To hop or not to hop
Early medieval beer brewing in Scandinavia and continental Europe

[1]

Version 1.4
20170616
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[1] Cover photo is from the book HUMLE, deg gröna guldet, Page 117

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Introduction

The purpose of this document is to explore the use of hops in beer brewing between 400 and 1600 in Scandinavia and continental Europe. Collecting and summarising a large number of primary sources I have attempted to map out the evidence of hop use in beer brewing. The earliest comes from 822, but there are some indications of hops being used before then. The first significant wave of hop use occurred in the early 800, right in the middle of the Viking “trade exploration era” with a second wave a few hundred years later.

Scope

This document focuses on the history of hop usage. It will not go into the detail about how to use hops in beer, nor will it explore the deep chemical reactions and other scientific areas of hop use. It will however mention several processes and brewing acronyms that are important in understanding the impact and importance of hops.

The science of what happens to a wort when boiled with hops is a large topic best left to its own document.

Editorial note

While this document is about hops, it’s impossible not to mention other forms of flavouring/preserving beer - if nothing else, as a counterpoint. The word “gruit” is a Dutch word, and was not used elsewhere, meaning a herb mixture used for bittering and flavoring beer. Modern brewers often use it as a catch-all descriptor for beer bittered with things other than hops. I have chosen to follow this convention; it does not mean I believe Vikings used the word. Further, the makeup of gruit is a wildly debated topic with a quite wide range of opinions. However, the general understanding (right or wrong) is that gruit could be made up of any number of herbs over time and in different places. Since this document is about hopped beer I am not going into that, except to note that one herb commonly referred to in this context in the Scandinavian sources is bog myrtle. When bog myrtle and hops are referred to side by side in law texts they refer to two different plants used to do a similar job.

Geographical clarification

Even though Denmark technically is not part of the Scandinavian peninsula, many academic papers include Denmark in their treatment of Scandinavia. I have followed this convention. This seems logical, especially given that Scania, which is now a part of Sweden, was frequently a part of Denmark during our timeframe.

What are hops?

“Hop, either of two species of the genus Humulus, nonwoody annual or perennial vines in the hemp family (Cannabinaceae) native to temperate North America, Eurasia, and South America. The hops used in the brewing industry are the dried female flower clusters (cones) of the common hop (H. lupulus)”[2]
“Cannabaceae, the hemp family of the rose order (Rosales), containing 11 genera and 270 species of aromatic herbs distributed throughout temperate parts of the Northern Hemisphere. Older authorities included the two genera, Cannabis and Humulus, in the mulberry family (Moraceae). These and the former hackberry family (Celtidaceae) are now included in Cannabaceae. Members of the family are erect or climbing plants with petalless flowers and dry, one-seeded fruits. Hemp (Cannabis) and hop (Humulus) are the only economically important species.”[3]

The hop plant is a climbing vine. There are two genders, male and female plants. Only the female plant produces the cones used in modern brewing. In some rare occasion, a single hop plant can produce both male and female flowers.

What do hops contain?

“The hop cone luperlin are like small chemical bombs and contain about 500 different chemical substances. There are few plants that contain this amount of bittering chemicals. The bittering agents are found in the resin in these luperlins. These bittering agents in turn consist of around one hundred different components.”
“The typical smell of hops however comes from the fugitive essential oils. Today, some 300 hop oils are isolated and named, but new oil substances are constantly being discovered. In a hop cone you will find, apart from oils and resins, also water, polyfenols, proteins and cellulose. The hop cone also contains tannins. The tannins can cause cloudiness in beer by releasing proteins, and in this way somewhat contribute to the preserving effect of the hops.”[4]

[2] https://www.britannica.com/plant/hop
[3] https://www.britannica.com/plant/Cannabaceae
[4] Translation from “Humle, det gröna guldet” (Hops, the green gold). P19 - 20.

Schematisk bild av humlekotten i genomskärning. Humlekotten byggs upp av en central axel och kalk- samt hylleblad. Det är vid hyllebladets bas som blomman bildas och senare humlekörtlarna utvecklas. Blommans två märken syns tydligt mot hyllebladet på den övre bilden.

[5]

The picture above is an illustration of the inside of a hop cone. The lupulin gland (Lupulinkörtel) produces all the chemicals that we are after when brewing.

Usage of Hops

Over time, hops have been used for medicine, cooking, fabric, rope making, dyeing, embalming, and brewing. This makes the hop a very versatile crop where almost all parts of the plant can be used in one way or another.

Fibre

Several of the different Cannabaceae, including hops, have traditionally been used for fibre. Hop fibres have been used for both rope and clothing throughout the period we study. This area of hop use is not the focus of this document, however it is important to acknowledge how versatile hops are. In medieval times, any plant that could be used for multiple things was highly valued.

There was a push in the late 18th Century to investigate the use of hops as a commercial fibre crop.[6] The shirt shown here was given to the Nordic Museum in 1917, and contains fibre from both hemp (the bodice) and hops (the skirt). The shirt was gifted by the son of the owner, who noted that

[5] The picture is from: “Humle, det gröna guldet” (Hops, the green gold). Page 20.
[6] “Humle, det gröna guldet” (Hops, the green gold). P257

when a garment like this was first worn the fibres were so stiff that as a rule, it would draw blood.[7]

While these cases are later than our period, there is at least one archaeological find that suggests the use of either hops or hemp as a fibre dating back as far as the 5th C. A wagon wheel of wood from that period was found in 1944 in a lake in Sörmland, Sweden. It had sunk into the mud and was surrounded by a significant amount of Cannabicae pollen suggesting that plants were being weighed down in the water for retting. Hemp and hop pollen cannot be told apart, but this find is strong supporting evidence for the use of such plant fibers at this early period. [8]

Hops in Food

Cooking

Pliny the Elder mentions an edible plant he calls ‘lupus salictarius’, which some interpret as wild hops.[9] This may or may not be the case. Hop shoots are however traditionally eaten like asparagus in the low countries and in Sweden it was known as “poor man’s asparagus”. It was also used there as a preservative in cooking[10], and was a relatively common additive to bread.

Brewing

Hops in brewing have several purposes. Preservation and bitterness is primarily provided by various acids. Flavour and aroma is primarily provided by essential oils.
For more information about acids and essential oils in hops, please look at Appendix A

Medicine

Hops were known and used as a medicinal herb during the middle ages. It’s mentioned by Galen, Hildegard von Bingen, and later on by Culpepper.

“Hops (hoppho) is a hot and dry herb, with a bit of moisture It is not much use for a human being, since it causes his melancholy to increase, gives him a sad mind, and makes his intestines heavy. Nevertheless, its bitterness inhibits some spoilage in beverages to which it is added, making them last longer.”[11]

Culpepper’s translation of Galen states:
“Government and virtues. It is under the dominion of Mars. This, in physical operations, is to open obstructions of the liver and spleen, to cleanse the blood, to loosen the belly, to cleanse the reins from gravel, and provoke urine. The decoction of the tops of Hops, as well of the tame as the wild, works the same effects. In cleansing the blood they help to cure the

[7] “Humle, det gröna guldet” (Hops, the green gold). P257 caption
[8] Zachrisson 1994
[9] Natural History, book 21, chapter 50: “In Itialia paucissimas novimus, fraga, tamnum, ruscum, batim inumarm, batim hortensiam, quam aliqui asparagum Gallicum vocant. Praeter has pastinacam pratensem, lupum salictarium, eaque verius oblectamenta quam cibos.”
[10] Lundberg, Christina, 1852. Oumbarlig hjelpreda i hushallet for unga husmödrar...
[11] Bingen, Hildegard von Bingen's Physica) Part of the book (translated) available online via https://books.google.co.nz/books?id=wl6w2cfCKTgC&pg

French diseases, and all manner of scabs, itch, and other breakings-out of the body; as also all tetters, ringworms, and spreading sores, the morphew and all discolouring of the skin. The decoction of the flowers and hops, do help to expel poison that any one hath drank. Half a dram of the seed in powder taken in drink, kills worms in the body, brings down women's courses, and expels urine. A syrup made of the juice and sugar, cures the yellow jaundice, eases the head-ache that comes of heat, and tempers the heat of the liver and stomach, and is profitably given in long and hot agues that rise in choler and blood. Both the wild and the manured are of one property, and alike effectual in all the aforesaid diseases. By all these testimonies beer appears to be better than ale."[12]

[12] CULPEPER'S COMPLETE HERBAL, http://www.complete-herbal.com/culpepper/hops.htm

Hops in the middle ages

Timeline details

The following list of primary sources starts with an approx year, followed by some quotes or detail, and finally reference data. Some of the data sets may also have footnote data to improve the traceability.

600	Järrestad, Scania (modern-day Sweden)	A noble/royal estate being excavated by Per Lagerås has yielded macro-fossils of hop “fruits”. Presumably refers to seeds, or possibly hop cones. (Heimdahl, 2014)
736	*Hallertau, Germany*[13]	*Evidence for growing hops* *(Behre 1983, P119)*
768	*Hallertau, Germany*	*Hops being commercially grown in Hallertau.* *(Hornsey 2003, P54)*
800	Birka, Sweden	Macro-fossils of seeds found (Hansson, 1993)
800-1000	Hedeby, Denmark	Macro fossils of seeds found. (Behre, 1983)
822	Corbie, France	Description of hops being used for brewing by Adlhardus, abbot of Corbie.[14] (Polyptyque de l'abbé Irminon ou Dénombrement des manses, des serfs et des revenus de l'abbaye de Saint-Germain-des-Prés sous le règne de Charlemagne: publié d'après le manuscrit de la Bibliothèque du Roi)
830	Wandrille, France	Abbot Ansegis of Wandrille talked about beer made with hops (Unger, 2003)

[13] The two 7xx Halertau sources are currently being questioned. I’m currently looking into this further. Establishing and getting “commercial” cultivation going does take time. ***If*** we have cultivated hops at 822 in Corbie, when did the cultivation start?

[14] *“De humlone quoque, postquam ad monasterium venerit, decima ei portio de singulis servidis per singulos menses detur. Si vero hoc ei non sufficit, ipse vel comparando, vel quolibet alio modo, sibi adquirat unde ad cervisas suas faciendas sufficienter habeat.”*
"*Regarding hops, too, after it has come to the monastery, a tenth portion will be given to [the gatekeeper] by each [serf (grower)?] in each month. If in fact this is not enough for him, he should acquire it for himself, either by collecting [it], or in whatever other way, until he has enough for making his beer.*" (translation provided in private correspondence with Latin scholar, Hanna Mason, March 2017.

832	St. Denis, Paris, France	Abbot Hilduin lists items due from neighbouring villages; including beer (HBT)
859-875	Hochstift, Bavaria	Hop gardens are mentioned in monastery documents (Behre, 1983)
950	Graveney, UK	Macro fossils of fruit (Wilson 1975)
1000	Lund, Scania	Macro-fossils of hops found in excavations,. (Hjelmqvist, 1991:243)
1070	Mecklenburg and Pomerania, Germany	Hop orchards mentioned in Mecklenburg and Pommern. Medieval towns like Gardelegen and Calvorde also have hops in their arms. (Barth, Klinke & Smidt 1994.)
1150	Diessenberg, Germany	Hops (hoppho) is a hot and dry herb, with a bit of moisture It is not much use for a human being, since it causes his melancholy to increase, gives him a sad mind, and makes his intestines heavy. Nevertheless, its bitterness inhibits some spoilage in beverages to which it is added, making them last longer. (Bingen, Hildegard von Bingen's Physica) [15]
1230	Viborg, Denmark	The Vita of Bishop Gunnar mentions a farmer in Viborg who drank imported german beer and became so wild he had to be tied to a wagon wheel.[16] This “Trave beer” was brewed in Lubeck.
1268	France	Records reflect the use of hops in beer during the reign of Louis IX. Law states beer should only contain malt and hops. “By the 11th century hopped beer was commonplace in France, and in 1268, King

[15] Part of the book (translated) available online via https://books.google.co.nz/books?id=wl6w2cfCKTgC&pg

[16] “For dansk øl og mjød var det, man først og fremmest brugte, mens det saxiske øl, hvor tørst afløses af ny tørst, og som man er vant til nu om dage, dengang endnu ikke var til købs i disse egne, og de fleste bekymrede sig heller ikke om en sådan drik. Da denne drik senere kom hertil som noget nyt og ukendt, var der i nærheden af Viborg by en bondemand, der købte den for de penge, han fik for et læs porse, som han solgte dér. Den blev han så afsindig fuld af, at han i sit vanvid sønderrev og bed alle, han mødte, som var han en rasende hund. Han blev dog overmandet af nogle andre og bundet til tremmeværket – på dansk lægterne – på sin egen vogn. Tre ret så kraftige stænger i tremmeværket splittede han ad og brækkede ved at bide dem over med tænderne. Dette skete i dagene forud for Kristi Himmelfart, men biskoppen holdt i de samme dage en prædiken til folket, hvor han sagde, at enhver kristen skulle undgå og afsky en sådan drik, der kunne gøre en enfoldig og sund mand vanvittig og afsindig.”
Translated by Johannes Thomsen. Full text in latin:
https://johsthomsen.files.wordpress.com/2013/01/biskop-gunner-scannet-text.pdf

		Louis IX issued a decree stipulating that, in his realm, only malt and hops may be used for beer making." (The Oxford Companion to Beer, Page 464)
1275	Sweden	Tithing declaration from Tierp hundred to the cathedral in Uppsala states a harvest of 272 kg of hops. (HGG P67: DS 5571 SDK 6992)
1281	Copenhagen, Denmark	Sale of German "Trave" beer. Beer from the Lubeck region, hopped for longevity. (HGG P67: DS 5571 SDK 6992)
1283	Denmark	King Erik VI proposes a ban on German beer in reaction to a large import market of cheap, and strong, beer. (Behre 42)
1296	Sweden	Upplandslagen states that hops must be cultivated as part of the tithe. Hgg p66
1303	Nuremburg, Germany	Town records regulate brewing beer (Unger, 2003) Beer in the middle ages and the renaissance, Page 55. Chapt 4 note 10.
1316	Scania	Sale of German hopped beer is permitted during the markets (Hybel and Poulsen 2007)
1327	Sweden	Södermannalagen, a regional law text, taxes the cultivation of hops. (HoW, 1940 Södermannalagen)
1328	Uppland, Sweden	For the funeral of Birger Persson, the estate purchased "humulus, mirtus et IV libra zucare", presumably for brewing beer. (Brøndegaard 1987)
1350	Sweden	Magnus Eriksson landlaw increases the penalty for theft of hops to a capital offense
1350	Sweden	Magnus Eriksson's landlaw also regulates when hops and bog myrtle may be harvested: Hops could be harvested after Bartelsmass (24th August) but bog myrtle could be gathered after Olsmass, (29th July). It also determines a fine for gathering either bog myrtle or wild hops from someone else's land.[17]

[17] "Flaar man bast- eller bryter queste aff eek - bryterm pors eller villehumbla - ij annars maz mark - gielde ater skadan ok a tre marker."

		Wiktorsson 1989, Sid. III f. HoW 1962, Magnus Erikssons landslag, Byggningabalken XXXV.
1355	Aabenraa, Denmark	City council records the sale of Trave beer[18] (Aabenraa byskrå)
1358	Sweden	New edition of the land law, with strong penalties for theft of hops from either a hop garden or growing wild. [19] -HoW 1966 Magnus Erikssons stadslag LXXXV.
1360	Greifswald	Death penalty for anyone caught exporting plants.[20] (Anonymous 1360)
1360	Denmark/Sweden	A letter prohibits the Hansa from transporting goods through öresund, excepting hops and beer. (Strese 2012)
1369	Finland	Archbishop Birger of Uppsala grants taxation rights to the bishop of Abo. (How, 1943, Gutalagen:3 P4)
1369	Hamburg, Germany	457 breweries producing hopped beer (Bracker, 1994)
1378	Leuwen	Brewers produce 77 times more gruit ale than hopped beer (Uytven 1973)
1407	Leuwen	Gruit ale production 4.5 times greater than hopped beer (Uytven 1973)
1414	Växjö, Sweden	According to the local law, each farm was required to grow hops in a hop garden (Strese 2012)
1436	Leuwen	Production was now exclusively hopped beer (Uytven 1973)

[18] (49) Fremdeles må fremmede, som bringer humle med sig, ikke sælge deni skæpper, men de skal sælge den i hele drømt (Drømt = mål for humle) eller tillige i halve.
(50) Fremdeles må de, som bringer hele stykker tøjer, ikke sælge det i alenmål,men i hele stykker.
(51) Fremdeles skal de der fører salt med sig, sælge det i tønder eller i store og hele pund og ikke i små skæpper til vore borgeres skade Ved at de mister detailhandleravancen
(52) Fremdeles skal de, der fører travenøl eller sild med sig, sælge det i hele tønder og ikke i småpartier eller i kander. Enhver som forser sig mod de foregående paragraffer eller handler derimod, skal betale 3 mark i bøde til fogeden og ligesåmeget til rådmændene.

[19] "Nw stiel man humbla bort v skaeriom, humblgardhum hema, eller i oidom ella hwar man waexter bindes a han stylden of f;ras till rdhstuv ok dömess epter thy thiuffnadhen aer til.

[20] "I ett brev från 1360 sägs att de på hansedagen i Greifswald beslutat om vid vite av dödsstraff och förlust av egendom all frakt av hanseatiska varor genom Öresund ska upphöra." Den svenska humlens ursprung.

1442	Denmark	Kristoffer's landlaw prescribe the cultivation of hops on all farms, and orders the planting of forty plants until there is a total of two hundred.[21] (Strese 2008)
1474	Sweden	Legal requirement that each farmer must grow 200 hop poles.[22] (HGG P.67)
1483	Kalmar	Kalmaress fordrag, prescribing cultivation of hops (Strese 2012)
1447	Munich, Germany	Early version of the Reinheitsgebot, regulating brewing to use only malt, water and hops. (Huber 1959)
1516	Bayern, Germany	Reinheitsgebot enacted (Huber 1959)
1524	Sweden	King Gustav Vasa writes[23] about how farmers ought to grow hops to limit the import of foreign hops and beer. He also describes the types of beer to be provided to various courtiers, detailing the amount of hops to use for each kind. (HGG P.67)
1591	Germany	Johannes Colerus publishes regarding different types of hop. Another expanded version is published in 1643. (Erici 1683)

[21] "Alle hemman böra humlegård hafwa, och lägger bonde goda rötter till fyratijo stänger hvart år, till dess de blifva tuhundrade vid ett helt hemman."
[22] Kalmar recess
[23] "Nyttugt wore at huar boonde hade en humblagard."

Stepping through time.

This section focuses on the raw primary sources and also notes key events in history related to hops that shows when, at the latest, a particular occurrence took place (growing/cultivating, brewing, export/distribution, drinking etc).

Pre 800

Even though there are indicators going back to approximately 400 CE we don't know for sure if the finds are of hemp or hops. Also we don't know what the usage was so we have to discard these sources.

The first definite Scandinavian hop find is from the 7th century, in Järrestad, Scania.

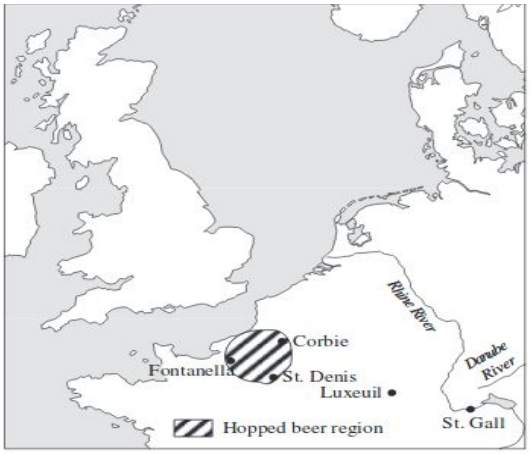
9th century

During the 9th century, we have a burst of data.

Three continental monasteries document the use of hops in beer brewing (822, 830 and 832). To date this is the earliest written proof for hopped beer.

Vikings were frequent "visitors" to continental Europe, where we know that some monasteries at least brewed with hops. Macro fossils have been found at two viking excavations, Birka and Hedeby. Consequently we do know that the Vikings had hops, although we don't know what they were used for, however we can be fairly certain that they had encountered hopped beer.

At the very end of the 9th century, we find more archaeological evidence of hops in Sweden. (See the table above)



Map 2 Monasteries serving beer and using hops.

11-12th century

During these centuries we see more written documentation about orchards and the use of hops in brewing and drinking.

13th century

The most important set of documentation from this century is from Denmark. In Bishop Gunnars Vita, the author describes an incident in Viborg in 1230 when a farmer drank hopped beer and got so wild he was tied to a wagon wheel. This is the very first (and only) description I've found regarding the consumption of hopped beer.

Apart from this drunk Dane, we have two more sources from Denmark that talk about the sale of imported hopped beer in Denmark; in 1281 “Trave beer” is traded in Copenhagen, and in 1283 King Erik VI tried to prohibit the import and sale of this german beer. “Trave beer” refers to beer brewed on the Trave river, I.e. in Lubeck.

In 1268, the council in Roskilde gave permission to local farmers to sell hopped beer in their city.

From this time period we also see localities named after hops. Such names include Humlebaek, Humlebakke, Humledal. They are all coastal settlements.

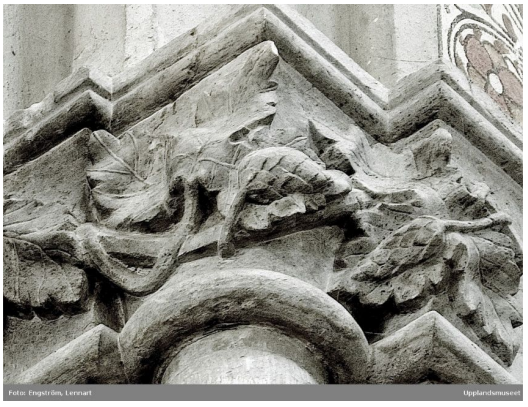
We now see evidence that at least some people were drinking imported hopped beer in Denmark. We also see that Danes were growing hops. Import of hopped beer on a larger scale had started to take place. Hop growing in Sweden had become so important that the death penalty was introduced for theft of hops**.**

14th century

We see documentation of hop growing and brewing from other regions in Europe.

In 1316, by royal decree German (hopped) beer was permitted to be sold in Scania, and in Åbenrås town records note the import of Trave beer.

By the 14th century hops had become so important in Sweden and northern Europe that we start to see them becoming part of arms and even architectural features. The pictures[24] below show pillars B3 and C12 from the Uppsala Cathedral. The C12 carving has been dated to early 1300. There are several primary sources[25] from Sweden showing the staggering amount of hops and money provided to the church. It is important to remember, this was the “taxation”, the tithe, not the full amount grown. It likely represents only around 10% of production.



[24] The two pictures are from https://digitaltmuseum.se in Sweden.
[25] Some of the sources:
DS 5571
SDHK 6992
DMS 1:4 Page 208
DS 3835, 314
Dahlbäck 1977 pages 60,80
1376 year christmas book for Uppsala domkyrka
SDHK 12314

15th century

Documentation from this century show that in less than 60 years, Leuven went from 77 times more gruit ale then hopped beer, to exclusively producing hopped Beer.

There is yet another round of legal mandate for farmers in Sweden to grow hops and the first version of a Reinheitsgebot (beer purity law) was published in 1487.

16th century

Apart from more legal mandates for hop growing in Sweden, we have two very important and interesting publications. The Reinheitsgebot was mandated in the former states of the Holy Roman Empire (centring around the country now known as Germany) and Johannes Colerus published a book that included different hop types.

What about other sources?

From now on, we are stepping away from primary sources. We will have a look at secondary sources and some botanic research recently done in Sweden.

Evidence suggests that hops (in one form or the other) have been in Scandinavia/Sweden since at least 600CE, and based on various archaeological excavations, probably pre 400[26].

Vikings

"The finds of hops from Viking Age sites show that hop as a beer additive was probably popular earlier than previously assumed. The finds of hops form a part of a regional pattern already originating in the late Iron Age, which, for instance, is seen in the finds of hop from the royal estate of Järrestad in Scania from the seventh century[27] and from early eighth-century marketplace of Ribe.[28] Several Medieval Swedish provincial laws, which include some regulations that are likely to have their origins in the Viking Age, contain information on the layout of and the directives for the hop garden[29]. Here it is mentioned that the hop garden can be located within as well as outside the area of a farm."[30]

"Although a native plant, hops may also have been grown or purposefully collected. It was present in trace amounts in two pits, but rather frequent through the fills of pit A65132, reaching an abundance of 3 (on the 4-point scale used) in two samples from context AL86018. Behre (1983, 1984) has described the finds of hops from Hedeby, and put them in the context of early medieval use of plants as flavourings for beer. This plant was frequent at Coppergate (Kenward and Hall 1995), and has also been recorded at Birka, Sweden (Hansson and Dickson 1997), and Novgorod (M. Monk, pers. comm.), whilst Aalto and Heinäjoki-Majander (1997) have demonstrated its importance in 9th-/10th-century deposits at the Viking-age town of Staraja Ladoga in western Russia. The use to which the hops were put does seem most likely to have been related to flavouring beer, though the plant is credited with other uses such as in dyeing."[31]

Hop types and varieties

The first written proof of knowledge of hop varieties shows up in the 16th century. However, there are strong indications of at least four different types of hops at this time. Contemporaries divided hops into long or short cone hops, and also distinguished between 'wild' and 'domesticated' hops.

[26] Pernille Rohde Sloth, Ulla Lund Hansen & Sabine Karg (2012) Viking Age garden plants from southern Scandinavia – diversity, taphonomy and cultural aspects, Danish Journal of Archaeology, 1:1, 27-38, DOI: 10.1080/21662282.2012.750445
[27] Lagerås 2003
[28] Jensen 1986, P. 18; Robinson et al. 2006, pp. 110
[29]Humlegården; Hoff 1997, p 117
[30] Pernille Rohde Sloth, Ulla Lund Hansen & Sabine Karg (2012) Viking Age garden plants from southern Scandinavia – diversity, taphonomy and cultural aspects, Danish Journal of Archaeology, 1:1, 27-38, DOI: 10.1080/21662282.2012.750445
[31] Interpreting the Plant and Animal Remains from Viking-age Kaupang

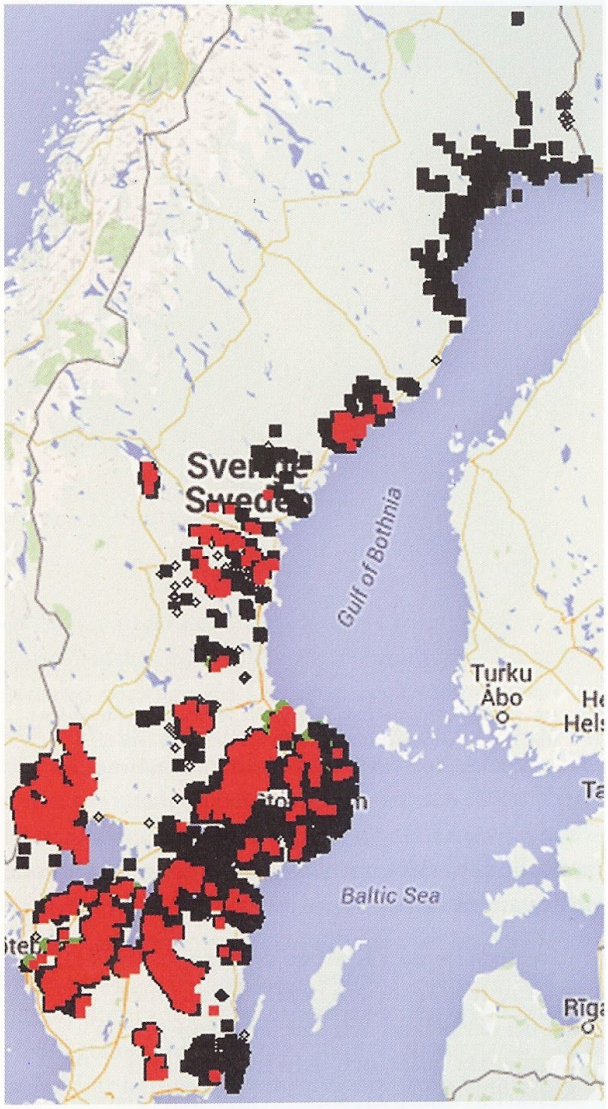
The division between long and short cone hops can still be observed today, although we divide hops further into different types within these groups. Each variety has different characteristics, but we have no evidence for how far back these types go. Hopefully more DNA testing will provide such evidence.

The two pictures above shows two typical shapes, short and long cones.

When it comes to the differentiation between ‘wild’ and cultivated’ hops, it is highly unlikely that we will ever discover if there is a linkage between wild/cultivated and the shape. Whilst older research refers to hops as native modern research in Sweden strongly indicates that hops are not native at least to Scandinavia.

Hop history in Sweden[32]

Over the past several years, a research team has worked its way through the entire country of Sweden locating and collecting 'wild' hops. These samples have been DNA tested and also sent to a seed bank / museum farm in Alnarp. With the exception of Norduppland, the majority of these hop finds were either in or directly adjacent to abandoned historical farms and villages, often dating back to medieval times. In Norduppland the search teams found hop plants at historically known sites of hop cultivation. We know these orchards in Norduppland go back to at least mid 1600 when they feature in the tax records.[33]



Översikt av humleodlingar omkring 1650 i databasen GEORG. Svart markerar geometriska kartor, rött och grönt där det både finns kartor och humleodlingar. Skåne, Halland, Blekinge, Gotland och Bohuslän ingår inte.

The picture to the left is a summary of the documented hop orchards in Sweden around 1650CE. Black shows locations found on historic maps. Red and green denote areas where map locations coincided with hop orchards.

The research team found several different hop types. Some of them were uniquely suitable to Sweden with its short season but long summer days; blooming in July and maturing in August/September. Some plants were simply incapable of reaching maturity in the Swedish climate. The research team also wrote about continental hop types which are even later than the Swedish varieties.

All in all, the research team decided to limit and preserve 54 types of hops in the national plant reservation bank.

Genetics

The research team focused on hops from areas where they knew that hops dated back to 1400 and 1600-1700. Some of the areas they tested had only male plants! Part of the testing used 25 old variants from continental Europe. They were able to establish that there were either no, or only a few hybrids that had occurred while the plants were untended. I.e these plants show a strong resistance to genetic change. The majority of plants tested were female.

[32] Information in this chapter is from the book, "Humle, det gröna guldet", Nordiska Museets Förlag, ISBN 978-91-7108-574-0
[33] The picture is from the book "Humle, det gröna guldet" Page 108.

The swedish hop material was clearly different from the continental european plants, even though several hundreds of thousand hop plants were imported from various european hop regions during the second half of the 19th century.[34]

“Atsushi Murakami and his colleges have made the assumption that the reason for the relatively high speed of hops spreading across Europe is due to brewing with Hops.”[35]

Even though there were some old orchards with only male plants, it is really important to note the overall findings from the research team. “Out of the inventoried places we only found male hop plants at 5% of the location”.[36]

How wild are the swedish hops?

There has been some speculation that in the Medieval texts “wild hops” in fact referred to Bog Myrtle (Pors), a key component of Scandinavian Gruit. However, as the book points out, this is unlikely as Bog Myrtle is actually mentioned in some legal documents, alongside wild hops.

Taxation

We have already touched on the importance of hops and taxation in Sweden. Continental Europe was no different. There is a long list of primary sources in continental Europe that touch on taxation. There are a couple of in-depth sections about this in the book “Beer in the Middle Ages and the Renaissance” by Richard Unger. Other than the references I already have, I don’t think I would enhance this document by regurgitating the sources and information provided by Unger. I do however want to show a really interesting table from this book that illustrate the numbers / proportion of beer tax and other taxes. The really interesting notes in the table is that tax from beer, at times, was more than 50% of the tax income for some areas, even up to 88.5% during 1437-1438 in Haarlem.

[34] “Det svenska humle materialet skilde sig klart från det kontinentala och detta trots att det togs in hundratusentals plantor från olika europeiska humle odlingsregioner under 1800 talets andra hälft.”
[35] Translation, with the reference “Murakami, Darby, Javornik et al. 2006, Page 66-74.
[36] Page 45.

TABLE 11. SHARE OF TOWN INCOME FROM TAXES ON BEER, FOURTEENTH THROUGH SEVENTEENTH CENTURY

Year	*Town*	*Share in percentages*	*Remarks*
1370–1387	Hamburg	4.6	Average
1391–1392	Delft	24.6	
1391–1392	Leiden	17	
1399	Leiden	47–53	
1413	Leiden	58	
1426	Leiden	42	
1427	Leiden	53	
1429	Dordrecht	14.8	
1433–1434	Leiden	59	
1437–1438	Haarlem	88.5	
1440–1443	Haarlem	35.1	Average
1449	Leiden	78	
1450	Dordrecht	13.2	
Fifteenth century	Mechelen	50	Approximate average
1452	Ghent	5	
1465–1466	Ghent	24.5	
1465–1496	Hamburg	8.6	Average
1490	Hasselt	33	
1492	Breda	52	
1502	Dordrecht	39.9	
1515	Hasselt	60	
1522	Dordrecht	39.3	
1528–1610	Ghent	41.3	Average
1530–1543	Antwerp	53.7	Average
1549–1560	Hamburg	11.9	Average
Sixteenth century	Leuven	39.3	Average
1552	Amsterdam	55	
1556–1558	Dordrecht	37.8	Average
1567–1568	's-Hertogenbosch	51	Approximate
1556–1560	Haarlem	65	
1575–1600	Lier	30.2	Average
1595–1599	Haarlem	23.3	
1600–1609	Haarlem	27.2	
1610–1612	Dordrecht	28.8	Average
1622	Hasselt	70	

Sources: Bing, *Hamburgs Bierbrauerei*, 308; Eykens, "De brouwindustrie te Antwerpen," 82; Hallema and Emmens, *Het bier en zijn brouwers*, 84–85; Martens, "Bier en stadsfinancien te Hasselt," 243; Soly, "De brouwerijenonderneming van Gilbert van Schoonbeke," 339, 1179–81; Soly and Thys, "Nijverheid in de zuidelijke Nederlanden," 47; Unger, *A History of Brewing in Holland*, 60–61, 69–71.

Diversity of hops

We now know that from early 800's there was beer brewed using hops, as well as with gruit. However, we don't know how that came to be the case, and in reality, we are unlikely to ever learn how hops came into use.

We have seen some really early finds in Sweden where hop seeds have been found. We also know that in some areas in Sweden there were orchards with just male plants. That begs the question; what were the Vikings doing with the hops? We know they very likely had been exposed to hopped beer when traveling in Continental Europe. Did whey want to brew their own? Were they using the fibre for rope or fabric? Yet again, we don't know. What we do know is that hops is a hugely diverse plant. All these alternative usages of hops, beyond just brewing, probably show us why hops spread so fast around Europe.

Research and genetic testing has shown that hops is not native to Sweden. Nor is it related to the influx of commercial hop varieties in the 19th century. The research strongly suggests that hops were brought into Scandinavia during the early Medieval period and firmly established there. The settlements where these plantations were established have since vanished, leaving us with 'wild' populations with distinct genetics. As hops are largely clonal plants, they are resistant to genetic changes over time[37], leaving us with a long-lived data record. This opens up an area of research where we should be able to track the spread of hops very clearly, with the use of DNA analysis. It would be fascinating not just for the specific research into hops but also for the insights into wider cultural changes, and I for one would buy the book!

Did hops kill the gruit?

Early medieval brewing of malted barley in continental Europe mostly used gruit when brewing ale. In scandinavia, bog myrtle is a frequently mentioned ingredient. As per the timeline above, Swedish law texts were often using both bog myrtle and hops in the same context.

Hops did not entirely kill gruit use although it did displace it to a large extent. In fact, in some areas, in Norway for example, people are still to this day brewing with both gruit and hops, depending on what they want to drink.

I would suggest we see hopped beer as a complement / alternative to wine, mead and ale (gruit flavored malt drinks). The reinheitsgebot laws were really created to control commercial brewing, not the small scale brewers who continued to use whatever they were accustomed to when supplying their own households.

Gruit is an interesting topic, to be sure, but well outside the scope of this document. I will leave all aspects of gruit brewing to others, at least for now.

[37] HGG

What's the most historically accurate brew?

Putting my beer brewer's hat on, I would say brew what you you like to drink and share. If you want a truly authentic medieval beer, I'm afraid we have to expand the scope much further than whether your beer is hopped or not. You would also have to consider what type of malt you use; light, dark[38], roasted, smoked etc. Malt may be an even bigger research topic than hops, and one I am likely to look into next. You also need to consider filtering. We know they used many different methods ranging from straw to various conifers such as spruce and juniper to filter the wort. How does that impact on your beer? And let's not forget the impact of their choice of water.

[38]A bit unclear how the beer got dark but in the book Beer in the Middle ages on age 61, there is a comment "And the income may have risen after 1374 when Hamburg brewers shifted from exporting dark beer to a lighter one of higher quality."

What kind of hops to use?

It looks like we have two options regarding using hops. We have the “traditional” (actually modern) unfertilized hop cones with the glands intact and full of the chemicals we are use to brew with. The other option is to use hop cones that have been fertilized and therefore contain seeds. Looking back at our sources, we can see that all of the early archeological finds are hop seed. This leaves us with a big question: When hops were used in medieval brewing, especially early medieval or possible even iron age brewing did they use fertilized hop cones (hop seed) or unfertilized hop cones? One indicator of the use of hop seed for brewing is some data regarding the amount of hops used when brewing. Given how unclear period sources are on wild/cultivated or male/female hops, one explanation for this could be the very real difference in potency between fertilised or unfertilised hop cones.

If this theory is true, it is unclear when the shift from seed to unfertilized hop cones took place. We have the early archeological finds (seed). We also start to see evidence of hop cultivation mid to end of the 700’s. Add to this the post 800 use of the new French word humularia[39] (hop orchard). I think we start to see the shift from brewing with hop seed to using unfertilized hop cones around the late 700’s or early 800’s.

Hop volume and quantity

I recently came across an interesting academic paper from Sweden called “Hop cultivation in Scania parishes between the years 1658 and 1758”. The paper is going back to 1400 to establish their theses.

One of the really interesting paragraphs in the document states that “Vid ölbryggning under historisk tid användes drygt 400 gram humle per 100 liter öl, vilket betyder att det gick åt cirka 100 humlestänger för att brygga mellan 1000-3000 liter öl (Karlsson Strese 2008).”
This translates to
“In historic times, when brewing, about 400 gram of hops was used per 100 litre beer. As such about 100 hop poles were needed to brew between 1000 and 3000 liter beer.”

This brings the hop volumes back down to more reasonable levels (about 2-3 times more than I use today when brewing).

The final source I’ve recently come across backs up the Swedish academic paper in terms of quantity. This paper even has a “recipes” for beer from 1510.

“Enligt Gustaf I >>fogdereglor>>, bryggdes en tunna >>fogdeöl>> af 1/2 tunna malt och 3 marker >>prysk>> eller 4 marker finsk humle, 1 tunna >>svenneöl>> af 2/5 tunna malt samt 2 mark preussisk eller 2 2/5 mark finsk humle och en tunna >>spisöl>>, som vid måltiderna utskönktes, af 1/5 tunna malt och 2/5 mark humle.”

The recipe translated into English and modern quantities:

[39] “Agrikulturhistoriska teckningar.”

- Fogde-Beer 146.6 litres of finished beer is made up of 73.3 litres malt, 637.5 grammes of Prussian hops or 850 grammes of Finnish hops.
- Svenne-Beer 146.6 litres finished beer is made up of 58.64 litres malt, 425 Prussian hops or 510 grammes of Finnish hops.
- Table-Beer served at mealtimes 146.6 litres finished beer is made up of 29.32 litres malt, 85 grammes hops.

The document also mentions the relative value of hops in Sweden 1530: 1 Pund (probably about 425 grammes) = 146.6 litres of malt = 194.5 Kg iron.

What hops should I use?

The final question I guess would be this: If I am to use hops, what variety should I use and should I use seed or unfertilized hops?

My short answer is, I don't know for sure. Sorry.

My understanding from the research program in Sweden is that medieval hops had low level of acids, similar to modern "low level acid" hop types. Modern hops have been refined a lot in the last few hundred years. Today we have bittering hops with huge levels (12% or higher) of alpha acids. We have more or less pure aromatic hop varieties. And we have some generic hop types that can be used both for bittering and aromatics.

For a medieval substitute, I would recommend aiming for a more generic hop type. Probably one of the noble hops, with lower alpha acid levels, probably sub 4%.

"A lot of home brewers are familiar with the term "Noble Hops" which refers to four variety of continental European hops originally grown in Central Europe."[40]

The noble hop varieties are:

- Hallertau mittelfruh
- Saaz
- Tettnanger
- Spalt

Personally I'm currently looking into Saaz, NZ Pacific Hallertau, and Hallertau mittelfruh for the time being. As we get more information on older types of hops, this may change. But for now, those varieties seem to represent the best option.

As mentioned before, a lot of the hop types found through the Swedish botanical project are being preserved. Some of them have also been given to "Julita Gård"[41] in Sweden where they are now cultivating Swedish hop types that may date back to medieval Scandinavia. It is hoped that these older varieties may prove commercially useful. When this project is further along, I'm hoping to be able to buy some of their hops or at least get a chemical breakdown in a not too distant future.

[40] http://beersmith.com/blog/2012/02/05/noble-hops-for-european-beer-styles/
[41] http://www.nordiskamuseet.se/slott-gardar/julita-gard

Conclusion

As northern european and scandinavian literature shows, hops has been used for beer brewing earlier in the area than has generally been thought, although we still don't know exactly when beer brewing using hops started. While we know Vikings had access to hops, we have no definitive knowledge of what they did with them. Hopefully there will be more research and analysis done to bring some clarity to the mystery.

Questions still remain around the genetics of scandinavian hops. “Wild” hops found in Sweden appear unrelated to modern european hops. When did modern hop varieties replace the earlier genetic material, and why are there no genetic links? Until more DNA studies are done, it is difficult to know exactly what modern hop varieties to use as substitutes when recreating early medieval beer.

Who am I then

I’m Martin Forest. I’m also known as Sir Asbjorn in the SCA. My family and I live on a lifestyle block an hour or so north of Wellington, New Zealand. I’ve been brewing since I was a student over 30 years ago. I primarily brew beer with the odd batch of mead and wine. I’m really interested in and am trying to recreate authentic medieval beer brewing. I have even recently planted both Norwegian spruce and juniper communis to get access to spruce and or juniper branches for my brewing.

Appendix A

Hops in beer have four primary functions, bittering, preserving, flavouring, and aromatizing. Bittering and preservation is primarily done by acids while aromatics and flavour is primarily provided by the essential oils.

The acids are typically divided into two groups, Alpha and Beta acids.

Alpha acids

The Alpha acids - consisting of Humulone (most important), Cohumulone, Adhumulone, Posthumulone, and Prehumulone - are the acids activated during the boiling of the wort. These acids provide an instant bittering effect and preservative. Higher acid levels will give more bitter beer (higher IBU[42]) compared with lower acid level using the same volume.

“The equation for International Bittering Units (IBUs) takes the amount of hops in AAUs and applies factors for the boil gravity, volume, and boiling time. IBUs are independent of batch size, and to a large extent, independent of style, unlike the AAU.”[43]

Another common measurement that brewers use is AAU.

Alpha Acid Units (AAUs) or Homebrew Bittering Units (HBUs), are the weight of hops (in ounces) multiplied by the percentage of Alpha acids. This unit is convenient for describing hop additions in a recipe because it indicates the total bittering potential from a particular hop variety while allowing for year to year variation in the %AAs.

Calculating Alpha Acid Units
AAUs are a good way to state hop additions in your recipes. By specifying the amount of alpha acid for each addition, rather than e.g. 2 oz of Cascade, you don't have to worry about year to year variation in the hop. An AAU is equal to the % AA multiplied by the weight in ounces.

For Example:
1.5 oz of Cascade at 5% alpha acid is 7.5 AAUs. If next year the alpha acid percentage in Cascade is 7.5%, you would only need 1 oz rather than 1.5 oz to arrive at the same bitterness contribution.”[44]

“Bittering hops are boiled in the wort for at least 60 minutes. A critical isomerization occurs during this time (~~see below~~). Flavor hops are added during the last 15 minutes of a boil,

[42] IBU is an abbreviation for the International Bitterness Units scale, a gauge of beer's bitterness. What IBUs measure are the parts per million of isohumulone found in a beer. - https://beerconnoisseur.com/articles/whats-meaning-ibu
[43] http://howtobrew.com/book/section-1/hops/hop-measurement
[44] http://howtobrew.com/book/section-1/hops/hop-measurement

and aroma hops are added during the last 1-5 minutes of the boil. The role is determined by how oxidized the hop chemicals get during the boil.
I want to just consider the bittering aspect right now. Hops contain varying amounts of what are known as alpha acids. Many hops range from 4-15% alpha acids. Humulone (as seen in the figure below) is one example of an alpha acid. There are of course many others, but they are all phenolic compounds that are only slightly soluble in water. The alpha acids get isomerized to iso-alpha acids during the boil in the slightly acidic wort. The iso-alpha acids are more soluble in water and contribute the bitterness of beer. A good 60 minute boil is necessary to extract and isomerize the alpha acids. The % alpha acids is a good measure of how bitter a hop will make the beer."[45]

These alpha acids fade over time as they oxidize. Most hop varieties have tables showing the typical ratio the alpha acids face over time.

Beta acids

The Beta acids - Lupulone, Colupulone, and Adlupulone - slowly become more and more bitter as they oxidize in a brew. Brewers typically prefer the Alpha and Beta acid content of hops to be "balanced", in order to maintain an even bitterness over time. I.e. as the Alpha acids oxidize and fade over time, the Beta acids oxidise and increase their bitterness.

"Beta acids, lupulones, make up part of the soft resins in hops. They have very low solubility in wort (~1 part per million); thus, only trace amounts survive the brewing process and end up in finished beer. Beta acids are fairly reactive with oxygen and can oxidize to a set of compounds called hulupones, each of which is derived from its beta acid analogue; for instance, cohulupulone comes from colupulone. Because they are not bitter and are only marginally soluble, beta acids do not contribute to beer flavor. However, hulupones are bitter and can contribute substantially to the final flavor of beer. Anecdotal claims suggest that hulupones have an unpleasant bitterness quality. Hulupones are relatively stable once formed and can survive all stages of the brewing process. They can be formed via the oxidative degradation of hops during storage. As hops oxidize, the bitterness that comes from iso-alpha acids diminishes because their precursors, alpha acids, are lost as a result of oxidation, but this is somewhat offset by the presence of bitterness from the hulupones. The ratio of alpha acids to beta acids ultimately dictates the degree to which the bitterness potential will diminish as hops oxidize. Higher levels of beta acids in the raw hops will result in a slower decline of bittering power as hops degrade oxidatively because of the resultant higher levels of hulupones. Hulupones can also be formed during wort boiling because the high temperatures accelerate the reactivity of beta acids. Alternatively, hulupones can form on trub following spent hops separation from boiled wort where the environment is hot and there is plenty of available oxygen. Bitterness contributions can be substantial in the latter case if the trub pile is added to a subsequent batch of beer, as is the case in some breweries."[46]

[45]Chemgeek - http://homebrewandchemistry.blogspot.co.nz/2007/02/hop-chemistry.html
[46]Thomas Shellhammer - https://beerandbrewing.com/dictionary/Bu1Rco6Cpn/hulupones/

When using hops as a bittering agent (added in the start of the boil) you normally want a high acid level, with a good balance. Consequently, modern hops have been bred for acid content in a concerted effort going back to the 19th Century.

Essential oils

Whilst the high acid hops are used primarily for bittering the more aromatic hops are used for flavour. It is also important to know that when boiling hops most essential oils are lost. This is why it is common to add new (aromatic) hops at the end of the boil or even during fermentation (dry hopping).

The aromatics are formed by the various essential oils present in the hop cone, and vary greatly with different varieties of hops. Brewers take advantage of this variety when producing specialty beers. The following are some of the most common/high profile oils brewers often talk about;

- ➔ Myrcene
  - ◆ Aromatic hydrocarbon. Very volatile in air. Helps carrying aromas.
- ➔ Humulene
  - ◆ Isomer of Caryophyllene. One of the key oils that give the “hoppy” aroma.
- ➔ Caryophyllene
  - ◆ Can give a dry wood, pepper, and earthy flavor.
- ➔ Farnescene
  - ◆ Provides green apple as well as flowery, citrusy, woody flavours. Prone to rapid oxidation and is best at end or post boil.

Aromatic hops are added in stages or at the end of the boil, or even as “dry hopping” during fermentation.[47]

Aromatic hops are their own commercial product and include a variety of exotic hop types. Again, the hop industry has been actively breeding for aromatics for centuries. It follows then that modern hops are likely quite different from medieval hops.

[47] The Beersmith has some good information about dry hopping: http://beersmith.com/blog/2008/05/21/dry-hopping-enhanced-hops-aroma/

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