Title
High Contrast Imaging of Early Demineralization on Enamel Surfaces using Near-Infrared Polarized Reflectance at λ = 1460 and 1550 nm

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Publication Date
2014

Peer reviewed|Thesis/dissertation

High Contrast Imaging of Early Demineralization on Enamel Surfaces Using Near-Infrared Polarized Reflectance at λ = 1460 and 1550nm

by

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THESIS

Submitted in partial satisfaction of the requirements for the degree of

MASTER OF SCIENCE

in

ORAL AND CRANIOFACIAL SCIENCES

in the

GRADUATE DIVISION

of the

UNIVERSITY OF CALIFORNIA, SAN FRANCISCO

[redacted]

DEDICATION

I would like to dedicate this to my family. To my husband, Abhishek Vallabhaneni, whose support and encouragement have been unconditional. To my family – my parents, Shailesh and Panna Parikh, and my brother, Spursh Parikh – you have provided me with incredible opportunities and urged me to work hard and do the best I could. Without all of you, I could not have accomplished what I have. Thank you for shaping me into the person I am today.

ACKNOWLEDGMENTS

I would like to thank my committee members who have helped me with this project. A special thanks to Dr. Daniel Fried, whose role in the development of this project was invaluable. His guidance and advice was crucial throughout this journey. Thank you to Dr. Cynthia Darling for her time and for always being available for help. Dr. Art Miller offered unconditional support and patience throughout the development of this project – your enthusiasm and energy were much appreciated. I also would like to express my deep appreciation to Kenneth Chan for his incredible support and help. This project would not have moved forward with him. Lastly, I would like to thank my co-residents, Dr. Renie Ikeda, Dr. Emerald Nguyen, Dr. Daniel Hardy, and Dr. Seth Lucas for being my second family. The past seven years have been truly unforgettable and I can't express enough my gratitude that we have supported each other through the bad and celebrated with each other for the good.

ABSTRACT

Introduction: In vivo and in vitro studies have shown that high contrast images of tooth demineralization can be acquired in the near-infrared at several wavelengths. The purpose of this study is to compare the lesion contrast in reflectance at near-infrared wavelengths coincident with high water absorption with those in the visible, the near-infrared at 1300nm, fluorescence, and polarization sensitive optical coherence tomography (PS-OCT) measurements for early lesions on buccal surfaces.

Methods: Bovine incisors (n=40) were used in this *in vitro* study. Teeth were sectioned so that they were greater than 8mm in length, 2mm in width, and had at least 1mm of remaining enamel and then mounted on resin blocks. A CO_2 laser was used to produce small incisions separating the four 2x2mm windows. Artificial lesions were created in two ways: (1) samples (n=20) were exposed for 4 days to pH 4.8 and pH 4.9; (2) samples (n=20) were exposed for 8 days to pH cycling between pH 4.7 and pH 7.0. Lesions were imaged using near-IR reflectance at three wavelengths, 1300, 1460, 1550nm, using an InGaAs camera. Visible light reflectance, fluorescence at 405nm excitation and greater than 500nm detection, and polarization sensitive optical coherence tomography were also used for comparison. Crossed polarizers were used for reflectance measurements to reduce interference from specular reflection.

Results: The contrast of both types of lesions were significantly higher ($P < 0.05$) for near-IR reflectance imaging at 1460 and 1550nm than it was for near-IR reflectance imaging at 1300nm, visible reflectance imaging, and fluorescence.

Conclusion: The markedly higher contrast at 1460 and 1550nm wavelengths, coincident with higher water absorption, suggest that these wavelengths are better suited than 1300nm for imaging early demineralization on tooth surfaces.

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INTRODUCTION

The use of full-fixed appliances in orthodontics has historically led to the serious side effect of poor oral hygiene and its effect on the teeth post-treatment. Most patients pursue orthodontic treatment due to esthetics, yet white spot lesions (WSL) and carious lesions are unappealing byproducts of poor oral hygiene compliance. In addition, the presence of brackets and bands on the teeth exponentially increase the number of available surfaces for plaque to reside, allowing biofilm development. After many months of treatment to achieve perfect occlusion, it can be disheartening for both patient and practitioner to see these lesions mar the completion of cases.

Martignon et al. conducted a study looking at oral hygiene, plaque, and caries level in patients treated with full-fixed appliances. The results showed 96% of patients undergoing treatment had at least one or more WSL as opposed to 56% of the pre-treatment patients. More importantly, it was found that the majority of lesions were found on the buccal surface, with more than a third being associated with brackets placed on the upper anterior teeth. [1] Hadler-Olsen conducted a study to determine the efficacy of an oral hygiene regimen including brushing, flossing, and use of fluoride rinse and plaque disclosing tablets. Between orthodontic and non-orthodontic patients, there was a 1.9 mean increase in WSL versus 0.4 and 0.5 mean versus 0.7 in caries, respectively.[2]

In a similar line, a study by Al Maaitah found that of the 230 patients included, 28.3% were found to have no WSL, while 165 exhibited 1 to 12 WSL. Results show that patients with WSL were significantly younger, and more likely to have pretreatment status of first permanent molars as diseased. Additionally, those with poor oral hygiene displayed more WSL post-treatment. [3] In 2007, Zachrisson conducted two separate studies concerning the correlation

between plaque levels and caries incidence[4] as well as the difference between caries incidence in orthodontic patients post-treatment compared to similar non-orthodontic patients[5]. Both studies found no correlation of caries incidence with age, treatment time, or initial caries experience; however, the second found that the bands actually served to protect the interproximal surfaces while there was increased caries incidence on buccal and lingual surfaces of anterior teeth.

To tie in all these results, Richter studied the relationship between WSL and caries incidence and various treatment variables, including sex, age, extraction therapy, and fluoridation sources. He found that the incidence of WSLs during treatment was 72.9% and that of caries was 2.3%.[6] All of these studies have shown that patients have an alarmingly higher risk of developing WSL during orthodontic treatment.

It is common practice for orthodontists to review oral hygiene practices with their patients prior to and throughout treatment. The current oral hygiene protocol, similar to non-orthodontic patients, involves brushing and flossing. Based on the studies presented, the traditional oral hygiene protocol falls short of adequate for many patients undergoing orthodontic treatment. The persistence of poor oral hygiene and post-treatment defects, however, raises several questions. First, are current oral hygiene protocols adequate for orthodontic treatment? Second, is intervention to prevent further demineralization occurring early enough in treatment? The development of technological advances brings the opportunity to monitor oral hygiene status among patients and detect demineralization at earlier stages than were previously possible.

Traditional imaging methods in dentistry include visual detection, tactile sensation, and two-dimensional radiography. In regard to demineralization producing WSL in orthodontic patients, however, these methods are insufficient. Demineralization of buccal surfaces, especially around brackets and bands, cannot be imaged radiographically. By the time these lesions are

visually or tactilely detected, the demineralization process is too far along to prevent the unaesthetic result of WSL. Though remineralization may be possible at this point, the actual lesion will still be visible due to altered enamel properties.

The structure of enamel is similar to hydroxyapatite, but contains several impurities that make it soluble at certain pH levels. Dental mineral has carbonate ions that replace phosphate ions that normally occur in the hydroxyapatite crystal lattice.[7] This allows organic acids produced by bacteria to dissolve calcium and phosphate on the enamel surface into the surrounding pellicle of the tooth. This demineralization leaves pores in the surface of the enamel due to the loss of mineral structure. WSL are the first clinical sign of demineralization, but the process has been continuing for several months. At this point, intervention is possible and the lesion can be reversed. If progression continues, the lesion eventually becomes cavitated and requires restoration depending on severity.[8] Remineralization, which is a repair process for developing lesions, utilizes calcium, phosphate and fluoride ions to re-create a crystal structure around previously formed pores. While this surface is actually more resistant to future acid-attack, it does have an altered structure as compared to sound and demineralized enamel.[9] Various imaging modalities (unlike the traditional ones outlined above) can utilize this altered structure of enamel to determine levels of demineralization and remineralization before they are clinically visible.

Several studies have explored new imaging methods that provide improved contrast between healthy and demineralized enamel. Optical imaging relies on scattering properties of sound versus demineralized enamel to quantify the extent of the lesion. In sound enamel, photons are less likely to be scattered; the disruptions of the crystal lattice structure due to demineralization create centers for light scattering. Thus, photons entering the surface of a lesion

have a shorter free path length and lower probability of absorption and unscattered transmission. This concept leads to understanding the clinical aspects seen with WSL. In sound enamel, most photons penetrate dentin before they are back-scattered (allowing the yellowish color of dentin to be visible through enamel less than 1mm thick, i.e. incisal edges). In demineralized enamel, photons are scattered from the surface and since the intensity is higher, the lesion appears white.[10] Various optical imaging methods have been developed over the last several decades that indirectly and directly utilize the scattering difference to quantify lesions. These include visible light reflectance, quantitative light fluorescence, near-infrared imaging (including trans-illumination and reflectance), and polarized sensitive optical coherence tomography.

Visible light reflectance is one of the initial optical methods developed for quantifying lesions that directly makes use of enamel's light-scattering properties. While this method is quite effective in an *in* vitro setting, there are several drawbacks that made it difficult to develop into an effective clinical tool.[9,11] While the intensity of reflected light is generally quantifiable, there is such variation in color of enamel among individuals that quantification of color *and* intensity is difficult. Another issue arises in specular reflection, which arises when the single light source is reflected in a single outgoing direction.[11] In the laboratory setting, these issues can be overcome with the use of crossed polarizers to remove surface glare while contrast can be increased between sound and demineralized enamel by using depolarization of scattered light.[12,13]

Quantitative light fluorescence (QLF) measures the loss of fluorescence of enamel and dentin as lesion size increases. Sound enamel and dentin manifest a native fluorescence when sound; as lesion size increases, the fluorescence level decreases and this change can be calculated and measured. When teeth are illuminated with blue-green light, they emit

yellow/green light.[14,15] Teeth are illuminated with light at a wavelength 405nm and the resulting fluorescence at wavelengths greater than the 500 nm is measured for both sound and demineralized enamel, with the latter having less intensity.[16] Since the light is detected at a different wavelength than the incident light, specular reflections are eliminated, a major advantage for QLF.[17] By choosing appropriate light sources and filters, the images of the teeth can be focused solely on the fluorescence being emitted. This image is then captured through a camera and computer. The lesion can then be quantified by comparing the amount of light emitted by the demineralized area to the amount emitted by a control.[18] While QLF has proven to be an effective optical imaging method *in vitro*, stains on tooth surfaces can be a problem as they absorb visible light and fluoresce.

Near-infrared (NIR) imaging of teeth utilize higher wavelengths that coincide with areas of higher water absorption allow for detection of early demineralization with high contrast. Though light scattering in sound enamel is generally weak, it noticeably diminishes in the NIR region of wavelengths.[19] Several previous studies have shown that enamel has the highest transparency at wavelengths close to 1300nm. At this wavelength, the optical attenuation is 1-2 orders of magnitude less than in the visible range.[20] At longer wavelengths, water absorption increases significantly and reduces the penetration of NIR light. In contrast, the light scattering of a demineralized surface increases by two to three magnitudes as compared to sound enamel. This can be attributed to the formation of pores on the surface of a lesion. This allows for caries to be imaged at high contrast.[19] In a previous study by Wu et al., image contrast of artificial lesions produced on buccal and occlusal surfaces between fluorescence, visible reflectance, NIR reflectance, and NIR trans-illumination at 1300nm were compared. NIR reflectance was shown to yield the highest contrast.[11] More recent studies have shown that even higher wavelengths,

particularly at 1450nm and 1600nm, produce even higher contrast between sound and demineralized enamel than previously seen.[21]

Optical coherence tomography (OCT) is a noninvasive technique for creating cross-sectional images of internal biological structures. This method measures the light reflected from each layer of the lesion, allowing for measurement of the lesion and sub-surface demineralization.[22] Polarized sensitive optical coherence tomography (PS-OCT) is a form of OCT that is sensitive to changes in the polarization of reflected light. Because of the ability of PS-OCT to image all the layers of a lesion, including demineralized and remineralized tooth structure, it is a great tool to evaluate not only the extent of lesions but the efficacy of agents that reverse the demineralization process.[11] Several studies have shown in lesions measured with PS-OCT, the integrated reflectivity measured (ΔR) correlates with the integrated mineral loss (ΔZ).[20,23,24] This allows for PS-OCT to be used as a valuable tool and standard to which other optical imaging methods can be compared.

The overall hypothesis underlying this study is that near-IR reflectance measurements at 1450-nm and 1600-nm will yield significantly higher contrast than visible light reflectance or quantitative light fluorescence measurements of early demineralization. A secondary hypothesis was that the clear varnish covering the tooth surface would not reduce lesion contrast. If these newer imaging modalities prove to be useful in improving lesion contrast and can detect white-spot lesions at earlier stages, it is likely that earlier and more effective intervention will be possible.

MATERIALS AND METHODS

Samples and Lesion Preparation

Healthy, mature bovine incisors were extracted and collected for use in this study. The incisors were sterilized using gamma radiation and roots were sectioned, leaving crowns for use. The crowns were sectioned, leaving samples that were 2 mm in width. These were further shaped so that they were at least 8 mm in length and about 3 mm in height. The samples were ground with 200 grit sandpaper to remove any exogenous contamination of enamel, leaving at least 1 mm of remaining enamel. Teeth were then mounted on black orthodontic acrylic blocks and samples were stored in a moist environment of 0.1% thymol to maintain hydration and prevent bacterial growth.

The outlines of four 2x2mm windows approximately 50μm deep were cut on the buccal surface of each of the 40 samples using a CO_2 laser (Impact 2500, GSO Lumonics Rugby UK) operating at a wavelength of 9.3μm, pulse duration of 15 microseconds and a pulse repetition rate of 5 Hz. A water spray was used, and the incident fluence was 170 J/cm^3 with a spot size of 150μm. There are multiple benefits to using the laser to section windows. Aside from physically demarcating each window, the laser incisions also inhibit decay in the laser area due to thermal modification of the enamel and are therefore very effective in providing separation between sound and demineralized areas. The channels cut by the laser also serve as reference points for optical coherence tomography and are sufficiently narrow that they do not interfere with calculations of the image contrast.

The enamel surrounding the four 2x2mm windows created by the laser was covered with clear acid-resistant varnish (Revlon, New York, NY) and these areas served as controls. The clear varnish was chosen as it was hypothesized that it will not interfere with imaging.[25] Imaging with all modalities was completed with varnish in place. The varnish was later removed using acetone after repeat imaging with all modalities was completed for comparison.

The 40 samples in the study were separated into three groups to produce various types of lesions: (1) surface-softened lesion demineralized at pH 4.8 (n=10) for 4 days; (2) surface-softened lesion at demineralized at pH 4.9 (n=10) for 4 days; (3) pH-cycled lesions demineralized at pH 4.7 and remineralized at pH 7.0 (n=20) for 8 days. 20 samples were used in the third group (pH-cycled) due to the time duration of 8 days, so 10 samples were used for days 1-4 and 10 samples for days 5-8.

Lesions were produced in the prepared bovine tooth sections using well-characterized demineralizing and remineralizing solutions for varying time periods to produce simulated caries lesions of progressing severity.[26,27,28] Two simulated caries methods were used that produced different lesion morphology and varied in the rate of demineralization. After exposure of the samples to the demineralizing and remineralizing solutions for each time period, varnish was applied to each window to prevent further lesion progression.

In the first method, the straight demineralization model, each sample was immersed in 40mL aliquots of a buffer solution containing 2.0mmol/L calcium, 2.0mmol/L phosphate, and 0.075mmol/L acetate maintained at pH 4.8 (Group 1) and pH 4.9 (Group 2) at a temperature of 37°C for periods of 24, 48, 72, and 96 hours.[29] This model results in rapid erosion of the enamel surface and does not accurately represent the acid challenge experiences in the mouth that usually consists of cycles of demineralization and remineralization as the pH changes before and after meals.

The second method, the pH cycling model, replicates this cycle of demineralization and remineralization that takes place naturally in the mouth as the pH fluctuates before and after meals.[21-23] Samples were exposed for 1-8 days to a daily regimen of 6 hours demineralization and 17 hours of remineralization. This model creates a surface zone due to remineralization;

erosion of the surface does not occur as the lesion progresses in depth. For pH-cycled lesions, each block was exposed to the same demineralizing solution as described above for 6 hours each day at pH4.7 followed by immersion overnight for 17 hours in a remineralizing solution of 1.5mmol/L calcium, 0.9mmol/L phosphate, 150mmol/L KCl, and 20mmol/L cacodylate buffer maintained at pH7.0 at 37°C.

Visible and Near-IR Cross-Polarization Images

In order to acquire reflected light images, either visible or NIR, light was shined directly at the buccal surface of the tooth through a broadband fused silica beamsplitter (1200-1600nm) Model BSW12 (Thorlabs, Newton, NJ), and reflected light coming out of the tooth surface was imaged. Crossed polarizers were placed after the light source and before the detector and used to remove specular reflection (glare) that interferes with measurements of the lesion contrast. In this method, the demineralized region appears lighter than the sound enamel because the demineralized region scatters the light increasing the amount of light scattered/reflected back toward the camera.

The near-IR reflectance images were captured using an InGaAs Camera (Model GA1280J) with a 1280x1024 pixel format, and a 15μm pixel pitch. In Figure 1, the schematic for the near-IR reflectance imaging is shown. In order to acquire visible light images, an Ocean Optics fiber-couples tungsten-halogen lamp (Model HL-2000-FHSA) with a DFK 31AF03 FireWire camera equipped with an Infinimite lens (Infinity Photo-Optical, Boulder, CO) was used and the images were captured using a CCD camera. A beamsplitter was not used and illumination was directed at the occlusal surface with a 5° angle from the surface normal, A and B of the Figure 1 rotated by 85° toward the camera D. Crossed polarizers were also used to reduce specular reflection of the visible light reflectance measurements.

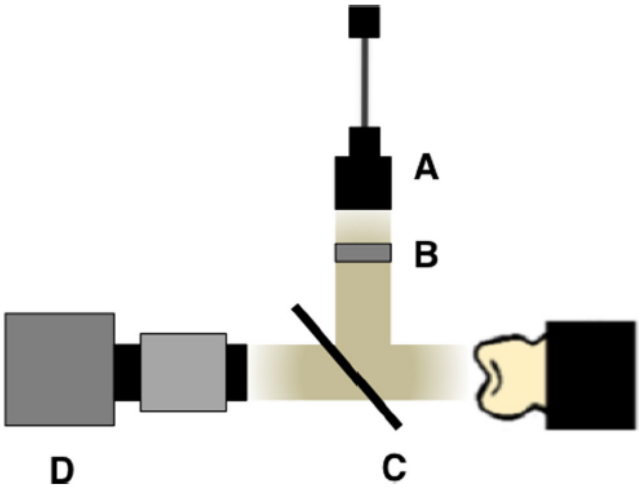

Fig. 1. Schematic diagram for near-IR reflectance imaging: (**A**) 1300, 1460, and 1600nm SLD light source, (**B**) near-IR linear polarizer, (**C**) beamsplitter, and (**D**) UTC Aerospace Systems (GA1280J) High-resolution InGaAs SWIR Camera (1280x1024 pixel format, 12.5mm pitch) (Princeton, NJ).

Fluorescence Loss Measurements

To collect fluorescence images, a GaN laser diode module "Blu-Ray" (λ=405nm) operating with 60-mW (Photonic Products, Salem, NH) was used as an excitation source. A 500nm long-pass filter #C47-616 (Edmund Scientific, Barrington, NJ) and a DFK 31AF03 FireWire camera (The Imaging Source, Charlotte, NC) with a 1024x768 element sensor equipped with a Infinimite lens (Infinity Photo-optical, Boulder, CO), were used to image the fluorescence from the surface at wavelengths longer than 500nm. Imaging was carried out in the dark to avoid the interference of ambient light.

QLF systems have been employed using several excitation wavelengths ranging from 370-488nm. The fluorescence emission spectra and quantum yields are expected to be independent of excitation wavelength, according to Kasha's law as long as there is sufficient energy to populate the excited state.[30] This was confirmed in a study by Endo et al.[31] as they

measured demineralization using two QLF systems operating at 488nm and 370nm and reported similar performance. In this study, the excitation wavelength of 405nm was chosen to be consistent with clinical systems and the best-reported diagnostic performance. QLF loss measurements are typically reported as a ration n intensity (fluorescence radiance) of the lesion area compared with an equivalent sound area on the tooth. This study utilized the more traditional approach of reporting the linear image contrast[32], which is less susceptible to errors caused by major variations in the tooth topography between the sound or reference area and the lesion area or window. Line-profiles across the sound and demineralized areas were used to calculate the ratio of intensity between the sound and demineralized regions. However, either method should yield similar results.

Polarization Sensitive Optical Coherence Tomograpy (PS-OCT System)

PS-OCT scans were used to acquire tomographic images of the lesions produced in each window. PS-OCT was used as a surrogate for histology as several studies have demonstrated that it can accurately measure the depth and severity of early lesions on smooth surfaces. PS-OCT is capable of determining the lesion depth and severity nondestructively without thin sectioning and destruction of the tooth. Previous studies have demonstrated that the integrated reflectivity measured with PS-OCT from the lesion area, ΔR (dB(decibels) x μm), correlates with ΔZ, the integrated mineral loss (volume%mineral x μm).[33,34,35] Although it is also a nondestructive imaging technique, it was not one of the four methods compared in this study.

An all-fiber-based optical coherence domain reflectometry system was used with polarization maintaining optical fiber, high-speed piezoelectric fiber-stretchers and two balanced InGaAs receivers that was designed and fabricated by Optiphase, Inc. (Van Nuys, CA). This two-channel system was integrated with a broadband superluminescent diode (SLD) Denselight

(Jessup, MD) and a high-speed XY-scanning system (ESP 300 controller and 850G-HS stages, National Instruments, Austin, TX) for *in vitro* optical tomography. This system is based on a polarization-sensitive Michelson white light interferometer. The high power (15mW) polarized SLD source operated at a center wavelength of 1,317 nm with a spectral bandwidth full-width at half-maximum (FWHM) of 84 nm was aligned using polarization controller to deliver 15 mW into the slow axis of the PM fiber of the source arm of the interferometer. This light was split into the reference and sample arms of the Michelson interferometer by a 50/50 PM-fiber coupler. The sample arm was coupled to an AR-coated fiber-collimator to produce a 6-mm diameter, collimated beam. That beam was focused onto the sample surface using a 20 μm and an axial resolution of 10 μm in air with a signal to noise ratio of greater than 40-50 dB. The PS-OCT system is completely controlled using Labview software (National Instruments). Acquired scans were compiled into *b-scan* files. Image processing was carried out using Igor Pro, data analysis software (Wavemetrics, Inc.). The lesion depth and integrated reflectivity were calculated using automated image analysis routines as described in previous studies.[36,37]

Image Analysis

Line profiles consisting of the entire 2 mm x 2 mm window were taken from each image, including sound enamel, Window 1, Window 2, Window 3, and Window 4 using Igor Pro Software (Wavemetrics, Lake Oswego). Once average values of each window were obtained, the raw data was used to calculate image contrast. Image contrast was calculated using two different equations. For visible and near-infrared, contrast was calculated using $(I_L-I_S)/I_L$. For QLF, contrast was calculated using $(I_S-I_L)/I_S$. For these equations, I_S is the mean intensity of the sound enamel, and I_L is the mean intensity of the lesion area. The image contrast varies from 0 to 1, with 1 being very high contrast and 0 being no contrast. Repeated measures 2-way analysis of

variance (ANOVA) followed by the Tukey-Kramer post hoc multiple comparison test was used to compare groups for each type of lesion as well as windows within samples. This was completed using Prism6 software from GraphPad (San Diego, CA).

RESULTS

Due to the volume of data, the data was sectioned according to the type of lesion that was created and whether it was imaged with or without varnish present. Thus, there are eight main sets of data:

1. pH 4.8 with varnish
2. pH 4.9 with varnish
3. Demineralization/Remineralization Days 1-4 with varnish
4. Demineralization/Remineralization Days 5-8 with varnish
5. pH 4.8 without varnish
6. pH 4.9 without varnish
7. Demineralization/Remineralization Days 1-4 without varnish
8. Demineralization/Remineralization Days 5-8 without varnish

Each of these data sets were then sectioned into four subsets of the contrast measurements, from Window 1 through Window 4, each of which had ten samples. The contrast measurements for different imaging modalities was also compared as follows:

1. Visible Light Reflectance (Dry Samples)
2. Visible Light Reflectance (Wet Samples)
3. Quantitative Light Fluorescence (Dry Samples)
4. Quantitative Light Fluorescence (Wet Samples)
5. Near-Infrared Reflectance (1300nm)

6. Near-Infrared Reflectance (1460nm)
7. Near-Infrared Reflectance (1550nm)

Significant differences within the data ($p < 0.05$) were determined after a 2-way ANOVA followed with Tukey-Kramer analysis.

Images

Figures 1 through 14 in the Index show examples of the images of each type of lesion as follows:

- Figure 2: Visible Light Reflectance of Dry Samples With Varnish
- Figure 3: Visible Light Reflectance of Wet Samples With Varnish
- Figure 4: Visible Light Reflectance of Dry Samples Without Varnish
- Figure 5: Visible Light Reflectance of Wet Samples Without Varnish
- Figure 6: Quantitative Light Fluorescence of Dry Samples With Varnish
- Figure 7: Quantitative Light Fluorescence of Wet Samples With Varnish
- Figure 8: Quantitative Light Fluorescence of Dry Samples Without Varnish
- Figure 9: Quantitative Light Fluorescence of Wet Samples Without Varnish
- Figure 10: Near-Infrared Reflectance at 1300 nm of Samples With Varnish
- Figure 11: Near-Infrared Reflectance at 1300 nm of Samples Without Varnish
- Figure 12: Near-Infrared Reflectance at 1460 nm of Samples With Varnish
- Figure 13: Near-Infrared Reflectance at 1460 nm of Samples Without Varnish
- Figure 14: Near-Infrared Reflectance at 1550 nm of Samples With Varnish
- Figure 15: Near-Infrared Reflectance at 1550 nm of Samples Without Varnish

Contrast Measurements

Average contrast measurements and standard deviations were calculated using raw data obtained from the program IgorPro. These results are tabulated in Table 1 (Index).

Visible Light Reflectance – Dry Samples

Average contrast measurements between each window with varnish for each type of lesion (surface-softened at pH 4.8 and 4.9 and pH-cycled Days 1-4 and Days 5-8) show an increase as each lesion progresses by day. For samples without varnish, the surface-softened lesions show a decrease in contrast by Window 4, alluding to the possibility of erosion of the enamel surface. Additionally, the contrast increases between the windows of pH-cycled samples; however, it should be noted that there is a decrease in contrast between Window 4 of sample set 3 (corresponding to Day 4 of lesion progression) and Window 1 of sample set 4 (corresponding to Day 5 of lesion progression). This is most likely due to the fact that there is some variation between samples since each sample could have come from a different bovine incisor.

Visible Light Reflectance – Wet Samples

Average contrast measurements within this group show similar results to the previous group for samples with and without varnish.

Quantitative Light Fluorescence – Dry Samples

Contrast measurements within the group with varnish show increasing contrast in both surface-softened lesion groups. The pH-cycled groups also show an increase in contrast; however, both start with negative contrast measurements. This can be explained by the lesion progression being so minimal that the lesion present in the first windows are not significantly different enough from sound enamel to show a positive contrast. Samples without varnish show increasing contrast measurements in the pH 4.8 group and the pH-cycled groups. Notably, the contrast continues to increase moving from Window 4 of sample set 3 (corresponding to Day 4 of lesion progression) and Window 1 of sample set 4 (corresponding to Day 5 of lesion

progression). Samples from the pH 4.9 group show steady contrast values until Window 4, in which the value drops.

Quantitative Light Fluorescence – Wet Samples

Contrast values for both surface-softened lesion groups with varnish increased with each window. The same groups without varnish had similar results, with the only difference being a drop in contrast in Window 4 of the pH 4.9 group, again signifying erosion of enamel. Both pH-cycled groups with and without varnish show several negative contrast values. It is believed that this is caused because the varnish decreases contrast between windows.

Near-Infrared Reflectance at 1300 nm

Both surface-softened lesions with and without varnish show increasing contrast values from Window 1 through Window 3, with a significant drop in contrast at Window 4. The pH-cycled groups with and without varnish show increasing contrast measurements independently. When considered together, there is a drastic decrease in contrast measurements from Window 4 of the Day 1-4 group to Window 1 of the Day 5-8 group for samples *with* varnish, whereas the contrast values remain steady as compared in the same windows of groups *without* varnish.

Near-Infrared Reflectance at 1460 nm

Both surface-softened lesions with varnish show increasing contrast values from Window 1 through Window 4, whereas samples without varnish show increasing values until Window 4, where the drop in values again suggests erosion of the enamel that is masked when imaging with varnish. The pH-cycled groups show similar results to the trend seen within the NIR at 1300 nm group, with the most notable difference being that the group without varnish also shows a dip between Window 4 of the Days 1-4 and Window 1 of the Days 5-8 groups (though not as drastic as the group with varnish).

Near-Infrared Reflectance at 1550 nm

Average contrast measurements within this group show similar results to previous group for samples with and without varnish.

Statistical Results

Images with Varnish

pH 4.8

Comparisons between measurements of all imaging of dry samples as a function of time can be seen in Figure 16.

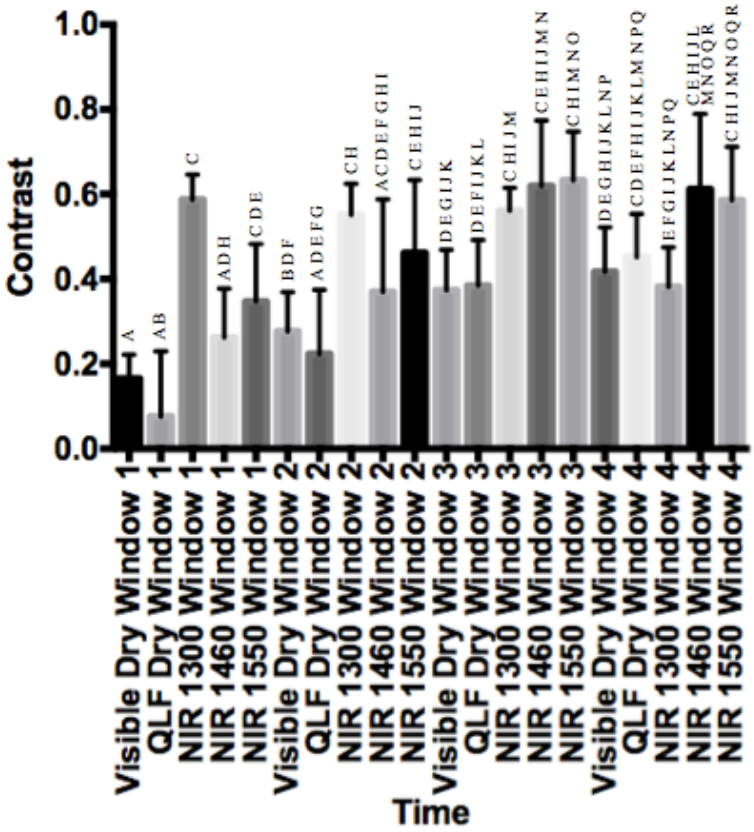

Figure 16. Repeated measures one-way ANOVA data at pH 4.8 (with varnish). Bars with the same letter are statistically similar ($p < 0.05$).

Multispectral contrast measurements comparing windows of each sample within each imaging modality are tabulated in Table 2 (Index). Measurements comparing each imaging

modality within the sample windows are tabulated in Table 3 (Index). Results show that for visible light reflectance, dry samples show a significant difference between each day of lesion progression. For wet samples, there was no significant difference between each day of lesion progression; however, there was a significant difference between the first and third windows (and subsequently, the first and fourth windows). QLF measurements show a significant difference between wet and dry samples, with dry samples showing better contrast between each day, whereas wet samples showed most significant difference between the first and fourth day. Measurements at wavelength of 1300 nm showed no difference between windows 1-3, but showed a significant difference of the fourth window from all others. NIR measurements at 1400 nm and 1550 nm showed almost opposite results, with significant differences between windows 1 through 3, but no difference between windows 3 and 4. In Table 2, results show the difference in various imaging modalities within each window of lesion progression. Most notably in window 1, there was a significant difference between QLF and NIR measurements at every wavelength, as well as a significant difference between NIR measurements at 1300 nm compared to both 1460 nm and 1550 nm. There was no difference between NIR measurements at 1460 nm and 1550 nm. In window 2, both VLR and QLF images showed significant difference in contrast measurements to NIR 1300 and 1550, as well as all QLF wet images as compared to NIR measurements at each wavelength. Window 3 measurements showed significant differences between most imaging modalities, except most notably between NIR measurements at all wavelengths. The most drastic change between windows 3 and 4 is the significant contrast between NIR wavelengths 1300 nm and 1460nm and 1300 nm and 1550 nm.

pH 4.9

Comparisons between measurements of all imaging of dry samples as a function of time can be seen in Figure 17.

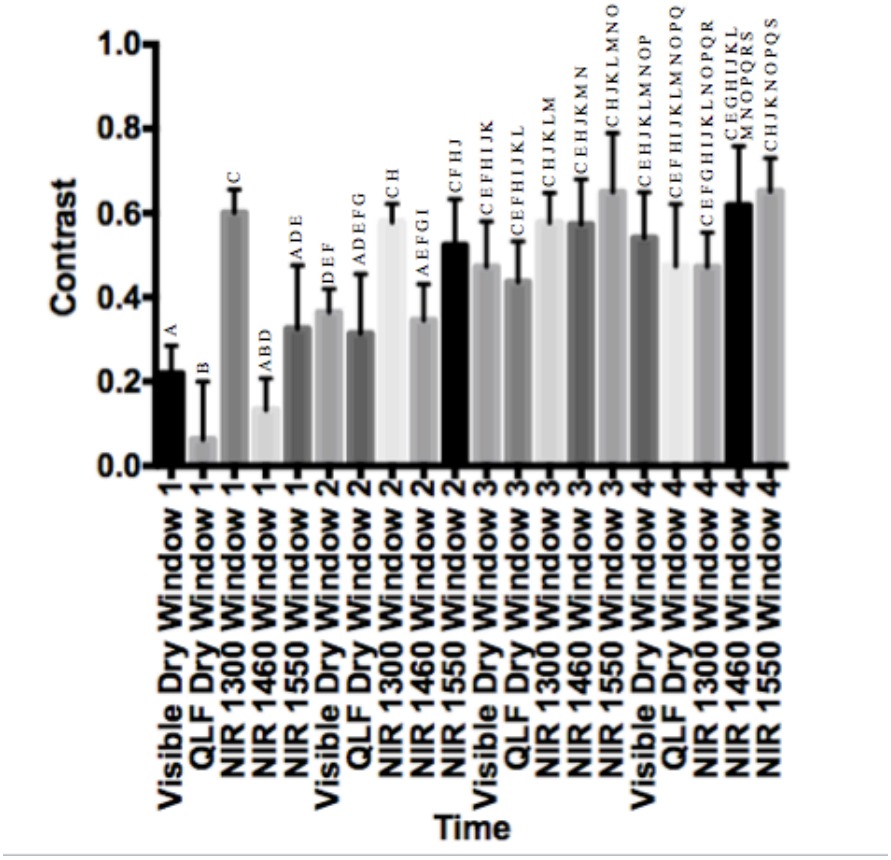

Figure 17. Repeated measures one-way ANOVA data at pH 4.9 (with varnish). Bars with the same letter are statistically similar ($p < 0.05$).

Multispectral contrast measurements comparing windows of each sample within each imaging modality are tabulated in Table 4 (Index). Measurements comparing each imaging modality within the sample windows are tabulated in Table 5 (Index). VLR and QLF measurements of dry samples and NIR measurements at wavelength 1460 nm and 1550 nm all showed significant differences between each day of lesion progression, except between window 3 and 4. Wet samples showed low contrast, suggesting that hydration of samples interferes with imaging. Generally, imaging of each day of lesion progression showed significant differences

between visible at NIR at 1300 nm, as well as between NIR at 1300 nm and NIR at both 1460 nm and 1550 nm.

Demineralization / Remineralization Days 1-4

Comparisons between measurements of all imaging of dry samples as a function of time can be seen in Figure 18.

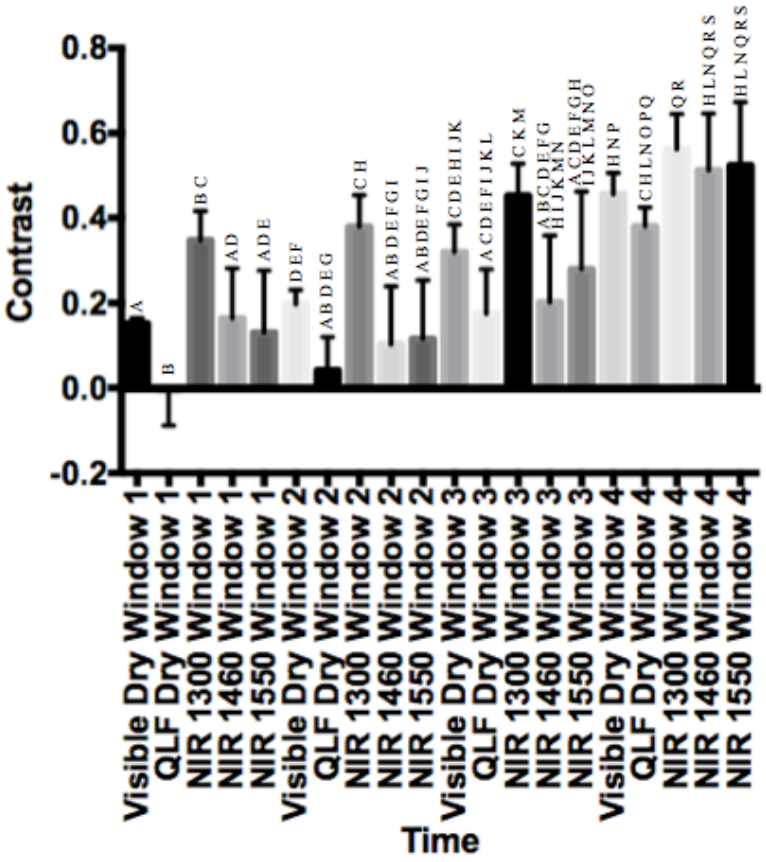

Figure 18. Repeated measures one-way ANOVA data of demineralization / remineralization days 1-4 samples (with varnish). Bars with the same letter are statistically similar.

Multispectral contrast measurements comparing windows of each sample within each imaging modality are tabulated in Table 6 (Index). Measurements comparing each imaging modality within the sample windows are tabulated in Table 7 (Index). VLR and QLF measurements of dry samples and NIR measurements at wavelength 1460 nm and 1550 nm all

showed significant differences between each day of lesion progression, except between window 1 and 2, suggesting that change in lesion size was not substantial between the first two days. No significant difference was found between any windows in QLF hydrated samples. Contrast measurements of window 1 show significant differences between QLF (dry samples) and NIR at 1300 nm and 1460 nm as well as VLR (dry samples) and NIR at 1300 nm. It is important to note that there is significant difference between all wet and dry samples, due to (as noted above) the hydration masking true contrast measurements. Windows 2 and 3 show similar results, while the most notable exception in window 4 is no significant difference between NIR measurements at all wavelengths.

Demineralization / Remineralization Days 5-8

Comparisons between measurements of all imaging of dry samples as a function of time can be seen in Figure 19.

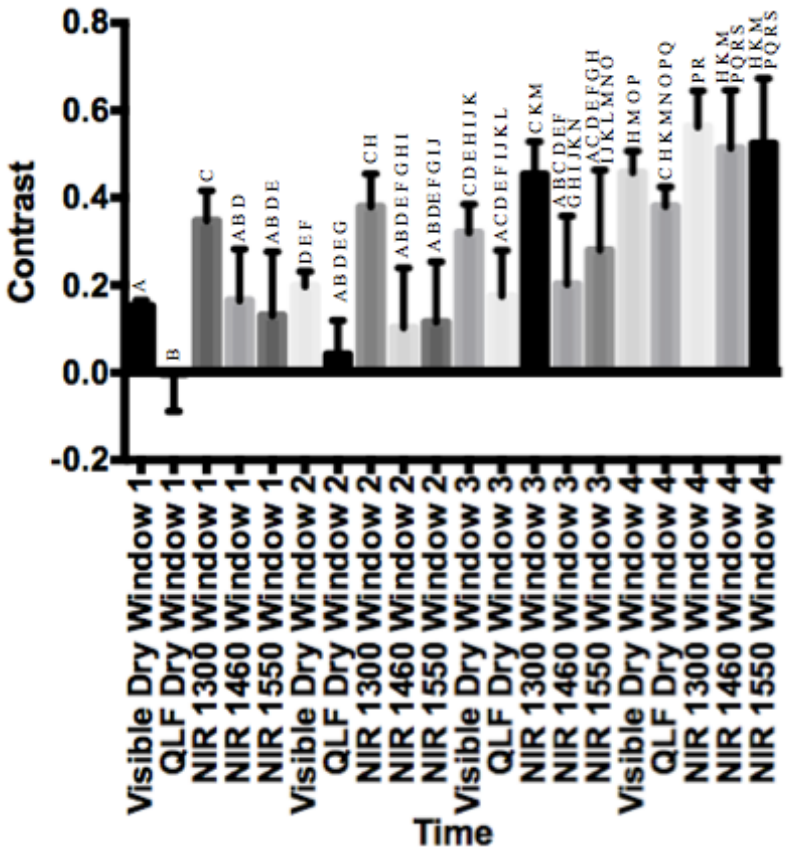

Figure 19. Repeated measures one-way ANOVA data of demineralization / remineralization days 5-8 samples (with varnish). Bars with the same letter are statistically similar.

Multispectral contrast measurements comparing windows of each sample within each imaging modality are tabulated in Table 8 (Index). Measurements comparing each imaging modality within the sample windows are tabulated in Table 9 (Index). In these samples, windows 1 through 4 correspond with lesion progression of days 5 through 8. VLR and QLF measurements of dry samples at NIR measurements at all wavelengths showed significant differences between each day of lesion progression, except between window 1 and 2. Contrast measurements of window 1 through 3 show a significant difference between VLR and QLF dry samples, as well as between QLF dry samples and NIR at 1300 nm and 1460 nm. No difference

between samples at NIR 1460 nm and 1550 nm were seen. Window 4 shows no difference between VLR and QLF dry samples or between NIR at all wavelengths.

Images without Varnish

pH 4.8

Comparisons between measurements of all imaging of dry samples as a function of time can be seen in Figure 20.

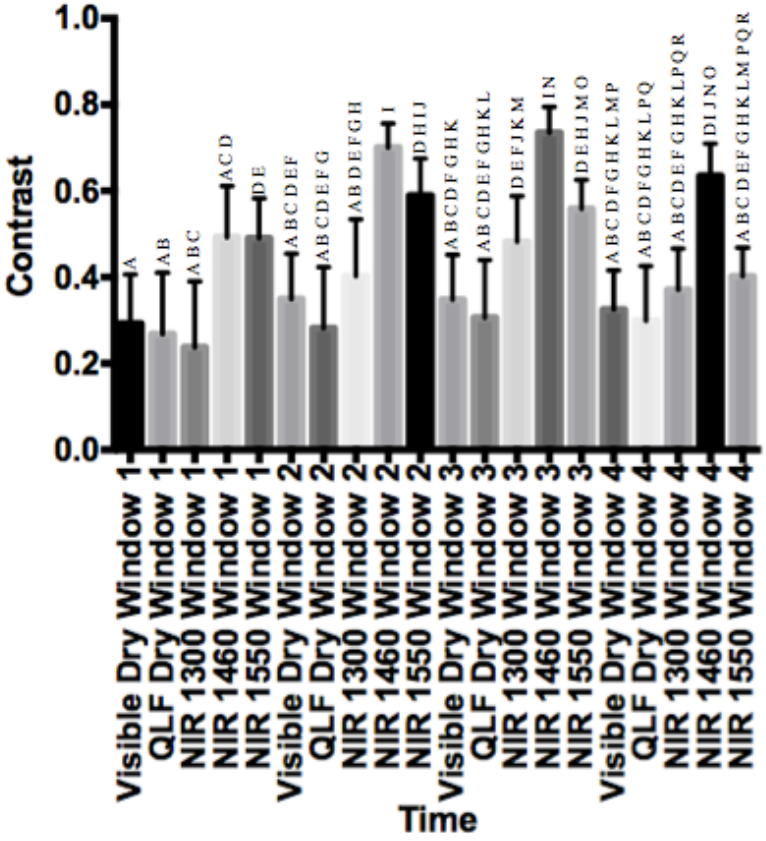

Figure 20. Repeated measures one-way ANOVA data at pH 4.8 (without varnish). Bars with the same letter are statistically similar.

Multispectral contrast measurements comparing windows of each sample within each imaging modality are tabulated in Table 10 (Index). Measurements comparing each imaging modality within the sample windows are tabulated in Table 11 (Index). No significant difference

was seen with lesion progression in VLR wet and dry samples and QLF wet and dry samples. There was significant difference between windows in NIR measurements at all wavelengths. Both windows 1 and 2 show no significant difference between dry samples of VLR and QLF. Significant differences were seen between VLR dry samples, QLF dry samples, and NIR at 1300 nm against NIR at wavelengths 1460 nm and 1550 nm. No difference was present between NIR samples at 1460 nm and 1550 nm. Window 3 showed a significant difference between both VLR and QLF dry samples and NIR at all wavelengths. Additionally, for windows 3 and 4 there was significant difference between NIR at 1300 nm and 1460 nm, and 1460 nm and 1550 nm; however, no difference was seen between NIR at 1300 nm and 1550 nm. In window 4, a significant difference was also seen between VLR and QLF dry samples against NIR at 1460 nm.

pH 4.9

Comparisons between measurements of all imaging of dry samples as a function of time can be seen in Figure 21.

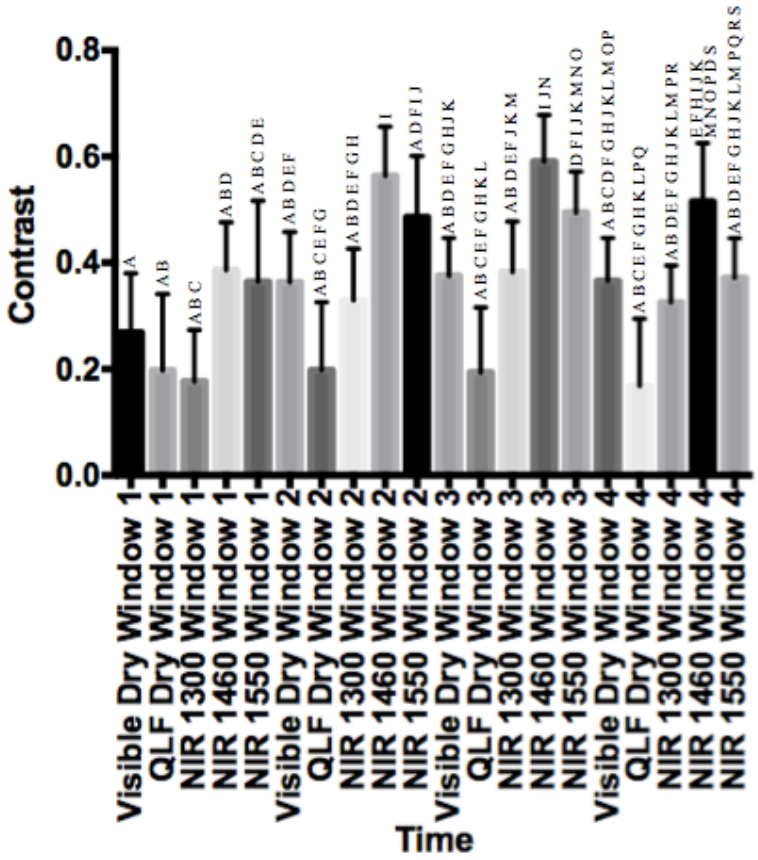

Figure 21. Repeated measures one-way ANOVA data at pH 4.9 (without varnish). Bars with the same letter are statistically similar.

Multispectral contrast measurements comparing windows of each sample within each imaging modality are tabulated in Table 12 (Index). Measurements comparing each imaging modality within the sample windows are tabulated in Table 13 (Index). Both VLR wet and dry samples and NIR at 1300 nm show a significant difference between window 1 and windows 2-4. QLF wet and dry samples show no difference between any windows. NIR at 1460 nm and 1550 nm shows a significant difference between most windows. Both windows 1 and 2 show no significant difference between dry samples of VLR and QLF. Significant differences were seen between QLF dry samples and NIR at 1300 nm against NIR at wavelengths 1460 nm and 1550 nm. No difference was present between NIR samples at 1460 nm and 1550 nm. The most notable

change in window 3 was the significant difference between VLR dry samples and QLF dry samples, while both windows 3 and 4 showed no significant difference between NIR at 1300 nm and NIR at 1550 nm.

Demineralization / Remineralization Days 1-4

Comparisons between measurements of all imaging of dry samples as a function of time can be seen in Figure 22.

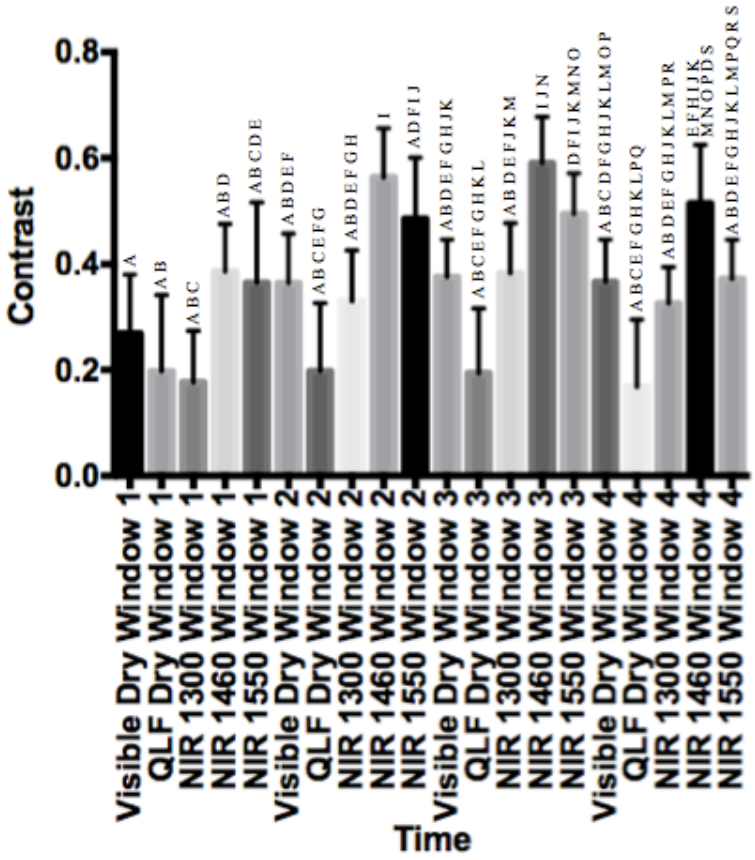

Figure 22. Repeated measures one-way ANOVA data of demineralization / remineralization days 1-4 samples (without varnish). Bars with the same letter are statistically similar.

Multispectral contrast measurements comparing windows of each sample within each imaging modality are tabulated in Table 14 (Index). Measurements comparing each imaging

modality within the sample windows are tabulated in Table 15 (Index). Of all imaging modalities, the most significant differences were seen within the NIR samples at 1460 nm and 1550 nm, between window 1 and windows 2-4. All windows showed a significant difference between VLR and QLF dry samples, between QLF dry samples and NIR at 1460 nm and 1550 nm, and between NIR at 1300 nm and NIR at 1460 and 1550 nm. No significant difference was seen between NIR at 1460 nm and NIR at 1550 nm.

Demineralization / Remineralization Days 5-8

Comparisons between measurements of all imaging of dry samples as a function of time can be seen in Figure 23.

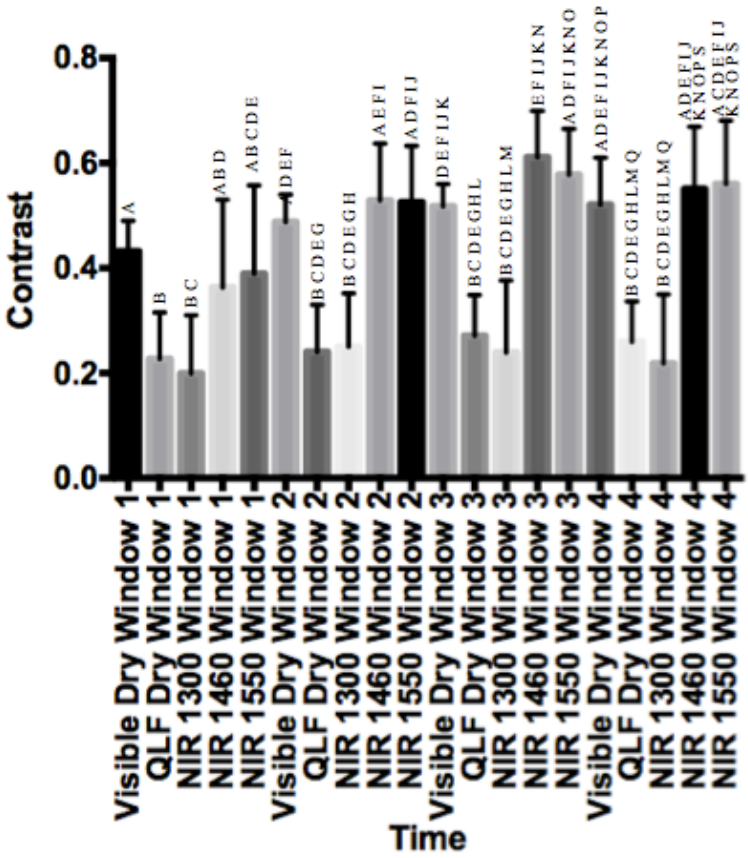

Figure 23. Repeated measures one-way ANOVA data of demineralization / remineralization days 5-8 samples (without varnish). Bars with the same letter are statistically similar.

Multispectral contrast measurements comparing windows of each sample within each imaging modality are tabulated in Table 16 (Index). Measurements comparing each imaging modality within the sample windows are tabulated in Table 17 (Index). In these samples, windows 1 through 4 correspond with lesion progression of days 5 through 8. Among all imaging modalities, the most significant differences occur within the NIR at 1460 nm and 1550 nm between window1 and windows 2-4. All windows showed a significant difference between VLR dry samples and QLF samples, between QLF dry samples and NIR at 1460 nm and 1550 nm, and between NIR at 1300 nm and NIR at 1460 nm and 1550 nm. No significant difference was seen between NIR at 1460 nm and NIR at 1550 nm.

DISCUSSION

Since there is potential to reverse early stages of tooth decay, there is great interest in various imaging modalities to detect this change in tooth structure as early as possible. Detection of demineralization before visible changes is ideal, but even detection before progression to a stage where restorative work is necessary is helpful. While it is relatively easy to spot white spot lesions around anterior brackets in orthodontic patients, it can be difficult in the posterior region if oral hygiene is poor and gingival inflammation covers much of cervical portion of teeth.[38] While visual inspection is still used in the clinic, it is difficult to detect very early stages of demineralization. Additionally, while the use of radiographs is important, caries progression seen on radiographs has reached a stage past reversibility and is usually in need of restoration.

The first objective of this study was to show the potential of near-IR reflectance imaging for imaging shallow demineralization on buccal surfaces of teeth. Because shallow lesions, such as white spot lesions, manifest high contrast in reflectance as opposed to transillumination, reflectance was used in this study at three wavelengths, including 1300, 1460, and 1550 nm. The

performance of visible light reflectance and quantitative light fluorescence was good in this study, suggesting that the process of creating a uniform surface by grinding may have enhanced the contrast for VLR and QLF. Other studies that have not employed this practice have found a significant difference in the performance of VLR and QLF as opposed to NIR.[11] The second purpose of this study was to determine whether there was a difference between imaging of teeth covered with varnish versus without varnish. A study that has employed this technique has not been found. However, determination that there is not a significant difference in the presence or absence of varnish can have an essential impact on using this technology *in vivo*. Considering orthodontic patients routinely develop white spot lesions due to plaque accumulation around brackets, many practitioners have adopted the practice of placing a sealant on the buccal surface of teeth before bonding brackets. Since the presence of varnish did not affect the contrast measurements of NIR at 1460 and 1550 nm, *in vivo* studies measuring the same using a sealant as varnish could be incredibly significant in stopping and reversing early demineralization.

Alternative NIR wavelengths besides 1300 nm, including 1460 nm and 1550 nm, are likely to provide higher contrast for certain imaging modes, particularly for imaging lesions on smooth buccal surfaces. Most newly discovered white-spot lesions are found on the smooth buccal surfaces of teeth. In reflectance, the lesions appear lighter than the surrounding sound enamel and in fluorescence the lesions appear darker. The reflectivity from the sound tooth areas in the NIR infrared reflectance images are extremely low due to the weak scattering by the sound enamel. Stains can be a major limitation for visible light reflectance imaging and fluorescence, but chromophores responsible for stains in the visible region do not absorb NIR light and do not interfere at the wavelengths utilized in this study.[14] Though it would not have affected NIR

imaging, the surface of all samples was removed using grinding paper to remove any contamination leaving a smooth surface of enamel.

Surface-softened lesions are not uniform in their physical appearance; however, the visible light reflectance images show a uniform appearance whereas there is variation in near-infrared images. Zhang et al explained this using recent reflectance measurements and Monte Carlo simulations of photon propagation. Lesion contrast does not increase equally for shorter and longer wavelengths as lesion depth and severity increases. Given this, there is more uniformity within VLR images than NIR.[12]

Two of the imaging modalities, including visible light reflectance and quantitative light fluorescence, were used in both hydrated and dehydrated conditions. While no difference was seen in VLR except in the pH-cycled lesions of Days 1-4, there was significant difference in every sample set for QLF. Lagerweij et al explains that errors from drying of the teeth can occur due to lesion size.[39] Smaller lesions may dry faster than larger ones.[40] Also, in more dehydrated teeth, scattering of the light is increased, because the refractive index of air to crystals is greater than that of water to crystals.[41] To prevent or minimize this error, strict drying times should be maintained in future studies.

The performance of reflectance measurements coincident with high water absorption, at 1460 and 1550 nm, was significantly higher than at 1300 nm. In previous studies, lesion contrast at 1300 nm was shown to be higher than that of QLF.[11] QLF has been investigated for several years and is considered a very sensitive method for detecting early demineralization. Early studies of measurements at higher NIR wavelengths, however, have shown higher contrast than QLF.[14]

NIR reflectance measurements at 1460 nm and 1600 nm yielded the highest contrast and it was significantly higher than for 1300 nm reflectance measurements, fluorescence, and the visible light reflectance measurements. Further publication will include measurements of the lesion depth and severity measured with polarization sensitive optical coherence tomography. This study demonstrates that NIR at higher wavelengths coincident with higher water absorption has substantial potential for the imaging of early demineralization. The high contrast between sound enamel and early demineralization suggest that NIR reflectance may be effective for routine monitoring white spot lesions during orthodontic treatment. Since NIR wavelengths are safe, multiple images of teeth over the course of treatment can be taken to determine if prophylactic therapy is needed and if it is effective in stopping and reversing the lesion. Though VLR and QLF performed well in this study under surface-softened lesion conditions, neither (especially QLF) was as effective in pH-cycled lesion conditions. Additionally, neither would be as effective *in vivo*, considering the possibility of staining of the teeth; the ability of NIR to function despite staining is a sizeable advantage.

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Figure 2: Images of dry samples with varnish using visible light reflectance; A. at pH 4.8; B. At pH 4.9; C. Demineralization / Remineralization Days 1-4; D. Demineralization / Remineralization Days 5-8

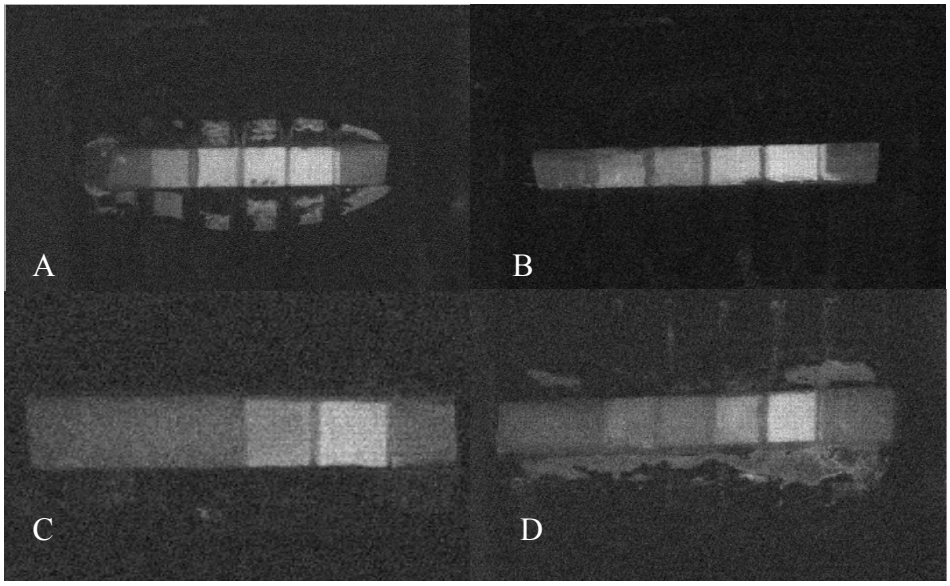

Figure 3: Images of wet samples with varnish using visible light reflectance; A. at pH 4.8; B. At pH 4.9; C. Demineralization / Remineralization Days 1-4; D. Demineralization / Remineralization Days 5-8

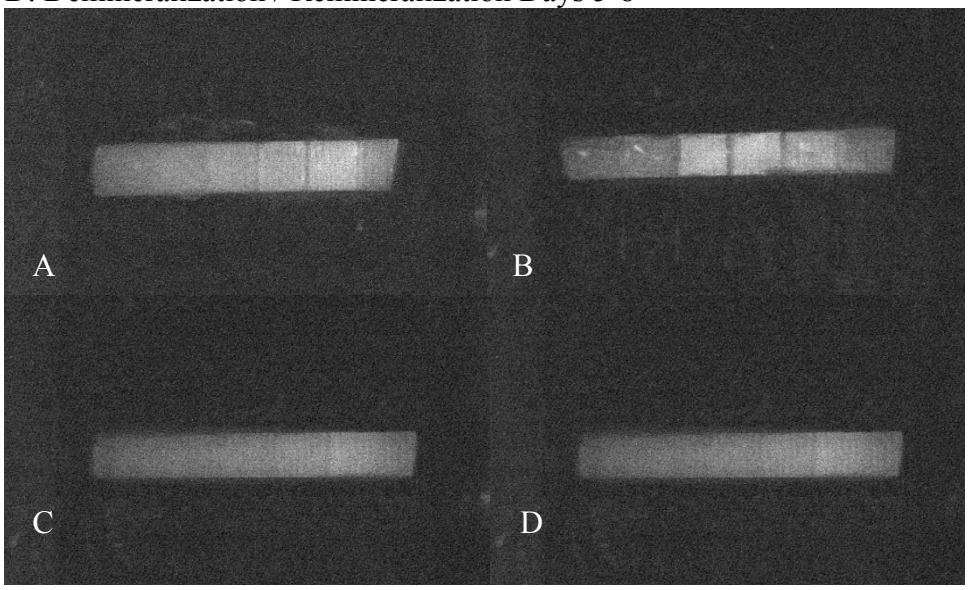

Figure 4: Images of dry samples without varnish using visible light reflectance; A. at pH 4.8; B. At pH 4.9; C. Demineralization / Remineralization Days 1-4; D. Demineralization / Remineralization Days 5-8

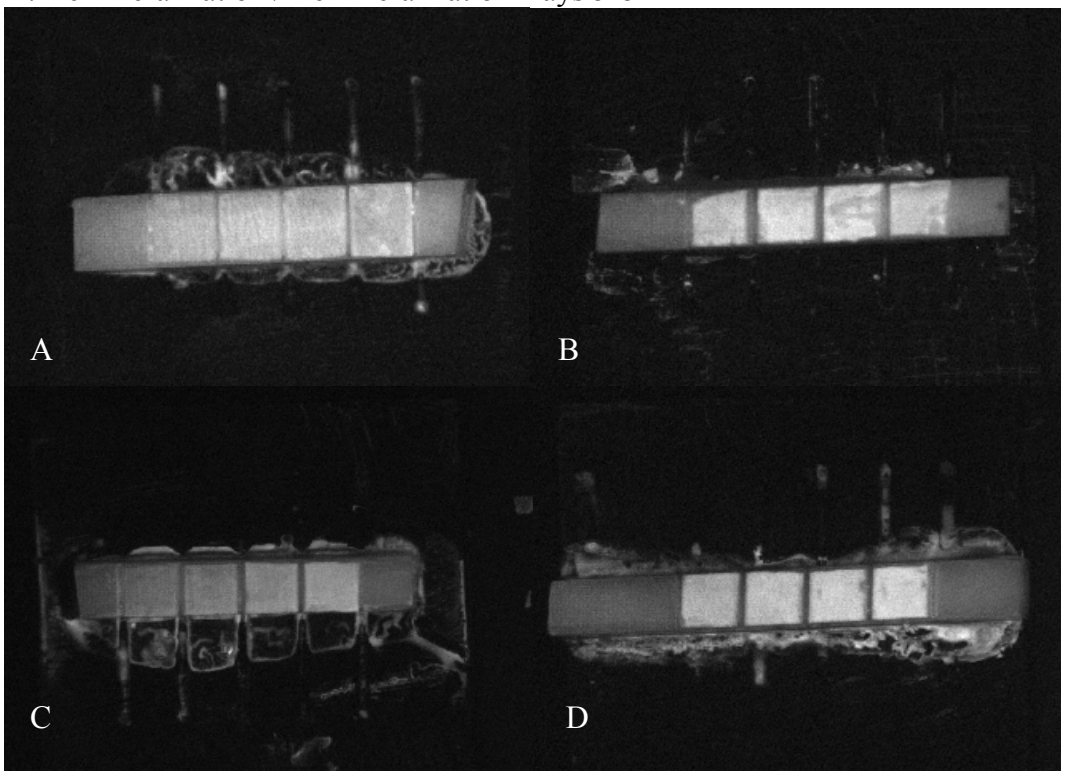

Figure 5: Images of wet samples without varnish using visible light reflectance; A. at pH 4.8; B. At pH 4.9; C. Demineralization / Remineralization Days 1-4; D. Demineralization / Remineralization Days 5-8

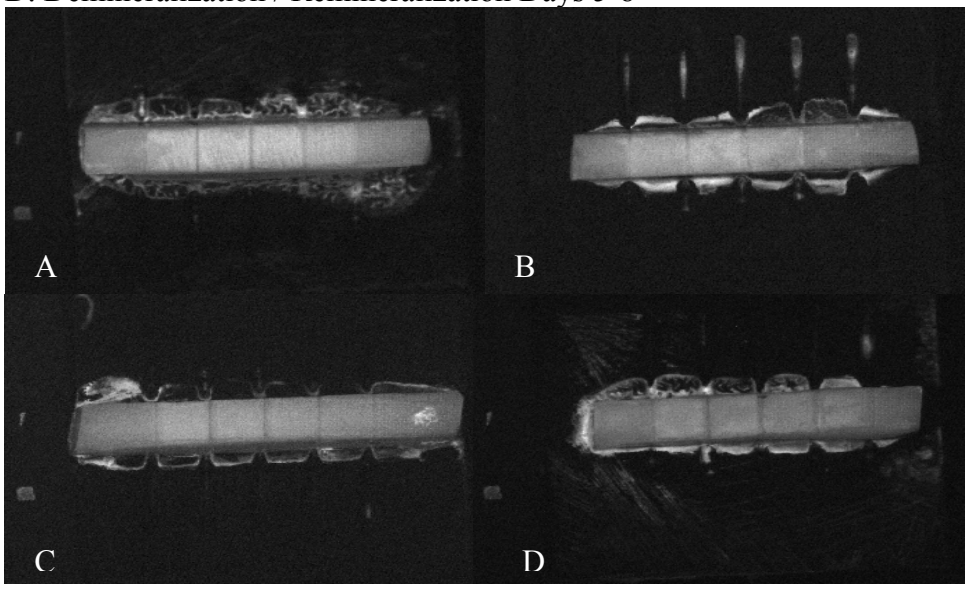

Figure 6: Images of dry samples with varnish using quantitative light fluorescence;
A. at pH 4.8; B. At pH 4.9; C. Demineralization / Remineralization Days 1-4;
D. Demineralization / Remineralization Days 5-8

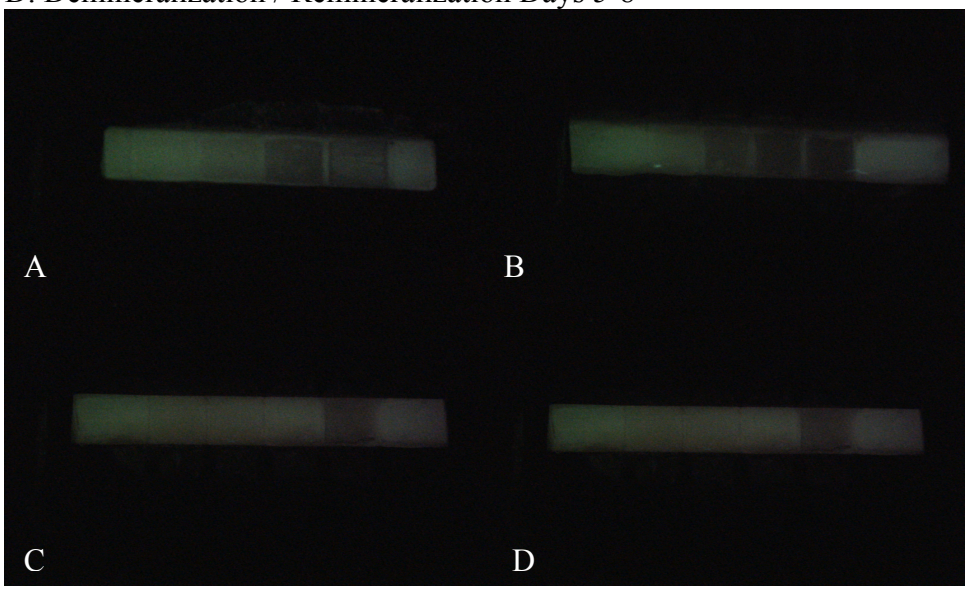

Figure 7: Images of wet samples with varnish using quantitative light fluorescence;
A. at pH 4.8; B. At pH 4.9; C. Demineralization / Remineralization Days 1-4;
D. Demineralization / Remineralization Days 5-8

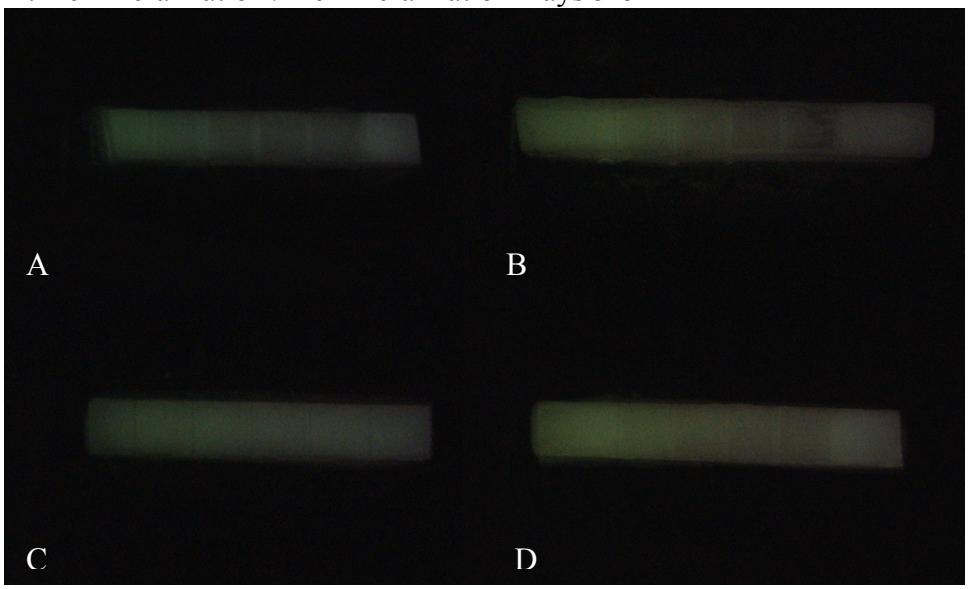

Figure 8: Images of dry samples without varnish using quantitative light fluorescence;
A. at pH 4.8; B. At pH 4.9; C. Demineralization / Remineralization Days 1-4;
D. Demineralization / Remineralization Days 5-8

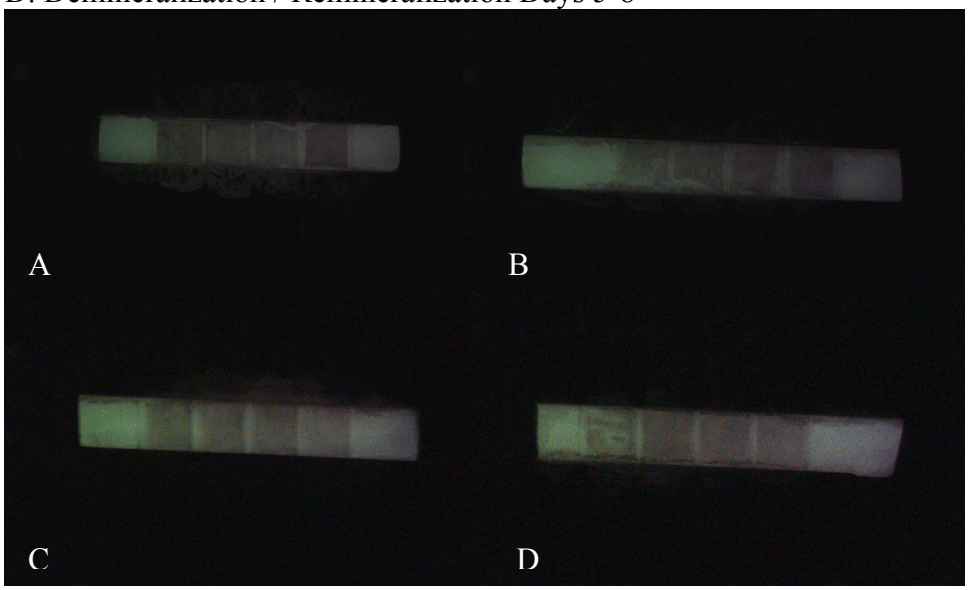

Figure 9: Images of wet samples without varnish using quantitative light fluorescence;
A. at pH 4.8; B. At pH 4.9; C. Demineralization / Remineralization Days 1-4;
D. Demineralization / Remineralization Days 5-8

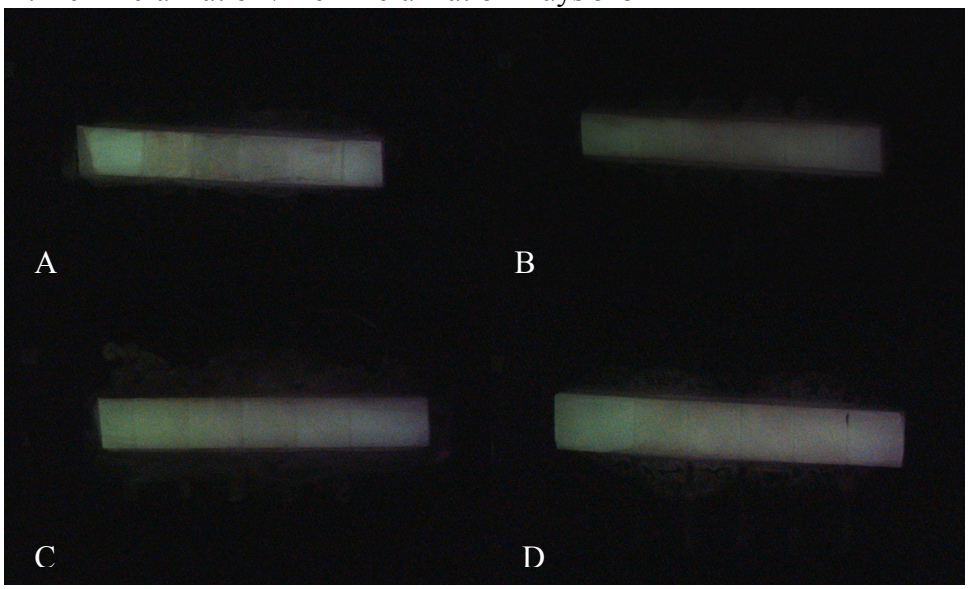

Figure 10: Images of samples with varnish using NIR at 1300 nm;
A. at pH 4.8; B. At pH 4.9; C. Demineralization / Remineralization Days 1-4;
D. Demineralization / Remineralization Days 5-8

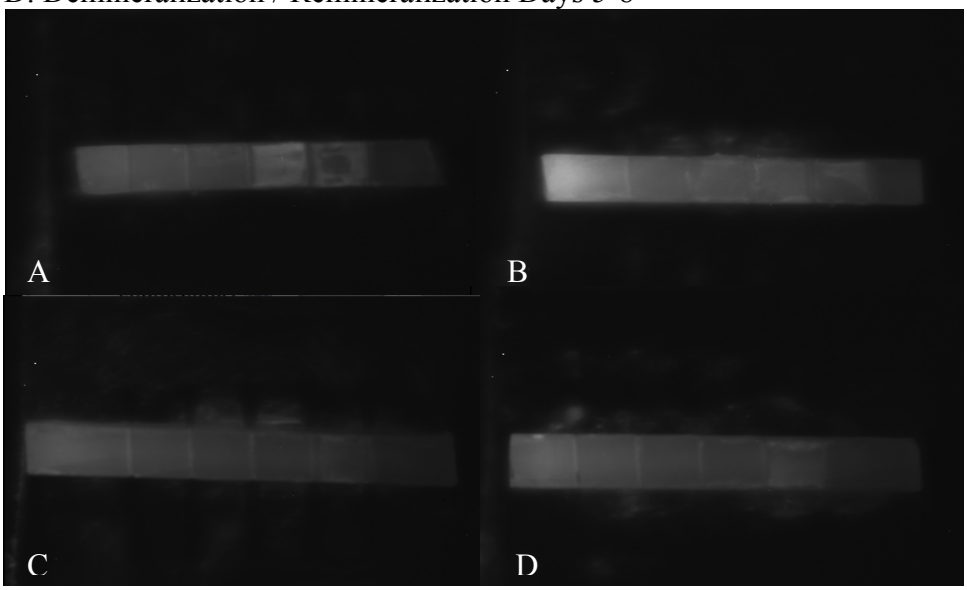

Figure 11: Images of samples without varnish using NIR at 1300 nm;
A. at pH 4.8; B. At pH 4.9; C. Demineralization / Remineralization Days 1-4;
D. Demineralization / Remineralization Days 5-8

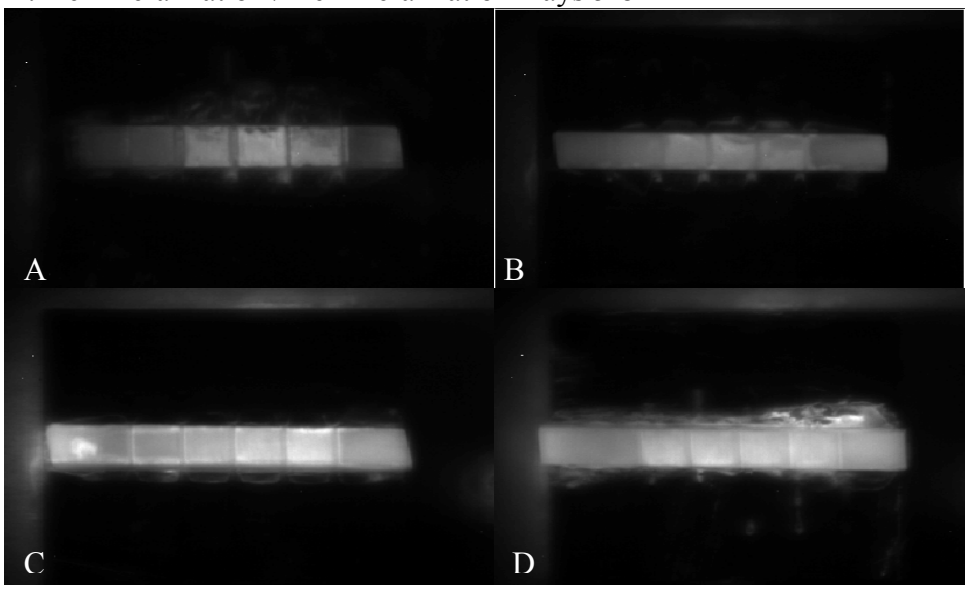

Figure 12: Images of samples with varnish using NIR at 1460 nm;
A. at pH 4.8; B. At pH 4.9; C. Demineralization / Remineralization Days 1-4;
D. Demineralization / Remineralization Days 5-8

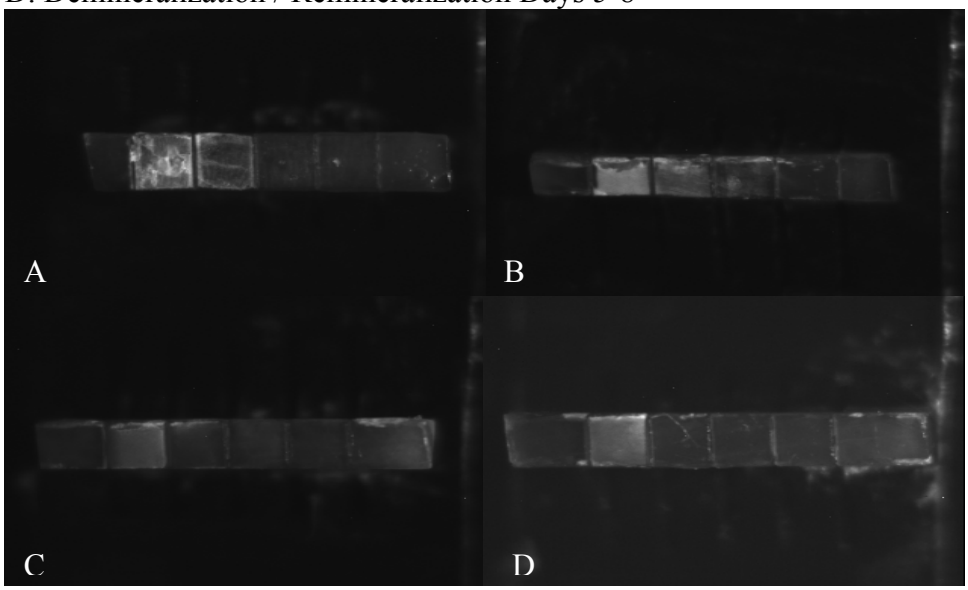

Figure 13: Images of samples without varnish using NIR at 1460 nm;
A. at pH 4.8; B. At pH 4.9; C. Demineralization / Remineralization Days 1-4;
D. Demineralization / Remineralization Days 5-8

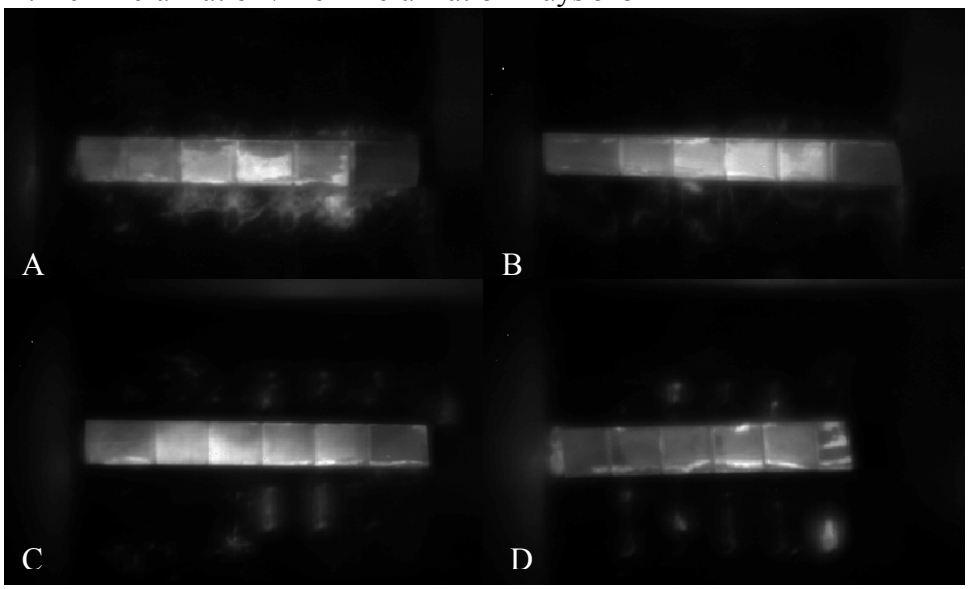

Figure 14: Images of samples with varnish using NIR at 1550 nm;
A. at pH 4.8; B. At pH 4.9; C. Demineralization / Remineralization Days 1-4;
D. Demineralization / Remineralization Days 5-8

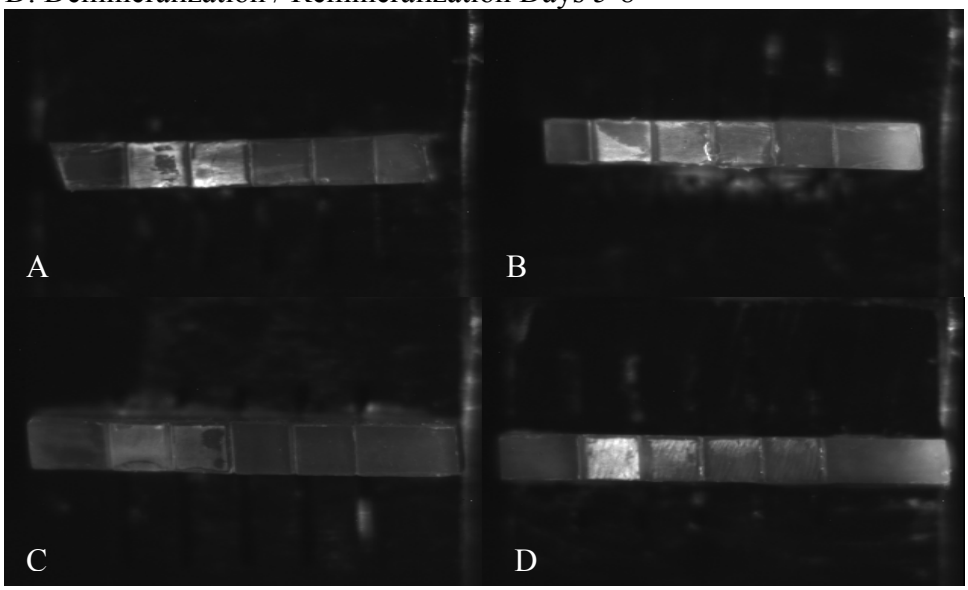

Figure 15: Images of samples without varnish using NIR at 1550 nm;
A. at pH 4.8; B. At pH 4.9; C. Demineralization / Remineralization Days 1-4;
D. Demineralization / Remineralization Days 5-8

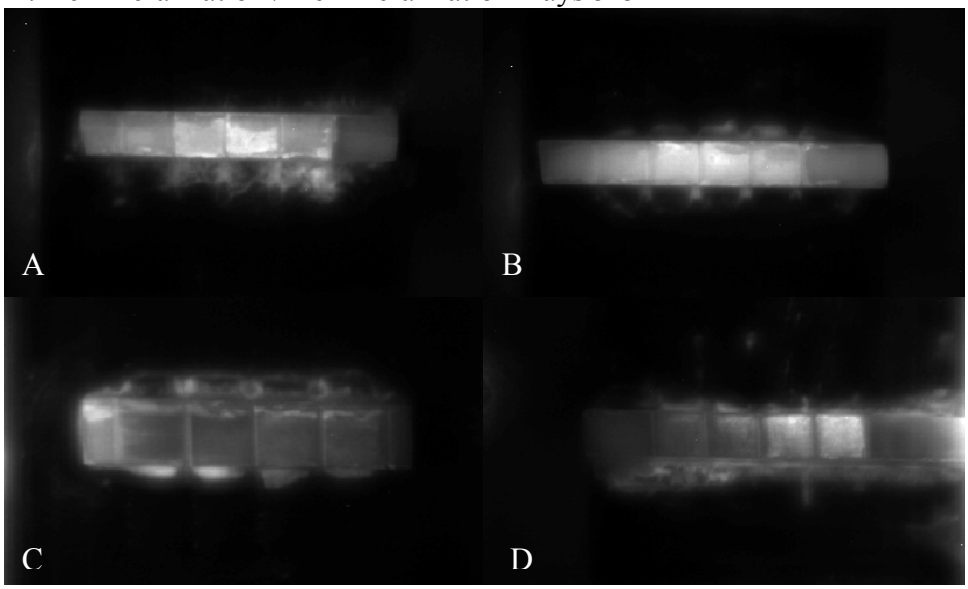

Table 1: Contrast Measurements

WITH VARNISH						WITHOUT VARNISH					
VISIBLE - DRY						**VISIBLE - DRY**					
		Window 1	Window 2	Window 3	Window 4			Window 1	Window 2	Window 3	Window 4
pH 4.8	AVG	0.165633	0.276527	0.373449	0.416989	*pH 4.8*	AVG	0.292353	0.349279	0.347552	0.325226
	ST DEV	0.056517	0.092636	0.095265	0.105139		ST DEV	0.113790	0.105248	0.104688	0.090765
pH 4.9	AVG	0.218837	0.364088	0.471622	0.540157	*pH 4.9*	AVG	0.268280	0.363295	0.375194	0.365700
	ST DEV	0.066557	0.056028	0.108883	0.109410		ST DEV	0.111732	0.094733	0.071464	0.080625
D/R 1-4	AVG	0.090930	0.159149	0.272643	0.441422	*D/R 1-4*	AVG	0.242857	0.360524	0.425987	0.472425
	ST DEV	0.021728	0.023615	0.075764	0.041256		ST DEV	0.054459	0.048982	0.045144	0.045523
D/R 5-8	AVG	0.151991	0.197290	0.319791	0.456634	*D/R 5-8*	AVG	0.432131	0.487375	0.517409	0.520546
	ST DEV	0.012798	0.033991	0.064909	0.049899		ST DEV	0.057807	0.052354	0.042605	0.089689
VISIBLE - WET						**VISIBLE - WET**					
		Window 1	Window 2	Window 3	Window 4			Window 1	Window 2	Window 3	Window 4
pH 4.8	AVG	0.171044	0.267826	0.347567	0.369545	*pH 4.8*	AVG	0.268929	0.329212	0.341722	0.303055
	ST DEV	0.057438	0.047625	0.049736	0.041420		ST DEV	0.048791	0.058833	0.076143	0.090303
pH 4.9	AVG	0.179808	0.332675	0.399976	0.440773	*pH 4.9*	AVG	0.192656	0.277737	0.324600	0.321150
	ST DEV	0.041245	0.061677	0.056456	0.066971		ST DEV	0.066790	0.065029	0.069650	0.053949
D/R 1-4	AVG	0.146632	0.209775	0.271338	0.320647	*D/R 1-4*	AVG	0.137169	0.193136	0.236578	0.260317
	ST DEV	0.058605	0.063369	0.054886	0.059649		ST DEV	0.027610	0.039137	0.045283	0.033895
D/R 5-8	AVG	0.180234	0.257502	0.312043	0.341438	*D/R 5-8*	AVG	0.212262	0.277159	0.304929	0.318006
	ST DEV	0.027350	0.028703	0.036521	0.049583		ST DEV	0.043433	0.049339	0.063273	0.077407
QLF - DRY						**QLF - DRY**					
		Window 1	Window 2	Window 3	Window 4			Window 1	Window 2	Window 3	Window 4
pH 4.8	AVG	0.075938	0.223284	0.384563	0.451525	*pH 4.8*	AVG	0.268055	0.281410	0.306274	0.299162
	ST DEV	0.153958	0.151119	0.107502	0.101569		ST DEV	0.142586	0.142113	0.133468	0.126714
pH 4.9	AVG	0.062046	0.313962	0.435911	0.472999	*pH 4.9*	AVG	0.197184	0.197680	0.193398	0.167715
	ST DEV	0.136797	0.140474	0.096340	0.148405		ST DEV	0.143911	0.127919	0.122011	0.127245
D/R 1-4	AVG	-0.095885	-0.034502	0.105253	0.303608	*D/R 1-4*	AVG	0.098052	0.172700	0.207500	0.202515
	ST DEV	0.069436	0.072953	0.117406	0.058514		ST DEV	0.120108	0.108043	0.093854	0.097291
D/R 5-8	AVG	-0.004014	0.041369	0.174966	0.379949	*D/R 5-8*	AVG	0.226745	0.240103	0.270933	0.259185
	ST DEV	0.084498	0.078093	0.104271	0.044716		ST DEV	0.088938	0.090075	0.078048	0.076963
QLF - WET						**QLF - WET**					
		Window 1	Window 2	Window 3	Window 4			Window 1	Window 2	Window 3	Window 4
pH 4.8	AVG	0.010956	0.088921	0.118106	0.165874	*pH 4.8*	AVG	0.087673	0.118736	0.143489	0.107843
	ST DEV	0.080485	0.080168	0.097614	0.094969		ST DEV	0.099769	0.093901	0.083764	0.099015

pH 4.9	AVG	-0.000367	0.122850	0.162321	0.174646	*pH 4.9*	AVG	0.037700	0.062140	0.094553	0.056875
	ST DEV	0.071144	0.085089	0.099930	0.170746		ST DEV	0.127869	0.112589	0.112201	0.119627
D/R 1-4	AVG	-0.136490	-0.167967	-0.159123	-0.137366	*D/R 1-4*	AVG	-0.011582	-0.032099	-0.032191	-0.032740
	ST DEV	0.071374	0.100225	0.109556	0.120650		ST DEV	0.110224	0.128152	0.128135	0.119144
D/R 5-8	AVG	-0.025985	-0.031503	-0.034549	-0.018681	*D/R 5-8*	AVG	0.068635	0.065810	0.077146	0.046467
	ST DEV	0.125354	0.123644	0.128564	0.126202		ST DEV	0.098130	0.095471	0.080203	0.087263
NIR 1300nm						**NIR 1300nm**					
		Window 1	Window 2	Window 3	Window 4			Window 1	Window 2	Window 3	Window 4
pH 4.8	AVG	0.586959	0.551501	0.560903	0.381114	*pH 4.8*	AVG	0.237217	0.402257	0.482139	0.370474
	ST DEV	0.059069	0.073211	0.053726	0.093457		ST DEV	0.153110	0.132015	0.105731	0.095671
pH 4.9	AVG	0.600701	0.578863	0.577563	0.471296	*pH 4.9*	AVG	0.176382	0.329243	0.382484	0.324994
	ST DEV	0.054926	0.043104	0.070577	0.081722		ST DEV	0.096857	0.096783	0.094886	0.069501
D/R 1-4	AVG	0.305551	0.374313	0.471523	0.591400	*D/R 1-4*	AVG	0.170947	0.220116	0.239295	0.205665
	ST DEV	0.043788	0.067480	0.052906	0.076344		ST DEV	0.092917	0.075313	0.093044	0.109132
D/R 5-8	AVG	0.347091	0.379006	0.452936	0.561938	*D/R 5-8*	AVG	0.199292	0.249943	0.239036	0.218200
	ST DEV	0.068819	0.075555	0.075252	0.082886		ST DEV	0.110866	0.101818	0.137710	0.131955
NIR 1460 nm						**NIR 1460 nm**					
		Window 1	Window 2	Window 3	Window 4			Window 1	Window 2	Window 3	Window 4
pH 4.8	AVG	0.262096	0.369528	0.619001	0.611903	*pH 4.8*	AVG	0.492756	0.700161	0.734432	0.634723
	ST DEV	0.115355	0.218463	0.154447	0.177275		ST DEV	0.118476	0.056151	0.060835	0.074696
pH 4.9	AVG	0.132141	0.345313	0.573039	0.618666	*pH 4.9*	AVG	0.386062	0.563275	0.590476	0.514561
	ST DEV	0.074748	0.085923	0.107209	0.139900		ST DEV	0.089874	0.093114	0.087566	0.110595
D/R 1-4	AVG	0.161023	0.122812	0.215570	0.457824	*D/R 1-4*	AVG	0.287715	0.435984	0.522915	0.524839
	ST DEV	0.141692	0.095889	0.105259	0.062731		ST DEV	0.198817	0.145064	0.097520	0.127165
D/R 5-8	AVG	0.163991	0.102144	0.201644	0.512599	*D/R 5-8*	AVG	0.362947	0.528417	0.610879	0.550309
	ST DEV	0.118043	0.137469	0.156593	0.133421		ST DEV	0.167226	0.108666	0.088616	0.118991
NIR 1550nm						**NIR 1550 nm**					
		Window 1	Window 2	Window 3	Window 4			Window 1	Window 2	Window 3	Window 4
pH 4.8	AVG	0.346924	0.461425	0.632208	0.585632	*pH 4.8*	AVG	0.490076	0.589349	0.558134	0.401667
	ST DEV	0.135549	0.172075	0.115516	0.126131		ST DEV	0.092602	0.085557	0.067207	0.066472
pH 4.9	AVG	0.325798	0.523363	0.649362	0.651547	*pH 4.9*	AVG	0.364184	0.485710	0.494145	0.371145
	ST DEV	0.149805	0.110247	0.140129	0.079268		ST DEV	0.152333	0.115225	0.077370	0.075037
D/R 1-4	AVG	0.168255	0.118060	0.240403	0.453690	*D/R 1-4*	AVG	0.313424	0.402394	0.406966	0.405668
	ST DEV	0.176796	0.105628	0.121185	0.073253		ST DEV	0.231684	0.179848	0.171196	0.200528
D/R 5-8	AVG	0.130206	0.115018	0.279144	0.523642	*D/R 5-8*	AVG	0.389015	0.525312	0.577610	0.559840

	ST DEV	0.146408	0.138601	0.184081	0.149085		ST DEV	0.168125	0.107734	0.087842	0.120714

Table 2: pH 4.8 with varnish

Tukey's multiple comparisons test	Mean Diff.	95% CI of diff.	Significant?	Summary
Visible - Dry				
Window 1 vs. Window 2	-0.1109	-0.2005 to -0.02128	Yes	**
Window 1 vs. Window 3	-0.2078	-0.2974 to -0.1182	Yes	****
Window 1 vs. Window 4	-0.2514	-0.3410 to -0.1617	Yes	****
Window 2 vs. Window 3	-0.09692	-0.1865 to -0.007308	Yes	*
Window 2 vs. Window 4	-0.1405	-0.2301 to -0.05085	Yes	***
Window 3 vs. Window 4	-0.04354	-0.1332 to 0.04607	No	ns
Visible - Wet				
Window 1 vs. Window 2	-0.09678	-0.1864 to -0.007167	Yes	*
Window 1 vs. Window 3	-0.1765	-0.2661 to -0.08691	Yes	****
Window 1 vs. Window 4	-0.1985	-0.2881 to -0.1089	Yes	****
Window 2 vs. Window 3	-0.07974	-0.1694 to 0.009872	No	ns
Window 2 vs. Window 4	-0.1017	-0.1913 to -0.01211	Yes	*
Window 3 vs. Window 4	-0.02198	-0.1116 to 0.06764	No	ns
QLF - Dry				
Window 1 vs. Window 2	-0.1473	-0.2370 to -0.05773	Yes	***
Window 1 vs. Window 3	-0.3086	-0.3982 to -0.2190	Yes	****
Window 1 vs. Window 4	-0.3756	-0.4652 to -0.2860	Yes	****
Window 2 vs. Window 3	-0.1613	-0.2509 to -0.07167	Yes	****
Window 2 vs. Window 4	-0.2282	-0.3179 to -0.1386	Yes	****
Window 3 vs. Window 4	-0.06696	-0.1566 to 0.02265	No	ns
QLF - Wet				
Window 1 vs. Window 2	-0.07796	-0.1676 to 0.01165	No	ns
Window 1 vs. Window 3	-0.1072	-0.1968 to -0.01754	Yes	*
Window 1 vs. Window 4	-0.1549	-0.2445 to -0.06530	Yes	****
Window 2 vs. Window 3	-0.02919	-0.1188 to 0.06043	No	ns
Window 2 vs. Window 4	-0.07695	-0.1666 to 0.01266	No	ns
Window 3 vs. Window 4	-0.04777	-0.1374 to 0.04185	No	ns
NIR 1300				
Window 1 vs. Window 2	0.03546	-0.05416 to 0.1251	No	ns
Window 1 vs. Window 3	0.02606	-0.06356 to 0.1157	No	ns

Window 1 vs. Window 4	0.2058	0.1162 to 0.2955	Yes	****
Window 2 vs. Window 3	-0.009402	-0.09902 to 0.08021	No	ns
Window 2 vs. Window 4	0.1704	0.08077 to 0.2600	Yes	****
Window 3 vs. Window 4	0.1798	0.09017 to 0.2694	Yes	****
NIR 1460				
Window 1 vs. Window 2	-0.1074	-0.1970 to -0.01782	Yes	*
Window 1 vs. Window 3	-0.3569	-0.4465 to -0.2673	Yes	****
Window 1 vs. Window 4	-0.3498	-0.4394 to -0.2602	Yes	****
Window 2 vs. Window 3	-0.2495	-0.3391 to -0.1599	Yes	****
Window 2 vs. Window 4	-0.2424	-0.3320 to -0.1528	Yes	****
Window 3 vs. Window 4	0.007097	-0.08252 to 0.09671	No	ns
NIR 1550				
Window 1 vs. Window 2	-0.1145	-0.2041 to -0.02489	Yes	**
Window 1 vs. Window 3	-0.2853	-0.3749 to -0.1957	Yes	****
Window 1 vs. Window 4	-0.2387	-0.3283 to -0.1491	Yes	****
Window 2 vs. Window 3	-0.1708	-0.2604 to -0.08117	Yes	****
Window 2 vs. Window 4	-0.1242	-0.2138 to -0.03459	Yes	**
Window 3 vs. Window 4	0.04658	-0.04304 to 0.1362	No	ns

Table 3: pH 4.8 with varnish

Tukey's multiple comparisons test	Mean Difference	95% CI of diff.	Sigdnificant?	Summary
Window 1				
Visible - Dry vs. Visible - Wet	-0.005411	-0.1552 to 0.1444	No	ns
Visible - Dry vs. QLF - Dry	0.08969	-0.06009 to 0.2395	No	ns
Visible - Dry vs. QLF - Wet	0.1547	0.004888 to 0.3045	Yes	*
Visible - Dry vs. NIR 1300	-0.4213	-0.5711 to -0.2715	Yes	****
Visible - Dry vs. NIR 1460	-0.09646	-0.2463 to 0.05333	No	ns
Visible - Dry vs. NIR 1550	-0.1813	-0.3311 to -0.03150	Yes	**
Visible - Wet vs. QLF - Dry	0.09511	-0.05468 to 0.2449	No	ns
Visible - Wet vs. QLF - Wet	0.1601	0.01030 to 0.3099	Yes	*
Visible - Wet vs. NIR 1300	-0.4159	-0.5657 to -0.2661	Yes	****
Visible - Wet vs. NIR 1460	-0.09105	-0.2408 to 0.05874	No	ns
Visible - Wet vs. NIR 1550	-0.1759	-0.3257 to -0.02609	Yes	*
QLF - Dry vs. QLF - Wet	0.06498	-0.08481 to 0.2148	No	ns
QLF - Dry vs. NIR 1300	-0.511	-0.6608 to -0.3612	Yes	****
QLF - Dry vs. NIR 1460	-0.1862	-0.3359 to -0.03637	Yes	**
QLF - Dry vs. NIR 1550	-0.271	-0.4208 to -0.1212	Yes	****

QLF - Wet vs. NIR 1300	-0.576	-0.7258 to -0.4262	Yes	****
QLF - Wet vs. NIR 1460	-0.2511	-0.4009 to -0.1014	Yes	****
QLF - Wet vs. NIR 1550	-0.336	-0.4858 to -0.1862	Yes	****
NIR 1300 vs. NIR 1460	0.3249	0.1751 to 0.4747	Yes	****
NIR 1300 vs. NIR 1550	0.24	0.09025 to 0.3898	Yes	****
NIR 1460 vs. NIR 1550	-0.08483	-0.2346 to 0.06496	No	ns
Window 2				
Visible - Dry vs. Visible - Wet	0.008702	-0.1411 to 0.1585	No	ns
Visible - Dry vs. QLF - Dry	0.05324	-0.09655 to 0.2030	No	ns
Visible - Dry vs. QLF - Wet	0.1876	0.03782 to 0.3374	Yes	**
Visible - Dry vs. NIR 1300	-0.275	-0.4248 to -0.1252	Yes	****
Visible - Dry vs. NIR 1460	-0.093	-0.2428 to 0.05679	No	ns
Visible - Dry vs. NIR 1550	-0.1849	-0.3347 to -0.03511	Yes	**
Visible - Wet vs. QLF - Dry	0.04454	-0.1052 to 0.1943	No	ns
Visible - Wet vs. QLF - Wet	0.1789	0.02912 to 0.3287	Yes	**
Visible - Wet vs. NIR 1300	-0.2837	-0.4335 to -0.1339	Yes	****
Visible - Wet vs. NIR 1460	-0.1017	-0.2515 to 0.04809	No	ns
Visible - Wet vs. NIR 1550	-0.1936	-0.3434 to -0.04381	Yes	**
QLF - Dry vs. QLF - Wet	0.1344	-0.01543 to 0.2842	No	ns
QLF - Dry vs. NIR 1300	-0.3282	-0.4780 to -0.1784	Yes	****
QLF - Dry vs. NIR 1460	-0.1462	-0.2960 to 0.003545	No	ns
QLF - Dry vs. NIR 1550	-0.2381	-0.3879 to -0.08835	Yes	****
QLF - Wet vs. NIR 1300	-0.4626	-0.6124 to -0.3128	Yes	****
QLF - Wet vs. NIR 1460	-0.2806	-0.4304 to -0.1308	Yes	****
QLF - Wet vs. NIR 1550	-0.3725	-0.5223 to -0.2227	Yes	****
NIR 1300 vs. NIR 1460	0.182	0.03218 to 0.3318	Yes	**
NIR 1300 vs. NIR 1550	0.09008	-0.05971 to 0.2399	No	ns
NIR 1460 vs. NIR 1550	-0.0919	-0.2417 to 0.05789	No	ns
Window 3				
Visible - Dry vs. Visible - Wet	0.02588	-0.1239 to 0.1757	No	ns
Visible - Dry vs. QLF - Dry	-0.01111	-0.1609 to 0.1387	No	ns
Visible - Dry vs. QLF - Wet	0.2553	0.1056 to 0.4051	Yes	****
Visible - Dry vs. NIR 1300	-0.1875	-0.3372 to -0.03767	Yes	**
Visible - Dry vs. NIR 1460	-0.2456	-0.3953 to -0.09576	Yes	****
Visible - Dry vs. NIR 1550	-0.2588	-0.4085 to -0.1090	Yes	****
Visible - Wet vs. QLF - Dry	-0.037	-0.1868 to 0.1128	No	ns
Visible - Wet vs. QLF - Wet	0.2295	0.07967 to 0.3792	Yes	***
Visible - Wet vs. NIR 1300	-0.2133	-0.3631 to -0.06355	Yes	***

Visible - Wet vs. NIR 1460	-0.2714	-0.4212 to -0.1216	Yes	****
Visible - Wet vs. NIR 1550	-0.2846	-0.4344 to -0.1349	Yes	****
QLF - Dry vs. QLF - Wet	0.2665	0.1167 to 0.4162	Yes	****
QLF - Dry vs. NIR 1300	-0.1763	-0.3261 to -0.02655	Yes	**
QLF - Dry vs. NIR 1460	-0.2344	-0.3842 to -0.08465	Yes	***
QLF - Dry vs. NIR 1550	-0.2476	-0.3974 to -0.09786	Yes	****
QLF - Wet vs. NIR 1300	-0.4428	-0.5926 to -0.2930	Yes	****
QLF - Wet vs. NIR 1460	-0.5009	-0.6507 to -0.3511	Yes	****
QLF - Wet vs. NIR 1550	-0.5141	-0.6639 to -0.3643	Yes	****
NIR 1300 vs. NIR 1460	-0.0581	-0.2079 to 0.09169	No	ns
NIR 1300 vs. NIR 1550	-0.0713	-0.2211 to 0.07848	No	ns
NIR 1460 vs. NIR 1550	-0.01321	-0.1630 to 0.1366	No	ns
Window 4				
Visible - Dry vs. Visible - Wet	0.04744	-0.1023 to 0.1972	No	ns
Visible - Dry vs. QLF - Dry	-0.03454	-0.1843 to 0.1153	No	ns
Visible - Dry vs. QLF - Wet	0.2511	0.1013 to 0.4009	Yes	****
Visible - Dry vs. NIR 1300	0.03587	-0.1139 to 0.1857	No	ns
Visible - Dry vs. NIR 1460	-0.1949	-0.3447 to -0.04513	Yes	**
Visible - Dry vs. NIR 1550	-0.1686	-0.3184 to -0.01885	Yes	*
Visible - Wet vs. QLF - Dry	-0.08198	-0.2318 to 0.06781	No	ns
Visible - Wet vs. QLF - Wet	0.2037	0.05388 to 0.3535	Yes	**
Visible - Wet vs. NIR 1300	-0.01157	-0.1614 to 0.1382	No	ns
Visible - Wet vs. NIR 1460	-0.2424	-0.3921 to -0.09257	Yes	****
Visible - Wet vs. NIR 1550	-0.2161	-0.3659 to -0.06630	Yes	***
QLF - Dry vs. QLF - Wet	0.2857	0.1359 to 0.4354	Yes	****
QLF - Dry vs. NIR 1300	0.07041	-0.07938 to 0.2202	No	ns
QLF - Dry vs. NIR 1460	-0.1604	-0.3102 to -0.01059	Yes	*
QLF - Dry vs. NIR 1550	-0.1341	-0.2839 to 0.01568	No	ns
QLF - Wet vs. NIR 1300	-0.2152	-0.3650 to -0.06545	Yes	***
QLF - Wet vs. NIR 1460	-0.446	-0.5958 to -0.2962	Yes	****
QLF - Wet vs. NIR 1550	-0.4198	-0.5695 to -0.2700	Yes	****
NIR 1300 vs. NIR 1460	-0.2308	-0.3806 to -0.08100	Yes	***
NIR 1300 vs. NIR 1550	-0.2045	-0.3543 to -0.05473	Yes	**
NIR 1460 vs. NIR 1550	0.02627	-0.1235 to 0.1761	No	ns

Table 4: pH 4.9 with varnish

Tukey's multiple comparisons test	Mean Diff.	95% CI of diff.	Significant?	Summary
Visible - Dry				

Window 1 vs. Window 2	-0.1453	-0.2282 to -0.06230	Yes	****
Window 1 vs. Window 3	-0.2528	-0.3357 to -0.1698	Yes	****
Window 1 vs. Window 4	-0.3213	-0.4043 to -0.2384	Yes	****
Window 2 vs. Window 3	-0.1075	-0.1905 to -0.02458	Yes	**
Window 2 vs. Window 4	-0.1761	-0.2590 to -0.09312	Yes	****
Window 3 vs. Window 4	-0.06854	-0.1515 to 0.01442	No	ns
Visible - Wet				
Window 1 vs. Window 2	-0.1529	-0.2358 to -0.06991	Yes	****
Window 1 vs. Window 3	-0.2202	-0.3031 to -0.1372	Yes	****
Window 1 vs. Window 4	-0.261	-0.3439 to -0.1780	Yes	****
Window 2 vs. Window 3	-0.0673	-0.1503 to 0.01565	No	ns
Window 2 vs. Window 4	-0.1081	-0.1911 to -0.02515	Yes	**
Window 3 vs. Window 4	-0.0408	-0.1238 to 0.04215	No	ns
QLF - Dry				
Window 1 vs. Window 2	-0.2519	-0.3349 to -0.1690	Yes	****
Window 1 vs. Window 3	-0.3739	-0.4568 to -0.2909	Yes	****
Window 1 vs. Window 4	-0.411	-0.4939 to -0.3280	Yes	****
Window 2 vs. Window 3	-0.1219	-0.2049 to -0.03900	Yes	**
Window 2 vs. Window 4	-0.159	-0.2420 to -0.07609	Yes	****
Window 3 vs. Window 4	-0.03709	-0.1200 to 0.04586	No	ns
QLF - Wet				
Window 1 vs. Window 2	-0.1232	-0.2062 to -0.04026	Yes	***
Window 1 vs. Window 3	-0.1627	-0.2456 to -0.07974	Yes	****
Window 1 vs. Window 4	-0.175	-0.2580 to -0.09206	Yes	****
Window 2 vs. Window 3	-0.03947	-0.1224 to 0.04348	No	ns
Window 2 vs. Window 4	-0.0518	-0.1347 to 0.03116	No	ns
Window 3 vs. Window 4	-0.01232	-0.09528 to 0.07063	No	ns
NIR 1300				
Window 1 vs. Window 2	0.02184	-0.06111 to 0.1048	No	ns
Window 1 vs. Window 3	0.02314	-0.05981 to 0.1061	No	ns
Window 1 vs. Window 4	0.1294	0.04645 to 0.2124	Yes	***
Window 2 vs. Window 3	0.0013	-0.08165 to 0.08425	No	ns
Window 2 vs. Window 4	0.1076	0.02462 to 0.1905	Yes	**
Window 3 vs. Window 4	0.1063	0.02331 to 0.1892	Yes	**
NIR 1460				

Window 1 vs. Window 2	-0.2132	-0.2961 to -0.1302	Yes	****
Window 1 vs. Window 3	-0.4409	-0.5239 to -0.3579	Yes	****
Window 1 vs. Window 4	-0.4865	-0.5695 to -0.4036	Yes	****
Window 2 vs. Window 3	-0.2277	-0.3107 to -0.1448	Yes	****
Window 2 vs. Window 4	-0.2734	-0.3563 to -0.1904	Yes	****
Window 3 vs. Window 4	-0.04563	-0.1286 to 0.03733	No	ns
NIR 1550				
Window 1 vs. Window 2	-0.1976	-0.2805 to -0.1146	Yes	****
Window 1 vs. Window 3	-0.3236	-0.4065 to -0.2406	Yes	****
Window 1 vs. Window 4	-0.3257	-0.4087 to -0.2428	Yes	****
Window 2 vs. Window 3	-0.126	-0.2090 to -0.04305	Yes	***
Window 2 vs. Window 4	-0.1282	-0.2111 to -0.04523	Yes	***
Window 3 vs. Window 4	-0.002186	-0.08514 to 0.08077	No	ns

Table 5: pH 4.9 with varnish

Tukey's multiple comparisons test	Mean Diff.	95% CI of diff.	Significant?	Summary
Window 1				
Visible - Dry vs. Visible - Wet	0.03903	-0.09551 to 0.1736	No	ns
Visible - Dry vs. QLF - Dry	0.1568	0.02225 to 0.2913	Yes	*
Visible - Dry vs. QLF - Wet	0.2192	0.08466 to 0.3537	Yes	****
Visible - Dry vs. NIR 1300	-0.3819	-0.5164 to -0.2473	Yes	****
Visible - Dry vs. NIR 1460	0.0867	-0.04785 to 0.2212	No	ns
Visible - Dry vs. NIR 1550	-0.107	-0.2415 to 0.02758	No	ns
Visible - Wet vs. QLF - Dry	0.1178	-0.01678 to 0.2523	No	ns
Visible - Wet vs. QLF - Wet	0.1802	0.04563 to 0.3147	Yes	**
Visible - Wet vs. NIR 1300	-0.4209	-0.5554 to -0.2864	Yes	****
Visible - Wet vs. NIR 1460	0.04767	-0.08688 to 0.1822	No	ns
Visible - Wet vs. NIR 1550	-0.146	-0.2805 to -0.01145	Yes	*
QLF - Dry vs. QLF - Wet	0.06241	-0.07213 to 0.1970	No	ns
QLF - Dry vs. NIR 1300	-0.5387	-0.6732 to -0.4041	Yes	****
QLF - Dry vs. NIR 1460	-0.0701	-0.2046 to 0.06445	No	ns
QLF - Dry vs. NIR 1550	-0.2638	-0.3983 to -0.1292	Yes	****
QLF - Wet vs. NIR 1300	-0.6011	-0.7356 to -0.4665	Yes	****
QLF - Wet vs. NIR 1460	-0.1325	-0.2671 to 0.002034	No	ns
QLF - Wet vs. NIR 1550	-0.3262	-0.4607 to -0.1916	Yes	****
NIR 1300 vs. NIR 1460	0.4686	0.3340 to 0.6031	Yes	****
NIR 1300 vs. NIR 1550	0.2749	0.1404 to 0.4094	Yes	****
NIR 1460 vs. NIR 1550	-0.1937	-0.3282 to -0.05911	Yes	***

Window 2				
Visible - Dry vs. Visible - Wet	0.03141	-0.1031 to 0.1660	No	ns
Visible - Dry vs. QLF - Dry	0.05013	-0.08442 to 0.1847	No	ns
Visible - Dry vs. QLF - Wet	0.2412	0.1067 to 0.3758	Yes	****
Visible - Dry vs. NIR 1300	-0.2148	-0.3493 to -0.08023	Yes	****
Visible - Dry vs. NIR 1460	0.01877	-0.1158 to 0.1533	No	ns
Visible - Dry vs. NIR 1550	-0.1593	-0.2938 to -0.02473	Yes	**
Visible - Wet vs. QLF - Dry	0.01871	-0.1158 to 0.1533	No	ns
Visible - Wet vs. QLF - Wet	0.2098	0.07528 to 0.3444	Yes	***
Visible - Wet vs. NIR 1300	-0.2462	-0.3807 to -0.1116	Yes	****
Visible - Wet vs. NIR 1460	-0.01264	-0.1472 to 0.1219	No	ns
Visible - Wet vs. NIR 1550	-0.1907	-0.3252 to -0.05614	Yes	***
QLF - Dry vs. QLF - Wet	0.1911	0.05657 to 0.3257	Yes	***
QLF - Dry vs. NIR 1300	-0.2649	-0.3994 to -0.1304	Yes	****
QLF - Dry vs. NIR 1460	-0.03135	-0.1659 to 0.1032	No	ns
QLF - Dry vs. NIR 1550	-0.2094	-0.3439 to -0.07486	Yes	***
QLF - Wet vs. NIR 1300	-0.456	-0.5906 to -0.3215	Yes	****
QLF - Wet vs. NIR 1460	-0.2225	-0.3570 to -0.08792	Yes	****
QLF - Wet vs. NIR 1550	-0.4005	-0.5351 to -0.2660	Yes	****
NIR 1300 vs. NIR 1460	0.2335	0.09901 to 0.3681	Yes	****
NIR 1300 vs. NIR 1550	0.0555	-0.07904 to 0.1900	No	ns
NIR 1460 vs. NIR 1550	-0.178	-0.3126 to -0.04351	Yes	**
Window 3				
Visible - Dry vs. Visible - Wet	0.07165	-0.06290 to 0.2062	No	ns
Visible - Dry vs. QLF - Dry	0.03571	-0.09883 to 0.1703	No	ns
Visible - Dry vs. QLF - Wet	0.3093	0.1748 to 0.4438	Yes	****
Visible - Dry vs. NIR 1300	-0.1059	-0.2405 to 0.02860	No	ns
Visible - Dry vs. NIR 1460	-0.1014	-0.2360 to 0.03313	No	ns
Visible - Dry vs. NIR 1550	-0.1777	-0.3123 to -0.04320	Yes	**
Visible - Wet vs. QLF - Dry	-0.03594	-0.1705 to 0.09861	No	ns
Visible - Wet vs. QLF - Wet	0.2377	0.1031 to 0.3722	Yes	****
Visible - Wet vs. NIR 1300	-0.1776	-0.3121 to -0.04304	Yes	**
Visible - Wet vs. NIR 1460	-0.1731	-0.3076 to -0.03852	Yes	**
Visible - Wet vs. NIR 1550	-0.2494	-0.3839 to -0.1148	Yes	****
QLF - Dry vs. QLF - Wet	0.2736	0.1390 to 0.4081	Yes	****
QLF - Dry vs. NIR 1300	-0.1417	-0.2762 to -0.007109	Yes	*
QLF - Dry vs. NIR 1460	-0.1371	-0.2717 to -0.002585	Yes	*
QLF - Dry vs. NIR 1550	-0.2135	-0.3480 to -0.07891	Yes	****

QLF - Wet vs. NIR 1300	-0.4152	-0.5498 to -0.2807	Yes	****
QLF - Wet vs. NIR 1460	-0.4107	-0.5453 to -0.2762	Yes	****
QLF - Wet vs. NIR 1550	-0.487	-0.6216 to -0.3525	Yes	****
NIR 1300 vs. NIR 1460	0.004524	-0.1300 to 0.1391	No	ns
NIR 1300 vs. NIR 1550	-0.0718	-0.2063 to 0.06274	No	ns
NIR 1460 vs. NIR 1550	-0.07632	-0.2109 to 0.05822	No	ns
Window 4				
Visible - Dry vs. Visible - Wet	0.09938	-0.03516 to 0.2339	No	ns
Visible - Dry vs. QLF - Dry	0.06716	-0.06738 to 0.2017	No	ns
Visible - Dry vs. QLF - Wet	0.3655	0.2310 to 0.5001	Yes	****
Visible - Dry vs. NIR 1300	0.06886	-0.06568 to 0.2034	No	ns
Visible - Dry vs. NIR 1460	-0.07851	-0.2131 to 0.05603	No	ns
Visible - Dry vs. NIR 1550	-0.1114	-0.2459 to 0.02315	No	ns
Visible - Wet vs. QLF - Dry	-0.03223	-0.1668 to 0.1023	No	ns
Visible - Wet vs. QLF - Wet	0.2661	0.1316 to 0.4007	Yes	****
Visible - Wet vs. NIR 1300	-0.03052	-0.1651 to 0.1040	No	ns
Visible - Wet vs. NIR 1460	-0.1779	-0.3124 to -0.04335	Yes	**
Visible - Wet vs. NIR 1550	-0.2108	-0.3453 to -0.07623	Yes	***
QLF - Dry vs. QLF - Wet	0.2984	0.1638 to 0.4329	Yes	****
QLF - Dry vs. NIR 1300	0.001703	-0.1328 to 0.1362	No	ns
QLF - Dry vs. NIR 1460	-0.1457	-0.2802 to -0.01112	Yes	*
QLF - Dry vs. NIR 1550	-0.1785	-0.3131 to -0.04401	Yes	**
QLF - Wet vs. NIR 1300	-0.2967	-0.4312 to -0.1621	Yes	****
QLF - Wet vs. NIR 1460	-0.444	-0.5786 to -0.3095	Yes	****
QLF - Wet vs. NIR 1550	-0.4769	-0.6114 to -0.3424	Yes	****
NIR 1300 vs. NIR 1460	-0.1474	-0.2819 to -0.01283	Yes	*
NIR 1300 vs. NIR 1550	-0.1803	-0.3148 to -0.04571	Yes	**
NIR 1460 vs. NIR 1550	-0.03288	-0.1674 to 0.1017	No	ns

Table 6: Demineralization / Remineralization Days 1-4 with varnish

Visible - Dry				
Window 1 vs. Window 2	-0.0453	-0.1190 to 0.02841	No	ns
Window 1 vs. Window 3	-0.1678	-0.2415 to -0.09409	Yes	****
Window 1 vs. Window 4	-0.3046	-0.3784 to -0.2309	Yes	****
Window 2 vs. Window 3	-0.1225	-0.1962 to -0.04879	Yes	***
Window 2 vs. Window 4	-0.2593	-0.3331 to -0.1856	Yes	****
Window 3 vs. Window 4	-0.1368	-0.2106 to -0.06313	Yes	****
Visible - Wet				

Window 1 vs. Window 2	-0.07727	-0.1510 to -0.003556	Yes	*
Window 1 vs. Window 3	-0.1318	-0.2055 to -0.05810	Yes	****
Window 1 vs. Window 4	-0.1612	-0.2349 to -0.08749	Yes	****
Window 2 vs. Window 3	-0.05454	-0.1283 to 0.01917	No	ns
Window 2 vs. Window 4	-0.08394	-0.1576 to -0.01022	Yes	*
Window 3 vs. Window 4	-0.02939	-0.1031 to 0.04432	No	ns
QLF - Dry				
Window 1 vs. Window 2	-0.04538	-0.1191 to 0.02833	No	ns
Window 1 vs. Window 3	-0.179	-0.2527 to -0.1053	Yes	****
Window 1 vs. Window 4	-0.384	-0.4577 to -0.3103	Yes	****
Window 2 vs. Window 3	-0.1336	-0.2073 to -0.05988	Yes	****
Window 2 vs. Window 4	-0.3386	-0.4123 to -0.2649	Yes	****
Window 3 vs. Window 4	-0.205	-0.2787 to -0.1313	Yes	****
QLF - Wet				
Window 1 vs. Window 2	0.005518	-0.06820 to 0.07923	No	ns
Window 1 vs. Window 3	0.008564	-0.06515 to 0.08228	No	ns
Window 1 vs. Window 4	-0.007304	-0.08102 to 0.06641	No	ns
Window 2 vs. Window 3	0.003047	-0.07067 to 0.07676	No	ns
Window 2 vs. Window 4	-0.01282	-0.08653 to 0.06089	No	ns
Window 3 vs. Window 4	-0.01587	-0.08958 to 0.05784	No	ns
NIR 1300				
Window 1 vs. Window 2	-0.03192	-0.1056 to 0.04180	No	ns
Window 1 vs. Window 3	-0.1058	-0.1796 to -0.03213	Yes	**
Window 1 vs. Window 4	-0.2148	-0.2886 to -0.1411	Yes	****
Window 2 vs. Window 3	-0.07393	-0.1476 to -0.0002168	Yes	*
Window 2 vs. Window 4	-0.1829	-0.2566 to -0.1092	Yes	****
Window 3 vs. Window 4	-0.109	-0.1827 to -0.03529	Yes	***
NIR 1460				
Window 1 vs. Window 2	0.06185	-0.01186 to 0.1356	No	ns
Window 1 vs. Window 3	-0.03765	-0.1114 to 0.03606	No	ns
Window 1 vs. Window 4	-0.3486	-0.4223 to -0.2749	Yes	****
Window 2 vs. Window 3	-0.0995	-0.1732 to -0.02579	Yes	**
Window 2 vs. Window 4	-0.4105	-0.4842 to -0.3367	Yes	****
Window 3 vs. Window 4	-0.311	-0.3847 to -0.2372	Yes	****
NIR 1550				

Window 1 vs. Window 2	0.01519	-0.05852 to 0.08890	No	ns
Window 1 vs. Window 3	-0.1489	-0.2227 to -0.07522	Yes	****
Window 1 vs. Window 4	-0.3934	-0.4671 to -0.3197	Yes	****
Window 2 vs. Window 3	-0.1641	-0.2378 to -0.09041	Yes	****
Window 2 vs. Window 4	-0.4086	-0.4823 to -0.3349	Yes	****
Window 3 vs. Window 4	-0.2445	-0.3182 to -0.1708	Yes	****

Table 7: Demineralization / Remineralization Days 1-4 with varnish

Window 1				
Visible - Dry vs. Visible - Wet	-0.02824	-0.1653 to 0.1089	No	ns
Visible - Dry vs. QLF - Dry	0.156	0.01891 to 0.2931	Yes	*
Visible - Dry vs. QLF - Wet	0.178	0.04088 to 0.3151	Yes	**
Visible - Dry vs. NIR 1300	-0.1951	-0.3322 to -0.05800	Yes	***
Visible - Dry vs. NIR 1460	-0.012	-0.1491 to 0.1251	No	ns
Visible - Dry vs. NIR 1550	0.02179	-0.1153 to 0.1589	No	ns
Visible - Wet vs. QLF - Dry	0.1842	0.04715 to 0.3213	Yes	**
Visible - Wet vs. QLF - Wet	0.2062	0.06912 to 0.3433	Yes	***
Visible - Wet vs. NIR 1300	-0.1669	-0.3040 to -0.02976	Yes	**
Visible - Wet vs. NIR 1460	0.01624	-0.1209 to 0.1533	No	ns
Visible - Wet vs. NIR 1550	0.05003	-0.08707 to 0.1871	No	ns
QLF - Dry vs. QLF - Wet	0.02197	-0.1151 to 0.1591	No	ns
QLF - Dry vs. NIR 1300	-0.3511	-0.4882 to -0.2140	Yes	****
QLF - Dry vs. NIR 1460	-0.168	-0.3051 to -0.03091	Yes	**
QLF - Dry vs. NIR 1550	-0.1342	-0.2713 to 0.002876	No	ns
QLF - Wet vs. NIR 1300	-0.3731	-0.5102 to -0.2360	Yes	****
QLF - Wet vs. NIR 1460	-0.19	-0.3271 to -0.05288	Yes	**
QLF - Wet vs. NIR 1550	-0.1562	-0.2933 to -0.01909	Yes	*
NIR 1300 vs. NIR 1460	0.1831	0.04600 to 0.3202	Yes	**
NIR 1300 vs. NIR 1550	0.2169	0.07979 to 0.3540	Yes	****
NIR 1460 vs. NIR 1550	0.03379	-0.1033 to 0.1709	No	ns
Window 2				
Visible - Dry vs. Visible - Wet	-0.06021	-0.1973 to 0.07688	No	ns
Visible - Dry vs. QLF - Dry	0.1559	0.01882 to 0.2930	Yes	*
Visible - Dry vs. QLF - Wet	0.2288	0.09170 to 0.3659	Yes	****
Visible - Dry vs. NIR 1300	-0.1817	-0.3188 to -0.04462	Yes	**
Visible - Dry vs. NIR 1460	0.09515	-0.04195 to 0.2322	No	ns
Visible - Dry vs. NIR 1550	0.08227	-0.05482 to 0.2194	No	ns
Visible - Wet vs. QLF - Dry	0.2161	0.07904 to 0.3532	Yes	****
Visible - Wet vs. QLF - Wet	0.289	0.1519 to 0.4261	Yes	****

Visible - Wet vs. NIR 1300	-0.1215	-0.2586 to 0.01559	No	ns
Visible - Wet vs. NIR 1460	0.1554	0.01826 to 0.2925	Yes	*
Visible - Wet vs. NIR 1550	0.1425	0.005388 to 0.2796	Yes	*
QLF - Dry vs. QLF - Wet	0.07287	-0.06422 to 0.2100	No	ns
QLF - Dry vs. NIR 1300	-0.3376	-0.4747 to -0.2005	Yes	****
QLF - Dry vs. NIR 1460	-0.06077	-0.1979 to 0.07632	No	ns
QLF - Dry vs. NIR 1550	-0.07365	-0.2107 to 0.06345	No	ns
QLF - Wet vs. NIR 1300	-0.4105	-0.5476 to -0.2734	Yes	****
QLF - Wet vs. NIR 1460	-0.1336	-0.2707 to 0.003450	No	ns
QLF - Wet vs. NIR 1550	-0.1465	-0.2836 to -0.009425	Yes	*
NIR 1300 vs. NIR 1460	0.2769	0.1398 to 0.4140	Yes	****
NIR 1300 vs. NIR 1550	0.264	0.1269 to 0.4011	Yes	****
NIR 1460 vs. NIR 1550	-0.01287	-0.1500 to 0.1242	No	ns
Window 3				
Visible - Dry vs. Visible - Wet	0.007748	-0.1293 to 0.1448	No	ns
Visible - Dry vs. QLF - Dry	0.1448	0.007729 to 0.2819	Yes	*
Visible - Dry vs. QLF - Wet	0.3543	0.2172 to 0.4914	Yes	****
Visible - Dry vs. NIR 1300	-0.1331	-0.2702 to 0.003952	No	ns
Visible - Dry vs. NIR 1460	0.1181	-0.01895 to 0.2552	No	ns
Visible - Dry vs. NIR 1550	0.04065	-0.09645 to 0.1777	No	ns
Visible - Wet vs. QLF - Dry	0.1371	-1.963e-005 to 0.2742	No	ns
Visible - Wet vs. QLF - Wet	0.3466	0.2095 to 0.4837	Yes	****
Visible - Wet vs. NIR 1300	-0.1409	-0.2780 to -0.003797	Yes	*
Visible - Wet vs. NIR 1460	0.1104	-0.02670 to 0.2475	No	ns
Visible - Wet vs. NIR 1550	0.0329	-0.1042 to 0.1700	No	ns
QLF - Dry vs. QLF - Wet	0.2095	0.07242 to 0.3466	Yes	***
QLF - Dry vs. NIR 1300	-0.278	-0.4151 to -0.1409	Yes	****
QLF - Dry vs. NIR 1460	-0.02668	-0.1638 to 0.1104	No	ns
QLF - Dry vs. NIR 1550	-0.1042	-0.2413 to 0.03292	No	ns
QLF - Wet vs. NIR 1300	-0.4875	-0.6246 to -0.3504	Yes	****
QLF - Wet vs. NIR 1460	-0.2362	-0.3733 to -0.09910	Yes	****
QLF - Wet vs. NIR 1550	-0.3137	-0.4508 to -0.1766	Yes	****
NIR 1300 vs. NIR 1460	0.2513	0.1142 to 0.3884	Yes	****
NIR 1300 vs. NIR 1550	0.1738	0.03670 to 0.3109	Yes	**
NIR 1460 vs. NIR 1550	-0.0775	-0.2146 to 0.05960	No	ns
Window 4				
Visible - Dry vs. Visible - Wet	0.1152	-0.02190 to 0.2523	No	ns
Visible - Dry vs. QLF - Dry	0.07669	-0.06041 to 0.2138	No	ns

Visible - Dry vs. QLF - Wet	0.4753	0.3382 to 0.6124	Yes	****
Visible - Dry vs. NIR 1300	-0.1053	-0.2424 to 0.03179	No	ns
Visible - Dry vs. NIR 1460	-0.05597	-0.1931 to 0.08113	No	ns
Visible - Dry vs. NIR 1550	-0.06701	-0.2041 to 0.07009	No	ns
Visible - Wet vs. QLF - Dry	-0.03851	-0.1756 to 0.09859	No	ns
Visible - Wet vs. QLF - Wet	0.3601	0.2230 to 0.4972	Yes	****
Visible - Wet vs. NIR 1300	-0.2205	-0.3576 to -0.08340	Yes	****
Visible - Wet vs. NIR 1460	-0.1712	-0.3083 to -0.03407	Yes	**
Visible - Wet vs. NIR 1550	-0.1822	-0.3193 to -0.04511	Yes	**
QLF - Dry vs. QLF - Wet	0.3986	0.2615 to 0.5357	Yes	****
QLF - Dry vs. NIR 1300	-0.182	-0.3191 to -0.04489	Yes	**
QLF - Dry vs. NIR 1460	-0.1327	-0.2697 to 0.004446	No	ns
QLF - Dry vs. NIR 1550	-0.1437	-0.2808 to -0.006597	Yes	*
QLF - Wet vs. NIR 1300	-0.5806	-0.7177 to -0.4435	Yes	****
QLF - Wet vs. NIR 1460	-0.5313	-0.6684 to -0.3942	Yes	****
QLF - Wet vs. NIR 1550	-0.5423	-0.6794 to -0.4052	Yes	****
NIR 1300 vs. NIR 1460	0.04934	-0.08776 to 0.1864	No	ns
NIR 1300 vs. NIR 1550	0.0383	-0.09880 to 0.1754	No	ns
NIR 1460 vs. NIR 1550	-0.01104	-0.1481 to 0.1261	No	ns

Table 8: Demineralization / Remineralization Days 5-8 with varnish

Tukey's multiple comparisons test	Mean Diff.	95% CI of diff.	Significant?	Summary
Visible - Dry				
Window 1 vs. Window 2	-0.0453	-0.1190 to 0.02841	No	ns
Window 1 vs. Window 3	-0.1678	-0.2415 to -0.09409	Yes	****
Window 1 vs. Window 4	-0.3046	-0.3784 to -0.2309	Yes	****
Window 2 vs. Window 3	-0.1225	-0.1962 to -0.04879	Yes	***
Window 2 vs. Window 4	-0.2593	-0.3331 to -0.1856	Yes	****
Window 3 vs. Window 4	-0.1368	-0.2106 to -0.06313	Yes	****
Visible - Wet				
Window 1 vs. Window 2	-0.07727	-0.1510 to -0.003556	Yes	*
Window 1 vs. Window 3	-0.1318	-0.2055 to -0.05810	Yes	****
Window 1 vs. Window 4	-0.1612	-0.2349 to -0.08749	Yes	****
Window 2 vs. Window 3	-0.05454	-0.1283 to 0.01917	No	ns
Window 2 vs. Window 4	-0.08394	-0.1576 to -0.01022	Yes	*
Window 3 vs. Window 4	-0.02939	-0.1031 to 0.04432	No	ns
QLF - Dry				

Window 1 vs. Window 2	-0.04538	-0.1191 to 0.02833	No	ns
Window 1 vs. Window 3	-0.179	-0.2527 to -0.1053	Yes	****
Window 1 vs. Window 4	-0.384	-0.4577 to -0.3103	Yes	****
Window 2 vs. Window 3	-0.1336	-0.2073 to -0.05988	Yes	****
Window 2 vs. Window 4	-0.3386	-0.4123 to -0.2649	Yes	****
Window 3 vs. Window 4	-0.205	-0.2787 to -0.1313	Yes	****
QLF - Wet				
Window 1 vs. Window 2	0.005518	-0.06820 to 0.07923	No	ns
Window 1 vs. Window 3	0.008564	-0.06515 to 0.08228	No	ns
Window 1 vs. Window 4	-0.007304	-0.08102 to 0.06641	No	ns
Window 2 vs. Window 3	0.003047	-0.07067 to 0.07676	No	ns
Window 2 vs. Window 4	-0.01282	-0.08653 to 0.06089	No	ns
Window 3 vs. Window 4	-0.01587	-0.08958 to 0.05784	No	ns
NIR 1300				
Window 1 vs. Window 2	-0.03192	-0.1056 to 0.04180	No	ns
Window 1 vs. Window 3	-0.1058	-0.1796 to -0.03213	Yes	**
Window 1 vs. Window 4	-0.2148	-0.2886 to -0.1411	Yes	****
Window 2 vs. Window 3	-0.07393	-0.1476 to -0.0002168	Yes	*
Window 2 vs. Window 4	-0.1829	-0.2566 to -0.1092	Yes	****
Window 3 vs. Window 4	-0.109	-0.1827 to -0.03529	Yes	***
NIR 1460				
Window 1 vs. Window 2	0.06185	-0.01186 to 0.1356	No	ns
Window 1 vs. Window 3	-0.03765	-0.1114 to 0.03606	No	ns
Window 1 vs. Window 4	-0.3486	-0.4223 to -0.2749	Yes	****
Window 2 vs. Window 3	-0.0995	-0.1732 to -0.02579	Yes	**
Window 2 vs. Window 4	-0.4105	-0.4842 to -0.3367	Yes	****
Window 3 vs. Window 4	-0.311	-0.3847 to -0.2372	Yes	****
NIR 1550				
Window 1 vs. Window 2	0.01519	-0.05852 to 0.08890	No	ns
Window 1 vs. Window 3	-0.1489	-0.2227 to -0.07522	Yes	****
Window 1 vs. Window 4	-0.3934	-0.4671 to -0.3197	Yes	****
Window 2 vs. Window 3	-0.1641	-0.2378 to -0.09041	Yes	****
Window 2 vs. Window 4	-0.4086	-0.4823 to -0.3349	Yes	****
Window 3 vs. Window 4	-0.2445	-0.3182 to -0.1708	Yes	****

Table 9: Demineralization / Remineralization Days 5-8 with varnish

Tukey's multiple comparisons test	Mean Diff.	95% CI of diff.	Significant?	Summary
Window 1				
Visible - Dry vs. Visible - Wet	-0.02824	-0.1653 to 0.1089	No	ns
Visible - Dry vs. QLF - Dry	0.156	0.01891 to 0.2931	Yes	*
Visible - Dry vs. QLF - Wet	0.178	0.04088 to 0.3151	Yes	**
Visible - Dry vs. NIR 1300	-0.1951	-0.3322 to -0.05800	Yes	***
Visible - Dry vs. NIR 1460	-0.012	-0.1491 to 0.1251	No	ns
Visible - Dry vs. NIR 1550	0.02179	-0.1153 to 0.1589	No	ns
Visible - Wet vs. QLF - Dry	0.1842	0.04715 to 0.3213	Yes	**
Visible - Wet vs. QLF - Wet	0.2062	0.06912 to 0.3433	Yes	***
Visible - Wet vs. NIR 1300	-0.1669	-0.3040 to -0.02976	Yes	**
Visible - Wet vs. NIR 1460	0.01624	-0.1209 to 0.1533	No	ns
Visible - Wet vs. NIR 1550	0.05003	-0.08707 to 0.1871	No	ns
QLF - Dry vs. QLF - Wet	0.02197	-0.1151 to 0.1591	No	ns
QLF - Dry vs. NIR 1300	-0.3511	-0.4882 to -0.2140	Yes	****
QLF - Dry vs. NIR 1460	-0.168	-0.3051 to -0.03091	Yes	**
QLF - Dry vs. NIR 1550	-0.1342	-0.2713 to 0.002876	No	ns
QLF - Wet vs. NIR 1300	-0.3731	-0.5102 to -0.2360	Yes	****
QLF - Wet vs. NIR 1460	-0.19	-0.3271 to -0.05288	Yes	**
QLF - Wet vs. NIR 1550	-0.1562	-0.2933 to -0.01909	Yes	*
NIR 1300 vs. NIR 1460	0.1831	0.04600 to 0.3202	Yes	**
NIR 1300 vs. NIR 1550	0.2169	0.07979 to 0.3540	Yes	****
NIR 1460 vs. NIR 1550	0.03379	-0.1033 to 0.1709	No	ns
Window 2				
Visible - Dry vs. Visible - Wet	-0.06021	-0.1973 to 0.07688	No	ns
Visible - Dry vs. QLF - Dry	0.1559	0.01882 to 0.2930	Yes	*
Visible - Dry vs. QLF - Wet	0.2288	0.09170 to 0.3659	Yes	****
Visible - Dry vs. NIR 1300	-0.1817	-0.3188 to -0.04462	Yes	**
Visible - Dry vs. NIR 1460	0.09515	-0.04195 to 0.2322	No	ns
Visible - Dry vs. NIR 1550	0.08227	-0.05482 to 0.2194	No	ns
Visible - Wet vs. QLF - Dry	0.2161	0.07904 to 0.3532	Yes	****
Visible - Wet vs. QLF - Wet	0.289	0.1519 to 0.4261	Yes	****
Visible - Wet vs. NIR 1300	-0.1215	-0.2586 to 0.01559	No	ns
Visible - Wet vs. NIR 1460	0.1554	0.01826 to 0.2925	Yes	*
Visible - Wet vs. NIR 1550	0.1425	0.005388 to 0.2796	Yes	*
QLF - Dry vs. QLF - Wet	0.07287	-0.06422 to 0.2100	No	ns
QLF - Dry vs. NIR 1300	-0.3376	-0.4747 to -0.2005	Yes	****
QLF - Dry vs. NIR 1460	-0.06077	-0.1979 to 0.07632	No	ns

QLF - Dry vs. NIR 1550	-0.07365	-0.2107 to 0.06345	No	ns
QLF - Wet vs. NIR 1300	-0.4105	-0.5476 to -0.2734	Yes	****
QLF - Wet vs. NIR 1460	-0.1336	-0.2707 to 0.003450	No	ns
QLF - Wet vs. NIR 1550	-0.1465	-0.2836 to -0.009425	Yes	*
NIR 1300 vs. NIR 1460	0.2769	0.1398 to 0.4140	Yes	****
NIR 1300 vs. NIR 1550	0.264	0.1269 to 0.4011	Yes	****
NIR 1460 vs. NIR 1550	-0.01287	-0.1500 to 0.1242	No	ns
Window 3				
Visible - Dry vs. Visible - Wet	0.007748	-0.1293 to 0.1448	No	ns
Visible - Dry vs. QLF - Dry	0.1448	0.007729 to 0.2819	Yes	*
Visible - Dry vs. QLF - Wet	0.3543	0.2172 to 0.4914	Yes	****
Visible - Dry vs. NIR 1300	-0.1331	-0.2702 to 0.003952	No	ns
Visible - Dry vs. NIR 1460	0.1181	-0.01895 to 0.2552	No	ns
Visible - Dry vs. NIR 1550	0.04065	-0.09645 to 0.1777	No	ns
Visible - Wet vs. QLF - Dry	0.1371	-1.963e-005 to 0.2742	No	ns
Visible - Wet vs. QLF - Wet	0.3466	0.2095 to 0.4837	Yes	****
Visible - Wet vs. NIR 1300	-0.1409	-0.2780 to -0.003797	Yes	*
Visible - Wet vs. NIR 1460	0.1104	-0.02670 to 0.2475	No	ns
Visible - Wet vs. NIR 1550	0.0329	-0.1042 to 0.1700	No	ns
QLF - Dry vs. QLF - Wet	0.2095	0.07242 to 0.3466	Yes	***
QLF - Dry vs. NIR 1300	-0.278	-0.4151 to -0.1409	Yes	****
QLF - Dry vs. NIR 1460	-0.02668	-0.1638 to 0.1104	No	ns
QLF - Dry vs. NIR 1550	-0.1042	-0.2413 to 0.03292	No	ns
QLF - Wet vs. NIR 1300	-0.4875	-0.6246 to -0.3504	Yes	****
QLF - Wet vs. NIR 1460	-0.2362	-0.3733 to -0.09910	Yes	****
QLF - Wet vs. NIR 1550	-0.3137	-0.4508 to -0.1766	Yes	****
NIR 1300 vs. NIR 1460	0.2513	0.1142 to 0.3884	Yes	****
NIR 1300 vs. NIR 1550	0.1738	0.03670 to 0.3109	Yes	**
NIR 1460 vs. NIR 1550	-0.0775	-0.2146 to 0.05960	No	ns
Window 4				
Visible - Dry vs. Visible - Wet	0.1152	-0.02190 to 0.2523	No	ns
Visible - Dry vs. QLF - Dry	0.07669	-0.06041 to 0.2138	No	ns
Visible - Dry vs. QLF - Wet	0.4753	0.3382 to 0.6124	Yes	****
Visible - Dry vs. NIR 1300	-0.1053	-0.2424 to 0.03179	No	ns
Visible - Dry vs. NIR 1460	-0.05597	-0.1931 to 0.08113	No	ns
Visible - Dry vs. NIR 1550	-0.06701	-0.2041 to 0.07009	No	ns
Visible - Wet vs. QLF - Dry	-0.03851	-0.1756 to 0.09859	No	ns
Visible - Wet vs. QLF - Wet	0.3601	0.2230 to 0.4972	Yes	****

Visible - Wet vs. NIR 1300	-0.2205	-0.3576 to -0.08340	Yes	****
Visible - Wet vs. NIR 1460	-0.1712	-0.3083 to -0.03407	Yes	**
Visible - Wet vs. NIR 1550	-0.1822	-0.3193 to -0.04511	Yes	**
QLF - Dry vs. QLF - Wet	0.3986	0.2615 to 0.5357	Yes	****
QLF - Dry vs. NIR 1300	-0.182	-0.3191 to -0.04489	Yes	**
QLF - Dry vs. NIR 1460	-0.1327	-0.2697 to 0.004446	No	ns
QLF - Dry vs. NIR 1550	-0.1437	-0.2808 to -0.006597	Yes	*
QLF - Wet vs. NIR 1300	-0.5806	-0.7177 to -0.4435	Yes	****
QLF - Wet vs. NIR 1460	-0.5313	-0.6684 to -0.3942	Yes	****
QLF - Wet vs. NIR 1550	-0.5423	-0.6794 to -0.4052	Yes	****
NIR 1300 vs. NIR 1460	0.04934	-0.08776 to 0.1864	No	ns
NIR 1300 vs. NIR 1550	0.0383	-0.09880 to 0.1754	No	ns
NIR 1460 vs. NIR 1550	-0.01104	-0.1481 to 0.1261	No	ns

Table 10: pH 4.8 without varnish

Tukey's multiple comparisons test	Mean Diff.	95% CI of diff.	Significant?	Summary
Visible - Dry				
Window 1 vs. Window 2	-0.05693	-0.1193 to 0.005438	No	ns
Window 1 vs. Window 3	-0.0552	-0.1176 to 0.007165	No	ns
Window 1 vs. Window 4	-0.03287	-0.09524 to 0.02949	No	ns
Window 2 vs. Window 3	0.001726	-0.06064 to 0.06409	No	ns
Window 2 vs. Window 4	0.02405	-0.03831 to 0.08642	No	ns
Window 3 vs. Window 4	0.02233	-0.04004 to 0.08469	No	ns
Visible - Wet				
Window 1 vs. Window 2	-0.06028	-0.1226 to 0.002082	No	ns
Window 1 vs. Window 3	-0.07279	-0.1352 to -0.01043	Yes	*
Window 1 vs. Window 4	-0.03413	-0.09649 to 0.02824	No	ns
Window 2 vs. Window 3	-0.01251	-0.07487 to 0.04985	No	ns
Window 2 vs. Window 4	0.02616	-0.03621 to 0.08852	No	ns
Window 3 vs. Window 4	0.03867	-0.02370 to 0.1010	No	ns
QLF - Dry				
Window 1 vs. Window 2	-0.01335	-0.07572 to 0.04901	No	ns
Window 1 vs. Window 3	-0.03822	-0.1006 to 0.02415	No	ns
Window 1 vs. Window 4	-0.03111	-0.09347 to 0.03126	No	ns
Window 2 vs. Window 3	-0.02486	-0.08723 to 0.03750	No	ns
Window 2 vs. Window 4	-0.01775	-0.08012 to 0.04461	No	ns
Window 3 vs. Window 4	0.007113	-0.05525 to 0.06948	No	ns

QLF - Wet				
Window 1 vs. Window 2	-0.03106	-0.09343 to 0.03130	No	ns
Window 1 vs. Window 3	-0.05582	-0.1182 to 0.006548	No	ns
Window 1 vs. Window 4	-0.02017	-0.08253 to 0.04219	No	ns
Window 2 vs. Window 3	-0.02475	-0.08712 to 0.03761	No	ns
Window 2 vs. Window 4	0.01089	-0.05147 to 0.07326	No	ns
Window 3 vs. Window 4	0.03565	-0.02672 to 0.09801	No	ns
NIR 1300				
Window 1 vs. Window 2	-0.165	-0.2274 to -0.1027	Yes	****
Window 1 vs. Window 3	-0.2449	-0.3073 to -0.1826	Yes	****
Window 1 vs. Window 4	-0.1333	-0.1956 to -0.07089	Yes	****
Window 2 vs. Window 3	-0.07988	-0.1422 to -0.01752	Yes	**
Window 2 vs. Window 4	0.03178	-0.03058 to 0.09415	No	ns
Window 3 vs. Window 4	0.1117	0.04930 to 0.1740	Yes	****
NIR 1460				
Window 1 vs. Window 2	-0.2074	-0.2698 to -0.1450	Yes	****
Window 1 vs. Window 3	-0.2417	-0.3040 to -0.1793	Yes	****
Window 1 vs. Window 4	-0.142	-0.2043 to -0.07960	Yes	****
Window 2 vs. Window 3	-0.03427	-0.09663 to 0.02809	No	ns
Window 2 vs. Window 4	0.06544	0.003075 to 0.1278	Yes	*
Window 3 vs. Window 4	0.09971	0.03734 to 0.1621	Yes	***
NIR 1550				
Window 1 vs. Window 2	-0.09927	-0.1616 to -0.03691	Yes	***
Window 1 vs. Window 3	-0.06806	-0.1304 to -0.005695	Yes	*
Window 1 vs. Window 4	0.08841	0.02604 to 0.1508	Yes	**
Window 2 vs. Window 3	0.03122	-0.03115 to 0.09358	No	ns
Window 2 vs. Window 4	0.1877	0.1253 to 0.2500	Yes	****
Window 3 vs. Window 4	0.1565	0.09410 to 0.2188	Yes	****

Table 11: pH 4.8 without varnish

Tukey's multiple comparisons test	Mean Diff.	95% CI of diff.	Significant?	Summary
Window 1				
Visible - Dry vs. Visible - Wet	0.02342	-0.1108 to 0.1577	No	ns
Visible - Dry vs. QLF - Dry	0.0243	-0.1099 to 0.1585	No	ns
Visible - Dry vs. QLF - Wet	0.2047	0.07045 to 0.3389	Yes	***

Visible - Dry vs. NIR 1300	0.05514	-0.07909 to 0.1894	No	ns
Visible - Dry vs. NIR 1460	-0.2004	-0.3346 to -0.06618	Yes	***
Visible - Dry vs. NIR 1550	-0.1977	-0.3320 to -0.06350	Yes	***
Visible - Wet vs. QLF - Dry	0.000874	-0.1334 to 0.1351	No	ns
Visible - Wet vs. QLF - Wet	0.1813	0.04703 to 0.3155	Yes	**
Visible - Wet vs. NIR 1300	0.03171	-0.1025 to 0.1659	No	ns
Visible - Wet vs. NIR 1460	-0.2238	-0.3581 to -0.08960	Yes	****
Visible - Wet vs. NIR 1550	-0.2211	-0.3554 to -0.08692	Yes	****
QLF - Dry vs. QLF - Wet	0.1804	0.04615 to 0.3146	Yes	**
QLF - Dry vs. NIR 1300	0.03084	-0.1034 to 0.1651	No	ns
QLF - Dry vs. NIR 1460	-0.2247	-0.3589 to -0.09047	Yes	****
QLF - Dry vs. NIR 1550	-0.222	-0.3562 to -0.08779	Yes	****
QLF - Wet vs. NIR 1300	-0.1495	-0.2838 to -0.01532	Yes	*
QLF - Wet vs. NIR 1460	-0.4051	-0.5393 to -0.2709	Yes	****
QLF - Wet vs. NIR 1550	-0.4024	-0.5366 to -0.2682	Yes	****
NIR 1300 vs. NIR 1460	-0.2555	-0.3898 to -0.1213	Yes	****
NIR 1300 vs. NIR 1550	-0.2529	-0.3871 to -0.1186	Yes	****
NIR 1460 vs. NIR 1550	0.002681	-0.1315 to 0.1369	No	ns
Window 2				
Visible - Dry vs. Visible - Wet	0.02007	-0.1142 to 0.1543	No	ns
Visible - Dry vs. QLF - Dry	0.06787	-0.06636 to 0.2021	No	ns
Visible - Dry vs. QLF - Wet	0.2305	0.09632 to 0.3648	Yes	****
Visible - Dry vs. NIR 1300	-0.05298	-0.1872 to 0.08125	No	ns
Visible - Dry vs. NIR 1460	-0.3509	-0.4851 to -0.2167	Yes	****
Visible - Dry vs. NIR 1550	-0.2401	-0.3743 to -0.1058	Yes	****
Visible - Wet vs. QLF - Dry	0.0478	-0.08643 to 0.1820	No	ns
Visible - Wet vs. QLF - Wet	0.2105	0.07625 to 0.3447	Yes	***
Visible - Wet vs. NIR 1300	-0.07305	-0.2073 to 0.06118	No	ns
Visible - Wet vs. NIR 1460	-0.3709	-0.5052 to -0.2367	Yes	****
Visible - Wet vs. NIR 1550	-0.2601	-0.3944 to -0.1259	Yes	****
QLF - Dry vs. QLF - Wet	0.1627	0.02845 to 0.2969	Yes	**
QLF - Dry vs. NIR 1300	-0.1208	-0.2551 to 0.01338	No	ns
QLF - Dry vs. NIR 1460	-0.4188	-0.5530 to -0.2845	Yes	****
QLF - Dry vs. NIR 1550	-0.3079	-0.4422 to -0.1737	Yes	****
QLF - Wet vs. NIR 1300	-0.2835	-0.4177 to -0.1493	Yes	****
QLF - Wet vs. NIR 1460	-0.5814	-0.7157 to -0.4472	Yes	****
QLF - Wet vs. NIR 1550	-0.4706	-0.6048 to -0.3364	Yes	****
NIR 1300 vs. NIR 1460	-0.2979	-0.4321 to -0.1637	Yes	****
NIR 1300 vs. NIR 1550	-0.1871	-0.3213 to -0.05286	Yes	***

NIR 1460 vs. NIR 1550	0.1108	-0.02342 to 0.2450	No	ns
Window 3				
Visible - Dry vs. Visible - Wet	0.00583	-0.1284 to 0.1401	No	ns
Visible - Dry vs. QLF - Dry	0.04128	-0.09295 to 0.1755	No	ns
Visible - Dry vs. QLF - Wet	0.2041	0.06984 to 0.3383	Yes	***
Visible - Dry vs. NIR 1300	-0.1346	-0.2688 to -0.0003593	Yes	*
Visible - Dry vs. NIR 1460	-0.3869	-0.5211 to -0.2527	Yes	****
Visible - Dry vs. NIR 1550	-0.2106	-0.3448 to -0.07635	Yes	***
Visible - Wet vs. QLF - Dry	0.03545	-0.09878 to 0.1697	No	ns
Visible - Wet vs. QLF - Wet	0.1982	0.06401 to 0.3325	Yes	***
Visible - Wet vs. NIR 1300	-0.1404	-0.2746 to -0.006189	Yes	*
Visible - Wet vs. NIR 1460	-0.3927	-0.5269 to -0.2585	Yes	****
Visible - Wet vs. NIR 1550	-0.2164	-0.3506 to -0.08218	Yes	****
QLF - Dry vs. QLF - Wet	0.1628	0.02856 to 0.2970	Yes	**
QLF - Dry vs. NIR 1300	-0.1759	-0.3101 to -0.04164	Yes	**
QLF - Dry vs. NIR 1460	-0.4282	-0.5624 to -0.2939	Yes	****
QLF - Dry vs. NIR 1550	-0.2519	-0.3861 to -0.1176	Yes	****
QLF - Wet vs. NIR 1300	-0.3386	-0.4729 to -0.2044	Yes	****
QLF - Wet vs. NIR 1460	-0.5909	-0.7252 to -0.4567	Yes	****
QLF - Wet vs. NIR 1550	-0.4146	-0.5489 to -0.2804	Yes	****
NIR 1300 vs. NIR 1460	-0.2523	-0.3865 to -0.1181	Yes	****
NIR 1300 vs. NIR 1550	-0.076	-0.2102 to 0.05823	No	ns
NIR 1460 vs. NIR 1550	0.1763	0.04207 to 0.3105	Yes	**
Window 4				
Visible - Dry vs. Visible - Wet	0.02217	-0.1121 to 0.1564	No	ns
Visible - Dry vs. QLF - Dry	0.02606	-0.1082 to 0.1603	No	ns
Visible - Dry vs. QLF - Wet	0.2174	0.08316 to 0.3516	Yes	****
Visible - Dry vs. NIR 1300	-0.04525	-0.1795 to 0.08898	No	ns
Visible - Dry vs. NIR 1460	-0.3095	-0.4437 to -0.1753	Yes	****
Visible - Dry vs. NIR 1550	-0.07644	-0.2107 to 0.05779	No	ns
Visible - Wet vs. QLF - Dry	0.003894	-0.1303 to 0.1381	No	ns
Visible - Wet vs. QLF - Wet	0.1952	0.06098 to 0.3294	Yes	***
Visible - Wet vs. NIR 1300	-0.06742	-0.2016 to 0.06681	No	ns
Visible - Wet vs. NIR 1460	-0.3317	-0.4659 to -0.1974	Yes	****
Visible - Wet vs. NIR 1550	-0.09861	-0.2328 to 0.03562	No	ns
QLF - Dry vs. QLF - Wet	0.1913	0.05709 to 0.3255	Yes	***
QLF - Dry vs. NIR 1300	-0.07131	-0.2055 to 0.06292	No	ns
QLF - Dry vs. NIR 1460	-0.3356	-0.4698 to -0.2013	Yes	****

QLF - Dry vs. NIR 1550	-0.1025	-0.2367 to 0.03172	No	ns
QLF - Wet vs. NIR 1300	-0.2626	-0.3969 to -0.1284	Yes	****
QLF - Wet vs. NIR 1460	-0.5269	-0.6611 to -0.3927	Yes	****
QLF - Wet vs. NIR 1550	-0.2938	-0.4281 to -0.1596	Yes	****
NIR 1300 vs. NIR 1460	-0.2642	-0.3985 to -0.1300	Yes	****
NIR 1300 vs. NIR 1550	-0.03119	-0.1654 to 0.1030	No	ns
NIR 1460 vs. NIR 1550	0.2331	0.09883 to 0.3673	Yes	****

Table 12: pH 4.9 without varnish

Tukey's multiple comparisons test	Mean Diff.	95% CI of diff.	Significant?	Summary
Visible - Dry				
Window 1 vs. Window 2	-0.09502	-0.1581 to -0.03194	Yes	***
Window 1 vs. Window 3	-0.1069	-0.1700 to -0.04384	Yes	***
Window 1 vs. Window 4	-0.09742	-0.1605 to -0.03434	Yes	***
Window 2 vs. Window 3	-0.0119	-0.07498 to 0.05118	No	ns
Window 2 vs. Window 4	-0.002405	-0.06548 to 0.06067	No	ns
Window 3 vs. Window 4	0.009495	-0.05358 to 0.07257	No	ns
Visible - Wet				
Window 1 vs. Window 2	-0.08508	-0.1482 to -0.02200	Yes	**
Window 1 vs. Window 3	-0.1319	-0.1950 to -0.06887	Yes	****
Window 1 vs. Window 4	-0.1285	-0.1916 to -0.06542	Yes	****
Window 2 vs. Window 3	-0.04686	-0.1099 to 0.01621	No	ns
Window 2 vs. Window 4	-0.04341	-0.1065 to 0.01966	No	ns
Window 3 vs. Window 4	0.00345	-0.05963 to 0.06653	No	ns
QLF - Dry				
Window 1 vs. Window 2	-0.0004958	-0.06357 to 0.06258	No	ns
Window 1 vs. Window 3	0.003785	-0.05929 to 0.06686	No	ns
Window 1 vs. Window 4	0.02947	-0.03361 to 0.09255	No	ns
Window 2 vs. Window 3	0.004281	-0.05880 to 0.06736	No	ns
Window 2 vs. Window 4	0.02997	-0.03311 to 0.09304	No	ns
Window 3 vs. Window 4	0.02568	-0.03739 to 0.08876	No	ns
QLF - Wet				
Window 1 vs. Window 2	-0.02444	-0.08752 to 0.03864	No	ns
Window 1 vs. Window 3	-0.05685	-0.1199 to 0.006225	No	ns
Window 1 vs. Window 4	-0.01917	-0.08225 to 0.04390	No	ns
Window 2 vs. Window 3	-0.03241	-0.09549 to 0.03066	No	ns

Window 2 vs. Window 4	0.005266	-0.05781 to 0.06834	No	ns
Window 3 vs. Window 4	0.03768	-0.02540 to 0.1008	No	ns
NIR 1300				
Window 1 vs. Window 2	-0.1529	-0.2159 to -0.08978	Yes	****
Window 1 vs. Window 3	-0.2061	-0.2692 to -0.1430	Yes	****
Window 1 vs. Window 4	-0.1486	-0.2117 to -0.08553	Yes	****
Window 2 vs. Window 3	-0.05324	-0.1163 to 0.009837	No	ns
Window 2 vs. Window 4	0.004249	-0.05883 to 0.06733	No	ns
Window 3 vs. Window 4	0.05749	-0.005588 to 0.1206	No	ns
NIR 1460				
Window 1 vs. Window 2	-0.1772	-0.2403 to -0.1141	Yes	****
Window 1 vs. Window 3	-0.2044	-0.2675 to -0.1413	Yes	****
Window 1 vs. Window 4	-0.1285	-0.1916 to -0.06542	Yes	****
Window 2 vs. Window 3	-0.0272	-0.09028 to 0.03588	No	ns
Window 2 vs. Window 4	0.04871	-0.01436 to 0.1118	No	ns
Window 3 vs. Window 4	0.07592	0.01284 to 0.1390	Yes	*
NIR 1550				
Window 1 vs. Window 2	-0.1215	-0.1846 to -0.05845	Yes	****
Window 1 vs. Window 3	-0.13	-0.1930 to -0.06688	Yes	****
Window 1 vs. Window 4	-0.00696	-0.07004 to 0.05612	No	ns
Window 2 vs. Window 3	-0.008435	-0.07151 to 0.05464	No	ns
Window 2 vs. Window 4	0.1146	0.05149 to 0.1776	Yes	****
Window 3 vs. Window 4	0.123	0.05992 to 0.1861	Yes	****

Table 13: pH 4.9 without varnish

Tukey's multiple comparisons test	Mean Diff.	95% CI of diff.	Significant?	Summary
Window 1				
Visible - Dry vs. Visible - Wet	0.07562	-0.05987 to 0.2111	No	ns
Visible - Dry vs. QLF - Dry	0.0711	-0.06440 to 0.2066	No	ns
Visible - Dry vs. QLF - Wet	0.2306	0.09509 to 0.3661	Yes	****
Visible - Dry vs. NIR 1300	0.0919	-0.04360 to 0.2274	No	ns
Visible - Dry vs. NIR 1460	-0.1178	-0.2533 to 0.01771	No	ns
Visible - Dry vs. NIR 1550	-0.0959	-0.2314 to 0.03959	No	ns
Visible - Wet vs. QLF - Dry	-0.004528	-0.1400 to 0.1310	No	ns
Visible - Wet vs. QLF - Wet	0.155	0.01946 to 0.2904	Yes	*
Visible - Wet vs. NIR 1300	0.01627	-0.1192 to 0.1518	No	ns

Visible - Wet vs. NIR 1460	-0.1934	-0.3289 to -0.05791	Yes	***
Visible - Wet vs. NIR 1550	-0.1715	-0.3070 to -0.03603	Yes	**
QLF - Dry vs. QLF - Wet	0.1595	0.02399 to 0.2950	Yes	**
QLF - Dry vs. NIR 1300	0.0208	-0.1147 to 0.1563	No	ns
QLF - Dry vs. NIR 1460	-0.1889	-0.3244 to -0.05338	Yes	***
QLF - Dry vs. NIR 1550	-0.167	-0.3025 to -0.03151	Yes	**
QLF - Wet vs. NIR 1300	-0.1387	-0.2742 to -0.003188	Yes	*
QLF - Wet vs. NIR 1460	-0.3484	-0.4839 to -0.2129	Yes	****
QLF - Wet vs. NIR 1550	-0.3265	-0.4620 to -0.1910	Yes	****
NIR 1300 vs. NIR 1460	-0.2097	-0.3452 to -0.07419	Yes	***
NIR 1300 vs. NIR 1550	-0.1878	-0.3233 to -0.05231	Yes	**
NIR 1460 vs. NIR 1550	0.02188	-0.1136 to 0.1574	No	ns
Window 2				
Visible - Dry vs. Visible - Wet	0.08556	-0.04994 to 0.2211	No	ns
Visible - Dry vs. QLF - Dry	0.1656	0.03012 to 0.3011	Yes	**
Visible - Dry vs. QLF - Wet	0.3012	0.1657 to 0.4366	Yes	****
Visible - Dry vs. NIR 1300	0.03405	-0.1014 to 0.1695	No	ns
Visible - Dry vs. NIR 1460	-0.2	-0.3355 to -0.06449	Yes	***
Visible - Dry vs. NIR 1550	-0.1224	-0.2579 to 0.01308	No	ns
Visible - Wet vs. QLF - Dry	0.08006	-0.05544 to 0.2156	No	ns
Visible - Wet vs. QLF - Wet	0.2156	0.08010 to 0.3511	Yes	****
Visible - Wet vs. NIR 1300	-0.05151	-0.1870 to 0.08399	No	ns
Visible - Wet vs. NIR 1460	-0.2855	-0.4210 to -0.1500	Yes	****
Visible - Wet vs. NIR 1550	-0.208	-0.3435 to -0.07248	Yes	***
QLF - Dry vs. QLF - Wet	0.1355	4.524e-005 to 0.2710	Yes	*
QLF - Dry vs. NIR 1300	-0.1316	-0.2671 to 0.003931	No	ns
QLF - Dry vs. NIR 1460	-0.3656	-0.5011 to -0.2301	Yes	****
QLF - Dry vs. NIR 1550	-0.288	-0.4235 to -0.1525	Yes	****
QLF - Wet vs. NIR 1300	-0.2671	-0.4026 to -0.1316	Yes	****
QLF - Wet vs. NIR 1460	-0.5011	-0.6366 to -0.3656	Yes	****
QLF - Wet vs. NIR 1550	-0.4236	-0.5591 to -0.2881	Yes	****
NIR 1300 vs. NIR 1460	-0.234	-0.3695 to -0.09854	Yes	****
NIR 1300 vs. NIR 1550	-0.1565	-0.2920 to -0.02097	Yes	*
NIR 1460 vs. NIR 1550	0.07757	-0.05793 to 0.2131	No	ns
Window 3				
Visible - Dry vs. Visible - Wet	0.05059	-0.08490 to 0.1861	No	ns
Visible - Dry vs. QLF - Dry	0.1818	0.04630 to 0.3173	Yes	**
Visible - Dry vs. QLF - Wet	0.2806	0.1451 to 0.4161	Yes	****

Visible - Dry vs. NIR 1300	-0.00729	-0.1428 to 0.1282	No	ns
Visible - Dry vs. NIR 1460	-0.2153	-0.3508 to -0.07979	Yes	****
Visible - Dry vs. NIR 1550	-0.119	-0.2544 to 0.01654	No	ns
Visible - Wet vs. QLF - Dry	0.1312	-0.004292 to 0.2667	No	ns
Visible - Wet vs. QLF - Wet	0.23	0.09455 to 0.3655	Yes	****
Visible - Wet vs. NIR 1300	-0.05788	-0.1934 to 0.07761	No	ns
Visible - Wet vs. NIR 1460	-0.2659	-0.4014 to -0.1304	Yes	****
Visible - Wet vs. NIR 1550	-0.1695	-0.3050 to -0.03405	Yes	**
QLF - Dry vs. QLF - Wet	0.09885	-0.03665 to 0.2343	No	ns
QLF - Dry vs. NIR 1300	-0.1891	-0.3246 to -0.05359	Yes	***
QLF - Dry vs. NIR 1460	-0.3971	-0.5326 to -0.2616	Yes	****
QLF - Dry vs. NIR 1550	-0.3007	-0.4362 to -0.1653	Yes	****
QLF - Wet vs. NIR 1300	-0.2879	-0.4234 to -0.1524	Yes	****
QLF - Wet vs. NIR 1460	-0.4959	-0.6314 to -0.3604	Yes	****
QLF - Wet vs. NIR 1550	-0.3996	-0.5351 to -0.2641	Yes	****
NIR 1300 vs. NIR 1460	-0.208	-0.3435 to -0.07250	Yes	***
NIR 1300 vs. NIR 1550	-0.1117	-0.2472 to 0.02383	No	ns
NIR 1460 vs. NIR 1550	0.09633	-0.03916 to 0.2318	No	ns
Window 4				
Visible - Dry vs. Visible - Wet	0.04455	-0.09094 to 0.1800	No	ns
Visible - Dry vs. QLF - Dry	0.198	0.06249 to 0.3335	Yes	***
Visible - Dry vs. QLF - Wet	0.3088	0.1733 to 0.4443	Yes	****
Visible - Dry vs. NIR 1300	0.04071	-0.09479 to 0.1762	No	ns
Visible - Dry vs. NIR 1460	-0.1489	-0.2844 to -0.01337	Yes	*
Visible - Dry vs. NIR 1550	-0.005445	-0.1409 to 0.1300	No	ns
Visible - Wet vs. QLF - Dry	0.1534	0.01794 to 0.2889	Yes	*
Visible - Wet vs. QLF - Wet	0.2643	0.1288 to 0.3998	Yes	****
Visible - Wet vs. NIR 1300	-0.003844	-0.1393 to 0.1317	No	ns
Visible - Wet vs. NIR 1460	-0.1934	-0.3289 to -0.05792	Yes	***
Visible - Wet vs. NIR 1550	-0.04999	-0.1855 to 0.08550	No	ns
QLF - Dry vs. QLF - Wet	0.1108	-0.02465 to 0.2463	No	ns
QLF - Dry vs. NIR 1300	-0.1573	-0.2928 to -0.02179	Yes	*
QLF - Dry vs. NIR 1460	-0.3468	-0.4823 to -0.2114	Yes	****
QLF - Dry vs. NIR 1550	-0.2034	-0.3389 to -0.06794	Yes	***
QLF - Wet vs. NIR 1300	-0.2681	-0.4036 to -0.1326	Yes	****
QLF - Wet vs. NIR 1460	-0.4577	-0.5932 to -0.3222	Yes	****
QLF - Wet vs. NIR 1550	-0.3143	-0.4498 to -0.1788	Yes	****
NIR 1300 vs. NIR 1460	-0.1896	-0.3251 to -0.05407	Yes	***
NIR 1300 vs. NIR 1550	-0.04615	-0.1816 to 0.08934	No	ns

NIR 1460 vs. NIR 1550	0.1434	0.007922 to 0.2789	Yes	*

Table 14: Demineralization / Remineralization Days 1-4 without varnish

Tukey's multiple comparisons test	Mean Diff.	95% CI of diff.	Significant?	Summary
Visible - Dry				
Window 1 vs. Window 2	-0.05524	-0.1182 to 0.007745	No	ns
Window 1 vs. Window 3	-0.08528	-0.1483 to -0.02229	Yes	**
Window 1 vs. Window 4	-0.08841	-0.1514 to -0.02543	Yes	**
Window 2 vs. Window 3	-0.03003	-0.09302 to 0.03296	No	ns
Window 2 vs. Window 4	-0.03317	-0.09616 to 0.02982	No	ns
Window 3 vs. Window 4	-0.003136	-0.06613 to 0.05985	No	ns
Visible - Wet				
Window 1 vs. Window 2	-0.0649	-0.1279 to -0.001908	Yes	*
Window 1 vs. Window 3	-0.09267	-0.1557 to -0.02968	Yes	**
Window 1 vs. Window 4	-0.1057	-0.1687 to -0.04275	Yes	***
Window 2 vs. Window 3	-0.02777	-0.09076 to 0.03522	No	ns
Window 2 vs. Window 4	-0.04085	-0.1038 to 0.02214	No	ns
Window 3 vs. Window 4	-0.01308	-0.07607 to 0.04991	No	ns
QLF - Dry				
Window 1 vs. Window 2	-0.01336	-0.07635 to 0.04963	No	ns
Window 1 vs. Window 3	-0.04419	-0.1072 to 0.01880	No	ns
Window 1 vs. Window 4	-0.03244	-0.09543 to 0.03055	No	ns
Window 2 vs. Window 3	-0.03083	-0.09382 to 0.03216	No	ns
Window 2 vs. Window 4	-0.01908	-0.08207 to 0.04391	No	ns
Window 3 vs. Window 4	0.01175	-0.05124 to 0.07474	No	ns
QLF - Wet				
Window 1 vs. Window 2	0.002825	-0.06017 to 0.06581	No	ns
Window 1 vs. Window 3	-0.008511	-0.07150 to 0.05448	No	ns
Window 1 vs. Window 4	0.02217	-0.04082 to 0.08516	No	ns
Window 2 vs. Window 3	-0.01134	-0.07433 to 0.05165	No	ns
Window 2 vs. Window 4	0.01934	-0.04365 to 0.08233	No	ns
Window 3 vs. Window 4	0.03068	-0.03231 to 0.09367	No	ns
NIR 1300				
Window 1 vs. Window 2	-0.05065	-0.1136 to 0.01234	No	ns
Window 1 vs. Window 3	-0.03974	-0.1027 to 0.02325	No	ns

Window 1 vs. Window 4	-0.01891	-0.08190 to 0.04408	No	ns
Window 2 vs. Window 3	0.01091	-0.05208 to 0.07390	No	ns
Window 2 vs. Window 4	0.03174	-0.03125 to 0.09473	No	ns
Window 3 vs. Window 4	0.02084	-0.04215 to 0.08383	No	ns
NIR 1460				
Window 1 vs. Window 2	-0.1655	-0.2285 to -0.1025	Yes	****
Window 1 vs. Window 3	-0.2479	-0.3109 to -0.1849	Yes	****
Window 1 vs. Window 4	-0.1874	-0.2504 to -0.1244	Yes	****
Window 2 vs. Window 3	-0.08246	-0.1455 to -0.01947	Yes	**
Window 2 vs. Window 4	-0.02189	-0.08488 to 0.04110	No	ns
Window 3 vs. Window 4	0.06057	-0.002419 to 0.1236	No	ns
NIR 1550				
Window 1 vs. Window 2	-0.1363	-0.1993 to -0.07331	Yes	****
Window 1 vs. Window 3	-0.1886	-0.2516 to -0.1256	Yes	****
Window 1 vs. Window 4	-0.1708	-0.2338 to -0.1078	Yes	****
Window 2 vs. Window 3	-0.0523	-0.1153 to 0.01069	No	ns
Window 2 vs. Window 4	-0.03453	-0.09752 to 0.02846	No	ns
Window 3 vs. Window 4	0.01777	-0.04522 to 0.08076	No	ns

Table 15: Demineralization / Remineralization Days 1-4 without varnish

Tukey's multiple comparisons test	Mean Diff.	95% CI of diff.	Significant?	Summary
Window 1				
Visible - Dry vs. Visible - Wet	0.2199	0.08836 to 0.3514	Yes	****
Visible - Dry vs. QLF - Dry	0.2054	0.07388 to 0.3369	Yes	***
Visible - Dry vs. QLF - Wet	0.3635	0.2320 to 0.4950	Yes	****
Visible - Dry vs. NIR 1300	0.2328	0.1013 to 0.3643	Yes	****
Visible - Dry vs. NIR 1460	0.06918	-0.06233 to 0.2007	No	ns
Visible - Dry vs. NIR 1550	0.04312	-0.08840 to 0.1746	No	ns
Visible - Wet vs. QLF - Dry	-0.01448	-0.1460 to 0.1170	No	ns
Visible - Wet vs. QLF - Wet	0.1436	0.01212 to 0.2751	Yes	*
Visible - Wet vs. NIR 1300	0.01297	-0.1185 to 0.1445	No	ns
Visible - Wet vs. NIR 1460	-0.1507	-0.2822 to -0.01918	Yes	*
Visible - Wet vs. NIR 1550	-0.1768	-0.3083 to -0.04524	Yes	**
QLF - Dry vs. QLF - Wet	0.1581	0.02660 to 0.2896	Yes	**
QLF - Dry vs. NIR 1300	0.02745	-0.1041 to 0.1590	No	ns
QLF - Dry vs. NIR 1460	-0.1362	-0.2677 to -0.004692	Yes	*
QLF - Dry vs. NIR 1550	-0.1623	-0.2938 to -0.03076	Yes	**

QLF - Wet vs. NIR 1300	-0.1307	-0.2622 to 0.0008530	No	ns
QLF - Wet vs. NIR 1460	-0.2943	-0.4258 to -0.1628	Yes	****
QLF - Wet vs. NIR 1550	-0.3204	-0.4519 to -0.1889	Yes	****
NIR 1300 vs. NIR 1460	-0.1637	-0.2952 to -0.03214	Yes	**
NIR 1300 vs. NIR 1550	-0.1897	-0.3212 to -0.05821	Yes	***
NIR 1460 vs. NIR 1550	-0.02607	-0.1576 to 0.1054	No	ns
Window 2				
Visible - Dry vs. Visible - Wet	0.2102	0.07871 to 0.3417	Yes	****
Visible - Dry vs. QLF - Dry	0.2473	0.1158 to 0.3788	Yes	****
Visible - Dry vs. QLF - Wet	0.4216	0.2901 to 0.5531	Yes	****
Visible - Dry vs. NIR 1300	0.2374	0.1059 to 0.3689	Yes	****
Visible - Dry vs. NIR 1460	-0.04104	-0.1726 to 0.09047	No	ns
Visible - Dry vs. NIR 1550	-0.03794	-0.1694 to 0.09357	No	ns
Visible - Wet vs. QLF - Dry	0.03706	-0.09445 to 0.1686	No	ns
Visible - Wet vs. QLF - Wet	0.2113	0.07984 to 0.3429	Yes	****
Visible - Wet vs. NIR 1300	0.02722	-0.1043 to 0.1587	No	ns
Visible - Wet vs. NIR 1460	-0.2513	-0.3828 to -0.1197	Yes	****
Visible - Wet vs. NIR 1550	-0.2482	-0.3797 to -0.1166	Yes	****
QLF - Dry vs. QLF - Wet	0.1743	0.04278 to 0.3058	Yes	**
QLF - Dry vs. NIR 1300	-0.009839	-0.1414 to 0.1217	No	ns
QLF - Dry vs. NIR 1460	-0.2883	-0.4198 to -0.1568	Yes	****
QLF - Dry vs. NIR 1550	-0.2852	-0.4167 to -0.1537	Yes	****
QLF - Wet vs. NIR 1300	-0.1841	-0.3156 to -0.05262	Yes	***
QLF - Wet vs. NIR 1460	-0.4626	-0.5941 to -0.3311	Yes	****
QLF - Wet vs. NIR 1550	-0.4595	-0.5910 to -0.3280	Yes	****
NIR 1300 vs. NIR 1460	-0.2785	-0.4100 to -0.1470	Yes	****
NIR 1300 vs. NIR 1550	-0.2754	-0.4069 to -0.1439	Yes	****
NIR 1460 vs. NIR 1550	0.003105	-0.1284 to 0.1346	No	ns
Window 3				
Visible - Dry vs. Visible - Wet	0.2125	0.08097 to 0.3440	Yes	****
Visible - Dry vs. QLF - Dry	0.2465	0.1150 to 0.3780	Yes	****
Visible - Dry vs. QLF - Wet	0.4403	0.3088 to 0.5718	Yes	****
Visible - Dry vs. NIR 1300	0.2784	0.1469 to 0.4099	Yes	****
Visible - Dry vs. NIR 1460	-0.09347	-0.2250 to 0.03804	No	ns
Visible - Dry vs. NIR 1550	-0.0602	-0.1917 to 0.07131	No	ns
Visible - Wet vs. QLF - Dry	0.034	-0.09751 to 0.1655	No	ns
Visible - Wet vs. QLF - Wet	0.2278	0.09627 to 0.3593	Yes	****
Visible - Wet vs. NIR 1300	0.06589	-0.06562 to 0.1974	No	ns

Visible - Wet vs. NIR 1460	-0.306	-0.4375 to -0.1744	Yes	****
Visible - Wet vs. NIR 1550	-0.2727	-0.4042 to -0.1412	Yes	****
QLF - Dry vs. QLF - Wet	0.1938	0.06228 to 0.3253	Yes	***
QLF - Dry vs. NIR 1300	0.0319	-0.09961 to 0.1634	No	ns
QLF - Dry vs. NIR 1460	-0.3399	-0.4715 to -0.2084	Yes	****
QLF - Dry vs. NIR 1550	-0.3067	-0.4382 to -0.1752	Yes	****
QLF - Wet vs. NIR 1300	-0.1619	-0.2934 to -0.03038	Yes	**
QLF - Wet vs. NIR 1460	-0.5337	-0.6652 to -0.4022	Yes	****
QLF - Wet vs. NIR 1550	-0.5005	-0.6320 to -0.3690	Yes	****
NIR 1300 vs. NIR 1460	-0.3718	-0.5034 to -0.2403	Yes	****
NIR 1300 vs. NIR 1550	-0.3386	-0.4701 to -0.2071	Yes	****
NIR 1460 vs. NIR 1550	0.03327	-0.09824 to 0.1648	No	ns
Window 4				
Visible - Dry vs. Visible - Wet	0.2025	0.07103 to 0.3341	Yes	***
Visible - Dry vs. QLF - Dry	0.2614	0.1299 to 0.3929	Yes	****
Visible - Dry vs. QLF - Wet	0.4741	0.3426 to 0.6056	Yes	****
Visible - Dry vs. NIR 1300	0.3023	0.1708 to 0.4339	Yes	****
Visible - Dry vs. NIR 1460	-0.02976	-0.1613 to 0.1017	No	ns
Visible - Dry vs. NIR 1550	-0.03929	-0.1708 to 0.09222	No	ns
Visible - Wet vs. QLF - Dry	0.05882	-0.07269 to 0.1903	No	ns
Visible - Wet vs. QLF - Wet	0.2715	0.1400 to 0.4030	Yes	****
Visible - Wet vs. NIR 1300	0.09981	-0.03170 to 0.2313	No	ns
Visible - Wet vs. NIR 1460	-0.2323	-0.3638 to -0.1008	Yes	****
Visible - Wet vs. NIR 1550	-0.2418	-0.3733 to -0.1103	Yes	****
QLF - Dry vs. QLF - Wet	0.2127	0.08121 to 0.3442	Yes	****
QLF - Dry vs. NIR 1300	0.04098	-0.09053 to 0.1725	No	ns
QLF - Dry vs. NIR 1460	-0.2911	-0.4226 to -0.1596	Yes	****
QLF - Dry vs. NIR 1550	-0.3007	-0.4322 to -0.1691	Yes	****
QLF - Wet vs. NIR 1300	-0.1717	-0.3032 to -0.04022	Yes	**
QLF - Wet vs. NIR 1460	-0.5038	-0.6354 to -0.3723	Yes	****
QLF - Wet vs. NIR 1550	-0.5134	-0.6449 to -0.3819	Yes	****
NIR 1300 vs. NIR 1460	-0.3321	-0.4636 to -0.2006	Yes	****
NIR 1300 vs. NIR 1550	-0.3416	-0.4732 to -0.2101	Yes	****
NIR 1460 vs. NIR 1550	-0.009531	-0.1410 to 0.1220	No	ns

Table 16: Demineralization / Remineralization Days 5-8 without varnish

Tukey's multiple comparisons test	Mean Diff.	95% CI of diff.	Significant?	Summary

Visible - Dry				
Window 1 vs. Window 2	-0.05524	-0.1182 to 0.007745	No	ns
Window 1 vs. Window 3	-0.08528	-0.1483 to -0.02229	Yes	**
Window 1 vs. Window 4	-0.08841	-0.1514 to -0.02543	Yes	**
Window 2 vs. Window 3	-0.03003	-0.09302 to 0.03296	No	ns
Window 2 vs. Window 4	-0.03317	-0.09616 to 0.02982	No	ns
Window 3 vs. Window 4	-0.003136	-0.06613 to 0.05985	No	ns
Visible - Wet				
Window 1 vs. Window 2	-0.0649	-0.1279 to -0.001908	Yes	*
Window 1 vs. Window 3	-0.09267	-0.1557 to -0.02968	Yes	**
Window 1 vs. Window 4	-0.1057	-0.1687 to -0.04275	Yes	***
Window 2 vs. Window 3	-0.02777	-0.09076 to 0.03522	No	ns
Window 2 vs. Window 4	-0.04085	-0.1038 to 0.02214	No	ns
Window 3 vs. Window 4	-0.01308	-0.07607 to 0.04991	No	ns
QLF - Dry				
Window 1 vs. Window 2	-0.01336	-0.07635 to 0.04963	No	ns
Window 1 vs. Window 3	-0.04419	-0.1072 to 0.01880	No	ns
Window 1 vs. Window 4	-0.03244	-0.09543 to 0.03055	No	ns
Window 2 vs. Window 3	-0.03083	-0.09382 to 0.03216	No	ns
Window 2 vs. Window 4	-0.01908	-0.08207 to 0.04391	No	ns
Window 3 vs. Window 4	0.01175	-0.05124 to 0.07474	No	ns
QLF - Wet				
Window 1 vs. Window 2	0.002825	-0.06017 to 0.06581	No	ns
Window 1 vs. Window 3	-0.008511	-0.07150 to 0.05448	No	ns
Window 1 vs. Window 4	0.02217	-0.04082 to 0.08516	No	ns
Window 2 vs. Window 3	-0.01134	-0.07433 to 0.05165	No	ns
Window 2 vs. Window 4	0.01934	-0.04365 to 0.08233	No	ns
Window 3 vs. Window 4	0.03068	-0.03231 to 0.09367	No	ns
NIR 1300				
Window 1 vs. Window 2	-0.05065	-0.1136 to 0.01234	No	ns
Window 1 vs. Window 3	-0.03974	-0.1027 to 0.02325	No	ns
Window 1 vs. Window 4	-0.01891	-0.08190 to 0.04408	No	ns
Window 2 vs. Window 3	0.01091	-0.05208 to 0.07390	No	ns
Window 2 vs. Window 4	0.03174	-0.03125 to 0.09473	No	ns
Window 3 vs. Window 4	0.02084	-0.04215 to 0.08383	No	ns

NIR 1460				
Window 1 vs. Window 2	-0.1655	-0.2285 to -0.1025	Yes	****
Window 1 vs. Window 3	-0.2479	-0.3109 to -0.1849	Yes	****
Window 1 vs. Window 4	-0.1874	-0.2504 to -0.1244	Yes	****
Window 2 vs. Window 3	-0.08246	-0.1455 to -0.01947	Yes	**
Window 2 vs. Window 4	-0.02189	-0.08488 to 0.04110	No	ns
Window 3 vs. Window 4	0.06057	-0.002419 to 0.1236	No	ns
NIR 1550				
Window 1 vs. Window 2	-0.1363	-0.1993 to -0.07331	Yes	****
Window 1 vs. Window 3	-0.1886	-0.2516 to -0.1256	Yes	****
Window 1 vs. Window 4	-0.1708	-0.2338 to -0.1078	Yes	****
Window 2 vs. Window 3	-0.0523	-0.1153 to 0.01069	No	ns
Window 2 vs. Window 4	-0.03453	-0.09752 to 0.02846	No	ns
Window 3 vs. Window 4	0.01777	-0.04522 to 0.08076	No	ns

Table 17: Demineralization / Remineralization Days 5-8 without varnish

Tukey's multiple comparisons test	Mean Diff.	95% CI of diff.	Significant?	Summary
Window 1				
Visible - Dry vs. Visible - Wet	0.2199	0.08836 to 0.3514	Yes	****
Visible - Dry vs. QLF - Dry	0.2054	0.07388 to 0.3369	Yes	***
Visible - Dry vs. QLF - Wet	0.3635	0.2320 to 0.4950	Yes	****
Visible - Dry vs. NIR 1300	0.2328	0.1013 to 0.3643	Yes	****
Visible - Dry vs. NIR 1460	0.06918	-0.06233 to 0.2007	No	ns
Visible - Dry vs. NIR 1550	0.04312	-0.08840 to 0.1746	No	ns
Visible - Wet vs. QLF - Dry	-0.01448	-0.1460 to 0.1170	No	ns
Visible - Wet vs. QLF - Wet	0.1436	0.01212 to 0.2751	Yes	*
Visible - Wet vs. NIR 1300	0.01297	-0.1185 to 0.1445	No	ns
Visible - Wet vs. NIR 1460	-0.1507	-0.2822 to -0.01918	Yes	*
Visible - Wet vs. NIR 1550	-0.1768	-0.3083 to -0.04524	Yes	**
QLF - Dry vs. QLF - Wet	0.1581	0.02660 to 0.2896	Yes	**
QLF - Dry vs. NIR 1300	0.02745	-0.1041 to 0.1590	No	ns
QLF - Dry vs. NIR 1460	-0.1362	-0.2677 to -0.004692	Yes	*
QLF - Dry vs. NIR 1550	-0.1623	-0.2938 to -0.03076	Yes	**
QLF - Wet vs. NIR 1300	-0.1307	-0.2622 to 0.0008530	No	ns
QLF - Wet vs. NIR 1460	-0.2943	-0.4258 to -0.1628	Yes	****
QLF - Wet vs. NIR 1550	-0.3204	-0.4519 to -0.1889	Yes	****
NIR 1300 vs. NIR 1460	-0.1637	-0.2952 to -0.03214	Yes	**

NIR 1300 vs. NIR 1550	-0.1897	-0.3212 to -0.05821	Yes	***
NIR 1460 vs. NIR 1550	-0.02607	-0.1576 to 0.1054	No	ns
Window 2				
Visible - Dry vs. Visible - Wet	0.2102	0.07871 to 0.3417	Yes	****
Visible - Dry vs. QLF - Dry	0.2473	0.1158 to 0.3788	Yes	****
Visible - Dry vs. QLF - Wet	0.4216	0.2901 to 0.5531	Yes	****
Visible - Dry vs. NIR 1300	0.2374	0.1059 to 0.3689	Yes	****
Visible - Dry vs. NIR 1460	-0.04104	-0.1726 to 0.09047	No	ns
Visible - Dry vs. NIR 1550	-0.03794	-0.1694 to 0.09357	No	ns
Visible - Wet vs. QLF - Dry	0.03706	-0.09445 to 0.1686	No	ns
Visible - Wet vs. QLF - Wet	0.2113	0.07984 to 0.3429	Yes	****
Visible - Wet vs. NIR 1300	0.02722	-0.1043 to 0.1587	No	ns
Visible - Wet vs. NIR 1460	-0.2513	-0.3828 to -0.1197	Yes	****
Visible - Wet vs. NIR 1550	-0.2482	-0.3797 to -0.1166	Yes	****
QLF - Dry vs. QLF - Wet	0.1743	0.04278 to 0.3058	Yes	**
QLF - Dry vs. NIR 1300	-0.009839	-0.1414 to 0.1217	No	ns
QLF - Dry vs. NIR 1460	-0.2883	-0.4198 to -0.1568	Yes	****
QLF - Dry vs. NIR 1550	-0.2852	-0.4167 to -0.1537	Yes	****
QLF - Wet vs. NIR 1300	-0.1841	-0.3156 to -0.05262	Yes	***
QLF - Wet vs. NIR 1460	-0.4626	-0.5941 to -0.3311	Yes	****
QLF - Wet vs. NIR 1550	-0.4595	-0.5910 to -0.3280	Yes	****
NIR 1300 vs. NIR 1460	-0.2785	-0.4100 to -0.1470	Yes	****
NIR 1300 vs. NIR 1550	-0.2754	-0.4069 to -0.1439	Yes	****
NIR 1460 vs. NIR 1550	0.003105	-0.1284 to 0.1346	No	ns
Window 3				
Visible - Dry vs. Visible - Wet	0.2125	0.08097 to 0.3440	Yes	****
Visible - Dry vs. QLF - Dry	0.2465	0.1150 to 0.3780	Yes	****
Visible - Dry vs. QLF - Wet	0.4403	0.3088 to 0.5718	Yes	****
Visible - Dry vs. NIR 1300	0.2784	0.1469 to 0.4099	Yes	****
Visible - Dry vs. NIR 1460	-0.09347	-0.2250 to 0.03804	No	ns
Visible - Dry vs. NIR 1550	-0.0602	-0.1917 to 0.07131	No	ns
Visible - Wet vs. QLF - Dry	0.034	-0.09751 to 0.1655	No	ns
Visible - Wet vs. QLF - Wet	0.2278	0.09627 to 0.3593	Yes	****
Visible - Wet vs. NIR 1300	0.06589	-0.06562 to 0.1974	No	ns
Visible - Wet vs. NIR 1460	-0.306	-0.4375 to -0.1744	Yes	****
Visible - Wet vs. NIR 1550	-0.2727	-0.4042 to -0.1412	Yes	****
QLF - Dry vs. QLF - Wet	0.1938	0.06228 to 0.3253	Yes	***
QLF - Dry vs. NIR 1300	0.0319	-0.09961 to 0.1634	No	ns

QLF - Dry vs. NIR 1460	-0.3399	-0.4715 to -0.2084	Yes	****
QLF - Dry vs. NIR 1550	-0.3067	-0.4382 to -0.1752	Yes	****
QLF - Wet vs. NIR 1300	-0.1619	-0.2934 to -0.03038	Yes	**
QLF - Wet vs. NIR 1460	-0.5337	-0.6652 to -0.4022	Yes	****
QLF - Wet vs. NIR 1550	-0.5005	-0.6320 to -0.3690	Yes	****
NIR 1300 vs. NIR 1460	-0.3718	-0.5034 to -0.2403	Yes	****
NIR 1300 vs. NIR 1550	-0.3386	-0.4701 to -0.2071	Yes	****
NIR 1460 vs. NIR 1550	0.03327	-0.09824 to 0.1648	No	ns
Window 4				
Visible - Dry vs. Visible - Wet	0.2025	0.07103 to 0.3341	Yes	***
Visible - Dry vs. QLF - Dry	0.2614	0.1299 to 0.3929	Yes	****
Visible - Dry vs. QLF - Wet	0.4741	0.3426 to 0.6056	Yes	****
Visible - Dry vs. NIR 1300	0.3023	0.1708 to 0.4339	Yes	****
Visible - Dry vs. NIR 1460	-0.02976	-0.1613 to 0.1017	No	ns
Visible - Dry vs. NIR 1550	-0.03929	-0.1708 to 0.09222	No	ns
Visible - Wet vs. QLF - Dry	0.05882	-0.07269 to 0.1903	No	ns
Visible - Wet vs. QLF - Wet	0.2715	0.1400 to 0.4030	Yes	****
Visible - Wet vs. NIR 1300	0.09981	-0.03170 to 0.2313	No	ns
Visible - Wet vs. NIR 1460	-0.2323	-0.3638 to -0.1008	Yes	****
Visible - Wet vs. NIR 1550	-0.2418	-0.3733 to -0.1103	Yes	****
QLF - Dry vs. QLF - Wet	0.2127	0.08121 to 0.3442	Yes	****
QLF - Dry vs. NIR 1300	0.04098	-0.09053 to 0.1725	No	ns
QLF - Dry vs. NIR 1460	-0.2911	-0.4226 to -0.1596	Yes	****
QLF - Dry vs. NIR 1550	-0.3007	-0.4322 to -0.1691	Yes	****
QLF - Wet vs. NIR 1300	-0.1717	-0.3032 to -0.04022	Yes	**
QLF - Wet vs. NIR 1460	-0.5038	-0.6354 to -0.3723	Yes	****
QLF - Wet vs. NIR 1550	-0.5134	-0.6449 to -0.3819	Yes	****
NIR 1300 vs. NIR 1460	-0.3321	-0.4636 to -0.2006	Yes	****
NIR 1300 vs. NIR 1550	-0.3416	-0.4732 to -0.2101	Yes	****
NIR 1460 vs. NIR 1550	-0.009531	-0.1410 to 0.1220	No	ns

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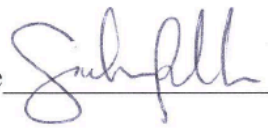
Author Signature  Date 06/12/14