Journal of Food Technology 3(2): 242-246, 2005

Cold Storage of Pineapple 'Smooth Cayenne Under Different Types of Packaging

[1]Antônio Fernandes Da Costa Netto, [2]Edmar Clemente and [3]Carlos Alberto Scapim
[1]Mestre em Agronomia - Departamento de Agronomia, Universidade Estadual de Maringá Av. Colombo 5790 - Maringá - CEP 87020-900- PR
[2]PhD em Ciências dos Alimentos - Laboratório de Bioquímica de Alimentos/DQI - Universidade Estadual de Maringá - Av. Colombo 5790 -Maringá - CEP 87 020-900-PR- Brazil
[3]Doutor em Agronomia - Departamento de Agronomia, Universidade Estadual de Maringá Av Colombo 5790 - Maringá - CEP 87020-900- PR

Abstract: Postharvest storage is important for any system of fruit commercialization. This work was carried out to study the influence of two temperatures (8°C and 12°C), and two packaging types (unpacked was the control, perforated and not perforated polyethylene packaging) on the blackheart of pineapples (*Ananas comosus* (L) Merr.) cv. Smooth Cayenne. A higher number of fruit were affected by endogenous darkening at 8°C. The incidence of this disorder was more rapid and with higher intensity at 8°C than 12°C. In both temperatures, the unpacked fruit were more affected by this injury, while the fruit kept in not perforated polyethylene showed less darkening. There was an increase in soluble solids, total acidity and fresh weight loss as the endogenous darkening increased, and a decrease in flesh firmness and pH. The pH was higher and the total acidity was lower in the unpacked fruits. Firmness declined during cold storage and showed a high influence of the packaging type.

Key words: Ananas comous (L.) Merr., Postharvest, Internal browning, Storage

Introduction

Pineapple (Ananas comosus (L.) Merr.) is 13th in the world ranking of fruit production, reaching 11.847.000 t. per year. Brazil contributes with 8,7% (1.030.689 t.), that places Brazil as the 3rd largest producer in the world (Fao, 1994). The pineapple fruit has so far been exploited predominantly by small farms and has a economic potential and social support option for small farms (Ceasa-PR, 1994; Emater – PR, 1998 and Seab, 1998). Export is also an important point in the commercialization of the fruit. Therefore, extend the postharvest conservation of the pineapple it is essential to access markets faraway from the production center.

The pineapple fruit has high moisture content and the active metabolism increases the deterioration of the fruit soon after the harvest (Chitarra and Chitarra, 1990). Although there are different forms to prolong the conservation period, there is a maintenance limit when the fruit becomes unacceptable in the market or for processing (Chitarra and Chitarra, 1990). After harvest, the pineapples can loss quality and also nutritional changes, that happen because the fruit is not marketed correctly and quickly (Chitarra and Chitarra, 1990). The quantitative losses corresponding to the reduction of the mass result from a decrease of water or dry matter of the fruit. The reduction of quality is associated with flavor and deterioration in texture and appearance, and this is described as standard quality accepted by local market. Decrease of nutritional value is due to the metabolic reactions that contribute to the decrease of nutrients such as vitamins, proteins and lipids (Chitarra and Chitarra, 1990). Pineapple conservation pineapple in low temperatures has been used to maintain quality. However, some parameters during the refrigeration can result in several changes in the quality of the product. For the pineapple, storage in low temperatures is commonly associated with physiological disorders such as endogenous darkening. The objective of this work was to evaluate the effect of the packing and two temperature levels, in the occurrence of endogenous darkening in pineapple fruits (Ananas comosus (L.) Merr.) c.v. Smooth Cayenne.

Materials and Methods

The pineapple fruit used in the experiment were the cv. Smooth Cayenne which were harvested in the Umuarama district, Northwest of the State of Paraná, located at 430 m above sea level, at 23rd 45 ' of South latitude and to a longitude of 53rd 17'40 " W-GR. The climate of the area is subtropical humid meso-thermic, with rainy and hot summers. The average annual precipitation is 1500 mm and the average relative humidity is 66%. The cultivation of the pineapple was carried out in Yellow Red Podzólico soil, sandy texture and undulating relief (Embrapa, 1994 and Fasolo *et al.*, 1998).

After the harvest, the select fruit were chosen in the yellow state of maturation 1/3 of the base, with mass varying from 2.0 to 2.3 kg, discarding fruits with defects. Benomyl aqueous solution 0.05% (w/v) was used for two minutes to control the decay (Derpsch *et al.*, 1990). Two hours after that treatment, the fruits were cooled in cold water until they reached a temperature of around 20°C; following this step the pineapple fruits were sheltered in a ventilated place for 12 hours (Abreu, 1995).

The fruits were stored in refrigerating chambers BOD with relative moisture (RH) of 80 ± 5%, under two different temperatures (8°C and 12°C ± 2°C) for a period up to 28 days. For each temperature level, experiment factorial 3 x 7 was applied, with three replications, in a randomized complete design. The factor packing presented three levels: a) Fruits without packing were designated as sample (A). b) Fruits packed in 30 liter polyethylene bags with thickness of 70μ, with 50 holes of 5mm of diameter, were designated as sample (B). c) Fruits packed in polyethylene bags with thickness of 70μ and capacity for 30 liter, were designated as sample (C). The factor analysis times presented seven levels (4, 8, 12, 16, 20, 24 and 28 days). The experimental unit was constituted by a fruit, with a total of 63 fruits for each evaluation temperature. The factor analysis times (days) were obtained by the continuous exhibition of the fruits in the cold chambers for the period of 28 days. The analyses were carried out every four days for each experimental unit independently.

The Following Assays were Carried out with four Days Interval

Internal Browning: the number of affected fruits and the intensity of physiological disorder. The intensity followed the scales: absence; minimum manifestation (smaller than 10% of the cross sectional area of the fruit); medium manifestation (more than 10% and less than 50% of the cross sectional area of the fruit); strong manifestation (more than 50% of the cross sectional area of the fruit). After the longitudinal cut half of them were processed for physical and chemical analyses, and the remaining half used for visual observation of the presence of endogenous darkening.

Pathological Damages: determined by direct observations and number of fruits affected. The results were expressed in percentage of fruits with the disorder (Hadlich, 1991).

Weigh Loss: obtained by the difference between the initial weight of each fruit and the weight on the day of the evaluation of the treatments. The fruits were immediately weighed after removal from the cold chamber to avoid the condensation of water on the surface. The results were expressed in percentage of fresh mass loss.

Firmness: was determined by a penetrometer (Watkins and Harman, 1981). Six determinations were made, three in each diametrically opposed side. On each side a measurement was carried out in the apex; one in the medium part and another in the basal part of the fruit, six readings of texture were carried out and the average of the results are expressed in (N).

Soluble Solids: determined by refractometry, the reading being done in °Brix. Three readings were carried out for each repetition and the average of the results were expressed in percentage of soluble solids (Aoac, 1990).

pH: the pH measurement was carried out using a pH-meter Hanna HI92000.

Titrable Acidity: determined by titration with sodium hydroxide solution 100mM and the results were expressed in percentage of citric acid (Aoac, 1990).

The statistical analysis followed the conventional procedure (Sas, 1990). When there was interaction between packing and times of significant analysis ($P < 0.05$) the necessary unfolding was proceeded. To study the behaviour of the variables in function of the analysis times the regression polynomial analysis was used (Steel *et al.*, 1996). In the choice of the best regression model, the following approaches were adopted: the significance of the regression for the test F, the deviations of the no-significant regression for the test F, the adjusted determination coefficient (r^2) and the analysis of residuals.

Results and Discussion

The pineapple fruits stored at 8°C and 80% RH, without packing, showed 100% presence of the endogenous darkening after four days (Table 1). The fruit conditioned in both perforated bags and not perforated had the symptoms after 8 days. In both the internal browning intensity was lower. In perforated polyethylene bags the disorder was verified in 66.6% of fruits. Fruit packed in polyethylene bags without perforation showed only 33.3%. The intensity was higher in the fruits no packed and lower in fruit packed in bags without perforation. After twelve days in refrigeration, all the treatments resulted in internal browning in the fruit. Pineapple fruit stored at 8°C for 10 days and 8°C for 20 days also presented higher increased intensity of internal browning when the fruit were moved to room temperatures (20°C and 25°C) (Abreu, 1991).

Fruit without package had internal browning in the second day after the removal of the fruit from the cold chambers. This is in agreement with the report by other researchers, where the removal of the fruits from the refrigerated environment promoted the occurrence of the disorder, although with lower intensity, after the second day at room temperature (Seab, 1998). After the 12th day of refrigeration, the internal browning began in the first day after removal of the fruit.

Fruit conditioned in perforated and not perforated bags, after the 16th day of storage had the symptoms of endogenous darkening in the first day. The fruits stored at 12°C and 80% RH also developed endogenous darkening, even so that disturbance happened so much with more retarded effect with relationship to the number of fruits and appearance intensity of the disturb (Table 1). Such data disagree with the observations where the symptoms of endogenous darkening in temperatures of 12°C or 20°C were not observed (Gueche, 1978). However, in others researches works shown the manifestation of this phenomenon when the fruits were submitted at to these temperatures (Gueche, 1978 and Abreu, 1991).

The use of the polyethylene bags with no perforation decreased the percentage of the disorder as well the intensity in both temperature 8°C and at 12°C. In a lower degree, the perforated polyethylene bags act as a barrier to the endogenous darkening. This is due to the reduction of the O_2 available that was a barrier to the oxidation (Abreu, 1995).

Table 1: Effect of package and temperature on severity of internal browning in pineapple fruits cv. Smooth Cayenne.

	Temperature													
	8°							12°						
	4	8	12	16	20	24	28	4	8	12	16	20	24	28
A	100	100	100	100	100	100	100	33.3	33.3	100	100	100	100	100
B	0	66.6	100	100	100	100	100	033.3	33.3	66.6	100	100	100	100
C	0	33.3	100	100	100	100	100	0	0	33.3	33.3	66.6	100	100

A- without packing, B- packing with perforated polyethylene bags, C- packing with polyethylene bags, Severity index: <10% minimum, >10% and <50% medium and >50% strong.

The losses of fresh mass are showed in Table 2. The equations for each packing and temperature according to the time in storage are in Table 3. For both temperatures, there were significant losses of fresh mass in function of the time according to the three packing types. For the coefficients of the regression fittings, it is verified, sharply, for the two temperatures (8°C and 12°C), fruit without packing showed 0.66% and 0.55% of the loss of fresh mass to every day of increment at that time of evaluation. The loss of fresh mass was larger in the fruits packed in perforated bags (0.20% for every day of increment at that time of evaluation) in relation to the fruits packed in non-perforated bags (0.10% for every day of increment at that time of evaluation), in the temperature of 8°C. However, for the temperature of 12°C the loss of fresh mass was higher in the fruit packed in non-perforated bags (0.21%) in relation to the fruit packed in perforated bags (0.19%). The readiness of O_2 can be attributed to the decrease of the oxidation reactions and for the low relative humidity of the air inside the cold chambers which stayed about of 80% ± 5%.

The firmness results are showed in Table 2. The decrease of the fruit firmness in function of the time for both temperatures is shown in Table 3. The results are in agreement with others works with pineapple cv. Red Spanish, Pearl and Smooth Cayenne, when a significant decrease in the firmness were observed from the 90th days after the end of blooming even for the fruit that continue in the plant (Gueche, 1978 and War *et al.*, 1988).

The highest reduction of the firmness was observed for fruit without package, mainly for the temperature of 8°C, it is coincident with the fruit of worse aspects at the end of the refrigeration. That firmness loss can be related to the action of enzymes, which have a link with the softening during the fruit ripening.

In general a linear growth of the contents of soluble solids (SS) was observed, with a increase of 0.074 units (°Brix) for every day in storage. The results showed which this can be associated to the internal browning, once a progressive increase of the number of affected fruits and also with the intensity of the disturbance in the fruit during the storage period. The results of soluble solids found in this work are similar, to other works with pack fruits stored at room temperature and under refrigeration where a decrease of totals soluble solids was just observed in the last storage period (Abreu, 1995).

The increase of the soluble solids in function of the evaluation times observed in this work is in agreement with works where the pineapple fruit were stored at room temperature (25°C to 30°C) and under controlled conditions (12°C and 80% of RH) (Bartolomé *et al.*, 1995).

A – without packing, B – packing with perforated polyethylene bags, C – packing with polyethylene bags In both temperatures, there was linear decrease in pH, the equations are showed in Table 3. The decrease of the pH was higher in the fruit packing with not perforated bags, fruit packing with perforated bags and no packing fruit respectively. The results observed are similar the results reported by Abreu (1991), Botrel (1991) and Bartolomé *et al.*, (1995).

Table 2: Means of fresh mass loss, texture, pH and total acidity in pineapple fruits cv. Smooth Cayenne stored at 8°C and 12°C.

Temperature	Days 8°c							12°c						
							Fresh Mass Loss (%)							
	4	8	12	16	20	24	28	4	8	12	16	20	24	28
A	1.55	5.71	10.0	19.80	15.00	16.19	17.60	2.56	6.73	7.67	10.62	11.88	15.59	16.07
B	0.42	1.61	1.07	3.34	3.70	4.20	5.20	1.26	1.59	1.93	2.64	4.64	4.52	5.60
C	0.02	0.51	0.16	1.29	1.36	1.57	2.25	0.36	0.59	0.26	3.67	4.10	3.98	4.73
							Firmness (N)							
A	6.83	5.90	5.00	4.43	4.36	4.16	4.06	5.53	5.46	5.03	5.23	4.73	4.20	3.33
B	5.90	4.96	4.70	4.56	5.16	4.26	3.76	5.46	5.83	5.26	5.23	4.60	4.63	4.10
C	5.76	5.50	5.03	5.53	4.36	4.60	4.40	5.73	5.69	5.23	5.10	4.63	4.26	4.00
							pH							
A	3.41	3.39	3.38	3.36	3.33	3.33	3.32	3.42	3.42	3.39	3.37	3.34	3.32	3.31
B	3.40	3.37	3.36	3.35	3.33	3.31	3.29	3.40	3.39	3.37	3.36	3.33	3.31	3.29
C	3.39	3.37	3.35	3.33	3.29	3.29	3.28	3.39	3.37	3.35	3.33	3.32	3.29	3.27
							Total acidity (%)							
A	0.72	0.73	0.74	0.75	0.77	0.78	0.79	0.74	0.76	0.78	0.78	0.80	0.82	0.84
B	0.72	0.74	0.76	0.77	0.79	0.80	0.82	0.74	0.77	0.79	0.81	0.83	0.86	0.87
C	0.74	0.77	0.80	0.83	0.85	0.88	0.90	0.75	0.77	0.79	0.82	0.84	0.87	0.89

Table 3: Linear equations of the variables dependent function of the times of assays, for each type of packing: (A)- without packing, (B) packing with polyethylene bags perforated and (C) – packing with polyethylene bags.

Variable	Treatments	Models	r^2
Fresh mass loss (Y_1) at 8°C	A	Y_1=0.25+0.662EA	0.9517
	B	Y_1=-0.39+0.200EA	0.9282
	C	Y_1=-0.45+0.102EA	0.8935
Fresh mass loss (Y_2) at 12°C	A	Y_2=1.24+0.558EA	0.9723
	B	Y_2=0.09+0.192EA	0.9330
	C	Y_2=-0.86+0.215EA	0.268
Firmness (Z_1) at 8°C	A	Z_1=6.74 – 0.112EA	0.8512
	B	Z_1=5.81 – 0.065EA	0.6912
	C	Z_1=5.97 – 0.059EA	0.7554
Firmness (Z_2) at 12°C	A	Z_2=6.14 – 0.085EA	0.8499
	B	Z_2=6.05 – 0.064EA	0.8573
	C	Z_2=6.20 – 0.078EA	0.9760
pH (K_1) at 8°C	A	K_1 = 3.42 – 0.0039EA	0.8512
	B	K_1 = 3.41 – 0.0043EA	0.9890
	C	K_1 = 3.40 – 0.0048EA	0.9646
pH (K_2) at 12°C	A	K_2 = 3.45 – 0.0051EA	0.9740
	B	K_2 = 3.43 – 0.0049EA	0.9960
	C	K_2 = 3.41 – 0.0048EA	0.9938
Total acidity (W_1) at 8°C	A	W1=0.70 + 0.0032EA	0.9858
	B	W1=0.71 + 0.0041EA	0.9920
	C	W1=0.72 + 0.0067EA	0.9925
Total acidity (W_2) at 12°C	A	W2=0.73 + 0.0038EA	0.9826
	B	W2=0.73 + 0.0053EA	0.9849
	C	W2=0.72 + 0.0062EA	0.9950

The increment of the total acidity in function of the analysis times happened with larger intensity in the following order: packing fruits, packing fruits with perforated bags and no packing fruits respectively. The results of total acidity are shown in Table 2 and the equations are in Table 3. An increase in the acidity of fruit was observed during the refrigeration period for the three treatments. Those results are in agreement with other works with pineapple under several temperatures where observed an increase in the total acidity at the end of the storage period (Brotel, 1991 and Abreu, 1995). Pineapple fruit submitted to the refrigeration, which developed internal browning, had a lower total acidity. In this work, it was observed that internal browning was higher in the treatment with no packing fruit. Also, these fruit showed smaller values for the total acidity.

In the early stage of the experiment a series of sanitary cautions were taken and the occurrence of rottenness at the end of the storage period was lower than 3%. Some fruits in polyethylene bag with perforation and bag with no perforation had black rottenness of the peduncle. Probably the micro-clime supplies conditions for the proliferation of the fungus. The occurrence of the rottenness starts after the fourth evaluation 16th day of storage.

Conclusions

The temperature of 12°C provided good conditions for the storage of the pineapple fruits, due to a delay in the time for the appearance and intensity of endogenous darkening. At both temperatures (8°C and 12°C), the bags with no perforation were more efficient in control of endogenous darkening. There was high depreciation of the fruits with no packing. There was a loss of fresh biomass in both temperatures. In view of the percentage of affected fruits and the intensity of the appearance of the endogenous darkening, the period more adapted for conservation of the pineapple would be 16 days for a temperature of 8°C and of to 20 days for a temperature of 12°C.

Acknowledgement

The authors would like to acknowledge CAPES for funding this research.

References

ABREU, C. M. P., 1995, Efeito da embalagem de polietileno e da refrigeração no escurecimento interno e composição química durante a maturação do abacaxi cv. Smooth Cayenne, 1995. Tese de Doutorado em Ciências dos Alimentos, Universidade Federal de Lavras, Lavras.

ABREU, C. M. P., 1991, Alterações no escurecimento interno e na composição química do abacaxi cv. Smooth Cayenne durante seu amadurecimento com e sem refrigeração, 1991. Dissertação de Mestrado em Ciências dos Alimentos. Universidade Federal de Lavras, Lavras.

AOAC, 1990. Official Methods of Analysis of the Association of the Agricultural Chem.15th Ed. Washington, 1990, 1015 bartolomé, A. P., P. Rupérez, c. fúster.,1995, Pineapple fruit, Morphological characteristics, chemical composition and sensory analysis of Red Spanish and Smooth Cayenne cultivars. Food Chem.pp.75-79.

Botrel, N., 1991, Efeito do peso do fruto no escurecimento interno e qualidade do abacaxi Smooth Cayenne. 1991. Dissertação de Mestrado em Ciências dos Alimentos. Universidade Federal de Lavras, Lavras.

Ceasa-pr., 1994. Evolution, situation and tendency of the commercialization of Paraná and of the Brazilian and world production. Paraná State Government. Curitiba CEASA.

Chitarra, M. I. F. and A. B. Chitarra., 1990. Pós-Colheita de frutos e hortaliças: fisiologia e manuseio. Lavras: Esal/faepe.

Derpsch, R., C. H. Roth, N. Sidiras and U. Köpke., 1990, Controle de erosão no Paraná, Brasil: Sistemas de cobertura do solo, plantio direto e preparo conservacionista do solo. Londrina: Iapar.

Emater – pr. Boletim de Pós-Colheita.,1998, Curitiba: Emater pp.2-10.

Embrapa., 1994, Rising of recognition of the soils of the State of Paraná. Londrina: IAPAR pp. 21-34.

F. A. O. Food and Agriculture Organization Of The United Nations – Production Yearbook, Rome, 48:165- 1994

Fasolo, P. J., Cardoso, A. P. Carvalho, D. P. Hochmüller, M. Rauen, J. of J. and R. O. Potter., 1998, Erosion - Inventory of critical areas in the Northwest of Paraná. Londrina : IAPAR, 23: 5-15.

Gueche, F., 1978, Effect of la temperature d'dentreposage sur l'evolution of quelques caracteristiques ananas physico-chimiques Red Spanish. In: Cooling, freezing, storage and transport: biological and technical aspects. Ed. Institut International du Froid Paris, Paris ,pp. 21-28.

Hadlich, E., 1991. Frigoconservação continua e intermitente de pêssegos (Prunus persica (L.) Batsch) cultivares Diamante and Eldorado, 1991. Dissertação de Mestrado em Agronomia, Universidade Federal de Pelotas.

SAS, Institute Inc., 1990. SAS Procedures Guide, version 6, 3rd edition. SAS Institute, Cary, NC.

SEAB., 1998. Pineapple - safra 96/97 In: Produção agropecuária municipal seab/deral. Umuarama, 20: 1- 5.

Steel, R. G. D., J. H. Torrie and D. Dickey, 1996. Principles and procedures of statistic McGraw, New York.

War, N. B, Z. Farah, J. S. Lion, P. M. M. B. Guimarães and E. Martins., 1998. Características de abacaxi Segundo o estado de maturação com vistas ao seu aproveitamento industrial. 1988.78f. Relatório Sudene/Inufpe. Universidade Federal de Pernambuco, Recife.

Watkins, C., J. Harman., 1981, Uses of penetrometer to measure flesh firmness of fruit. The Orch,2:14-16.