HACKO

INSTRUCTIONS FOR FABRICATION

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1. HACKO
General Description

1.1 What is HACKO

Many people understand that fermented foods are good for your health. On the other hand, many Europeans have the impression that making fermented foods is very time-consuming, tedious, and reserved for a few geeks.
In our Project HACKO ("Hakko" = "fermentation" in Japanese + "Hack"), we aim to develop an automated fermented food production machine that can be used at home by automating the production process of such fermented food itself, taking Nukazuke/Nukadoko as a subject. Nukazuke is one of Japan's representative fermented foods that is not yet well known in the West. It has high nutritional values and could be created in any household. In order to make Nukazuke, you first need to make Nukadoko (fermented rice bran bed). Nukadoko is made of rice bran and other ingredients mixed together and fermented for a few weeks. Once you are ready with Nukadoko, you can make Nukazuke by pickling ingredients inside it for a certain period of time.

System Overview: device and elements
We designed a monitoring and sensing device to keep track of the state of fermentation and help to create an optimal environment for fermentation. At the same time, we created some tools to support the everyday maintenance of Nukadoko making.

To achieve this, we combined technologies such as microcontrollers, various sensor modules, and 3D printing. In order to make the designed solution open and reproducible by anyone, we found a way to realize the above mechanisms by utilizing modules that are generally available.

1.2 What is Nukazuke and why is it healthy and circular?

History of Nukazuke
It is said that Nukazuke has been widely introduced since the Edo period (17th Century). This is due to the development of rice-polishing technology. It became easier to separate rice bran from brown rice and people started to utilize rice bran to preserve food. In order to survive the winter when crops do not grow, people preserved and ate a variety of agricultural products harvested in spring, summer, and fall. This wisdom has given birth to the fermentation culture of Nukazuke.

Cultural Values
Nukazuke is one of Japan's representative fermented foods and it is very popular on the tables of Japanese households. In the past, every household had its own Nukadoko. Although fewer and fewer people of today's generation are maintaining it, it is being reevaluated as "immunity-boosting" because of the new coronavirus disaster. Through this project we want to reinforce the consumer trend to micro produce their own fermented foods at home.

Nutritional Values
Nukazuke is made by pickling your favorite vegetables and other ingredients in a lactic acid fermented rice bran called Nukadoko for a couple of hours. Almost any vegetable may be preserved using this technique. The lactic acid bacteria in Nukazuke are probiotics that aid the intestinal flora and are good for your health. Fermented rice bran is rich in nutrients such as

vitamin B1 and potassium, and pickling vegetables in it increases their nutritional value. Using cucumbers as an example, when you compare raw cucumber and nuka pickled cucumbers (nukazuke) the amount of potassium is about 3 times higher and the amount of vitamin B1 is about 8 times higher, indicating that the amount of nutrients is increased by pickling in nukadoko.

Circular Values

Italian rice is grown on an area of 220,000 hectares. About 4,000 Italian farms harvest 1.40 million tons of product per year, equal to about 50% of the entire EU production. The center of rice production is in the northern Po Valley, 1 hour drive from Milano.
When rice is processed into white rice, nearly 10% of its weight is refined as rice bran, a byproduct. Rice bran has a high nutritive value. Besides proteins, rice bran is an excellent source of vitamins B and E. Bran also contains small amounts of antioxidants, which are considered to lower cholesterol in humans. However, we have noticed that many farmers in the region are discarding rice bran due to lack of methods to utilize them. There is a significant potential of upcycling and creating value out of otherwise discarded rice bran, by making Nukazuke popular in Europe.

2. How to make HACKO
A kit that allows you to easily ferment food.

2.1 Bill of materials

COMPONENTS	PART N°	LINK	PRICE	COMMENTS
BOX	1	https://docs.google.com/document/d/1Nc0rj5CMVXkVf_ZQQTj5XM1yQs5YEmHW/edit	€21,67	Acid-resistant, food-safe material
FILAMENT	1	Link	€25,99	
M2.5 x 4	6	Commonly found components	N/D	
M3 x 1	1	Commonly found component	N/D	
INSERTI PER STAMPE 3D	11	Link	€8,99	
ESP 8266 NODE MCU Amica Board	1	https://tinyurl.com/3jb775x9	€2,36	
USB LiIon/LiPoly charger - v1.2	1	https://www.adafruit.com/product/259	€12,23	
LIPO BATTERY 3.7 V	1	https://www.adafruit.com/product/258	€9,39	
TEMPERATURE AND HUMIDITY PROBE (SHT10)	1	https://www.mouser.it/ProductDetail/DFRobot/SEN0227?qs=0l0eLiL1qyZif04OhDexqw%3D%3D	€21,15	
EC SENSOR COMPONENTS	2 - Diodes Stainless steel wire (2 mm) 1 - 10K Resistor Wires	Commonly found components	N/D	
REAL TIME CLOCK DS3231	1	https://tinyurl.com/537n33b6	€2,89	
TOUCH BUTTON	1	https://tinyurl.com/2p8mpsab	€1,20	

2.2 Instructions for making HACKO devices and components

2.2.1 Controller Device

Device. It uses a simple set of sensors (the humidity and temperature probe and the handmade EC sensor) and the communications it's based around a NeoPixel led on the device and the Telegram bot. Although it's reduced to the basic elements it's sufficient for monitoring the Nuka. However, if you are not an expert in producing the Nukadoko, it could be difficult to understand what possibly it's off from the normal parameters, so a telegram bot it's added for easing communication. Be aware that the firmware will need to be uploaded before you close the device, so make a check if everything it's working perfectly before closing it.

How *to fabricate the device*

As with other tools PETG it's recommended, be aware that the device will have to be inserted in the Nuka for a long period of time, so clean the sensors and the device before using it.
The parts of the device are 3D printed and joined using inserts for M2.5 and M2 screws, follow the instructions in the next section.

Prints the files within the following folder:
"Eletronics shell"

Download the files within the following folder:
"Code"

2.2.2 Drainage Pipes

There are two types of drainage systems:

- *System1.* A multiple system consisting of four vertical pillars. It is recommended to place them at the corners or in the middle of the Nukadoko bed.
- *System2.* A single system whose function is also to divide the Nukadoko into two parts so as to create different sections into which different types of food can be placed.

The system is recommended where there are foods that release a large amount of water.
The type of drainage system is a free choice.

How to fabricate the pipes

Print material recommended: PETG; Production technology: FDM 3D printing

Prints the files within the following folder:
"Drainage containers"

2.2.3 Spatula & Handle

Skin contact is preferred because it promotes an exchange of bacteria useful for the fermentation process. However, during the preparation and maintenance stages of Nukadoko, a tendency to develop skin irritation due to contact between the hands and the bran emerged; therefore, a spatula with a handle was developed to avoid contact.

How to fabricate the Spatula

Print material recommended: PETG; *Production technology:* FDM 3D printing
The two parts are 3D printed and joined by an M3 self-tapping screw.

Prints the files within the following folder:
"Spatula"

2.2.4 Box


The container used is a PET box. This box will have to be modified to allow the device to be attached and positioned. The box can be found in the Bill of Materials document. Take the box and proceed as listed below:

1. the cut must be made through a 50mm cup and finished later with a box cutter. Maximum precision is not required as an air exchange is necessary;
2. download the files of the two connectors;
3. 3D print the two hooks;
4. insert threaded inserts into Connector 1;
5. take the connectors and place Connector 1 under the lid of the box. Finally, place Connector 2 on top of the lid and fasten them with an M3 screw.

How to fabricate the bayonet coupling

Print material recommended: PETG *Production technology:* FDM 3D printing

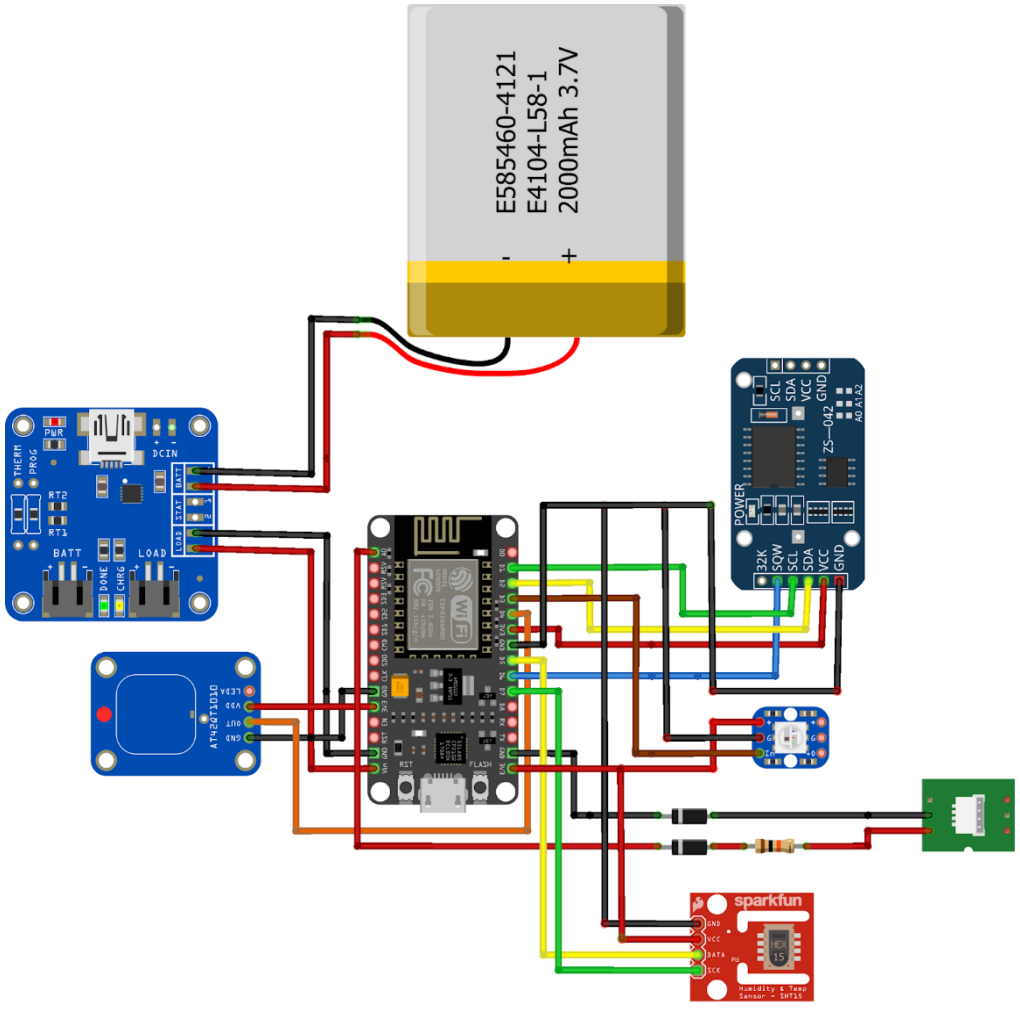
Prints the files within the following folder:
"Lid"

2.3 Assembly and set up the controller device

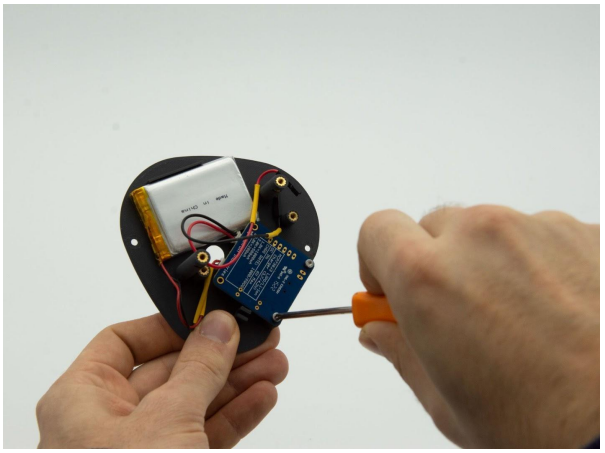
2.3.1. Mount the electronics

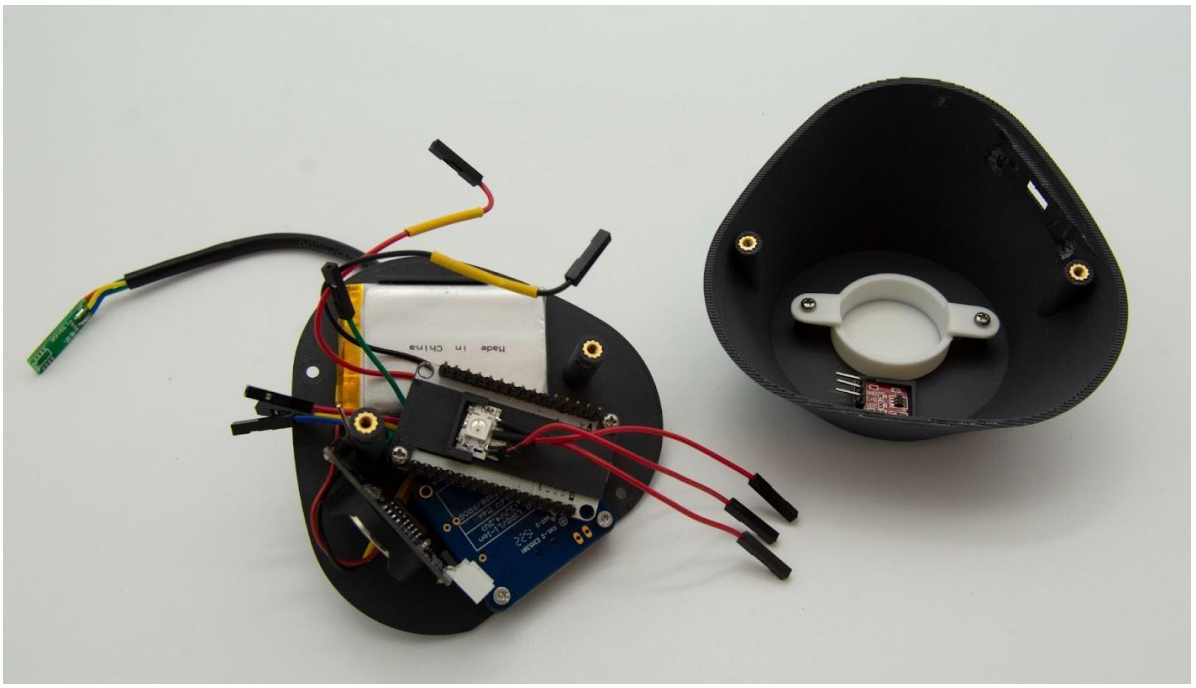
The space inside the device is built considering an organized balancing between all the components inside so you will have to be aware of the direction of some components. As you will have to connect some pins to the Node MCU board we suggested being the last element to mount as you will have to look at the name of the pin for connection. Follow the photos for instructions.

The wiring of the system should be set like this:



2.3.2 Secure display and components





2.3.3 Real-Time Clock

Connect the PIN following this scheme, the RTC will have to be secured like the photo above. We used a DS3231 RTC as it is the most trustworthy on the market.

Two considerations:

- put a fully recharged battery on the RTC following the basic procedure (link), it will last for at least 3-4 years.
- If, like ours, it has another set of connections on the other side, consider desoldering the pins in order to make space.

2.3.4. Temperature & Humidity Probe

The temperature and humidity probe needs to be cut on the correct dimensions. We have also added some Female header pins in order to connect to the Node MCU board. Our probe uses an SHT10 type of sensor, but as long as it has the cover for the sensor it should be okay.
First, make a cut around 18 cm on the wire (not comprehending the sensor head), then strip the wires and solder the female connectors, securing it with heat shrink tubes.
For the sensor head, remove the O-ring and the stopping header, they will be replaced by our 3D-printed parts. Then insert them in the larger hole of the bottom part. If you insert first the sensor and then the cover from the other side, it should guarantee a perfect fit.

2.3.5 Making the EC sensor

The EC sensor it's used for monitoring the levels of salt in the compost when they will reach a level below the recommended one. You will then need to add more salt to the Nuka.
EC sensor measures the electrical conductivity between two poles, so you will need some stainless-steel wire (2 mm dimension (to check) disposed of in parallel at a constant distance between each other. Stainless steel is required as it is a food-safe material able to be conducive enough for the sensor to work. For making the EC we followed this method (there are a lot of them, but this one is indicated for the dimensions that we considered):

- Take a male pin connector for the board, we used only two pins, so you will have to cut it out;
- On the long part insert a Female-to-Female wire connector;
- On the short side, solder the 2 stainless steel wires;
- Now that it is connected, secure all the connections, and protect them using heat shrink tubes.

The EC sensor will now be inserted in the little space in front of the Temperature & Humidity Probe.
Depending on the quality of your print you will need to enlarge the smaller holes in the button. We have used a simple screwdriver for it. As the ESP8266 NodeMcu that we use has only one Analog Pin, we have to put two diodes for the pin, this will help in timing the reading of the values of the Pin and permit us to have two analog readings. Solder the diodes and the resistor at the end of the female connectors, and connect them at pin A0 and Ground. For adding the resistor simply cut one of the wires, strip it, and solder it in between, using heat shrink tubes will secure a more stable build.
See the video How to Build an Electro-Conductivity Sensor as a sample.

2.3.6 Mounting the Device on the Lid

For mounting the device on the lid, you will first have to make a hole of 50 mm on the upper part. Clean it using a knife for a better look and for making sure that no pieces will fall on the Nuka. Anaerobic fermentation requires a constant change of air to work, so if a little raggedy or not precise it will not be a problem, just be sure to not exceed the dimension as then the device will not fit.

Mount on the sides of the lid the two mounting rings possess a bayonet attack that will secure the device in its place.

2.3.7 Recommendations

When you finish aligning all the components, be aware to have at least 2/3 of the Probe Metallic part inserted inside the Nuka.

2.4 Assembly and set up the fermenter box

2.4.1 Calibration of the sensors

EC Sensor. For calibrating the EC, you will need first to make some measurements. The methods used are similar at the calibration with soil that the EC it's normally used for, but with Nuka instead. As the particularities of EC values depend a lot on the type of Bran, Water, etc. we suggest that you make yourself your calibration. Here is a simple video that shows how to do it, you will then need to change the corresponding value on the library "HackoEC.h"
See the video How to Build an Electro-Conductivity Sensor as a sample.

RTC. The DS3231 it's a reliable real time clock for data uploading but if you are in a different time zone or if your RTC it's new, you will need to calibrate it. There are a lot of different methods but we used the same one on this blog which is really reliable. In the code the RTC it's already setted so you will only need to calibrate and then to comment the void.calibrate() function before flashing it in the ESP8266.
See the video DS3231 - Real-time clock • Wolles Elektronikkiste as a sample.

How does communication work?
Hacko allows you to interact directly with the fermentation, understand its state at any time and take care of it. Depending on the condition of the fermentation and the type of information you want to get, communication takes place on two levels: light feedback on the device and a Telegram chatbot.
Level 1 : By pressing the button on the top of the device, light feedback communicates the status of the fermentation. A white light will indicate correct fermentation, a red light will communicate problems. Once the fermentation process has been going for four weeks, a green light will indicate that it is time to start placing food. *Level 2:* Once a day, an automatic chatbot message is sent with updates on the measured parameters (temperature, humidity and EC, used to measure salinity).

2.4.2 How to connect to the Telegram chat Bot

Telegram is an instant messaging service that allows for the creation of bots. Bots can be configured to send and receive messages. This is useful for Arduino projects as you can receive updates from your project or issue commands via your Telegram app from anywhere.
To generate your new Bot, you need an Access Token. Talk to BotFather and follow a few simple steps described here.
You also need your Telegram chat ID, it can be found talking to @myidbot on Telegram.
In the Hacko code you will simply need to put your http address and char ID.

3. How to prepare NUKADOKO and NUKAZUKE

3.1 Guidelines to make your good and healthy "NUKA"

Firstly before starting preparing your Nukadoko you have to collect all the ingredients that you'll need for the preparation. In order to make fermented Nukadoko, you need to go through a phase called *Sutezuke* pickling.
Sutezuke pickling lasts for the first 3 weeks after the preparation, and during this period you must pickle leftover vegetables and mix the rice bran everyday to feed and grow the lactic acid bacteria inside. Once you have the fermented Nukadoko, you can start making *Nukazuke* pickles. By putting ingredients inside the Nukadoko for 8-12 hours, you will get Nukazuke ready to eat.

3.2 List of ingredients

The amounts indicated in the following recipe are to prepare a good rice bran bad for 2-3 people.

1. 1 kg of raw rice bran
2. 1 liter of water (same as rice bran)

3. 130 g of salt (about 13% of rice bran)
4. 3 pieces of 5 cm square of Kombu/3 dried tomatoes
5. 2 dried chili peppers
6. 8 g of Katsuobushi
7. About 5 dried shiitake mushrooms/dried porcini mushrooms
8. Leftovers of vegetables (carrots, turnip skins and leaves, broccoli cores) or 4 leaves of cabbage

Step 1 - Preparation of Rice Bran bed (Nukadoko)
Place the rice bran in the container, add the salt first and mix briefly. Then add your water (leave about 50-100 ml of water) at this point, mix and stir from the bottom in order to combine perfectly rice bran, salt and water.

The bran can cause a little allergic reaction to your hands, if this is the case use the *Hacko Spatula* to do actions in which you have to directly touch the bran.

As a guideline for the right amount of water roll the bran into a table tennis size ball and squeeze it tightly in your hand. If the amount is right the water will gradually come out from between your fingers. If it's not, add the water left in the step before.

Step 2 - Add the flavoring ingredients
Add gradually all the ingredients (dried chili peppers, Katsuobushi, dried shiitake mushrooms/dried porcini). Be sure to mix all the ingredients well inside your rice bran bed.
The ingredients such as Katsuobushi, and Shiitake mushrooms are a big umami source. The adding of these ingredients will bring a lot of taste to the vegetables that will be pickled inside your Nuka.
On the other side the chili peppers will bring a refreshing aroma but mainly they have the function to protect your Nuka from the insects.

Step 3 - Add the pickled vegetables or cabbage leaves for *Sutezuke*

Add the leftovers of vegetables or 4 leaves of cabbage and cover them with the rice bran.
The vegetables are useful for replenishing nutrients and moisture for fermenting the rice bran bed.

Step 4 - Add the Kombu/dried tomatoes
Add the Kombu/dried tomatoes and cover them with the rice bran.

The Kombu is added at the end since it's very sharp and can cause some wounds during the mixing processes. After squeezing the surface with the *Hacko Spatula* to remove the air inside. This step is important since lactic acid bacteria like an environment with few oxygen.

Then add the *Hacko draining pipes* depending which model you decide to use:

- System 1: it's recommended to place them at the corners or in the middle of the rice bran bed.
- System 2: place it in the middle of the rice bran bed to divide it in 2 sections in which you'll be able to pickle ingredients with different water content without influencing the fermentation of each other.

Finally clean the surface of the container with the *Hacko Spatula* and use clean cloth to wipe out the extra bran stuck on the surface.

3.1 How to ferment the Nukadoko during the *Sutezuke* pickling period

Step 1 - Mount the *Hacko controller device*
When the preparation of the Nukadoko is done, mount the *Hacko controller device* in the specific slot that you created on the box lid. During this step be sure that the sensor pins touch the rice bran bed.

Step 2 - Daily maintenance of the Nukadoko
Before starting mixing remove the extra water collected by the *Hacko draining pipes*.

Mix thoroughly from the bottom twice a day for the first 10 days, then reduce to once a day for the next 10-20 days .

The leftovers of vegetables/cabbage leaves have to be replaced after 4/5 days.

When you are changing the vegetables, remove as much rice bran as possible (from the vegetables) then squeeze out the juice from the vegetables, and add it back to the Nukadoko. Be sure to squeeze the vegetables well as the juice brings a lot of flavor to the Nukadoko.

Then add again your new vegetables leftovers/cabbage leaves. This step has to be repeated 3 times for a total *Sutezuke* pickling period of 20 days.

After this processes, place back your *Hacko draining pipes*.

After the Sutezuke period, throw away your cabbage leaves.

3.2 How to monitor the conditions for the fermentation

Thanks to the *Hacko controller device* you will be able to monitor three fundamentals parameters:

- Temperature: has to be between 20 - 25°C
- Humidity: has to be between 59 - 63%
- Salinity: has to be kept stable with the initial amount

To control the state of the Nuka you will have two ways:

- *Telegram Hacko chat Bot*: in this chat you will find updates of the abovementioned parameters
- Button on *Hacko controller device*: to see how your Nuka is doing without opening the telegram chat you have the possibility to have visual info from the *Hacko controller device*. To do so you will have to touch the button on top of the tool. In base of the conditions of the Nuka you will have 3 differents lights colors:
    - White: everything is fine in your Nukadoko.
    - Red: there is a problem with your Nukadoko. In this case please go to the *Hacko telegram chatbot* to see specifically what's wrong and to have some hints on how to recover the situation.
    - Green: indicate that it is time to start placing food inside the Nukadoko. After the first time you will see the green light will substitute the white one.

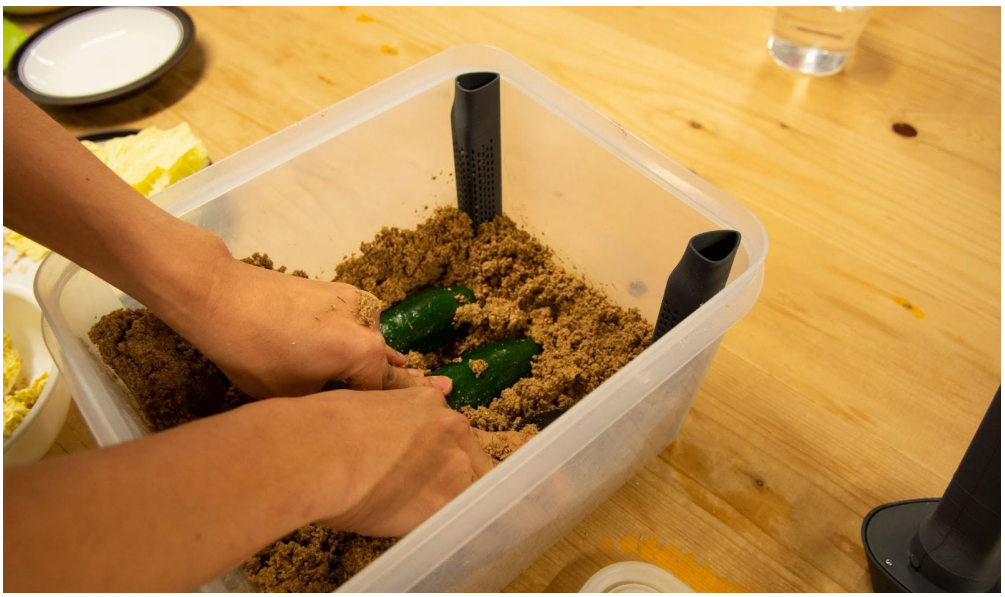
If the rice bran bed is over 30°C, the bacteria in the rice bran bed may ferment abnormally, so it is recommended to put it in the refrigerator during the hot summer months.

3.3 How to pickle and make Nukazuke inside the Nukadoko

Firstly the most recommended foods to pickle are:

- Cucumber
- Carrot
- Radish
- Eggplant
- Mozzarella (control very well the water amount inside the Nukadoko)

The ingredients before pickling should be washed with water, lightly rubbed with salt and then covered inside the rice bran bed.



The ingredients should stay inside the Nukadoko from 8 to 12 hours, you can adapt the time based on your taste. If you cut the ingredients the pickling time will be less as more surface is exposed to the Nukadoko.

During the pickling period you can check the fermentation parameters with *Hacko controller device.*
If you pickle more the flavor and the saltiness get stronger otherwise it could be lighter flavor and lighter saltiness. Remember to keep under control the Nukadoko parameters and to mix at least once in 2 days to keep the fermentation alive.

4. Credits Hacko

Hacko is a project publicly released and made available in open source mode according to the Creative Common License (CCBY) and promoted by Distributed Design Platform with the related documentation. The authors of Hacko are by Kentaro Sohara, Giovanni Bruno, Gaia Rubino, Luca Grosso, Andrea Somenzi, Federico Denni, Martina Comola, Valerio Libardo.
Hacko is a project developed with the collaboration of Polifactory within the Distributed Design Platform project co-funded by the Creative Europe Programme of the European Union.

5. Downloadable files

Hacko files can be download at polifactory

6. Contacts

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