ECONOMIC COMMISSION FOR EUROPE

COMMITTEE FOR TRADE, INDUSTRY AND
ENTERPRISE DEVELOPMENT

<u>Working Party on Agricultural Quality Standards</u>

<u>Specialized Section on Standardization of Fresh Fruit and Vegetables</u>
Forty-ninth session, 17-20 June 2003, Geneva

REPORT OF THE FORTY-NINTH SESSION

<u>Addendum 7</u>

Sensory Consumer Acceptance Of Citrus

Note by the secretariat: The following document on Sensory Consumer Acceptance of Citrus has
been reproduced by the secretariat as received from the delegation of Spain.

GE.03-32035

1. Introduction

INTERCITRUS requested from AINIA a project to research the relationship between the different physical-chemical parameters and the sensory acceptance in different varieties of citrus (mandarins and oranges).

The study started in the 2000-2001 campaign, and continued during the 2001-2002 campaign. The study for the 2002-2003 campaign is currently under way.

The objectives of the study are the following:

✓ The study of the existing relationship between consumer acceptance and different physical-chemical parameters: acidity, ° Brix, maturity index (quotient between ° Brix and acidity), % of juice and color index.

✓ Valuation of the adequacy of the maturity index (MI) as an indicator of the acceptability of the citrus from the point of view of the consumer.

2. DESCRIPTION OF THE STUDY

2.1 General methodology

The experimental part of the project is based on the performance of physical-chemical determinations and consumer tests (sensory acceptability) on different samples of citrus collected throughout their ripening period, and throughout several campaigns of citrus cultivation.

The citrus analyzed are mainly Spanish in origin, although fruit from other geographical locations has been punctually introduced, especially from the tropics. In the 2002-2003 campaign, the incorporation of a larger number of Cuban citrus has been planned.

In each citrus campaign different varieties have been studied, from pre-selected plots. The study of each variety has been performed through the ripening period (as long as circumstances permitted).

The selection of the plots has been done so they are as representative of this crop. In each of the varieties studied in the successive campaigns, the location of the plot has been different, with the objective of incorporating the variability that this factor can introduce on the physical-chemical and sensory parameters of the citrus.

The study must be undertaken during several citrus campaigns to incorporate the variability existing between campaigns and obtain more representative results.

2.2 – Campaigns studied

The variety of oranges studied in each campaign and the number of samples evaluated per variety and campaign can be seen in the table below:

Sample	Campaign		
	N° of controls 00-01	N° of controls 01-02	N° of controls 02-03(*)
Navelina Spain	18	23	
Lanelate Spain	11		14
Val. Late Spain	10		8
Valencia Late Cuba	1		2
Navel Uruguay		2	
Navel Argentina		2	

Table 1: Varieties of oranges studied.
(*) The tests from the 2002-2003 campaign are in the final phase.

On the table below you can observe the varieties of mandarins studied in each campaign and the number of samples evaluated per variety and campaign, although the results of these samples are not the object of this report, since the data corresponding to the varieties of orange are analyzed.

Sample	Campaign	
	N° of controls 00-01	N° of controls 01-02
Marisol Spain	6	18
Clemenules Spain	18	
Hernandina Spain	21	
Satsuma Spain		13

Table 2: Varieties of mandarins studied.

2.3 – Sampling

The samples of citrus are picked up from previously selected and marked trees. The samples are randomly collected from all the areas of the trees. The number of pieces of fruit picked up per sample is 120 (24 pieces for physical-chemical analysis and 75 pieces for the sensory acceptability analysis).

2.4 – Analysis performed on the citrus samples

After extracting the juice of 24 oranges, a serving of 200 ml of each variety is taken, based on which we determine:

✓ Color index, using the citrus colorimetric table (Brogdex scale).

✓ % of filtered juice (always performed by the same operator).

✓ Total acidity, potentiometric titration to 8.1 pH, officia l method.

✓ ºBRIX, through refractrometric valuation at 20ºC, official method.

✓ Sensory acceptability. Evaluation performed by a representative sample of 60-96 consumers in AINIA's sensory analysis laboratory. The questionnaire used is found under ATTACHMENT 1. The consumers evaluated a serving of orange segments, from a sample of 75 oranges previously peeled, segmented and mixed.

3. – Results

3.1 Tables and graphics with results from the physical-chemical and sensory acceptability analysis.

The results of the physical-chemical parameters of total acidity, º Brix, maturity index, % of juice and color index are shown in tables 3, 4, 5, 6 and 7, respectively, and in graphics 1, 2, 3, 4, and 5, respectively.

The results of the global appreciation parameter of the consumer tests performed are shown in table 8 and graphic 6.

NOTE: Most of the treatment of the results presented in this report correspond to varieties Navelina 00-01 , Navelina 01-02, Lane Late 00-01 and Lane Late 02-03. There is not enough information available on the Valencia Late Spain 00-01 and the Valencia Late Spain 02-03.

3.2 – Study on the relationship between the IM and the GA in each variety studied.

In the following graphics, you can see the results of the Maturity Index (IM) compared to the global appreciation (GA) for each of the four varieties studied. The linear relationship (straight line) and the quadratic relationship (parabolic line) of the results have been shown.

Relationship between the Maturity Index and the consumer's Global Appreciation NAVELINA 00-01
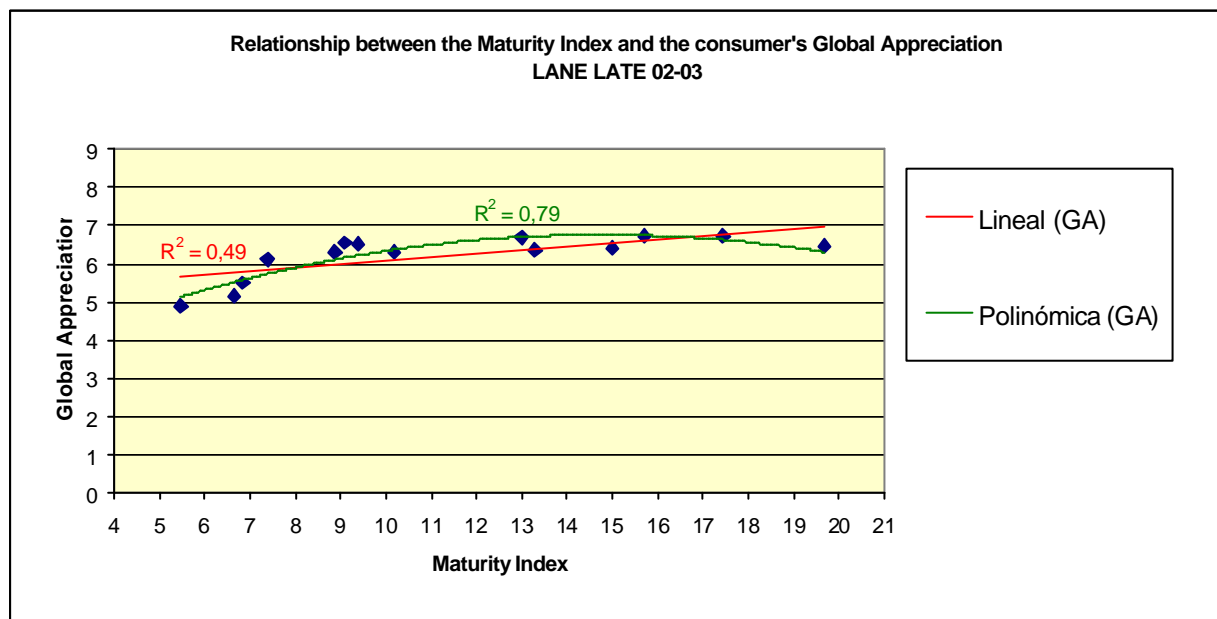
$R^2 = 0.80$

$R^2 = 0.54$
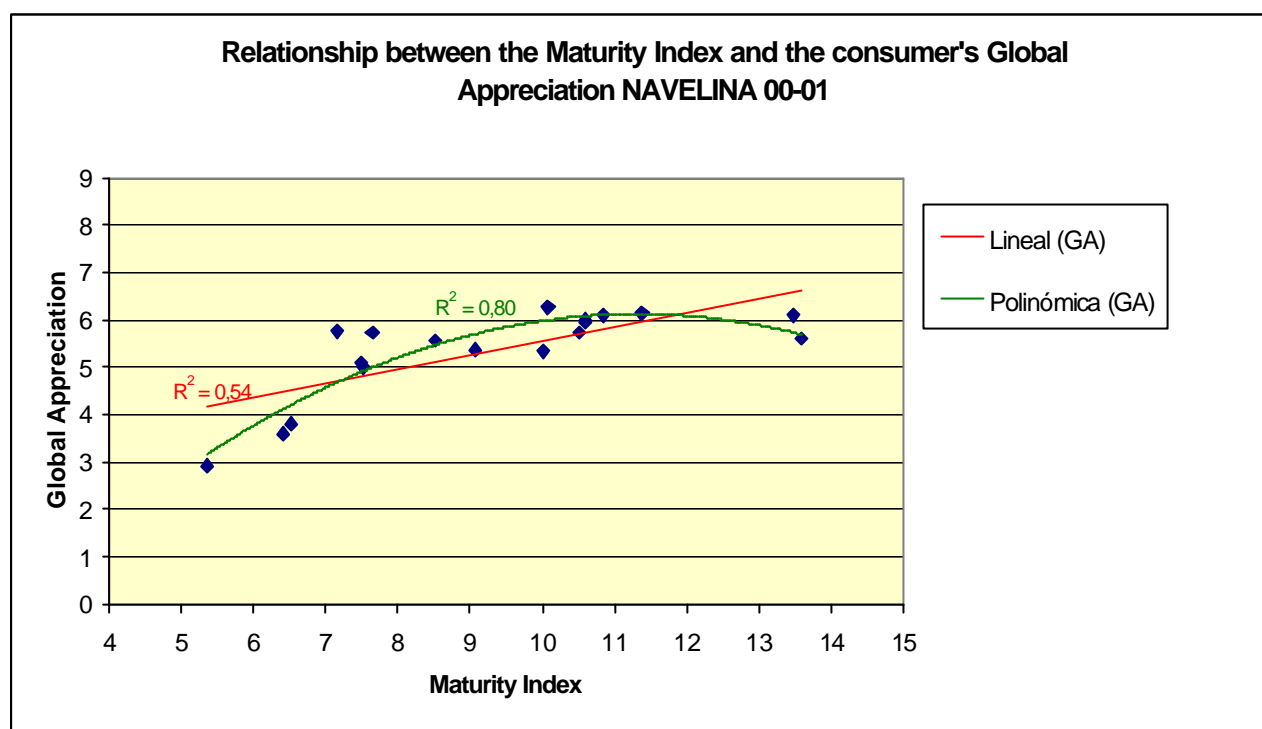
Graphic 7: Representation of the linear and polynomial regression of the 2º. Navelina 00-01
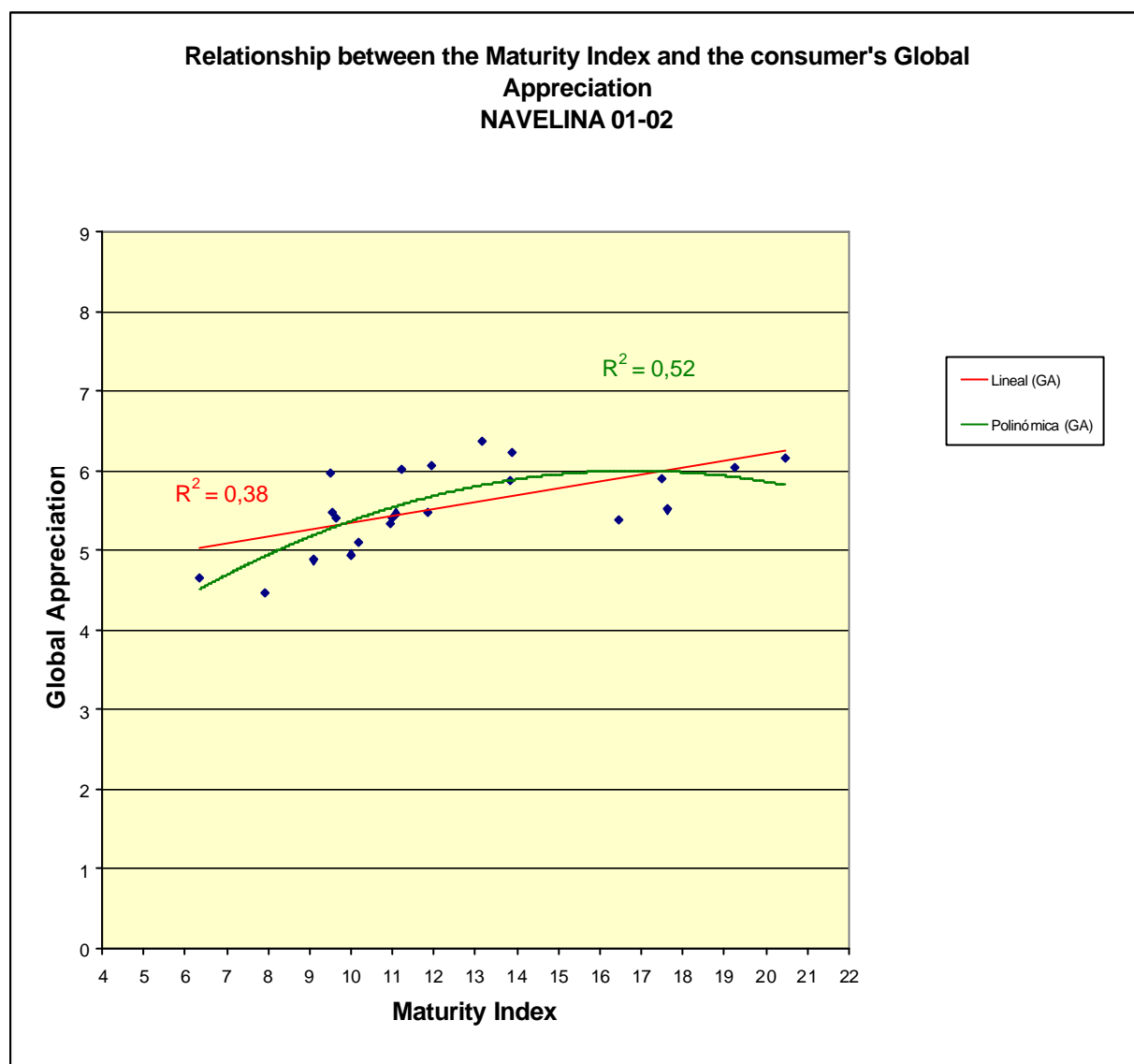
Graphic 8: Representation of the linear and polynomial regression of the 2º.Navelina 01-02
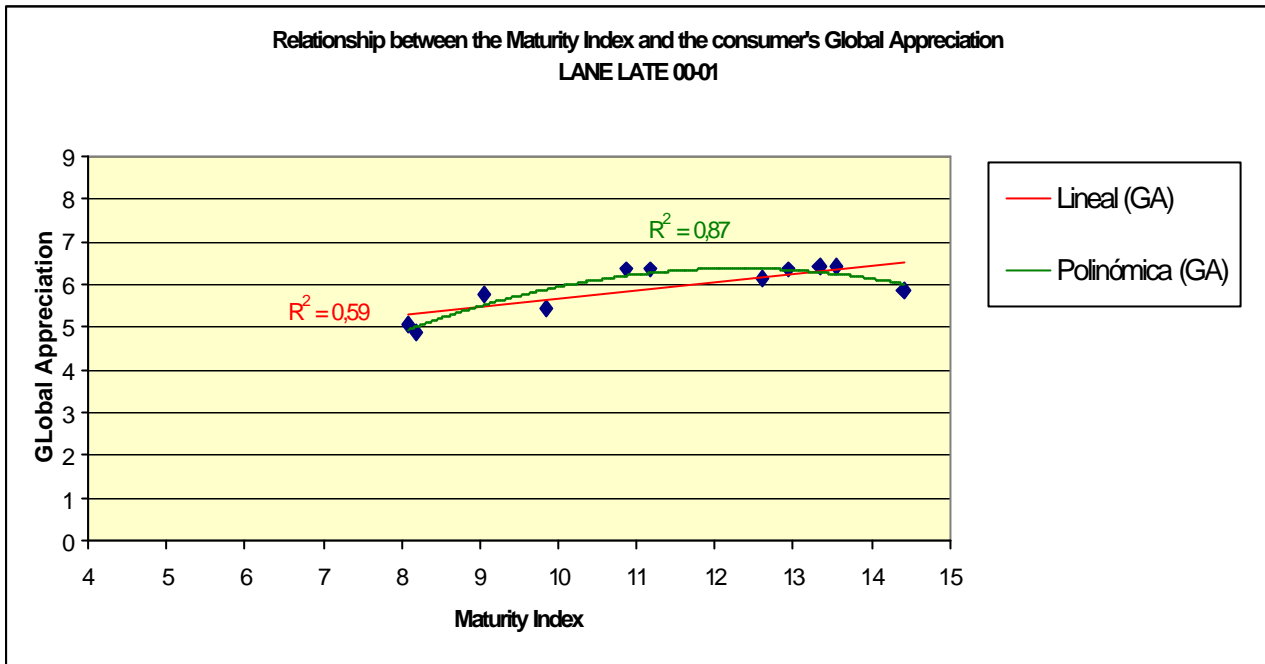
Graphic 9: Representation of the linear and polynomial regression of the 2º. Lane Late 00-01

Graphic 10: Representation of the linear and polynomial regression of the 2º. Lane Late 02-03

Conclusion:

the coefficients of correlation of the quadratic relationship (parabolic) are bigger than the linear correlation in all the varieties studied. So THE RELATIONSHIP BETWEEN THE MATURITY INDEX AND THE GLOBAL APPRECIATION IS BEST EXPLAINED AS A QUADRATIC RELATIONSHIP (BEST ADJUSTMENT) RATHER THAN AS A LINEAR RELATIONSHIP.

We will now analyze whether the quadratic relationship studied is statistically meaningful. The following table shows the proposed equation, as well as the significance (P-value) of the quadratic term of the equation, for each variety studied

Variety	P-value IM^2	Relationship between variables
Navelina Spain 00-01	0.0006*	AG=-4.5448 + 1.8854 * IM -0.0833 * IM^2
Navelina Spain 01-02	0.0303*	AG=2.173 + 0.455 x IM -0.013 x IM^2
Lane Late Spain 00-01	0.0036*	AG=-5.8268 +1.9832 * IM -0.0806 * IM^2
Lane Late Spain 02-03	0.0024*	AG=2.6508 +0.5573 * IM -0.0188 * IM^2

Table 9: P-values of the coefficients of the IM^2 variable.
(*): Significant at a confidence level of 95%.

The quadratic terms of the equation are significant for the explanation of the relationship existing between the IM and the GA in all cases. Thus, the quadratic equation explains the relationship between the IM and the GA better than the linear equation.

3.3 – Comparison between the information provided by the IM (ºBrix /acidity) to the information provided by the ºBrix and acidity parameters separately.

The following graphic shows in blue the value of the coefficient of the correlation of the equation that relates the IM with the GA (simple regression), and in red the coefficient of the correlation of the equation that relates º Brix and Acidity with GA (multiple regression).
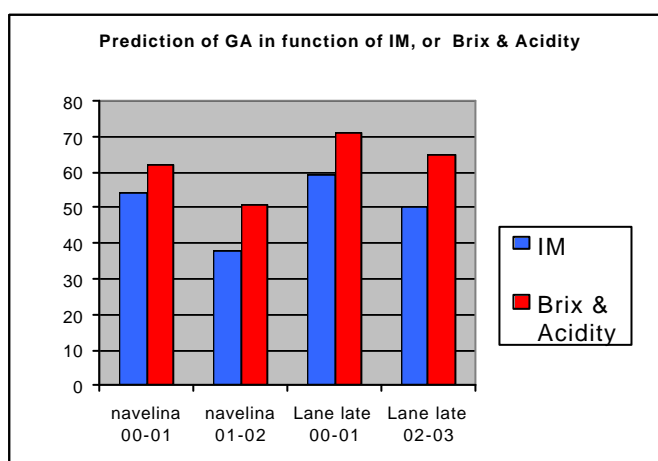
Graphic 10: Values of the coefficient of correlation (R^2) of RI with GA, and ºBrix and acidity with GA

The values of the coefficients of correlation are shown in the table below.

| Coefficient of regression (%) of GA with:		
Samples:	IM	Brix & acidity
Navelina 00-01	53.83	62.30
Navelina 01-02	37.97	50.73
Lane late 00-01	59.05	70.68
Lane late 02-03	49.89	64.87

Table 10: Coefficient of correlation (R^2) of the equations of regression.

The information provided by the two variables ºBrix and acidity separately, for the prediction of the Global Appreciation (GA) is bigger than the information provided by the quotient of both variables (IM). GROUPING THE VARIABLES ºBrix AND ACIDITY IN THE QUOTIENT PRODUCES A LOSS OF INFORMATION.

3.4 – Global Appreciation Maps in function of ºBrix and Acidity.

The representation of the values of the variables º Brix and acidity with the GA and their posterior modeling shows the relationship that exists between the variables. In the following generated contour maps, we can observe the acidity in the abscissa, and the ºBrix in the ordinates. The global appreciation is shown in different colors, so the same color represents homogeneous GA values. (The global appreciation is also shown in numbers from 1 to 9, in each delimited area).

The representation has been performed for the citrus studied in the 00-01 campaign (marisol, navelina, clemenules, hernandina, lane late and valencia late), and the 01-02 (marisol, satsuma, and navelina). Thus, it includes both oranges and mandarins.
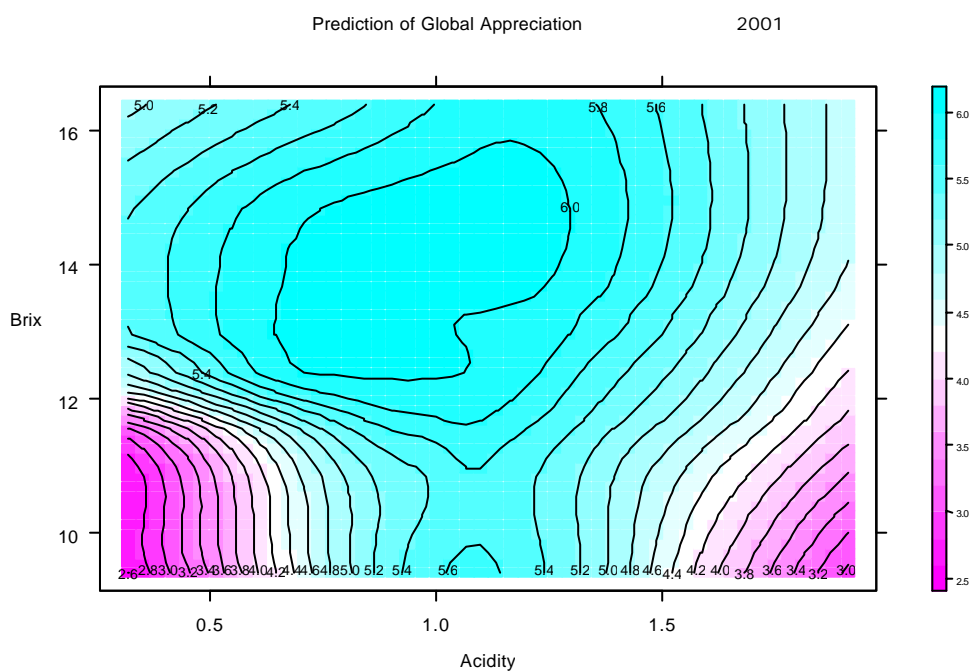
Graphic 11: Contour Map. 00-01 Campaign
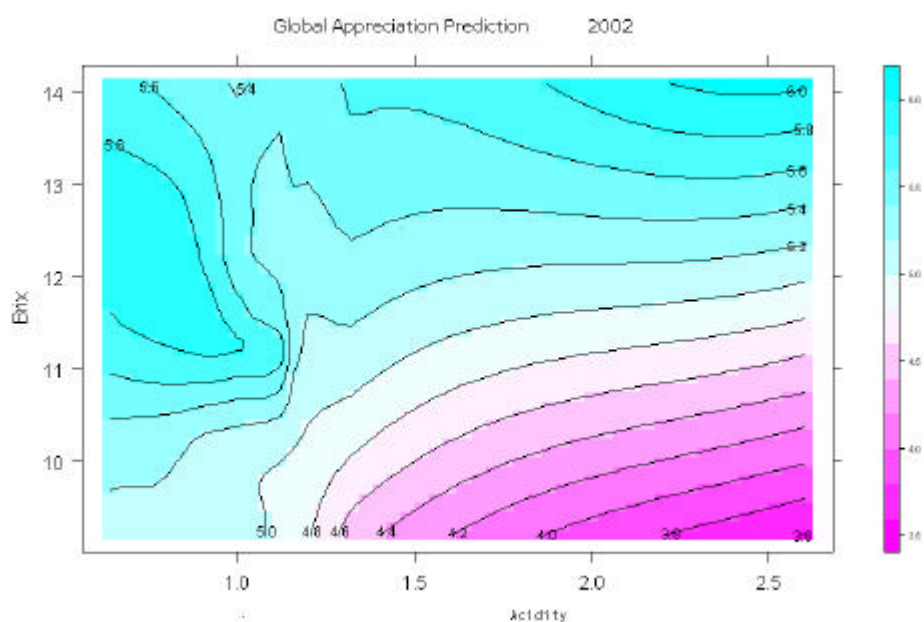
Graphic 12: Contour Map. 01-02 Campaign

By observing the contour maps, we can conclude that:

- The maps of the different campaigns are different. There is a variation, due perhaps to the different varieties analyzed, and to the variability produced by factors related to the different campaigns (climatology, location of the plots, etc.)

- In campaign 00-01 it is observed that, for the studied varieties and in approximate form, the maximum GA corresponds to levels of acidity around 0.7-1.3, and ºBrix values of 12.5-15.5.

This means THAT THE MAXIMUM GA VALUES CORRESPOND TO MID VALUES IN ACIDITY, AND MID-HIGH VALUES IN BRIX.

- In the 01-02 campaign, along general lines, it is observed that as the ºBrix augments and the acidity diminishes, there is an increase in Global Appreciation. Also, it is observed that an increase in ºBrix does not produce the same increase in the Global Appreciation throughout the rank of the Acidity values: when the acidity is low, the increase in global appreciation is lower than when the acidity is high.

3.5 – Study of citrus from different locations (Cuba).

Below you can find a graphic in which the Maturity Index (IM) and the Global Appreciation (GA) values are shown for all the orange samples studied (Navelina 00-01 and 01-02, Lane Late 00-01 and 02-03 and Valencia late 00-01 and 02-03), as well as the samples from Cuba.
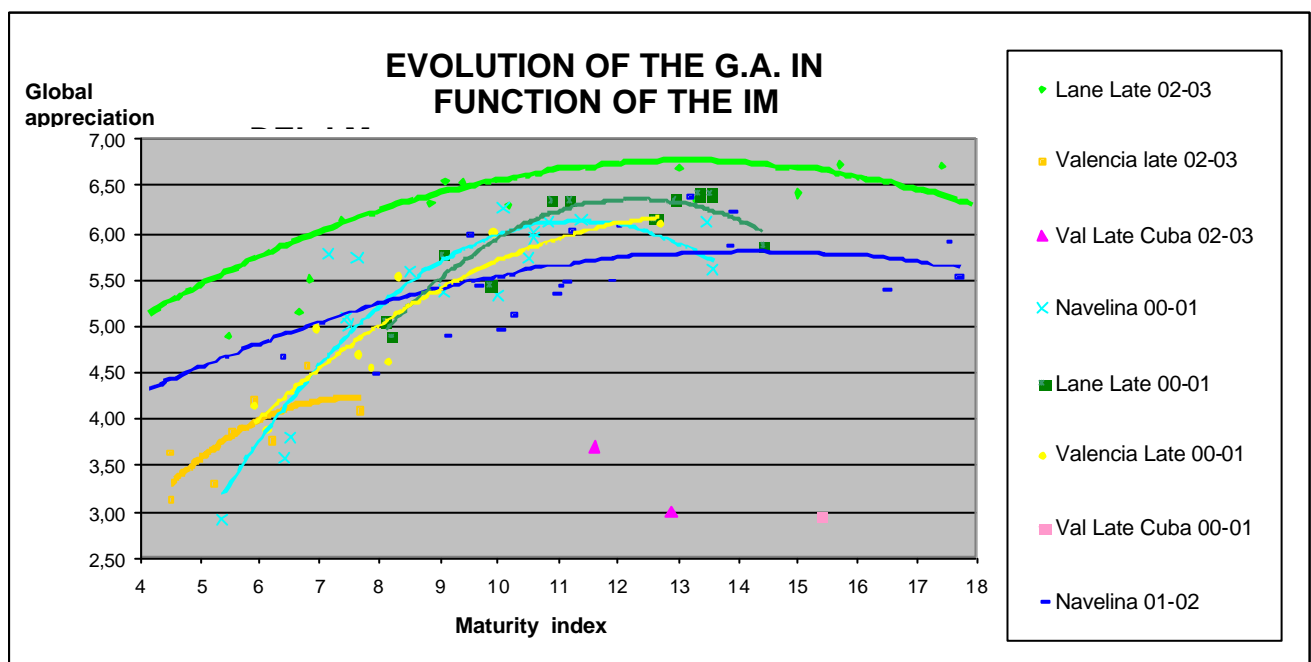
Graphic 13: Relationship between the Ripening Index and the Global Appreciation for the total of varieties of citrus studied in the three Campaigns.

From the graphic, it is gathered that:

- Each variety takes different IM and GA values.

- The same variety will take different IM and GA from one year to the next.

- Within the same IM values, THE GA VALUES VARY IN FUNCTION OF THE VARIETY AND THE YEAR, BUT THIS VARIATION IS A LOT MORE NOTICEABLE IF THE LOCATION OF ORIGIN OF THE CITRUS ALSO CHANGES.

3.6 – Study of the relationship between the Maturity Index (IM) and the Global Appreciation (GA): Effects of the variety and the campaign.

The study of the parabolic relationship between the Maturity Index and the Global Appreciation was done by multiple regression, for the total of data from the varieties of Navelina 00-01, Navelina 01-02, Lane Late 00-01, and Lane Late 02-03. Below is a graphic showing the adjusted coefficient of correlation and the standard error of the estimation of the GA, both for the regression performed on the group of varieties studied, and for the one performed in each variety separately.
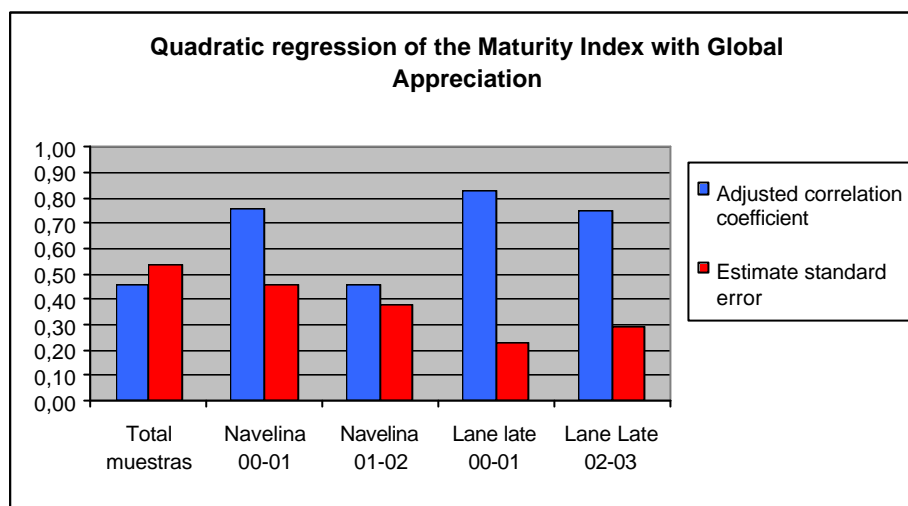
Graphic 14: Study of the parabolic relationship between the Maturity Index and the Global Appreciation. Correlation coefficients and errors in the estimate.

As you can observe, the separate studies of each variety gives us coefficients of correlation between the IM and the GA that are larger than those provided by the group study of the varieties. As to the error that would be made in the estimation of the GA and the IM by studying the 4 varieties as a group, a larger error is obtained that that obtained by studying each of the varieties separately.

This is due to the DISTINCT BEHAVIOR OF EACH VARIETY AND CAMPAIGN, which results in more complexity in the study of the group of varieties and campaigns than the study of each separately. It would thus be convenient for the performance of the studies in successive campaign and the performance of the study for each variety to be separate, so results with greater validity can be achieved.

4. – CONDUSIONS

✓ The relationship between global appreciation and the maturity index is not linearly proportional, so a variation in the maturity index does not produce the same variation in the global appreciation throughout the ripening period. The quadratic (parabolic) relationship is more adequate.

✓ The generation of prediction equations for global appreciation entitles with greater reach in the study, since the variety, the campaign and the origin of the citrus induce variations in the existing relationship between the physical-chemical parameters and the GA.

✓ The prediction of the global appreciation through equations generated from the ºBrix and acidity parameters would not be very precise, since the GA is not only determined by the studied physical-chemical parameters, but other variables, such as the volatile components that make up the aroma, the fibrous residue, the color and look of the segments, etc., have great influence.

✓ The quotient of the variables of ºBrix and acidity (Maturity Index) yields less information to predict the global appreciation of the consumer than the information yielded by ºBrix and acidity separately.

✓ To generate a GA indicator with universal validity it would be necessary to study a greater number of campaigns to include the greater possible variability in relationship to weather, plots, agricultural practices…, as well as the incorporation of other physical-chemical parameters that affect the consumer global appreciation.

5. – BIBLIOGRAPHY.

➢ Stone H.; Sidel J.L.; "Sensory Evaluation and Practices". Academic Press; 1985.

➢ Piggot J.R. "Sensory Evaluation of Foods" Elsevier Applied Sciende LTD; 1988.

➢ Evaluation Sensorielle. Manual Methodologique. Technique & Documentation Lavoisier; 1990.

➢ O'Mahony, M.; "Sensory Evaluation of Food. Statistical Methods and Procedures"; Marcel Dekker; 1986.

➢ Escamilla C.; MacFie HJH.; "Development of a method to set up sensory quality specifications for oranges".

➤ W.F. Wardowski, S. Nagy, W. Grierson; Fresh Citrus Fruits; 1988.

➤ James Soule and William Grierson.; "Maturity and grade standards".

➤ Primo. E.; , 1971, "Quality of orange varieties. X. Minimum and optimum maturity indices and ripening schedule for several varieties"; Revista de agroquímica y tecnología de Alimentos; 11 (4) 549-561, 2 ref.

➤ Young Ju Oh.; "Physicochemical characteristics and sensory evaluation of greenhouse Satsuma mandarin".

**ANNEX 1: Evaluation Questionnaire
on Sensory Acceptability.**

ORIGINAL: SPANISH

AINIA® | AGROALIMENTARIO INSTITUTO TECNOLÓGICO

SENSORY ANALYSIS LABORATORY

09/19/01

Name:_____

Subject #:_____

Booth #: 1

PRODUCT: CITRUS

SAMPLE CODE: 628

1.- General appraisal:

Not pleasant at all…..Very pleasant

2.- Ripeness appraisal:

Not very ripe………...Very ripe

3.-Sweet flavour:

Satisfactory

Insufficient..........………..Excessive

4.-Acid flavour:

Satisfactory

Insufficient..........………..Excessive
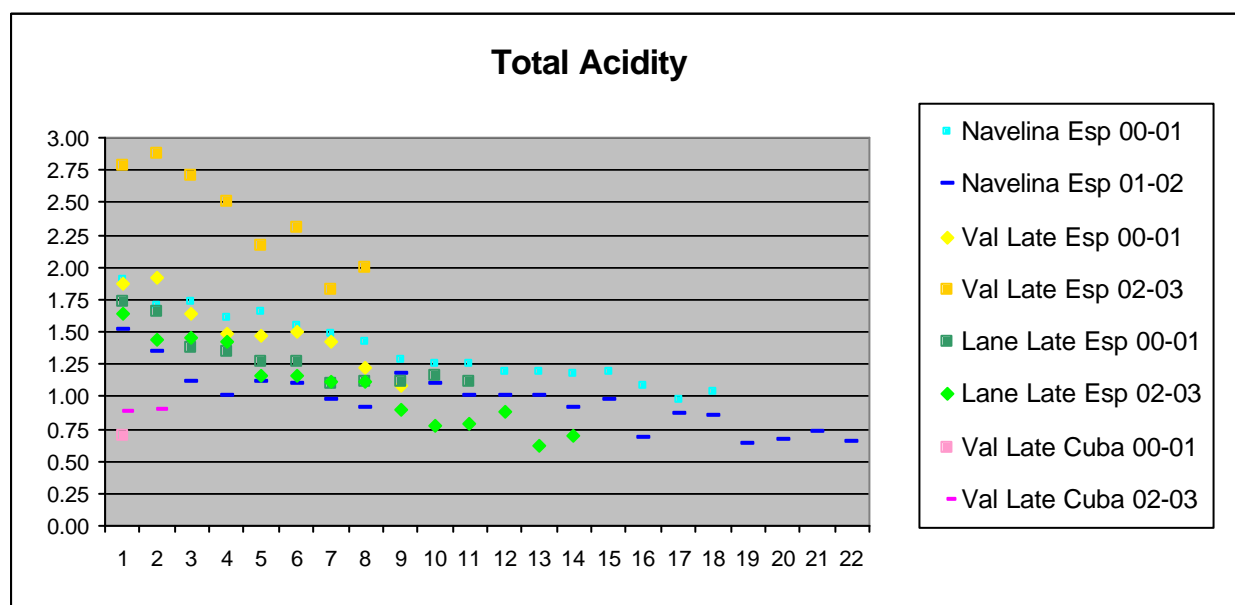
5.-Flavour:

Not pleasant at all…..Very pleasant

6.-Juiciness:

Not very juicy...............Very juicy

ANNEX 2: Results of Physicochemical and Sensory Acceptability Parameters

Total Acidity							
Navelina Esp 00-01	Navelina Esp 01-02	Val Late Esp 00-01	Val Late Esp 02-03	Lane Late Esp 00-01	Lane Late Esp 02-03	Val Late Cuba 00-01	Val Late Cuba 02-03
1.90	1.51	1.87	2.79	1.73	1.64	0.69	0.88
1.70	1.34	1.91	2.88	1.66	1.44		0.90
1.73	1.11	1.64	2.70	1.37	1.46		
1.61	1.01	1.48	2.50	1.34	1.42		
1.66	1.12	1.47	2.17	1.27	1.16		
1.55	1.10	1.50	2.30	1.27	1.16		
1.48	0.97	1.43	1.82	1.10	1.11		
1.42	0.91	1.22	2.00	1.11	1.12		
1.29	1.18	1.08		1.11	0.90		
1.25	1.10			1.16	0.78		
1.26	1.01			1.11	0.79		
1.19	1.00				0.88		
1.19	1.00				0.62		
1.18	0.92				0.7		
1.19	0.97						
1.09	0.68						
0.98	0.86						
1.03	0.85						
	0.64						
	0.66						
	0.72						
	0.65						

Table 3: Total Acidity.

Graph 1: Total Acidity

Brix °							
Navelina Esp 00-01	Navelina Esp 01-02	Val Late Esp 00-01	Val Late Esp 02-03	Lane Late Esp 00-01	Lane Late Esp 02-03	Val Late Cuba 00-01	Val Late Cuba 02-03
10.20	9.60	11.50	12.60	14.00	9.00	10.60	10.20
10.90	10.60	11.30	13.10	13.60	9.60		11.60
11.30	10.10	11.40	14.20	1240	10.00		
12.10	10.30	11.30	13.90	13.20	10.50		
11.90	10.70	12.00	13.50	13.80	10.30		
11.60	10.60	11.80	13.60	14.2	10.9		
11.30	10.60	11.90	14.00	14.9	10.10		
12.10	10.80	12.1	13.60	14.8	11.40		
11.70	11.20	13.7		14	11.70		
12.50	11.00			15	11.70		
12.7	11.2			16	12.40		
12.6	11.00				11.70		
12.5	11.20				12.20		
12.5	12.1				12.2		
12.9	11.6						
12.4	11.2						
13.2	11.9						
14	11.8						
	11.2						
	12.7						
	12.7						
	13.3						

Table 4: Brix º

Graph: Brix º

Ripeness Index							
Navelina Esp 00-01	Navelina Esp 01-02	Val Late Esp 00-01	Val Late Esp 02-03	Lane Late Esp 00-01	Lane Late Esp 02-03	Val Late Cuba 00-01	Val Late Cuba 02-03
5.37	6.36	6.15	4.52	8.09	5.49	15.36	11.59
6.41	7.91	5.92	4.55	8.19	6.67		12.89
6.53	9.10	6.95	5.26	9.05	6.85		
7.52	10.20	7.64	5.56	9.85	7.39		
7.17	9.55	8.16	6.22	10.87	8.88		
7.48	9.64	7.86	5.90	11.18	9.40		
7.64	10.93	8.32	7.69	13.55	9.10		
8.52	11.87	9.91	6.80	13.33	10.18		
9.07	9.49	12.68		12.61	13.00		
10.00	10.00			12.93	15.00		
10.08	11.09			14.41	15.70		
10.59	11.00				13.30		
10.5	11.20				19.68		
10.59	13.15				17.43		
10.84	11.96						
11.38	16.47						
13.47	13.84						
13.59	13.88						
	17.5						
	19.24						
	17.64						
	20.46						

Table 5: Maturity Index
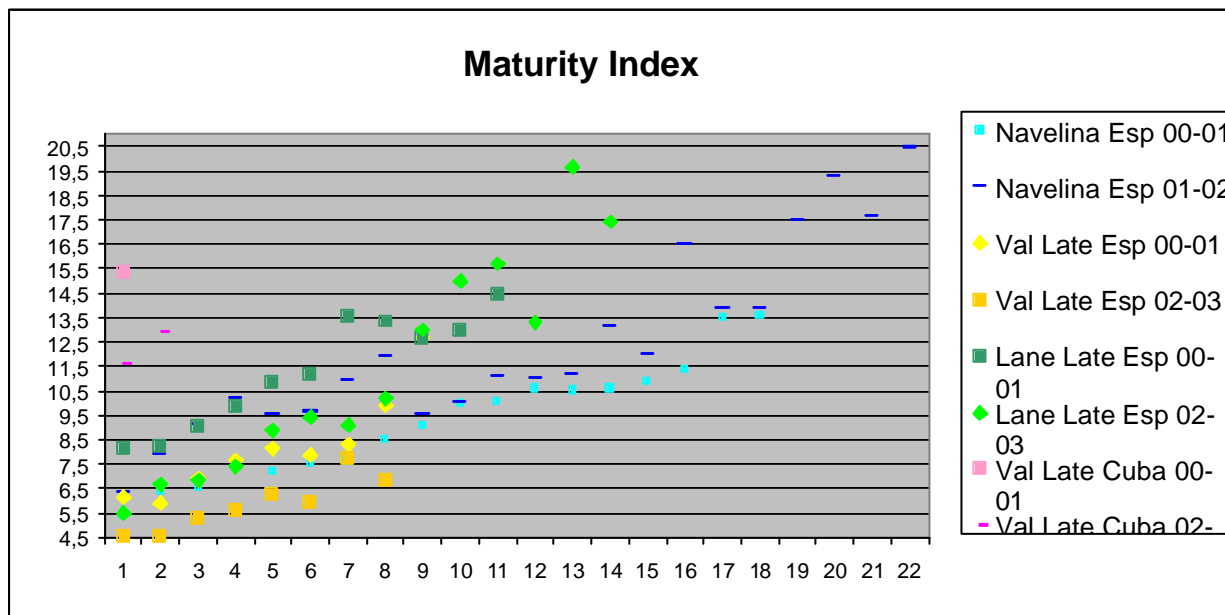
Graph 3: Maturity Index

% of Juice							
Navelina Esp 00-01	Navelina Esp 01-02	Val Late Esp 00-01	Val Late Esp 02-03	Lane Late Esp 00-01	Lane Late Esp 02-03	Val Late Cuba 00-01	Val Late Cuba 02-03
42.37	51.25	55.48	51.88	43.18	58.31	50.12	51.37
43.33	53.11	55.49	54.92	46.10	57.87		46.72
45.50	51.52	56.24	54.31	51.44	54.20		
50.63	52.22	55.65	53.68	45.01	58.49		
49.87	47.77	55.22	52.18	46.49	56.76		
50.47	51.41	53.40	55.98	44.81	56.52		
50.10	51.65	54.30	55.62	45.97	55.37		
49.71	49.69	52.47	54.01	46.94	55.03		
51.04	50.98	53.96		51.49	56.19		
48.44	52.12			45.52	55.56		
50.62	50.58			43.99	56.10		
48.73	49.97				55.33		
45.42	47.51				55.50		
49.42	49.28				54.00		
48.53	48.79						
46.33	48.24						
48.92	48.89						
46.46	46.76						
	47.48						
	45.32						
	44.94						
	44.72						

Table 6: % of Juice
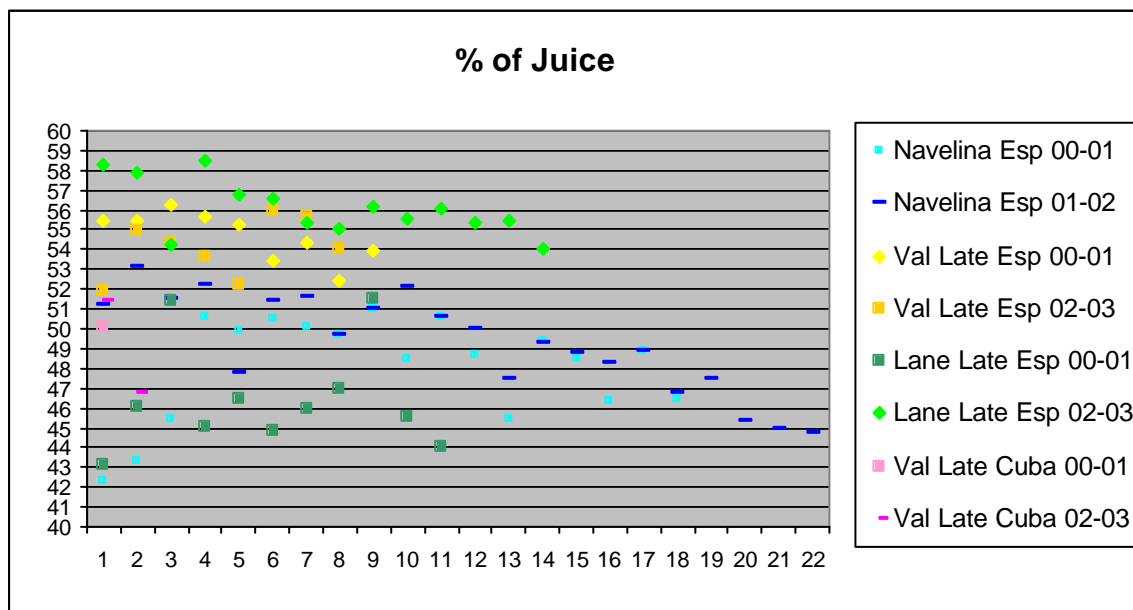
Graph 4: % of Juice

Colour Index							
Navelina Esp 00-01	Navelina Esp 01-02	Val Late Esp 00-01	Val Late Esp 02-03	Lane Late Esp 00-01	Lane Late Esp 02-03	Val Late Cuba 00-01	Val Late Cuba 02-03
-	-13.27	-	9.11	-	-14.44	-	-12.43
-	-9.03	-	9.73	-	-10.31		-0.44
-	-8.36	-	10.53	-	-5.83		
-	-4.96	-	10.07	-	2.15		
-	-3.02	-	10.66	-	7.00		
-	2.02	-	11.53	-	7.71		
-	3.53	-	11.63	-	10.86		
-	5.29	-	11.71	-	11.09		
-	8.63	-		-	11.32		
-	11.18			-	10.94		
-	11.83			-	12.17		
-	11.81				12.86		
-	13.80				11.79		
-	15.2				12.14		
-	14.01						
-	16.84						
-	14.63						
-	15.05						
	15.77						
	15.3						
	16.04						
	15.11						

Table 7: Colour Index
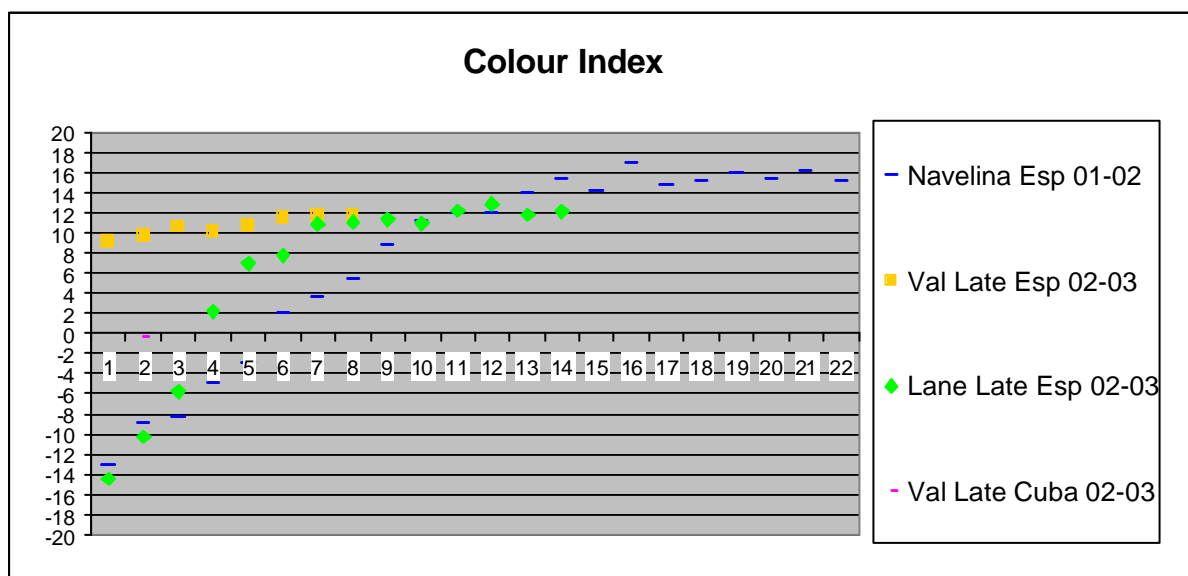
Graph 5: Colour Index

General Appraisal							
Navelina Esp 00-01	Navelina Esp 01-02	Val Late Esp 00-01	Val Late Esp 02-03	Lane Late Esp 00-01	Lane Late Esp 02-03	Val Late Cuba 00-01	Val Late Cuba 02-03
2.92	4.67	3.87	3.65	5.05	4.89	2.95	3.69
3.58	4.47	4.13	3.14	4.88	5.15		2.99
3.79	4.88	4.95	3.30	5.77	5.50		
5.00	5.10	4.68	3.84	5.45	6.13		
5.77	5.48	4.62	3.76	6.35	6.31		
5.08	5.42	4.53	4.20	6.35	6.52		
5.73	5.33	5.52	4.07	6.42	6.55		
5.57	5.48	6.00	4.57	6.42	6.30		
5.37	5.97	6.08		6.15	6.69		
5.33	4.95			6.35	6.42		
6.27	5.47			5.86	6.74		
5.93	5.42				6.35		
5.73	6.02				6.47		
6.00	6.37				6.72		
6.10	6.07						
6.13	5.38						
6.10	5.87						
5.60	6.23						
	5.9						
	6.05						
	5.52						
	6.17						

Table 8: General appraisal. Consumers test.
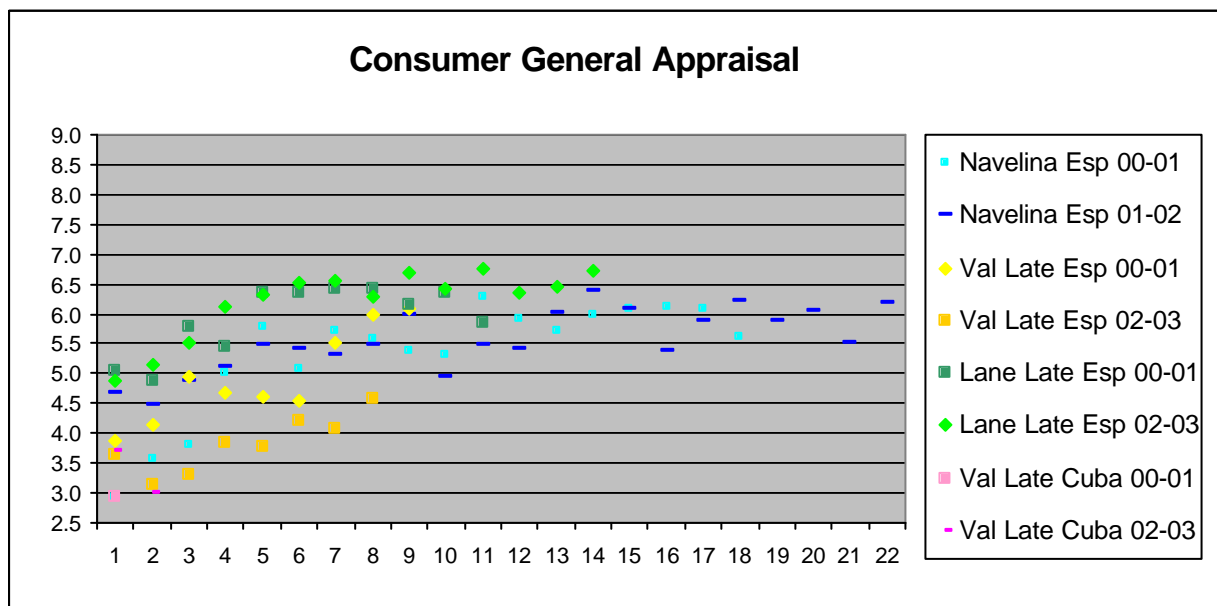
Graph 6: General appraisal. Consumers test.