

Recipe Formulation Guide

How to Formulate a Grain Bill

1. Set a target OG range (i.e. 1.048 to 1.056), a target gravity (i.e. 1.052), and convert to gravity units (i.e. 52)
 - a. $(SG_{original} - 1) \times 1,000 = GU$
2. Establish the finished volume of beer to be produced (i.e. 5.5 gallons) and multiply by the GU to get the GU_{total}
 - a. $xGallons \times GU = GU_{total}$
3. Establish what fermentable ingredients you wish to use, and their approximate proportions
4. Calculate the gravity that should come from each fermentable source, or the total Ingredient Gravity Units (IGU)
 - a. $p(total\ grist) \times GU_{total} = IGU$
5. Establish a value for the efficiency of extraction per ingredient (typically 65 to 80 percent for grain, 100 of non-grain fermentables)
6. Calculate the number of pounds for each ingredient needed. This is done by taking the IGU and dividing by the GUs extracted per pound, or potential GU per pound times the mash efficiency. To find the potential GU per pound of grain, reference Homebrew Dad's [Grain Database](#).
 - a.
$$\frac{IGU}{(GU\ per\ pound\ of\ fermentable \times Mash\ efficiency)} = Total\ pounds\ needed$$

How to Estimate Beer Color (SRM) using Malt Color Units (MCUs)

Malt color units, or MCUs, are standard units of measurement to determine the color contributed by an individual grain in the grain bill. Since there are several other factors that contribute to the color of a beer, the MCU alone cannot predict the color of the end product. Other factors that influence color, include:

1. Maillard, or browning, reactions that produce both color pigments and flavor compounds
2. Caramelization products
3. Oxidation products

However, if a standard boil time of 60 to 90 minutes is utilized, and efforts are taken to minimize oxidation, the MCU can be strongly correlated to SRM, as shown in reference table 1.

The following equation can be used to calculate the MCUs of an individual grain in the grain bill. The sum of these units equals the MCU value of the entire grain bill (MCU_{total}).

$$MCU_i = \frac{(Lovabond\ rating \times Pounds\ of\ grain)}{Gallons}$$

$$MCU_{total} = \sum MCU_i$$

The MCU_{total} then be correlated to the SRM using reference table 1 to estimate the final SRM.

How to Formulate a Hop Bill

1. Decide on your target IBU
2. Determine the amounts of flavor and aroma hops to be added, and of what type
3. Determine the IBUs contributed by the flavor and aroma hops (hops boiled less than 30 minutes)

a.
$$IBU = \frac{Woz. \times U\% \times A\% \times 7,489}{(Vgal. \times Cgravity)}$$

Where...

Woz. = Weight of hops in ounces

U% = Utilization percent as a decimal from the utilization table (table 2)

A% = Alpha acid percentage as a decimal

Vgal = Volume of final wort in gallons

Cgravity = Correction for worts that have a gravity above 1.050. Utilize the value of 1 if the gravity is below 1.050.

i.
$$Cgravity = 1 + [(Gboil - 1.050) \div 0.2]$$

4. Subtract the IBU contribution from the flavor and aroma hops from the target IBU value
5. Use the IBU equation to determine the quantity of the bittering hops needed to produce the remaining IBUs for the recipe

a.
$$Woz. = \frac{Vgal. \times Cgravity \times IBU}{U\% \times A\% \times 7,489}$$

Where...

Vgal = Volume of final wort in gallons

Cgravity = Correction for worts that have a gravity above 1.050. Utilize the value of 1 if the gravity is below 1.050.

i.
$$Cgravity = 1 + [(Gboil - 1.050) \div 0.2]$$

IBU = Target IBU

U% = Utilization percent as a decimal from the utilization table (table 2)

A% = Alpha acid percentage as a decimal

Other Important Information & Formulas

Mash Efficiency

$$\text{Mash efficiency} = \frac{\text{Total gravity of wort}}{\text{Total potential gravity of grains}}$$

Assessing Gravity During Brewing

Since total gravity at the beginning of the boil equals the total gravity at the end of the boil, the following statement allows one to determine the ending gravity

$$\text{Ending GU} = \frac{(\text{Beginning GU} \times \text{Beginning volume})}{\text{Ending volume}}$$

Gravity Correction During Brewing

After assessing the gravity during brewing, one can adjust the gravity of the finished beer in the following ways:

*If the actual gravity is **lower** than the target gravity...*

1. Boil longer to produce a smaller volume of finished beer
2. Add sufficient malt extract to bring the gravity up to expected
 - a. The amount of extract needed can be calculated with the following equation: (Total expected gravity in GU - Total actual gravity in GU) / (Gravity per pound of extract in GU)
 - b. i.e. (408 GU - 355 GU) / (45GU/lb.) = 1.2 lb

*If the actual gravity is **higher** than the target gravity...*

1. Produce a larger volume of beer so the finished beer has the gravity desired
2. Remove a portion of the wort from the boil pot and use it for another purpose

Apparent Attenuation

$$A = (OG - FG) / (OG - 1)$$

Reference Tables...

Table 1: MCU to SRM

MCU	SRM	Color
1 – 10	1 – 10	Pale to light amber
11 – 20	8 – 12	Amber to dark amber
21 – 30	11 – 15	Dark amber to copper
31 – 40	15 – 17	Copper
41 – 50	17 – 20	Light brown to brown
50 – 85	20 – 30	Brown to black
>85	>30	Black to opaque

Basic Hop Utilization Values

Boil Time (minutes)	Whole-Hop Utilization (%)	Pellet-Hop Utilization
Dry hop	0	0
0 to 9	6	6
10 to 19	12	15
20 to 29	15	19
30 to 44	19	24
45 to 59	22	27
60 to 74	24	30
75 or longer	27	34

