Humulus lupulus - Hops

Entry prepared by Sean Conway ‘08 and Reid Snyder‘08
in College Seminar 235 Food for Thought: The Science, Culture, & Politics of Food
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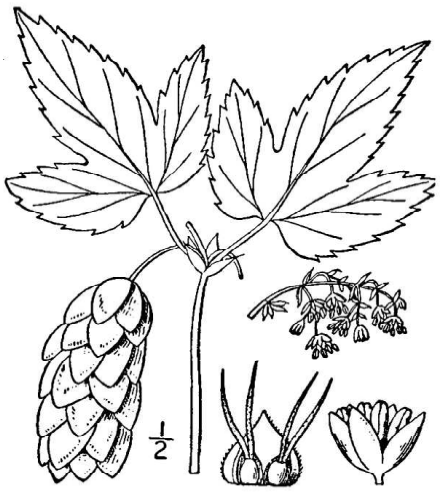
Etymology

The hop plant, *Humulus lupulus*, belongs to the family Cannabinaceae, which also contains the genus *Cannabis* (hemp). The etymology of *Humulus lupulus* is derived in part from Latin. *Lupulus* comes from the Latin lupus (wolf) because as Pliny described in his Naturalis Historia, “when the plant is produced among osiers, it strangles them by its light, climbing embraces, as the wolf does a sheep”. It is believed that *humulus* is derived from humus, rich organic matter of the soil in which the plant grows. The English word hop is derived from the Anglo-Saxon word *hoppan* (to climb).

Scientific Classification	
Kingdom	Plantae
Phylum	Magnoliophyta
Class	Magnoliopsida
Order	Urticales
Family	Cannabinaceae
Genus	*Humulus*
Species	*H. lupulus*



The Hop Plant
USDA-NRCS PLANTS Database / Britton, N.L., and A. Brow
northern United States, Canada and the British Possessions . V

Botanical Description

Hops are known as bine plants because they make use of stiff downward facing hairs for stability unlike vines, which use other methods of climbing. Hops are dioecious, meaning that there are separate male and female plants. The female plants produce cones known as strobili. Both the pollinated and unpollinated strobili from the female plants only are harvested and used in brewing. Much of the character of the hop desired for brewing is contained in the lupulin glands. These are located inside the base of the bracteoles, under the small leaves of the strobili, and contain the resins humulone (alpha acids), lupulone (beta-acids), and the aromatic hop oils.

Nutritional Value and Common Uses

The nutritional value of hops is derived mainly from its use as the major additive and preservative in beer. The alpha and beta acids contained within the strobili contribute a bitter taste when the hops are added to beer. Alpha acids consist of a complex hexagonal structure with several side chains that include ketone and alcohol groups. The major types of different alpha acids are humulone, cohumulone, adhumulone, prehumulone, and

posthumulone. These all differ in the makeup of the side chains in their chemical structure. These side chains can break down as hops are stored for long periods of time. In addition, the levels of alpha acids begin to decline as soon as the strobili are harvested. Humulone, cohumulone, and adhumulone account for over 95% of the alpha acids found in hops. Cohumulone in addition to providing bitterness to beer has also been found to increase head retention and foam stability in beer by forming cross linkages with specific proteins.[1] As a result of research into the bitterness of hops, certain varieties are bred to contain up to 19% alpha acids, called super-alpha-hops.[2] Beta acids also contribute to the bitterness of hops, although the compounds themselves are not bitter. Their bitterness develops as the compounds oxidize during storage. The main beta acids found in hops are colupulone, lupulone, and adlupulone and are structurally similar to the alpha acids.

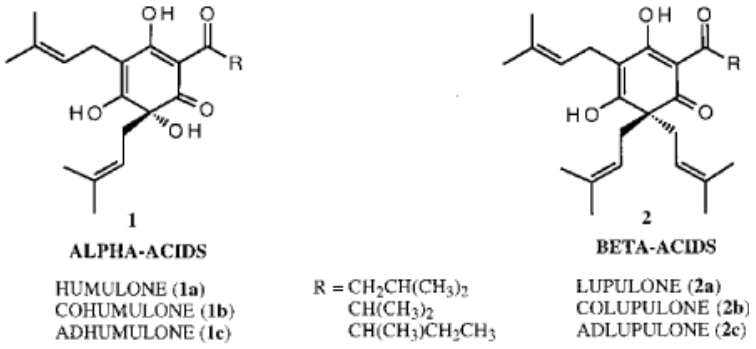


Figure 1. Chemical structures of humulones and lupulones [3]

> Hops have a long history of herbal remedy for various effects:
> "Hops are stated to posses sedative, hypnotic, and topical bactericidal properties. Traditionally, they have been used for neuralgia, insomnia, excitability, priapism, mucous colitis, topically for crural ulcers, and specifically for restlessness associated with nervous tension headache and/or indigestion."[4]

Hops have also been documented to show antibacterial properties against gram-positive bacteria. Lupulin produced from the female strobili has been shown to increase milk

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[1] Nickerson, G.B., Williams, P.A., Haunold, A. *Varietal Differences in the Proportions of Cohumulone, Adhumulone, and Humulone in Hops*. Presented at51st Annual Meeting, Milwaukee, WI, June 1985. Cooperative investigation of the Oregon Agricultural Experiment Station, Department of Agricultural Chemistry,and the Agricultural Research Service, U.S. Department of Agriculture,Corvallis, Oregon

[2] De Keukeleire, J., Ooms, G., Heyerick, A., Roldan-Ruiz, I., Van Bockstaele, E., De Keukeleire, D. *Formation and Accumulation of of Alpha-Acids, Beta-Acids, Desmethylxanthohumol, and Xanthohumol during Flowering of Hops (Humulus lupulus L.)*. J. Agric. Food Chem. 2003, 51, 4436-4441.

[3] De Keukelire. "The fundamentals of beer and hop chemistry". Quím. Nova 23(1) São Paolo Jan./Feb. 2000. pp. 108-112.

[4] Newall, Carol A., Linda A. Anderson, and David Phillipson. "Hops." In *Herbal Medicines: A Guide for Health-Care Professionals*, pp. 162-163. London: Pharmaceutical Press, 1996.

production in nursing mothers.[5] Hops also contain flavonoids, which are important as plant secondary metabolites in humans. Flavonoids are known for their antioxidant activity in neutralizing free radicals within the body. Free radicals can damage cells and cause cancer. Hops are the major source of the flavonoid xanthohumol in the human diet. Xanthohumol in addition to its antioxidant properties has also been shown to prevent the growth of tumor cells and in particular prostate cancer.

Extensive research has been done on the effects of xanthohumol and its preventative effects on various other health problems. One study performed on its antiinfective potential showed xanthohumol against bovine diarrhea virus, cytomegalovirus, herpes simplex virus type 1 and 2, and human immunodeficiency virus 1. The same study also showed xanthohumol to have a strong response against the replication of *Plasmodium falciparum*, the causative agent of malaria.[6] A separate study investigated the effet of other prenylated flavonoids found in hops on various human cancer cell lines and demonstrated that xanthohumol and isoxanthohumol have potential chemopreventive activity against breast and ovarian cancer in humans.[7] The value of hops and compounds within the hop plant have extensive health effects that may not have yet been fully realized. However, a person would have to drink 120 gallons of beer a day to experience any significant biological effect of the xanthohumol found in hops.[8] Research is also being done in terms of extraction techniques and harnessing the useful compounds outside of their use in brewing.

Origin and History

The hop plant, a perennial, is indigenous to much of the Northern Hemisphere. With origins in Europe, the crop is best produced between April and September. High levels of rainfall during the growing period coupled with plentiful sunlight in the fruiting period allow for the most successful harvest.[9] As such, the major crop producing regions in the Northern Hemisphere are found in the United States, Germany, the Czech Republic and England.[10] Today roughly 50 million tons of hops are produced in the United States annually.[11] Given the ideal conditions for hop farming and the crop's geographic tendencies, it is no surprise that Central New York was one of America's greatest producing regions throughout the 19th century.

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[5] Plants for a Future Database http://www.pfaf.org/database/plants.php?Humulus+lupulus (C) Plants For A Future, 1996-2003. Last modified: June 2004

[6] Gerhäuser, C. *Broad spectrum antiinfective potential of xanthohumol from hop (*Humulus lupulus L.) *in comparison with activities of other hop constituents and xanthohumol metabolites.* Mol. Nutr. Food Res. 2005, 49: 827-832

[7] Miranda, C.L., Stevens, J.F., Helmrich, A., Henderson, M.C., Rodriguez, R.J., Yang, Y.H., Deinzer, M.L., Barnes, D.W., Buhler, D.R. *Antiproliferative and cytotoxic effects of prenylated flavonoids from hops (Humulus lupulus) in human cancer cell lines*. Food and Chemical Toxicology. April 1999. 37:4. P. 271-285

[8] Victory, Joy, "Drinker's Delight: Beer may Fight Disease" on ABC News Nov. 7, 2005 http://abcnews.go.com/Health/story?id=1282177 Copyright © 2008 ABCNews Internet Ventures

[9] "Hop," Microsoft® Encarta® Online Encyclopedia 2007 http://encarta.msn.com © 1997-2007

[10] "Hops" Encyclopedia of Food and Culture

[11] "Hop," Microsoft® Encarta® Online Encyclopedia 2007 http://encarta.msn.com © 1997-2007

The widespread cultivation of the plant, as the case with much of its history is closely associated with the making of beer. First planted in 736 A.D. in Bavaria, hops became a popular additive in the beverage in medieval Europe. As international beer production increased, so to did the organized farming of the bitter hop plant. With changes in world travel, additional hops were added to preserve the beer over the course of a long voyage. During English colonization the crop was introduced to America in 1629.[12] A general outline for the process of brewing and when hops are added is included below.

- Mashing of barley malt and starch-rich adjuncts with brewing water
- Degradation of starch and proteins by malt enzymes
  - Filtration -» WORT
- Wort boiling - addition of whole hops
  - Filtration -» HOPPED WORT
- Fermentation
  - Yeast removal -» "GREEN BEER" or "YOUNG BEER"
- Maturation - Lagering
  - Filtration -» BEER
- Packaging

Figure 2. General outline of the brewing process indicating timing for the addition of hops. [13]

Cultivation

As with any crop, hop farming is most productive and efficient when particular conditions are met. During the growing season, which generally stretches from June to August, an average temperature of 50-66°F is ideal.[14] Sunlight is equally important, as the plants crave between 15:27 and 18:42 hours per day.[15] Given this factor, summer is clearly the natural time to grow hops. Rainfall is necessary to a degree, with an optimal amount between 2.5 and 22.4 inches of precipitation during the growing season.[16] The

[12] Glazier, Nancy. "Hop Production- Coming Back to New York?" Cornell University Cooperative Extension. December 19, 2007.

[13] De Keukelire. "The fundamentals of beer and hop chemistry". Quím. Nova 23(1) São Paolo Jan./Feb. 2000. pp. 108-112.

[14] "Hops." Encyclopedia of Food and Culture

[15] "Hops." Encyclopedia of Food and Culture

[16] "Hops." Encyclopedia of Food and Culture

soil should be damp but proper drainage is necessary. Ideally, the soil itself should not contain high levels of alkaline or saline.[17]

When farming hops, it is best to plant after the possibility of frost, yet no later than May.[18] The area must be relatively free of weeds. Thorough tilling, as well as the addition of straw to the soil, helps to eliminate the presence of unwanted plant growth. In addition to a potential weeds problem, a farmer must express concern over disease. Downy Mildew is a disease that is entirely exclusive to the hop plant. Occurring most often in humid conditions, Downy Mildew completely stunts the growth of a hop shoot and the farmer must address the infection immediately.[19] The gardener must remove the diseased shoot to prevent the loss of the entire crop. Finally, pests present another gardening obstacle. Hop aphids and spider mites are the most common insects to attack the hop plant. In our region, the hop aphid is a more likely challenge, one that can be prevented through the application of insecticide or the introduction of a ladybug population.[20]

Hops are native to the temperate zones of the northern hemisphere and are grown worldwide between the 30th and 50th latitudes. The have a permanent root stock that can grow over 12 feet deep into the soil and survive for over 25 years. Hop plants only grow about 6 feet tall during their first year of growth, because most of their energy is spent expanding their root systems. In a good year, a mature hop plant can be expected to grow 25-30 feet tall and produce up to 2 pounds of hops. This only occurs under optimal conditions where the plant can thrive.[21]

Much of the hop plant's success depends on the soil conditions and its fertility. Hop plants grow best on a well-drained that is not heavily nitrogenated and maintains a good soil structure. The optimal pH for the hop plant is 6.0-6.2, a moderately acidic soil, although the hop plant can grow anywhere in a range of 6.0-8.0. Often, the use of chemical fertilizers causes a buildup of excess nitrogen, which can harm the plant's development. The use of nitrogen-fixing legume crops as a type of "green manure" ensures a slow release of nitrogen back into the soil as well as the accumulation of calcium, potassium, and other essential micronutrients that the hop plant requires for growth. Drainage is important the hop plant as well. Hops require a large supply of water during the growing season, but does not respond well to water pooling at the base of the plant. This increases the chance of causing disease in the plants which can be very difficult to control.[22] One solution many hop farmers turn to is to plant their hops into hills and to ditch the space between the rows. This ensures that no water will pool near the base without impeding the plant's growth.

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[17] Carter, P.R. et al. "Hop." Alternative Field Crops Manual. University of Wisconsin Cooperative Extension and University of Minnesota Center for Alternative Plant and Animal Products. www.hort.purdue.edu/newcrop/afcm/hop.html

[18] "Hop Gardening." Freshops. 3/11/2005. http://www.freshops.com/gardening.html#planting

[19] Carter, et al. "Hop."

[20] "Hop Gardening." Freshops. 3/11/2005. http://www.freshops.com/gardening.html#planting

[21] "Hop Gardening." Freshops. 3/11/2005. http://www.freshops.com/gardening.html#planting

[22] Kneen, R. 2001. Small Scale and Organic Hops Production. Left Fields BC

Temperature is also a key factor in the growth of the hop plant. It is a perennial and lies dormant in the winter. The vines located in the crown of roots usually do not break ground until early spring flowers have already bloomed. A minimum of 120 days is required to produce a ripened crop of flowers. Even after the flowers ripen and are harvested, the vine will continue to grow until the first frost in the fall in order to build up reserve energy for winter.[23]

Hops arise annually from a permanent root stock called a crown. In addition to the true roots and aerial vines, the crown also produces rhizomes. Rhizomes are underground stems that resemble roots and posses many buds. The rhizomes are used in vegetative propagation, ensuring that all individual plants in any variety will be genetically identical.

Planting of the rhizomes should occur only after the chance of frost to avoid rotting. The rhizomes should be planted with the buds facing upward approximately 1-2 inches below the soil surface, and 5 feet apart if they are of different varieties, or three feet apart if they are of the same variety. It is important to provide a support system for the plant to grow. In the United States, commercial hop farms use an 18 foot trellis. Smaller gardens can use shorter support systems, which don't necessarily have to be a trellis. Strong twine of tall poles can be used in place of a trellis. The support structure can also be as short as six feet tall, but this will cause the plant to become bushy, as the hop has a natural tendency to grow vertically like a vine.[24]

When the length of the newly grown vines reaches about 1 foot long, 2-3 hearty vines are selected and wound clockwise up a string or pole in order to train them to grow vertically along the support system. The main reason for this is to prevent tangling. Trimming is also essential every few weeks to remove lateral branches and clear the lowest portions of the plant in order to aid in air circulation and reduce the possibility of disease. The strobili only grow on the highest parts of the hop plant. The hop plant spends much of its energy in its first growing season expanding its root system. As a result, it will require frequent short waterings to encourage this growth. Mulching the soil surface around the plant helps to soak up excess moisture and also aids in controlling weeds.[25]

When it is time for the harvest, it is easiest to lower the vines in order to collect the hops. The time of harvest varies with the climate. The goal is to pick the hops when the lupulone is most aromatic, and the strobili are just starting to dry. This ensures that the bitterness will be preserved and that the cones will not be destroyed during processing. After the harvest the vines should be cut and some of the healthy bottom vines should be buried so that they can propogate rhizomes for the next spring. The hop plant will greatly expand its root system over its first winter and there will be only a few rhizomes. However, once the plant matures and grows a full root system, a farmer can expect between 20 and 30 healthy rhizomes per plant.

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[23] Kneen, R. 2001. Small Scale and Organic Hops Production. Left Fields BC

[24] Montell, S. 1994. Hops in the Backyard: From Planting to Harvest and the Hazards in Between. BrewingTechniques. May.June 1994.
http://brewingtechniques.com/library/backissues/issue2.3/montell.html

[25] Cobbett, W. 1856. The American Gardener. 2003 Modern Library Paperback edition. pp. 124-126.

Common Domestic Hop Varieties

Hop Type	Approximate Alpha Acid Content (%)	Description	Used in
Amarillo	8-11	Aroma type	Pale ales
Bullion	8	Bittering hop with strong spicy flavors	Dark lagers and stouts
Cascade	5.5	Aroma and bittering hop with citrus flavors	Ales and lagers
Centennial	10.5	Aroma hop described as a stronger version of cascade	Medium to dark American ales
Chinook	12	Bittering hop with intense aroma	American ales and lagers
Clusters	6.5	Mild bittering hop	Light and dark American lagers
Columbus	12.5	Super high alpha content	Medium American ales
Crystal	4	Clean flavor	Light ales and lagers
Fuggles	5	Aroma hop	Pale ales, porters, and stouts
Galena	11.5	Bittering hop blends well with finishing hop	American ales and lagers
Liberty	4.5	Finishing hop	American and German ales and lagers
Mt. Hood	6.5	Aroma and bittering hop	American and German ales and lagers
Northern Brewer	9	Bittering hop. Rougher flavor and aroma than imports	California common ales, dark English ales, and German lagers
Nugget	13	Bittering hop	Medium to dark American ales and lagers
Perle	8	Bittering hop	Lagers, wheats, and pilsners
Tettnang	4	Aroma hop. Traditional German hop known for its floral aroma	Wheats and German lagers
Williamette	5	Aroma hop. Related to Fuggles	American and British ales
Yakima Magnum	12	West coast bittering hop with high alpha acid content	American strong ales

[26] [27] [28]

Hop farming in Central NY

"Those were the days when the hop was king, and the whole countryside was one great hop yard, and beautiful. It was the hop that built many of the big farmhouses, now abandoned. Many a farmer made the value of his farm out of a single good year's crop."
- James Fenimore Cooper in Reminiscences of Mid-Victorian Cooperstown

Given the nature of our research, it is interesting to note the importance of hop growing in central New York. For much of the 19th century hop farming served as one of the areas major agricultural industries. Otsego County, located south of Hamilton College ranked first in the state in hop production until roughly the 1870's.[29] This tremendous production contributed to the economic growth of the area. Coupled with dairy farming, agriculture formed the nucleus of the region's commerce. In addition to Otsego County, Oneida County and neighbors formed New York's "hop belt". The region's soil, climate and terrain proved ideal for the widespread planting of the crop. The hop growing in the area increased exponentially after the high market potential was realized. From the mid 1800's until the early 1900's New York produced over 70% of all hops grown in the United States.[30]

In 1815 Solomon Root sold two tons of hops for $1,000. Soon after hop farming in the area took off, a social and economic business. By 1879 Otsego and Oneida Counties combined to raise roughly 8.5 million pounds of hops and in the same year, hop fields covered over 40,000 acres of New York state farmland.[31] The business was so prosperous that individuals employed various tactics to profit from the volume in production. Major growers in Waterville and Cooperstown started to broker hops, buying and selling the crop for others.[32] These businessmen traveled the nation, distributing central New York's product throughout. The area's hop operations were highly effective, enveloping all aspects of production. Together farmers and brokers accounted for the cultivation, picking, drying, baling and selling of the crop. By 1855, this region was producing over 1 million pounds of hops annually. At the brewing industry's peak during

[26] http://www.homebrewzone.com/hops_varieties.htm
[27] http://www.rooftopbrew.net/?page_id=239
[28] http://www.hopunion.com/hvcb/
[29] Larkin, F.D. 1978. Cooper County. Presented at the 1st Cooper Seminar, James Fenimore Cooper: His Country and His Art at the State University of New York College at Oneonta, July, 1978. http://external.oneonta.edu/cooper/articles/suny/1978suny-larkin.html
[30] *Country Roads Revisited*, "Economy, Agriculture," A Madison County Historical Society Letter, `1976.
[31] Lawrence, W.A. "Hop Culture in the State of New York." Waterville, New York. Found in Hop Culture in the United States by E. Meeker. 1883
[32] Tomlan, Michael A., Tinged With Gold: Hop Culture in the United States. University of Georgia Press. 1992, pg 90.

the last quarter of the 19th century, they consumed over 30 million pounds of hops, most of them coming from central New York.[33]

The following synopsis highlights the seasonal timeline for hop farming in central New York. The source is a private journal from local diary farmer John Gillett in 1910 in Otsego County. Mr. Gillett ran a self-sustaining dairy farm and used hop production to augment the farm's income. Mr. Gillett's journal describes a diverse farm that picked apples, produced maple syrup, cut ice, butchered hogs, and grew potatoes and squash in addition to the primary function of producing milk. Because of the booming hop industry present in the region, hops offered many farmers like Mr. Gillett the opportunity earn extra income apart from their primary agricultural products. As hop farming methods changed little between 1812 and 1910, the journal provides an excellent resource to understand the timetable associated with hop cultivation.

[33]Beardslee, G.William. "When Hops Were King." New York Archives . Volume 6 Number 2. Fall 2006.

April 20-22: Plowed hops and dragged
April 23: Set hop poles
April 24-27: Grubbed hops
April 29: Finished cultivating hops
May 3: Worked in hop fields
May 4: Went to Lodi after hop twine
May 6: Set out more hops
May 17-20: Wound hops
May 22-24: Worked in hops, women helped too
May 30: Sprouted hops and wound hops
June 5-6: Worked on hops
June 9: Hilled hops
June 30: Cultivated hops
August 23: Went to Clarksville to get the hop groceries
August 24: Went to Oneonta after hop pickers
August 25: Commenced picking hops
September 6: Finished picking hops, the pickers went home today
September 9: Pressed hops
October 13: Sharpened hop poles
October 14-16: Sharpened hop poles
October 31: Pressed hops
November 1-3: Plowing and set hop poles

Gillett Journal entry describing hop cultivation. [34]

The journal continues to discuss the social traditions associated with hop farming. Additionally, it represents a connection to our focus period, a time when the area was the biggest producer in the state. Hop pickers were recruited and often stayed on the farm during picking season. The author states that for the picking there was a "constant stream of visitors to feed, stay over night, etc. And they went calling on the neighbors, and visiting relatives."[35] In the mid-1800's hop farming became part of the area's culture. Young people in the area picked hops as a means of employment, a chore often portrayed as enjoyable. Irish and German immigrants often found hop picking to provide a temporary means of earning a respectable wage.[36] Dinners, public affairs and even

[34] Gillett, John. Personal Journal, 1910. Roseboom Otsego County, New York.
[35] Gillett Journal
[36] Tomlan, pg. 126

private relationships all stemmed from the traditions of hop farming.[37] As such, the crop was truly associated with the people and workings of the rural communities.

Despite the hop plant's cultural status, by the 1920's, hop farming vanished from New York. Its disappearance can be partly attributed to downy mildew disease, prohibition, and competition from growers in the Pacific Northwest who could produce higher yields more cheaply than the farmers in central New York.[38]

Despite the disappearance of the hops crop from central New York, remnants of its processing remain common even today. The hop yard, or hop house, was a simple structure that began to appear around 1850 in the area of central New York that housed all of the major steps of processing hops in one location. Many of these simple barn-like structures still stand and have become popular stops on heritage tours.[39] Generally hop yards had four main sections. The first section consisted of a stove room. This room had high ceilings and a large stove with large windows and a connection to cowls in the roof for ventilation. This room generated heat through a system of stove pipes that would heat a slatted floor in the room above. The second section is the drying room, located directly above the stove room. Here hops were places between 1-2 feet thick on top of a fabric covering over the slatted floor. The hops would be turned over the course of several hours to ensure a thorough drying without the scorching or burning of any of the hops. The third section would be a storeroom. This room contained a hole in the floor, which connected to the press room. Here hops were stored and let cool before packaging. The fourth section consisted of a press room. It was located directly below the storeroom. The press collected hops sent through the ceiling and bailed them for distribution. This basic design for a hop yard can be seen below.

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Figure 3. The general layout for a typical hop yard including the four main rooms. [40]

[37] Beardslee, G.William. "When Hops Were King." New York Archives . Volume 6 Number 2. Fall 2006.
[38] Beardslee, G.William. "When Hops Were King." New York Archives . Volume 6 Number 2. Fall 2006.
[39] Madison County Hop Heritage Trail Guide 2006. www.madisontourism.com/trail_hop.pdf
[40] Tomlan, Michael. *Tinged with Gold: Hop Culture in the United States*. University of Georgia Press. Athens, GA. 1992. p. 160, 157-213

Another mark of the hops and brewing culture that was so prevalent in central New York is the F.X. Matt Brewery in Utica, NY. It was founded as The West End Brewing Company in 1888 by German immigrant Francis Xavier Matt. Shortly after the brewery's founding, it became of most popular of the twelve breweries that existed in Utica at the time.[41] The brewery survived prohibition by producing soft drinks and other products. It is also noted for brewing Utica Club, the first beer officially sold after prohibition. Today the brewery still thrives producing the Saranac line of beers, and is highly regarded as one of the top craft breweries on the east coast.

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