PHOTO: PETER REES

Jill Mulvaney
is distiller, extractor and blender of aromatics and principal director of Alembics New Zealand.

With over 25 years of experience, Jill now teaches and consults on all aspects of plant extraction, aroma, and natural flavour, advancing ideas and products that can be utilised across a broad range of industries. Jill leads regular events and workshops that educate people about the exciting possibilities of botanical distillation and plant extraction, and her teaching will be available online soon at The Alembics Lab. Jill is passionate about the character of plants, the alchemical wonder of distillation, and enjoys sharing her knowledge with others.

Jill's formative years, growing up on an isolated farm in Hawkes Bay, her recent teaching partnerships with internationally renowned phytochemists and aromatic distillers in Europe and America, and her experience distilling New Zealand and Australian natives, forms the basis of her deep engagement with the natural world—which remains her greatest inspiration.

JILL MULVANEY, ALEMBICS NZ AND THE ALEMBICS LAB

Understanding Alcohol Distillation And Its Many Applications

INTRODUCTION

Alcohol— and a discussion of how to go about fermenting and distilling it— may not be foremost in the minds of medical herbalists who dive into an *Avena* publication. But alcohol is the predominant ingredient in every bottle of herbal extract you reach for when you come to prescribe to your clients. Even glycerine is a form of alcohol. For this reason alone, it's useful for practitioners to know more about the alcohol they're using, and where it comes from. Distilling is a fascinating process, and if this piques your interest, perhaps you should consider making your own.

So what is alcohol? The term actually refers not to a single substance, but to a collection of molecules, and these alcohol molecules are amongst some of the most common organic compounds. At a chemical level, alcohol is a molecule that contains one or more hydroxyl (-OH) functional group.[1] But there are many different types of alcohol molecules, so correct naming is important. Calling the substance we use for tincturing 'alcohol' is confusing, as it could mean any number of alcohols (outlined below) or a mixture of alcohols (like denatured alcohol)—many of which are toxic and not suitable for dermal or internal use.

Here are examples of some common alcohol molecules. I have listed them from lightest to heaviest, as that's how I came to know them— in an alcohol distillation, the lightest, most volatile alcohols with the lower boiling points come over in the first part of the distillation, and the heaviest ones at the end.

- **Acetone**—boiling point 56.5°C (134°F). Colourless, volatile and extremely flammable. Has a sweet, ketone-like smell, closely associated with nail polish remover (which is one of its many uses). Acetone is used in the medical, laboratory and cosmetic industries as a solvent and in cleaners. It is also used in paint strippers, hair dye, baby wipes and sunscreen.[2]
- **Methanol**—boiling point 64°C (147°F). Also known as methyl alcohol or wood alcohol, this is a toxic type of alcohol, because our liver breaks down the methyl alcohol into formaldehyde and formic acid. Obviously, we don't want to drink it, and it is easy to separate out during the early stages of the distilling process. Methanol is used in cleaning products and as fuel for camping stoves. Methylated spirits are mainly ethanol with (as much as 50%) methanol added along with a blue dye. Methanol is added to ethanol to give it an unpleasant smell and render it unsafe to drink, this mixture is called 'denatured alcohol'.[3]
- **Ethyl acetate**—boiling point 71.1°C (172°F) This is used as an industrial solvent, especially in paints. It is an effective solvent for laboratory use and is used to decaffeinate coffee. It is irritating to the eyes and respiratory tract and can cause drying and cracking of skin.
- **Ethanol**—boiling point 78°C (172°F) Ethanol (or ethyl alcohol) is what we focus on in distilling when we want clean, safe alcohol to use for practice and consumption. Ethanol is recommended for making botanical extracts, tinctures, perfume and recreational spirits. It is the only alcohol molecule that can be imbibed, and if you're lucky enough to live in a jurisdiction that allows it, you can embark on learning how to distil it yourself.
- **2- Propanol**—boiling point 82°C (180°F) Also known as isopropyl alcohol (or rubbing alcohol), it has a strong aroma and is used in antiseptics, hand sanitizers, disinfectants and detergents. It is unsafe to drink—being more toxic than ethanol, but less so than methanol. Interestingly, though it's more toxic than ethanol, it is gentler on skin as it has less of a drying effect.
- **1-Propanol**—boiling point 97°C (207°F) is a colourless liquid and an isomer of 2-propanol. It is formed naturally in small amounts during many fermentation processes and used as a solvent in the pharmaceutical industry—mainly for resins and cellulose esters, and sometimes as a disinfecting agent.
- **Butanol**—boiling point 116°C (241°F). Also known as butyl alcohol, butanol has many industrial applications, with uses in a wide variety of chemical and textile processes. It's also used in brake fluid, and it's a primary ingredient of water-based acrylic paint. In small quantities, butanol esters are used in fruit flavourings and perfumes.
- **Amyl alcohol**—boiling point 137.8°C (280°F). Commercial amyl alcohols are colourless liquids, slightly soluble in water, and are described as having a characteristic 'penetrating odour' [1] It's used as a solvent for resins and oily materials.
- **Furfural**—boiling point 161°C (322°F). Furfural is colourless but darkens on contact with air. It is denser than water, and its vapours are also heavier than air. Furfural is used in the production of lubricating oils, rosin, and diesel fuel. [1]

Diluting Spirits

PHOTO: PETER REES PHOTOGRAPHY

AN EXCELLENT SOLVENT

As you will see from this brief summary, all alcohols are useful solvents. A solvent is a fluid (or mixture of fluids) which, when tincturing, extracts constituents from the plant matrix. Solubility is based on a principle of 'like dissolves like'—meaning polar (water soluble) substances are soluble with each other, and nonpolar (soluble in fat and oil) substances are soluble with each other. Polar and nonpolar substances are immiscible.

As we've already mentioned, the safest alcohol to use as a solvent for making plant extracts and tinctures is **ethanol**, as it's the least toxic. Ethanol is also a great solvent because it has both polar and nonpolar molecules, meaning it can dissolve both polar and nonpolar compounds. Very useful.

ETHANOL—SOURCING AND ABV (ALCOHOL BY VOLUME)

The laws around selling ethanol are restricted in New Zealand, but as a trained herbalist you can apply to the customs department to get a permit to buy 96% ABV ethanol. This is ideal as it comes from a reliable source with data sheets so you can be assured it hasn't had any additives to 'denature it'. An ABV of 96% is the highest you can obtain and means 96% of the liquid is ethanol and the balance of 4% is water.

Another option is to buy vodka which is essentially just ethanol. However, most vodka has an ABV of 37–40% which is not high enough for many tinctures and is an expensive option. If you are making your own plant extract and tinctures, a high ABV ethanol will give you more choices and flexibility. The active constituents of plants don't all share the same polarities and require in some cases a high ABV to extract them—the higher the concentration of alcohol, the more powerful solvent it is. *Calendula officianalis* (marigold/calendula), Cannabidiol (CBD) and tetrahydrocannabidiol (THC) are examples that spring to mind and need at least 90% ABV for a good extraction. Most essential oils are also soluble in 96% ABV [4]. *Althaea officinalis* (marshmallow) root or flowers on the other hand only needs 20-30%.

Using a high ABV ethanol gives you the flexibility to use it over many applications, as you can easily dilute it for those substances requiring lower ABVs. Increasing the ABV however, is not quite as simple, as it requires distillation. Which is one reason that learning how to distil yourself becomes an attractive option—and New Zealand is one of the few countries in the world where it's legal to make your own spirits.

Being able to make my own, high ABV ethanol for my work was one of the main reasons I got into alcohol distillation, however I do also enjoy making aromatic spirits. But whether you use it recreationally or not, ethanol is useful in so many other facets of our lives, as:

- *Sanitising*
- *Pain relief*
- *Making water safe to drink*
- *Odour management*
- *Relaxation*
- *As a solvent to extract the active compounds of plants for phytome dicine*
- *Bartering in times of crisis.*

I have also become fascinated with the process. And I've realised that in our changing world, it could be important to know how to make alcohol that's safe to use, with ingredients we have to hand (or can obtain easily from our local supermarket).

Alcohol distillation is not a modern technique, though it has been refined over the centuries. At its heart lies the simple, fundamental process of fermentation—which is carried out by a living creature—yeast. This or-

ganism is remarkable, and certainly sparked my curiosity.

YEAST—THE LIVING BEING BEHIND FERMENTATION

Yeast is a single-celled microorganism that is responsible for fermentation. It feeds on sugars, and in the process, converts it into ethanol and carbon dioxide. Yeasts are everywhere, and we humans have had a long and intimate relationship with it and its processes—which is not just about making alcohol but also another staff of life—bread.

Let me take you through this process of creating ethanol—beginning with making the simplest kind of alcoholic ferment—a tomato paste sugar wash (TPW) using that incredible organism, yeast. Specifically, we are using baker's yeast *Saccharomyces cerevisiae*.

After yeast has done the hard work of creating the ethanol for us, we then use the distillation process to refine, purify and concentrate the wash into clean, safe alcohol. (Please note that this is an outline of the process. If you're interested in the nitty-gritty of making alcohol yourself, we'll be running much more in-depth courses on The Alembics Lab learning platform.) With that in mind, let's dive in.

Budding yeast cells

PHOTO: SCIENCE PHOTO LIBRARY

THE WASH (OR FERMENT)

This is where it all begins. It takes yeast, and a suitable sugary liquid for fermentation to occur. Yeast is like us—it loves fast food (sugar) which gives it heaps of energy to reproduce. But like us it also needs vitamins, nutrients, a comfortable pH and a nice warm even temperature so that it doesn't get stressed. Stressed yeast (like us and most organisms), produce off-notes and flavours. To achieve a good fermentation, just in the same way we look after our domesticated pets, we need a controlled environment.

INGREDIENTS

- **Yeast**—For this wash, we use baker's yeast, *Saccharomyces cerevisiae*. You can get this at your local food market.
- **Sugar**—Yeast likes to take the easy route and feast on simple sugars. We use ordinary white table sugar, as it's inexpensive and readily available.
- **Oxygen**—Yeast needs to breathe when it's waking up and uses oxygen for sterol synthesis and this keeps its cell wall pliant, which is important for cell growth and general health. We use a power drill with a paint stirrer attachment to oxygenate our TPW.
- **Lemon juice**— (or citric acid diluted in a little warm water). This helps to bring the acidity to an appropriate level for fermentation.
- **Water**—Tap is okay but needs to be filtered to have the chlorine removed. Groundwater and rainwater is recommended.
- **Nutrients**—Fermentation is hard work. Yeast needs all its essential vitamins and minerals to get through the fermentation in good shape and remain ready to work another day—just like we do. That's why we add Epsom salts, and tomato paste for nutrients. Always choose the low sodium variety tomato paste, as yeast loves it. (Salt inhibits yeast, you may know this already from cooking).

WHY TOMATO PASTE?

Because it contains most of the essential vitamins and minerals yeast thrive on. It is a source of potassium (vitamin K) and various B-vitamins—specifically, vitamin B3 (niacin), vitamin B5 (pantothenic acid), and vitamin B7 (biotin). It can also include some calcium. The actual concentrations of these are dependent on the types of tomatoes used (and the processing of them).

These vitamins and minerals support the yeast in its work, and assist in creating a good, clean ferment. For example, vitamin B3 is involved in the synthesis of nicotinamide adenine dinucleotide (NAD+), a coenzyme that is important in the process of ethanol fermentation. While vitamin B5 is involved in the metabolism of sugars and lipids. A deficiency of this vitamin could lead to increased hydrogen sulphide production, creating off-aromas in the resulting alcohol.

The calcium (which may or may not be in significant concentration in the tomato paste) and the Epsom salts (for magnesium) do a few things. The first is that both support cell metabolism. The second is that they both enhance ethanol tolerance. The magnesium also protects yeast cells from stress caused by temperature and osmotic pressure. [5]

THE FERMENTATION SYSTEM

You need a clean, sterile container with a lid and possibly an air lock (though this is optional). As the ferments we work with at The Alembics Lab are usually upwards of 50L, there is always lots of activity going on, so we don't use an airlock—the lid is loose enough for the CO_2 to escape but can also form a cap above the ferment to keep bacteria and wild yeast out. There are many options ranging from as little as 4$NZ.

We use a 70L stainless steel mash tun. It's like a giant stock pot but fitted with a thermometer and a tap. The tap is attached to a filter coil. We like stainless steel, as it's easy to clean and won't leach any unwanted chemicals into our ferment.

TEMPERATURE CONTROL

If yeast gets too cold or too hot, it will run into problems—it either dies (too hot) or goes to sleep (too cold).

Having a thermometer will enable you to make sure it's in the most comfortable range—around 26–30 degrees Celsius (79–82°F). This is optimal for the yeast. Baker's yeast is quite forgiving, and is comfortable from 20–35°C, but other hybrid yeasts can be very fussy. It pays to check the preferred temperature range of the particular yeast you are using. A 50L ferment generates its own energy which keeps the yeast warm. If it gets chilly at night, we use heat straps that wrap around the mash tun to keep it warm.

FERMENTATION MONITORING

Once all the wash ingredients are mixed and oxygenated, I will use a wine hydrometer to check the initial specific gravity (SG) reading. An SG reading of 1.060–1.090 is acceptable, but most distillers aim for below 1.070 to reduce off-flavours in their wash. If the SG is too low, I will gradually add more sugar. If the SG is too high, I will slowly add more water until I reach that desired range.

Then, I check the temperature daily, making sure it's within that range that yeast enjoys. I also like to take a daily reading with the hydrometer to track the progress of the wash (tracking how much sugar the yeast is eating) but it's not vital. Your wash is ready when the SG has reached around 0.990—anywhere between 5–14 days. This indicates that the yeast has eaten all the sugar, and the wash is ready to distil. If it's still not at 0.990 after 15 days, wait until the wash stops bubbling, then take note of the SG for reference and proceed.[6–7]

And finally, check the aroma, you will know if the yeast is not happy or if bacteria have invaded its space, as it will start creating off-notes. It should smell like you could drink it.

THE DISTILLATION RUNS

Now, thanks to yeast, we have our alcohol—around 50L at a concentration of approximately 12%ABV (alcohol by volume). The next step is a 'stripping run', to reduce the volume of our fermented wash and concentrate the alcohol by removing most of the water. I use a 40L stainless steel Explorer and do two distillation runs of 20L as it suits my timeframe and set up (but you can do one, longer run if you prefer). After our stripping run (which takes about four hours for 20L) I am left with 13L at around 45% ABV.

Setting up to do an alcohol distillation

PHOTO: PETER REES PHOTOGRAPHY


Taking a hydrometer reading

PHOTO: PETER REES PHOTOGRAPHY

Our final step in creating the kind of high ABV alcohol I work with is called the 'spirit run' or rectification. This refines, concentrates and purifies the spirit, giving us what we hope will be a high-quality neutral spirit, with an ABV between 85–90%. I like to use a 30L traditional copper alembic still with a refining lentil attached to the top. This style of still is useful as a finishing still, as the contact with copper in both the still and the refining lentil will help remove off-notes and make a smooth, clean spirit.

The spirit run is where I take fractions and make 'cuts' to get the best end result—removing those parts of the distillate that have undesirable compounds in them—to get a safe, clean spirit. Do you remember the list of alcohol molecules and their boiling points we outlined earlier? These different types of alcohols and other molecules in the wash (known as congeners) all have different boiling points, so they can be effectively separated through the distillation process.

As the wash heats, the lightest, most volatile alcohols with the lower boiling points come over in the first part of the distillation. This is why you want to gently heat your wash—not bring it to the boil—a fast boil means you lose the opportunity to take fractions and remove those alcohols with lower boiling points that are undesirable in a final blend.

In an alcohol distillation, the distillate from this run can be divided into three main fractions—heads, hearts and tails.

Heads refers to the first part of the distillation, which contains a higher concentration of those more volatile alcohol compounds with lower boiling points like acetone and methanol (which are harsh smelling, like nail polish remover). When starting out, it's best to discard all the heads, or you can keep them for cleaning the coil of your still.

The **hearts** are the good stuff, from the middle of the distillation. It's mostly ethanol, and is the purest, cleanest part of your distillation. This is what we are aiming to collect.

Tails is the distillate from the final part of the distillation, which is lower in alcohol and higher in the heavier molecules like fusel oils and fatty acids that come over at higher temperatures.

Distillers must decide what parts of these fractions they want to include in their final product—where you draw those lines are called your cuts. In short, cuts are nothing more than the distiller making a decision about the qualities of the final spirit. Experienced distillers use their knowledge of the process and their senses to decide where to make these cuts, and it's what elevates good spirits to excellent ones

At the end of our spirit run, we are left with the kind of alcohol that is useful for aromatic distillers high ABV neutral spirit that can be used for consumption, tincturing, perfumery, and other aromatic projects.

And as a final note, the laws governing distilling spirits and still ownership vary from jurisdiction to jurisdiction. Always check your local laws before embarking on distilling alcohol yourself.

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PHOTO: KAREN NOBLE

Karen Noble
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Karen lives under the Southern Alps in Canterbury. She studied at South Pacific College of Natural Medicine in Ellerslie, Auckland to become a Medical Herbalist and Naturopath while working full time as an RN in the larger Auckland community. The goal at the time was to help those people she cared for with an intellectual disability who were over medicated and under nourished. Chronic conditions remain an interest and focus along with chronic pain management, and metabolic syndrome.

Since a young age of seventeen Karen has worked in the medical industry helping people with all sorts of inflictions mentally, emotionally and physically in various roles over the years. She believes in using the healing power of nature to create balance within the body and loves to observe the changes that happen for people when this process is supported. Treating the cause rather than suppressing the symptoms is important in her practice and of course treating the whole person. Karen sees herself as a teacher, here to educate, empower and motivate clients towards complete wellbeing using the phytochemicals nature provides.

KAREN NOBLE

Ocimum Basilicum – The Medicinal Benefits Of The Culinary Herb Basil.

Two different forms of basil, with very similar actions, are discussed within this article. Anything specific to *Ocimum sanctum* will be referred to as such.

Common name: sweet basil or basil and tulsi or holy basil
Botanical name: *Ocimum basilicum L.* (basil) and *Ocimum sanctum* (tulsi)
Family: Lamiaceae
Parts used: whole aerial parts of the plant - leaves, stems and flowers.
Phytochemicals: beta-carotene, beta-ocimene, limonene, lycopene, myrcene, eugenol and menthol. Polyphenols caffeic and rosmarinic acids and quercetin are also provided. Provitamins provided in *Ocimum basilicum* are vitamins B1, B2, B6, C and E and minerals magnesium, phosphorus, potassium, selenium and zinc[2].

ENERGETICS

Ocimum basilicum is associated with the wood, fire and earth elements and is a warming herb that tonifies *yang* (the active, metabolic energy in Traditional Chinese Medicine (TCM)) and strengthens the *shen* (the mind and spirit in TCM). This makes *O. basilicum* great for those who are physically and mentally exhausted and suffer from nervous depression and melancholy. It also tends to warm the lungs, expel phlegm, and can relieve coughing[3].

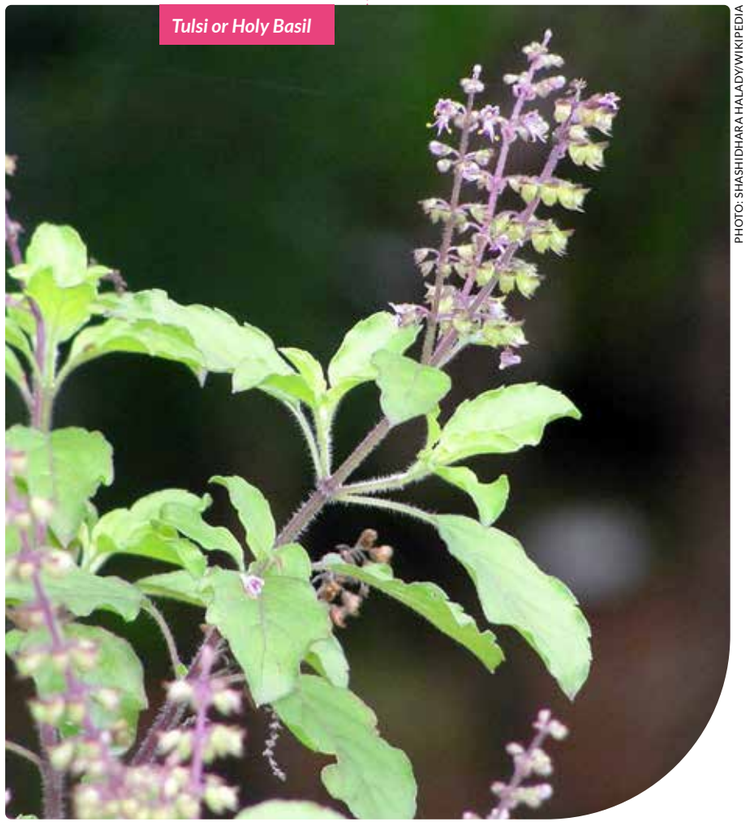
Tulsi or Holy Basil

PHOTO: SHASHIDHARA HALADY/WIKIPEDIA