Indoor Cultivation for the Future

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(Presented by Chieri Kubota, The University of Arizona)
Background in Japan

• Issues:
  – Increasing pressure to change the structure of Japanese agriculture and food production
  – Public concerns over nutrition and food safety

• Trends:
  – Increasing interest in plant factories in Japan

• Advantages:
  – Strong support from local and federal governments
  – Consumer’s appreciation of high technology in agriculture
Hardware and Software Needs for Indoor Cultivation

Hardware

• Affordable systems for various scales of production

Software

• High quality and nutritional produce
• Manuals -- Suitable for beginners
Indoor Cultivation
Vertically Integrated Business Models

System Design & Manufacturing
Production & Consultation
Marketing, Distribution & Service

Technology service
Innovative applications
Key Technologies (Hardware)

- **Production capacity (examples)**
  - 300 lettuce heads /day (60 m² or 650 ft² footprint)
  - 10,000 lettuce heads /day (1200 m² or 0.3 acre)

- **Hydroponic (NFT) system**
  - Nutrient circulation
  - EC/pH control

- **Environmental control**
  - Thermostat-based temperature control
  - CO₂ control
  - Fluorescent lamps and/or LEDs

- **Hygiene**
  - Air cleaning (filtering) system, lab suit
  - Air shower for workers before entering
  - Water shower prior to access for complete removal of pathogens in large scale facilities
Typical Production Schedule (Lettuce)

Seeding & high density production

Transplanting

Harvesting

Transplanting

fresh weight (g)
Competitive advantages

- Food safety
- Traceability
- Little waste
- Standardized quality
- Year-round availability

Lettuce produced in GreenRoom™
- 97-98% harvestable aerial biomass
- Waste 2-3 % of biomass

Conventional lettuce head
- 60-70% harvestable aerial biomass
- Waste 30-40% of biomass (outer leaves and center cores)
Technologies (Software)

Growing manuals for 40 different leafy crops/herbs.
Opportunities - Designing Flavor

\[ \text{Flavor} = f (\text{Genotype, Environment, Human Perception}) \]
Applications

14 plant factories in 10 prefectures

Hokkaido
Okinawa
Yamagata
Kyoto
Tokyo
Chiba
Kanagawa
Kochi
Mie
Shizuoka

Prefectures:
- Hokkaido
- Okinawa
- Yamagata
- Kyoto
- Tokyo
- Chiba
- Kanagawa
- Kochi
- Mie
- Shizuoka
Applications – Retail + Indoor Cultivation

• Renovating existing buildings in urban/suburban areas
• Integration of production system inside the retail stores (zero transportation).
• Urban “roadside stand”
Applications – Restaurant + Indoor Cultivation

• A large restaurant chain with ~200 locations in Japan
• ~6 tons of Mizuna leaves are produced for 100 of their chain restaurants in Japan
Applications – Restaurant + Indoor Cultivation

- A large pizza restaurant chain with ~59 locations in Japan
- Indoor production for romaine lettuces for their salads
Unique Applications - Responses to 3/11 Disasters

• Collaboration with GE Japan to build an indoor cultivation farm in Miyagi, Japan.

• Kids veggie farms (school projects to support STEM education and lunch programs) in Fukushima, Japan.
Unique Applications – Extreme Climate + Indoor Cultivation

- South Pole Showa Station
- ~3 m² mini system built in 2008 to supply fresh vegetables
- Online consulting
Unique Applications – Shopping Mall + Indoor Cultivation

- LaLaPort Shopping Mall, Kashiwanoha, Japan
- A 6.6 m² (71 sq ft) for demonstrating production of lettuce and herbs
Industry-Academia Collaborations

• Plant Factory Consortium funded by Ministry of Agriculture, Forestry and Fisheries (MAFF)
• Consortium members
  Mirai (Leader)
  Chiba University (Organizer)
  Iwatani (CO₂, Pest management)
  Kajima Construction
    (Architectural design)
  Showa Denko (LED)
  Panasonic (Fluorescent light)
  Marubeni (Marketing)
  Toyo Valve (Nutrient sterilization)

MAFF Demonstration Plant
Community Application

• Regional community social network for micro gardeners
  A collaboration with Chiba University, Panasonic, and Mitsui-Fudosan (urban developer)
Kashiwanoha community networking pilot project

University research park

Consulting and supplying materials/recipes

MIRAI garden website/SNS

MIRAI garden

Kashiwa City

Kashiwanoha district

Community user group

Shopping mall veggie garden (transplant supply)
### Economic analysis of indoor lettuce production

<table>
<thead>
<tr>
<th>Items</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building size (modular building)</td>
<td>1,300 m² (14,000 ft²) footprint (1,100 m² or 12,000 ft² footprint for 4,536 m² production area)</td>
</tr>
<tr>
<td>Crop</td>
<td>Leafy lettuce (10,080 heads per day, 100 g per head)</td>
</tr>
<tr>
<td>Nutrient delivery and lighting systems</td>
<td>NFT</td>
</tr>
<tr>
<td></td>
<td>Combination of LEDs and white fluorescent lamps</td>
</tr>
<tr>
<td>Other facilities</td>
<td>Office space, packing area, storage, cold storage (200 m²)</td>
</tr>
<tr>
<td>Other equipment</td>
<td>Cooling/heating, seedling production systems, irrigation tanks and injection systems, climate controller etc.</td>
</tr>
<tr>
<td>Equipment/facility life</td>
<td>Production systems for 7 years; 15 years for other equipment; 20 years for the building</td>
</tr>
</tbody>
</table>

### Balance estimate

<table>
<thead>
<tr>
<th>Items</th>
<th>Income/Expense</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual gross sales</td>
<td>~$4.1 M (331M Yen)</td>
<td>~$5.68/lb (10% product loss)</td>
</tr>
<tr>
<td>Annual costs (total)</td>
<td>~$3.4 M (274M Yen)</td>
<td>~$4.70/lb</td>
</tr>
<tr>
<td>Investment return</td>
<td></td>
<td>6th year</td>
</tr>
</tbody>
</table>

1 lb = 0.45 kg
### Capital costs: 7.4 million US dollars (590M Yen)

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<th>Items</th>
<th>Costs</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building</td>
<td>180M Yen (31%)</td>
<td>New construction</td>
</tr>
<tr>
<td>Construction</td>
<td>110M Yen (19%)</td>
<td>Utility set up</td>
</tr>
<tr>
<td>Equipment and facilities</td>
<td>300M Yen (51%)</td>
<td>NFT systems, irrigation systems, lighting systems, others</td>
</tr>
</tbody>
</table>

### Annual operation costs: 3.4 million US dollars (274M Yen)

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<th>Items</th>
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<tr>
<td>Salaries and wages</td>
<td>71.3M Yen (26%)</td>
<td>Two full time workers + hourly laborers (210 h/day, $10/h)</td>
</tr>
<tr>
<td>Materials</td>
<td>15.4M Yen (6%)</td>
<td>Packing materials, seeds, light bulbs, fertilizers, chemicals, etc.</td>
</tr>
<tr>
<td>Utilities</td>
<td>72.6M Yen (26%)</td>
<td>369MW/month power use + water use</td>
</tr>
<tr>
<td>Transportation and shipping</td>
<td>6.0M Yen (2%)</td>
<td></td>
</tr>
<tr>
<td>Other costs</td>
<td>49.2 M Yen (18%)</td>
<td>Facility/equipment maintenance, consulting</td>
</tr>
<tr>
<td>Depreciation</td>
<td>59.2 M Yen (22%)</td>
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VF Challenges – Our Experiences

• It is all about having the **right kind of people with experience and training** in the production operation
  – “*Just like successful wineries and sake makers need excellent viticulturists and sake masters*”

• Indoor cultivation will never be the same as ‘industrial factory manufacturing’ and needs a **non-linear approach** by understanding the nature of biology and agricultural business
Questions?