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Comparison of Waste Food Machines

Comparing Dry and Wet Types

1 Introduction

1.1 General

There are two basic ways to help you dispose of your waste food on site: dry types of machine and wet types of machine.[1] These types of machines are designed to process the waste food generated each day in a commercial environment. They have capacities ranging from 20 kg (40 lb) per day to 1800 kg (4000 lb) per day.[2] Often they are constructed of stainless steel and designed to be installed in the kitchen of the establishment. Some models of drying machine are painted and designed to be placed outdoors, generally under a cover. For a machine designed to handle 200 kg (450 lb) per day, the machine is the size of a work-bench or large desk.

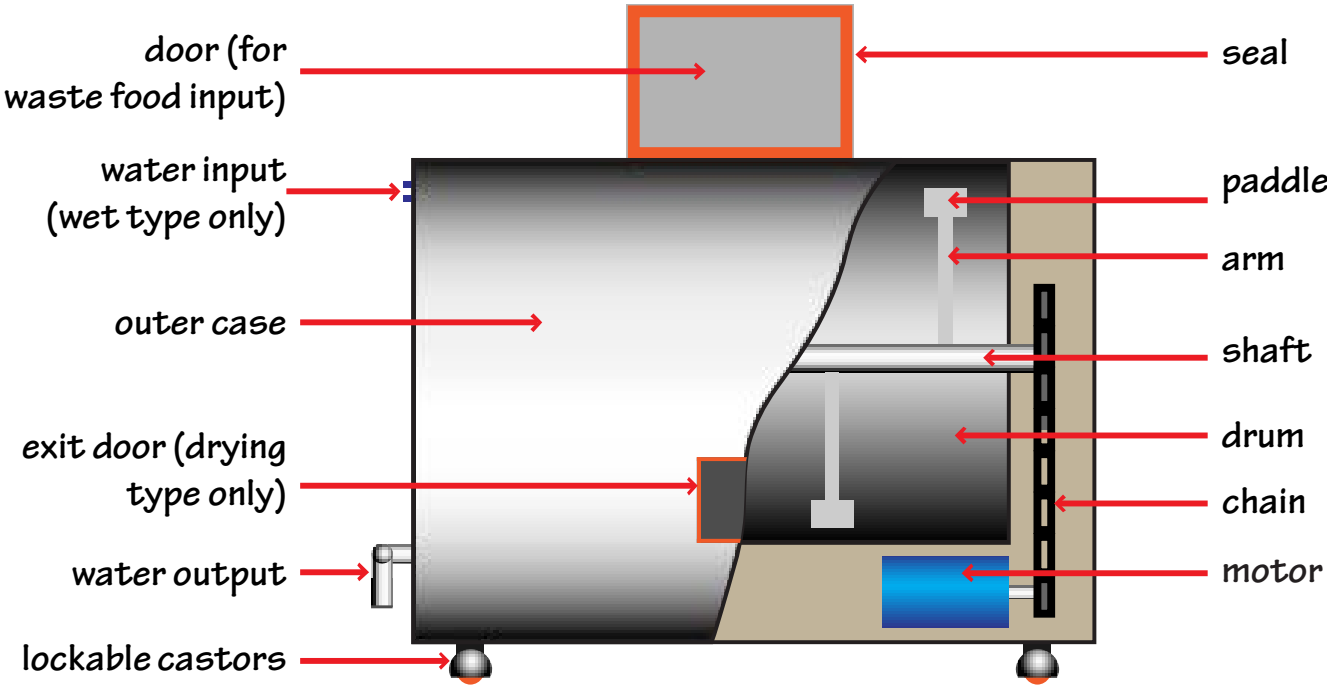
The basic construction of the machines is similar; the differences lie in how the waste food is processed. The machines have a door on top of the machine through which you put the waste food. The waste food enters a cylindrical drum. An electric motor turns a horizontal shaft which has arms that mix the waste food. On a drying machine, these arms may be more complex as they may aid in cutting the waste to pieces. The figure on the next page shows the basic construction.

1.2 Drying Machines

A drying machine dries waste food. After you have added the waste food you shut the door and start the process. This is a batch process that once started should not be disrupted. The machine heats the food to about 90°C (195°F). While it heats the waste food, the machine mixes the waste which helps to break it into small pieces. After 10 to 18 hours (depending on the model), the waste food is completely dry and the heating stops. After a period of cooling, the dried waste can be removed. A trap door, usually on the front of the machine, is opened and the dried food is expelled into a bucket or bowl. Once emptied, you can start to put more waste food into the machine.

Drying machines are often called a dehydrator. Some manufacturers call them “composters,” though as we discuss later, the output is dried waste food and not compost.

1. Another option to dispose of the waste food is to decompose in a compost heap or large compost machine on site. Most organizations do not have the land available for such a process or the staff to administer it, so it is not discussed in this article.
2. Larger systems are available for municipalities. These are not discussed here.



1.3 Wet Machines

A wet machine composts the waste food in real time. You add the waste food at any time. The waste food is decomposed using a special blend of microorganisms (which often contains enzymes). The machine uses water (generally hot water) to keep the mixture moist. The waste food decomposes to water and carbon dioxide (CO_2). This waste exits the machine through a drain that generally goes to the sewer as grey water.

The microorganisms live in wood chips or specially manufactured bio-chips. The microorganisms need replenishing periodically and the bio-chips need to be replaced every few years.

1.4 Summary

The general operation is summarized as:

Drying Machine	Wet Machine
• Waste food in — dried food out	• Waste food in — grey water out

2 Technology

Many of the machines manufactured to process waste food originate from Korea. Korea is a small peninsular which comprises 72% mountains. Land is scarce and in 1991 the country mandated the separation of waste food from other materials. A market evolved to dispose of the waste food at source so products have been developed in Korea over the past 25 years. The way the country handles it garbage is seen as a model

for other countries to follow and Japan has now similar restrictions. The USA has no similar policy, though certain cities (such as San Francisco, Austin, and Portland) and certain states (such as California and Massachusetts) are advanced in their thinking about how the disposal of waste food affects our environment.

Over the past few years, companies to manufacture waste food machines have become established in the USA, Europe, and other Asian countries. The author estimates that the biggest markets for these machines are still in Korea and Japan.

3 Sizing

Drying machines are rated by the typical capacity that can be processed in one batch. For example, a machine may process 100 kg (225 lb) in a batch. If the process time is 12 hours or less, the manufacturer may rate such a machine as processing 200 kg (450 lb) per day. However, operating the machine twice a day may not be practical in many instances.

The capacity of a wet machine depends on the type of waste food and how frequently it is added to the machine. Items such as rice and bread are decomposed in a few hours. Fruits and vegetables are decomposed in eight hours. However, items such as heads of pineapples and corn husks may take several days to decompose. A manufacturer may rate a machine as capable of processing 400 kg (900 lb) per day assuming that foods which are quickly digested are fed to the machine regularly throughout a 24 hour day. Another manufacturer may rate the same machine as having a capacity of 200 kg (450 lb) per day based on a 12 hour working day and a mixture of food types.

4 Prices

Prices vary from manufacturer to manufacturer and from dry type to wet type. As a rough guide, the price for a machine that can process 200~300 kg (450~650 lb) per day will cost between $30,000 and $60,000. Leasing is usually available to allow an organization flexibility in how it pays for the machine. Leasing a machine that can process 200~300 kg (450~650 lb) per day may typically cost $650 to $1200 per month.

5 Advantages

5.1 Drying Machines

It may be possible to further process use the output material for fertilizer. However as discussed below, the material is not suitable for applying directly to plants because it needs further processing to make matured usable compost. If such processing is available, it is a great advantage to be able to recover the nutrients to help grow further crops or plants.

Because the drying machines raise the temperature of the waste food to 90°C (195°F), most pathogens (bacteria that are harmful to people) are destroyed.[1] The resulting material is therefore safe to handle.

The machine needs no water input. It also does not require the addition of microorganisms, enzymes, or bio-chips.

Depending on the manufacturer of the machine, a drying machine may accommodate bones and shells. Such items could be ground as they enter the machine or cut to pieces by the arms during the drying process. This means that the waste food does not need to be separated before going in the machine and it also means that less waste goes to the landfill. However most drying machines do not permit the entry of such items in the same way they are prohibited from entry to a wet machine.

A drying machine processes all waste food in the same time. So foods that may decompose quickly or slowly in a wet machine are all consistently processed in a drying machine.

For a drying machine, a drain is not necessarily mandatory. Instead, the output water may be clean water and saved in a bucket. You can empty the bucket at the same time as you empty the waste. For example, on a machine that processes 100 kg in each batch, perhaps 85% will be removed as water. So, there will be 85 kg (85 litres, or 22 gallons).

5.2 Wet Machines

The waste food is input to the machine continuously as the food is generated. This is more convenient than a batch process, especially for any restaurant that is serving meals throughout the day. As food is prepared, the scraps can be discarded without accumulating it until the machine is available.

The waste food is decomposed aerobically in the liquid food composting machine. This process has minimal odor so such machines are almost always placed in the kitchen where food is prepared and where the waste food is generated. The bottom of the drum has a fine mesh screen and over 99% of the material exiting through this mesh is truly decomposed waste food.

This waste exits the machine as a grey water that is rich in nutrients.[2] After filtering this may be used for irrigation but more normally it is sent down the drain.[3] In either case, the machine does not need emptying once or twice a day.

The wet machine uses little electricity and little water. For example, a machine that processes 200 kg (450 lb) per day may cost about $1 per day to operate.

1. For example, E. coli and Salmonella are largely destroyed at 70°C (160°F) according to the United States Department of Agriculture (USDA). Milk is pasteurized at 72°C (162°F) for 15 seconds. http://www.fsis.usda.gov/Regulations_&_Policies/Compliance_Guides_Index/
2. This is sometimes referred to as “tea water,” but this author does not think it is an appropriate term.
3. The nutrients are not lost to the environment but are instead recycled through the sewage facility.

5.3 Summary

The advantages are summarized as:

Drying Machine	Wet Machine
• Pathogens are destroyed • Requires no water input • A permanent drain may not be necessary • May take bones and shells • Consistent time to process regardless of food type	• Continuous process • Decomposes waste food • Does not need emptying • Low operating cost • Indoor installation (close to waste food)

6 Disadvantages

6.1 Drying Machines

The machine processes the waste food as a batch process. That is, you fill the machine, start the process, and return many hours later. The drying process typically takes from between 10 and 23 hours. Most machines can therefore process one load a day. This is an advantage if the machine is used at a banquet facility, for example, where one meal is prepared a day. At the end of the banquet, all the waste food (both from the preparation of the meal and the remains from plates) is put in the machine before staff leave. But in most cases, the time to process is seen as a disadvantage, especially if the restaurant is serving meals throughout the day. In this case, the waste food must be accumulated until the last batch has been completed by the drying machine.

A drying machine uses much energy. Significant heat is required to get all the waste food to the high temperature required to dry it. For example, a machine that can process 100 kg (250 lb) may require anything from 40 kWh to 80 kWh per batch depending on the actual volume of the waste food.[1]

The drying process produces much odor. As a result, such machines are often sited outside and have a chimney to divert the odor away from people. More sophisticated machines have a special process to remove odors so a chimney is not required and the machine may be installed indoors.

At the end of the cycle, the machine produces waste that must be emptied; with most machines this is a manual task.

The waste that exits a drying machine is dried waste food; it is not a fertilizer. It looks like a dark brown fibrous powder. Some more complex drying machines automatically start a process to decompose this dried waste but most machines expel the waste untreated from the machine.

The volume of waste is anywhere from 10% to 20% of the original volume and weight of the waste food. If this waste is now discarded, it will save the operator money on the collection of trash. However, because the waste is not decomposed, then when it goes to a landfill it will decompose there. That decomposition

1. See Appendix A on page 9 for an analysis.

will usually happen in the absence of oxygen and therefore produce methane, just as if the original material were discarded. In this case, the organization has not reduced its carbon footprint.

In some jurisdictions it may be permitted to spread the waste on top of soil and as such the waste from a drying machine is sometimes referred to as a "soil amendment," "soil conditioner," or "primary compost."[1] When you dispose of the waste by spreading it on top of the soil, it will absorb moisture over time and decompose naturally. The decomposition takes place in the presence of oxygen so it is an aerobic decomposition which is much less harmful than an anaerobic decomposition. This will release nutrients to the soil which are beneficial for growing.

However, if the waste is tilled into the soil, it will likely decompose in the absence of oxygen and thus produce methane. In this case, the waste contributes to global warming and may become acidic as it decomposes. The soil should be left for many months to allow the acids to disperse before growing plants.

In any event, if the material is to be used for fertilizer, you need to test it for the presence of salt. Most plants can tolerate less than 1% salt in the fertilizer and if the dried material has greater than this you may need to treat it before using it.

Often, the handling of the waste from a drying machine is seen as an inconvenience and a disadvantage.

6.2 Wet Machines

The wet machine needs a supply of water. Generally warm water is supplied to keep the waste food moist as well as accelerate the process. Cold water is supplied to rinse the sludge out of the bottom of the machine and down the drain.

The drain output must be permanent to allow the grey water to exit at any time. However, the flow of this grey water is fairly slow. For example, on a machine that processes 100 kg a(220 lb) day, the water flow is approximately 15 litres per hour (0.3 gallons per minute).

Although the grey water can safely be sent down the drain, any pathogens that were in the waste food are not guaranteed to be killed. The drum temperature is normally between 35°C to 45°C (95°F to 113°F), too low to guarantee the same level of sterilization as in a drying machine.

The wet machine relies on a special blend of microorganisms and enzymes to decompose the waste food. This accelerates the decomposition process but over time, this blend will become diluted. Depending on the type of waste food added to the machine, this blend needs to be replenished. Some manufacturers spray additional microorganisms into the drum periodically while others recommend replenishment every six to 18 months.

The microorganisms use a medium of bio-chips that permanently reside in the machine. These bio-chips may be natural (for example made from wood) or may be a special plastic. In either case, the chips lose their ability to house the microorganisms over time and need to be replaced. For wooden chips this is typically done every six months; plastic chips may typically be replaced every three to five years.

1. It is illegal in the State of California (our home state) to spread the output of a drying machine on the ground. It is considered waste (albeit dried) and you require a landfill permit to throw waste onto the ground.

A wet machine can typically digest only what the human stomach can digest. This precludes large bones, for example, which can sometimes be placed in a drying machine.

6.3 Summary

The disadvantages are summarized as:

Drying Machine	Wet Machine
• Batch mode • Needs emptying after every operation • Just dries food – does not decompose it • Outdoor installation (away from kitchen) • High electricity cost • Needs drain output • Produces odors	• Cannot take bones or shells • Needs water supply • Needs drain output • Pathogens are not guaranteed to be killed • Requires periodic addition of microorganisms and replacement of bio-chips

7 Cost Comparison

A drying device uses much power and energy. From the specifications for two major manufacturers of these machines we obtain the following for drying machines that can process 300 kg (660 lb) of waste per cycle:

	Manufacturer 1	Manufacturer 2
Specified capacity (per cycle)	650 lb	660~1100 lb
Voltage requirement	208~220 V, 3Ø	200~220 V, 3Ø
Current requirement	75 A	100 A
Specified power	15 kW	24~30 kW
Cycle time	18~21 hours	18~23 hours
Anticipated energy used, if heated 2/3 of time	15 kW x 19.5 h x 67% = 196 kWh	17 kW x 20.5 x 67% =233 kWh

The average of these two units is 214.5 kWh per day. If the cost of electricity is 16¢ per kWh then the drying machine costs $34.32 per day to operate. This is $12,527 per year.

A comparable alternative is the LFC-300 from Power Knot. This can digest 660~1200 lb per day. This machine uses 10 kWh of electricity per day and therefore costs $1.60 per day to operate. The LFC-300 also uses 210 gallons of water per day and this costs $0.42.[1] Other operating costs for the LFC are the costs of

1. The US EIA (Energy Information Administration) reports (July 2013) that average cost of electricity in California ia 15.98¢ per kWh. The average cost throughout the US is 10.71¢ per kWh. These numbers do not include other costs imposed by the delivery or peak demand of the electricity which can typically add 20% to a utility bill. The US EPA reports (May 2011) that the average cost of water in the USA is $2.00 per 1000 gallons.

Powerzyme and Powerchips. These costs amount to $3.02 per day or $1102 per year. The total operating costs for the LFC-300 are therefore $1840 per year.

Here is a summary table:

	Drying machine	LFC-300
Nominal capacity per day	300 kg (660 lb)	300 kg (660 lb)
Daily costs		
Electricity	$34.32	$1.60
Water	—	$0.42
Microorganisms and bio-chips	—	$3.02
Total	$34.32	$5.04
Yearly costs	$12,527	$1,840
Five year costs of operation	**$62,635**	**$9,200**

If we assume the initial purchasing costs are the same and the maintenance costs are similar, the cost of ownership for the dry machine is significantly more than for the wet machine.

8 Conclusion

We should not be discarding waste food in the landfill. This is detrimental to our environment and uses resources unnecessarily to transport the waste away from where it is generated.

The choice of a dry or wet machine to process the waste food depends on the criteria of the specific establishment. Either type of machine will streamline the operation, reduce costs, and improve the environment. Any establishment that generates over 10 kg (25 lb) of waste food per day should seriously investigate installing a machine like this to help save the planet.

Power Knot provides safe and economically sound solutions for commercial, industrial, and military customers globally seeking to reduce their carbon footprint. The LFC (Liquid Food Composter) allows customers to reduce the expense, inconvenience, and mess of disposing of waste food that would otherwise be hauled to a landfill. Models are available that process from 20 kg (40 lb) per day to 1800 kg (4000 lb) per day of waste food. Our technologies are proven, available today, have been in reliable use for many years, and offer a payback period typically of less than three years. Power Knot is a profitable company and we design, develop, and assemble the LFCs at our headquarters in Silicon Valley, California. For more information, access www.powerknot.com.

Appendix A

Energy Required by a Drying Machine

This analysis describes the physics of a drying machine. If you have a certain mass of waste food at room temperature, you require a certain amount of energy to dry that waste food. This is physics and cannot be overcome no matter how "efficient" the manufacturer of the drying machine may claim.

Mass of waste food	100 kg	
Specific heat of typical waste food	2 kJ/(kg.K)	
Initial temperature of waste food	20°C	
Boiling temperature of water	100°C	
Temperature rise of waste food to boiling	80 K	
Energy required to raise temperature	16,000 kJ	7%
Heat loss per hour	20%	
Duration of heat (cycle time is slightly longer)	12 hours	
Energy required to maintain temperature	38,400 kJ	16%
Content of waste food that is water	75%	
Mass of water	75 kg	
Latent heat of water	2257 kJ/kg	
Energy required to boil this water	169,275 kJ	70%
Power of motor	400 W	
Energy used by motor	4.8 kWh	
Energy used by motor	17,280 kJ	7%
Total energy required for process	240,955 kJ	100%
Total energy required for process	67 kWh	

Operating costs for 100 kg (220 lb) per day drying machine

Power of machine	6 kW
Operating time	12 hours
Energy consumed per cycle	67 kWh
Cost of energy, per kWh	$0.28
Cost per cycle (per day)	$18.76
Energy cost per month	$570.62
Energy cost over five years	**$34,237.00**