JUBE

BIO-INSPIRED SOLUTION FOR EDIBLE INSECTS CONSUMPTION

BIOMIMICRY GLOBAL DESIGN CHALLENGE

BiOX

www.BioX.tech

By BioX team, Thailand

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Introduction

2 billion
people globally are suffering from malnutrition.

388,600
Thai people are not getting enough nutrition.

The amount of population in the world is increasing, especially in low- and middle-income countries, causing the demand for food to soar up. The fact that land for cultivation is reducing, and the continuation of unpredictable climate and water supplies stretched to the limit, one of the realistic options is to find a new source for food that is barely depend on those factors. Edible insects is one of the answer for global food crisis due to the high protein level and rich in essential micronutrients, such as iron and zinc. Insects also don't need as much space as livestock, emit lower levels of greenhouse gases, and have an extremely high feed conversion rate. The team develops Jube, a bio-inspired device for capturing edible insects, the food of the future. Jube appears like a pitcher plant, and its trapping mechanism is akin to a lobster-pot trap (a carnivorous plant). After putting insect food, such as the leftover food, inside the chamber, the wickerwork fabric allows the wind flow through and spread the food odor to the surrounding environment. Insects smell the food and enter the chamber. From then on, the insects are trapped. Until now, Jube has been tested in both laboratory and field testing which yield an exceptional results toward capturing insects.

2,000
species of insects around the world are edible insects

– FAO –

Only 1 kilogram of cricket has protein 12 times more than beef protein

– Anthes –

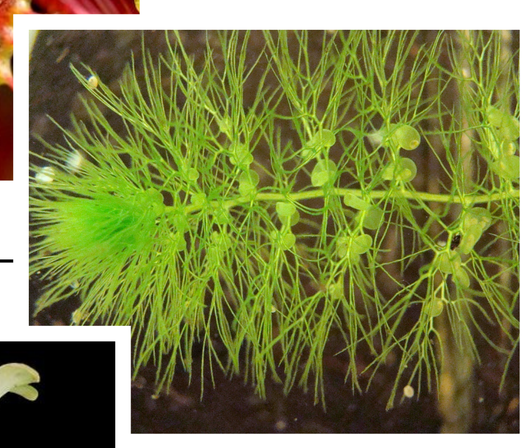
INSPIRATION & DESIGN

Carnivorous plant is known for their unique ways to gather nutrients. They lure small insects to come into their trap and then digest that prey into nutrients. This kind of plants are usually found in nutrient-starved area or acidic soil. The traps can be classified into 5 main groups due to their mechanisms.

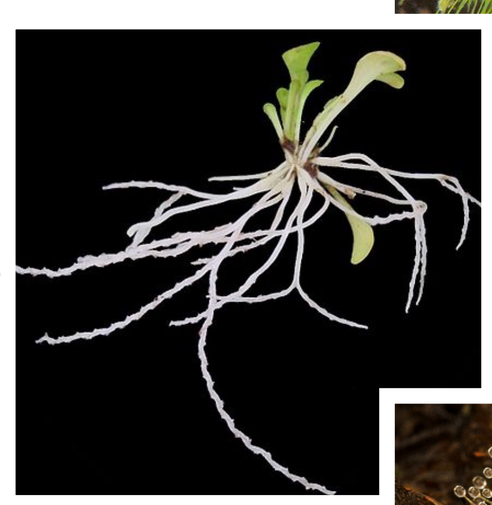
The first carnivory structure is "**Pitfall trap**" which is a pit with lubricant on top. It attracts prey through visual and chemical signals, and kill the prey through an enzymes of symbiotic bacteria in its pitfall trap. The example of this kind is *Heliamphora*.

The second kind is "**flypaper trap**". The structure is like a stick covered by sticky mucilage. This structure is found to be an extremely effective trap for small flying insects. The example of this kind is *Pinguicula gigantea*.

"**Snap trap**" is a jaw - liked carnivory structure which actually are leaves whose terminal section is divided into two lobes. Inside the jaw, there are needles that would let the jaw close due to the open of stretch-gated ion channels when the insect step in. The prey will slowly digested afterward. The example of this kind is Venus flytrap.



"**Bladder traps**" is a kind of trap that sucked its prey into the bladder by generating a partial vacuum inside by osmosis due to ion pumping in the interior cell. The example of this kind is *Utricularia vulgaris*.

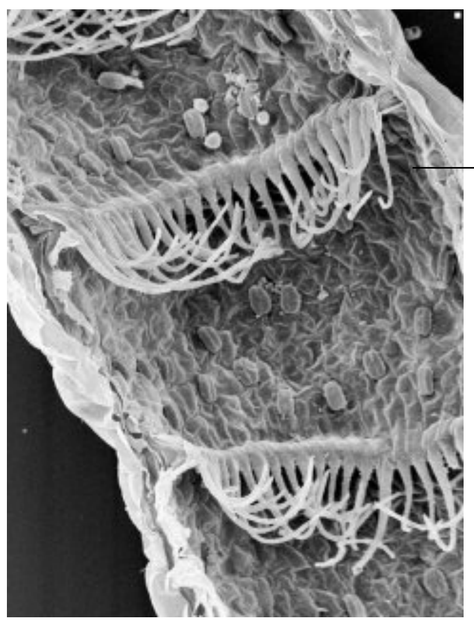


"**lobster-pot trap**" is a Y-shaped modified leaf chamber that is easy to get in, but it is either difficult to find or obstructed by inward-pointing hair, which force the prey to move in a particular direction. The stomach of the plant is in the lower arm of the Y, where the insects are digested. The example of this kind is *Genlisea violacea*.

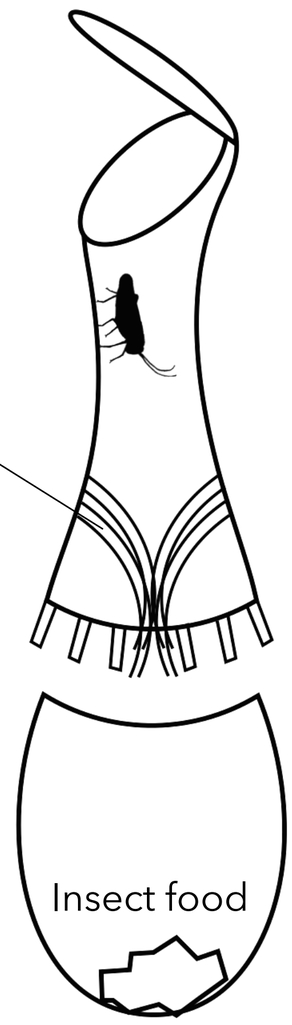
"**Combination traps**" combines flypaper and snap traps together. This mechanism is found in sundew *Drosera glanduligera*.

After analyzing each carnivorous plant's strategies, we are interested in mimicking **lobster-pot trap** for the trapping mechanism because this tactics is one of the two that utilized the physical structure instead of using secretion liquid to capture the insects. The other strategy that we didn't use is the **Snap trap**, found in the venus flytrap. We didn't mimic it because of the essential cellular mechanism behind the snap trap is in the micro - scale, which would not be compatible to fabricate in the area that even the food is lack.

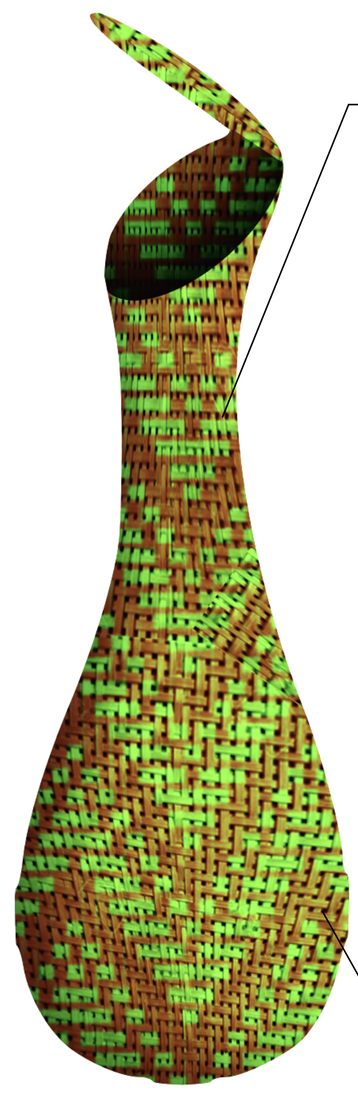
The microscopic structure of the **lobster-pot trap**



To mimic the **lobster-pot trap**, we designed the structure of hair pointing inward, which would prevent the insects that step in to turn back, by using dry rattan (a very cheap material that can be found in Thailand). In other area, the local material that is thin and flexible can be used to replace the rattan.



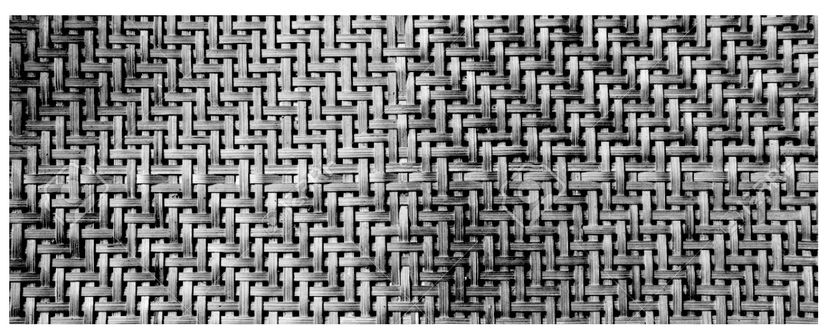
Outline

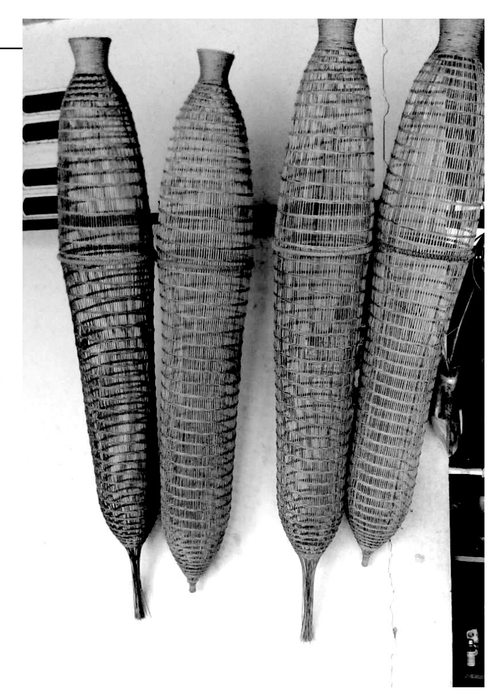


Realistic rendered

Pitcher plant

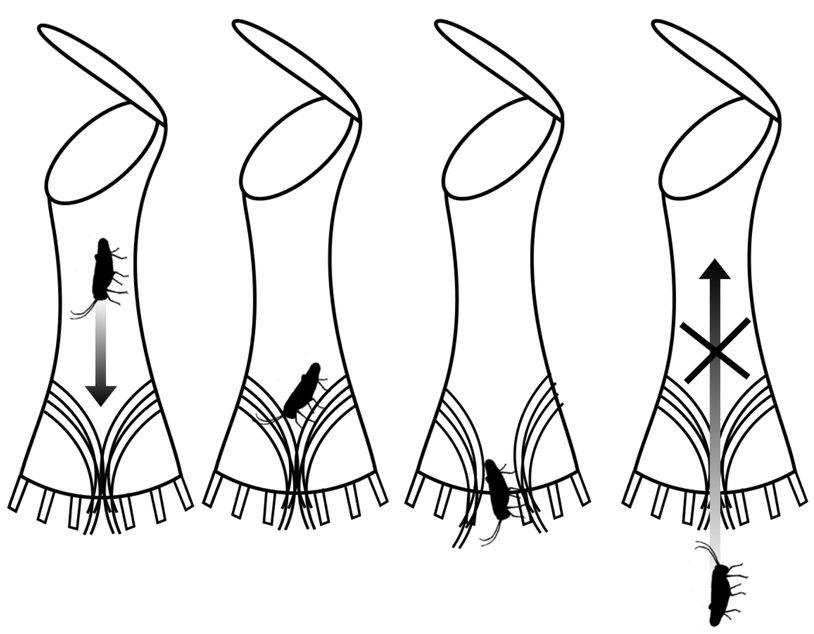
We also mimic the shape of the device from the pitcher plant due to its fascinating shape. We as a team are really concerned about creating a product that is **friendly with the user**. One of the most important feature from the plant that we can mimic is its natural shape. By doing that people would easily adopt our product because of the organic and natural liked feeling from the design.





To make this product affordable, we are inspired by the traditional weaving technique of Thai people. This method were used by folk people to produce baskets and fishery tools. **The w used for this method is dry rattan, which is very cheap, strong, and sustainable.**

Jube, a bio-inspired chamber for capturing edible insects, the food source of the future. The trapping mechanism is the result of the Genlisea violacea's lobster-pot trap biomimicry. In order to mimic the lobster-pot trap, the team designed the structure of hair pointing inward, which would prevent the insects that step into Jube to turn backward. The overall look of Jube is like a pitcher plant, which is the intention of the designers to mimic the fascinating shape of nature in order to make Jube more like a plant and less like a machine which can be alienated for general people. To use Jube, the user need to put some insect food into the bottom part of Jube to lure the insects. The wickerwork structure of Jube would spread the food odor to surrounding environment. Once the insects follow the odor and step into Jube, they would not be able to turn back due to the structure of hair pointing inward.



Jube's method to capture the insects is the result of *Genlisea violacea's* lobster-pot trap biomimicry.

BUSINESS MODEL

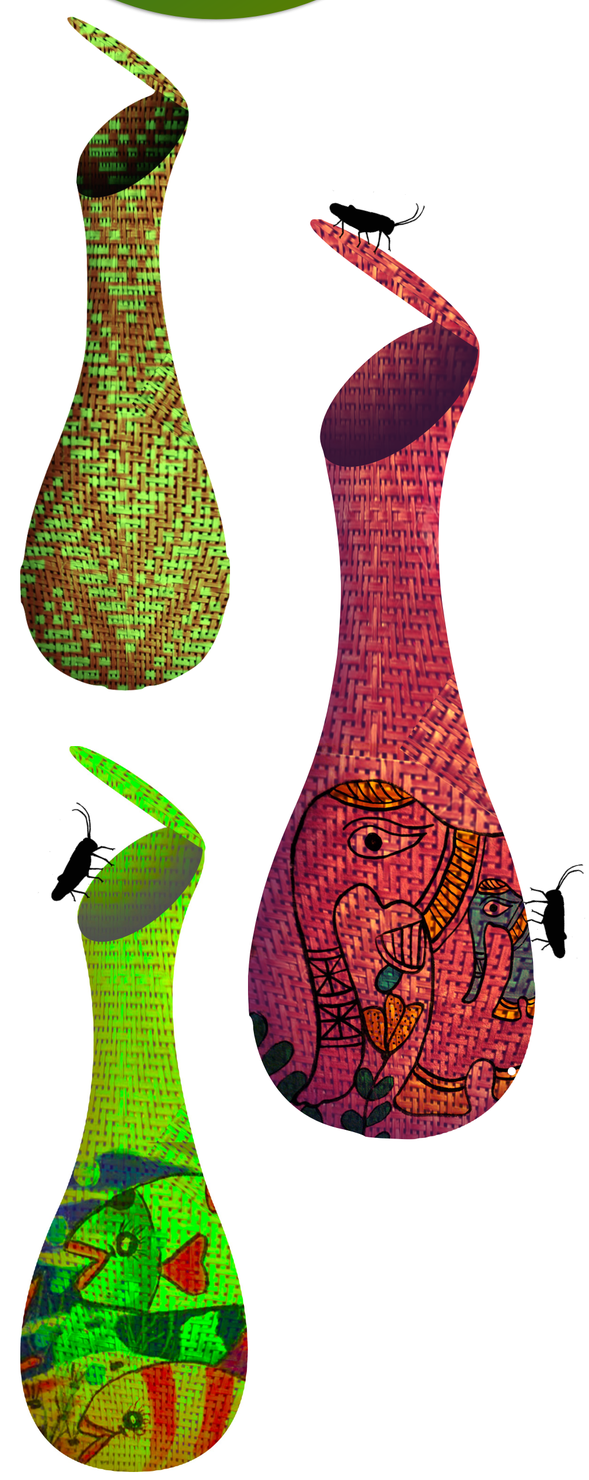
Our business is a social enterprise. Therefore, our business model comprises of education and commercialization. First, we design a program to teach undernourished people to attract insects by creating the device. We believe that the community must be able to sustained themselves first. After that we will encourage community members to paint and decorate Jube in their own cultural styles.

After engaging with potential customers, we realized that we can sell Jube as a piece of arts and crafts. We have validated our model by interviewing peoples and found that there is a demand for this product for it's functionality and unique design.
We also found that Jube can help farmers in agricultural production due to the fact that Jube can reduce population of grasshopper and other crop destroyer insects by converting them into consumable protein source.

Therefore, our early adopters are

- People that value Jube as an art piece.
- Farmers/ Agricultural producer
- People that consume edible insects

60% of revenue from selling Jube will go back to the community that created them, and 40% will come back to the organization for further research and development. The team has a strong connection with NSTDA (National Science and Technology Development Agency of Thailand) and research universities in Southeast Asia which can help promote this product nationally and internationally.



Jube Lean Canvas

Problem

Current
- Failed harvests cause by the extreme weather
- By 2050, double Asia's demand for food
- land for cultivation is decreasing
- X% of people are starving for protein
- Some insects like locust are problematics for agricultural areas.

Future
- The price of livestocks will increase more.

Existing Alternative

For locus
- Trap crop
- Physical barriers and traps
- Biological controls
- Hopper Whopper

Food crisis
- Edible insects
  - Insect farming (large scale)
  - LEPSIS (personal farm)
- Many solutions

Solution

- A device that proactively help catch edible insects.
- Reduce insects that destroy agricultural products.

Key Metrics

number of insects captured by the device on average

number of people that use the device

#Understand market sale for raw insects

Unique Value Proposition

- Convert insects that destroy agricultural products into edible food
- Proactiv solution
- Require minimum setup + maintenance
- Beautiful design
- Cost for producing one insect (cricket flour can easily induce sticker shock, costing between $20 and $40)

High Level Concepts

- A device that proactively help catch edible insects

Unfair Advantages

- Simple design which is easy to adapt for different situations
- Recyclable materials
- Human friendly design
- Connection with research universities

Channels

- Networking/ connections
- Cold contacts
- Conference
  - Industry
  - Academic

Customer Segments

Partner
- Edible insect manufacturing company such as Malangtod Hiso

Customers
- Edible insect manufacturing company (Challenge)
- Farmers
- Individual that want to catch insects for themselves.

Early Adopters

- Farmers
- Individual that want to catch insects for themselves.

Cost structure

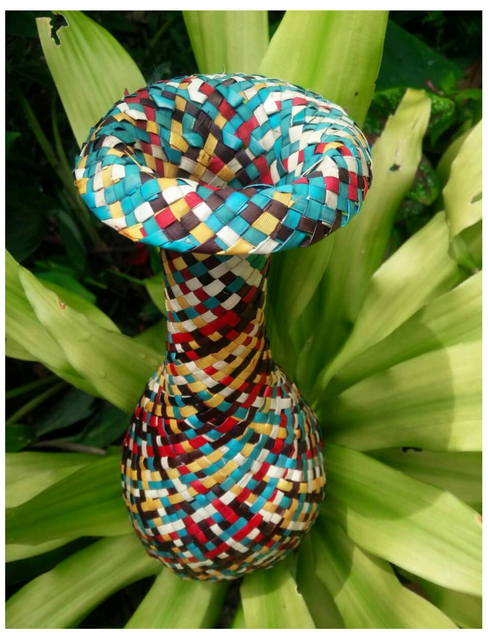
Valuable
- Material for producing the device
- The method of creating the device

Revenue streams

- Selling insects to edible insect manufacturing company (Challenge)
- Selling device as a sculpture + art works
- Selling device to farmers, Individual that want to catch insects for themselves.
- Selling insects as a product.

MAJOR MILESTONES

- We have developed a working prototype of Jube by collaborating with local communities in the south of Thailand. We have learned many valuable knowledge working with them.



- We have 2 intellectual properties; one patent is filed (ID : 1601005808) and one is in process.
- We have ongoing research & evaluation of Jube in both open environment and lab setting. We realized that some of the baits we used worked better than one another.
- We have evaluated the life span and physical properties of the prototype.
- We have connected with Dr. Yupa Hanboonsong professor of entomology, who is affiliated with UN Food and Agriculture Organization.
- We have developed a relationship with one of the largest edible insects company, Malangtod Hiso, in Thailand for knowledge exchange.
- We develop a partnership with Prince of Songkla University International College to form Biomimicry Thailand, a community for people that are interested in biomimicry.

Business Model for Sustainability

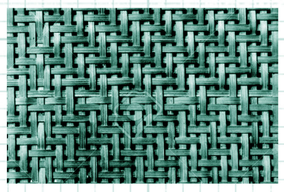
All of the team members have a passion in making this world a better place, so we only care about business just to make sure that the thing that we created is sustainable. The first step in our execution plan is to teach the undernourished people to capture the insects by creating the device. After that we will encourage the those people to paint and decorate Jube in their own style. By doing that we will promote the product (Jube) from that group of undernourishment people as a piece of art and craft that can also help create a sustainable life to other people. The money from selling Jube will go back to the person that created it, so that they can use it to improve their quality of life. The team has a strong connection with NSTDA (National Science and Technology Development Agency of Thailand), and Ministry of education of Thailand, which can help promoting this project nationally and internationally.

Distribution and Installation

As mentioned earlier, the team is targeting people that are suffering from malnutrition and also people that are not.
For the person that are suffering from malnutrition, we will teach them how to build Jube by using local materials, so that they can have a device that can help them get more nutrients. After that we will gather people in the area that are interested in working with us to create Jube for selling out to the people who are not malnourished. For those people, we are purposing them a sustainable way of dining by selling a sophisticated insects capturing device that is unique and beautifully crafted in order to promote edible insects consuming.

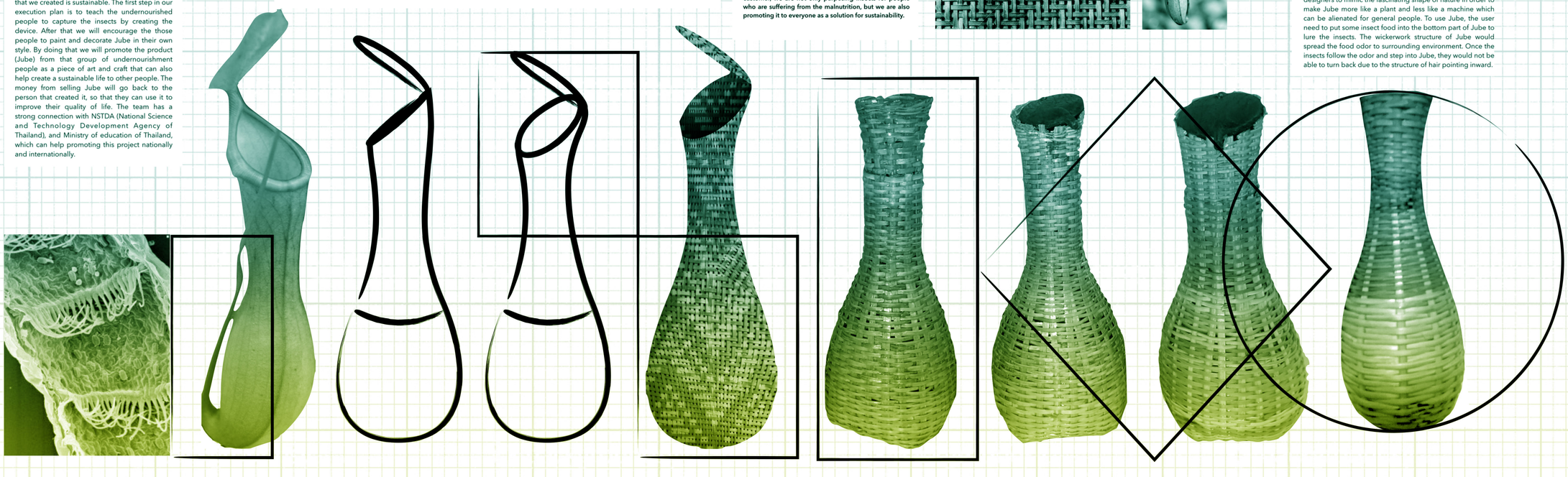
Scope of the project

Edible insects are one of the answer to global food crisis. However each region of the world are uniques, there are diversities in insect species, dining culture, geography, and other parameters that are specific to each area, so the team decided to use Thailand (our home) as the primary target, and provide option for further adaptation to other part of the world. For the customer, **we are not only purposing insects for people who are suffering from the malnutrition, but we are also promoting it to everyone as a solution for sustainability.**



Product overview

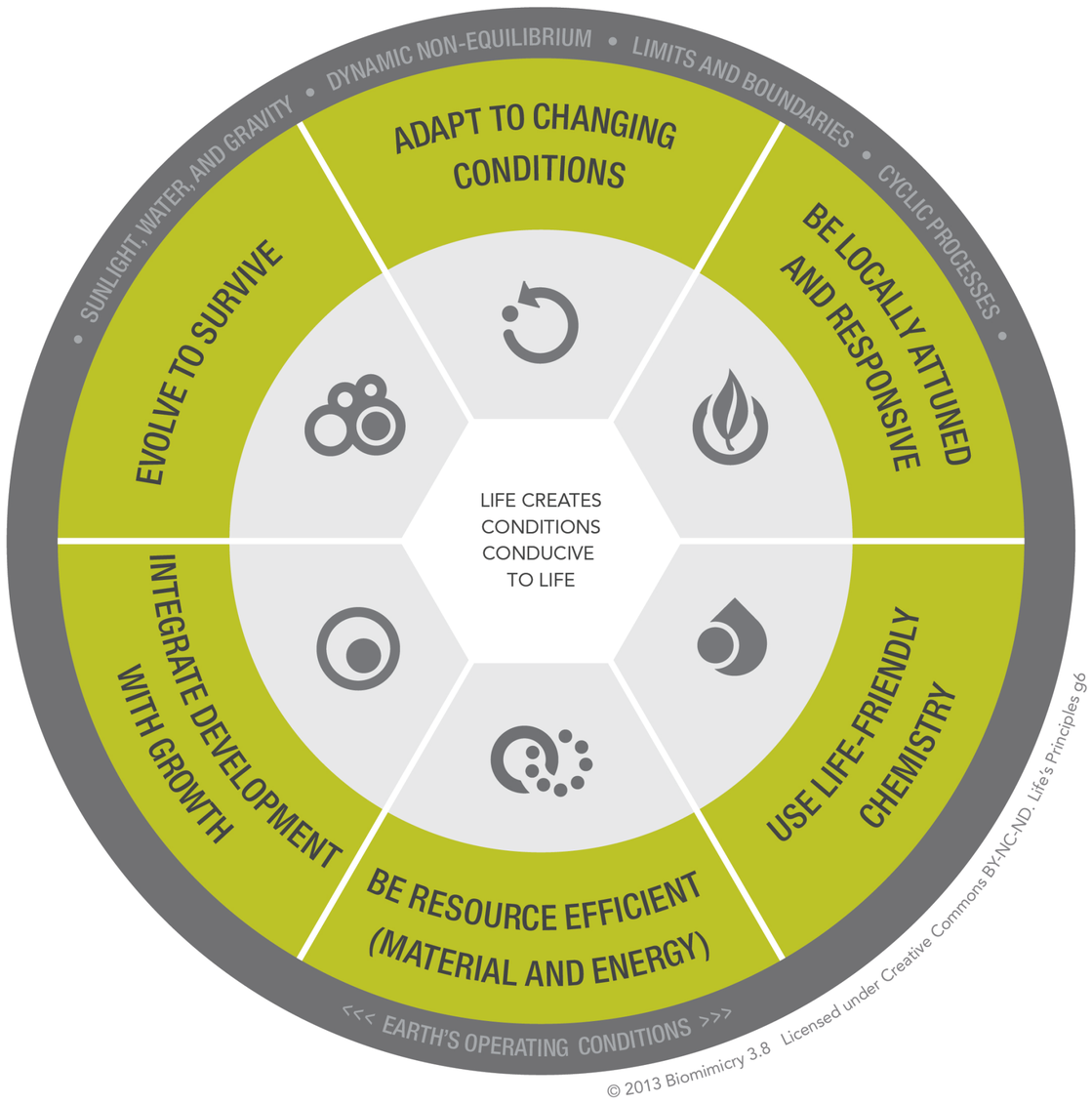
Jube, a bio-inspired chamber for capturing edible insects, the food source of the future. The trapping mechanism is the result of the Genlisea violacea's lobster-pot trap biomimicry. In order to mimic the lobster-pot trap, the team designed the structure of hair pointing inward, which would prevent the insects that step into Jube to turn backward. The overall look of Jube is like a pitcher plant, which is the intention of the designers to mimic the fascinating shape of nature in order to make Jube more like a plant and less like a machine which can be alienated for general people. To use Jube, the user need to put some insect food into the bottom part of Jube to lure the insects. The wickerwork structure of Jube would spread the food odor to surrounding environment. Once the insects follow the odor and step into Jube, they would not be able to turn back due to the structure of hair pointing inward.



- The evolution of the prototype we have developed.

BIOMIMICRY PRINCIPLES

The process of designing Jube aligns with Life's principle. Our product mimics the beauty and functionality of a beautiful plant species that develop a solution to capture insects. Our designs have evolved around the environment we worked with, and relied on local knowledges in order to optimizes the resources. We used life friendly chemistries and materials to fabricate the product in order to make it sustainable and integratabtle with nature.



USE LIFE-FRIENDLY CHEMISTRY

The design of Jube mainly consist of dry rattan, which is highly accessible, strong, and recyclable. The colors used in dyeing Jube are all natural colors from herbs and flowers such as turmeric and butterfly pea, and coated with palm oil. The leftover food used as a bait to lure insects reduce among of food waste in household. All the materials used in Jube are life friendly chemicals.

BE RESOURCE EFFICIENT (MATERIAL AND ENERGY)

The functionality of Jube is biomimicking carnivorous plant which has a passive strategies to capture insects using smell. Thus, make Jube achieve high energy conservation and has minimal energy footprint. The fact that Jube is created by weaving natural materials such as dry rattan to form an insects trap make it accessible even in the area that has no electricity. There is no part of Jube that require industrial manufacturing and heavy machines which result in a minimum energy consumption. The local materials used in creating Jube reduces energy and cost for transporting external raw materials from the outside. All together makes Jube accomplish energy conservation.

INTEGRATE DEVELOPMENT WITH GROWTH

Since Jube is designed to be builded by using Thai traditional weaving technique. By teaching modern people to weave Jube is the way in which keeping the traditional knowledge alive in the modern context. The creation process of Jube is human-centered, which mean it is designed to emphasize the uniqueness of human being and cultivate human power to create an environmental friendly product. 60% of revenue from selling Jube will go back to the community that created them. These help motivating the young generation to keep learning about innovation that improve their lives. 40% of revenue will come back to the organization for further research and growth development.

BIOMIMICRY PRINCIPLES

EVOLVE TO SURVIVE

Jube is an innovative, yet simple design fabricated by local people to solve local problem. The method for creating Jube relies on the unique culture and traditional wisdom. For example, the design team first worked with Thai people to fabricate Jube using Thai traditional weaving techniques. However, this model is adaptable in the sense that if people in India would like to adopt this model, we can encourage them to use their own weaving technique and their local materials to produce Jube.

BE LOCALLY ATTUNED AND RESPONSIVE

Jube also promote a decentralize society where people are empowered to cultivate their own nutritions from nature, which reflect a deep connection between human and nature in symbiotic way. Jube helps people cultivate insects from nature which create an awareness to reduce insecticide and help promote environmental friendly activities among people living in the area. This design is not "one size fit all" but rather a product that also remind people to invest in nature and have responsibility with all their actions. The materials used in the fabrication of Jube are highly recyclable which can always goes back to enrich the quality of soils and land.

ADAPT TO CHANGING CONDITIONS

The team are inspired by traditional weaving technique of Thai people, which is very innovative because it only rely on natural materials and does not required synthetic chemical in the fabrication process. This method were used by folk people to produce crafts, baskets and fishery tools. By using natural materials, it demonstrate how Jube has the potential to transform people's relationship to the natural world through the manufacturing process, design and use of the product.

JUBE BIO-INSPIRED SOLUTION FOR EDIBLE INSECTS CONSUMPTION

FINANCIAL PRO FORMA

REVENUE	2000	2001	2002	2003
Gross sales	$500	$650	$720	$850
Net Sales	$500	$650	$720	$850
COST OF SALES				
Beginning inventory	$350	$360	$420	$435
Plus goods purchased / manufactured	120	165	185	190
Total Goods Available	$470	$525	$605	$625
Less ending inventory	360	420	435	440
Total Cost of Goods Sold	$110	$105	$170	$185
Gross Profit (Loss)	$390	$545	$550	$665
OPERATING EXPENSES				
Selling				
Salaries and wages	$35	$41	$46	$52
Commissions	12	14	16	18
Advertising	10	12	14	20
Depreciation	14	15	16	16
Other	5	6	6	7
Total Selling Expenses	$76	$88	$98	$113
General/Administrative				
Salaries and wages	$12	$14	$16	$18
Employee benefits	4	5	5	6
Payroll taxes	2	3	3	4
Insurance	6	6	7	7
Rent	8	8	9	9
Utilities	2	2	2	3
Depreciation & amortization	3	4	4	5
Office supplies	1	1	1	1
Travel & entertainment	3	3	3	4
Postage	1	1	1	2
Equipment maintenance & rental	0	0	1	1
Interest	0	1	1	2
Furniture & equipment	3	4	4	5
Total General/Administrative Expenses	$45	$52	$57	$67
Total Operating Expenses	$121	$140	$155	$180
Net Income Before Taxes	$269	$405	$395	$485
Taxes on income	22	32	26	28
Net Income After Taxes	$247	$373	$369	$457
Extraordinary gain or loss	$0	$0	$43	$0
Income tax on extraordinary gain	0	0	12	0
NET INCOME (LOSS)	$247	$373	$400	$457

JUBE

BIO-INSPIRED SOLUTION
FOR EDIBLE INSECTS
CONSUMPTION

FEATURED

BIOMIMICRY INSTITUTE

BIOMIMICRY GLOBAL DESIGN CHALLENGE #2nd WINNER

FAST COMPANY

theguardian

GreenBiz

NATIONAL GEOGRAPHIC

Eco SXSW

dif DISRUPTIVE INNOVATION FESTIVAL

gizmag

สวทช NSTDA

เดลินิวส์

THOUGHT FOR FOOD Global Summit

คิด Creative Thailand สร้างเศรษฐกิจไทยด้วยความคิดสร้างสรรค์

ASU

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The information resource for the future of sustainable agriculture

ABOUT THE TEAM

Pat Pataranutaporn
Pat is a creative biologist, artist, designer, and a freshmen at College of Liberal Arts & Sciences, Arizona State University. His work examines a range from environmental biotechnology to interactive technologies at the intersection of biology, DIY, and computation. Right now he is a research fellow at the Biodesign Insitute and School of Art, Media + Engineering at ASU, and the founder of tech startup - Arkhumanity. In launching Jube project, Pat is a project leader and creative director.

Ratchaphak Tantisanghirun
Ratchaphak is an interdisciplinary scholar. His interests are vary from materials science to biomechanical engineering. He is a recipient of Thai government's Undergrad Intelligence Scholarship, and a visiting student at CERN (European Organization for Nuclear Research).
In launching this project, Ratchaphak is in charge of analyzing bio-strategies and facilitating the conversation.

Purichaya Kuptajit
Purichaya is a Senior at chemical engineering department, Faculty of Engineering, Chulalongkorn university. Her interests is in materials science . She is a member of the most prestigious gifted young scientist society in Thailand, JSTP. She was invited to showcase her research project on the waste recycling in the international conferences throughout the world. In launching this project, Purichaya is commit to work on finding product materials and product development.

Kotchakan Promnara
Kotchakan is a high school student at Saparachinee trang School. His interests are in vary from 3D fabrication to human evolution and biological simulation. He is also a member of the most prestigious gifted young scientist society in Thailand, JSTP. In launching this project, Kotchakan is an expert on edible insects.

Tavita Kulsupakarn
Tavita is becoming a Freshmen at Prince of Songkla University International College. Her interests is in computer graphics, digital media, Japanese anime culture, and psychology. Her works are famously showcasing on many platforms under the name "umbrella bear". In launching this project, Tavita is working on designing the product and doing a background research.

Associate Member
Tawan Thintawornkul, Nanthiya Chayaphat, Sorawit Promnual

Advisory Board
In establishing the project, the team is receiving advices from the following mentors.

Prof. Werasak Surareungchai (Ph.D.) - Director of Biosensor technology, KMUTT (King Mongkut's University of Technology Thonburi)
Rob logan University of California San Diego
Chris Allen Biomimicry Institute
Prof. Bank Ngamarunchot - Economics and business lecturer, KMUTT
Potiwat Ngamkajornwiwat (Ph.D. candidate) - Robotics researcher at FIBO (Institute of field robotics)

The team would like to acknowledge our friends who joined the discussion on this project.
Panwong Kuntanawat. Wasin Tuchinda, Tanadet Pipatpolkai, Sahutchai Gla Inwongwan, Ping Harn, Ju Chulakadabba, Tawan Thintawornkul, Cher Tonanon, Thanadol Sutantiwanichkul, Natthawoot Panitlertumpai, Ice Kanokrat, Tesla Atom, and Meng Nakpradit.