HOT PEPPERS: XII. TOWARDS A QUALITY ASSURANCE MODEL FOR CARIBBEAN HOT PEPPER (*CAPSICUM CHINENSIS* L.) FRESH FRUITS AND PROCESSED PRODUCTS.

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Caribbean Hot peppers

- very pungent
- flavorful
- fresh European, UK and North American markets
- Process local [seasonal]

issues Caribbean peppers

- variability
  - inconsistency
  - yield
  - pungency
  - colour
- no grading criteria for color or pungency

Standard for Quality Assurance [QA]

- color descriptors

- quantification of “hotness”

- relative pungency

Processing

- mash
- chilli powder   [fairly consistent quality]
- No standards for color or pungency.

Grades

1. US grades of (Sweet Peppers)
2. black pepper (*Piper nigrum*)
3. Codex Standard for Fresh chilli peppers

geography based characterization

- Jamaica’s Scotch Bonnet,
- Trinidad’s Scorpion,
- Guyana’s Wiri Wiri
- Bahamas’s Goat Peppers.


Brown Congo
Habanero
Jalapeño
Scorpion
Chilli
7-Pot
Carvalho Hot
Scotch Bonnet
Bhut Jolokia

QA standards

- Advantages
  - *incentive*
  - *labelling*
  - *relative pungency i.e.*
    - mild,
    - hot,
    - extremely hot.

proposed model

development of a processing industry for

- *chilli powder,*
- *flakes and sauces*

- ■ Quantitative
  - *colour and [capsaicin]*
- ■ standard for Caribbean fresh hot peppers
  - *flavor/pungency/ colour*
  - *Certification*
    - ■ Variety
    - ■ Geographic
    - ■ Farmer

proposed model

- main Quantitative factors

i. Fruit colour [FC]

ii. Fruit morphology [FM]

iii. Relative pungency [Rp]

Quality Assurance [QA]

- QA = FC + FM + Rp
  - colour [FC],
  - Fruit morphology [M]
  - **Relative pungency [FM]**

i. Fruit Color [FC]

- color of pericarps descriptors
- [FDA and EU food grade colors]

- **FC = L* + a* + b* + Ho**

$$FC = L^* + a^* + b^* + Ho$$

- lightness (L*),
- redness (a*),
- yellowness (b*)
- Hue angle (Ho) = arctan b*/a *

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Colour standard for whole fresh Caribbean hot peppers using colorimeter

F_C	Pericarp colour	L*	a*	b*	CI	H°
F_R	Red	51.29	-18.11	32.54	1664.9	34.4
F_G	Green	51.29	-18.11	32.54	-928.8	120.2
F_Y	Yellow	62.91	18.57	56.23	1168.2	71.7
F_B	brown	29.43	9.15	2.25	269.2	13.8

CIEB standard for absorbance [460 nm in UV–VIS dual beam spectrophotometer] and total and oleoresin extractable color

pericarp colour	Oleoresin extractable color		Total extractable color		
	Absorbance (460nm)	(ASTA units)	Absorbance (460nm)	(ASTA units)	PACI 1
F_R	0.07	11.80	1.008	1653.12	933.71
F_G	0.02	4.75	0.406	665.84	-413.9
F_Y	0.50	82.49	7.042	11548.88	366.90
F_B	0.60	98.72	8.428	13821.92	324.72

Chilli pepper in flakes and powder standards

Chilli pepper in flakes and powder standards

PEPPER	Product	L*	a*	b*	Hue angle
Chilli peppers	fresh (Green)	43.15	-16.93	27.34	58.23
	Air-dried Sliced	27.90	16.43	20.61	51.43
	Whole (aged) Dry	44.97	5.46	5.59	45.67
	Ground Powder	46.98	15.09	17.18	48.70
	Freeze-dried flakes	44.22	15.35	7.76	44.93
Carvahlo hot	Grinding	36.62	27.79	12.20	23.70
	Whole (aged) Dry	28.00	21.29	4.93	13.03
	Air-dried Sliced	36.62	27.79	12.20	23.70
	Freeze-dried flakes	46.53	25.35	15.22	30.98
	Ground Powder	44.22	25.35	6.76	14.93
	Mean [SE]	39.92	16.30	12.98 2.29	23.9 10.2

Pepper mash color retention standards

Pepper mash color retention standards.

Preserving agent	L*	a*	b*	hue
Acetic Acid	31.83	11.79	6.54	29.01
Alcohol	33.46	10.03	6.10	31.30
Citric Acid	36.16	7.69	13.48	60.29
Control	36.24	6.59	13.29	63.62
Sodium Benzoate	31.35	9.08	6.21	34.36
X [SE]	33.2 [0.479]	7.8 [0.594]	8.7 [0.743]	29.01

Fruit morphology [FM]

■

FM = FQ + FD :

- **FQ = St + Ap + Sh + Fl + Ar:**
- **FD = Ln + W + L + S + Pl + Pe + OY**

CARVALHO HOT BROWN CONGO GREEN SCOTCH BONNET YELLOW SCOTCH BONNET

fruit dimension [FD]

- **FD = Ln + W + L + S + Pl + Pe + OY:**
  - *length (Ln)*
  - *width (W)*
  - *nos of lobules (L)*
  - *seed nos (S) per fruit*
  - *placenta wt. (Pl)*
  - *pericarp thickness (Pe)*
  - *fixed Oil (OY) yield*

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Selected fruit dimension [FD] of landraces of hot peppers

FD = L + W + L + S + Pl + Pe + OY

FD : Fruit dimension	Landraces									
	Scotch Bonnet	Seven Pot	Carvahlo Hot‘	Bhut Jolokia	Habanero	Scorpion	Chilli	Bird	Jalapeno	x [S.E ±]
Length [cm]	3.1	2.8	2.9	7	3.2	5.3	11.3	3.68	5.7	5.07 [1.062]
Width [cm]	2.7	2.6	2.8	2	2.6	1.62	1.8	0.8	1.8	2.16 [0.367]
Nos. Lobules	3	4	3	3	3	4	1	1	1	2.75 [0.817]
Nos. Seed.fruit^{-1}	118	72	69	27	79	26	44	29	36	58.87 [33.5]
Placenta wt. [g]	0.34	0.41	0.9	0.32	0.39	0.61	0.79	0.07	0.21	0.49 [0.055]
Skin thickness	1	1	2	1.82	1.4	1.1	1.9	0.11	1.7	1.49 [0.286]
Oil yield.100g^{-1}	3.5	5.0	9.0	6.0	4.0	5.0	1.0		1.0	4.31 [1.021]

Fruit Quality [FQ]

- FQ = St + Ap + Sh + Fl + Ar:
  - *St : Skin texture*
  - *Ap : Appearance*
  - *Sh : Shape*
  - *Fl : Flavour*
  - *Ar: Aroma*

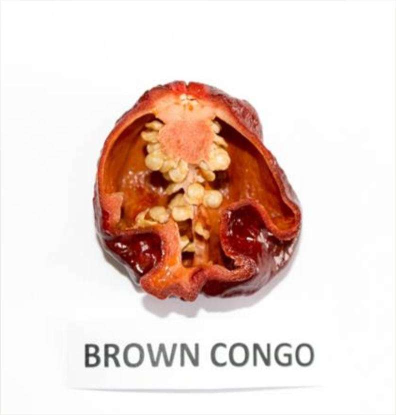

Table 3. Fruits quality [FQ] characteristics of hot pepper landraces.

FQ Characteristics	Hot pepper Landraces								
	Scotch Bonnet	Seven Pot	‘Carvahlo Hot’	Bhut Jolokia	Habanero	Scorpion	Bird	Chilli	Jalapeno
Skin texture	Smooth, firm	Rough, firm	Very rough, firm	Rough, thin membrane	Smooth, firm	Rough, thin membrane	smooth	Smooth, firm	Smooth, firm
Appearance	Vivid, glossy	Vivid	Vivid	Vivid	Waxy, glossy	Vivid	Slight sheen	Vivid, waxy, glossy,	Waxy, glossy,
Shape	Globular	Globular	Globular tapered end	Triangulate elongated, tapered end	Globular	Triangulate elongated, tapered end	Conical Tapered end	Elongated, cylindrical, tapered end	Elliptical, elongated, tapered end
Flavour	Hot	Very hot	Extremely hot	Very hot	Hot	Very hot	hot	Hot, fruity	Medium heat, fruity
Aroma	Mild	Pungent	Very pungent	Pungent	Mild	Pungent	Medium	Medium	Medium, fruity

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Relative pungency [Rp]

- **Rp = RA + Cc + Dc**
  - capsaicin [Cc]
  - dihydrocapsaicin [Dc]
    - U3000-HPLC
- Relative area (Ra)
- pungency conversion :
  - fixed Oil (OY)
  - [capsaicinoids]
  - Scoville Heat Units (SHU)/μg

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Calibration data of the HPLC method for the determination of capsaicinoids (µg/g). of 10 Caribbean Hot peppers

Landraces	**RA** Rel. Area %	**Cc** Capsaicin concentration (mg/ml	**Dc** Dihydrocapsaicin concentration (mg/ml
Scorpion	78.02	1.61	0.46
Chilli	78.22	0.12	0.04
Cherry	86.88	0.09	0.02
Scotch Bonnet	77.99	0.18	0.05
Carvahlo Hot‘	74.11	0.79	0.28
Jalapeno	57.74	0.09	0.07
Kiri-kiri	82.83	0.45	0.10
Bird	78.31	0.10	0.03
Bhut Jolokia	73.32	0.37	0.14
Seven Pot	71.99	0.78	0.30
Habanero	78.03	0.27	0.08
Capsaicin	100.00	1.20	
Dihydrocapsaicin	0.41	0.01	

Quality Assurance Model for Caribbean hot pepper fresh fruits and processed products

- QA = FC + FM + Rp
  - colour [FC],
  - Fruit morphology [FM]
  - **Relative pungency** [*Rp*]

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Thank you

have a peppery day
have a ‘Trinidad Scorpion’

Paper

Hot Peppers: XII. Towards a Quality Assurance Model for Caribbean hot pepper (*Capsicum chinensis* L.) fresh fruits and processed products.

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Abstract

The sustainable cultivation and international marketing of Caribbean hot pepper fruits and processed products needs to maintain consistency for pungency, color and fruit characteristics. This will allow them to be more viable and competitive and also to maintain the unique Geo-brand of the different island peppers. This paper proposed a Quality Assurance model [$\mathbf{Q_A = F_C + F_M + Rp}$] which is predicated on the sum relationship of fruit colour [$\mathbf{F_C}$], Fruit morphology [$\mathbf{F_M}$] and Relative pungency [$\mathbf{F_M}$]. The model further ascribed for each main factor, the qualitative [$\mathbf{F_Q}$]and quantitative [$\mathbf{F_D}$] sub-factors that contributed to it. The model used colorimetric testing, microbial evaluation, and HPLC analysis for colour, fruit morphological characteristics, capsaicin content and risk of spoilage for both fresh and processed products. The standard for Caribbean fresh hot peppers was validated on both fresh and processed products, and now ready for commercial evaluation.

Kew words: Quality Assurance model, Relative pungency, Capsaicin.

Towards a Quality Assurance Model for Caribbean hot pepper fresh fruits And processed products.

Introduction

The Caribbean produces several very pungent peppers which are exported for the fresh European, UK and North American markets or as hot sauces (Bridgemohan *et al*., 2017). The major local food processors use some of the fresh fruits which is available seasonally, but also import a significant amount of pepper mash, flakes and chili powder. However, the local farmers have not done any processing during periods of high production/low market prices to access this local market (Mohamed and Bridgemohan, 2014).

There are issues of variability and inconsistency in yield, pungency and colour retention with Caribbean peppers. The farmers trade their produce based on fresh weight and volume of wholesome fruits and there is no grading criteria for color or pungency (Mohammed *et al.*, 2016). There is a gap in the value chain between the farmers, consumer of fresh fruit and processors using products. Farmers engaged in the export trade are faced with significant financial losses due to the microbial infection and loss of fruit quality or color loss eg. shriveling of immature fruits (Mohammed *et al.*, 2014).

There is an absence of a quality standard proper for color descriptors or quantification of "hotness" or relative pungency of hot pepper fruits or processed products. This will impact in the variability in taste/flavor and relative pungency between farmers, seasons, harvests, and processed products varieties (Bridgemohan *et al*., 2016). Currently, Processor use imported mash with preservatives or chilli powder and these are fairly consistent in quality. However, local farmers who desire to pursue processing are challenged by absence of standards for color or pungency.

Internationally, the US grades of Peppers (other than Sweet Peppers) classed the fruits as U.S. Fancy, and U.S. No. 1 and 2 based on mature peppers of similar varietal characteristics of varieties and/or colors), and free pest and disease, injury, and discoloration (Anon, 2011; Neibauer and Maynard, 2002**).** Grades and standards exist for black pepper (*Piper nigrum*) as these are traded on the international spice market (Nam, 2008**).** The only other standard is reported by González-Estrada T (2011) as a Codex Standard for fresh chilli peppers grown from *Capsicum spp.*, of the *Solanaceae* family. This was similar to the US system and was categorized on Class I and II and Extra Class,

Additionally, there is an absence of geography based characterization of some Caribbean peppers, e.g. Jamaica's Scotch Bonnet, Trinidad's Scorpion, Guyana's Wiri Wiri and or Bahamas's Goat Peppers. This is more complicated when they are cultivated and marketed outside the home territory and the authenticity of the quality is questioned.

The absence of an established standard for Quality Assurance [QA] for Caribbean hot pepper fruit Production and processing has affected the grades and price, entry into foreign markets, and also has de-incentivized farmers from increasing their production base. Both farmers and processors can be assured of the consistency of quality characteristics for the variety based on a QA model. The trade in fresh pepper can be based on a qualitative/number system e.g. No 20 Scotch Bonnet which can denote 20 fruits/100g. It will serve as a guide on fruit colour, pericarp, placenta, weight, size, in addition to establish the Capsaicin content and Scoville heat units.

Generally, QA standards allow for agencies to provide incentive / subsidies for farmers to produce for higher price and quality based on quotas. This will also allow for the improved labelling for fruits so that consumers are aware of the relative pungency i.e. mild, hot, extremely hot. This proposed model will provide for the development of a processing industry for chilli powder, flakes and sauces based on colour and capsaicin content. This paper proposed a model for the development of a standard for Caribbean fresh hot peppers based on flavor/pungency, colour and certification of variety, and validated it on both fresh and processed products.

Materials and methods

The Quality Assurance **[QA]** Model for Caribbean hot peppers production and processing was developed based on several studies conducted at the Waterloo Research Campus of the University of Trinidad and Tobago [UTT} and published in several international journals. The series of experiments were conducted during the period 2010 to 2018, both at UTT and the University of the West Indies [UWI]. All the fruits from the different varieties / landraces utilized in the study were cultivated on site using the normal agronomic practices, under both the greenhouse and field conditions. All the crops are grown with minimum pesticide inputs and were treated with micro-fertigation (Bridgemohan *et al*., 2017).

The 3 main factors in the proposed model were:

i. Fruit colour **[F_C]**

ii. Fruit morphology **[F_M]** , and

iii. Relative pungency [Rp]

The Quality Assurance [**Q_A** **]** model is predicated on the sum relationship of fruit colour [**F_C**], Fruit morphology [**F_M**] and Relative pungency **[F_M**]. This was based on a standards for fresh and processed peppers products (Eqn.1). The model further ascribed for each main factor, the qualitative and quantitative sub-factors that contribute to it.

$$Q_A = F_C + F_M + Rp \qquad \text{Equation 1}$$

i. Fruit Color [F_C]

The color of the pericarps were based on descriptors used by the FDA (Anon, 2007; 2017) and EU food grade colors . The pericarp color for the ten varieties was determined using HunterLab ((Hunter et al., 1987). The changes or loss of pigments were determined by color reflectance from a colorimeter for lightness (**L*),** redness (**a*),** and yellowness **(b*) (** Kim and Chun, 1975; Hu and Xia, 2011**).** Jung *et al*. (2011) found the colorimeter to be effective to determine a* (reflected light in the red-to-green color spectrum) of the **L*a*b*** uniform color scale for pepper spray potency (Eqn.2). The Hue angle **(H°)** for each sample was also computed as **arctan b*/a *** (Sreenarayanam, 2000 ; Romano et al., 2011).

$$F_C = L^* + a^* + b^* + CI + H^o .\qquad \text{Equation 2}$$

ii. Fruit morphology [F_M]

The Fruit morphology **[F_M]** was computed based on both qualitative and quantitative sub-factors of fruit dimension [F_D] and fruit quality [F_Q] (Eqns., 3,4, and 5). The mature ripe peppers F_D used were *viz*: length (**Ln**), width [**W**], number of lobules (**L**) , seed number (**S**) per fruit^{-1}, placenta wt. [**Pl**], pericarp thickness [**Pe**], and fixed Oil (**OY**) yield [ml/100g] according to (Krishna (2004). The F_Q used were to describe color and skin texture description according to Valls **(2007**) and Mohamed (a &b, 2014). The model for fruit morphology was proposed as :

$$F_M = F_Q + F_D, \text{ where} \qquad \text{Equation 3}$$

$$F_Q = St + Ap + Sh + Fl + Ar \qquad \text{Equation 4}$$

$$F_D = Ln + W + L + S + Pl + Pe + OY \qquad \text{Equation 5}$$

iii. Relative pungency [Rp]

The relative pungency **[Rp]** is based (Eqn. 6) on the quantitative determination of the capsaicin **(Cc**) and dihydrocapsaicin (**Dc**) content using the U3000-HPLC high performance liquid chromatography (HPLC), and standard curves which were generated by plotting peak area against concentration to calculate the Relative area (**Ra**) (Bridgemohan *et al.*, 2016; 2017). The pungency was computed based on the conversion of fixed Oil (**Fo**) and the total concentration of capsaicinoids to Scoville Heat Units (SHU)/µg (Canto-Flick *et al.*,2008; Bridgemohan *et al.*, 2017).

$$Rp = R_A + C_c + D_c \quad \text{Equation 6}$$

The model was applied and tested on both fresh and processed pepper products such as flakes, powder and mash. The freeze- and oven- dried lakes were vacuum packed [Vamaster VP210] to reduce atmospheric oxygen, thus inhibiting microbial growth and preventing the evaporation of volatile components (Akhtar and Pandey, 2015). The mash were made from fresh sanitized peppers and were treated with different preserving agents *viz*: acetic acid, citric acid, alcohol, or sodium benzoate.

Results and discussion.

i. Fruit Color [F_C]

The four major colors spectrum of Caribbean hot peppers were used to calibrate the color scheme and to set the standards for the quantification of colors for all other pepper fruits based on the model :

$$F_C = L^* + a^* + b^* + CI + H^o . \quad \text{Equation 2}$$

The color of the pericarp of were represented by the following varieties / landraces [Table 1] : Carvalho hot (Red = F_R); Chili & Scotch bonnet (Green = F_G); Scotch bonnet Scotch bonnet (Yellow = F_Y) ; and Congo (brown = F_B). The standards of the whole fruits were based on the "**L" value which** ranged from brown pericarp [29.43 , and was lower than that for red [42.77] , compared to mature green [29] or yellow fruits [62.91]. The highest **a*** value (38.46) demonstrated the most redness (cv. Carvalho hot), while the Hue angle determined the color purity. The red peppers [F_R] had hue angle of 34.4^0 with a red color intensity **[CI]** of 1644.9, compared to the yellow[F_Y] (71^0()or green [F_G] (120^0]. The total extractable color [Table 2] based on the Absorbance (460nm) ranged from 665.8 (green) to 1382.92 (brown) ASTA units indicating that carotenoid pigments for red coloration was higher than of commercial paprika (2151 ASTA units) (Nieto-Sandoval, 1999).

ii. Fruit morphology [F_M]

There is close relationship between fruit quality and dimension in the sub-factors : $F_M = F_Q + F_D$ [Eqn 3], where the pericarp texture [**Pe**] which varied between smooth and very rough. It is confirmed that the more rough skin was associated with greater to flavour and pungency [**Rp**] (Table 3, Eqn 5). Most of the fruits appearance [**Ap**]are globular and rounded, with cv. Scotch Bonnet possessing a distinct bonnet at the base of the fruit. Three of the pepper landraces were longer [**Ln**] with tapered ends (Carvahlo, Bhut Jalokia, and Scorpion) and these were classified as very hot to extremely hot (Bridgemohan *et al.,* 2017). The tapered ends are described as the 'scorpion tail' and is observed to be the hottest peppers. The F_D [Eqn 5] of the other fruits had 3 or more lobules [**L**]with Carvalho having the highest placenta **[Pl**] weight (9g) compared to Scorpion and Chilli. While the mean number of seed **[S**]per fruit was 58, Seven Pot, Carvalho and Habanero produced in excess of 69 seeds / fruit (Table 4). The **[RA**] is directly related to the [**PL**] and [**S]** and influenced the pungency.

Scorpion, had a placenta [**Pl**] weight 2 to 3 times greater than all other peppers. This suggest that within the pepper fruit, as in the case of Seven Pot, capsaicinoids [**Cc**] can accumulate along the epidermal cells of the interlocular septum, derived from the tissue connecting the placenta [**Pl**] to the pericarp [**Pe**] (Judd et al., 1999). In the more pungent landraces, there were marked epidermal protrusions or rough skin which arises from the lifting of the cuticle layer from the cell wall during the filling of subcuticular cavities with capsaicinoids (Rao and Paran, 2003).

iii. Capsaicin content

The Fixed Oil [**OY**] content is a complex of all the capsaicinoids [**Cc** and **Dc**] which were mainly capsaicins (homo-, dihydro-, nordihydro- and homodihydro-capsaicins) but also included other aromatic compounds which add to the flavour and pungency **[Rp**] of the fruit. The **OY** of Carvahlo hot' is high (9.0 ml) and has the potential for pharmaceutical use (Bridgemohan etal, 2017) compared to Bhut Jalokai (6.0 ml) and other seven pepper landraces.

The Caribbean possesses *Capsicum chinense* landraces which included some of the most pungent chili peppers in the world which. The SHU for Habanero [100,000 to 350,000 SHU](Bosland and Baral,2007; Bridgemohan etal.,2010, 2016) and Bhut Jolokia [879,953 to 927,199 SHU] are less than Trinidad Scorpion. However, when these same cultivars were grown under the experimental conditions in Trinidad, the pungency were much higher for both Habanero pepper (5,337,000 SHU) and Bhut Jolokia (7,707,000 SHU). The capsaicinoids is responsible for the pungency and the characteristic sharp taste or sensation of heat caused by the fruit when consumed (Mohammed *et al*., 2008).

Processed products development and application of the QA model.

The QA model was validated on both fresh and processed pepper products such as, flakes, Chili powder, and mash. The three problems encountered in processing hot pepper in both dry and mash forms were loss of pungency, colour retention and microbial infection. The study indicated that QA model was able to detect and monitor such changes. It was observed that were no changes to the color standards after 1000 days after processing as the two hottest peppers maintained L*= 43 to 44.

The QA model revealed that processed Carvalho hot in all the states maintained **L*** values similar to the fresh red state (42), but its lightness was reduced in the processed (30) mash. Fresh Chili maintained its greenness[$\mathbf{F_G}$] (a*= -16.93) for long period (21 days) at chilled temperatures, but deteriorated to brown[$\mathbf{F_B}$] (**a***= 5.4 to 16) after 400 days due to the drying. Carvalho maintained retained a high level of redness (**a*** reduced from 38 to 25) over the 1200 days experimental period. However, in the mash form, this was significantly reduced (**a***= 8.30) and appeared more brownish.

Generally, the model was able to monitor changes in **L*, a*** and **b*** from the fresh to freeze dry processed stage, and found that oven drying had a lighter color (L*), but blending into mash caused pigment degradation resulting in a reduction in **a*** and **b*** values. However, the Mash created over a 50% loss in color and similarly, any processing or slicing resulted in significant color loss

In the mash form, color pigmentation remained consistent. However, sodium benzoate treatments had approximately 25% reduction in “L**”** compared to the freshly harvested fruits. Both the citric acid and control (**L*=**36) retained similar color intensity to the fresh state. Further, in all the preserving agents the level of redness as indicated by **a*** was reduced by >75% and bordered on more brownish appearance with less red pigmentation probably due to oxidative reactions. On the **b*** axis, all the treatments were between 5 to 13, and were at a lower degree of yellow coloration hue associated with this axis.

In commercial pepper sauces production, pasteurization of the mash and addition of 12-15% salt has promoted color enhancement (Bozkurk and Erkman 2004). In addition to heat treatment, it is accepted that lactic acid and oxygen are other important factors that would contribute to the attainment of color development (Bozkurk and Erkman 2004). Many factors affect pepper color change during storage, and the most important is oxidative degradation of carotenoids, caused by exposure to heat, light and oxygen.

Conclusion

This study has demonstrated that the applicability and relevance of the QA model to the production and processing of the wide selection of Caribbean hot peppers. It has shown that there are potential varieties which have met the standards set by ASTA for red color and pungency. Further, the analysis based on the model revealed that Carvalho hot can be classed as is the second most pungent pepper cultivar (1.07mg capsaicinoids and 16m SHU), has no significant variation in Hue angle (13^0 - 30^0), and is similar to commercially graded paprika. The ASTA value for it in acetic acid (377 ASTA units) and in ground state are similar to the bright red state (366 ASTA units) in the fresh mature hot fruit. The pepper fruit can be used for industrial processing as mash, flakes, or powder without loss of color or pungency, thereby pinpointing a new avenue for investment.

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Table 1. Colour standard for whole fresh Caribbean hot peppers using colorimeter

F_C	Pericarp colour	L*	a*	b*	CI	H°
F_R	Red	51.29	-18.11	32.54	1664.9	34.4
F_G	Green	51.29	-18.11	32.54	-928.8	120.2
F_Y	Yellow	62.91	18.57	56.23	1168.2	71.7
F_B	brown	29.43	9.15	2.25	269.2	13.8

Table 2. CIEB standard for absorbance [460 nm in UV–VIS dual beam spectrophotometer] and total and oleoresin extractable color [ASTA units]

pericarp colour	Oleoresin extractable color		Total extractable color		
	Absorbance (460nm)	(ASTA units)	Absorbance (460nm)	(ASTA units)	PACI 1
F_R	0.07	11.80	1.008	1653.12	933.71
F_G	0.02	4.75	0.406	665.84	-413.9
F_Y	0.50	82.49	7.042	11548.88	366.90
F_B	0.60	98.72	8.428	13821.92	324.72

Table 5. Calibration data of the HPLC method for the determination of capsaicinoids (µg/g). **of 10 Caribbean Hot peppers.**

Landraces	**RA** Rel. Area %	**Cc** Capsaicin concentration (mg/ml	**Dc** Dihydrocapsaicin concentration (mg/ml
Scorpion	78.02	1.61	0.46
Chilli	78.22	0.12	0.04
Cherry	86.88	0.09	0.02
Scotch Bonnet	77.99	0.18	0.05
Carvahlo Hot'	74.11	0.79	0.28
Jalapeno	57.74	0.09	0.07
Kiri-kiri	82.83	0.45	0.10
Bird	78.31	0.10	0.03
Bhut Jolokia	73.32	0.37	0.14
Seven Pot	71.99	0.78	0.30
Habanero	78.03	0.27	0.08
Capsaicin	100.00	1.20	
Dihydrocapsaicin	0.41	0.01	
Mean	72.14	0.47	0.14
[S.E ±]	13.601	0.286	0.084

Table 6 . Chilli pepper in flakes and powder standards.

PEPPER	Product	L*	a*	b*	Hue angle
Chilli peppers	fresh (Green)	43.15	-16.93	27.34	58.23
	Air-dried Sliced	27.90	16.43	20.61	51.43
	Whole (aged) Dry	44.97	5.46	5.59	45.67
	Ground Powder	46.98	15.09	17.18	48.70
	Freeze-dried flakes	44.22	15.35	7.76	44.93
Carvahlo hot	Grinding	36.62	27.79	12.20	23.70
	Whole (aged) Dry	28.00	21.29	4.93	13.03
	Air-dried Sliced	36.62	27.79	12.20	23.70
	Freeze-dried flakes	46.53	25.35	15.22	30.98
	Ground Powder	44.22	25.35	6.76	14.93
	Mean [SE]	39.92 2.30	16.30 4.32	12.98 2.29	23.9 10.2

Table 7. Pepper mash color retention standards.

Preserving agent	L*	a*	b*	hue
Acetic Acid	31.83	11.79	6.54	29.01
Alcohol	33.46	10.03	6.10	31.30
Citric Acid	36.16	7.69	13.48	60.29
Control	36.24	6.59	13.29	63.62
Sodium Benzoate	31.35	9.08	6.21	34.36
X [SE]	33.2 [0.479]	7.8 [0.594]	8.7 [0.743]	29.01

Table 3. Fruits quality [**FQ]** characteristics of hot pepper landraces.

FQ Characteristics	**Hot pepper Landraces**								
	Scotch Bonnet	**Seven Pot**	**'Carvahlo Hot'**	**Bhut Jolokia**	**Habanero**	**Scorpion**	**Bird**	**Chilli**	**Jalapeno**
ST : Skin texture	Smooth, firm	Rough, firm	Very rough, firm	Rough, thin membrane	Smooth, firm	Rough, thin membrane	smooth	Smooth, firm	Smooth, firm
Ap : Appearance	Vivid, glossy	Vivid	Vivid	Vivid	Waxy, glossy	Vivid	Slight sheen	Vivid, waxy, glossy,	Waxy, glossy,
Sh : Shape	Globular	Globular	Globular tapered end	Triangulate elongated, tapered end	Globular	Triangulate elongated, tapered end	Conical Tapered end	Elongated, cylindrical, tapered end	Elliptical, elongated, tapered end
Fl : Flavour	Hot	Very hot	Extremely hot	Very hot	Hot	Very hot	hot	Hot, fruity	Medium heat, fruity
Ar: Aroma	Mild	Pungent	Very pungent	Pungent	Mild	Pungent	Medium	Medium	Medium, fruity

Table 4. Selected fruit **dimension [FD]** of landraces of hot peppers

FD : Fruit dimension	**Hot pepper Landraces**									
	Scotch Bonnet	Seven Pot	Carvahlo Hot'	Bhut Jolokia	Habanero	Scorpion	Chilli	Bird	Jalapeno	x [S.E ±]
L : Length [cm]	3.1	2.8	2.9	7	3.2	5.3	11.3	3.68	5.7	5.07 [1.062]
W : Width [cm]	2.7	2.6	2.8	2	2.6	1.62	1.8	0.8	1.8	2.16 [0.367]
L: Nos. Lobules	3	4	3	3	3	4	1	1	1	2.75 [0.817]
S : Nos. Seed.fruit^{-1}	118	72	69	27	79	26	44	29	36	58.87 [33.5]
Pl : Placenta wt. [g]	0.34	0.41	0.9	0.32	0.39	0.61	0.79	0.07	0.21	0.49 [0.055]
S : Skin thickness [mm]	1	1	2	1.82	1.4	1.1	1.9	0.11	1.7	1.49 [0.286]
OY : Oil yield.100g^{-1}	3.5	5.0	9.0	6.0	4.0	5.0	1.0		1.0	4.31 [1.021]

FD = L + W + L + S + Pl + Pe + OY