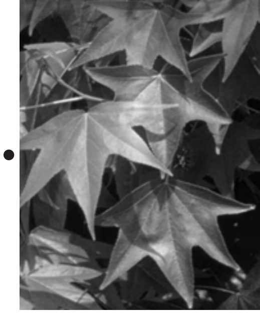

3

GETTING THE RIGHT MIX[1]

Once the bin or bioreactor is constructed, it is time to add the organic materials that will form compost. If you have several materials that you want to compost, how do you figure out the appropriate mix to ensure the proper balance of carbon, nitrogen, and moisture content? You may want to do this by simply estimating the right mix of materials that are wet and rich in nitrogen, such as food scraps, with other materials that soak up moisture and are high in carbon, such as wood chips. In fact, many experienced composters develop a "feel" for what works, following the general rules of thumb described in this chapter for estimating appropriate mixtures of compost ingredients.

Other composters, especially compost researchers and operators of large-scale commercial systems, combine general guidelines with more precise calculations. For those who prefer to be exact about adding ingredients, the second section of this chapter shows how to calculate a mixture of organic materials that is balanced in terms of carbon, nitrogen, and moisture content.

CHOOSING THE INGREDIENTS: GENERAL RULES OF THUMB

MOISTURE

One of the most important considerations for successful composting is the moisture content of the ingredients. In general, you want to achieve a balance between materials high in moisture, such as fruit and vegetable scraps, with dry materials such as wood chips. A common rule of thumb is that the compost mixture has the right moisture content if it is about as wet as a wrung-out sponge, with only a drop or two expelled when it is squeezed.

Composting proceeds best at a moisture content of 50–60% by weight. Table 3–1 lists typical moisture contents of common compost ingredients.

Table 3–1. Moisture Content of Common Compost Ingredients.[2] *(These data should be viewed as representative ranges, not as universal values.)*

Material	Moisture content (% wet weight)
Vegetables and fruits	80–90
Grass clippings	80
Leaves	40
Sawdust	40
Shrub trimmings	15

Instead of relying on typical figures such as those in Table 3–1, you may wish to measure the moisture content of your compost. You can use the following procedure to measure moisture either in the mixture as a whole or in the individual ingredients prior to mixing.

MEASURING COMPOST MOISTURE

1. Weigh a small container, such as a paper plate or cupcake wrapper.

2. Weigh 10 g of compost into the container.

3. Dry the sample for 24 hours in a 105–110°C oven. (Using a microwave oven is a possible alternative, but this requires some experimentation to determine the drying time. Begin by spreading the compost into a thin layer in a microwave-safe container, then heat for one minute at full power. Remove the sample and weigh it. Reheat for another minute, then weigh it again. Repeat this cycle until the weight change becomes negligible. If the sample becomes burned or charred, start over and use reduced power or shorter heating times.)

4. After drying, reweigh the sample, subtract the weight of the container, then calculate the percent moisture content using the following equation:

Equation 1:

$$M = \frac{W_w - W_d}{W_w} \times 100$$

in which:

M = *moisture content (%) of compost sample*

W_w = *wet weight of the sample, and*

W_d = *weight of the sample after drying.*

If you have used a 10 g compost sample, this simplifies to:

$$M = \frac{10 - W_d}{10} \times 100 = (10 - W_d) \times 10$$

CARBON-TO-NITROGEN RATIO

The second important consideration for successful composting is the balance between carbon and nitrogen. High-carbon and high-nitrogen materials should be mixed to achieve a C:N ratio of roughly 30:1 (Table 3–2). High-carbon materials usually are brown or woody. They include autumn leaves, wood chips, sawdust, and shredded paper. High-nitrogen materials generally are characterized as green and include grass clippings, plant cuttings, and fruit and vegetable scraps.

Table 3–2. C:N Ratios of Common Compost Ingredients.[3] *(These data should be viewed as representative ranges, not as universal values.)*

Materials High in Carbon	C:N
autumn leaves	40–80:1
sawdust	200–750:1
wood chips or shavings—hardwood	450–800:1
wood chips or shavings—softwood	200–1,300:1
bark—hardwood	100–400:1
bark—softwood	100–1,200:1
straw	50–150:1
mixed paper	100–200:1
newspaper	400–900:1
corrugated cardboard	600:1
Materials High in Nitrogen	**C:N**
vegetable scraps	10–20:1
fruit wastes	20–50:1
coffee grounds	20:1
grass clippings	10–25:1
cottonseed meal	10:1
dried blood	3:1
horse manure	20–50:1

Although tree leaves in general are considered to be high in carbon and low in nitrogen, this varies considerably according to the species or genus (Table 3–3).

Table 3–3. C:N Ratios of Common Tree Leaves.[4]

Tree	C:N of Leaves	Tree	C:N of Leaves
Alder	15:1	Birch	50:1
Ash	21:1	Aspen	63:1
Elm	28:1	Spruce	48:1
Black elder	22:1	Beech	51:1
Hornbeam	23:1	Red oak	53:1
Linden	37:1	Pine	66:1
Maple	52:1	Douglas fir	77:1
Oak	47:1	Larch	113:1

OTHER CONSIDERATIONS

In addition to moisture content and C:N ratios, several other considerations are important when choosing materials to compost. Prime among these is the time that the materials will need to break down. Woody materials, including wood chips, branches, and twigs, can take up to two years to decompose unless they are finely chipped or shredded. Other materials that break down slowly include corn cobs and stalks, sawdust, straw, and nut shells. When shredded or chipped, these materials can be used as bulking agents to increase aeration within the pile.

The organic materials may be placed in the compost pile all at once (batch composting) or added over time as they become available. If the materials are added gradually, the pile will not heat up significantly until it is large enough to be self-insulating. Although in the past composters often layered various materials, it is probably better to mix the different ingredients to ensure optimal C:N ratios and moisture contents throughout the pile. Always cover food scraps with a layer of sawdust, leaves, or finished compost to trap odors and to avoid attracting flies or other pests.

Research Possibility: *What is the effect of layering versus mixing organic ingredients on the compost pile temperature profile?*

Almost all natural organic materials will compost, but not everything belongs in a classroom or school-yard compost pile. Some organic materials, such as meat and dairy products and oily foods, should be avoided because they tend to attract rodents, raccoons, and other pests. Cat and dog manures may contain harmful pathogens that are not killed during composting. If you plan to use the compost for growing plants, you should avoid adding pernicious weeds because their seeds or runners might survive the composting process. Some weeds to avoid include bindweed, comfrey, and rhizomatous grasses such as Bermuda and crab grass.

CALCULATIONS FOR THERMOPHILIC COMPOSTING

by Tom Richard and Nancy Trautmann

You can use the algebraic equations below to compute the best combination of compost ingredients. The calculations are optional, but they can be useful in a number of situations, such as for figuring out what quantity of wood chips to mix with a known quantity of food scraps from the cafeteria. These calculations also provide an opportunity to apply algebra to a real-world problem.

MOISTURE

The following steps outline how to design your initial mix so that it will have a suitable moisture level for optimal composting.

1. Using the procedure on p. 44, measure the moisture content of each of the materials that you plan to compost. Suppose, for example, that you weigh 10 g of grass clippings (W_w) into a 4-g container and that after drying, the container plus clippings weigh 6.3 g. Subtracting the 4-g container leaves 2.3 g as the dry weight (W_d) of your sample. Using Equation 1, the percent moisture would be:

$$M_n = \frac{W_w - W_d}{W_w} \times 100$$

$$= \frac{10 - 2.3}{10} \times 100$$

= 77% for grass clippings

2. Choose a moisture goal for your compost mixture. Most literature recommends a moisture content of 50–60% by weight for optimal composting conditions. Note that the grass clippings exceed this goal. That is why piles of fresh grass clippings turn into a slimy mess unless they are mixed with a drier material such as leaves or wood chips.

3. Calculate the relative amounts of materials to combine to achieve your moisture goal. The general formula for percent moisture is:

Equation 2:

$$G = \frac{(W_1 \times M_1) + (W_2 \times M_2) + (W_3 \times M_3) + \ldots}{W_1 + W_2 + W_3 + \ldots}$$

in which:

G = *moisture goal (%)*
$\mathbf{W_n}$ = *mass of material* **n** *("as is," or "wet weight")*
$\mathbf{M_n}$ = *moisture content (%) of material* **n**

You can use this formula directly to calculate the moisture content of a mixture of materials, and then try different combinations until you get results within a reasonable range. Although this trial and error method will work to determine suitable compost mixtures, there is a faster way. For two materials, the general equation can be simplified and solved for the mass of a second material (W_2) required to balance a given mass of the first material (W_1). Note that the moisture goal must be between the moisture contents of the two materials being mixed.

Equation 3:

$$W_2 = \frac{(W_1 \times G) - (W_1 \times M_1)}{M_2 - G}$$

For example, suppose you wish to compost 10 kg of grass clippings (moisture content = 77%) mixed with leaves (moisture content = 35%). You can use Equation 3 to calculate the mass of leaves needed in order to achieve a moisture goal of 60% for the compost mix:

$$W_2 = \frac{(10 \times 60) - (10 \times 77)}{35 - 60}$$

= 6.8 kg leaves needed

The moisture content and weights for mixtures of three materials can be derived in a similar way, although the algebra is more complicated. For an exact solution, you need to specify the amounts of two of the three materials, and the moisture contents of all three. Then, you can use Equation 4 to determine the desired quantity of the third ingredient.

Equation 4:

$$W_3 = \frac{(G \times W_1) + (G \times W_2) - (M_1 \times W_1) - (M_2 \times W_2)}{M_3 - G}$$

CARBON-TO-NITROGEN RATIO

To calculate the amounts of various materials to add to a compost pile with a C:N ratio of 30:1, you need to know the nitrogen and carbon contents of the individual ingredients. You can use the typical C:N ratios shown in Table 3–3 (p. 45) to calculate the carbon content of an ingredient provided that you know its nitrogen content, or its nitrogen content provided that you know its carbon content. The carbon content of your compost ingredients can be estimated using the **Organic Matter Content** procedure outlined in Chapter 5 (p. 87). Or, you can have your compost ingredients tested for nitrogen and carbon at a soil nutrient laboratory or environmental testing laboratory.

Once you have the percent carbon and nitrogen for the materials you plan to compost, Equation 5 enables you to figure out the C:N ratio for the mixture as a whole:

Equation 5:

$$R = \frac{W_1[C_1 \times (100 - M_1)] + W_2[C_2 \times (100 - M_2)] + W_3[C_3 \times (100 - M_3)] + \ldots}{W_1[N_1 \times (100 - M_1)] + W_2[N_2 \times (100 - M_2)] + W_3[N_3 \times (100 - M_3)] + \ldots}$$

in which:

R = *C:N ratio of compost mixture*
W_n = *mass of material* **n** *("as is," or "wet weight")*
C_n = *carbon (%) of material* **n**
N_n = *nitrogen (%) of material* **n**
M_n = *moisture content (%) of material* **n**

This equation can be solved exactly for a mixture of two materials if you know their carbon, nitrogen, and moisture contents. You specify the C:N ratio goal and the mass of one ingredient, then calculate the mass of the second ingredient. Equation 6 is derived by limiting Equation 5 to two ingredients and rearranging the terms to allow you to solve for the mass of the second ingredient:

Equation 6:

$$W_2 = \frac{W_1 \times N_1 \times \left(R - \frac{C_1}{N_1}\right) \times (100 - M_1)}{N_2 \times \left(\frac{C_2}{N_2} - R\right) \times (100 - M_2)}$$

Returning to the previous example of grass and leaves, assume the nitrogen content of the grass is 2.4% while that of the leaves is 0.75%, and the carbon contents are 45% and 50% respectively. Simple division shows that the C:N ratio of the grass is 19:1, and the C:N ratio of the leaves is 67:1. For the same 10 kg of grass that we had before, if our goal is a C:N ratio of 30:1, the solution to Equation 6 is:

$$W_2 = \frac{10 \times 2.4 \times (30 - 19) \times (100 - 77)}{0.75 \times (67 - 30) \times (100 - 35)}$$

$$= 3.5 \text{ kg}$$

Note that we need only 3.5 kg leaves to balance the C:N ratio, compared with 6.8 kg leaves needed to achieve the 60% moisture goal according to our previous moisture calculation. If the leaves were wetter or had a higher C:N ratio, the difference would be even greater. Given the disparity between these results, how should you decide how many leaves to add?

If we solve Equation 5 for the 10 kg of grass and the 6.8 kg of leaves (determined from the moisture calculation) and use the same values for percent moisture, C, and N, the resulting C:N ratio is approximately 37:1. In contrast, if we solve Equation 2 for 10 kg of grass and only 3.5 kg of leaves, we get a moisture content over 66%. (To gain familiarity with using the equations, check these results on your own.)

For mixtures toward the wet end of optimum (>60% moisture content), moisture is the more critical variable. Thus, for the example above, it is best to err on the side of a high C:N ratio. This may slow down the composting process slightly, but it is more likely to avoid anaerobic conditions. If, on the other hand, your mixture is dry, you should optimize the C:N ratio and add water as required.

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[1] Portions of this chapter were adapted from Dickson, N., T. Richard and R. Kozlowski. 1991. *Composting to Reduce the Waste Stream*. Northeast Regional Agricultural Engineering Service. 152 Riley-Robb Hall, Cornell University, Ithaca NY 14853.

[2] Rynk, R., ed. 1992. *On-Farm Composting Handbook*. Northeast Regional Agricultural Engineering Service, 152 Riley-Robb Hall, Cornell University, Ithaca NY 14853.

[3] Rynk, R., ed. 1992. *On-Farm Composting Handbook*. Northeast Regional Agricultural Engineering Service. This manual includes a table of C:N ratios and %N of a wide range of compost materials. *Available on-line at:*
http://www.cals.cornell.edu/dept/compost/OnFarmHandbook/apa.taba1.html,
or in print from: Northeast Regional Agricultural Engineering Service, 152 Riley-Robb Hall, Cornell University, Ithaca NY 14853.

[4] Schaller, F. 1968. *Soil Animals*. University of Michigan Press, Ann Arbor.