## **Seed Coat Darkening**

## **Terms**

* ND: Non-darkening (Wit-rood Boontje)
* SD: Slow darkening (some pinto beans)
* RD: Regular darkening (all other pinto and cranberry beans
* PHD: Post-harvest darkening

## **General Notes**

* Both pinto beans and cranberry beans undergo post-harvest darkening (PHD), in which the white background of the seed coat becomes orange-brown after UV exposure. See this for yourself by going through some of the seed harvested this year at Lods - some pinto beans will have darkened significantly, while others will still be fairly pale.
  + To get granular, the darkening occurs as a result of accumulating proanthocyanidin precursors. Check out Erfatpour et al. 2020 listed below if you would like a detailed enzymatic pathway.
  + PHD reduces market value pretty significantly. It is also likely that PHD affects nutritional quality, but the details are unclear. Keep your eyes open for new papers on the subject. It can also be an indicator of age, meaning that the beans will likely be more dried out and take longer to cook if not properly soaked.
* “Wit-rood boontje” is Dutch for “white-red bean.” Sometimes you’ll see it marked as just “Wit-rood” which is still the same cultivar, but whoever gave the label just didn’t feel the need to specify that it’s a bean.
* Phil Miklas (USDA), Philip McClean (UND), and
* Common bean was domesticated in multiple places. The main two centers of domestication, and thus the two major gene pools, were Mesoamerica and the Andes. As a very general overview, Mesoamerican beans tend to be smaller and rounder (navy and black beans, small red beans, pinto beans) while Andean beans tend to be larger, sometimes flatter, and with a large range of light colors (yellow beans, cranberry beans, large white beans, etc). The main point of this is that the two main darkening market classes, pinto beans and cranberry beans, come from different gene pools. It would be really interesting to compare which markers are shared by both and which might be specific to one gene pool or the other.
  + [Giolia et al. 20](https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0211342)19 has a good overview of the two gene pools.
  + [Delfini et al. 2021](https://www.nature.com/articles/s41598-021-82437-4) gives population structure for Brazil
  + Population structure studies are often the first step in any project like this, meaning that there’s a ton of literature out there for any population that you want to look at.
* Wit-rood boontje is the gold standard for ND in cranberry beans
* ***Bring back the seed packets you use before seed treatment and planting season -*** get in touch with Shamus and Valerio about when that will be.

## **Literature**

**Erfatpour et al. 2020 “**[**A R2R3-MYB gene-based marker for the non-darkening seed coat trait in pinto and cranberry beans (Phaseolus vulgaris L.) derived from ‘Wit-rood boontje**](https://link.springer.com/article/10.1007/s00122-020-03571-7)**’”**

Marker

* Single nucleotide deletion (homozygous recessive) causing ND in Wit-rood Boontje

Cultivars

* Wit-rood boontje for ND
* **1533-15** (not in storage) for SD
* Othello, CDC Pintium, and Etna for RD

Camille’s Notes

* This paper has a FANTASTIC overview of the chemical/enzymatic process of darkening!
* Phil Miklas’ lab is in the process of turning this SNP into a KASP marker - keep in touch with him, or ask Valerio how it is going in a few months (Feb-March).
* Validate using *Phaseolus cuneatus* or any non-*vulgaris* seeds that we have on hand. DO NOT order any [*Mucuna pruriens*](https://en.wikipedia.org/wiki/Mucuna_pruriens) like this paper used - the leaves and pods cause extreme itching if touched, plus there’s shedloads of nicotine and bufotoxin in there. It can, however, cure snakebite and maybe Parkinson’s (high-risk, high-reward?).

**Alvarez et al. 2019 “**[**Generation and validation of genetic markers for the selection of carioca dry bean genotypes with the slow-darkening seed coat trait**](https://digitalcommons.unl.edu/usdaarsfacpub/2389/)**”**

Marker

Cultivars

* CDC Pintium (available), **Sublime, Estilo, and Notavel (not available)** for RD
* **SC117433 (not available)** for SD

Camille’s Notes

* Most of the varieties tested in this paper were from the Brazilian market, which we don’t have much material from. However, that doesn’t mean we can’t test them out on some other beans.
  + Brazilian carioca (pinto) beans are generally from the Mesoamerican gene pool, but cranberry beans come from the Andean gene pool. It could be useful to see if this marker is present in both types of darkening beans from both populations!!

**McClean et al 2018** “[White seed color in common bean (Phaseolus vulgaris) results from convergent evolution in the P (pigment) gene”](https://nph.onlinelibrary.wiley.com/doi/full/10.1111/nph.15259)

Camille’s Notes

* This paper is more for population structure than having a very impactful marker, but still good to read through.
  + Especially important to know the two main loci controlling seed coat color - J locus and the P locus. SNP markers for ND have been developed for both loci, but ND from the J locus tends to make a too-bright white background that doesn’t sell well. Targeting the P locus seems to be a better bet.