MECHANISMS AND IMPLICATIONS OF CANNABIS PHOTOBLEACHING

DR. DAVE HAWLEY; PRINCIPAL SCIENTIST, FLUENCE

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PHOTOBLEACHING IN CULTIVATION

WHAT IS PHOTOBLEACHING?

In production, photobleaching manifests as the whitening (i.e., 'bleaching') of inflorescences at the top of cannabis plants. Once dehydrated, these inflorescences appear beige-brown.

Bleaching is a product of photo-oxidative destruction of chlorophyll in the upper inflorescences of cannabis plants.

Otherwise known as "white tips", this phenomenon is negatively perceived by consumers, associating this appearance with poor flavor, reduced potency, less freshness, and generally lower quality.

Fresh, photobleached

Dehydrated (~12% ww), photobleached

Note: these aren't the same plant; this is just representative of photobleaching before and after dehydration.

WHAT PRODUCTION PRACTICES INDUCE PHOTOBLEACHING?

Assuming no other problems in cultivation...

Within commercially relevant ranges, photobleaching is induced by the absolute quantity of red photons to which the plants are exposed.

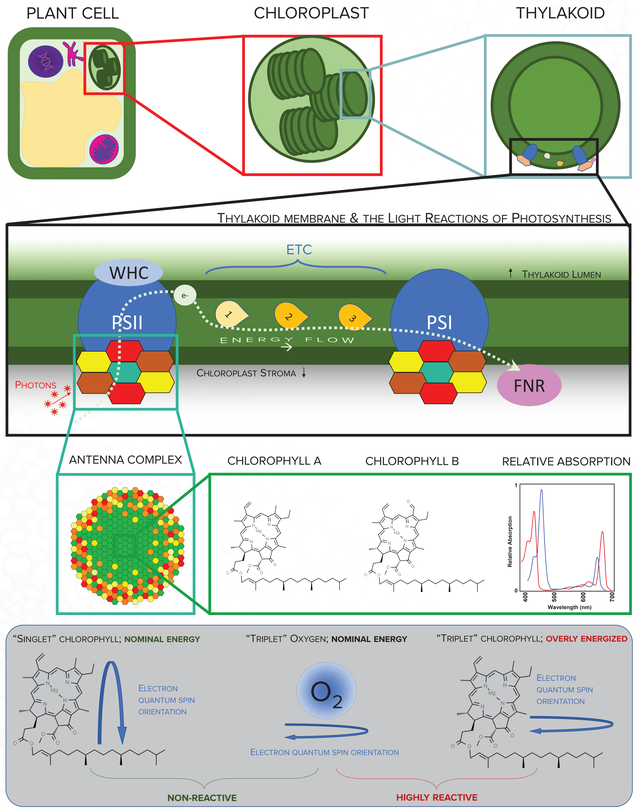
HOW CAN YOU AVOID PHOTOBLEACHING?

At low light intensities
(ie. < 500 µmol·m^{-2} ·s^{-1})
most cultivars can tolerate up to 95% red light without bleaching.

At high intensities
(ie. up to 2500 µmol·m^{-2} ·s^{-1})
most cultivars will not bleach when grown under spectra with low red light % (ex. Fluence's 'R4' Spectrum; ~40% red)

At average commercial production intensities
(ie. ~ 1200 µmol·m^{-2} ·s^{-1})
Low red light % is recommended (ex. Fluence's 'R4' Spectrum)

MECHANICS OF PHOTOBLEACHING



LIGHT REACTIONS 101

1) The light reactions of photosynthesis occur on the thylakoid membrane, in chloroplasts, in plant cells.

2) Light energy is used to split water at the water harvesting complex (WHC), liberating an electron (e-) in the process.

3) The electron is passed along an electron transport chain (ETC) and is eventually consumed in the generation of the energetic molecule NADPH, via ferredoxin-NADP+ reductase (FNR).

THE ANTENNA COMPLEX and ROS's

Consists of various pigments that absorb different wavelengths of light.

Chlorophylls are the most abundant pigments and absorb red and blue light as energy.

This energy must be passed to the ETC. If not, chlorophylls become over-energized, react with oxygen and are destroyed.

Since chlorophyll appears green, its destruction yields a "bleached" appearance.

COMMERCIAL IMPLICATIONS

MARKETABILITY OF BLEACHED BUD

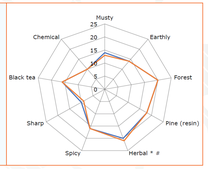
Like many horticultural crops, cannabis consumers "eat with their eyes". In other words, if something looks bad, it is bad, no matter the potency, aroma, or flavor. Moreover, many cannabis consumers don't have the opportunity to judge fresh flower on the store shelf on anything but its appearance. Thus, flower that has an off-putting bleached appearance will not sell.

BLEACHED BUD FOR EXTRACTION

Spanning several studies and cultivars, Fluence Research has found that, on average, cannabinoid and terpene content does not differ significantly between bleached and unbleached flower. Therefore, producers growing for extraction do not necessarily need to concern themselves with excess red light and associated bleaching; their final product will have no difference in appearance, yield, or chemistry.

SENSORY EXPERIENCE

In a blind aromatic sensory study conducted by Fluence Research and Wageningen University and Research, 22 trained assessors were generally unable to discern between the aromas of bud grown in bleaching and non-bleaching conditions, noting only a somewhat more herbal smell from the plants grown in bleaching conditions.



NEXT STEPS

While we understand the fundamental mechanisms of bleaching, our collective understanding of environmental conditions induce bleaching remain in their infancy. Further research on environmental inputs, beyond just lighting, is required.
Our aromatic sensory panel was a good first step toward characterizing consumers' perceptions of bleach vs un-bleached bud, though a formal consumption study is required to fully understand the implications of bleached flower on consumer preferences and flower market value.

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/davewhawley

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ABOUT THE AUTHOR

Dr. Dave Hawley is the Principal Scientist at Fluence and holds his Masters and PhD in Environmental Sciences, focusing on photobiology in controlled environment agriculture systems.
Since 2016, Dr. Hawley has been investigating the relationship between light and cannabis development with an emphasis on biochemical photo-regulation of cannabinoids and terpenes. With Fluence, the research objectives are to characterize optimal lighting solutions that maximize quality, yield, and consistency, to maximize producer's bottom lines and help the world grow smarter.

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