusion process

Dr Kai Knoerzer
Principal Research Scientist/Engineer
CSIRO Food Innovation Centre

Current focus:
High Pressure Thermal Processing,
AI and Food,
Company Creation

CSIRO Food Program

Our Aspiration

As a **trusted partner** to the food manufacturing sectors, we enable innovation to support food manufacturing and product innovation while focusing on sustainable, economic & social outcomes.

Our Goal

To **advance knowledge** in food science and support the food industry through driving innovation, technology development and transfer to secure competitiveness.

Re-imagine Food Manufacturing

Food Design for the Future

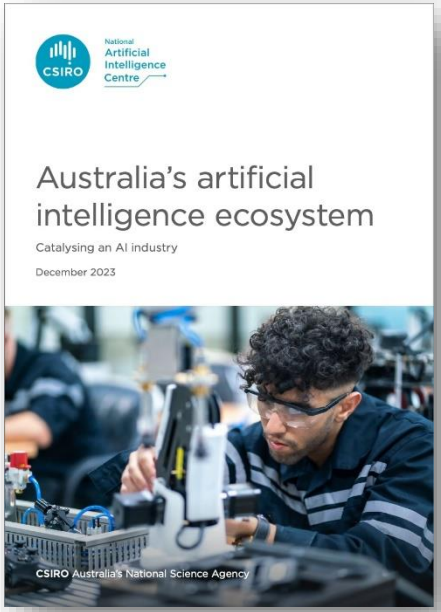
Food System Integrity

Cross Cutting Science: DIGITAL, AI/ML, SUSTAINABILITY, HEALTH, SOCIAL LICENCE

CSIRO's National AI Centre

"A world-first program bringing together experts, regulatory bodies, training organisations, and practitioners to focus on responsible artificial intelligence (AI) solutions for Australian industry."

- 544 AI companies in Australia
- 1.2% of job postings in 2022 were AI-related
- Top 3 AI research areas: (1) Livestock production (2) Medical technologies (3) Horticulture
- Insights from consultations with 28 stakeholders across the AI ecosystem in Australia



Link: NAIC

Australia's AI Ecosystem

Key insights based on interviews held with 28 stakeholders including AI companies (startups, SMEs & large enterprises), academia & government agencies:

(1) Challenge in separating the hype from reality

(2) More awareness of local AI service providers needed

(3) Deciding on what AI to build, buy or borrow

(4) Prioritising being an AI specialist over an AI generalist

(5) An opportunity for safe and responsible AI

(6) The benefits of socio-cultural diversity

(7) Strengthening linkages across the AI ecosystem

(8) Growing Australia's AI talent and business ecosystem

Food Australia Article

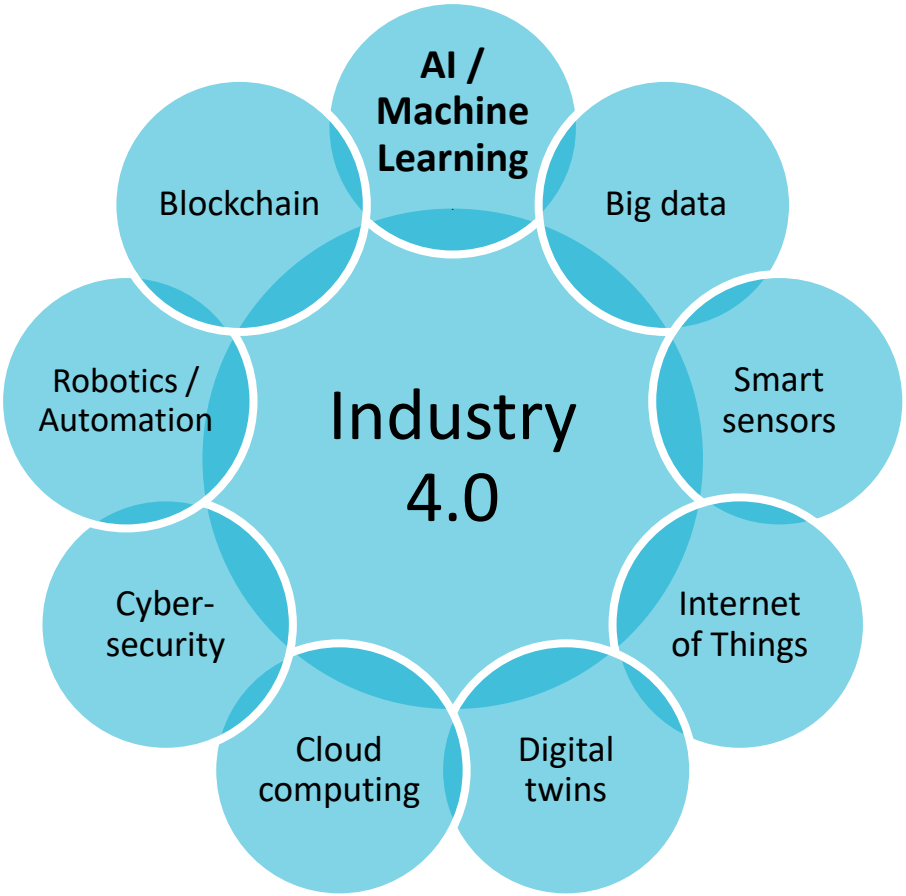
food australia
OFFICIAL PUBLICATION OF AIFST

FUTURE FOOD

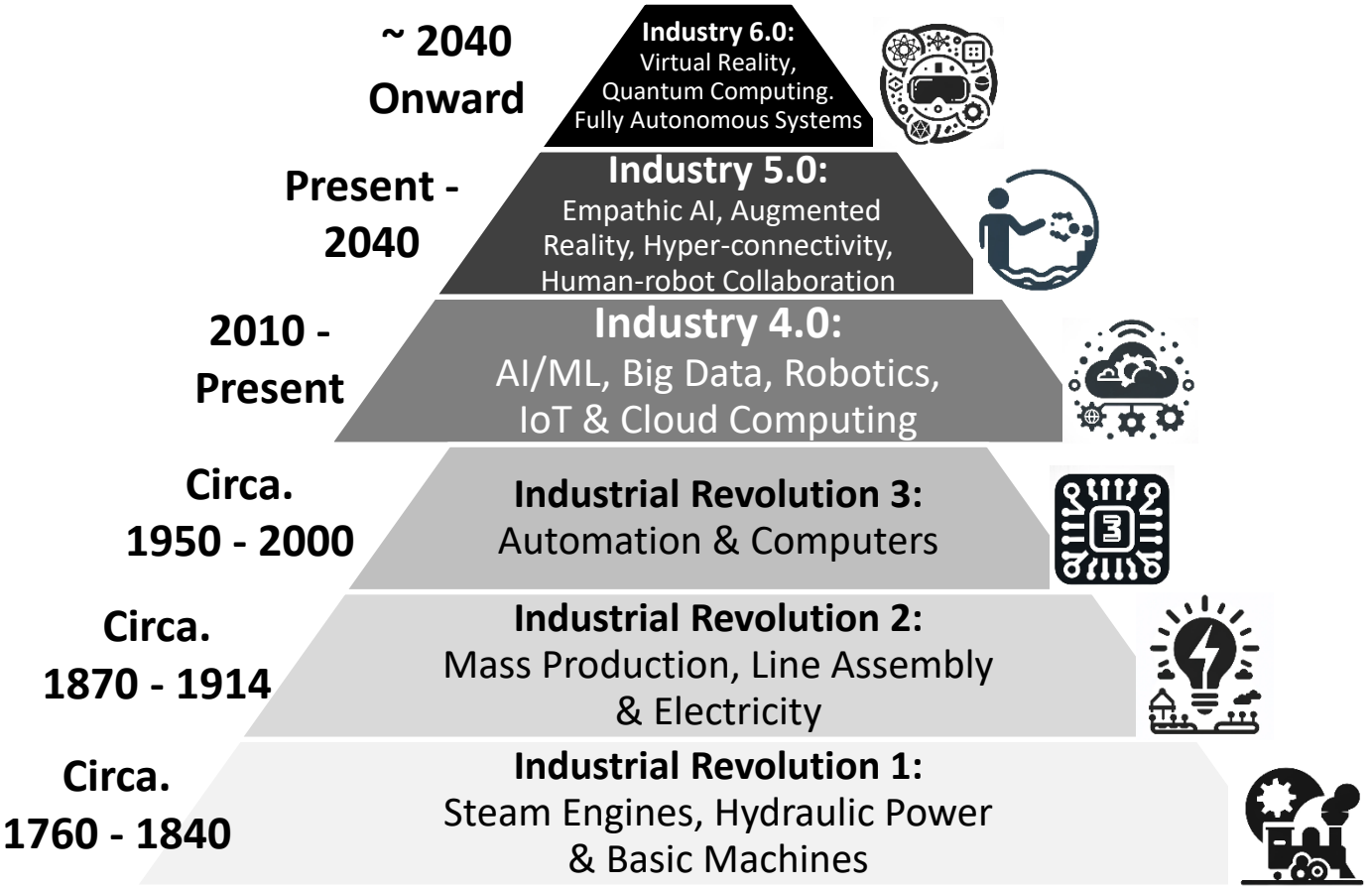
AI in the food industry: the next industrial revolution from farm to fork

Words by Drs Jordan Pennells, Peter Watkins, Danyang Ying and Kai Knoerzer

Industry 4.0 Concepts



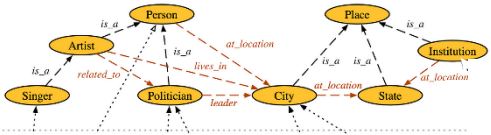
Industrial Revolutions



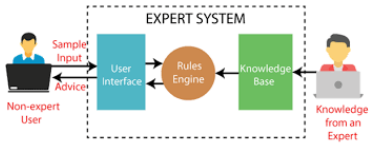
Artificial Intelligence Timeline

Artificial Intelligence (AI) is not a novel concept

Symbolic AI



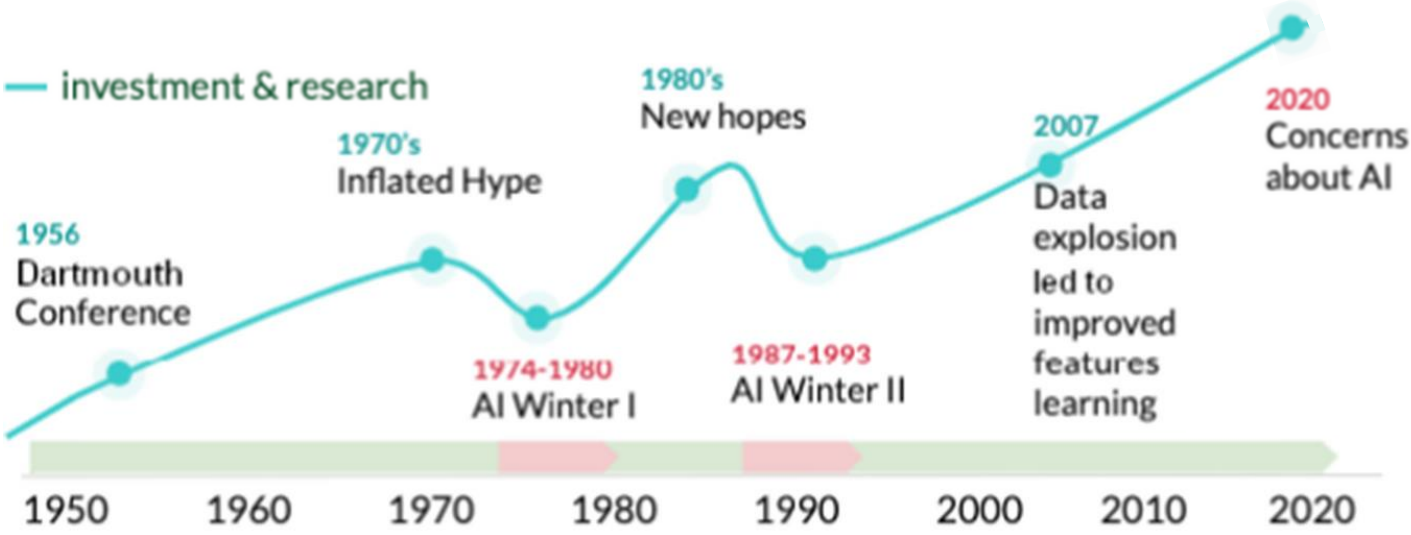
Expert Systems



Machine Learning

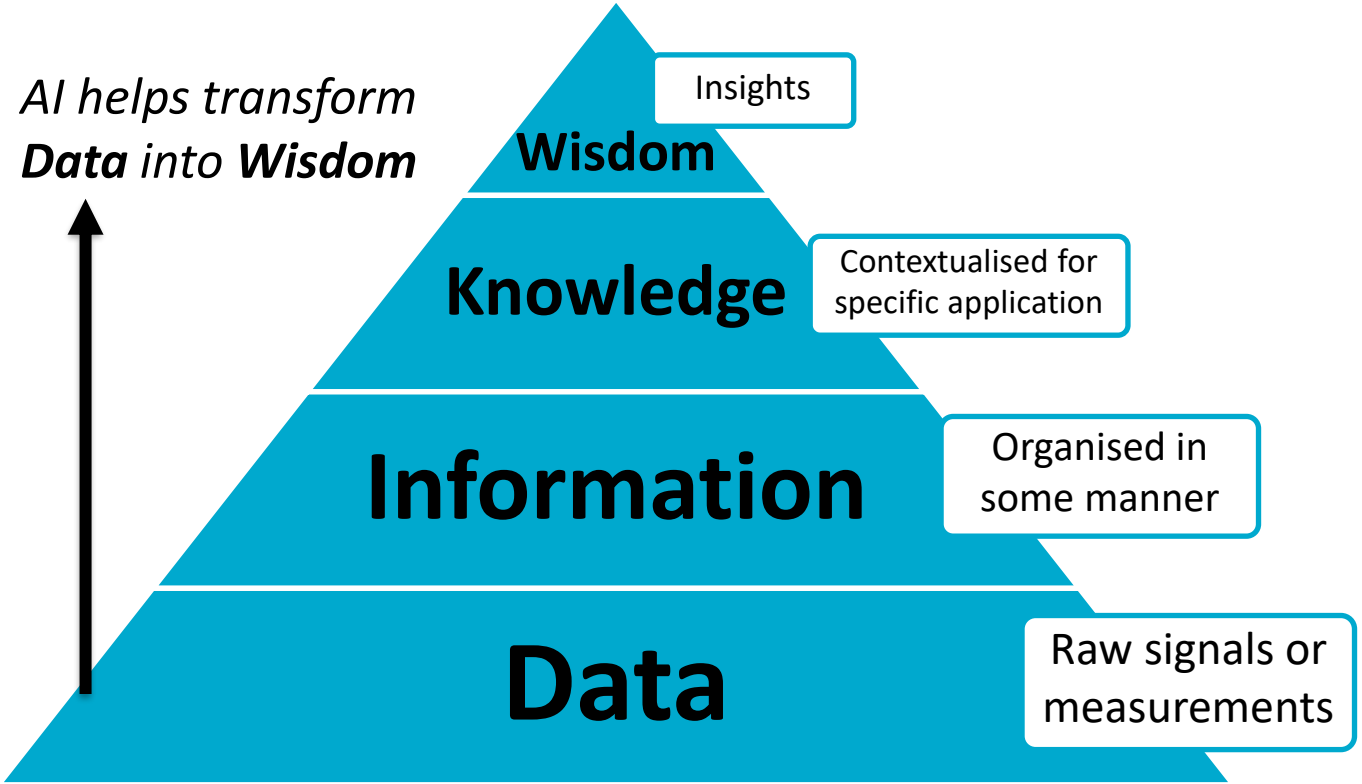
Generative AI

ChatGPT

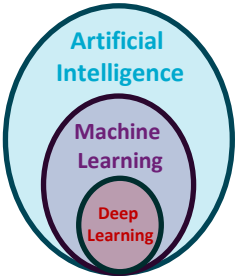


Source: Francesconi, E. The winter, the summer and the summer dream of artificial intelligence in law. *Artif Intell Law* (2022)

DIKW Model of Data Science



Definitions for AI Concepts



Data Science	The field of extracting knowledge and insights from structured and unstructured data using various techniques, including statistics, machine learning, and data mining
Artificial Intelligence	Algorithms that enable machines to analyse large amounts of data, identify patterns or relationships, and make predictions or decisions that would typically require human intelligence
Machine Learning	A subset of AI that focuses on the development of algorithms that enable computers to learn from and make predictions or decisions based on data
Deep Learning	A subset of machine learning that uses neural networks with many layers to learn complex patterns in large amounts of data
Data Mining	Analysing large datasets to discover meaningful patterns, trends, and relationships within the data
Pattern Recognition	A subset of data mining, to identify regularities and structures in data, often used in machine learning to classify or categorize data.
Fine-tuning	Adapting an existing model on a more specific dataset to improve its accuracy for a certain application

What is and isn't AI?

Is not AI:	Is AI:
Techniques with **well-defined** behaviour for a **specific** task based on **predefined** rules, **without adaptation** over time.	Techniques that enable machines to analyse large amounts of data, identify patterns & make predictions or decisions that typically require human **intelligence**.
Basic Automation (e.g. Automated Packaging Machines)	→ **Adaptive Automation** (e.g. Self-optimizing Production Lines)
Simple Rule-Based Systems (e.g. Conventional Process Control Systems)	→ **Intelligent Decision Systems** (e.g. AI-based Process Optimization)
Traditional Analysis (e.g. Direct Chemical Analysis)	→ **Predictive Analysis** (e.g. Spectral Imaging & Composition Prediction)
Barcode Scanning Systems (e.g. Inventory Management)	→ **Computer Vision Systems** (e.g. Object Recognition for Inventory Tracking)
Computational Modelling (e.g. Heat & Mass Transfer Modelling)	→ **AI Surrogate Modelling** (e.g. Accelerated Engineering Simulations)

Overview of Artificial Intelligence

Sub-Domains	Machine Learning, Deep Learning, Intelligent Robotics, Computer Vision, Expert Systems, Natural Language Processing, Image & Video Generation, Speech Recognition & Generation
Specific Techniques	Neural Networks, Genetic Algorithms, Random Forest Decision Trees, Reinforcement Learning, Support Vector Machines, Principal Component Analysis (PCA), Clustering Algorithms, Fuzzy Logic Systems
Abilities	Classification, Regression, Generation, Clustering, Dimensionality Reduction, Anomaly Detection, Sentiment Analysis

Abilities of Artificial Intelligence

Supervised Learning:

Uses *labelled data* that has already been classified for model training

Classification

Objective: Predict the category or class based on its features
Examples: Email spam detection, image recognition

Regression

Objective: Predict a continuous value based on input data
Examples: Predicting house prices, temperature forecasts

Sentiment Analysis

Objective: Determine the emotional sentiment in a piece of text
Examples: Analysing customer reviews, social media opinions

Unsupervised Learning:

Tries to find structure or patterns within *unlabelled data* for model training

Clustering

Objective: Group similar instances together based on their features
Examples: Customer segmentation, grouping similar documents, identifying patterns in sensor data.

Dimensionality Reduction

Objective: Reduce the number of features in the data while preserving important information
Examples: Principal Component Analysis (PCA) for data visualization, reducing noise in data, feature selection.

Anomaly Detection

Objective: Identify instances that deviate significantly
Examples: Fraud detection, predictive maintenance, product quality

Generation

Objective: Generate new data that resemble the training data
Examples: Generating realistic images, text, music, or code

AI in the Agrifood System – Farm to Fork

Supply Chain

- Traceability
- Supply chain optimisation
- Authentication

Farm Level

- Crop Yield Forecasting
- Precision Agriculture
- Crop & Livestock Monitoring
- Pest Detection
- Automation

Food Manufacturing

- Product Development
- Process Optimisation
- Process Monitoring
- Process Automation
- Quality Control & Safety
- Predictive Maintenance

Retailers

- Freshness Detection
- Demand Forecasting
- Insight Marketing
- Intelligent Packaging
- Automated Service

Consumers

- Sensory Prediction
- Trend Analysis
- Product Recommendation
- Personalised Nutrition

AI Opportunities for Food Manufacturing

R&D

Ingredient Identification

shiru

NotCo

CLIMAX FOODS

HOOW FOODS

Product Development

ATINARY
ENABLING SELF-DRIVING LABORATORIES

Sensory Prediction

gastrograph

Process Efficiency

Process Optimisation

GREENPROTEIN AI

Process Automation

Predictive Maintenance

AUGURY

Food System

Supply Chain Logistics

Helios

Quality & Safety

Food Quality

impact vision

Consumer Insights

Consumer Trends

SPOONSHOT®

Givaudan

aipalette

AI Opportunities for Food Manufacturing

Ingredient Identification

Shiru uses AI, bioinformatics, and precision biology to discover & produce high-value ingredients from functional **proteins found in nature**

HUNDREDS OF MILLION PROTEINS

01: Predict

Our discovery platform, Flourish, uses AI to identify proteins found in nature that are likely to meet desired performance characteristics.

HUNDREDS OF HUNDREDS OF PROTEINS

02: Produce

The selected proteins are then produced in host microoganisms for functional testing in the next phase. We leverage high throughput automated workflows to process hundreds of protein sequences at a time.

TENS OF PROTEINS TENS OF PROTEINS

03: Test

We validate the AI-selected proteins through proprietary high throughput-screening assays. We further validate the best-performing proteins by producing them in our pilot facility and testing in real world end-use applications.

SELECTED PROTEINS

04: Commercialize

We bring our discoveries to market by producing novel functional proteins, optimizing existing protein isolates for new applications, and leveraging our insights to support our partners and customers.

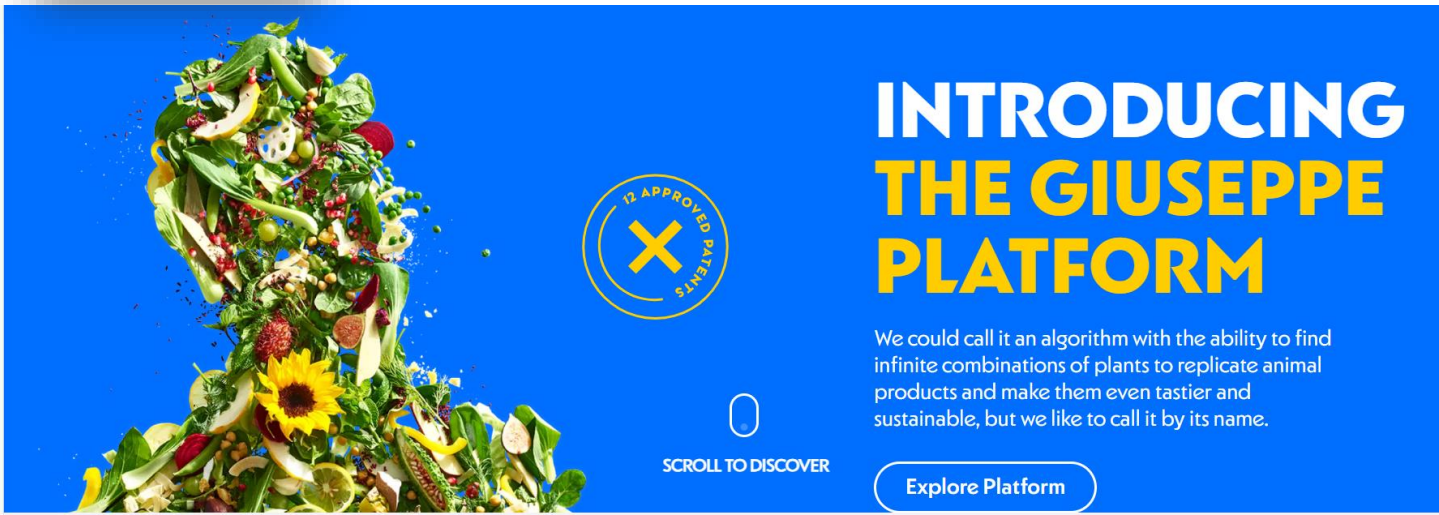
OleoPro™ platform

Shiru's technology leverages plant-based proteins to create unique protein scaffolds that structure liquid oils. This highly tunable protein technology allows oils to be used in new ways to deliver a range of previously impossible functionality for food and consumer products. The technology can structure an unsaturated, liquid oil, to create a high-performance structured fat that looks and acts like saturated animal fat (lard, tallow, etc.) or solid plant-based fat (coconut oil, palm oil, etc.) while reducing saturated fat by over 80%.

AI Case Studies for Food Manufacturing

Ingredient Identification | **Product Development**

NotCo (est. 2015, Chile) has their AI system – **Giuseppe** – explore the plant kingdom, accelerate research, and bring new plant-based products to market at record speed. Giuseppe is based on a proprietary dataset of 1000s of plant-based ingredients & animal product properties (i.e. physicochemical, molecular, nutrition).



AI Case Studies for Food Manufacturing

NotCo

Ingredient Identification

Product Development

GIUSEPPE DISCOVERY

Ingredient Recommendation

A vast database that includes detailed data and analytics of 1000s of plant-based ingredients and animal products, including nutritional, functional & compositional properties. The system helps scientists understand which ingredients will work best for developing new products, with data sourced from target products, ingredient manufacturers & website information.

GIUSEPPE TOOLBOX

Product Matching

An AI-assisted optimisation tool that helps chefs and scientists accelerate the development of formulations that mimic the characteristics of animal-based products, through matching the texture and functionality.

GIUSEPPE FLORA

Aroma Mapping

With over 30,000 molecules in its system, Flora maps aroma compounds from plants and animals to replicate the complex taste profiles of dairy or meat. Flora helped identify compunds in tomatoes, peaches & strawberries that helped develop the meat-like taste of their NotChicken product.

GIUSEPPE BIAGIO

Sensory Feedback

An interactive system for NotCo's Research Culinary team to provide feedback on their plant-based formulations. Chefs document their creations using NotCo's products & input sensorial reviews (i.e. taste, texture, aroma). The goal is to create a database of innovative recipes and continually improve their plant-based products through human-AI interaction.

AI Case Studies for Food Manufacturing

Ingredient Identification | **Product Development**

Climax Foods (est. 2019, USA) is a biotechnology company innovating alternative dairy products made from plants, with "precision formulation" and its AI platform (**Deep Plant Intelligence**) to optimise taste, smell, texture, nutrition & price.

"We use machine learning frameworks to find out at the molecular level what makes animal-based foods so craved and loved by mass consumers"

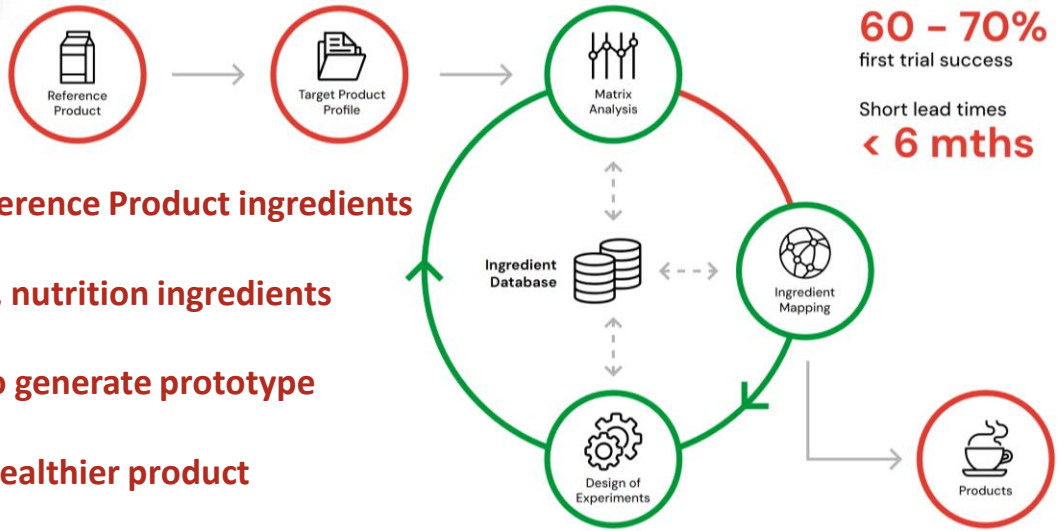
Their platform helped develop the world's first plant-based ingredient that mimics the functionality, flavour, texture, melt, and stretch of the dairy protein casein

AI Case Studies for Food Manufacturing

Ingredient Identification | **Product Development**

Hoow Foods (est. 2018, Singapore) is a food-technology company building a healthier world through food. Their AI-based **RE-GENESYS platform** aims to transforming familiar foods into healthier versions without sacrificing taste and texture, through identifying ingredients that can replace things like fat & sodium.

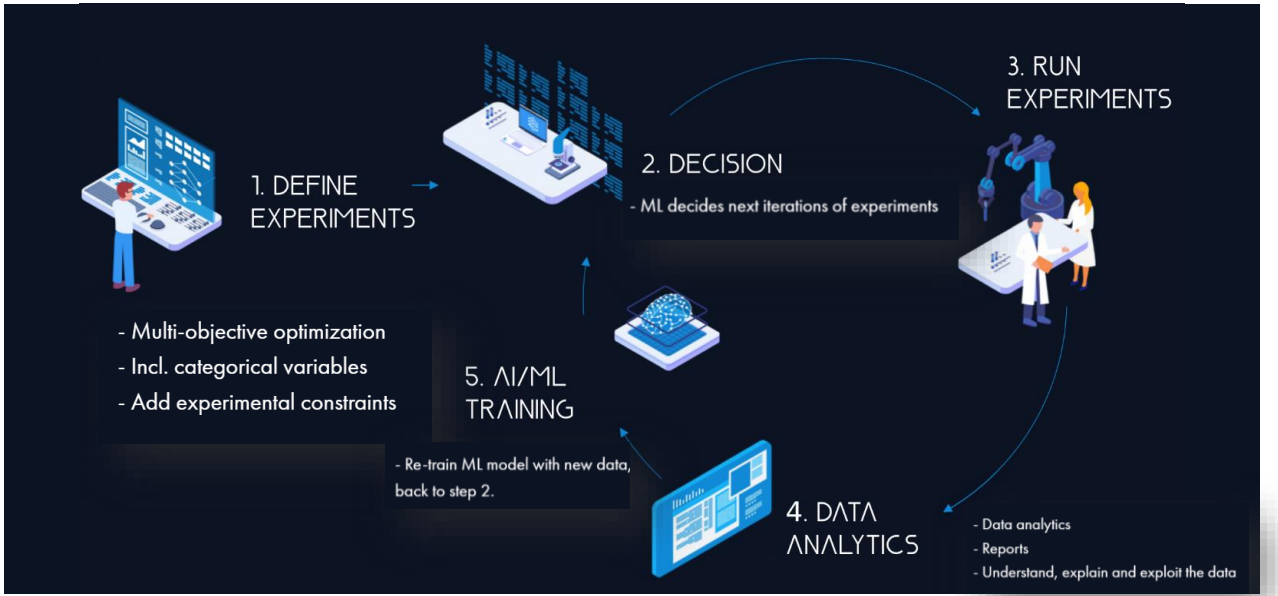
- **Breakdown of Reference Product ingredients**
- **Mapping of novel, nutrition ingredients**
- **Iterative testing to generate prototype**
- **Development of healthier product**



AI Case Studies for Food Manufacturing

Product Development

Atinary Technologies (est. 2019, Switzerland) is a deeptech startup providing no-code machine learning software as a service to accelerate R&D and discover novel molecules and materials across industries.



AI Case Studies for Food Manufacturing

Process Optimisation

GreenProtein AI (est. 2023, Israel) is an initiative led by Food System Innovations, focusing on leveraging advanced AI technology to optimize the extrusion process for plant-based meat production.

Companies in the plant-based meat sector are facing challenges related to fibrous texture optimization, mainly due to the high costs associated with extrusion R&D. These texture issues have hindered the mainstream adoption of plant-based meat

© FoodPlant

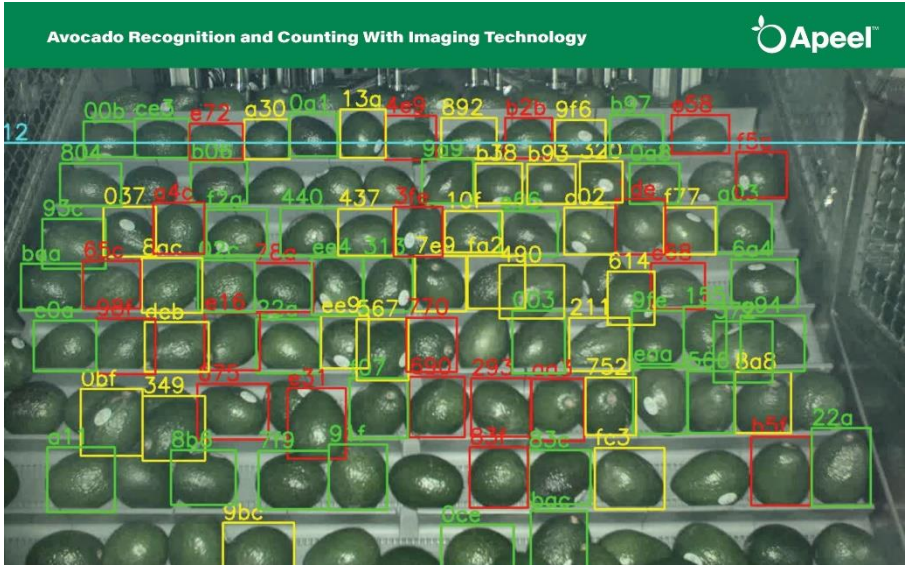
AI Case Studies for Food Manufacturing

Product Quality

ImpactVision (est. 2015, USA) is a machine learning company applying hyperspectral imaging technology to food supply chains to deliver consistent food quality, generate premium products and reduce supply chain waste.

Avocado Case Study:

ImpactVision's technology provides real-time insights into the quality of avocados. Dry matter content, which is a key indicator of ripeness and quality, can be assessed rapidly & non-invasively. This helps fight food waste, enhances avocado consistency & improves supply chain logistics



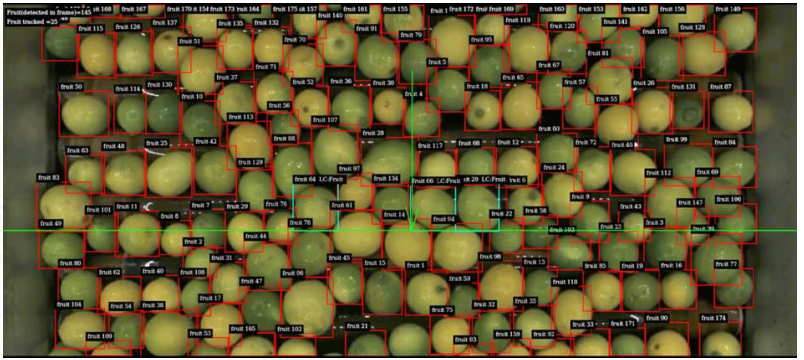
ImpactVision was acquired in 2021 by the food waste tech company Apeel Sciences

AI Case Studies for Food Manufacturing

Process Automation

TOMRA (est. 1972, Norway) design and manufacture sensor-based sorting machines for the food industry, using the world's most advanced grading, sorting, peeling, and analytical technology.
TOMRA Food has been utilizing artificial intelligence since 2019 to make sorting and grading solutions more accurate than traditional techniques.

The Spectrim X equipment can assess thousands of high-resolution, multi-channel fruit images every second.



AI Case Studies for Food Manufacturing

Predictive Maintenance

Augury (est. 2011, USA) is an AI-driven machine health solution provider, using machine learning to analyse the entire production process and look for anomalies that could indicate problems.

Data Monitoring:

- Vibration patterns
- Temperature fluctuations
- Magnetic field changes

Benefits:

- Optimised asset care
- Maximised yield & capacity
- Reduced unplanned downtime

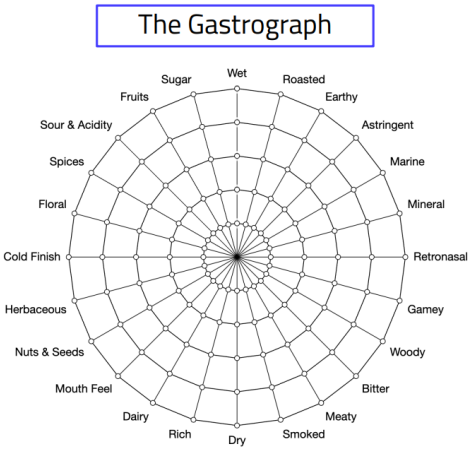
AI Case Studies for Food Manufacturing

Sensory Prediction

Gastrograph (est. 2011, USA) is an AI platform using the world's largest sensory database to gain insight into food and beverage products.

"By aggregating large data sets on consumers, products, and preferences, AI systems can predict the outcomes of consumer studies ***without the need to run sensory tests****"*

- ☑ Market Leader in Predictive Sensory Perception of Flavour, Aroma & Texture
- ☑ Across various demographics (Age, Race, Gender, Socio-Economic)
- ☑ 12,000+ Consumer Products Profiled
- ☑ 38 Countries/Regions in Sensory Dataset
- ☑ 1.5 Billion+ Distinct Demographic Data Points



AI Case Studies for Food Manufacturing

ai palette

Consumer Trend Analysis

AI Palette *(est. 2018, Singapore) is a platform using AI to help food and beverage companies create products that consumers love.*

1. Foresight Engine
Identify unmet consumer needs and emerging trends by analysing 61 billion data points from social media, online recipes & e-commerce platforms.

2. Concept Genie
Generate new product concepts based on insights from the Foresight Engine.

3. Screen Winner
Virtually validate new products generated by Concept Genie to determine their viability in a particular category or market.

Predictive Analytics

Computer Vision

NLP

Generative AI

Reinforcement Learning

AI Case Studies for Food Manufacturing

Trend Analysis

SPOONSHOT®

(Est. 2015, USA) Delivering food & beverage intelligence by leveraging AI and food science to reveal emerging consumer & market needs

Trend Watch:
Discover trends, receive data-backed insights & make confident decisions.

Concept Generator:
Explore food pairings to create food concepts with a single click.

F&B Explorer:
Understand the current market landscape to develop well informed, data-driven product strategies.

Make high-confidence decisions by leveraging our AI #foodbrain

aipalette

(Est. 2018, Singapore) A platform using AI to help food and beverage companies create products that consumers love

Foresight Engine:
Identify unmet consumer needs and emerging trends by analysing data from social media, online recipes & e-commerce platforms.

Concept Genie:
Create new product concepts based on insights from Foresight Engine.

Screen Winner:
Virtually validate new products generated by Concept Genie to determine their viability in a particular category or market.

Givaudan

(Est. 1895, Switzerland) A multinational manufacturer of flavours, fragrances & active cosmetics

Customer Foresight:
A 'futurescaping' platform leveraging Givaudan's human expertise, big data and AI to anticipate tomorrow's challenges, foresee consumer expectations, and create winning food experiences.

AI Case Studies for Food Manufacturing

Supply Chain Optimisation

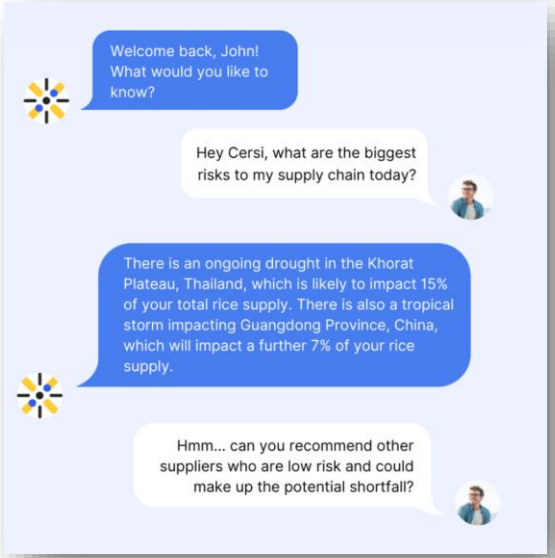
Helios (est. 2023, USA) is a software company predicting agricultural supply chain disruptions through collecting data on climate, economic, and political risks affecting suppliers. Their **AI-powered supply chain analyst** (Cersi) provides live alerts & insights in real time via a ChatGPT-style interface.

Data Sources:

- Historical weather trends
- Commodity economic indicators
- Political signals

What they track:

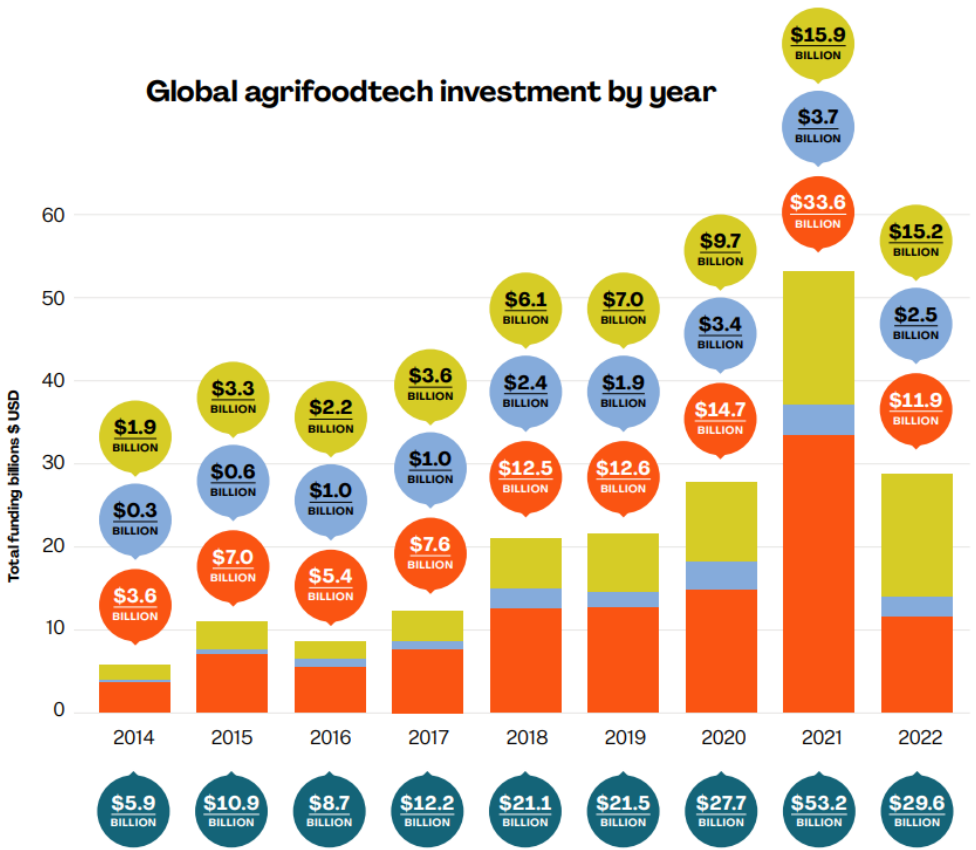
- Climate risks
- Economic risks
- Force majeure events



Challenges for AI in the Food Industry

- ‘Big data’ volume, accessibility & quality
- Integration with existing data systems
- Linking manufacturing data to properties to product quality
- Availability of technical expertise
- Initial cost of investment (i.e. smart sensors, data software)
- Reliability, explainability & trust of AI systems
- Ethical & security considerations

Where is AgFoodTech investment going?



Upstream:
- Ag Biotech
- Novel Farming Systems
- Bioenergy & Biomaterials

Midstream:
- Food Processing
- Quality Control & Safety
- Logistics & Supply Chain

Downstream:
- Retail & Distribution
- Consumer-facing Technologies

Source: *AgFunder Global AgriFoodTech Investment Report 2023*

AI Strategy & Roadmap – CSIRO Food Program

- AI Strategy & Roadmap developed for CSIRO Food Program
- Aim to build internal capabilities & support food industry
- Internal consult to identify ‘low hanging fruit’ for AI
- Industry consult planned for July 2024 onwards

AI Core Team

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Principal Research Engineer

Dr Jordan Pennells
Postdoctoral Researcher

Dr Peter Watkins
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Thank you!

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