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Abstract

The definition of food quality has varied over time but has evolved so that current definitions are based on meeting customer demands. However, in order to better define food quality a more comprehensive evaluation based in key variables is required. This study aims to propose a Cocoa Quality Index (CQI). A better understanding of what affects cocoa quality will allow researchers and managers to improve their product, benefiting producers and consumers. The present analysis was based on known desired characteristics of the cocoa bean. Total fat, total acidity, total phenols, phenolic acids, organic acids, heavy metals, amino acids, caffeine, theobromine, pH, sugars and macro and micronutrients were the main variables included in the CQI for the *Forastero* cocoa beans. The analysis was run on beans from two separate sites in Bahia, an Oxisol and an Alfisol. CQI values from the two sites did not differ statistically, but the adopted qualitative classification identified that the Alfisol had a 'good' CQI (0.703) while the Oxisol was classified as 'regular' one (CQI = 0.652). The difference was due to the better edaphic characterists of the Alfisol. Results suggested that improving the cocoa bean in Bahia will require that total fat, phenolic compounds and glucose be increases and that total phenols, heavy metals, organic acids and caffeine be decreased. The proposed CQI method can be adapted to other agricultural products.

Keywords *Theobroma cacao* L., Food, Evaluation, Marketing, Health.

Abbreviations

CQI Cocoa Quality Index

1. Introduction

Cocoa (*Theobroma cacao* L.) is a species from the Malvaceae family, native of Central and South America tropical forests (Mororó, 2012; Müller & Valle, 2012). Among the 22 known species of the genus *Theobroma*, cacao is one of the few that is economically exploited (Sodré, 2007). Cocoa seeds, the main product from this species, are considered as a stimulant due to the presence of methylxanthines (purine alkaloids) such as theobromine and caffeine. Chocolate, extracted from the processed beans, has high nutritional and food value especially due to its high concentration of carbohydrates, lipids, proteins and more than 300 other chemically active compounds (Doran & Parkin, 1994).

Cocoa also offers benefits to human health (Araujo et al., 2013). The quality and quantity of antioxidants in cocoa are high. The flavonoids in the beans reduce the number of free radicals involded in cardiovascular and cancerous diseases (Jalil & Ismail, 2008), in addition to having "anti-aging" properties (Kelishadi, 2005). They also appear to protect neurons from damage induced by neurotoxins, to reduce neuroinflammation and to promote memory, learning and cognitive function (Nehlig, 2013). The theobromine and caffeine in the chocolate stimulate the central nervous system, increasing muscular endurance and acting as a diuretic and appetite stimulant (Kelishadi, 2005).

The theoretical concepts regarding the quality of general goods started during the Industrial Revolution (1750-1830) and have gained new dimensions after the Second World War (1939-1945). The first descriptions of obtaining an analysis system of quality for foods were conducted by several authors (Schulz & Kopke, 1992). Some related examples are reported: in agriculture (Mengel & Kirkby, 1987; Barros et al., 2004; Vieira et al., 1999; Naves et al., 2004); in forest science (Oliveira et al., 2010); in soil science (Cihacek et al., 1996; Rousseau et al., 2012; Harris et al., 1996; Doran & Parkin, 1994; Harris et al., 1996).

The search for an index to food quality has brought about conflicting points of view (Schulz & Kopke, 1992) among the different actors involved in assessing food quality such as nutrition technicians, food producers, government officials, consumers and market (Shi et al., 2005; Shiba et al., 1993). Each food product has features that can be measured by physicochemical, sensory and microbiological indices. Some features are readily apparent, others are not so obvious. Understanding the characteristics of food quality is essential to adequate food quality control. Today, food quality is a complex concept that is often measured using objective indices related to the nutritional, microbiological, physical-chemical properties of food (Cardello, 1995). However, when food quality is defined in terms of "degree of excellence", none of these measures serves as adequate indices of food quality.

Martins (1982) proposed the Food Quality Index (FQI) which was later refined by succeeding researchers resulting in Quality Function Deployment (QFD) (Benner et al., 2002).

From the standpoint of food science, the quality of a product is based on the characteristics of individual units that determine the degree of acceptance by the buyer (Urbansky, 1992). Sensory quality is defined as the acceptance of the characteristics of a product perceived by consumers who are regular users of the product category or who comprise the target market.

Food quality has been determined by three main features: external quality (ex., commercial variety), the consumption value (manufacture and manufacturing) and biological quality expressed by the balance of nutrients. The FQI (Martins, 1982) can be a good tool for developing snack menus and to complement and/or enrich diets. The FQI has been suggested for nutrition education programs.

Chemical characteristics influencing the flavor of cocoa have been studied by several researchers (Adeyeye et al., 2010; Adrian 1973; Barel et al., 1983; Reneccius et al., 1972; Rohan & Steward, 1967; Sukha et al., 2008; Zak, 1988) relating proteins and amino acids of cocoa with the post-harvest processing of cocoa beans. Other scientific research on the sensory analysis of cocoa have been described (Lopez & McDonald, 1981; Moreno et al., 2012; Urbansky, 1992; Schwan et al., 1990).

Compared with other cocoa producing countries, generally Brazilian cocoa beans are considered to develop a very weak flavor of chocolate combined with high acidity, bitterness and astringency. In general, desirable flavor such as "nutty" and "fruity" are often missing. These sensory properties predict consumer acceptance (Rohan & Steward, 1967).

The southeast region of Bahia is the largest producing area of cocoa in Brazil. Until the 1980s, Brazil was the second largest world producer of cocoa before dropping to fourth place due to a progressive reduction in planted area and changes in technological standard adopted in response to falling international prices and the spread of the disease known as witches' broom. From the 1980s until now, Brazil has gone from a net exporter to net importer of cocoa beans (Suframa, 2003).

The current market faces the question of how to assess, to identify and provide the food product that consumer wants. A tool able to help in determining the quality of cocoa beans is the development of a quality index. The quality index refers to the properties, processes and characteristics of the conditioning chemical, physical and biological analysis of the product.

Part of the recovery of the Brazilian cocoa market will depend on increasing the quality of cocoa beans. With the goal of contributing to the analysis of cocoa quality, this work aims to propose a quality index for cocoa beans.

2. Material and Methods

Cocoa beans of the *Forastero* group, known as Cacau Comum (common cocoa, the most widely spread variety of cocoa) were obtained from cocoa pods harvested from trees grown in Latosol Red-Yellow argisolic / Hapludox (Site 1: 14 ° 51 '47 "S and 39 ° 06' 47" W) and Nitosol Eutrophic typical / Hapludalf (Site 2: 46 ° 08 'S and 39 ° 13' 26 "W). The physic-chemical properties of soils are described in Table 1. The fruits were harvested under the same conditions and the cacao pods were processed (post-harvest curing) by standard procedures including fermenting 50 fruits (approximately 8 kg of fresh seeds) in a polystyrene box and drying with 36-38^{o}C air-forced ventilation.

Table 1. Chemical (A) and physical (B) attributes of the Red-Yellow Latosol argisolic (LVAd) and the Nitosol Eutrophic typical (Nxe) sites in southeast Bahia, Brazil

(A)

Site - Soil	Horizon / Depth (cm)	pH H_2O	C (g kg⁻¹)	OM (g kg⁻¹)	N (g kg⁻¹)	C/N	P (g kg⁻¹)	Sorptive Complex ($cmol_c\ dm^{-3}$) Ca^{++}	Mg^{++}	K^+	Na^+	Al^{+++}	H^+	S	CEC	V (%)	m (%)
Site 1 – Latosol	A - 00 – 10	5.7	21.0	36.2	0.31	68	1	0.9	0.7	0.26	0.06	0.1	4.6	1.92	6.62	29	5.0
	BA - 10 – 19	5.5	10.9	18.8	1.32	8	0	0.4	0.3	0.14	0.03	0.2	3.6	1.02	4.82	21	16.4
	Bw1 - 19 – 38	5.4	8.5	14.7	0.9	9	0	0.3	0.3	0.13	0.03	0.3	3.5	0.76	4.56	16	28.3
	Bw2 - 38 -128	5.1	5.4	9.3	0.76	7	0	0.1	0.2	0.09	0.02	0.1	2.8	0.41	3.31	12	19.61
	Bw3 - 128 - 200+	5.1	4.2	7.2	0.45	9	0	0	0.2	0.06	0.03	0.1	2.4	0.29	2.79	10	25.64
Site 2 - Nitosol	Ap - 00 – 11	6.2	12.2	21.0	1.09	11	5	7.1	2.6	0.06	0.08	0	5.5	9.84	15.34	64	0
	E - 11 – 22	5.4	7.9	13.6	0.62	13	7	5.3	1.4	0.03	0.1	0	5.5	6.82	12.33	55	0
	Bt1 - 22 – 39	5.5	6.0	10.3	0.59	10	9	4.9	0.9	0.02	0.12	0	4.9	5.94	10.84	54	0
	Bt2 - 39 – 76	5.5	5.8	10.0	0.42	14	11	4.0	0.8	0.01	0.11	0.2	10.1	4.92	6.22	79	0
	Bt3 - 76 – 117	5.3	2.1	3.6	0.34	6	17	1.8	1.4	0.04	0.14	0.6	7.2	11.18	11.18	30	1.34
	Bt4 -117 - 165+	5.4	3.6	6.2	0.25	14	21	2.0	2.0	0.01	0.11	1.0	7.0	9.24	9.24	44	1.95

OM = Organic Matter; S = Sum of Bases; CEC = Cation Exchange Capacity; V = Bases Saturation; m = Aluminum Saturation [100 Al / (Al + S)]

(B)

Site – Soil	Horizon / Depth (cm)	Particle Size Analysis (g kg⁻¹) Sand Gross	Sand Fine	Silt	Clay	Natural Clay (g kg⁻¹)	Silt / Clay	Texture	FD (%)	Bd (g dm⁻³)	Pd (g dm⁻³)	Pt ($m^3\ m^{-3}$)	EU ($m^3\ m^{-3}$)
Site 1 - Latosol	A - 00 – 10	418	117	199	266	19	0.73	Sandy loam	95.9	1.19	2.52	0.53	26.14
	BA - 10 – 19	327	99	218	356	88	0.52	Clay sandy loam	71	1.29	2.64	0.51	25.59
	Bw1 - 19 – 38	314	98	173	415	58	0.42	Clay	86	1.15	2.69	0.57	33.97
	Bw2 - 38 – 128	231	89	131	549	22	0.24	Clay	96	1.2	2.65	0.55	37.22
	Bw3 - 128 - 200+	200	77	180	543	23	0.33	Clay	95.8	1.12	2.54	0.56	43.61
Site 2 – Nitosol	Ap - 00 – 11	88	158	321	433	21	0.74	Clay loam	95	1.15	2.67	0.57	39.3
	E - 11 – 22	65	115	222	598	6	0.37	Clay	99	1.25	2.66	0.53	43.4
	Bt1 - 22 – 39	77	108	210	605	11	0.35	Very Clay	97	1.22	2.6	0.53	45.4
	Bt2 - 39 – 76	82	84	177	657	17	0.27	Very Clay	98	1.05	2.6	0.6	45.9
	Bt3 - 76 – 117	36	76	277	611	11	0.45	Very Clay	98	1.09	2.6	0.58	45.9
	Bt4 - 117 - 165+	53	130	340	477	9	0.71	Clay	98	1.19	2.62	0.55	47.2

FD = Floculation Degree; EU = Equivalent Humidity; Pd = Partícule Density; Bd =Bulk Density; Pt = Total Porosity

The procedure for preparation and determination of the Cocoa Quality Index (CQI) was based on adaptations of the quality index developed for soils by Karlen & Stott (referenced in Rousseau et al., 2012) adapted to be applied to food products. This was the chosen method because it could provide an integrated evaluation of a cocoa crop.

Use of the CQI involves the following steps: (1) definition of the purpose of the evaluation, (2) choose functions, (3) selection of the indicators that are related to each function, (4) definition of the relative weights of functions and indicators, (5) definition of the behavior of indicators, (6) establishement of the indicators critical limits, (7) standardization of values, (8) standardization of values between 0 and 1.0, and (9) determination of the CQI.

The functions used in the CQI are related to flavor and human health criteria wanted by industry, namely: IND - for interest to the cocoa industry / manufacturing, FLA - for the chocolate flavour, and MED - interest for medicine, human health and food safety (Table 2). Different weights were assigned to these functions such that there are a total of 100 possible points. The functions and their weights were set according to the objectives of the evaluation. Thinking about the chocolate market the highest weight was assigned to IND (weight 40), followed by FLA (weight 35) and MED (weight 25). The function variables t and respective weights are shown in Table 2.

The use of the chosen function variables indicators was based on rounds series of discussions with scientists, entrepreneurs, technical staffs and others involved in cocoa technology and quality. Organizations involved in these discussions were the Cocoa Research Center (Cepec / Ceplac), State University of Santa Cruz (UESC), State University of Campinas (Unicamp), Institute of Food Technology (ITAL), Federal Institute of Bahia (I F Baiano), Biocenter Klein Flottbek / University of Hamburg (Germany) and Centre de Coopération Internationale en Recherche Agronomique pour le Development (CIRAD) (France).

Table 2. Functions and indicators, with respective weights, selected to compose the proposed cocoa quality index

Function	Weight	1st Indicator	Weight	2nd Indicator	Weight
For the interest of Cocoa **Industry (IND)**	40	Total Fat	20		
		pH	15		
		Total acidity	20		
		Total phenols	10		
		Phenolic substances	10	Catechin	50
				Epicatechin	50
		Organic acids	10	Acético	40
				Lático	60
		Heavy metals	15	Ba	25
				Cd	25
				Pb	25
				Cu	25
For the interest of **Flavour** of the Chocolate (**FLA**)	35	Total amino acids	20		
		Caffein	15		
		Teobromin	15		
		pH	10		
		Total phenols	20		
		Organic acids	10	Acetic	40
				Lactic	60
		Sugars	20	Saccharose	20
				Fructose	40
				Glucose	40
For the interest of **Medicine** / Human health / Food security **(MED)**	25	Phenolic substances	20	Catechin	50
				Epicatechin	50
		Teobromin	15		
		Caffein	15		
		Total amino acids	10		
		Heavy metals	10	Ba	25
				Cd	25
				Pb	25
				Cu	25
		Organic acids	10	Acetic	40
				Lactic	60
		Macronutrients	10	P	20
				K	30
				Ca	30
				Mg	20
		Micronutrients	10	Si	20
				Fe	30
				Mn	20
				Zn	30

The values defined for each variable were converted into scores ranging from 0 to 1, by means of a standardized scoring function, as the following behaviors: (a) More is better, suited to standardize scores for properties (indicators) of cocoa beans into cocoa quality that is associated with higher values, (b) Less is better, for properties of cocoa beans in the cocoa quality is associated with lower values, and (c) Optimal value, for properties of cocoa beans that have a positive effect on increasing the quality of cocoa until an optimal value, from which its influence is negative (Table 3).

There was considerable difficulty in finding adequate information on universal (worldwide) critical limits values for most variables therefore, critical limits (Table 3) are based on the ranges of values obtained from the analysis of 45 composited samples of cocoa beans which were part of the project: "Linking soil quality and cocoa quality in Bahia, Brazil", coordinated by the Cocoa Research Center / Ceplac.

Table 3. Behavior and limits of the proposed indicators to the cocoa quality index

Indicator (Variable)	Unit	Behavior (expected)	Critical Limits		
			Inferior	**Medium (optimal)**	**Superior**
Caffeine (flavour)	%	Less	0.32		
Caffeine (health)	%	Optimal	0.32	0.58	0.96
Heavy metal – Ba	mg kg^{-1}	Less	1.90		
Heavy metal – Cd	mg kg^{-1}	Less	0.20		
Heavy metal – Cu	mg kg^{-1}	Less	0.68		
Heavy metal – Pb	mg kg^{-1}	Less	<4.3		
Macronutrient – Ca	g kg^{-1}	Optimal	2.21	2.65	3.09
Macronutrient – K	g kg^{-1}	Optimal	0.58	1.89	7.48
Macronutrient – Mg	g kg^{-1}	Optimal	0.16	0.20	0.24
Macronutrient – P	g kg^{-1}	Optimal	0.20	0.26	0.31
Micronutrient – Fe	mg kg^{-1}	Optimal	0.55	2.80	9.20
Micronutrient – Mn	mg kg^{-1}	Optimal	1.11	2.04	3.29
Micronutrient – Si	%	Optimal	0.04	0.16	0.47
Micronutrient – Zn	mg kg^{-1}	Optimal	2.19	2.94	4.24
Organic acid – Acetic	mg g^{-1}	Optimal	0.93	2.15	3.60
Organic acid – Lactic	mg g^{-1}	Less	0.47		
pH		Optimal	5.60	6.01	6.57
Phenolic substances – Catechin	ppm	More	82.79		
Phenolic substances – Epicatechin	ppm	More	2223.44		
Sugar – Fructose	mg g^{-1}	More	2.59		
Sugar – Glucose	mg g^{-1}	More	0.85		
Sugar – Saccharose	mg g^{-1}	Less	0.76		
Teobromine (flavour)	%	Less	2.47		
Teobromine (health)	%	Optimal	2.47	3.04	3.78
Total acidity	g 100g^{-1}	Optimal	10.53	14.95	19.37
Total amino acids	ppm	Optimal	8504.35	14230.78	20033.81
Total fat	g 100g^{-1}	More	30.77		
Total phenols	ppm	Less	45990.50		

Due to the different units of measurement used for each variable, the standardization on the observed values was resulting in scores ranging from 0 to 1. The score curves were generated from the mathematical equation employed by Glover et al. (2000), Harris et al. (1996), and Wymore (1993). The equation calculated the slope of the tangent of the score curve at the critical value of the indicator, expressed by the formula:

$$f(S) = \frac{\log\left(\frac{1}{x}\right) - 1}{\log\left(\frac{B-L}{x-L}\right) . 2(B + x - 2L)}$$

then, the following equation of Vieira et al. (1999) was applied to determine the observed values of the indicators in standard scores:

$$v = \frac{1}{1 + \left((B - L)/(x - L)\right)^{2s(B+x-2L)}}$$

Where **v** is the standardized score, **B** is the critical value of the indicator, whose standardized score is 0.5, **L** is the initial value, **S** is the slope of the tangent of the curve at the critical value of the indicator and **x** is the observed or measured value of the indicator.

After standardization of variable the cocoa quality was calculated using a model of Karlen & Stott (1994) with adaptations by Fernandes et al. (2013) and Souza et al. (2003) originally used to evaluate soil quality. The quality of cocoa was calculated in two steps:

(1) $q\ FPn = I_1\ x\ W_1 + ... + I_n\ x\ W_n$

(2) $CQI = q\ FP1\ x\ (w_1) + q\ FP2\ x\ (w_2) + ... + q\ FPn\ (w_n)$

Where ***q (FPn)*** are the main functions, $\boldsymbol{I_n}$ are the standard scores for quality indicators associated with each major function, and ***Wn*** are the weights associated with each indicator or each major function.

The calculated scores for each indicator were multiplied by the respective assigned weights. The sum of the product of the indicators for this function gave the score of the function. Likewise, for each function, the weight was multiplied by the score function, obtaining the sub-indices of performance to the function. The sum of these sub-indices gave the CQI.

In this proposal, the following classification is used for CQI: **low** if less than or equal to 0.5; **regular** (medium) is between 0.51 and 0.70; and **high** above 0.70.

An ANOVA was performed to check variations in cocoa quality depending on the soil type. The averages were compared with a Tukey test at 5% significance level, using the statistical program Assistat (Silva, 1996; Silva & Azevedo, 2009).

3. Results and Discussion

There is no significant difference between average values of CQI (Table 4) of the sites 1 (Latosol) and 2 (Nitosol). The coefficient of variation is 1.90 % and LSD equals to 0.0298. Table 4 also shows the CQI by function. In sites 1 and 2, the function IND showed the higher value of CQI comparing with the other functions, with 39 and 42% of the total possible CQI. The function MED participated with 31 and 29%, and FLA with 28 and 30% in CQI total, respectively for sites 1 and 2.

Table 4. Cocoa Quality Index of the functions in the studied sites

Functions	Site 1 – Latosol		Site 2 – Nitosol	
	CQIf	%	CQIf	%
IND	0.253	39	0.292	42
FLA	0.182	28	0.209	30
MED	0.202	31	0.202	29
CQI Sites	0.652 a		0.703 a	

Averages followed by equal letters in the inferior line (between the CQI of the sites) do not differ as per a Tukey test with a 5% probability.

In spite of no difference between average values of CQI of the sites 1 (Latosol) and 2 (Nitosol) (Table 4), considering the degree of classification adopted in this study, the site 2 had a ‘good’ CQI (0.703), while site 1 (0.652) would be considered as a ‘regular’ value (Table 4). These values can be related to differences on physical and chemical properties of soils in the study areas (Tables 1 and 2). The Nitosol (an Alfisol) showed a general superiority in important properties such as pH, cation exchange capacity, base saturation index, content of clay, porosity and humidity.

Details of these results are presented in Table 5. Total acidity was the primary indicator for IND followed by pH and total fat; indicators heavy metals and organic acids were those of less influence. In contrast, total phenols and total amino acids contributed to higher values for the CQI function for FLA t. Theobromine had no influence on this function. The MED function was mainly influenced by phenolic compounds with secondary effects from catechin and epicatechin.

In both locations, the CQI can be increased. If the interest is for IND then managers should seek to increase fat and phenolic compounds, while decreasing total phenol, lactic acid and heavy metals. If the interest is for FLA then increasing glucose and decreasing total phenols and caffeine would be beneficial. Finally, if other ones are interested in MED, they should increase phenolic compounds and reduce lactic acid and metals.

Table 5. Cocoa Quality Index to the functions and indicators of the studied sites

Function	1st Indicator	2nd Indicator	Site 1 – Latosol Observed Value	Score	Score/weight Indicator	%	CQIf	%	Site 2 – Nitosol Observed Value	Score	Score/weight Indicator	%	CQIf	%
IND	Total fat		37.27	0.536	0.107	17	**0.253**	40	39.60	0.549	0.110	15	**0.292**	41
	pH		5.71	0.753	0.113	18			6.28	0.975	0.145	20		
	Total acidity		18.71	0.727	0.145	23			14.74	0.999	0.200	27		
	Total phenols		84814.67	1.000	0.100	16			75266.17	1.000	0.100	14		
	Phenolic substances	Catechin	368.31	1.000	0.100	16			229.82	1.000	0.100	14		
		Epicatechin	12149.50	1.000					6326.84	1.000				
	Organic acids	Acético	2.10	1.000	0.045	7			1.31	0.927	0.046	6		
		Lático	0.54	0.076					0.54	0.151				
	Heavy metals	Ba	4.95	0.000	0.022	4			8.85	0.000	0.026	4		
		Cd	0.95	0.000					1.2	0.000				
		Pb	<4.3	0.500					<4.3	0.500				
		Cu	1.09	0.092					0.78	0.206				
FLA	Total amino acids		17325.05	0.834	0.167	30	**0.182**	28	16401.09	1.000	0.200	34	**0.209**	30
	Caffeine		0.48	0.224	0.034	6			0.53	0.073	0.011	2		
	Teobromine		3.44	0.000	0.000	0				0.001	0.000	0		
	pH		5.71	0.753	0.075	13			6.28	0.975	0.098	17		
	Total phenols		84814.67	1.000	0.200	36			75266.17	1.000	0.200	34		
	Organic acids	Acetic	2.10	1.000	0.045	8			1.31	0.927	0.046	8		
		Lactic	0.54	0.076					0.54	0.151				
	Sugars	Saccharose	1.04	0.080	0.042	7			1.19	0.082	0.042	7		
		Fructose	6.64	0.000					5.23	0.000				
		Glucose	2.01	1.000					1.86	1.000				
MED	Phenolic substances	Catechin	368.31	1.000	0.200	25	**0.202**	32	229.82	1.000	0.200	25	**0.202**	29
		Epicatechin	12149.50	1.000					6326.84	1.000				
	Teobromine		3.44	0.863	0.129	16			3.46	0.795	0.119	15		
	Caffeine		0.48	0.994	0.149	18			0.53	0.996	0.149	18		
	Total amino acids		17325.05	0.834	0.083	10			16401.09	1.000	0.100	12		
	Heavy metals	Ba	4.95	0.000	0.013	2			8.85	0.000	0.013	2		
		Cd	0.95	0.000					1.2	0.000				
		Pb	<4.3	0.500					<4.3	0.500				
		Cu	1.09	0.092					0.78	0.206				
	Organic acids	Acético	2.10	1.000	0.045	6			1.31	0.927	0.046	6		
		Lático	0.54	0.076					0.54	0.151				
	Macro-Nutrients	P	0.21	0.734	0.094	12			0.23	0.848		11		
		K	4.85	0.984					0.65	1.000				
		Ca	2.29	1.000					2.32	0.831				
		Mg	0.16	1.000					0.17	0.761				
	Micro-Nutrients	Si	0.14	1.000	0.094	12			0.40	1.000	0.087	11		
		Fe	1.45	1.000					2.36	0.886				
		Mn	1.3	0.710					1.66	0.960				
		Zn	2.3	1.000					2.46	0.892				
CQI							0.652						0.703	

The general lesson gained from this study is that to increase the quality of cocoa in SE Bahia researchers and managers should focus on increasing fat, phenolic compounds, fructose, and glucose; while decreasing the levels of total phenols, organic acids, metals, and caffeine.

4. Conclusions

By the proposed Cocoa Quality Index, it was possible to identify some of the specific indicators that can be changed in order to improve cocoa bean quality. The proposed method can be adapted to other food products.

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Highlights / Cocoa Quality Index - a Proposal (Araujo et al.)

An index for cocoa quality evaluation including an important (composite) pool of biochemical components is proposed.

The proposed Index can be adjusted by the interests of involved segments (ex. farmers, consumers, industry, and medicine).

The proposed Quality Index method can be adapted to other agricultural products.

The proposed Index enables to identify the specific indicators that improve or decrease the food quality.