Standard Operating Protocol for Characterization of Instrumental Color of Raw Matooke

Kampala, Uganda, 10/04/2024

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Ethics: The activities, which led to the production of this document, 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.

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RTBfoods / RTB Breeding

SOP: Characterization of Instrumental Color of Raw Matooke

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

'Matooke', made from the East African highland cooking bananas is a main staple food in the Uganda and other parts of Africa. The colour of Matooke is one of the key drivers to its acceptability by the consumers. Matooke breeders should be able to accurately measure this attribute in order to select hybrids with the required color quality. This Standard Operating Procedure was developed using 25 different Matooke genotypes, including those the users describe their color as good, medium and bad. The color was determined by the principle of CIELAB colour space using a calibrated Chroma meter. The CIELAB colour space is used to visualize and quantify the colour of food. In the colour space, each color is represented by a color point (L*, a*, b*); the color coordinates of the color point are L*, a*, and b*. The procedure involves the harvesting of mature green Matooke bunches, plucking of fingers from the second and third hands and labeling the hands. Select five fingers and cut them into two pieces to expose the pulp, placing the cut piece on a white surface and taking a reading. The data records included both the absolute values L*a*b* displayed and the color differences as ΔL*, Δa*, Δb*, and ΔE*L*, a*, b* and values. The results showed that the L*raw pulp (lightness), the*raw pulp (redness to green region) and the b*raw pulp (yellowness to blueness) showed significant variation across the cultivars. Statistically significant differences ($p<0.05$) were observed for ΔL and Δb. This analysis can help identify which samples exhibit significant color changes, useful for applications in Matooke breeding, quality control, or any field where color metrics are critical.

Key Words: Matooke, color, quality traits, CIELAB colour space, discrimination

1 SCOPE AND APPLICATION

The East African Highland Bananas also known as Matooke, with their characteristic features, represent a unique and integral part of the agricultural landscape of the region. Apart from the taste and nutritional value, the color of these bananas emerges as a captivating aspect that reflects the rich agricultural diversity in East Africa. The colour of the uncooked bananas here referred to as the “raw Matooke colour” unfolds a story of cultural significance as well as agricultural intricacies.

This SOP describes the analysis of colour of raw Matooke samples.

The objective of this SOP is to measure, using a Chroma Meter CR-400, the colour of different cultivars of bananas prepared as Matooke.

2 DEFINITIONS

EAHCB-East African Highland Cooking Banana.

The fruits of this crop are usually harvested at mature green stage before preparing them for a meal. When cooked, the fruits are characterized by a unique insipid taste and aroma, golden yellow colour and a tender texture. These attributes have endeared an EAHCB meal to consumers and constitute the unique quality described as ‘tookeness’, originating from the term ‘Matooke’ used to describe a cooked meal of the EAHCB.

The maturity period of EAHCB varies from one cultivar to another but usually about 12-15 months from plant sucker emergence. The fruits are harvested when still green. The commonly used indicators of maturity are (a) Fruit skin colour changes from dark green to pale green; (b) Ridges on the fruit surface change from angular to round; (c) Falling off of the dried flower parts at the finger tops and (d) Drying of top-most leaves. Harvesting is done by lopping the pseudo-stem with a hatchet over half-way through the stem, allowing the bunch to fall slowly to avoid damage. The bunch is then removed by cutting it off at the peduncle, leaving about over 30cm of the stalk to ease handling.

The colour of food is a significant aesthetic component. A given colour is perceived differently by various people. As a result, it's critical to have an objective method for describing food colours and measuring colour variations.

Pulp colour of Matooke is a very important attribute as it is an indicator of maturity.

3 PRINCIPLE

Colour measurement of food is done using the Chroma meter, CR-400 which uses the principle of the CIELAB colour space.

The CIELAB colour space is used to visualize and quantify the colour of food. Three perpendicular axes are used to construct the three-dimensional colour space. In the colour space, each color is represented by a color point (L*, a*, b*); the color coordinates of the color point are L*, a*, and b*.

The lightness of an object is indicated by its L* value, which is 100 for white objects and 0 for black ones on the L* axis. The L*-axis is home to the achromatic colours, or shades of grey.

The two axes in the horizontal plane are used to characterize chromatic (or "real") colours. The a* axis represents the green and red colours, while the b* axis make up the blue (-b*) and yellow (+b*) colours.

The new colour scheme, L*, a*, and b*, is denoted by an asterisk (*), signifying that it is an advancement over the previous CIELAB system. Although the simplified notation of the Lab-values, without the * symbol, is frequently employed, the new approach is now widely utilized for the quantification of colours.

4 APPARATUS

a. Chroma meter, CR-400 (Konica Minolta, Inc.) equipped with a measuring head and a data processor
b. A white calibration plate
c. Precision Cell
d. Knife
e. Kitchen paper towel
f. White paper (acts as the background) on which the sample is placed

5 PROCEDURE

1. The banana fingers are picked from the 2nd and 3rd clusters of a bunch. They are picked in triplicates, i.e., three fingers per variety.
2. They are cleaned and labeled.

Figure 1: Labeled banana fingers.

3. The Chroma Meter is plugged in to a power source and the input key ('ENTER' key) is pressed to turn it on. The cursor is moved using the upward and downward keys to select the setting item. The 'ENTER' key is pressed to change settings.
4. The chroma meter is calibrated by placing the measuring head perpendicular to a white calibration plate near the middle of the plate (Figure 2). The measuring head has an LCD display screen on which results are showed. The 'CAL' key is then pressed then the 'ENTER' key. The coordinates of the calibration plate are shown in Figure 3. The data on the white calibration plate is confirmed to be the same with that on the chroma meter screen.

Figure 2: The measuring head of the Chroma Meter placed on a white calibration tile.

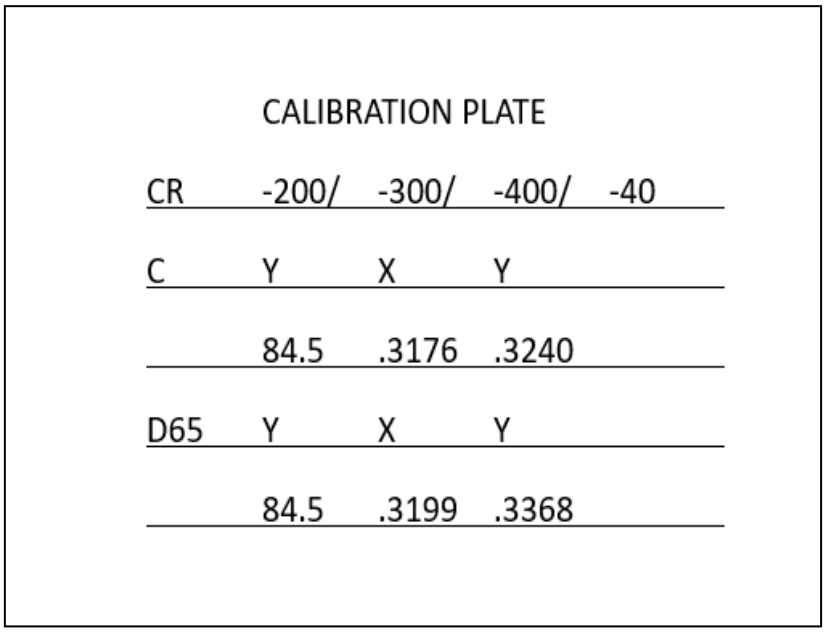

Figure 3: The white calibration plate showing the coordinates.

5. After flashing 3 times, the calibration is complete and the LCD screen will appear as shown in Figure 4.

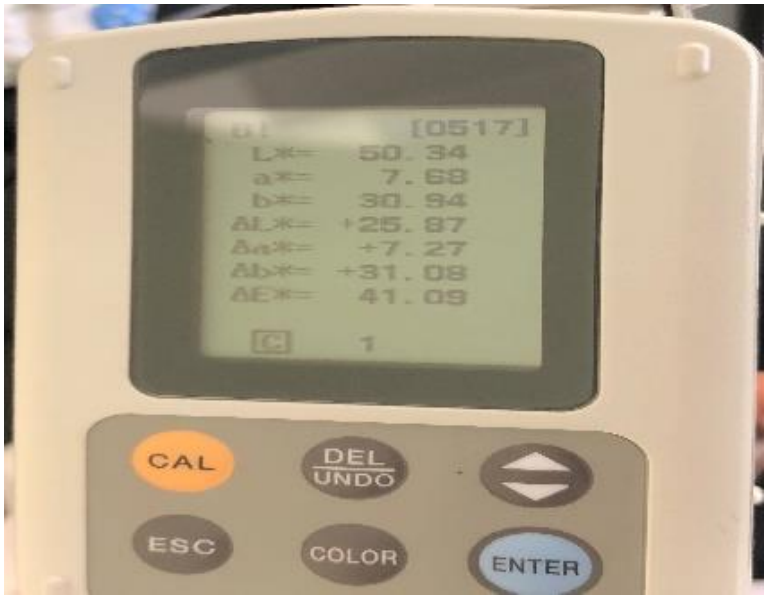

Figure 4: Basic screen layout after calibration.

6. The Chroma meter has different colour spaces so selecting of the adequate colour space is important. This is obtained from the color space and colour difference settings. By pressing the 'COLOR' key, the L*a*b* color space was selected. The absolute values displayed are the L*a*b* and the color differences are ΔL*, Δa*, Δb*, and ΔE*.
7. One finger at a time is put on a white paper and the measuring head focused on the peeled portion. The 'measure button' of the chroma meter is pressed, and after the flash, the colour measurements are displayed on the screen.
8. The process is repeated with the rest of the banana fingers for the different varieties. Three repetitions are done for each measurement.

6 COLOR MEASUREMENT

1. Cut the banana finger into two parts at its middle point
2. Peel the middle section of the finger
3. Cut it into a cylindrical shape that fits in the precision cell.

Figure 5: Cutting of the banana finger to obtain small piece.

4. The peeled sample is placed into a precision cell which is placed on a white background.

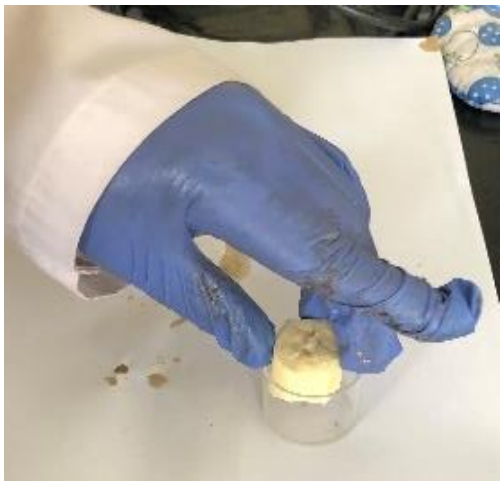

Figure 6: The pulp sample being placed into a precision cell.

5. The measuring head of the chroma meter is vertically placed on the precision cell containing the pulp sample.

Figure 7: The measuring head focused on the precision cell.

6. The "Ready Lamp" on the measuring head flashes a green light as indication of readiness to take measurements.
7. The measure button (Enter Key) is then pressed and results displayed on the screen. They are then recorded. The measurements are done in triplicates.

7 EXPRESSION OF RESULTS

Table 1 shows L*a*b* results of Matooke for each cultivar. The cultivar name, sample code, type which indicates whether it is a landrace or a hybrid are also given. The landrace varieties used included KIBUZI, KISANSA, MBWAZIRUME, MPOLOGOMA, MUSAKALA, NAKITEMBE, NANDIGOBE, and NFUUKA while the hybrids included M30, NAROBAN 4, NARITA 4, NARITA 8, NARITA 9, NARITA 10, NARITA 11, NARITA 12, NARITA 13, NARITA 14, NARITA 15, NARITA 18, NARITA19, NARITA 21, and NARITA 26.

Table 1: L*a*b* values of Raw Matooke samples for selected cultivars.

Cultivar	L*rawpulp	a*rawpulp	b*rawpulp
MPO	61.40^{abcd}	0.61^{ab}	25.76^{bc}
NKT	62.32^{abcd}	0.03^{abc}	25.50^{bcd}
KBZ	62.11^{abcd}	0.44^{ab}	23.88^{cde}
NFK	69.73^{ab}	-3.66^{d}	32.35^{a}
MBW	57.83^{abcd}	0.67a	25.03^{bcde}
N4	71.50^{a}	-1.23^{bc}	24.26^{cde}
MPO	58.47^{abcd}	-0.07^{abc}	29.73^{ab}
MSK	61.61^{abcd}	0.10^{bc}	21.62^{cdefg}
N11	69.59^{ab}	-1.02^{abc}	23.50^{cde}
N12	62.50^{abcd}	-0.79^{abc}	22.71^{cdef}
N26	59.03^{abcd}	-0.17^{bc}	24.87^{bcde}
NRBN 4	56.46^{bcd}	0.71^{a}	23.31^{cde}
KIS	60.28^{abcd}	-0.27^{abc}	23.76^{cde}
N13	61.58^{abcd}	-0.59^{abc}	21.46^{cdefgh}
M30	60.63^{abcd}	-0.32^{abc}	21.76^{cdefg}
N14	62.35^{abcd}	-0.87^{abc}	20.15^{efghi}
N10	61.23a^{bcd}	-0.94^{abc}	21.70^{cdefg}
N18	65.23^{abc}	-1.49^{c}	17.56^{ghij}
NAND	50.47^{d}	0.69^{a}	16.41^{ij}
N19	60.87^{abcd}	-1.49^{c}	20.93^{cdefghi}
N9	55.06^{cd}	-0.24^{bc}	17.99^{fghij}
N21	59.30^{abcd}	-1.16^{bc}	20.72^{defghi}
N15	61.35^{abcd}	-1.59^{c}	16.52^{hij}
N8	57.60^{abcd}	-0.59^{abc}	14.13^{j}
Pr > F(Model)	0.001	<0.0001	<0.0001
Significant	Yes	Yes	Yes

Values sharing the same letter are not significantly different from each other.

Results are means of triplicate values. Same superscript letters in a column indicates no significantly different (p>0.05).

- The L*raw pulp (lightness) was significantly different across the selected Matooke cultivars
- Similarly, the a*rawpulp (redness to green region) showed significant variation
- The b*raw pulp (yellowness to blueness) showed significant variation across the cultivars

Table 2: Means across Matooke types.

Type	L*rawpulp	a*rawpulp	b*rawpulp
Landraces	60.60[a]	-0.20 [a]	24.43[a]
Hybrid	61.62[a]	-0.79[a]	20.71[b]
Pr >F(Model)	0.63	0.18	0.00
Significant	No	No	Yes

- The results indicate the statistical differences observed and whether they are significant.
- For L*rawpulp and a*rawpulp, the differences between Landraces and Hybrids are not statistically significant (p>0.05).
- Whereas for b*rawpulp, the differences are statistically significant (p<0.05).
- This is confirmed by ANOVA in Figure 8.

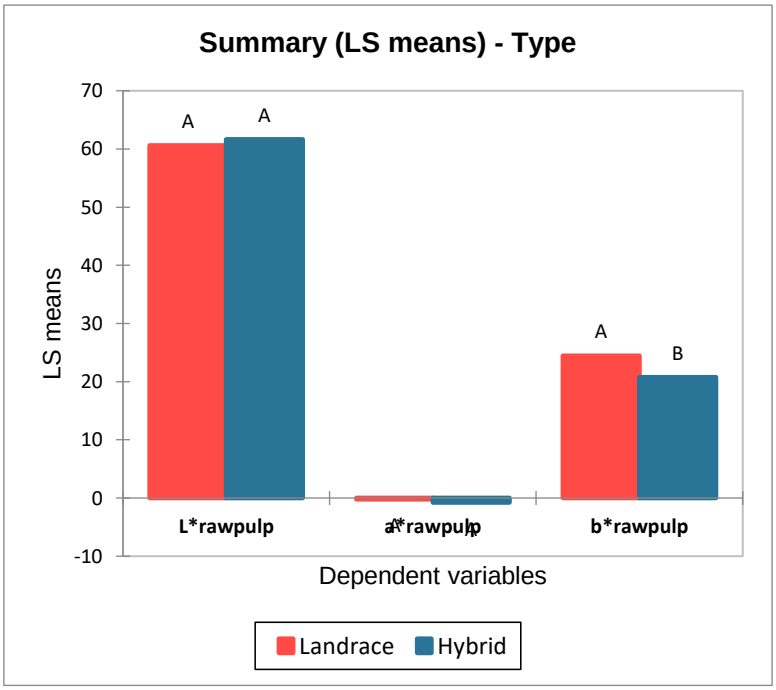

Figure 8: ANOVA showing differences in the colour parameters of Raw Matooke.

Table 3: Illustration of changes in lightness, a, and b.

	Δ L	Δa	Δb
MPO	53.00^{a}	-0.34^{a}	29.87^{a}
NKT	37.58^{abcd}	0.66^{a}	27.40^{abc}
M30	36.22^{abcd}	-0.47^{a}	25.02^{abcd}
KBZ	34.31^{cd}	0.02^{a}	24.02^{abcde}
KIS	39.14^{abcd}	-0.79^{a}	23.25^{bcde}
MBW	34.87^{bcd}	-0.24^{a}	23.86^{abcde}
N15	37.00^{abcd}	-1.18^{a}	25.31^{abcd}
N4	46.43^{ab}	-1.63^{a}	24.00^{abcde}
NRBN 4	31.99^{cd}	0.30^{a}	23.45^{bcde}
N9	29.55^{de}	-0.36^{a}	24.35^{abcd}
MSK	39.31^{abcd}	-1.34^{a}	21.81^{bcde}
N14	37.41^{abcd}	-1.29^{a}	21.53^{cde}
N10	36.51^{abcd}	-1.01^{a}	21.14^{cde}
N13	38.20^{abcd}	-1.10^{a}	19.79^{def}
N21	35.46^{bcd}	-0.73^{a}	19.95^{def}
NFK	40.52^{abcd}	-1.51^{a}	19.71^{def}
N26	35.12^{bcd}	-7.86^{a}	25.64^{abcd}
N12	35.41^{bcd}	-1.30^{a}	21.29^{cde}
N18	40.47^{abcd}	-1.95^{a}	17.61^{ef}
N11	34.86^{bcd}	-0.75^{a}	19.37^{def}
N19	36.39ab^{cd}	-1.90^{a}	21.07^{cde}
N8	33.16^{cd}	-1.01^{a}	14.27^{fg}
NAND	19.76^{e}	-0.68^{a}	9.90^{g}
Pr > F(Model)	<0.0001	0.55	<0.0001
Significant	Yes	No	Yes

Values sharing the same letter are not significantly different from each other.

1. ΔL: This column represents the change in lightness. Higher values indicate a greater increase in lightness. The values range from 19.757 to 53.000. The p-value is <0.0001, indicating significant differences in lightness changes among the samples. MPO (53.000 a) shows the highest increase in lightness while NAND (19.757 e) shows the lowest increase.

2. Δa: This column represents the change in the red/green coordinate. Positive values indicate a shift towards red, while negative values indicate a shift towards green. The values range from -7.857 to 0.663. The p-value is 0.546, indicating no significant differences in the red/green coordinate changes among the samples. NKT (0.663 a) has the highest shift towards red while N26 (-7.857 a) has the most significant shift towards green.

3. Δb: This column represents the change in the yellow/blue coordinate. Positive values indicate a shift towards yellow, while negative values indicate a shift towards blue. The Values range from 9.897 to 29.870. The p-value is <0.0001, indicating significant differences in yellow/blue coordinate changes among the samples. MPO (29.870 a) shows the highest increase towards yellow while NAND (9.897 g) shows the lowest increase towards yellow (or highest shift towards blue).

Statistically significant differences (p<0.05) were observed for ΔL and Δb.

This analysis can help identify which samples exhibit significant color changes, useful for applications in Matooke breeding, quality control, or any field where color metrics are critical.

8 CRITICAL POINTS OR NOTE ON THE PROCEDURE

- The banana fingers picked should be physically good with no damage on them
- Each banana finger is clearly labeled and replicated 3 times to give an estimate of the true sample value
- Banana fingers have sap which may stain the glass light projection tube. Sample should be placed in a precision cell to avoid direct contact with the glass light projection tube.
- The chroma meter should always be fully charged before use otherwise the "Ready lamp" may not work.