

The influence of cultivar, location and season on cactus pear (*Opuntia ficus-indica*) fruit quality.

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N. Shongwe, P. Nel, G. Osthoff, M. Labuschagne



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OUTLINE

- **Introduction**
- **History**
- **Today**
- **Quality characteristics**
- **Aims**
- **Materials & Methods**
- **Results & Discussion**
- **Conclusions**
- **Acknowledgements**

INTRODUCTION

- Native to arid and semi-arid regions
- Successful as sustainable agricultural system, due to
 - adapt to a variety of weather conditions and high temperatures
 - resistance to draughts
 - adapt to unfertile soils
 - excellent productivity
- High water efficiency



HISTORY

- **First introduced to SA in 17th century (spiny)**
- **In 1914, Grootfontein Research Institute (Middelburg) imported 22 spineless Burbank varieties**

TODAY

- **Research at Grootfontein – focused mainly on fodder**
- **Grootfontein orchard not maintained**
- **Dept. of Agriculture: establish primary orchard with original genetic material at Mara in Limpopo**
- **Secondary germplasms in Bloemfontein (Waterkloof), Cradock and Oudtshoorn**
- **Locations representative of different agro-ecological areas**
- **> 78 varieties**

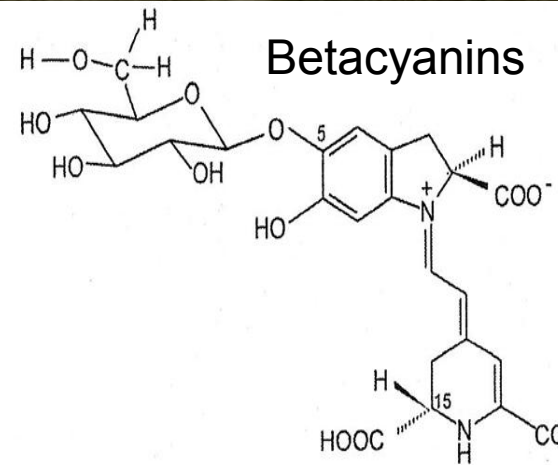
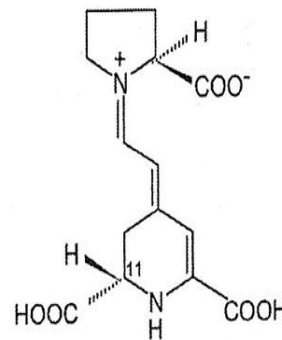
CHEMICAL COMPOSITION

Component	Content (100g edible portion)
Water	87.69 %
Energy	172 kJ
Proteins	0.7 g/100g
Fats	0.5 g/100g
Carbohydrates	7.8 g/100g
Fructose	5-6 %
Glucose	6-8 %
Fiber	3.15 %
Calcium	56 mg/100g

Chemical composition continues

- Amino acids: proline, taurine, serine
- Vitamins: ascorbic acid, riboflavin, vitamin B1, B6, niacin and pantothenic acid
- Minerals: calcium, potassium and magnesium
- Organic acids: citric-, oxalic-, malic- and succinic acids
- Pigments: betaxanthins, betacyanins (antioxidants)
- Ethanol as main volatile

Betaxanthin



QUALITY CHARACTERISTICS

Quality parameter	Content
Fruit mass	100 - 240 g
Pulp percentage	> 55 %
Ascorbic acid	20 - 30 mg/100g
Total soluble solids	13 °Brix
pH	5.0 - 7.0
Titratable acid content	0.03 - 0.12 %

AIMS

- To determine the nutritional composition of cactus pear fruit from different cultivars grown at different agro-ecological regions
- To determine the most stable (suitable) cultivar with eating quality at the three localities

MATERIALS

- ◆ 42 cultivars from Waterkloof (Free State)
- ◆ 16 from Cradock (Eastern Cape)
- ◆ 14 from Oudtshoorn (Western Cape)
- ◆ 2 seasons (2008 and 2009)

Agro-climatic data	Waterkloof	Cradock	Oudtshoorn
Altitude (m)	1354	926	328
Latitude	29°1' S	32°14' S	33°6' S
Longitude	26°3' E	25°63' E	22°19' E
Climatic region	Dry Highveld Grassland	Eastern Karoo	Little Karoo
Total annual rainfall (mm) 2008	557.1	450.7	875.7
Total annual rainfall (mm) 2009	537.9	532.3	524.2
Rainfall (last four months) 2008	253	199.7	417
Rainfall (last four months) 2009	240.4	259.9	173.1

METHODS

- Analysis on fresh fruit (50 % colour break stage):
 - Fruit mass, percentage pulp and percentage peel
 - Total soluble solids content (°Brix) (refractometer)
- Chemical analysis on fruit pulp:
 - pH (pH meter)
 - Ascorbic acid (AA) (2,6 dichlorophenolindophenol)
 - Titratable acidity (TA) (as % citric acid)
 - Sugar content (Glc and Fru) (HPLC)
- Statistical analysis
 - Single and combined ANOVA
 - AMMI, PCA and IPCA

RESULTS AND DISCUSSION

Statistical analysis: single ANOVAs

Table of mean squares of measured characteristics (2008)

Parameter	<u>Waterkloof</u>				<u>Cradock</u>				<u>Oudtshoorn</u>			
	Cultivar		Replication		Cultivar		Replication		Cultivar		Replication	
Fruit Mass	3048.18	**	241.26	NS	1533.82	**	44.28	NS	1170.73	NS	212.17	NS
Pulp %	11.74	NS	8.33	NS	40.61	*	20.58	NS	73.19	NS	22.12	NS
Peel %	11.74	NS	8.33	NS	39.98	*	17.51	NS	73.19	NS	22.12	NS
TSS (°Brix)	3.48	**	0.88	NS	7.83	**	0.26	NS	12.21	**	0.86	NS
Pulp pH	0.23	**	-	-	0.99	**	0.01	NS	1.74	**	0.06	NS
Pulp TA	0.04	**	0.02	**	0.18	**	0.04	NS	0.20	**	0.02	NS
Pulp AA	30.16	**	0.56	NS	2.23	*	0.69	NS	8.60	**	0.35	NS
Pulp Fru %	0.22	NS	0.13	NS	0.25	NS	0.51	NS	4.08	**	0.13	NS
Pulp Glc %	1.02	**	0.27	NS	0.32	NS	0.41	NS	7.03	**	0.08	NS

** P ≤ 0.01; * P ≤ 0.05; NS = Not Significant

De Wit *et al.*, 2010

Statistical analysis - Combined ANOVAS

Table of mean squares and contribution to variation (2008)

Waterkloof, Cradock and Oudtshoorn

Parameter	Location		% Contrib	Cultivar		% Contrib	Loc X Cultivar		% Contrib
Fruit Mass	7249.32	**	12.52	3252.61	**	30.91	1250.06	**	23.76
% pulp	583.08	**	29.68	40.73	*	11.40	42.41	**	23.74
% peel	588.75	**	29.85	39.57	*	11.03	42.67	**	23.80
Brix	23.90	**	11.58	7.01	**	18.67	8.26	**	44.01
Pulp pH	8.40	**	32.80	0.46	**	9.79	1.25	**	53.84
TA pulp	0.38	**	11.31	0.11	**	17.95	0.16	**	52.85
Asc Acid pulp	69.19	**	21.41	11.90	**	20.26	14.54	**	49.49
Pulp Frct %	1.71	**	4.87	1.33	**	20.83	1.61	**	50.54
Pulp Glc %	0.79	NS	1.33	2.45	**	22.76	2.96	**	54.81

** P ≤ 0.01; * P ≤ 0.05; NS = Not Significant

De Wit et al., 2010

STATISTICAL ANALYSIS - single ANOVAs

Table of mean squares for quality parameters 2009

Parameter	Waterkloof				Cradock				Oudtshoorn			
	Cultivar		Replication		Cultivar		Replication		Cultivar		Replication	
Fruit mass	1020.13	**	94.24	**	1719.06	**	390.32	**	913.92	**	1561.31	**
% pulp	86.65	**	0.23	NS	124.98	**	35.68	**	42.23	**	21.26	**
% peel	67.5	**	6.27	**	103.33	**	45.62	**	70.77	**	6.27	**
TSS (°Brix)	6.69	**	0.19	NS	2.55	**	0.4	NS	2.79	**	0.64	**
Pulp pH	0.5	**	0.04	NS	1.59	**	0.1	NS	0.12	**	0.09	NS
Pulp TA	17.83	**	0.41	NS	8.57	**	0.45	**	245.07	**	0.93	**
Pulp AA	1521.83	**	5.29	**	529.25	**	2.03	**	526.45	**	5.68	**
Pulp % fru	7.14	**	0.37	**	1.72	**	0.1	NS	3.15	**	0.06	NS
Pulp % glc	1.69	**	0.37	**	3.41	**	0.17	**	2.44	**	0.03	NS

** $p \leq 0.05$; NS = Not Significant

Combined ANOVAs

Table of mean squares and contribution to variation (2009)

Waterkloof, Cradock and Oudsthoorn

Parameter	Location		Cultivar		Loc X Cult				
		% Contr		% Contr		% Contr			
% pulp	129.19	**	7.79	119.01	**	39.45	38.15	**	25.29
°Brix	141.4	**	56.3	5.70	**	12.48	4.01	**	17.56
pH pulp	0.65	**	5.33	0.78	**	35.47	0.51	**	46.36
TA pulp	80.75	**	4.19	141.26	**	40.31	95.45	**	54.47
Vit C pulp	3065.35	**	18.85	618.94	**	20.93	826.19	**	55.87
Fru pulp %	29.56	**	29.88	4.52	**	25.13	3.33	**	37.01
Glc pulp %	0.72	**	1.38	1.92	**	20.13	3.42	**	71.9

** p ≤ 0.05 ; NS = Not Significant

Combined ANOVAs (2008 & 2009)

Table of mean squares and contribution to variation

Parameter	Location	%contribution	Variety	% contribution	Season	% contribution	Location x variety	% contribution	Location x season	% contribution	Variety x Season	% contribution	Location x variety x season	% contribution
Fruit mass	9085**	13.67	3740**	29.8	2456**	13.23	1068**	11.30	957**	3.49	1028**	3.45	687**	9.03
% pulp	493.1**	14.94	113.0 **	17.12	124.70 **	1.89	48.27 **	14.62	146.1 **	4.43	54.23 **	8.21	34.16 **	10.35
% peel	1574.**	28.81	99.48**	9.10	1190.6**	10.90	59.16 **	10.83	177.0**	3.24	59.75 **	5.47	40.56 **	7.42
TSS (°Bx)	102.8**	21.96	9.88 **	10.54	107.80 **	11.51	7.46 **	15.93	31.26 **	0.07	3.87 **	4.13	5.19 **	0.11
Pulp pH	2.10**	4.93	1.32 **	15.33	14.06 **	16.52	0.85 **	20.01	4.62 **	10.85	0.43 **	5.03	0.89 **	20.85
Pulp TA	34.11**	5.85	6.60 **	5.65	645.05 **	55.28	5.93 **	10.15	37.53**	6.43	5.39 **	4.62	5.96 **	10.22
Pulp AA	956.4**	14.30	330.1**	2.47	105994**	79.35	318.7**	4.77	925.0**	1.39	345.1 **	2.58	462.7**	6.93
Pulp % Fru	6.00 **	4.92	3.45 **	14.18	23.00 **	9.44	2.06 **	16.94	14.22 **	11.68	2.80 **	11.5	2.39 **	19.63
Pulp % Glc	1.53 **	0.99	2.55 **	8.28	94.70**	30.74	4.59 **	29.80	0.43 **	0.28	1.92**	6.24	2.29 **	14.84

** p ≤ 0.05 ; NS = Not Significant

Table of mean squares and contribution to variation

Best performing cultivar (combined seasons):

Cultivar	Fruit mass	% pulp	TSS	Pulp pH	Pulp TA	Pulp AA	Pulp % Fru	Pulp % Glc
Algerian	115.46	59.89	11.89	5.70	3.38	22.58	2.88	3.05
Gymno Carpo	109.85	59.22	11.70	6.11	2.11	26.05	3.03	2.81
Meyers	124.65	58.88	12.89	5.96	2.28	31.16	3.54	2.82
Morado	120.91	57.05	13.22	6.07	1.89	19.28	2.90	2.79
Nudosa	153.58	54.74	10.87	5.93	2.26	26.90	2.70	1.91
Roedtan	134.53	55.52	12.84	5.84	2.84	19.41	2.84	2.84
Skidders Court	148.01	51.83	12.99	5.42	2.49	26.52	1.96	2.09
Tormentosa	147.36	54.42	12.95	5.31	2.91	32.79	2.94	2.93
Turpin	110.06	56.16	12.91	5.70	2.08	26.56	2.91	2.73
Van As	132.92	56.94	12.91	6.07	1.61	23.67	2.08	2.28
Zastron	98.77	53.61	13.04	6.02	3.51	28.11	2.55	2.88

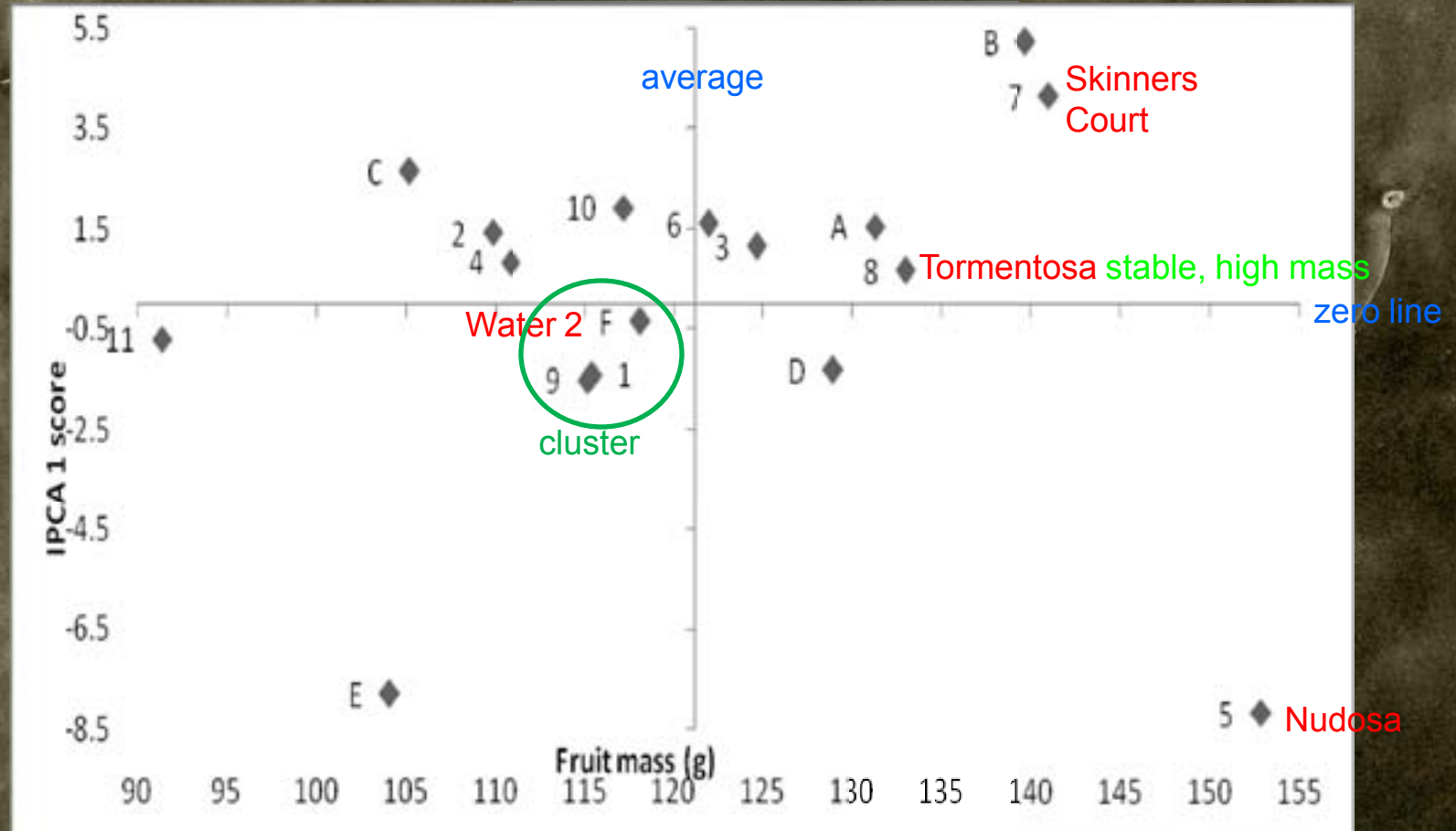
PCA and IPCA scores:

- representation of the genotype and environment interaction
- summarizes patterns and relationships of the genotypes and environments.

Cultivars		Environments	
1	Algerian	A	Oudtshoorn season 1
2	Gymno carpo	B	Oudtshoorn season 2
3	Meyers	C	Cradock season 1
4	Morado	D	Cradock season 2
5	Nudosa	E	Waterkloof season 1
6	Roedtan	F	Waterkloof season 2
7	Skinners court		
8	Tormentosa		
9	Turpin		
10	Van as		
11	Zastron		

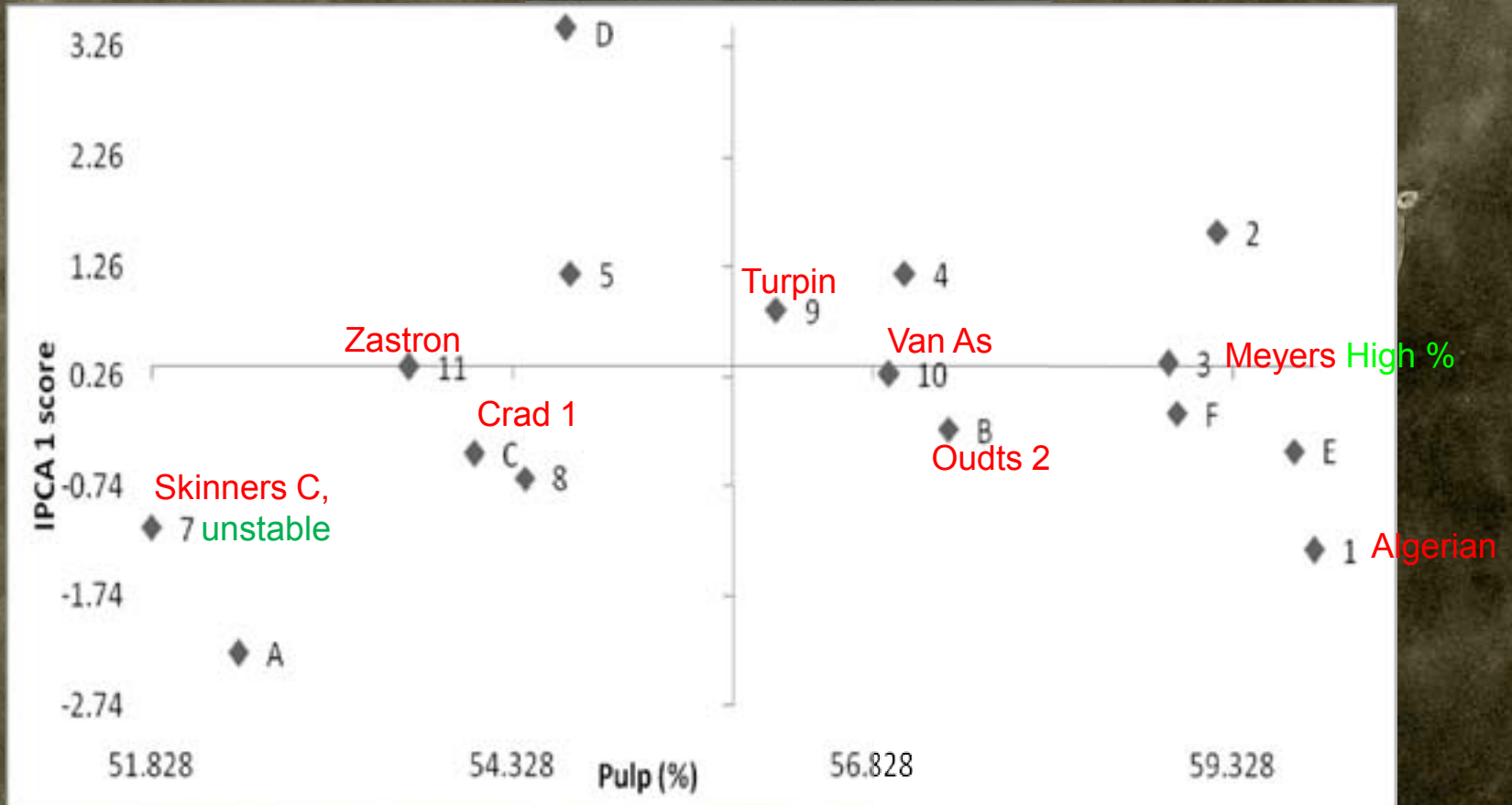
Combined ANOVAs

IPCA: fruit mass



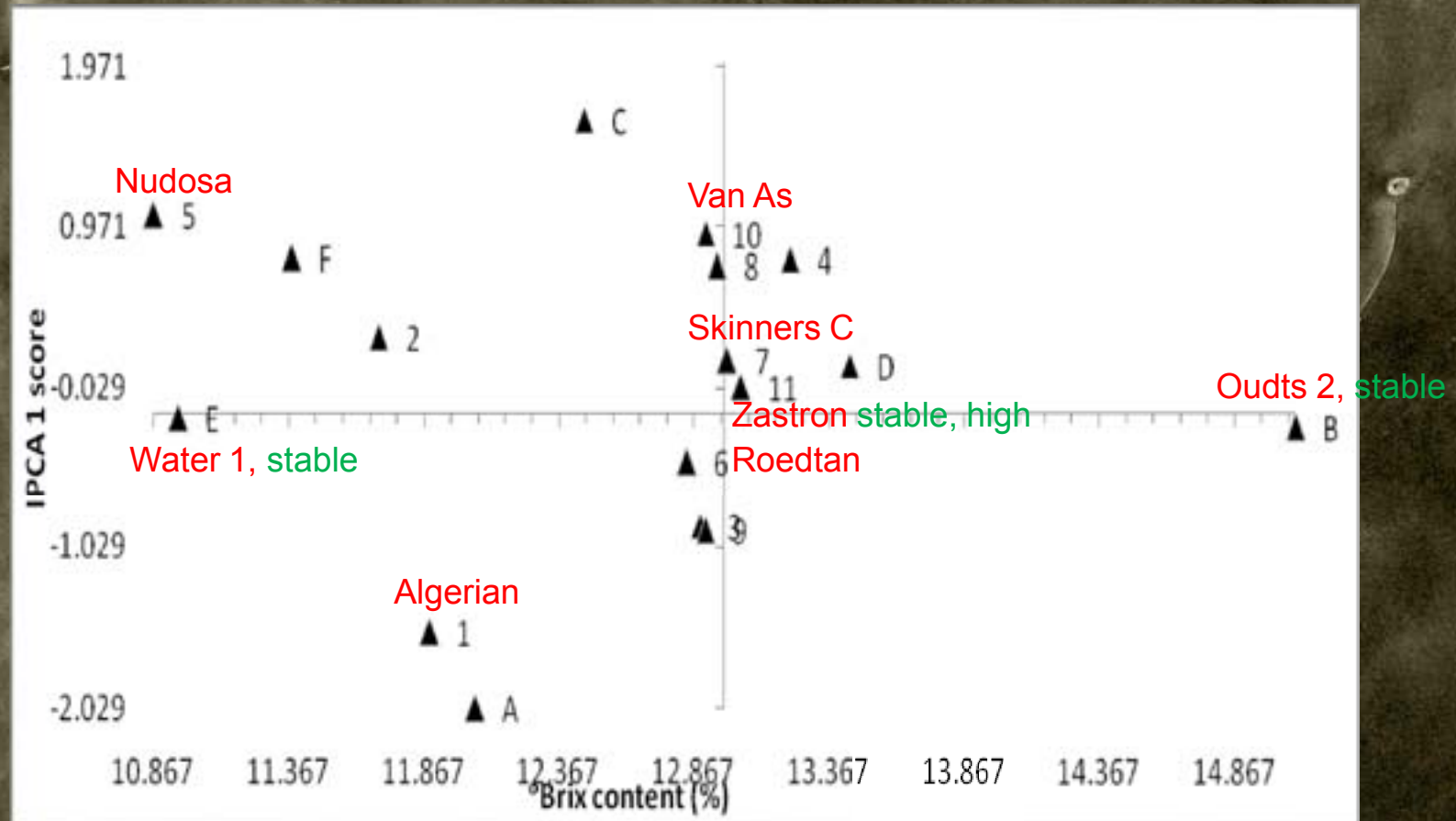
Combined ANOVAs

IPCA: % pulp



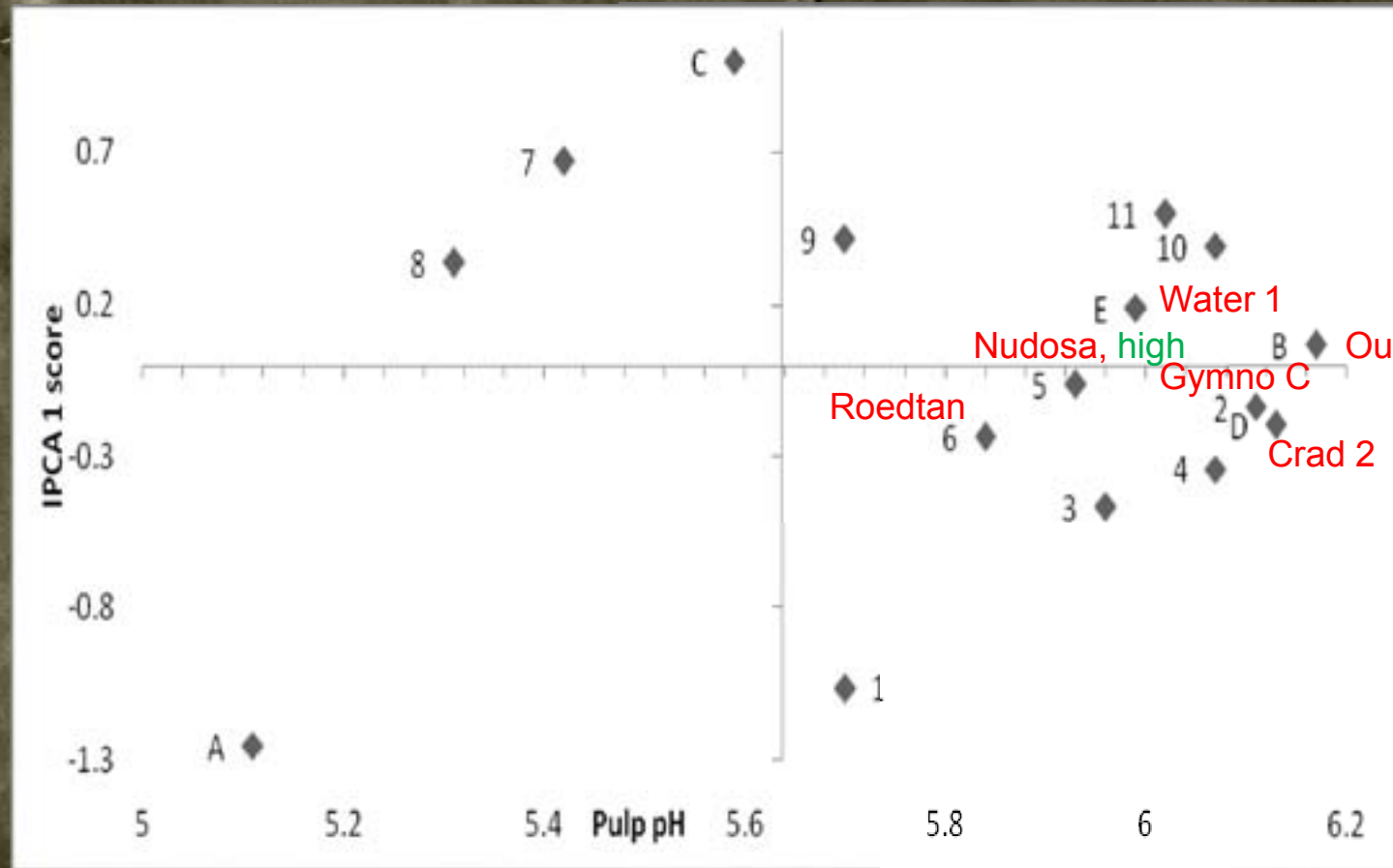
Combined ANOVAs

IPCA: TSS (°Brix)



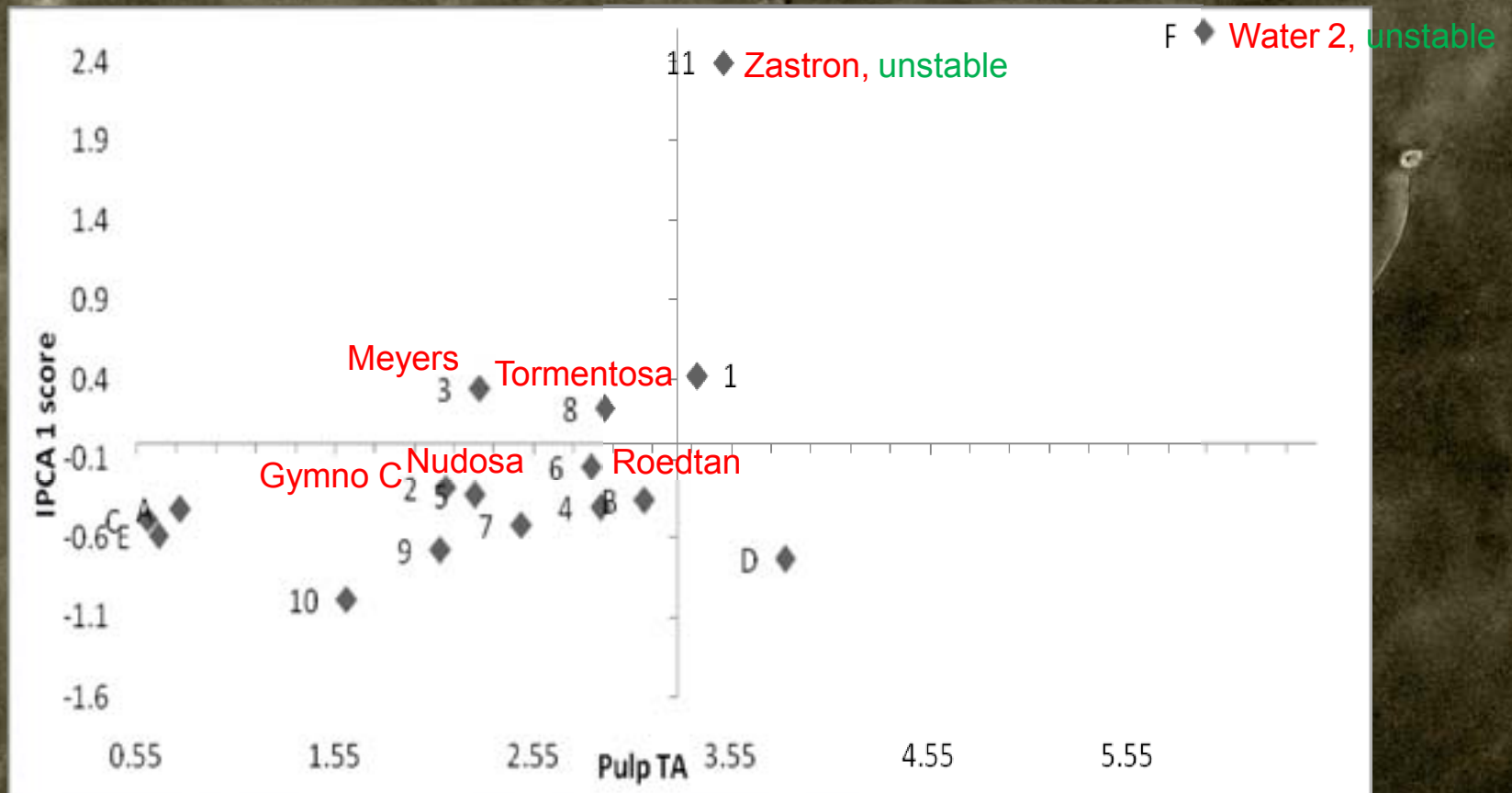
Combined ANOVAs

IPCA: Pulp pH



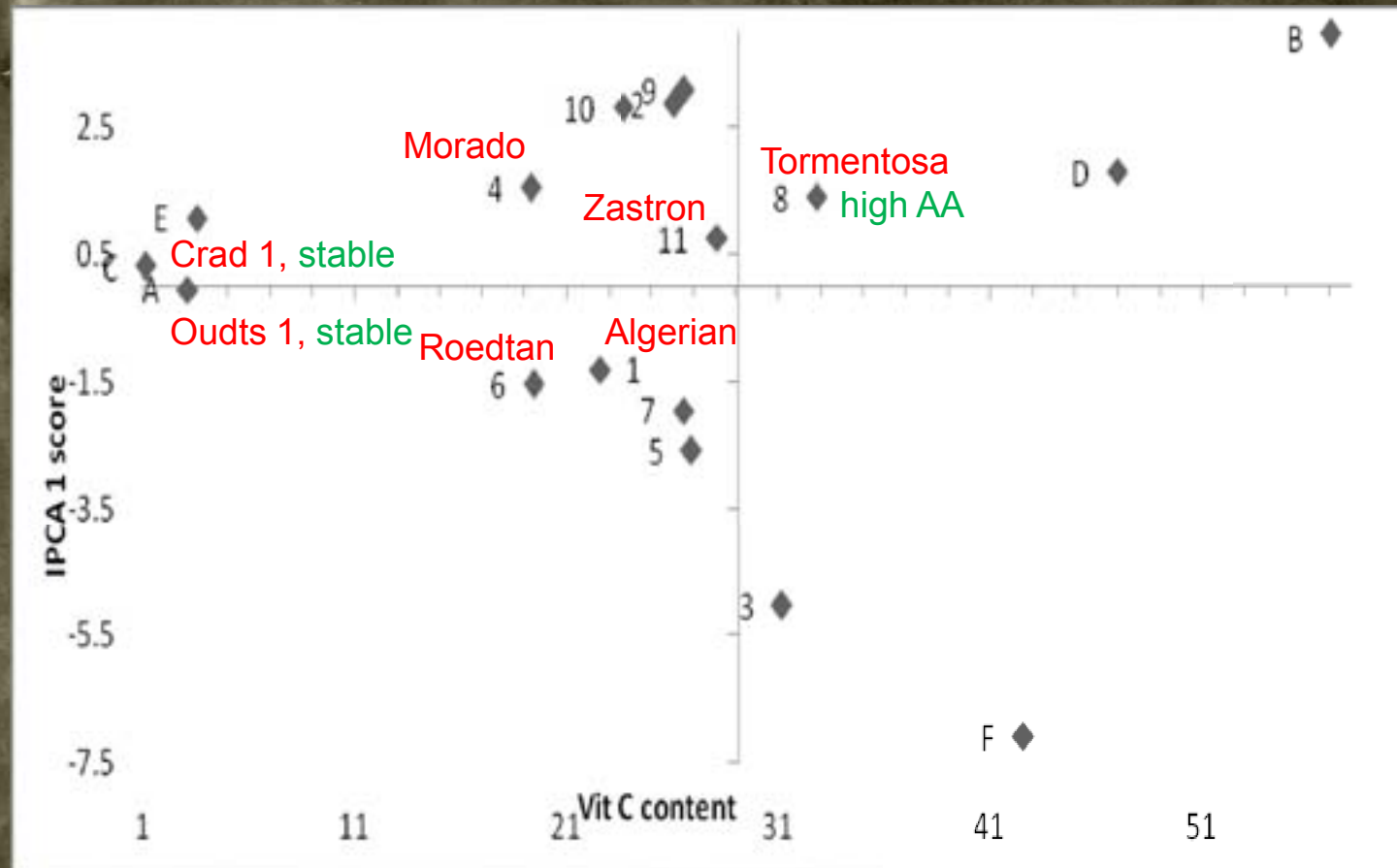
Combined ANOVAs

IPCA: Pulp TA



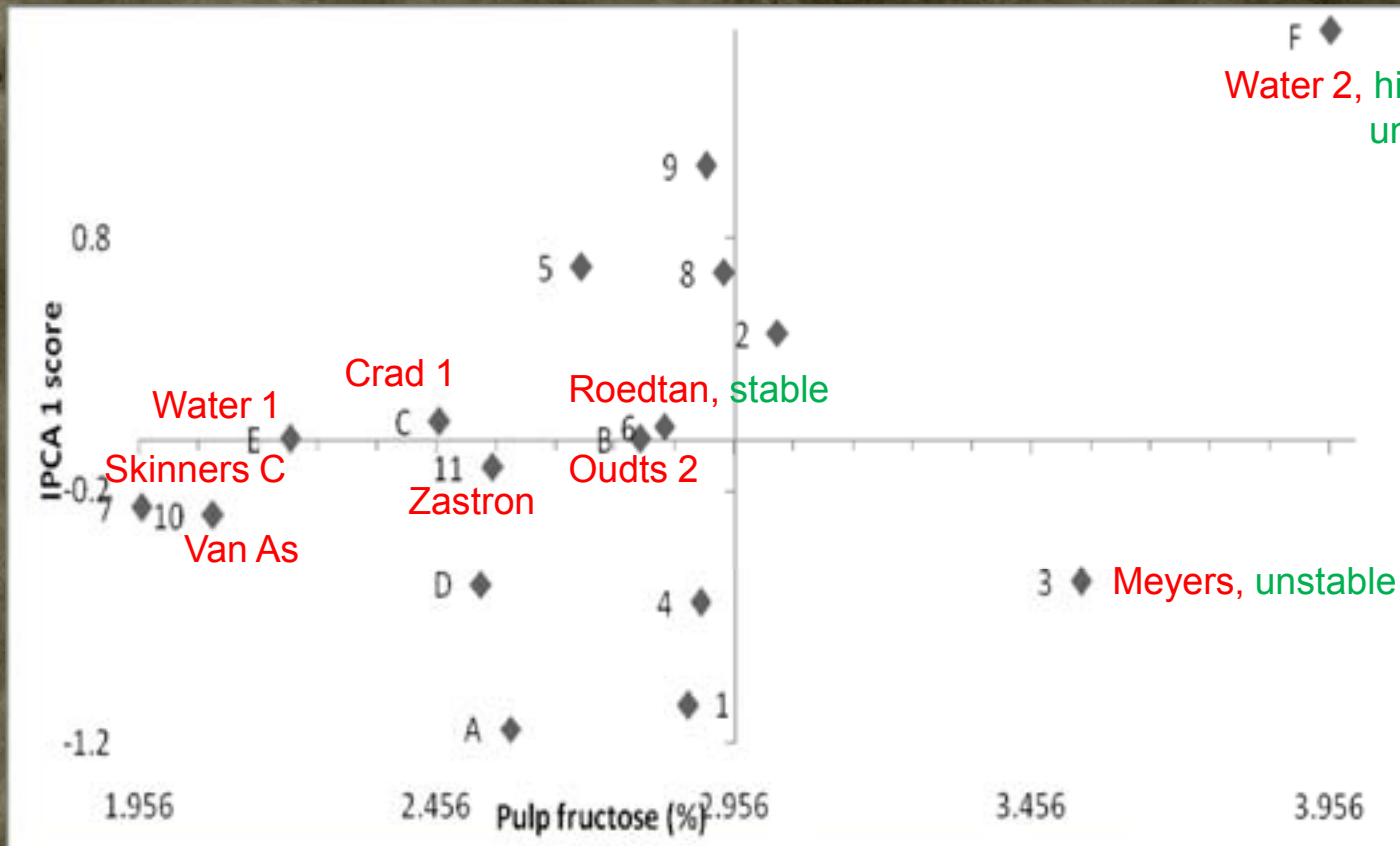
Combined ANOVAs

IPCA: Pulp AA



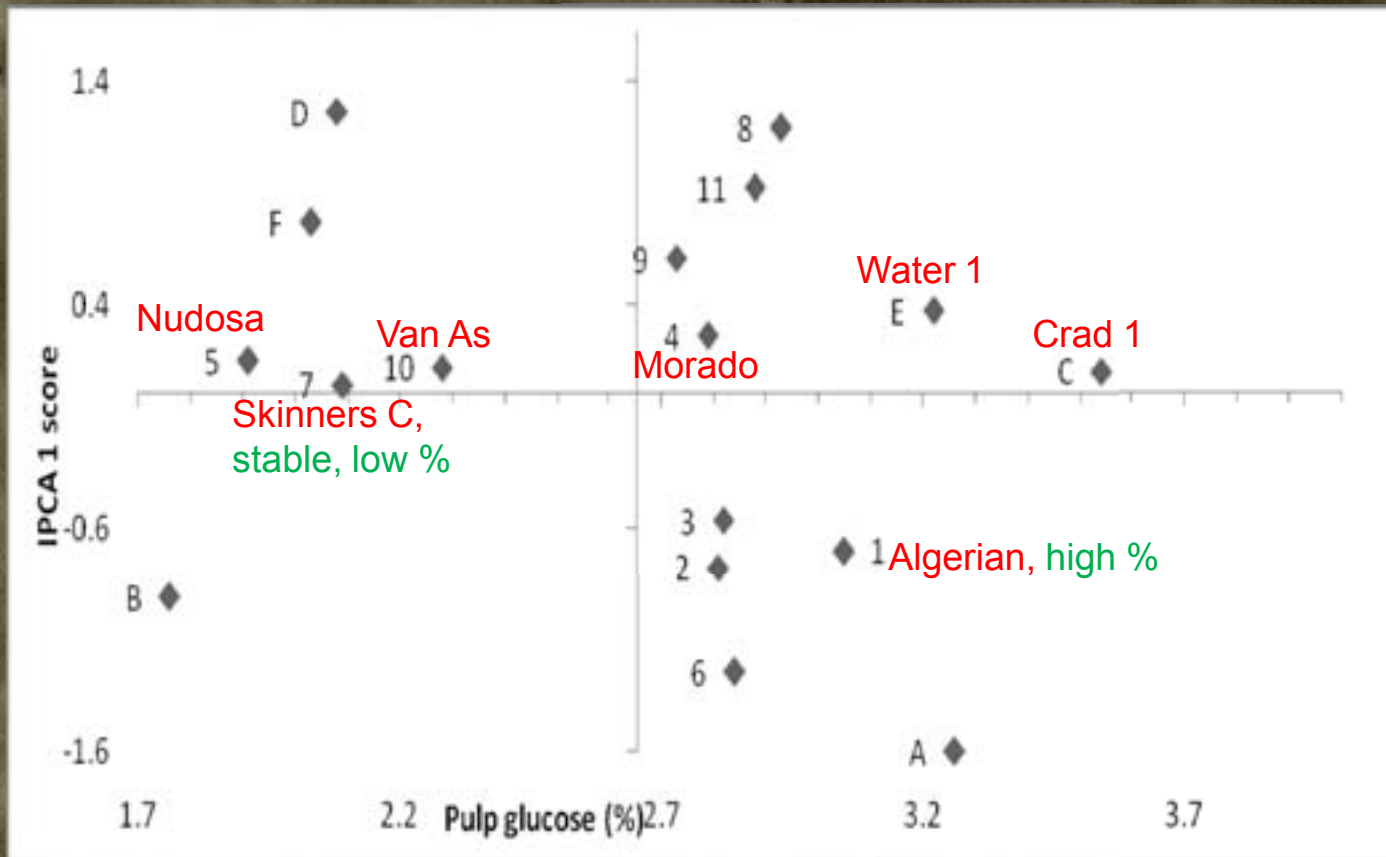
Combined ANOVAs

IPCA: Pulp % fructose



Combined ANOVAs

IPCA: Pulp % glucose



CONCLUSIONS

- Genetic material, location as well as interactions between cultivars, locations and seasons have influence on fruit quality
- Effect of location and season more profound on parameters regarding sugar- and acidity levels
- According to ANOVA: Tormentosa performed best over both seasons
- According to AMMI: Meyers most stable over both seasons

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