

INFLUENCE FROM MANAGEMENT AND SOIL AND WEATHER CONDITIONS ON 'SEMIL 34' AVOCADO (*Persea americana* Mill) FRUIT QUALITY IN THE DOMINICAN REPUBLIC

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Several agricultural practices, soil and weather factors are said to affect avocado fruit quality during the growth period. In the Dominican Republic, avocado has a significant economic importance, being the country's second most exported fruit. In addition, it is ranked seventh among avocado producing countries. A research was conducted to determine how these agricultural, soil and weather factors affect fruit quality of 'Semil 34' avocado in two major producing areas (Moca and Cambita). Fruit samples from 27 farms were randomly selected in each area. For each farm, soil and leaf samples were taken. Furthermore, global positioning and socioeconomic data were collected in every farm. Oil and dry matter content of fruits were analyzed and compared between the two locations, as well as fruit appearance and organoleptic attributes. Results from each area were compared and significant differences were determined for oil content ($p=0.037$) and fruit appearance ($p<0.0001$). No significant differences were found for other variables. For both areas, fruit quality is good and oil content is above the international market standards ($>8\%$).

Key words: oil content, dry matter, fruit appearance, organoleptic attributes

INFLUENCIA DEL MANEJO Y CONDICIONES EDAFOCLIMÁTICAS SOBRE LA CALIDAD DEL AGUACATE (*Persea americana* Mill) CV. 'SEMIL 34' EN REPÚBLICA DOMINICANA

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Las frutas son afectadas en su calidad por diferentes factores durante el proceso productivo. Entre ellos se puede citar, el manejo y las condiciones edafoclimáticas. En la República Dominicana el aguacate tiene un alto valor comercial y es el segundo fruto de exportación nacional. Además, el país ocupa el séptimo lugar en producción de aguacate a nivel mundial. A fin de determinar la influencia del manejo y condiciones edafoclimáticas de las zonas productoras, se investigó, cómo estos factores influyen en la calidad del rubro para el cultivar Semil 34. Se seleccionaron las dos principales zonas productoras en el norte y sur del país, Moca y Cambita. Se eligieron al azar 27 fincas para tomar las muestras en ambas localidades. Se hicieron análisis de suelo y foliar, georeferenciación y encuestas a productores. Como variables de calidad del

aguacate, se determinaron variables químicas, contenido de aceite y materia seca, fenológicas, de calidad de maduración y organolépticas. Se compararon los resultados de ambas localidades y se encontraron diferencias significativas en el contenido de aceite ($P = 0,037$) y en las variables fenológicas ($P < 0,0001$). No se encontraron diferencias en la calidad de maduración, ni en los resultados organolépticos. Estos aguacates son de buena calidad y cumplen con el parámetro mínimo aceptable de contenido de aceite, que debe ser mayor al 8%, según el estándar creado en California.

Palabras claves: Aceite, Materia seca, fenológicas, maduración, zonas

1. Introduction

The avocado is a crop of high strategic value for the development initiatives in agriculture in the Dominican Republic. This because of its comercial potencial and the advantages for the geographic position offers for exportation compared to other countries. According to FAO (2006) Dominican Republic occupies the 7th position on worlds avocados production (140,000 t) preceded by Mexico, Indonesia, United States, Colombia, Brasil and Chile. The 98.8% of all exports are to E.E.U.U. and Puerto Rico (CEI-RD, 2007).

An anonymous source said s/f1,: "The importance of the avocado is based upon its nutritional characteristics and its high calory content. (10 g of pulp has 150 a 300 cal), Natural oils (5-30 %), Proteins (1-4.6%), Carbohidrates (0.3 to 4 %), Vitamins (A,B,C,D,E and K) y Minerals (5.31 % just the calcium, Phosphorus and Iron) that contribuye to our diet and have open new markets around the world Duch as England, France, Germany, Italy, Belgium, lower countries and others".

Kruger (1999), studied how the weather conditions influence the harvest quality of avocados cultivated in South África, he discover that temperature and pluviometry have great influence on the oils accumullation. The oil content was incremented at high rate on the years that the country had more rain. He also tested the differences between Hass and Fuerte.

At a nacional level the 63.9% of the planted area is cv. `Semil 34´ and we understand the existance of variability due to the climatic conditions of each of the productive areas and the management of the plantations. These are the reasons why we studied the characteristics and attributes of the fruits in each cultivar for the different areas.

The quality indicators were base on its oil content at harvest that should not be less than 8% and the minimum dry matter content estimated at 19%. Also the stickiness of the skin, texture, and creamy pulp, shell life for more than 8 days and pear shape.

¹ Technical recomendations for avocados. Available on line: http://www.icta.gobgt/fpdf/recom_/frut_ls/cultivoaguacate.PDF
Consulted February 24, 2007. p. 2

In order to standardize the oil contents of the avocado fruit on 1925 California Law N° 422 agreed to a minimum of an 8% of the total weight of fresh fruits. Even though the oil content varies from one cultivar to another and the weather conditions can influence it (Lee 1981) cited (López 1998 & Mortons 1987).

Based on Mexico's exporting experience, with an average of 22% of dry matter and a minimum of 20% (Dorantes *et al.* 2004), they reach good flavor and low calories. About this Kader y Arpaia (2000), mention the requisites for the maturation index are between 19 y 25%, depending on the cultivar.

General objective: Determine the effect of the climatic conditions and management of the crop have on the avocados cv. 'Semil 34' quality in two productive areas located to the North and the South of the Dominican Republic.

Specific Objectives:

- Determine the effect of the area conditions on the chemical and physical characteristics of the cv. 'Semil 34' avocado.
- Determine the effect of the area conditions maturation quality of the cv. 'Semil 34' avocado.
- Determine the effect of the area conditions on the organoleptic characteristics of the cv. 'Semil 34' avocado.

2. Materials and Methods

For this study two major production areas were selected, one in the Northern region (Moca, Espaillat Province) and the South (Cambita, San Cristobal Province). The variety chosen was the Semil 34 because it occupies 63.9% of the cropping area and currently covers the 21% and 11.5% of the total area for this regions respectively in 2006-07.

2.1 Description of the area: according to Holdridge (1987), is described as a humid tropical forest, both zones. The soil are highly mountainous. The pluviometry is of 2,100 mm well distributed annually and the average annual temperature is 25.8°C in the North and 26°C in the South. The altitude in the Northern areas is about 447 msnm and in the South 334 msnm.

2.2 The Experiment: this study was exploratory and does not have an established design.

Variables measured: a) Climatic conditions : Temperature, pluviometry, relative humidity, altitude. b) Soil Characteristics (micro and macro-nutrients, pH, organic matter, salinity and texture). c) management of plantation (Fertilization, pruning, weed control, sanitation, age and plantation framework among others). d) Quality attributes: chemical-physical (% oils, % dry matter, carbohydrates, weight, length, diameter). Quality of maturation (time of maturation, peeling, seed, maturation evenness) Organoleptic (flavor, texture, color, aroma of the pulp, grass flavor, fiber content, appearance and preference).

Within the study area 12 farms were selected randomly in Moca and 15 in Cambita (samples selected with a 90% of certainty and 15% error of a population of 141 farms at Cambita and 141 in Moca) whose production is destined to exportation.

Once inside the farm a plot of 629 m² was selected, and 3 trees of perfect competence were marked to take 13 fruits for exportation. The fruits were harvested at the optimal time according to the producer, 28 days after flowering.

The soil and foliar analysis were done for each farm as well as the Global Reference coordinates. To know the management strategies for each plantation during the tree selection period the farmers were interviewed and climate data was collected during the crop cycle.

The harvest was done manually, cutting the stem with scissors. Of 13 collected fruits, 5 were destroyed the same day to determine the chemical and physical characteristics. Consequently 8 avocados were stored at ambient temperature (25 to 27°C), until ripening. Ripening was confirmed by touch. According to Eaks (1991), the optimal temperature for maturation and to obtain quality fruit varies from 21 to 27°C.

At maturation point 3 fruits were selected to carry on the maturation quality tests, weight loss, uniformity, pulp, age, peeling and seed (with a scale from 1 to 5, 5 being the fruit who had the best peeling and the best pulp). The presence of visible fibers was also documented.

On the organoleptic qualities, a board of six consumers was used, (not trained) whom tasted the avocados, to offer their opinion. These testers tried out at least 3 different fruits in each sample.

The data analysis of the chemical and physical analysis primarily, exploratory analysis were done to test the fulfillment of the assumptions for the variance analysis.

Attention was paid to the normal distribution and the residuals, the homogeneity of the variance between localities and the farms studied. The hypothesis of normal distribution was done through Shapiro-Wilks test of normality ($p < 0.05$).

The Variance homogeneity hypothesis was tested through the Levene test (*H₀: the variance among the populations is equal*). To carry out this test it was necessary to make a variance analysis of the absolute values of the residuals for each variable. (Steel y Torrie, 1989; Fernández, 1992).

For the data that did not comply to the requirements on the variance test, the differences between the median of the localities for the variables were evaluated by the Wilcoxon (Mann-Whitney) non-parametric test, for independent samples. For the qualitative variables about quality of maturation and organoleptic

properties the same test described before was used. The statistical analysis was done through InfoStat, 2004 edition.

2.3 Agonomical management: a survey was conducted to know the agronomical practices of each farm, the findings include:

Table 2.1 Agricultural practices of avocado farms in two producing areas of the Dominican Republic

Description	CAMBITA (South)	MOCA (North)
No. evaluated farms	15	12
Altitud average (msnm)	334	447
Mínimum	266	319
Máximum	494	649
Edad plantaciones		
• Less than 10 years	93% (14)	58% (7)
• Between 10 and 20 years	7% (1)	42% (5)
Surfice		
• Less than 2 ha	27% (4)	
• Between 2 and 6 ha	33% (5)	25% (3)
• Between 6 and 63 ha	33% (5)	58% (7)
• 63 ha or more	7% (1)	17% (2)
Intercropping		
• Yes	53% (8)	100%
• No	47% (7)	
Details	Fruits, crops and forest	Fruits, crops and forest
Avocado varieties		
• Just Semil´34	33% (5)	
• Semil and others	66% (10)	100%
	Choquete, Pollock, Melendez, Hall, Lula, Popenol, Waldin, Carla, Dr. Dupui, Príncipe Negro	Choquete, Pollock, Melendez, Hall, Lula, Popenol, Carla
Pest Control		
• Yes	93% (14)	92% (11)
• No	7% (1)	8% (1)
	Chemical Control	Chemical Control
Weed Control		
• No	7% (1)	
• Manual Control	33% (5)	
• Manual and Qco	60% (9)	100%

Fertilization • No • Yes	7% (1) 93% (15), 1 - 4 times a year	0% 67% 1 - 2 times 33% between 3 y 6 times a year
Soil Conservation • Yes • No	67% (10) 33% (5) live and death barriers Barreras vivas y muertas	92% (11) 8% (1) Barreras vivas y muertas, zanjas de contorno, desperdicios
Foliar Fertilization • Yes • No	No answers	83% (10) 17% (2)
Pruning • No • Yes	20% (3) 80% (12) 1 y 2 veces.	100% minimum 1 time a year
Plantation framework	mean 6 x 6 m	Mean 6 x 6 m
Irrigation	20 % (3)	No irrigation 100%
% of fruti residuals	10%	18%

The basic parameters used by the producers to determine the moment of harvest are change in color and weight, also they adjust the harvest to the demand and prices of the market.

3.3 Soil Characteristics

Table 2.2 Soil chemical properties at farm level in two avocado producing areas

CHARACTERISTICS	MOCA	CAMBITA
pH H ₂ O	7.80	7.80
C.E.	0.34	0.32
%CaCO ₃	0.00	11.70
Ca (Meq/100 ml)	74.30	83.80
Mg (Meq/100 m)	2.90	2.20
K (Meq/100 m)	0.71	0.60
Na (Meq/100 m)	0.20	0.20
H, Al (Meq/100 ml)	0.00	0.00
CICE	77.80	86.80
Ca/Mg	30.00	44.00
Ca/Mg	4.40	4.70
Ca+Mg/K	127.40	184.00
PSAI	0.00	0.00
PS-Ca	95.00	96.50
PS-Mg	3.80	2.60
PS-K	0.90	0.70

PS-Na	0.30	0.30
Fe (ppm)	21.90	17.50
Mn (ppm)	11.70	27.10
Cu (ppm)	3.60	1.50
Zn (ppm)	2.10	2.00
P (ppm)	9.20	8.20
%MO	4.60	4.40

Table 2.3 Chemical properties of avocado leaves from two producing areas

LOCALITY	% N	% P	% K	% Ca	% Mg	Fe	Mn	Zn	Cu	B
Cambita (South)	2.00	0.11	0.73	2.14	0.30	60	38	17	37	16
Moca (North)	2.04	0.13	0.76	1.88	0.32	125	38	22	34	20
Desirable range	1.70	0.10	0.75	1.00	0.35	60	80	5	30	30
	2.10	0.20	1.50	3.00	0.70	300	400	15	100	60

According to the table no. 2.2 and 2.3 we observe that not only the soils in Moca and Cambita are basic and calcareous rich in calcium (high values of CaCO_3 free) but also present a imbalance in the magnesium-calcium relation wich deteriorate the magnisium nutrition. (relation Ca/Mg is bigger than 6). The potasium content is from normal to high (bigger than 0.5 meq/100 ml). In the two areas predomiates the tendency to low levels of zinc and manganese. The organic matter in both areas is high this is very favorable for the nitrogen nutrition and for the physical and chemical characteristics of the soil.

None of the two producing areas have critical or extreme soil situations that could effect negatively the crop (Salinity,m pH, etc). The soil presents very favorable characteristics for the crop.

The foliar analysis reflects the observed tendency found in the soil about the manganeso, zinc and magnesium. In bith localities the magnesium reaches a low level; the zinc is low in Moca and normal in Cambita, but the manganese is at low levels in both communities. The boron is another microelement present in both localities. In general the levels of nitrogen, phosphorous and potasium are favorable to the avocado crop and are very similar in both areas.

We must highlight that from the nutritional point of view the goal is to reach normal values in the foliar analysis, besides, this is no garanty for a good production or quality due to both variables are afected by many other soil factors, weather and management not only nutrition.

According to Agroinformación (s/f^2) the recomendado soils for the avocado crop are of light textura, neutral pH o slightly acid. (5.5 to 7). The avocado could be planted in clay soil and clay loamy if they have good drainage. Well distributed 1,200 mm of anual precipitation are considered good.

² The Avocado crop. Available at: http://www.infoagro.com/frutas/frutas_tropicales/aguacate.htm Consulted September 14, 2006. p. 2

3. Results and Discussion

3.1 *Chemical characteristics*: the oil content and dry matter were compared. No significant differences were found in the dry matter percentage %MS (P = 0.3287), but was found in the %GT (P = 0.037). The higher levels of oils were found in the south. (see Table 3.1).

Tabla 3.1 Means percentage of Oil Content (%GT) and Dry Matter (%DM) of Semil 34 avocado fruits from two producing areas

DESCRIPTOR	% GT		% MS	
	Mean	DES STD	Mean	DES STD
CAMBITA	9.66	1.66	19.82	1.68
MOCA	9.07	1.79	19.74	2.48
P*	0.0377		0.3287	
Pr<W**	< 0.0001		<	
Pr >F	0.3327		0.0001	0.0069
Residuales ***				

* Wilcoxon test (Mann-Whitney) (P ≤ 0.05)

** Shapiro-Wilks (*H₀*: distribution of the residual is normal) ***Levene, Pr>F (|Residuales|)

3.2 *Phenological characteristics*: In table 3.2, is observed that there is a high significant difference between the physical characteristics of the localities studied, of which could be because of the habitat characteristics and the age of the plantations, where the 93% of the farms of the south have less than 10 years and the opposite case of 42% of the farms from the north have more than 12 years.

The weight, diameter and length of the fruit at harvest time, show that the avocado from Cambita has bigger dimensions. The width of the shell and pulp show no significant differences among the two farms. (P = 0.429 and 0.5714 respectively).

Table 3.2 Means of fruit weight, fruit diameter and fruit longitude of Semil 34 avocado fruits from two producing areas

DESCRIPTOR	Weight (g)		DIÁMETER (mm)		LENGTH (mm)	
	Media	D STD	Media	D STD	Media	D STD
CAMBITA	624.91	86.22	96.19	7.26	187.92	21.95
MOCA	536.63	58.00	92.35	4.44	161.05	11.94
P	< 0.0001		0.0039		<	
Pr<W*	< 0.0001		< 0.0001		<	
					0.0001	
					<	
					0.0001	

Pr>F Residuals ***	0.0015	0.0486	< 0.0001
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*Wilcoxon test (Mann- Whitney)

** Shapiro-Wilks (*H₀*: the distribution of residuals is normal) ***Levene, Pr>F |Residuals|)

At ripening the avocados showed significant differences between the percentage of peel, pulp and seed ($P = 0.0357$). The major percentage was hold by the fruits from the south with a less peel and seed weight (see Table 3.3)

Table 3.3 Percent mean weight of skin, pulp and seed of Semil 34 avocado fruits from two producing areas

DESCRIPTOR	% SKIN		%PULP		%SEED	
	Media	D STD	Media	D STD	Media	D STD
CAMBITA	7.00	0.53	79.07	1.74	13.93	1.21
MOCA	8.84	0.58	73.38	1.84	17.76	1.61
P*	0.0357		0.0357		0.0357	
Pr<W**	<		<		<	
Pr>F Residuales ***	0.0001		0.0001		0.0001	
	0.7434		0.2959		0.9256	

*Wilcoxon test (Mann- Whitney)

** Shapiro-Wilks (*H₀*: the distribution of the residuals is normal) ***Levene, Pr>F |Residuals|)

3.3. Quality of *ripening*: In table 3.4, there was a high significant difference in ripening when the harvest days and percentage of weight loss in both localities were compared ($P < 0.0001$). In Cambita (10.44%) had less weight loss than Moca (20.49%). The average of total of green days to reach maturation in Cambita was of 9.42 against 15.77 days in Moca.

Tabla 3.4 Means and standard deviation of percent weight loss (%PPM), days to ripening and ripening uniformity in Semil 34 avocado fruits from two producing areas

DESCRIPTOR	% PPM		Maturation Days		UNIF. MAD.	
	Media	D STD	Media	D STD	Media	D STD
CAMBITA	10.44	6.68	9.42	3.54	76.70	17.39
MOCA	20.49	8.19	15.77	4.35	71.30	17.11
P*	<		<		0.125	
Pr<W**	0.0001		0.0001		5	
	<		<			
	0.0001		0.0001			

Pr>F Residuals ***	0.0803	0.3702
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*Wilcoxon test (Mann- Whitney)

** Shapiro-Wilks (*H₀*: the distribution of the residuals is normal) ***Levene, Pr>F (Residuals)

In general none of the localities riped, the fruits only riped in the 75% of the cases. In both farms there was a desireble peelin of the skin and it was almost negligable the number of fruits that had the skin of the seed attach to the pulp.

A significant difference was found ($P = 0.0299$) in the status of the pulp between localities, but resolting in good acceptance. One general evaluation of the fruit did not show signifiican differences ($P = 0.1635$). the mean of the observations made was between 69 and 75%. These was asociated to the fact that the fruits never riped totally. And no tipe of fumigation was aplied during ripening, in some of the fruits, we found rotting of the stem. According INFOAGRO (s/f), this rotening is caused by *Botryodiplodia theobromae* Pat. and apears as a browning or black coloration that iniciates at the stem and reaches the floral tip, finally covering the whole fruit. *Dothiorella gregaria* Saac. is other cause of rotening and the scaring of the ítem in riped avocados for compsumption.

Light visible fibers were found in 13 of the visited farms at Cambita and only one in Moca.

3.4 Organoleptic Characteristics: from these charateristics color, aroma, flavor, texture, grass flavor, residual flavor, appearance y preferente on the samples was analyzed.

A scale was used with values from 1 to 10 were: 10 Excelent, 9 very good, 8 good, 7 Aceptable, 6 Indiferent, 5 I don't like it a little, 4 I don't like it, 3 I like it but I don't bye it, 2 bad, 1 very bad.

There were no signifiican differences among the localities in none of the descriptors in all the level of $P > 0.05$. The avocados resulted between aceptable and good for both areas. We have to take into consideration that the testers panel was not properly trained, were simply consumers that like the fruits. The organoleptic profile is in Figure 3.1.

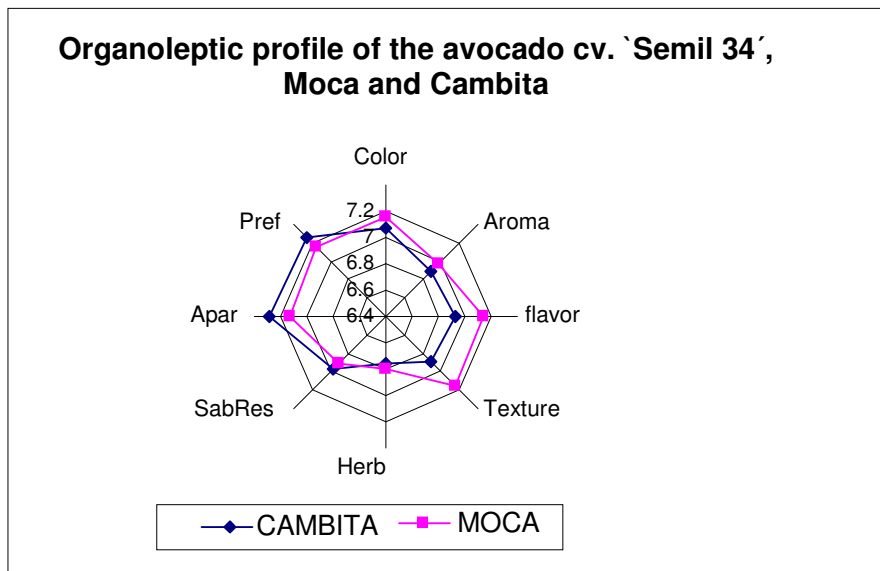


Figura 3.1. Organoleptic profile of Semil 34 avocado fruits from two producing areas

4. Conclutions and recommendations

The area had a slight significant influence on the oil content at harvest time. Both localities have a minimum oil content over the 8%.

The plantations with the higger oil contest were the ones from the South (Cambita), were the 93% of the sampled crops had less than 10 years y en las del Norte (Moca) el 52% tienen 12 años o más. En el contenido de materia seca no hubo influencia de la zona y se encuentra dentro de los estándares mínimos requeridos.

The major difference between the areas was in the phenologic characteristics of the fruits, were the dimentiones of the avocado from cambita were much bigger than the ones from Moca (weight, diameter, lenght, % of skin content, pulp and seed). The thikness of the skin and the pulp dont present statistical differences.

The area also influenced the quality of ripening. A high significan difference was confirmed on the percentage of weight loss at ripening, been the less for Cambita and the variable green life were the avocados produced in the Northern areas (Moca) had a longer green life (15.77 Days).

The weather and management conditions of the area did not influence the organoleptic characteristics, the visible fibers were the only remarkable feature in Cambita 90% of fruits. The fruit preference was qualified as good.

Ander the conditions of this study the fruits of cv. `Semil 34`, cultivated in Cambita and Moca, could be characterize as:

CARACTERÍSTICAS	CAMBITA	MOCA
% Oils	9.66 ± 1.66	9.07 ± 1.79
% Dry matter	19.82 ± 1.68	19.74 ± 2.48
Weight (g)	624.9 ± 86.22	536 ± 58.00
Diameter (mm)	96.19 ± 7.26	92.36 ± 4.44
Lenght (mm)	187.92 ± 21.95	161.05 ± 11.94
Skin thikness (mm)	1.27 ± 0.06	1.38 ± 0.28
Pulp thikness (mm)	17.60 ± 1.42	16.27 ± 1.61
Shell life	9.42 ± 3.54	15.77 ± 4.35
% skin	7.00 ± 0.53	8.84 ± 0.58
% pulp	79.07 ± 1.74	73.38 ± 1.84
% seed	13.93 ± 1.21	17.76 ± 1.61
% weight loss at ripening	10.44 ± 6.68	20.49 ± 8.19
Visible fibers	Yes	No

We recomend to repeat this study, at least two years more, in order to confirm the results obtained at these harvest season and to stablish the cultivar characteristics of each production area.

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