Laboratory Standard Operating Procedure

SOP for Image Capture in Sweetpotato and Potato and Sensory Attribute Prediction

High-Throughput Phenotyping Protocols (HTPP), WP3

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Ethics: The activities, which led to the production of this manual, were assessed and approved by the CIRAD Ethics Committee (H2020 ethics self-assessment procedure). When relevant, samples were prepared according to good hygiene and manufacturing practices. When external participants were involved in an activity, they were priorly informed about the objective of the activity and explained that their participation was entirely voluntary, that they could stop the interview at any point and that their responses would be anonymous and securely stored by the research team for research purposes. Written consent (signature) was systematically sought from sensory panelists and from consumers participating in activities.

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RTBfoods

WP3: High-Throughput Phenotyping Protocols (HTPP)

SOP: Image Capture and Sensory Attribute Prediction

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ABSTRACT

The applications of computer vision technology for acquiring and analysing images have been extended to the evaluation of important crop traits for enhancing breeding programmes. Imaging technology is a fast, non-destructive high-throughput phenotyping tool that has been used widely for accurate acquisition of crop traits on a large scale. A variety of imaging sensors are currently used in research and commercial practices to quantify complex crop traits for breeders. The DigiEye (DigiEye System, VeriVide Ltd., Leicester, UK) provides color and appearance measurement and assessment that captures both the colour and product texture. Color and appearance are closely related to the chemical composition and sensory properties of food. The SOP highlights the procedure of digieye image capture in sweetpotato and potato, as well as color and mealiness prediction. The aim is to give a step-by-step process for easy replication of the activities.

Key words : image analysis, color, mealiness, sweetpotato, potato, DigiEye, phenotyping tool

1 SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) describes how to operate the tool and predict the sweetpotato and potato attributes, using image analysis of DigiEye images.

2 REFERENCES

Yamashita R, Nishio M, Do RKG, Togashi K (2018) Convolutional neural networks: an overview and application in radiology. Insights into Imaging 9, 611-629.

Nantongo J, Serunkuma E, Gabriela B, Fabrice D, Meghar K, Ssali R (2022) SOP for near infrared spectroscopy (NIRS) acquisition on sweetpotato roots and potato tubers. WP3.

Nakatumba J., Katumba A., et al., Standard Operating Procedure for DigiEye Calibration, DigiEye and Image analysis as a breeding tool. WP3

3 DEFINITIONS

Machine learning models were developed by applying computer vision techniques to analyse the DigiEye images and extract data from images. Computer vision is an application of machine learning and artificial intelligence that takes information from digital images and videos and makes meaningful decisions based on that information. One of the essential technologies used to accomplish this is use of convolutional neural networks (Yamashita et al. 2018). Machine learning uses algorithmic models that enable a computer to teach itself about the context of visual data.

4 EQUIPMENT

a) Sample preparation

To prepare samples the following equipment and materials are required:

- **Gloves** - Wearing gloves ensures that you do not stain your hands during sample handling.
- **Cutting board - This** is where the samples are placed while cutting into sections before placing them on the DigiEye blueboard for image capture.
- **Knife - This** is used to peel and cut samples into sections as needed.
- **Tissue paper -** We dampen tissue paper with water or Ethanol to aid in cleaning surfaces, boards and knives during sample preparation.
- **Water -** This is used to clean the DigiEye blueboard every after a sample is removed from the board.
- **Ethanol - Ethanol** is a crucial agent in cleaning up stains that cannot be cleaned by a tissue dampened with water.

b) Operation of tool

To operate the tool; the following are required;

1) **Desktop personal computer** where the tool can be set up to run locally (on the machine without the internet) or remotely deployed to a server and accessed with an internet connection.
2) **Stable internet connection** to provide access to the tool remotely deployed to a server

5 PROCEDURE

5.1 Sample preparation

Images are taken from both raw-intact and cooked-intact sweetpotato roots and potato tubers. Sample selection and preparation is detailed in the NIRS SOP (Nantongo et al 2022, DOI:10.18167/agritrop/00708). The images are taken either after peel (from the distal or proximal ends; Figure 1) and as a cross-section (Figure 1).

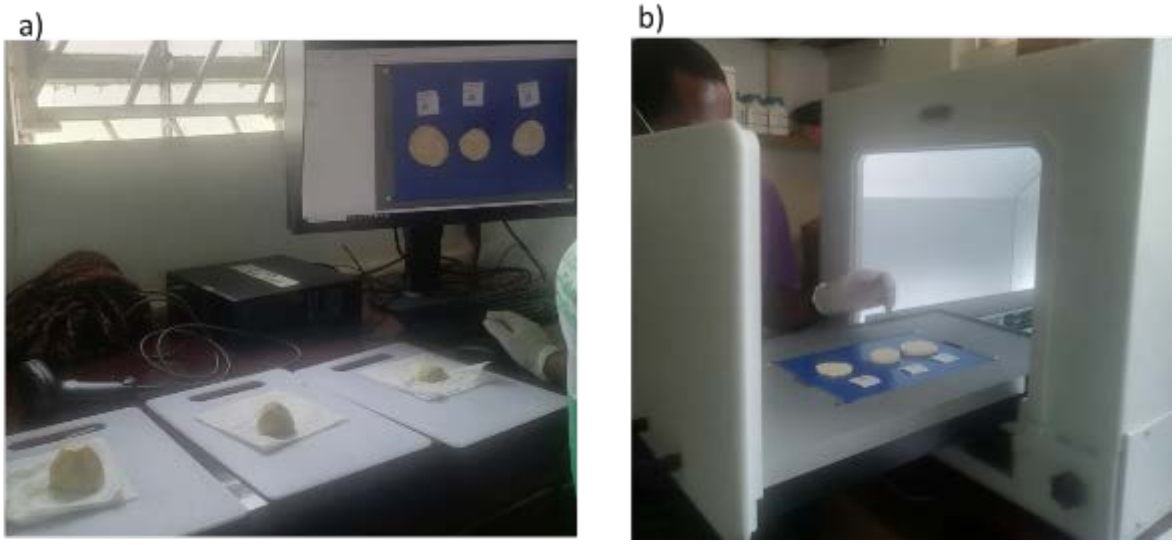

Figure 1: a) after peel and b), middle cross section samples

5.2 Image capture and resizing

5.2.1 Capture

Place slices of the sample on the DigiEye blue board, with corresponding sample labels.

Figure 2: Slices of raw cross sections of a sample with their corresponding labels placed on the DigiEye blue board in the illumination cabinet.

2) Close the illumination cabinet of the DigiEye and tap the live view button to view how the samples are positioned on the board. The Live View button opens the camera live view window. This gives a live video feed from the camera and allows you to check the position of samples and or to align the camera correctly. Adjust the samples as needed to ensure that at least one sample is positioned at the intersection of the blue board as seen using the live view. Note: You must close the live view window before taking an image. It is not possible to take an image with the live view window open. The x button in the top right-hand side of the window closes the live view (Figure 3). The description of the DigiEye calibration and general function is described in a different SOP (Nakatumba et al, 2022)

3) Input the name of the variety in the space for the image name (Figure 3). The name should follow the naming convention and should reflect the variety whose image is being taken. i.e. If the variety whose image is being captured is Alisha, then the image name should be; Alisha-CC where CC stands for Cooked Cross section.

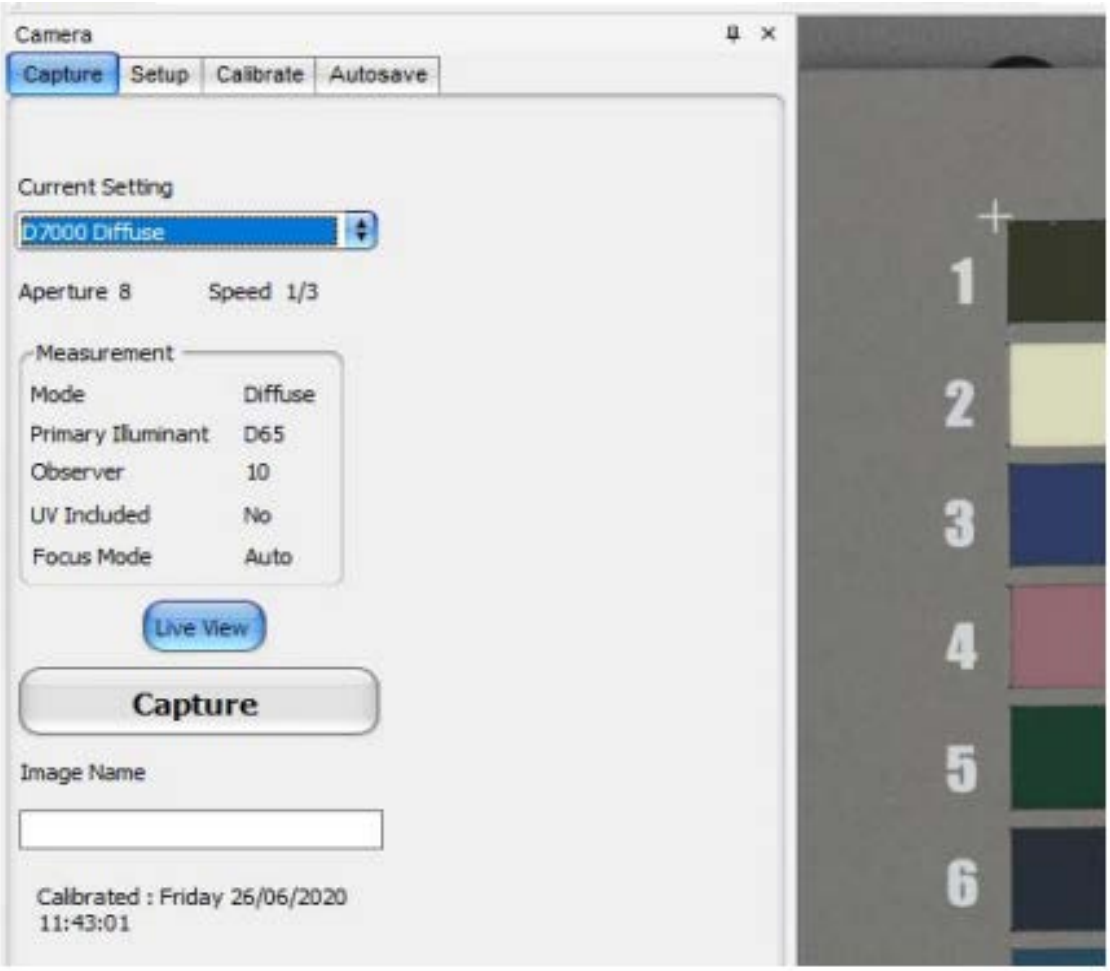

Figure 3: Camera operation window with live view button highlighted in blue.

After capture, open the illumination cabinet and remove the sample slices from the blue board. Clean the blue board with a tissue paper slightly dampened with water. If the board has a persistent stain, clean it with a tissue paper dampened with ethanol, followed by wiping it with a water dampened tissue paper and lastly a clean dry tissue paper to ensure that the board is clean and dry before placing a sample from another variety onto it.

5.2.2 Resizing

The image analysis tool takes images in a number of formats for example, tiff, png, jpg, and jpeg. However, for best performance, we recommend converting large images that are generated from the Digi eye machine in the *tiff* format to the *png* format as these take up significantly less memory while still producing model results. We recommend the use of tools like ImageJ (https://imagej.nih.gov/ij/download.html) for this conversion.

After installation of the ImageJ tool, you open the tool. Navigate to the *Process* tab on the toolbar. Tap on the *Process* tab and scroll down, select the *Batch* option on the dropdown and then the *Convert* option (**Figure 4**).

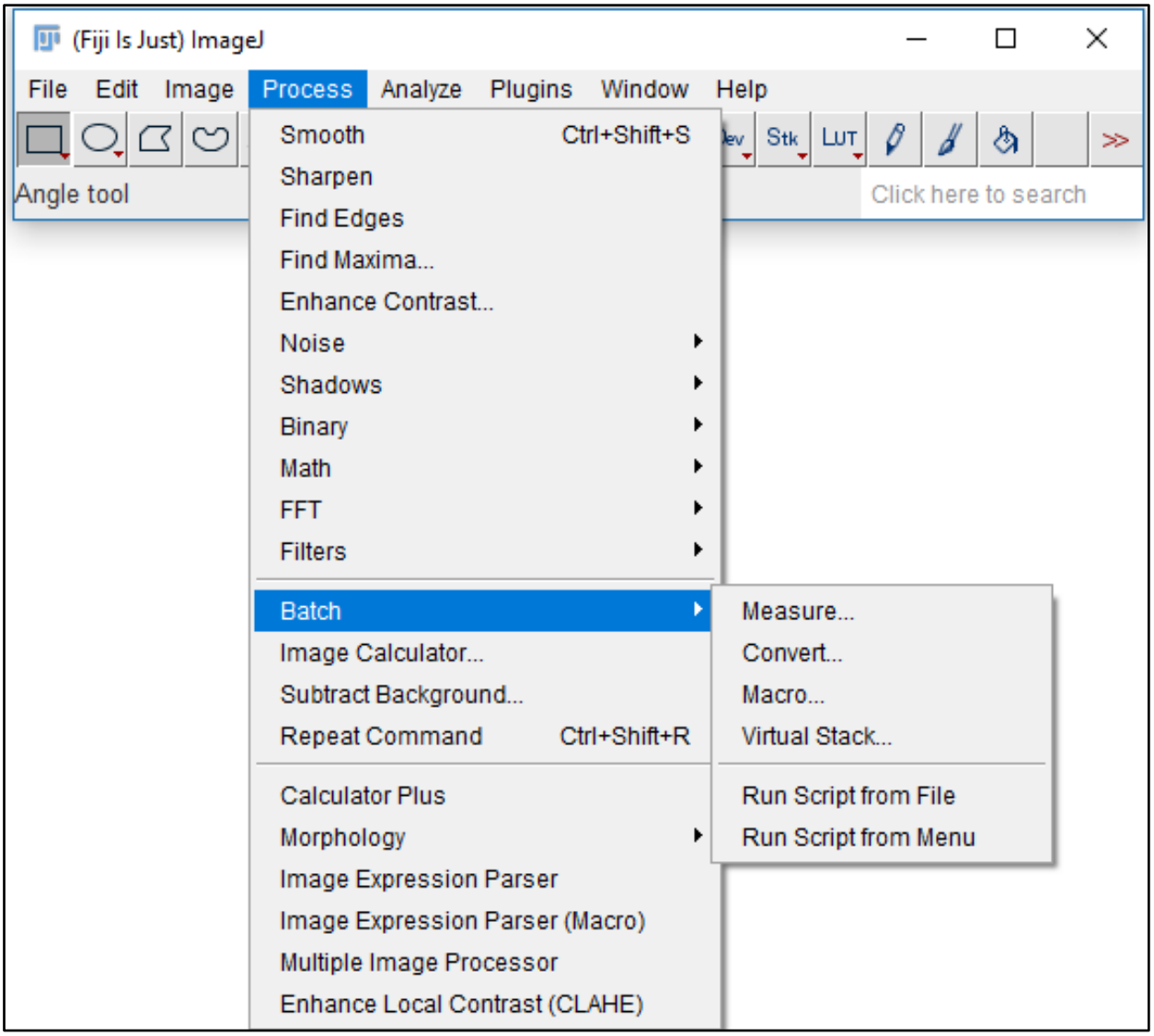

Figure 4: ImageJ navigation to batch image conversion function.

The *Convert* option will open up a pop-up window with the *Conversion* functions (**Figure 5**).

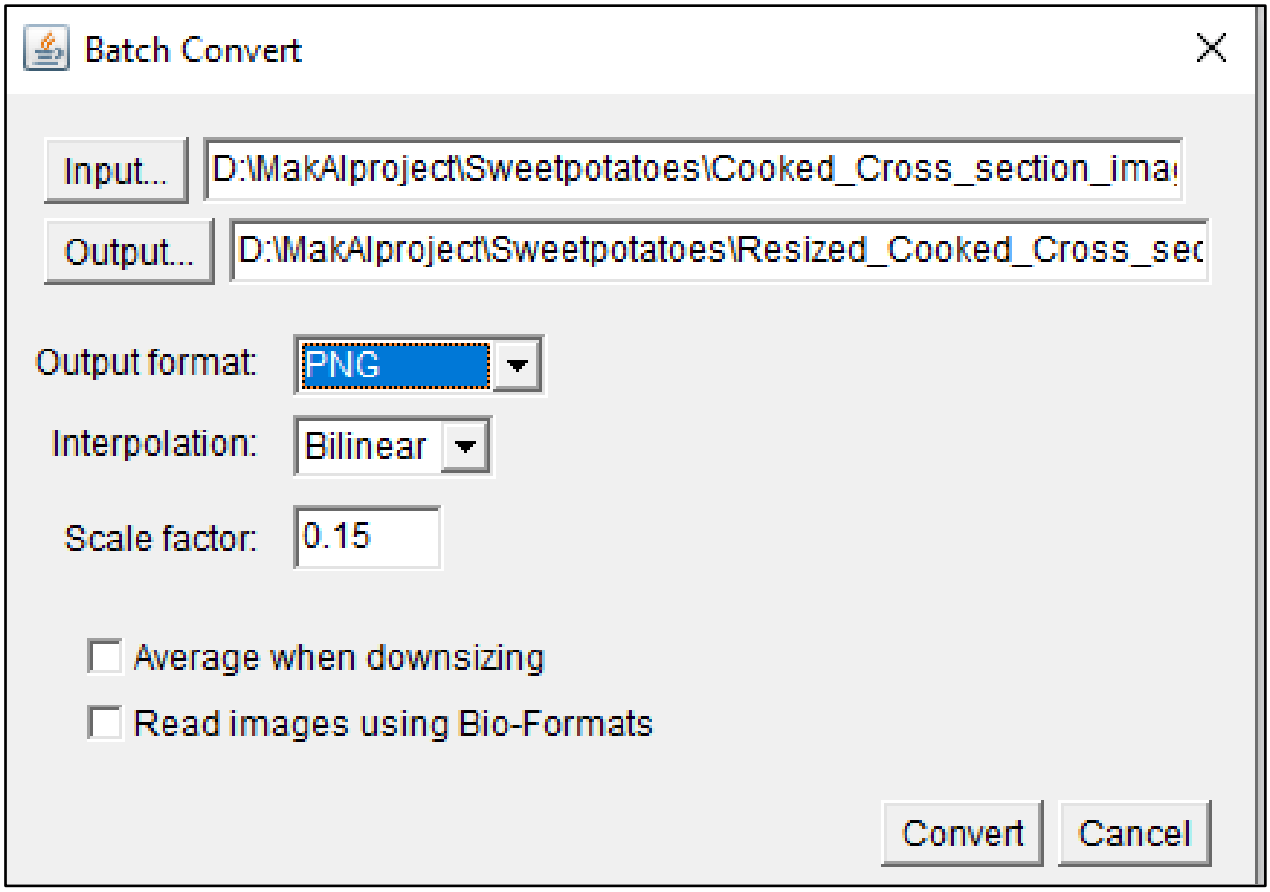

Figure 5: Batch conversion using ImageJ to resize multiple images at once.

For the input option, choose the folder where the DigiEye images that have to be resized are located. For the output, choose a folder where the resized images can be saved after the resizing process is complete. As a **standard scale factor**, choose **0.15** to resize all the input images by 85%.

After resizing the images, and with the calibrations already installed on the computer, prediction of selected traits can proceed.

5.3 Prediction

The following section illustrates the prediction of sweetpotato color and mealiness. The models have been optimised on cooked samples.

Open the “Sweetpotato Sensory Attributes Prediction” web tool in your browser. ***Figure 6*** below shows the home page of the web tool from which one can navigate the different sections and interact with the different models. The tool is currently only locally accessible.

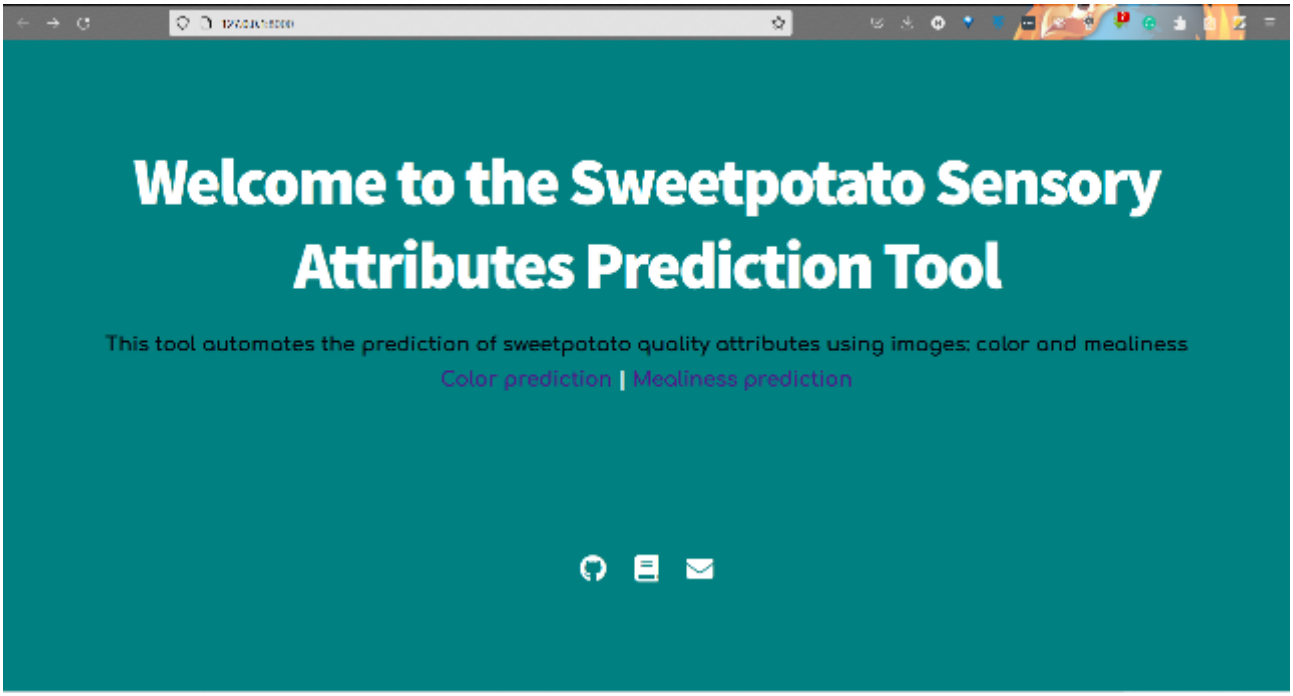

Figure 6: Home page of Digi eye - sweet potato webtool

5.3.1 Procedure for Predicting the Colour Score

Step 1: From the home page as shown in ***Figure 6***, navigate to the first option “Colour prediction” option. Upload images for prediction by drag and drop as seen in ***Figure 7***

a) One can drag and drop images into the upload plane provided.

b) One can select an entire folder of images by clicking the “Select Folder” button and it will redirect you to your local file system to choose a folder.

c) The “Reset button” clears images after a prediction has been completed.

Step 2: Click “Upload” to start the upload process. The progress of processing per image is shown in ***Figure 7*** as the upload is taking place.

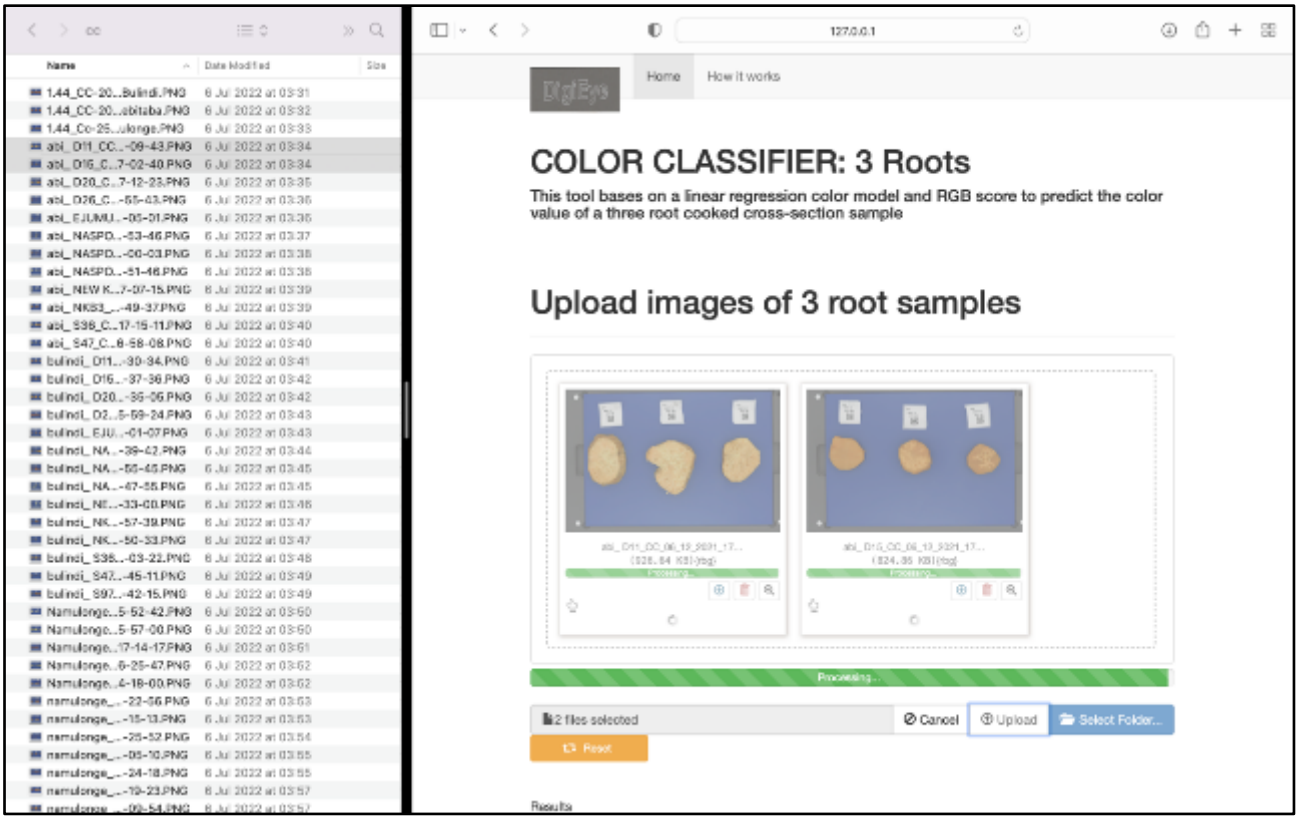

Figure 7: Progress of image processing during colour prediction

Step 3: View the results. The tool gives an overview of the results for each processed image as shown in **Figure 8**. However, a detailed view per image can be accessed by clicking the “Search icon” at the bottom right corner of any image.

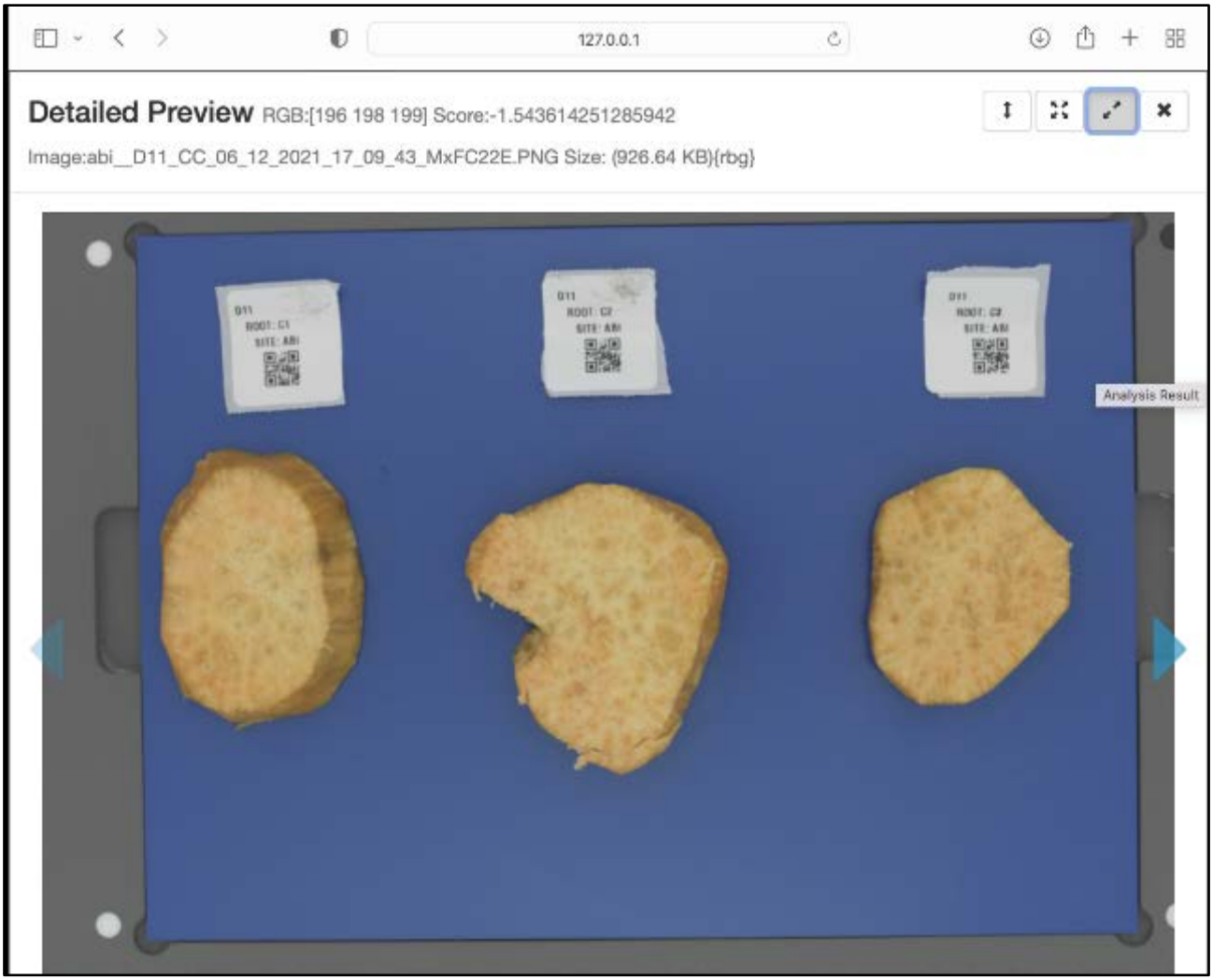

Figure 8: Detailed preview of an image result from colour prediction.

5.3.2 Mealiness Prediction Procedure

Step 1: From the home page in ***Figure 6***, navigate to the first option “Mealiness Prediction” tab. This leads to the section shown in ***Figure 9*** of the tool that provides an interface to upload three root images and get a mealiness score value.

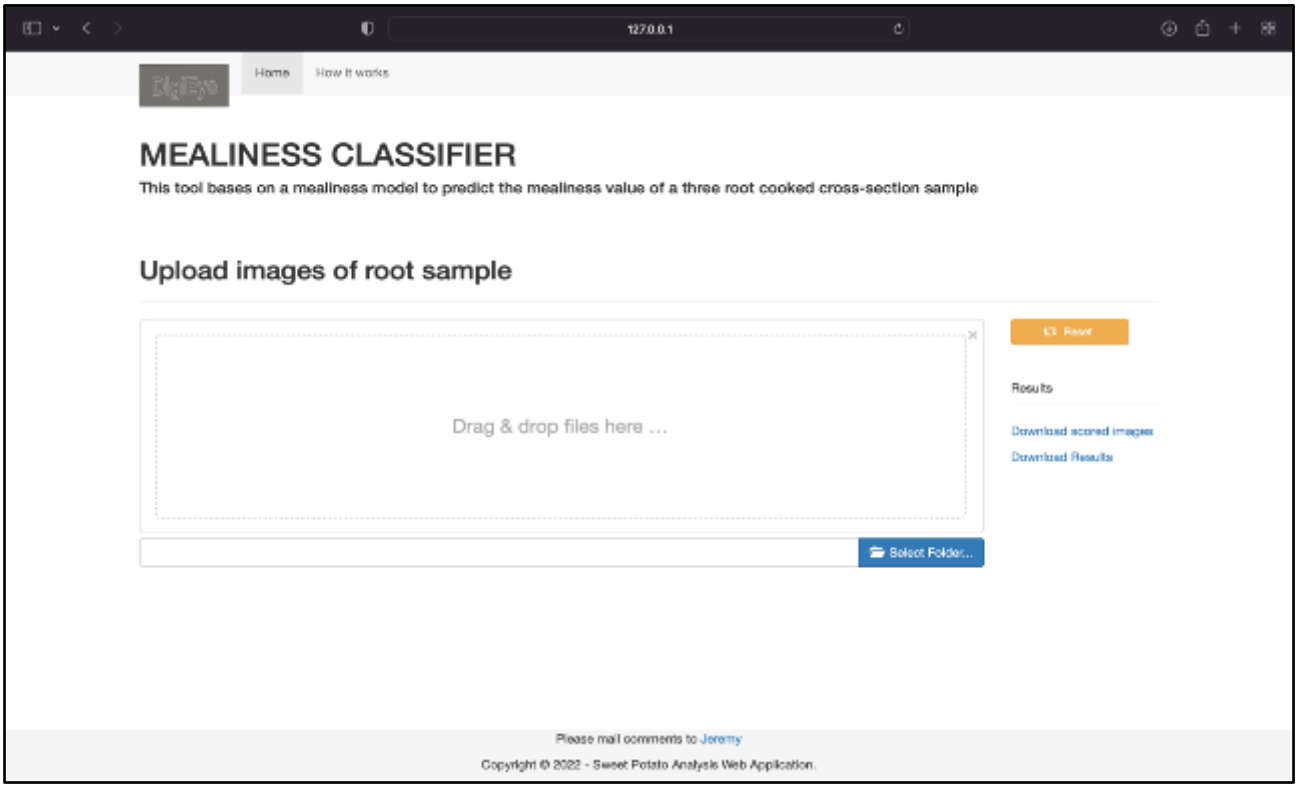

Figure 9: Interface to process the mealiness score of an image.

Step 2: Upload image(s) into the upload plane as described above.

Step 3: View results. The tool gives an overview of the results for each image processed as shown in **Figure 10.** A detailed view per image can be accessed by clicking the search icon at the bottom right corner of any image.

Figure 10: Detailed view of individual image result from the mealiness prediction tool.

5.3.3 Expression of results

The web tool results from **section 5.3.1** and **section 5.3.2** can be downloaded in the form of a csv file. **Figure 13** below is a sample of how the results appear in the csv file.

A	B	C	D
Image Name	**Prediction type**	**Root Score**	**Date**
NASPOT8__01_11_2022_15_20_44.png	Color evalution 3 roots	6.545540234	11/4/2022
EJUMULA__02_11_2022_14_46_25.png	Color evalution 3 roots	7.851609931	11/4/2022
MKN1210__01_11_2022_15_47_17.png	Color evalution 3 roots	0.734738498	11/4/2022
NASPOT8__01_11_2022_15_20_44.png	Mealiness evalution	4.056925702	11/4/2022
EJUMULA__02_11_2022_14_46_25.png	Mealiness evalution	5.069937951	11/4/2022
MKN1210__01_11_2022_15_47_17.png	Mealiness evalution	4.279698082	11/4/2022

Figure 11: Downloaded csv file with mealiness and colour prediction scores.

6 CRITICAL POINTS OR NOTE ON THE PROCEDURE

There are important points to note while carrying out all the procedures described in this SOP. These include;

1. Ensure that the DigiEye imaging system is calibrated before preparing the samples for image capture (see calibration SOP).
2. In sample preparation, naming convention of samples taken using the digieye image should be standard. Special care must be taken that no errors are made in the naming of the images as this affects the prediction results (See **section 5.2.1)** for naming of samples).
3. Ensure that the DigiEye blue board is wiped clean after use and dried before it is stored away to avoid board degradation.
4. It is vital to resize images that were taken using digieye following the standard mentioned in **section 5.2.2** before using the web tool to predict the colour and mealiness scores. The high-resolution images taken using the digieye are large in size and uploading them to the web tool as they are could lead to slow processing and cause a delay in return of results for prediction.
5. Resizing the images before uploading does not affect the quality or pixels of the image but ensures that the time taken to process a batch of images using the web tool is significantly reduced. See **section 5.2.2** for image resizing.

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