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Fresh Consumption Quality of the Apple of Some Brazilian Early Dwarf Cashew Clones (*Anacardium occidentale*)

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Abstract. In 1996, 11 clones with orange to red colored apple (consumers' preferences) were selected within an experiment of clone competition and evaluation, set up under dry conditions in Pacajus, Ceará, Brazil. Clone CAP 29 (CCP-76) was used as control. From the 11 clones evaluated, only one was inferior to the control for apple color. Clones CAP-11, CAP-15 and CAP-22, stood out as significantly ($p < 0.05$) firmer than the control, which suggests that they might have extended shelf lives as compared to the others. As related to the physical characteristics of the selected cashew apples, it was found that clones CAP-02, CAP-11 and the control CAP-29 (CCP-76) produced average apples (type 4), the most distinguished for market purposes. No significant difference was found among the clones for soluble solids and acidity, whose mean contents were respectively 11.88 °Brix and 0.36%. The amounts of soluble solids (around 10 °Brix) in this experiment were above those usually reported for cashew in Brazil.

Resumen. Durante el año 1996 fueron seleccionados 11 clones con manzanas de coloración de naranja a rojo, de un experimento de competición e evaluación de 30 clones, instalado sin riego en Pacajus, Ceará, Brasil. El clon CAP 29 (CCP-76) fue usado como testigo. De los 11 clones seleccionadas, sólo uno presentó color de la manzana inferior el de lo testigo. Los clones CAP-11, CAP-15 e CAP-22 destacaron como significativamente más firmes que el testigo ($p < 0,05$), lo que sugiere que ellos puedan tener vida útil postcosecha más prolongada que los demasado. Con relación a las características físicas de las manzanas, se observó que solo los clones CAP-02, CAP-11 e el testigo tenderán a producir manzanas tipo 4, la más valorado para el mercado de frutas frescas. No fueran encontradas diferencias significativas entre los clones para las características sólidos solubles y acidez, del cual las promedias fueran respectivamente 11,88 °Brix e 0,36%.

The breeding program for early, dwarf cashew trees in Brazil was initiated in 1965 at the Pacajus experimental station. It started from the traditional individual phenotype selection process followed by clone selection (Barros and Crisóstomo, 1995). This program has allowed the Ceará State Agricultural Research Corporation-EPACE to release the CCP-06 and CCP-76 clones in 1983 (Barros *et al.*, 1984), and the CCP-09 and CCP-1001 clones in 1987 (Barros and Crisóstomo, 1995) and clone EPACE CL-49 in 1993 (Almeida *et al.*, 1993a). These clones constituted the change-inducing factors for the extensive and casually cultivated cashew industry in Northeastern Brazil (Almeida *et al.*, 1993b). The dwarf clones have a field potential of 1300 kg of nuts/ha but kernel weight is below 2.53 g, the minimal weight required by the international market. Two of these clones, CCP-09 and CCP-76 have been preferred for the weight of their kernels and color of apples. For this reason, new clones and progenies - in a search for new gene combinations - are being evaluated aiming productivity above 1300 kg of nuts/ha, fruits with kernel weighing 2.53 g or more and apple with potential for the fresh fruit market. These genotypes would make cashew production economically viable without irrigation in coastal and transition areas (Barros, 1996). Information generated by postharvest research on cashew apple has already produced an increase in the commercialization of fresh cashew apple (Menezes, 1992; Menezes and Alves, 1995). Until very recently cashew apple was sold exclusively in local street fairs. Today it reaches supermarkets in other parts of the country located up to 4000 km from the production area. There is at the present a great availability of cashew genotypes under investigation. However, breeding programs have been directed towards nut quality and yield, neglecting the characteristics of the apple. Therefore a selection will be carried out among the available genotypes to identify those with high yield and those which meet the requirements of the increasing market for fresh apples, i.e. red skin color, high soluble solids/acidity ratio and high resistance to handling, as evaluated through texture. In this study, apples of cashew clones obtained from the Embrapa/Agroindústria Tropical Breeding Program were evaluated for their physical, physicochemical and chemical characteristics with the objective of identifying those with best characteristics for fresh consumption.

Materials and Methods

During the first semester of 1996 cashew apples (peduncles) with potential for fresh consumption were evaluated from early, dwarf cashew clones (CAP). This experiment was initiated in 1990 in Pacajus-CE, without irrigation, and consisted of thirty clones, planted in plots of 4 plants replicated 4 times. Trees are spaced 7 m x 7 m, and include the clones recommended for commercial planting CAP-28 (CCP-09), CAP-29 (CCP-76) and CAP-30 (CCP-1001). During November 1996, 11 clones were selected, according to skin color (from orange to red). A sample varying from 13 to 46 apples of each clone was harvested at commercial maturity and transported to the Laboratory of Postharvest, Physiology and Technology of Embrapa, Fortaleza, for physical evaluations of texture, weight, length, diameter and color. The apples were then frozen and stored at -20°C for later evaluation of total soluble solids (SS), total titratable acidity (TA) and pH. The following methodology was used: Size - measurements were taken for length, apex and base diameters, according to Almeida *et al.* (1987); Weight - a semi-analytical scale was used; Skin color - evaluated by an Plant Color Atlas - DIN 6164 (Biesalski, nd); Pulp firmness - measured in the whole apples with a hand penetrometer FT011(0-5 kg) with 8 mm diameter plunger; SS - measured with a refractometer and expressed in °Brix as recommended by AOAC (1992); TA - determined titration with diluted NaOH, as recommended by IAL (1985); SS/TA ratio: calculated as the quotient between the two characteristics; pH - measured by potentiometry using glass electrode, according to AOAC (1992). Results expressed in pH units. The experiment was conducted in a completely randomized design with 4 replications (samples of up to 13 apples/4 plants) and 11 clones. For physical analyzes all harvested cashews were considered individually.

Results and Discussion

The evaluation was made to identify clones with color shades as close as possible to red, which is preferred by consumers, taking as reference CAP-29 (CCP-76) which has deep-orange color and is presently the most cultivated for fresh consumption (Alves *et al.*, 1997; Filgueiras *et al.*, 1997). It was found that all clones except CAP-28 exhibited at least the color of CAP-29 (Table 1). Cashew grading for fresh fruit market in Brazil is based upon the number of cashews per tray (550-600 g), which usually varies from 4 to 8. Considering that consumer's preference is for cashews types 4 to 6 (fruits/tray) the most adequate fruit are those weighing in average 100 g (Filgueiras *et al.*, 1997). The physical characteristics (Table 2) of the cashews selected in this experiment show that clones CAP-02, CAP-11 and the reference CAP-29 (CCP-76), produce cashews of type 4 on average, whereas cashews from clones CAP-06, CAP-14, CAP-15, CAP-22 and CAP-30 produces types 5 and 6.

Table 1. Apple Color of some Brazilian early dwarf cashew clones.

CLONES	Identification	'Atlas'	Color
CAP-02	P-147E	7E(7:7:1,5)	Light red
CAP-06	P-500E	7,5E(7,5:7:1,5)	Red
CAP-09	P-464E	6E(6:5,5:1,5)	Deep orange
CAP-11	P-76D	6E(6:5,5:1,5)	Deep orange
CAP-14	MII-52	6E(6:5,5:1,5)	Deep orange
CAP-15	MII-53	7E (7:7:1,5)	Light red
CAP-22	CLONAR-46	7E (7:7:1,5)	Light red
CAP-25	C-10P5(G18)	7E (7:7:1,5)	Light red
CAP-28	CCP-09	5E(5:7:1,5)	Orange
CAP-29	CCP-76	6E(6:5,5:1,5)	Deep orange
CAP-30	CCP-1001	7E (7:7:1,5)	Light red

Table 2. Physical characteristics of apple and nut of some Brazilian early dwarf cashew clones.

'CAP' Clones	Whole weight (g)	Nut weight (g)	Apple weight (g)	Apex diameter (cm)	Base diameter (cm)	Length (cm)
02	161.87 A*	7.66 D	154.21 A	5.95 AB	4.31 AB	7.12 ABC
06	117.19 C	10.14 ABC	107.06 C	5.36 C	3.24 F	7.64 A
09	95.72 DE	7.83 D	87.89 DE	5.01 D	3.58 EF	6.65 CD
11	136.65 B	11.34 A	125.33 B	5.96 A	3.87 CDE	7.20 ABC
14	101.86 CDE	8.94 BCD	92.94 CDE	5.07 CD	3.74 CDE	6.30 D
15	113.50 CD	8.84 CD	104.66 CD	5.44 C	4.08 BC	6.72 BCD
22	106.82 CD	7.66 D	98.89 CD	5.30 CD	3.89 CD	6.75 BCD
25	85.39 E	10.41 AB	74.97 E	5.13 CD	3.85 CDE	5.19 E
28	87.15 DE	8.08 CD	79.08 DE	4.87 D	3.61 DEF	5.98 D
29	145.65 AB	9.07 BCD	136.58 AB	5.82 AB	4.39 A	7.32 AB
30	109.58 CD	8.63 CD	100.95 CD	5.38 C	3.73 DE	6.49 D
CV	21.84	22.45	22.65	7.93	9.83	11.24

* Means followed by same letters in the columns do not differ significantly according to Tukey's test. (p<0.05).

Table 3. Texture, soluble solids, acidity, SS/TA ratio and pH of apple and nut of some Brazilian early dwarf cashew clones.

'CAP' Clones	Texture (kg)	Soluble Solids (°Brix)	Titr. Acid. (g malic acid/100g)	SS/TA Ratio	pH
02	2.02 BC*	11.15	0.36	30.57	4.11 E
06	2.11 BC	12.48	0.36	34.32	4.39 BCD
09	1.94 C	12.43	0.36	34.69	4.67 A
11	2.67 A	12.33	0.36	34.45	4.09 E
14	2.03 BC	12.07	0.36	34.89	4.66 AB
15	2.58 A	11.45	0.36	30.51	4.17 DE
22	2.41 AB	11.15	0.36	30.57	4.11 E
25	1.75 C	12.25	0.36	34.10	4.29 CDE
28	1.99 BC	12.60	0.35	35.67	4.49 ABC
29	1.88 C	11.27	0.36	31.48	4.33 CDE
30	1.95 C	11.83	0.36	32.01	4.53 ABC
CV	24.75	7.08	2.06	6.56	2.38

* Means followed by same letters in the columns do not differ significantly according to Tukey's test. (p<0.05).

In general the data on apple weight found in this experiment were higher than those reported in literature for clone/type evaluations. Souza Filho (1987) reports mean weights varying from 110 to 143g for CAP-29 and from 68 to 91 g for CAP-30, whereas Silva Júnior and Paiva (1994) found mean weights of 69, 97 and 37 g for clones CAP-28, CAP-29 and CAP-30. Kundu and Ghosh (1994) report apple weights varying from 23.8 to 61.7 for 31 types of cashews in India. As related to texture, clones CAP-11, CAP-15 and CAP-22 were significantly firmer than the pattern one (CAP-29), suggesting that they may have longer useful postharvest life as compared to the others (Table 3). No significant SS and TA differences ($p>0.05$) were found among the clones evaluated in this study, whose mean figures were respectively 11.88 °Brix and 0.36%. It should be noticed that the figures for SS in the present study were higher than those usually reported for cashews (Menezes and Alves, 1995). Nagaraja and Nampoothiri, (1986) reported about 10 °Brix for cashew varieties in India, although these were lower than those reported by Kundu and Ghosh (1994), from 13.45 to 18.3 °Brix. The SS/TA ratio demonstrated that all the clones had equivalent sweetness, since no significant difference was found. There were small differences in pH among clones, but all values found were above 4.0 (Table 3).

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