

Designing Belgian Ales

Daniel Morey
November 2001

Belgian ales are an eclectic collection of brews. From light easy drinking session beers to hearty winter warmers, Belgians' have it covered. From yeast to bacteria, Belgians' have it covered. Belgian ales offer the home brewer latitude to experiment, and plenty of opportunity to explore a vast spectrum of flavors, aromas, and ingredients.

In this paper, I hope to provide you with a set of guidelines for successful Belgian brewing. The suggestions presented are primarily based upon the common trends found in recipes that have previously won medals at the National Homebrew Competition. Information has also been gathered from articles in Zymurgy, the Classic Beer Series, and other texts found on the internet such as the Homebrew Digest.

The styles that will be presented are: Abbey ales (Dubbels and Tripels), Wit beers, and Lambics.

Abbey Ales

In general, abbey ales are top fermented and bottle conditioned. They include the Trappist ales, dubbels, and tripels. Most exhibit a soft malty profile with a sweet finish. Fruity and phenolic character from the yeast may be present. Hop character should be subdued. Of course there are exceptions such as Orval (which is one of my favorites). Most are highly carbonated with levels between 2.0 and 3.5 volumes.

The two main subclasses of abbey ales are dubbels and tripels. Not all brewers label their beers as dubbels or tripels. Some better known examples are Westvletern 4 (dubbel) and Chimay Cinq Cents or Blanche (tripel).

Dubbel

Vital Statistics:
Original Gravity: 1.063 - 1.070*
Final Gravity: 1.012 - 1.018
Alcohol: 6.0 - 7.5% v/v*
IBUs: 20 -35
SRM: 10 - 20

* Guidelines from Belgian Ale by Pierre Rajotte. BJCP guidelines are 1.040 -1.080 and 3.2 - 7.8% v/v.

Pilsner malt (or pale malt extract) should form the backbone of the grain bill. Pilsner malt should comprise between 80 and 90% of the total grain bill (including copper sugars). Toasted Belgian malts such as aromatic and biscuit are popular as substitutes for a portion of the base pilsner malt. The combination of biscuit and aromatic malts should be limited to 10% or less (count these malts towards the base malt percentage). Sugar is a key ingredient in dubbels. Sugar helps keep the malt balance correct. Without it, the resulting beer would resemble a doppelbock or barley wine. Sugar comprises between 6 and 9% of the total grain bill (0.75 - 1.0 lb per 5 gallon batch). Dark candi sugar is the sugar of choice. Ordinary table sugar can be used, but more color malts will be required to get the correct color. Color malts should make up the remaining 4 - 14%. Special B (~100°L) is an excellent color malt for dubbels. Special B contributes a plum flavor that is prevalent in dubbels. Other popular color malts are CaraMunich, CaraVienna, crystal 20-60°L, and brown malt. I've also seen Munich malts used in Dubbel formulations. Dark roasted grains such as chocolate malt, black patent, and roast barley should be avoided.

Pilsner, Pale malt, or pale extract	80 - 90%
Aromatic or biscuit malt	Up to 10%
Sugar (Dark candi sugar or table sugar)	6 - 9%
Color malts	4 - 14%

The mash should be relatively thick (1 to 1.33 quarts per pound of grist). A single temperature infusion around 151°F for 60 to 90 minutes is sufficient. Mash out at 170°F for five minutes.

A boil time of 90 minutes or longer is recommended. Add sugars during the boil. Stir the wort until the sugar is dissolved or you may end up with burnt sugar on the bottom of your kettle (worst yet, ruin the batch)!

An average of 0.29 bittering units per gravity unit is recommended with a range of 0.20 to 0.36 BU:GU. With this ratio, most dubbels will fall between 18 and 25 IBUs with most example towards the lower end of the range. Bittering and aroma hops should be used for this style. Preferred varieties and bittering fractions are listed below:

Recommended Hops:

Bittering hop additions: Styrian golding, Hallertauer, Tettnager
 Aroma hop additions: Saaz and Hallertauer

TABLE 1: Dubbel Hop Schedule

Option	Bittering		Flavor		Aroma		Dry
	%	minutes	%	minutes	%	minutes	oz/gal
1	98 - 99	60 - 80	n/a	n/a	1 - 2	1 - 2	n/a
	98	70	---	---	2	2	---

A good quality Belgian yeast should be used. Fermentation temperature in excess of 75°F should be avoided. Fermentation temperature between 60 - 70°F are optimum for most of the Wyeast and White Lab offerings. Wit beer yeasts is not recommended.

Tripel

Vital Statistics:
 Original Gravity: 1.070 - 1.095*
 Final Gravity: 1.013 - 1.020
 Alcohol: 7.0 - 10.0% v/v
 IBUs: 20 -35
 SRM: 3.5 - 6

* Guidelines from Belgian Ale by Pierre Rajotte. BJCP guidelines are 1.065 -1.095 and 6.3 - 10.0% v/v.

Again, Pilsner malt (or pale malt extract) should form the backbone of the grain bill. Pilsner malt should comprise about 90% of the total grain bill. Like dubbels, sugar is a key ingredient. Sugar should make up the remaining grain bill (1.5 to 2.0 lbs per 5 gallon batch). Light candi sugar is the traditional choice, but ordinary table sugar works just fine. Dark candi sugar can darken the beer beyond the style guidelines. For this reason dark candi sugar is not recommended.

Pilsner, Pale malt, or pale extract	~90%
-------------------------------------	------

Sugar (Light candi sugar or table sugar)

~10%

The mash should be relatively thick (1 to 1.33 quarts per pound of grist). A single temperature infusion around 151°F for 60 to 90 minutes is adequate. Mash out at 170°F for five minutes.

A boil time of 90 minutes or longer is recommended. Stir the wort while adding the sugar. Continue stirring until the sugar is dissolved.

An average of 0.38 bittering units per gravity unit is recommended with a range of 0.30 to 0.45 BU:GU. With this ratio, most tripels will fall between 27 and 36 IBUs. Unlike dubbels, tripels have a variety of hopping schedules. Even though option 3 presents aroma additions, this is not typical. Usually tripels will use bittering and flavoring additions only. Preferred varieties and bittering fractions are listed below:

Recommended Hops:

Bittering hop additions: N. Brewer, Willemette, Hallertauer, Styrian golding
Flavoring hop additions: Saaz and Willemette
Aroma hop additions: Saaz

TABLE 2: Tripel Hop Schedules

Option	Bittering		Flavor		Aroma		Dry
	%	minutes	%	minutes	%	minutes	oz/gal
1	88 - 93	60 - 80	7 - 12	10 -15	n/a	n/a	n/a
	92	60	8	13	---	---	---
2	100	35 - 50	n/a	n/a	n/a	n/a	n/a
	100	40	---	---	---	---	---
3	98 - 99	60+	n/a	n/a	1 - 2	1 - 2	n/a
	99	85	---	---	1	1	---

The same yeast recommendations from dubbels apply.

Witbier

The first thing you notice about wit beer is its cloudy almost white color. This due to the high portion of wheat, usually unmalted, used in the grain bill. The specific yeasts that are used also contribute to the appearance. These yeasts are also responsible for the mild acidity that is present. Spices, malt, and wheat should dominate the aroma. Hop aroma should be minimal. Beside hops, spice such as coriander and bitter orange peel are often used to flavor the beer. These beers are lively and have high carbonation levels (2.0 - 3.0 volumes).

Vital Statistics:

Original Gravity: 1.042 - 1.055

Final Gravity: 1.008 - 1.012

Alcohol: 4.2 - 5.5% v/v

IBUs: 15 - 22

SRM: 2 - 4

Wit beers use a high proportion of wheat in their formulation, but Pilsner or pale still makes up the backbone. Pilsner or pale malts should make up 50 to 60% of the grain bill. The remaining grain bill is comprised of mainly wheat, but can include other grains such as oats and rye. Raw or flaked wheat is the traditional choice. White varieties are preferred over red varieties. Wheat malt, while not traditional, is an acceptable substitute. If you choose to use oats or rye, the combination should be limited to 10% or less of the total grain bill (count these grains towards the wheat portion of the grain bill). If making wit beers from extract, a 50:50 combination of pale and wheat extract should be used. Unlike the abbey beers, sugar is not commonly included. If you do choose to add sugar, keep it below 5% of the grain bill.

Pilsner or Pale malt	50 - 60%
Flaked wheat, raw wheat, or wheat malt	40 - 50%
Oats and/or rye	Up to 10%
Sugar	Less than 5%

For all grain formulations, a step infusion or decoction schedule should be followed. A thin mash with between 1.5 and 2 quarts of water per pound of grist is recommended. Start with a protein rest between 117 and 126°F for about 45 minutes. Raise the mash temperature to saccharification (151 - 153°F). Hold this temperature for 45 minute to one hour. Mash out at 170°F for five minutes.

A boil time of 90 minutes or longer is recommended.

An average of 0.40 bittering units per gravity unit is recommended with a range of 0.33 to 0.48 BU:GU. With this ratio, most wits will fall between 17 and 22 IBUs. Preferred varieties and bittering fractions are listed below:

Recommended Hops:

Bittering hop additions:	Saaz or Goldings
Flavoring hop additions:	Saaz or Goldings
Aroma hop additions:	Saaz or Goldings

TABLE 3: Witbier Hop Schedules

Option	Bittering		Flavor		Aroma		Dry
	%	minutes	%	minutes	%	minutes	oz/gal
1	94 - 98	60+	n/a	n/a	2 - 6	1 - 5	n/a
	96	60	n/a	n/a	4	3	---
2	65 -75	60+	25 - 35	10 - 15	n/a	n/a	n/a
	70	60	30	12	---	---	---

As mentioned, spice are often used to flavor wit beers. The most frequently used spices are coriander and bitter orange peel. Use bitter orange peel at a rate of 0.04 to 0.07 ounces (1 - 2 grams) per gallon. Add the bitter orange peel during the last 20 minutes of the boil. Use between 0.15 and 0.20 ounces (4 - 6 grams) of ground coriander per gallon. Coriander should be added in the last 5 minutes of the boil. Other spices have been used to give each brewer their own unique signature. Examples of other spice that have found use are: Cum in, cardamom, anise, and black pepper. These “extra” spices should be used in limited quantities and should remain far in the background. As with the other spices, they should be added at knockout or during the last 5 minutes. See summary below:

Bitter orange peel	0.20 - 0.35 ounce (5 - 10 g) for final 20 minutes for 5 gal
--------------------	---

Coriander	0.65 - 0.80 ounce (20 - 24 g) for final 5 minutes for 5 gal
Others	<0.20 ounces (<5 g) at knockout for 5 gal

Belgian wit yeasts are preferred, but German wheat yeast can be used. If using a German wheat yeast keep temperature toward lower end of the fermentation range to minimize the phenolics (clove) produced. American wheat yeast will not produce the mild acidity necessary for wits.

Lambics

Lambics are truly unique beers. When comes to making lambic style beers you can forget most of “rules” you have learned about home brewing. True lambics come from a ten mile area surrounding Brussels. By decree they must contain at least 30% unmalted wheat and must be spontaneously fermented. But you don’t have to follow these “laws” if you want to brew a good “lambic style” beer.

What makes lambics so different? Three primary differences distinguish lambics from all other beers. First all are the products of spontaneous fermentation. All have an acetic aroma and sour flavor. Several microflora are active to produce the eclectic mix of organic acids that create these aromas and flavors. The diverse microflora at work require a wort rich in carbohydrates which includes unconverted starches which is the second major difference. The last major difference is the use of old (two to three years) hops. Oxidation degrades the available alpha and beta acids. Minimal hop character is extracted, but the preservative qualities are realized.

Lambics are grouped into three groups: Gueuze, Fruit, and Faro. Gueuze is a mixture of old and new lambics. Gueuze tends to be highly carbonated. The color ranges from golden to “honey brown.” They are void of hop bitterness and a rather winery or cidery aroma is predominate. The flavor is acidic.

Vital Statistics:
 Original Gravity: 1.044 - 1.056
 Final Gravity: 1.006 - 1.012
 Alcohol: 4.7 - 5.8% v/v
 IBUs: 10 - 15
 SRM: 4 - 15

The two classic fruit lambics are: Kriek and framboise. Other fruits are coming into use such as peaches, strawberries, kiwi, etc... The profile of fruit lambics vary greatly with some sweet and others sour. Color is largely determined by the fruit used. They are made from the same wort as gueuze.

Vital Statistics:
Original Gravity: 1.044 - 1.056 (plus fruit)
Final Gravity: 1.008 - 1.016
Alcohol: 4.7 - 5.8% v/v
IBUs: 10 - 15
SRM: 4 - 15

Faro is a blend of young lambic with another beer or with sugar. Faro is generally cloudy with moderate carbonation. The sourness is offset by the blended beer and/or sugar that has been added. Color will vary. There are no BJCP guidelines for faro.

As with other Belgian beers, Pilsner or pale malts are the backbone. Pilsner or pale malts should make up 50 to 70% of the grain bill. The remaining grain bill is comprised of mainly wheat. Raw or flaked wheat is the traditional choice. White varieties are preferred over red varieties. Wheat malt, while not traditional, is an acceptable substitute. In nearly half of the recipes reviewed for this paper, some form of crystal or carapils malts was used. These malts should compose no more than 5% of the total grain bill. Crystal 40°L should be considered the upper limit for dark crystal malts. A small portion (~15%) of the recipes used sugar in their formulation. Sugar is probably more applicable to those who wishes to try their hand at faro.

Pilsner or Pale malt	50 - 70%
Flaked wheat, raw wheat, or wheat malt	30 - 50%
Crystal or carapils	Up to 5%
Sugar	Up to 5%

Due to the residual starches that are necessary in lambic beers, extract only beers are not recommended.

Mash schedules are unique for lambic brewing. The traditional method is known as turbid mashing. This old method is similar to decoction, but the portion removed is not returned to the main mash. Additional infusions of hot water are added to the main mash to dilute the enzymes and increase temperature for each rest. Those who are interested in turbid mashing should do further reading in the references listed. A simpler method used by some commercial lambic brewers is a multi-step infusion. The mash programs detailed in table 4 should produce a thin wort that contains the necessary unconverted starches.

TABLE 4: Mash Programs for Lambic home brews

Step	Mash Schedule #1		Mash Schedule #2	
	Temperature	Time	Temperature	Time
1	117°F	15 min	95°F	15 min
2	136°F	15 min	113°F	15 min
3	149°F	15 min	131°F	15 min
4	162°F	15 min	149°F	15 min
5	Bring entire mash to boil and hold for 15 minutes.		162°F	15 min
6			Bring entire mash to boil and hold for 15 minutes.	

By boiling the entire mash, starches and tannins are extracted. After the mash sparge with 200°F water. This higher temperature also extracts the unconverted starches and tannins that the unique microflora will use.

A boil length of 120 minutes or longer is recommended.

An average of 0.17 bittering units per gravity units is recommended with a range of 0.06 to 0.35 BU:GU. With this ratio, most lambics will fall between 8 and 10 IBUs. Aged noble hops are preferred. Use the following values as a rough rule of thumb for calculating alpha acid degradation vs age:

1 year	70%
2 years	50%
3 years	35%

When calculating the weight of hops, adjust the alpha acid percentage by the percentages shown above.

Recommended Hops:

Bittering hop additions: Hallertauer, Fuggle, Saaz, or Tettnager

TABLE 5: Lambic Hop Schedule

Option	Bittering		Flavor		Aroma		Dry
	%	minutes	%	minutes	%	minutes	oz/gal
1	100	full boil	n/a	n/a	n/a	n/a	n/a
	100	120+	n/a	n/a	n/a	n/a	n/a

Lambics require a blend of yeasts and bacteria. The primary organisms besides saccharomyces are *Pediococcus* (bacteria) and *Brettanomyces* (yeast). These can be purchased separately, or as a blend of yeast with *Pediococcus* and *Brettanomyces*. Fermentation can take between 8 months and two years.

For fruit lambics, you will use more fruit than normal for ordinary fruit beers. This is because the flavors

and aroma will degrade with the long aging period required for lambics. The common fruits are: cherries, raspberries, and peaches. Fruits can be grouped into two categories: mild and assertive. As expected, mild fruits take more for their character to come through. Mild fruits require about 4 lbs of fruit per gallon while assertive fruits are usually used at a rate between 1.5 to 3.0 lbs per gallon. Use the whole fruit. Add the fruit to the fermenter after primary fermentation is complete. Vanilla is often used in fruit lambics. Use 0.2 oz fresh crush vanilla per gallon of finished beer. Add vanilla at the same time the fruit is added.

<u>Mild Fruits</u> (~4lb/gal)	<u>Assertive Fruits</u> (1.5 - 3.0 lb/gal)
Peaches	Cherries
Strawberries	Raspberries
Apricot	Blackberries
Mango	Passion Fruit
Blueberries	

Many people are concerned that equipment used for making a lambic cannot be adequately sanitized and will contaminate other brews. This is a valid concern for porous items such as airlocks, plastic tubing, stoppers, racking canes, o-rings, and plastic fermenters. Glass and stainless steel should not pose a problem when using good cleaning and sanitation practices. If using a corney keg for a fermenter or dispensing, remember to change to o-rings. Glass bottles can be sanitized with dry heat by placing them in a oven for 2 hours at 250°F.

Water

The following water profiles have been taken from Dave Draper's web page:

Belgian towns:	Ca++	CO3–	Cl-	Mg++	Na+	SO4–
Antwerp	90	76	57	11	37	84
Poperinge	8	528	206	2	380	124
Eeklo	138	255	65	28	115	8
Luik	98	134	142	14	110	14
Brugge	132	326	38	13	20	99
Gent	114	301	38	17	18	84
Willebroek/Rumst	68	143	60	8	33	70
Mechelen	116	330	36	14	16	62
Beerse	41	91	26	8	16	62
Brussels region	100	250	41	11	18	70

Antwerp	De Koninck
Popering	St. Sixtus, Van Eecke; Belgian hopgrowing region
Eeklo	Bios (western Belgium)
Luik	(Eastern Belgium)
Willebroek/Rumst	Moortgat, makers of Duvel; Palm
Mechelen	Het Anker, makers of Gouden Carolus
Beerse	Westmalle
All others are from western, northwestern, or central Belgium.	

Yeast

The following are commonly available yeast from Wyeast and White Labs. The descriptions and optimum fermentation ranges are taken from their respective web sites:

Wyeast

1214 Belgian Ale yeast

Abbey-style top-fermenting yeast, suitable for high-gravity beers. Estery. Flocculation medium; apparent attenuation 72-76%. (58-68° F)

1388 Belgian Strong Ale yeast

Robust flavor yeast with moderate to high alcohol tolerance. Fruity nose and palate, dry, tart finish. Flocculation low; apparent attenuation 73-77%. (65-75° F)

1762 Belgian Abbey Yeast II

High gravity yeast with distinct warming character from ethanol production. Slightly fruity with dry finish. Flocculation medium; apparent attenuation 73-77%. (65-75° F)

3463 Forbidden Fruit yeast

From classic Belgian brewery for production of wits to classic grand cru. Phenolic profile with subdued fruitiness. Seasonal availability. Flocculation low; apparent attenuation 73-77%. (63-76° F)

3522 Belgian Ardennes yeast

One of many great beer yeasts to produce classic Belgian ales. Phenolics develop with increased fermentation temperatures, mild fruitiness and complex spicy character. Flocculation high; apparent attenuation 72-76%. (65-85° F)

3787 Trappist High Gravity

Robust top cropping yeast with phenolic character. Alcohol tolerance to 12%. Ideal for Biere de Garde. Ferments dry with rich ester profile and malty palate. Flocculation medium; apparent attenuation 75-80%. (64-78° F)

3942 Belgian Wheat yeast

Estery low phenol producing yeast from small Belgian brewery. Apple and plum like nose with dry finish. Flocculation medium; apparent attenuation 72-76%. (64-74° F)

3944 Belgian Witbier yeast

A tart, slightly phenolic character capable of producing distinctive witbiers and grand cru-style ales alike. Alcohol tolerant. Flocculation medium; apparent attenuation 72-76%. (62-75° F)

3278 Belgian Lambic blend

Contains a selection of *Saccharomyces cerevisiae* which include Belgian style wheat beer yeast, sherry yeast, two *Brettanomyces* strains and Lactic Acid Bacteria. While this mixture does not include all possible cultures found in Belgian Lambics, it is representative of the organisms which are most important for the desirable flavor components of these beer styles. Individual components available from this blend are numbered below. Flocculation low to medium; apparent attenuation 65-75%. (63-75° F)

3112 *Brettanomyces bruxellensis*

Wild yeast isolated from brewery cultures in the Brussels region of Belgium. Produces the classic sweaty horse hair character indigenous to beers of this region; gueuze, lambics, sour browns. Ferments best in worts with lower pH after primary fermentation has begun. This strain is generally used in conjunction with *S. Cerevisiae* as well as other wild yeast and lactic bacteria. Produces some acidity and may form a pellicle in bottles or casks. Generally requires 3-6 months aging for flavor to fully develop. Flocculation medium; apparent attenuation low. (60-75° F)

3526 *Brettanomyces lambicus*

Wild yeast isolated from Belgian lambic beers. Produces a pie cherry like flavor and sourness along with distinct brett character. Ferments best in worts with reduced pH after primary fermentation has begun, and may form a pellicle in bottles or casks. Works best in conjunction with other yeast and lactic bacteria to produce the classic Belgian character. Generally requires 3-6 months of aging to fully develop flavor characteristics. Flocculation medium; apparent attenuation low. (60-75° F)

4335 Lactobacillus delbrueckii

Lactic acid bacteria isolated from a Belgian Brewery. This culture produces moderated levels of acidity and is commonly found in many types of beers including gueuze, lambics, sour brown ales and Berliner Weisse. Always used in conjunction with *S. cerevisiae* and often with various wild yeast. (60-95° F)

4733 Pediococcus cerevisiae

Lactic acid bacteria used in the production of Belgian style beers where additional acidity is desirable. Often found in gueuze and other Belgian style beer. High acid producer which usually increases overall acid levels in beer as storage time increases

White Labs

WLP400- Belgian Wit Ale Yeast:

Slightly phenolic and tart, this is the original yeast used to produce Wit in Belgium.

Attenuation: 74-78%

Flocculation: Low to Medium.

Optimum Fermentation Temperature: 67-74° F.

WLP410- Belgian Wit II Ale Yeast:

Less phenolic than WLP400, and more spicy. Will leave a bit more sweetness, and flocculation is higher than WLP400. Use to produce Belgian Wit, Spiced Ales, Wheat Ales, and Specialty Beers.

Attenuation: 70-75%

Flocculation: Low to Medium+.

Optimum Fermentation Temperature: 67-74° F.

WLP500- Trappist Ale Yeast:

From one of the six Trappist breweries remaining in the world, this yeast produces the distinctive fruitiness and plum characteristics. Excellent yeast for high gravity beers, Belgian ales, dubbels and trippels.

Attenuation: 73-78%

Flocculation: Medium to low.

Optimum Fermentation Temperature: 65-70° F. Lower temperatures (under 65° F) will result in less fruity and more earthy beers. Many authentic Trappist style beers are brewed at 75° F.

WLP530- Abbey Ale Yeast:

Used to produce Trappist style beers. Similar to WLP500, but is less fruity and more alcohol tolerant (up to 15% ABV). Excellent yeast for high gravity beers, Belgian ales, dubbels and trippels.

Attenuation: 73-78%

Flocculation: Medium to high.

Optimum Fermentation Temperature: 66-72° F.

WLP550- Belgian Ale Yeast:

Saisons, Belgian Ales, Belgian Reds, Belgian Browns, and White beers are just a few of the classic Belgian beer styles that can be created with this yeast strain. Phenolic and spicy flavors dominate the profile, with less fruitiness than WLP500.

Attenuation: 72-78%

Flocculation: Medium.

Optimum Fermentation Temperature: 68-78° F.

WLP565- Belgian Saison I Yeast:

Classic Saison yeast from Wallonia. It produces earthy, peppery, and spicy notes. Slightly sweet. With high gravity saisons, brewers may wish to dry the beer with an alternate yeast added after 75% fermentation.

Attenuation: 65-75%

Flocculation: Medium.

Optimum Fermentation Temperature: 68-75° F.

WLP570- Belgian Golden Ale Yeast:

From East Flanders, versatile yeast that can produce light Belgian ales to high gravity Belgian beers (12% ABV). A combination of fruitiness and phenolic characteristics dominate the flavor profile. Some sulfur is produced during fermentation, which will dissipate following the end of fermentation.

Attenuation: 75-80%

Flocculation: Low.

Optimum Fermentation Temperature: 68-75° F.

References

Classic Beer Style Series:

Guinard, Jean-Xavier. *Lambic*, Classic Beer Style Series, Brewers Publications, 1990

Rajotte, Pierre. *Belgian Ale*, Classic Beer Style Series, Brewers Publications, 1992

Other Books:

Daniels, Ray. *Designing Great Beers - The Ultimate Guide to Brewing Classic Beer Styles*, Brewers Publication , 1996

Zymurgy Magazine:

"Winners Circle" **Zymurgy** (Vol. ?, No. ? thru Vol ? No ?)

Dorsch, Jim. "Dubbel Vision," **Zymurgy** Jan/Feb 2000 (Vol. 23, No. 1), pp. 32-35, 60

Isenhour, John. "For the Love of Lambic," **Zymurgy** Fall 1997 (Vol. 20, No. 3), pp. 19-21, 81-87

Brewing Techniques Magazine:

Lodahl, Martin. "Lambic: Belgium's Unique Treasure," **Brewing Techniques** July/August 1995 (Vol. 3, No. 4), pp. 35-46

Internet:

<http://hbd.org/~ddraper/beer/waterpro.html>

<http://realbeer.com/spencer/Belgian/>

http://www.brewingtechniques.com/library/styles/2_6style.html

http://www.brewingtechniques.com/library/styles/2_4style.html

<http://belgianstyle.com/mmguide/>

<http://www.whitelabs.com>

<http://www.wyeastlab.com/>

<http://www.bjcp.org/>

Other:

Personal correspondence with Wyeast Laboratories.