

## Genetic results obtained from the hop leaf samples from the year 2012-2019

During the years 2012-2019 we received over 800 hop leaf samples were received from the Finnish residents.

**I would like to cordially thank every each of You for that!** Our work is not possible without that.

Samples arrived from all over the country and each one had assigned unique LUKE number for easier tracking of the results. A whole genomic DNA was isolated and stored for the purpose of genetic diversity analysis. At this moment (2019) we are using genetic markers called microsatellites or SSR.

Our sample samples also included hops from Canada, Estonia, Lithuania, Norway Slovenia and Sweden\*. Those samples we received from our colleagues who are doing hop research in their own countries and beyond, by the courtesy of Natasa Stajner (SLO); Mette Thomsen (NOR); Patrick Savard (CAN), Nerijus Jurkonis (LTH); Annika Michelson (EST) and colleagues from Sweden.

So far, a subset of samples received from Slovenia included 94 samples that represent *Humulus lupulus* L. (wild hops and cultivars) and different hop species (*Humulus lupuloides*, *Humulus neomexicanus* and *Humulus pubescens*) from Australia, Arizona, Austria, Bosnia and Herzegovina, China, Colorado, Czech Republic, Denmark, ex-Yugoslavia, France, Georgia, Germany, Iowa, Italy, Japan, Kazakhstan, Macedonia, Manitoba, Missouri, Montana, New Mexico, New Zealand, North Dakota, Russia, Saskatchewan, Slovenia, South Africa, Spain, Serbia, United Kingdom, USA, Utah and Wisconsin. This subset we call reference set of markers.

A DNA from the all sets of the hops samples (> 1000) were analyzed with the 25 microsatellite markers and the dendrogram was created in order to visualize unique hops, duplicates and possible family relationships between different hops. Unique hops and duplicates are certain designation while family relationships are somewhat more speculated categories (lower probability of being certainly true). Explanations of the way how the dendrogram was interpreted and meanings of the dendrogram «symbols» or «characteristics» are shown in (Table 1).

**Table 1. Interpreting the hop dendrogram; some hints and some of the possibilities ☺**

No.	Hop designation on dendrogram	Explanation of the designation	Dendrogram «symbols» or «characteristics»
1	UNIQUE HOPS	Hops having a unique genetic profile that appears only one single time within all the samples	One horizontal line
2	DUPLICATES	Groups of genetically identical hops i.e. two or more hops whose genetic profiles are exactly the same among each other	Vertical (line connecting same (identical) samples
3	PROBABLY DUPLICATES**	Groups of genetically highly similar hops (almost identical) i.e. two or more hops whose genetic profiles are different in minimal number of genetic markers	«Very shallow Loop» (this loop includes duplicates and their nearest neighbors) (Vertical lines connected with very short horizontal line)
4	Possible FAMILY RELATIONSHIPS between the hops (brothers and sisters, grandchildren, grand grandchildren ... )	Hops having > 80% of genetic similarity among themselves might be considered as putative siblings; while e.g. those ones >60% GS might be speculated to be children from same grand grandparents	«Fairly small loop» (Vertical lines connected with very short horizontal line)

An example of how the «reading» of the dendrogram was performed is presented in Figure 1.

**Finnish hops are labeled in black color while reference hops were in red (SLO; mainly); Norwegian hops in orange (NOR); Lithuanian hops in green (LTH), Canadian hops in blue (CAN), Estonian hops in purple (Viro)**

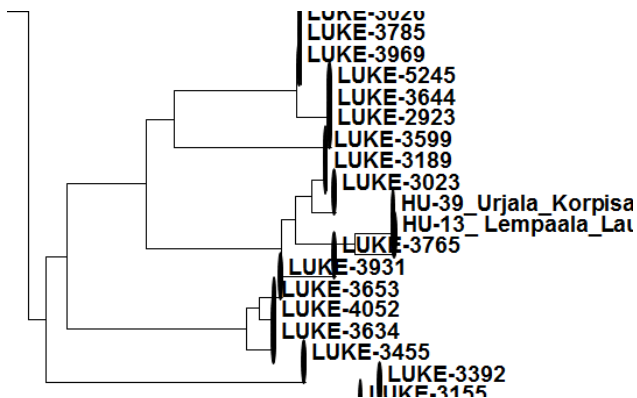


Figure 1. A section of the whole hop dendrogram including years 2012-2019.

Some exemplar comments on readings of the dendrogram representing all hop samples:

- Samples grouped with the most of the reference hops («red» section of the dendrogram where 90% of reference samples are concentrated) might be of “foreign origin”; or hops resulted from some selection or some breeding program.
- LUKE 2691 clustered next to the well-known Serebrianka. They might be related to each other and it would be interesting to see brewing properties of the LUKE 2691.
- The rest of the samples may have a very unique Finnish origin. This is imputing that Finnish hops represent hops distinct from the hops from the rest of the world and may have a very authentic and unique origin that is separating them into a special group.
- Estonian, Norwegian, Lithuanian are dispersed among Finnish hops; but well distinctive and never duplicated.
- Lithuanian and Canadian hops grouped mainly with bred, reference hops.

Notice: During the years we are receiving hop samples from all over the World; but mostly from Finland. In March 2020 the dendrogram was updated with many diverse samples and some changes in the results may be noticed when compared to previous years. E.g. unique hops from 2017 may not be unique anymore as they could match to some new hop sample or some new hop from 2019 may replace your hop in a certain (family) group and “move “ it to another etc. **Thank you for understanding.**

\*In order to include Swedish hops back to dendrogram; we would have to decrease number of markers to 10. This is possible to do on request.

\*\*Probable duplicates can be confirmed/rejected in detail on request.

For any further details on available results of genetic analysis of your hop please do not hesitate to ask.

I will be happy if I could help you =)

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