CIP INTERNATIONAL POTATO CENTER

CGIAR

Procedures for standard evaluation and data management of advanced potato clones

Practical guide to assessing potato clones for drought tolerance under field conditions

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CGIAR RESEARCH PROGRAM ON Roots, Tubers and Bananas

Procedures for standard evaluation and data management of advanced potato clones

Module 12. Post-Harvest Traits
International Cooperators' Guide

September 2020

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Module 12. Post-Harvest Traits. International Cooperators' Guide

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International Potato Center
Av. La Molina 1895, La Molina, Peru
Apartado 558, Lima 12, Peru
cip@cgiar.org • www.cipotato.org

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Contents

1. Assessing the post-harvest traits

The primary objective of evaluating post-harvest traits is to obtain information about the potential of advanced clones for diverse end uses, ranging from fresh consumption to processing. These evaluations provide important information to guide potato breeding and selection programs, and the results may be useful for recommending new varieties for specific uses.

This protocol details procedures for determining:

- Dry matter content and specific gravity
- Chipping performance

1.1 Conducting post-harvest evaluation

Post-harvest and storability characteristics can be evaluated using healthy tubers harvested from tuber yield trials.

1.1.1 Conditions:

Environmental factors (principally temperature fluctuations, rainfall, altitude, and soil fertility), management and genotype x environment interaction influence post-harvest performance.

Soils: Medium textured soils, such as sandy loams, loams, and silt loams, generally produce potatoes with higher specific gravity than very sandy or heavy clay soils. Well-managed loam soils have good water-holding and nutrient supplying characteristics that allow for high rates of growth and tuber dry matter production. We considered all variables for a complete analysis of soils (Annex 5).

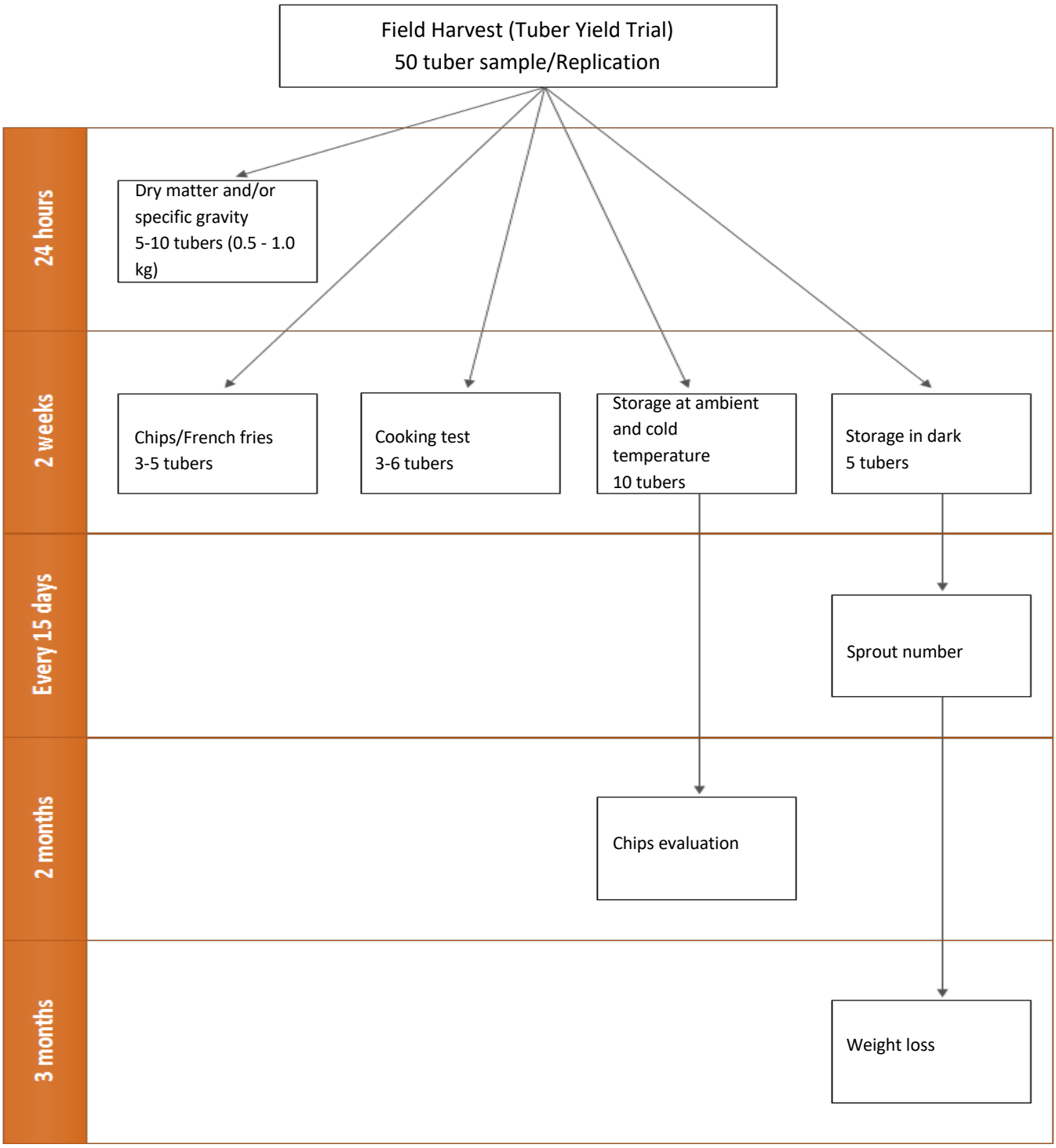
Site, weather (Annex 6), and management conditions of the production materials should therefore be recorded on the appropriate field book datasheet.

To determine varietal stability of traits, evaluations should be conducted on material produced in contrasting environments (for instance, in two sites or multi-locational trials), particularly if altitude or season is relevant to the particular ecology of the area being targeted for variety development.

1.2 Materials: clones, control varieties

In each replication, samples are taken of one or more healthy tubers of commercial size per plant until obtaining a minimum of 25 tubers per clone. The sampled tubers should be uniform and representative of the clone's size and shape. If processing quality is to be determined, at least one locally important chipping/French fry variety should be included in the trial for comparison.

The recommended number of necessary tubers and the timing of the test evaluations are shown as follows:



2. Assessing solid content of tubers

2.1 Materials

If possible, dry matter content should be measured within 24 hours after harvest to avoid post-harvest changes due to shrinkage. Tubers should be free of disease and undamaged. Peeling is not necessary. The measure of all parameters requires a balance accurate to 0.1 g

2.2 Evaluation parameters

2.2.1 Dry matter content (DM):

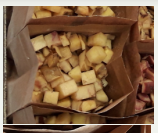
In addition to the balance, an oven is needed to determine dry matter content. Annex 1

Step 1

Chop five tubers (about 500 g totals) into small 1-2 cm cubes, mix thoroughly, and take two sub-samples of 200 g each. It is important to sample all parts of the tuber, because dry matter content is not uniform throughout the tuber. Determine the exact weight of each sub-sample and record it as fresh weight.

Step 2

Place each sub-sample in an open container or paper bag and put in an oven at 80˚C for 72 hours or, after checking sample weight at regular intervals, until constant dry weight is reached.



Step 3

Weigh each dried sample immediately and record as dry weight. Calculate the percent dry matter content for each sub-sample with the following formula:

Dry matter content (DM)= (dry weight / fresh weight) x 100

Step 4

Calculate the mean dry matter of the two sub-samples.

2.2.2 Specific gravity (SG):

Specific gravity can also be used to indirectly evaluate the dry matter content of one clone. Two methods can be used for determining tuber specific gravity: the weight in air/weight in water method (which is more accurate) and the hydrometer method.

A. - Determining specific gravity with the weight in air (TWA)/weight in water (TWW) method

This method requires the use of a scale equipped with a hook underneath in order to hold a basket, which will be immersed in water. Annex 2

The weight in air/weight in water method can be performed as follows:

Step 1

Place a plastic beaker or metal basket on a balance, and re-calibrate the balance to zero.

Step 2

Place 4 kg of commercial size potatoes in the basket and weigh, record data as weight in air.

Step 3

Immerse the plastic beaker or metal basket and potatoes in water and weigh again; record data as weight in water.

Step 4

Calculate specific gravity with the following formula:

Specific gravity (SG) = (Tuber weight in air) / (tuber weight in air – tuber weight in water)

B. - Determining specific gravity with the hydrometer method

If a calibrated hydrometer is available, it can be used as follows:

Step 1

Place a plastic beaker or metal basket on a balance, and re-calibrate the balance to zero.

Step 2

Place the exact weight of 3629 grams of commercial size potatoes in the beaker or basket (one potato will have to be cut in order to obtain this exact weight). The 3629 grams is a standard amount to be used if the hydrometer is calibrated (nevertheless, check the manufacturer's manual for confirmation).

Step 3

Immerse a metal basket and the potatoes in water and connect it to the hydrometer. The specific gravity can be read directly from the hydrometer.

Note: Always be sure that the hydrometer is calibrated (for more detailed information, consult the manufacturer's manual).

You can get dry matter data by interpolating the information of specific gravity according to her hydrometer manual that use. CIP use the table from Annex 3

2.2.3 Glucose concentration mg/dl (GLU):

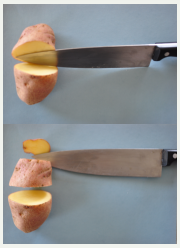
This trait can help to determine final fry or chip color, since a dark fry or chip color is usually related to a high concentration of glucose. The assessment of glucose concentration within tubers is done in a single tuber following the steps below:

Step 1

One tuber is selected as a sub-sample from each plot representative sample of 5 randomly selected potatoes. All tuber must be cleansed before reaching step 2.

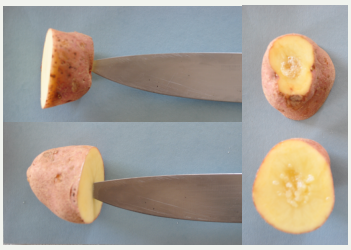
Step 2

The tuber must be cut in half to prepare 2 sub-samples of 50 µl: one at the medulla, or center of the tuber, and another at the apical cortex, or peel.



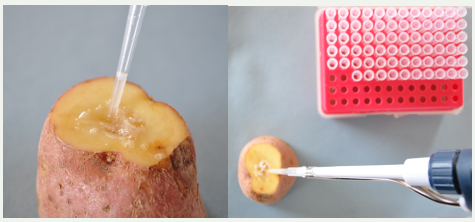
Step 3

The first sample, or *medullar sample*, is prepared by exposing liquid from the medullar tissue after gently scraping its surface with a stainless-steel knife or any other utensil. The second sample, or *cortex sample,* is collected as the previous sample but at the apical peridermal level.



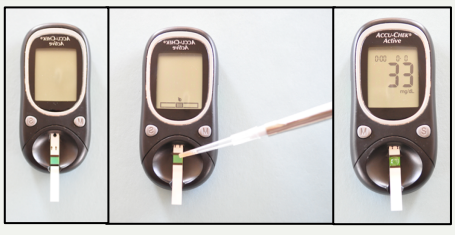
Step 4

Prepared tubers must be sampled for a drop, or 50 µl, immediately after tuber sample preparation to avoid oxidation and water evaporation.



Step 5

The drops collected must be placed in a blood glucose meter strip attached to the Blood Glucose Monitoring System from Accu Check® to calculate the glucose concentration in mg/dl.



After gathering the information, the percentage of glucose on a fresh-weight basis is measured as follows: 0.000705 GLU + 0.00453 (Brand, 2012).

2.3 Data recording

Use HIDAP Software.

2.4 Data analysis

The data, dry matter percentage and/or specific gravity, glucose concentration can be analyzed according to the design (entry, repetition) used in the field when the samples are taken from each experimental unit of the field trial.

Simple statistics such as mean, standard error, frequency distribution and boxplots should be used to explore the data. Continuous data expressed in percentage (such as percentage dry matter and glucose concentration) do not need to be transformed before the analysis.

Dry matter percentage and/or specific gravity besides glucose concentration data are analyzed using variance analysis and means are compared using LSD, Tukey, Waller- Duncan, Bonferroni and/or other tests. Orthogonal contrast is used to compare the clones with the local control (Dunnett test). Data are analyzed using R or other statistical packages.

You can get dry matter data by interpolating the information of specific gravity according hydrometer manual. Annex 3

Percent dry matter and specific gravity are highly correlated and are two alternative means of estimating the solid content of tubers. Both variables give an indication of processing and cooking quality.

The Accu-Chek Active equipment uses the principle of photometric determination of glucose, glucose staining with oxidoreductases or reaction by means of glucose dehydrogenase pyrrolequinolinequinone , this equipment gives us results in quantitative values from 10 mg / dl to 600 mg / dl. When the value is less than 10 mg / dl the equipment shows Lo and when it is higher it shows Hi.

For statistical analyzes, “Lo” data should be substitute by the 5 mg / dl value and the “Hi” data for the 650 mg / dl value.

2.5 Selection criteria

In general, dry matter content of more than 20% and a specific gravity of 1.080 or greater are considered acceptable. These values correspond to a solid content of about 18%. Tubers meeting these criteria produce high yields of chips that absorb less oil and have better texture than chips made from potatoes with lower solids. Lower values than these indicate unacceptable quality for most processing purposes.

A reduced content of sugars gives a good color to the frying. A high sugar content in potatoes produces a dark color that brings with it a distortion of the taste (bitter). To produce potato chips, varieties that have a maximum of 0.02% reducing sugars are needed (Pumisacho and Sherwood, 2000).

3. Assessing chipping performance

3.1 Materials

Harvested tubers should rest ("stabilize") at room temperature for 10 days before evaluating the chipping performance.

3.2 Evaluation parameters

Variables to be measured are the degree of darkening that occurs during frying and the amount of oil absorbed in the process.

3.3 Chipping color (Chip_color)

Tubers should be free of disease and undamaged. Peeling is not necessary. Each sample comprises six tubers.

Step 1

Cut each tuber perpendicular to the long axis and take three 0.5 mm slices from the central part of each half.

Step 2

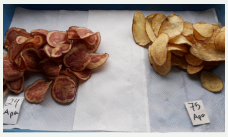
Rinse the slices in water, shake the water off the slices and allow the surfaces to dry.

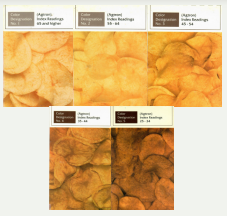
Step 3

Fry the slices in oil at 176-180°C until the oil stops bubbling (approximately 3mn).

Step 4

Evaluate the color of the chips in CIP is with 1 to 5 scale.





Scale	State	Description
1	**Light**	Light white to cream.
2	**Moderately light**	Light with light dark spots.
3	**Moderately dark**	Light with dark spots or very light brown.
4	**Dark**	Strong presence of dark spots, or brown color.
5	**Very dark**	Dark brown.

4. French fry test

This test is designed to replicate the commercial process for frozen French fries. Evaluation is conducted by a trained four-person taste panel, who evaluate the external appearance and color on the whole sample. To asses this evaluation, follow the next steps:

- ✓ A 3-tuber sample is selected. Tubers should also be free of diseases and undamaged. Tubers are sliced to give strips 3/8 inch in section
- ✓ Because the specific gravity (dry matter content) varies in different parts of the tuber and because quality is influenced by dry matter, it is recommended that slices be taken from the center and the outer parts of the tuber.

  Slices can usually be distinguished by the slant at the ends.

  Each of the four samples - one for each panel member - is made up of one slice from each of the three parts from each of the three tubers to give a total of nine strips in each sample. Each of the nine strip samples is then taken through the following process.
- ✓ Par fry in cooking oil at 193°C for 1 minute. Drain off excess oil.
- ✓ Fast freeze and store at -7°C.
- ✓ To evaluate, complete frying in cooking oil at 193°C for 1½' and present to panel members.
- ✓ To evaluate it is necessary to sort strips into inside and outside slices.

  External appearance and external color are scored on the whole sample.

  Internal color is obtained by breaking the fries and squeezing the flesh oil to allow visual examination.

  Observation of the flesh is also required to observe texture (mealiness). The texture of the strips is scored differently for the inside and outside of the strips at the distal and central regions, since dry matter is often irregular through the complete structure of the strips. The score is weighted to give a higher importance to central regions.

  Color is evaluated using the same color scale as for chipping performance (Chapter 3)

5. Oil absorption or Oil Content Percentage (AOCP)

In addition to the innate or physical characteristics of a variety (for example, specific gravity), several other factors affect oil content, so it is important to use uniform procedures.

A. - Determining oil absorption rate with the press method

This method requires a carver press, a balance and paper towels. Annex 4

Step 1

Grind 20 to 30 g of fresh, cooled potato chips in a mortar and pestle or other suitable apparatus and thoroughly mix the sample.

Step 2

Place paper towels in the bottom of the sample chamber to absorb the expressed oil.

Step 3

Weigh a sample of about 10 g of the ground chips (record the data as initial weight) and place it in the sample chamber.

Step 4

Place the piston portion of the assembly on the sample and chamber.

Step 5

Place the entire assembly in the press and pump it up at a rate of one stroke per two seconds until the pressure reaches 15,000 pounds/inch2 (psi).

Step 6

Allow 20 seconds for the pressure in the press to drop off and then pump it back up to 15,000 psi.

Step 7

Set the timer for three minutes.

Step 8

At the end of three minutes, release the pressure and remove the sample cake from the chamber. Take great care to not to leave any of the cake behind and not to take any oil with the cake.

Step 9

Weigh the sample cake (record the data as final weight).

Step 10

Determine oil content in a 10g sample with the following formula:

*Oil absorption =100-[(weight final / weight initial)*100]*

Note: Percentage oil content less than 25% are considered acceptable.

5.1 Data recording

You should record and compute data for both chipping color and oil absorption in HIHAP software.

5.2 Data analysis

Chip darkening data are considered quantitative ordinal data and are analyzed with nonparametric analysis. Values of entries are compared using the Friedman, Durbin or Kruskal Wallis tests (Conover, 1999).

The variable “absorbed oil in a 10 g sample” is analyzed using variance analysis (ANOVA) and means are compared using statistical comparison tests such as LSD, Tukey or Waller-Duncan. Orthogonal contrasts (obtained by using the Dunnett test) can be used to compare the performance of the clone with the performance of the control(s).

These analyses can be performed using R or other statistical packages. HIDAP, which uses the R package, gives analysis and reports on the results.

5.3 Selection criteria

Light colored chips are preferred, with degree of darkening up to 3 usually accepted by the industry.

Oil used in the manufacture of potato chips or other fried potato products may be one of the most costly ingredients. Excessive oiliness in fried products indicates not only a poor quality product, but also the loss of an expensive ingredient. Excessive oil results in greasy or oily chips-- traits that are undesirable to the consumer. Oil absorption greater than 40% is considered unacceptable.

6. Texture and flavor components of cooking quality

Cooking quality evaluations of boiled potato tubers is performed with the aid of a trained taste panel consisting of 6-12 members, whose combined judgement will minimize any individual sensitivity variation error in the outcome of every single test. A numerical scoring method is available to perform flavor evaluation:

1. The selection of a tasting panel should be trained to differentiate color, texture and flavor of cooked potatoes, and local varieties of good and poor cooking quality should be used as controls.
2. A 3-6 tuber sample is selected. Tubers should be free of diseases, undamaged and washed free of soil and debris. A code is assigned a code to each entry and the relation recorded (it is not recommended to evaluate by known names or identifiers). If a microwave is used, wrap each in a paper towel, then wet the samples with water and drain them with the hands
3. Cook in microwave oven (full power) for 10½' (the time recommended for 3 medium potatoes of approximately 7.5 cm diameter). At mid time, turn the potatoes to reach a uniform cooking.
4. For boiling, tubers are placed in boiling water until a pin/probe penetrates the tissue, and the average time needed for the stem and bud ends to cook is recorded.
5. Immediately after cooking, wrap the potatoes in aluminum thin foil to keep hot until evaluation.
6. At the evaluation moment cut one tuber in half for each panelist.
7. A numerical scale sheet of organoleptic evaluation for cooked potatoes is presented **(Annex 7).** The values to score are written in parenthesis and the rating for each sample is the total score for the six components.

7. Bibliography

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8. Annexes

Annex 1. Variable observed and calculated for Dry matter Content

Name of Variable	Abbreviation	Formula	Unit
Fresh weight of tuber sample 1	FWTS1		g
Fresh weight of tuber sample 2	FWTS2		g
Dry weight of tuber sample 1	DWTS1		g
Dry weight of tuber sample 2	DWTS2		g
Dry Matter Content Sample1	DM1	(Dry weight of tuber sample 1/Fresh weight of tuber sample 1)*100	Percentage
Dry Matter Content Sample2	DM2	(Dry weight of tuber sample 2/Fresh weight of tuber sample 2)*100	Percentage
Average Dry Matter	AVDM	(Dry Matter Content Sample 1+Dry Matter Content Sample 2)/2	Percentage

Annex 2. Variable observed and calculated for specific gravity

Name of Variable	Abbreviation	Formula	Unit
Tuber weight in air	TWA		g
Tuber weight in water	TWW		g
Specific Gravity	SG	Tuber weight in air/ (Tuber weight in air-Tuber weight in water)	

Annex 3. Effect of specific gravity of potato on yield and oil content of chip

Specific gravity	Dry matter	Percent water	Yield of chips percent	Oil content of chips
1.065	16.6	81.7	29.22	45.71
1.07	17.7	80.8	30	44.38
1.075	18.8	79.8	30.78	43.05
1.08	19.9	78.8	31.56	41.72
1.085	21	78	32.23	40.39
1.09	22	77	33.11	39.06
1.095	23	76.1	33.89	37.73
1.1	24	75.1	34.67	36.4
1.105	25	74.2	35.45	35.07

Annex 4. Variable observed and calculated for Oil Content

Name of Variable	Abbreviation	Method of measure	Unit
Initial weight sample 1	IWS1	Grind 20 to 30 g of fresh, cooled potato chips in a mortar and pestle and thoroughly mix the sample. Weigh a sample of about 10 g of the ground chips (record the data as initial weight) and place it in the sample chamber.	
Initial weight sample 2	IWS2	Grind 20 to 30 g of fresh, cooled potato chips in a mortar and pestle and thoroughly mix the sample, weigh a second sample of about 10 g of the ground chips and place it in the sample chamber.	
Final weight sample 1	FWS1	It is weight the sample 1 obtained after use a carver press (pressure reaches 15,000 pounds/inch2 (psi) per two times)	
Final weight sample 2	FWS2	It is weight the sample 2 obtained after use a carver press (pressure reaches 15,000 pounds/inch2 (psi) per two times)	
Oil Content Sample1 Percentage	OCS1	100 - [(Final weight sample 1/ Initial weight sample 1)*100]	%
Oil Content Sample2 Percentage	OCS2	100 - [(Final weight sample2/ Initial weight sample2)*100]	%
Average Oil Content Percentage	AOCP	[(Oil Content Sample1 Percentage + Oil Content Sample2 Percentage)/2]	%

Annex 5. Variable of complete analysis of soils

Name of Variable	Abbreviation	Formula	Unit
Date	DATE		
Requester	RQSTR		
Operator	OPRTR		
Latitude	LATD		
Longitude	LOND		
Laboratory code	LabCo		
Sample code	SCo		
Field code	FDCo		
Soil pH	pH		
Electrical conductivity	EC		mhos/cm
Calcium Carbonate	$CaCO_3$		percentage
Organic matter	MO		percentage
Total nitrogen	N		percentage
Extractable Phosphorus	P		ppm
Extractable Potassium	K		ppm
Base Saturation	BS		percentage
Sand	Sand		percentage
Silt	Silt		percentage
Clay	Clay		percentage
Soil texture	STEX		
Cation exchange capacity	CEC		Meq/100g
Exchangeable Calcium	ExCa2	Ca^{+2}	Meq/100g
Exchangeable Magnesium	ExMg2	Mg^{+2}	Meq/100g
Exchangeable Potassium	ExK	K^{+2}	Meq/100g
Exchangeable Sodium	ExNa	Na^{+2}	Meq/100g
Exchangeable Aluminium + hidrogenum	ExAl3_H+	Al3_H+	Meq/100g
Total Cations	TCA	$ExCa_2$+$ExMg_2$+ExK+ExNa+$ExAl_3$_H	Meq/100g
Total Anions	TAN	$ExCa_2$+$ExMg_2$+ExK+ExNa	Meq/100g
Soluble Calcium	Ca	Ca^{+2}	Meq/ L
Soluble Magnesium	Mg	Mg^{+2}	Meq/ L
Soluble Potasium	K	K^{+2}	Meq/ L
Soluble Sodium	Na	Na^{+2}	Meq/ L
Soluble Chloride	Cl	Cl	Meq/ L
Soluble Carbonate	Sol_Ca	CO3=	Meq/ L
Soluble Bicarbonate	Sol_Mg		Meq/ L
Soluble Nitrate	Sol_K	NO3-	Meq/ L
Soluble Sulfate	Sol_Na		Meq/ L
Soluble Phosphate	Sol_Cl		Meq/ L

Soluble Boron	CO3		ppm
Iron	(CO3)2		ppm
Zinc	NO4		ppm
Copper	Cu		ppm
Manganese	Mn		ppm
Gypsum content	GC		Meq/ L
Water capacity retention	WCR		percentage
Capacity field	CC		percentage
Wilted point	WP		percentage
Soil temperature	SoTEM		

Annex 6. Variable observed and calculated for Glucose concentration (GLU)

Name of Variable	Abbreviation	Formula	Unit
Glucose concentration evaluation 1	GLU_Ev1		mg/dL
Glucose concentration Percentage evaluation 1	PGL_Ev1	Accu-check = 0.000705(Glucose_Ev1) + 0.00453 OneTouch=0.000741(Glucose_Ev1) - 0.00713	%
Glucose concentration evaluation 2	GLU_Ev2		mg/dL
Glucose concentration Percentage evaluation 2	PGL_Ev2	Accu-check = 0.000705(Glucose_Ev2) + 0.00453 OneTouch=0.000741(Glucose_Ev2) - 0.00713	%
Tuber Glucose Concentration Average	AGLU	(GLU_Ev1 + GLU_Ev2)/2	mg/dL
Tuber Glucose Concentration Average Percentage	APGL	(PGL_Ev1 + PGL_Ev2)/2	%

Annex 7. Evaluated parameters of weather

Name of Variable	Abbreviation	Formula	Unit
Date	DATE		
Hour of weather observation	HOURW		
Mean temperature	Tmean		°C - °F
Relative humidity	Rhum		Percentage
Total precipitation	Prec		mm/day
Maximum air temperature	Tmax		°C - °F
Minimum air temperature	Tmin		°C - °F
High-Resolution Temperature	High-Res Temp		°C - °F
Dew point temperature	Tdew		°C - °F
Total photosynthetic radiation (PAR)	PAR	PAR	w/m2 o uE
Total evapotranspiration	Evap		mm/day
Total solar radiation	Rad		w/m2
Barometric Pressure	Vap		mmHg o Hpa
Total sunshine hours	ssh		hours
Total wind run	wnd		m/s
Wind direction	wndd		direction
Soil Temperature	Tsoil		°C
Water Content	WaC		m^3/m^3(LOC:)
Mean temperature	Tmed		°C
Maximum air temperature	Tmax		°C
Minimum air temperature	Tmin		°C
Diurnal temperature range	dtr		°C
Night radiative cooling	Nrc		°C
Solar radiation	Rad		w/m2
Photoperiod	PhotoP		hours
Hour of Sunrise	Hss		hours
Hour of Sunset	Hps		hours
Maximum Relative humidity	Rhmax		%
Minimum Relative humidity	Rhmin		%
Evapotranspiration	Evap		mm/day

Annex 8. Format of the organoleptic evaluation for cooked potatoes

FRENCH FRY SCORE SHEET										
Test number: _____ **Panelist:** _____ **Date:** _____										
For each sample, and for each quality factor, indicate your assessment by making a cross (X) in the square opposite to your assessment and vertically bellow the sample number. Assess external appearance for ALL samples at the beginning, before assessing other factors for each sample.										
Factor	**Sample number**									
External appearance (overall appearance of the entire sample)										
Excellent										
Very good										
Good										
Fair										
Poor										
External color (overall appearance of the entire sample)										
Light, whitish										
Light golden										
Golden										
Slightly brown										
Dark										
Internal color (break, open the fries)										
Bright, white, 'crystaline'										
Bright, white										
Off-white, 'opaque'										
Greyish										
Dark grey										
Texture (mealiness) of outside strips										
Crispy										
Moderately crispy										
Moderately soggy										
Soggy										
Texture (mealiness) of inside strips										
Mealy										
Moderately mealy/soggy										
Slightly mealy/soggy										
Soggy										
Very soggy										
Overall french fry quality	0	0	0	0	0	0	0	0	0	0

Annex 9. Format of the organoleptic evaluation for cooked potatoes

First Name	
Last Name	
Date	
Code	
Gender	

Characterist	First Turn									Second Turn								
Darkness																		
None																		
slight dark																		
Moderate darkness																		
high darkness																		
Extreme darkness																		
Texture																		
Extremately dry																		
Very dry																		
Moderately dry																		
Intermediate (dry / moist)																		
Moderate moisture																		
Very moist																		
Extremely moist																		
Flavor																		
Very tasteful																		
Tasteful																		
Moderately tasteful																		
Intermediate (tasteful/unpleasant)																		
Moderately unpleasant																		
Unpleasant																		
Very unpleasant																		
Strange flavor																		
None																		
Slight																		
Moderate																		
Plenty																		
Extreme																		

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CIP is a research-for-development organization with a focus on potato, sweetpotato and Andean roots and tubers. It delivers innovative science-based solutions to enhance access to affordable nutritious food, foster inclusive sustainable business and employment growth, and drive the climate resilience of root and tuber agri-food systems. Headquartered in Lima, Peru, CIP has a research presence in more than 20 countries in Africa, Asia and Latin America.
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For more information, please contact CIP Headquarters. Av. La Molina 1895, La Molina. Apartado 1558, Lima 12, Peru.

+51 1 3496017 *cip-cpad@cgiar.org* *www.cipotato.org* *@cipotato* *@Cipotato* *@cip_cipotato*