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An Introduction to Bokashi Fertilizers and Soil Amendments

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The Concept of Bokashi

Around the world, many agriculturists and gardeners are adopting soil amendments and fertilizers that are called bokashi. Bokashi is a Japanese word that has no good translation into English, according to Yukiko Oyanagi, a staffer with the Asian Rural Institute (ARI) in Japan. However, all types of bokashi are produced through fermentation processes.

There are at least two distinct types of bokashi being promoted and used by agriculturists, farmers and gardeners. One we shall describe as fermented bokashi fertilizer and the other is kitchen bokashi. Both are described in this article.

Fermented Bokashi Fertilizer

The fermented bokashi fertilizer promoted and used by ARI and others in Asia is comprised largely of dried manure and forest soil. According to Oyanagi, the dried manure provides nutrients and organic matter, while the soil helps to preserve nutrients, absorb bad smells, and provide a comfortable living space for microorganisms. If charcoal is added (i.e. charred rice husks or wood charcoal powder) the effects of the soil are greatly enhanced. The following is a list of bokashi ingredients recommended by ARI:

- **Dried manure** should comprise 50-60 percent of the materials in a batch of bokashi and can include cow, pig, goat, chicken, duck or water buffalo manure as well as bat guano.
- **Soil from the forest** should constitute 20-30 percent of the materials.
- **Rice bran**, a carbohydrate source for beneficial microorganisms, should make up 10-20 percent of the mixture.
- **Rice husk charcoal** should comprise 5-10 percent.
- If available, small amounts of beneficial **indigenous microorganisms** (IMO) collected from forests or fields as well as **fermented plant juice** (FPJ) or **Effective Microorganisms** (EM), which helps with the fermentation process, should be applied to other bokashi materials via a water solution (see Multiplication and Use of Soil Microorganisms, EDN 110, January 2011 by Dawn Berkelaar). Although these supplemental microbe solutions are recommended to help stimulate the fermentation process for bokashi production, lack of access to such supplements should not deter anyone from making fermented bokashi fertilizer as beneficial microorganisms are already likely to be present in the soil and manure.


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ARI recommends that the materials be blended by dumping dry ingredients into a pile and using a shovel to mix the ingredients thoroughly. It is also recommended that the mixing process and fermentation take place under the shade of a roof to avoid strong sunlight, rain and wind. While mixing, add water (with or without IMO, EM and/or FPJ) to provide about 50 percent moisture to the mixture. This level of moisture can be monitored by taking handfuls of the moistened materials and squeezing. If no liquid can be squeezed out and the material still holds shape after being released, but crumbles when tapped, an appropriate amount of moisture has been reached.

The freshly mixed bokashi fertilizer should be covered with rice straw (or similar dried materials that are available on the farm) to retain moisture and heat. The mixture should be turned whenever it becomes hot (around 60ºC/140ºF); usually once a day. Moisture should be checked and adjusted to 50 percent as needed. When the temperature of the bokashi fertilizer stabilizes and becomes the same as the surrounding air, and you can no longer smell the manure, it is ready to use. Fermented bokashi fertilizer can be dried and stored for a period of six months to one year.

Because the nutrients of the finished bokashi product are fairly concentrated, and because inputs such as rice bran might need to be purchased, ARI recommends that bokashi fertilizer be applied somewhat sparingly. Such bokashi should be applied either topically over the root zone of established plants or mixed into the soil where new plants are being established.

ECHO Asia has found very limited information regarding the nutrient content of bokashi fertilizers, probably due to the diversity of "homegrown" bokashi fertilizer mixtures across the region. However, in 2011, a development organization in Myanmar had their fermented bokashi fertilizer product analyzed at Mae Jo University in Chiang

Mai. This particular fermented bokashi fertilizer was comprised of a mix of dried chicken manure (100 kg/220 lb.), forest soil (80 kg/176 lb.), bone meal (45 kg/99 lb.), rice bran (30 kg/66 lb.), groundnut cake (30 kg/66 lb.), fish meal (30 kg/66 lb.), firewood ash (15 kg/33 lb.), charred rice husk (15 kg/33 lb.), raw sugar (1 kg/2.2 lb.), and wood vinegar (4 liters/1.1 U.S. gallon). This somewhat elaborate bokashi formulation included ingredients that supplement certain key nutrients, such as bone meal for phosphorus as well as fish meal and groundnut cake for nitrogen.

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Two samples from this batch of bokashi yielded the following nutrient analysis (averaged):

pH - **6.82**; electrical conductivity (EC) **– 10.34 dS / m**; total nitrogen (N) - **1.93%**; total phosphorus (P) - **2.47%**; total potassium (K) **– 1.31%**.

Thailand's National Bureau of Agricultural Commodity and Food Standards has developed criteria for commercial compost, which is also applied to organic fertilizer. In view of such official criteria, the average pH of the Myanmar bokashi samples (6.82) fell within the acceptable 5.5-8.5 range. However, the average electrical conductivity of the batches (10.34 dS / m) was considerably higher than specifications that require the EC of commercial compost to be less than or equal to 3.5 dS / m as well as specifications by Thailand's Department of Agriculture for natural fertilizers to be less than 6 dS / m. The average N-P-K analysis of the Myanmar sample was 1.93-2.47-1.31 which is well above Thai government specifications requiring commercial compost to be greater than or equal to 1.0 % by weight for N, greater than or equal to 0.5 % by weight for P and greater than or equal to 0.5 % by weight for K.

The main limitation of the bokashi sample from Myanmar was the high EC level. EC measures the amount of soluble salts in the medium. Most fertilizer materials (e.g. nitrates, ammonium, phosphates, potassium) contribute to the EC content (Whipker and Cavins). Organic materials, such as urea, also contribute to the EC content after they have been changed from an insoluble to soluble form. High EC levels can result in poor crop performance, often due to "burn" from the high concentration of salts in the medium. Therefore, it is important for producers and users of natural fertilizers, such as bokashi, to be aware of EC levels and to exercise caution in the amounts applied to nourish crops.

Beng Ngoun, who farms a few hectares in Battambang, Cambodia, reported his experience with fermented bokashi fertilizer. He applied 200 kg (441 lb.) per hectare of rice that had been established less than one month. His 600 kg (1,323 lb.) batch of bokashi was comprised of 200 kg of dried manure, 200 kg of forest soil, 100 kg of rice bran, 100 kg of ground wood charcoal and 5 liters (1.3 US gallons) of fermented plant juice solution.

Around one month after applying the bokashi, Beng Ngoun saw no immediate visible effects from the application of the natural fertilizer, and he began to lose hope that he would see any benefits from his investment. He admitted that his neighbors even laughed at him and asked, "Why do you use this organic fertilizer?" In contrast, the neighbors' rice fields were very green. They had broadcast chemical fertilizer, which he estimates was applied at 200-300 kg per hectare (178-267 lb. per acre).

Somewhat later, about two weeks before his rice crop began to head, Beng Ngoun also sprayed FPJ solution mixed with molasses onto the rice crop, applying the solution in the evening or around sunrise. [Ed: no other details on the formulation and rate of FPJ application were provided, and any possible correlation regarding the effect of the FPJ on the crop is unknown.] About the same time, he began to see that the color of the rice crop was changing from light green to dark green. "I was so happy and then my neighbors came to look every day. Now they ask me for the organic fertilizer method," he reported.

When he harvested his rice, Beng Ngoun found that his yield was greatly increased. He shared, "Before, we produced 1-1.5 (metric) tons of grain per hectare (0.45-0.67 U.S. tons per acre). But this year I got 3-4 (metric) tons (1.35-1.8 U.S. tons per acre). I praise God so much. Next year I will need to put the fertilizer during first plowing."

Kitchen Bokashi – A Response to the Global Food Waste Problem

The Food and Agriculture Organization (FAO) of the United Nations reports that roughly one third of food produced in the world for human consumption every year — approximately 1.3 billion tons — gets lost or wasted. However, a considerable disparity exists regarding per capita food waste by consumers in Europe and North America (estimated between 95-115 kg/209-253 lb. a year), compared to consumers in sub-Saharan Africa and South and Southeast Asia (who throw away only 6-11 kg/1.3-24.3 lb. a year).

Consumers often purchase more food than can be eaten, or fail to plan their food purchases properly. This results in food being thrown away when "best before" dates expire. In response, the FAO recommends that rich-country consumers be taught that throwing food away needlessly is unacceptable. The agency also suggests that given the limited availability of natural resources, reducing food losses might be more effective than increasing food production in order to feed a growing world population.

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In addition to the loss of potential to nourish humankind, and the wasted money for individuals, families and businesses, food waste has a negative impact on the environment. Food disposed of in the garbage is a source of flies, unpleasant odors and possible disease. And once in the landfill, food waste produces methane, a potent greenhouse gas.

While some degree of food waste is inevitable in most households and kitchens, there are earth-friendly and even profitable farm and garden uses for leftover food. For example:

Add appropriate, non-greasy/fatty food leftovers, such as expired fruit and vegetables, to compost so that these nutrient-rich materials can be recycled to produce more fruit and vegetables. However, greasy and meat-type leftovers are not particularly desirable for composting. They may attract flies, rodents and other pests, as well as produce bad odors.
Vermicompost (use earthworms to breakdown wastes); this is another means of producing an excellent soil amendment for farms and gardens, although greasy, meattype leftovers are generally undesirable.
Feed appropriate types of leftovers to farm animals such as chickens and pigs.Use leftovers as feedstock for home biogas systems. Appropriate materials, such as fruit and vegetable peelings as well as leftover cooked rice and vegetables, should be ground or blended and mixed with water to create a slurry that can be fed into biogas digesters (Vig, page 23). For more information about household biogas systems that can accept food waste and other feedstock see the following:

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(/resources/1d226877-6e72-441d-a155-048519967606)

- Appropriate Rural Technology Institute (ARTI) webpage - ARTI Biogas Plant: A Compact Digester for Producing Biogas from Food Waste (http://http//www.arti-india.org/index2.php?option=com_content&do_pdf=1&id=45)
- Heifer International Biogas Manual (http://http//c.ymcdn.com/sites/www.echocommunity.org/resource/collection/F6FFA3BF-02EF-4FE3-B180-F391C063E31A/Biogas_-_Heifer_International.pdf)
- Baron Small-Scale Biogas Digester (http://Baron Small-Scale Biogas Digester (from the Border Green Energy Team website)) (from the Border Green Energy Team website)

Another practical means of putting unused food of all types to use is by turning it into kitchen bokashi, the second type of bokashi. Kitchen bokashi is a soil amendment produced by fermenting food wastes under anaerobic conditions. The fermentation process keeps the materials from rotting and becoming putrid, as would occur under normal aerobic conditions. The production of kitchen bokashi offers households and institutions the following:

A convenient and manageable means of reducing the volume of household or institutional waste going into landfills, by recycling food leftovers (including greasy food, as well as scraps of meat and fat) without objectionable odors and mess.
Continual access to an excellent soil amendment that improves garden soil structure and fertility, benefiting helpful soil organisms as well.

To produce kitchen bokashi, food scraps are collected in airtight containers and inoculated with a carrier, such as rice or wheat bran, containing **fermentation microorganisms** (e.g. natural lactic acid bacteria, yeast, phototrophic bacteria). One source of such microorganisms is a commercial product called **Effective Microorganisms (EM)** which is often sold in various formulations. Non-commercial sources of similar microorganisms are IMO-1 or -2, described in the Writer's Supplement (http://www.echonet.org/repository#938:d:Issue110Supplement.) to Berkelaar's article.

Each shallow layer of food scraps is liberally sprinkled with inoculated bran carrier, with layers continuing until the container is full. Stored under near anaerobic conditions, microbes will expand throughout the kitchen scraps and ferment the materials.

If done correctly, there will be no spoilage or putrid smell. Fermented food wastes can be collected and stored over the long term, even for months, until burial. Finally, weeks after incorporation into the garden, the bokashi will become soil-like, providing both organic matter and plant nutrients to the soil.

At Mae Jo University, lab analysis of a batch of kitchen bokashi showed N-P-K levels that compare favorably to other natural fertilizers and animal manures (Silva and Uchida):

- kitchen bokashi 2.39 – 0.77 – 0.97
- worm castings 0.5 - 0.5 – 0.3
- blood meal 13 – 2 – 0
- chicken manure 4.4 – 2.1 – 2.6
- cow manure 2.4 – 0.7 – 2.1

Making the Inoculated Bran Carrier for Kitchen Bokashi

Inoculated bran carrier, which is typically bran treated with EM, is used to inoculate food wastes with the fermentation organisms that are essential for producing kitchen bokashi. The following ingredients and method are widely used for inoculating a small batch (5 kg/11 lb.) of bokashi carrier:

- 5 kg (11 lb.) of rice bran
- 20 ml (1.4 tablespoons) EM•1® (the basic, unextended commercial formulation of EM) or IMO-1/IMO-2.
- 20 ml (1.35 tablespoons) molasses
- 1 liter of water (1.05 quarts)

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The Procedure for Inoculating the Bran Carrier is as follows:

1. To activate and extend an adequate supply of EM microbes to produce 5 kg of inoculated bran carrier, dissolve 20 ml of molasses into 1 liter of water (non-chlorinated is usually advised) along with 20 ml of EM•1® or IMO-1/IMO-2. Keep the solution in a sealed plastic bottle for 5-7 days away from direct sunlight. Quickly vent off excess gases once a day (if needed).
2. After several days, mix the expanded solution of EM or IMO-1/IMO-2 thoroughly with 5 kg of bran in a bucket. Avoid adding too much of the liquid, as a 40-50 percent level of moisture in the bran is desired. To monitor the moisture content while adding the expanded EM or IMO-1 solution, occasionally squeeze some of the bran into a ball. As with the fermented bokashi fertilizer, if no liquid can be squeezed out of the bran ball, and the material holds shape after being released but crumbles when tapped, then the bran contains an appropriate amount of moisture. It may not be necessary to add the entire liter of expanded solution to moisten 5 kg of bran.

If using a strong plastic bag in which to ferment the carrier, press the moistened material down to displace any air pockets and then tie the bag tightly after displacing excess air. Leave the bag of inoculated bran carrier undisturbed for two weeks or longer.
After near anaerobic storage for two weeks or more, the carrier will have a fermented, malt-like smell. It may also have some white mold growing on it, which

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indicates the presence of beneficial fermentation microorganisms. However, the presence of undesirable black or green mold probably means that the carrier was exposed to too much air or contaminants or that the inoculated bran was too moist when it was stored. Do not use the bran carrier if it has black or green mold growing on it.

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Break the moist, fermented carrier apart with your hands and spread it out on a canvas in a sunny location to dry. Every half hour or so, use a rake to spread and respread the inoculated bran until the material is completely dry.
Use a rolling pin to break apart any dry clods of bran, both large and small.
Store the fine, dry inoculated bran in a sealed plastic bag or other airtight container for long-term storage. Under dry, near anaerobic conditions, the inoculated carrier can be stored for a year or more.

For bigger batches of inoculated carrier for institutional/farm use, all of the materials listed above can be mixed in larger proportions. Additionally, other variations of the bokashi carrier are produced and used. Keith Mikkelson at Aloha House in Palawan, Philippines uses the following carrier mix:

- 1 sack of copra (dried coconut meat) meal.
- 3 sacks of carbonized rice husks.
- 3 sacks of low-grade rice bran.
- 00 ml (6.8 US oz.) of extended EM (EME) which is an EM solution that has already been activated and extended, making it ready for immediate use.
- 200 ml of molasses

At Aloha House, one sack of copra meal is mixed with three sacks of low-grade rice bran and three sacks of carbonized rice husks [Ed: for more information about carbonizing rice husks, the PhilRice Open Type Carbonizer]. The ingredients are mixed dry with shovels on a cement floor.

After mixing the dry ingredients, the EM solution (made from 200 ml EME and 200 ml molasses mixed in 10 liters/2.6 U.S. gallons of water) is watered in and mixed with the dry ingredients to obtain the desired 40-50 percent moisture content. The inoculated carrier is fermented and stored in airtight containers (e.g. PVC barrels or 20-liter plastic containers) until use.

Fermenting Food Scraps

When the inoculated carrier is ready, the production of kitchen bokashi can begin. Using a plastic bucket with an air-tight lid, apply a layer of newspaper or cardboard to the bottom to help soak up excess liquid (this step is optional). Then sprinkle a handful of inoculated bran over the bottom of the bucket.

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From that point, food scraps (not rotten) can be layered inside the bucket with a thin layer of inoculated bran sprinkled on top of the layered material. The inoculated bran does not need to be added thickly. At minimum, the bran should be sprinkled atop every 1-2 inches of layered food scraps. To increase anaerobic conditions, press down on the food scraps inside the bucket to eliminate air spaces. Continue layering in such fashion until the bucket is full.

If the container is not completely airtight, plastic bags may be used as a supplemental seal between the bucket and lid. To further lessen contact with air, you might place another layer of plastic bags on top of the compacted materials and weigh them down with a heavy item, such as a wooden chopping block.

To keep mess to a minimum, you can try to exclude liquid from the bucket. However, some commercial kitchen bokashi buckets come equipped with spigots that allow liquid “bokashi tea” to be easily removed, diluted with water and used to nourish plants.

Once the bucket is full, it should remain sealed with the lid tightly closed. Allow the contents to ferment for at least two weeks in a cool, shaded location. With lactic acid fermentation, little if any pressure will build up as the production of gases will be minimal. However, white mold is likely to appear on top of the product, indicating the presence of beneficial bacteria. As noted above, should there be mostly gray, black or green mold and a putrid odor, the fermentation process was probably unsuccessful and the materials should be disposed of. Under appropriate conditions, kitchen bokashi can be stored for months.

Despite efforts to seal bokashi fermentation containers, somehow, adult black soldier flies (Hermetia illucens) often manage to enter containers of bokashi and lay eggs. Masses of the oval, yellow or cream colored, 1 mm long eggs may be found deposited within the sheets of plastic covering the bokashi. Several days after the eggs are laid, a mass of larvae will emerge. Fortunately, neither the black soldier fly adults or larvae are pests; the larvae are actually a good source of protein for chickens or fish. The larvae may be fed to chickens and/or fish or relocated to compost/vermicompost production areas with abundant food suitable for their development. There, they can continue to be harvested as long as they last.

Applying the Fermented Kitchen Bokashi as a Soil Amendment

After it has fermented sufficiently, the finished bokashi should be buried in holes or trenches in the garden under at least 15-20 cm (6-8 in.) of soil to keep it from being disturbed by rats or other animals. Mixing soil with the bokashi will help speed the final decomposition process.

Black soldier flies may burrow down through the soil to any shallow bokashi and lay eggs, with larvae visible several days later. Again, this should not be a concern. However, if the buried bokashi be disturbed before it has finished composting in the soil, there may be an unpleasant smell.

After several weeks (depending on conditions), the fermented kitchen bokashi will have changed into a composted, soil-like material. When the composting process is complete, the former food waste should not have any bad odor.

Once incorporated into the soil, the finished kitchen bokashi will add nutrients and beneficial microbes, and will contribute to improved soil structure. Worms, arthropods and other small creatures—indicators of soil health—will thrive in the composted bokashi. Crops will benefit, too.

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Conclusion

Both fermented bokashi fertilizer and kitchen bokashi are relatively easy to produce and offer multiple benefits. Use of both types of bokashi has spread well beyond Japan and around the world. Though different in composition and application, both the fermented bokashi fertilizer and kitchen bokashi can be readily produced for use on small farms and in household gardens.

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