

Effect of various coatings on the chemical changes of different pineapple cultivars (N36 and Gandul) at low temperature storage

[Kesan pelbagai bahan penyalutan pada kualiti kultivar nanas (N36 dan Gandul) semasa penyimpanan sejuk]

O. Zaulia*, M. Suhaila**, O. Azizah** and M. Mohammed Selamat***

Key words: fresh pineapple, coatings, palm oil, paraffin, *Semperfresh*, N36, Gandul, storage

Abstract

The chemical changes in N36 and Gandul pineapples stored at 10 ± 1 °C; 85–88% RH and the effects of various surface coatings (palm oil, liquid paraffin, *Semperfresh*) were examined by monitoring fruit total soluble solids (TSS), titratable acidity (TA), sugar-acid ratios (TSS:TA), pH and individual sugars (glucose, fructose and sucrose). Palm oil was effective in reducing ascorbic acid losses of N36 pineapple. All surface treatments significantly ($p < 0.05$) reduced the TSS value in all pineapple cultivars except for N36 pineapple treated with palm oil. In N36 pineapple, the palm oil caused an increase in the TSS during storage.

Sugar-acid ratio was significantly ($p < 0.05$) increased by palm oil as observed in all pineapples, however, sample treated with *Semperfresh* and paraffin caused an increase in the sugar-acid ratio as observed in Gandul and N36 pineapples, respectively. Titratable acidity (TA) was significantly ($p < 0.05$) reduced by all surface treatments in all pineapples except for paraffin treatment on Gandul pineapple. Paraffin treatment retained ascorbic acid in all pineapples during storage. However the palm oil coating only retained ascorbic acid on N36 pineapple. Paraffin coating significantly ($p < 0.05$) reduced fructose and sucrose in N36 pineapple, but significantly ($p < 0.05$) increased the fructose content in Gandul pineapple. Fructose, sucrose and total sugar in Gandul pineapple were significantly ($p < 0.05$) reduced by palm oil and *Semperfresh* treatments.

Introduction

Surface coating treatment after harvest gives an attractive appearance, promotes colour, reduces moisture loss (Ryall and Pentzer 1974) and impedes invasion of pathogens (*Escherichia coli* and *Salmonella*) thus retarding decay (McGuire and Hallman 1995; Kenney and Beuchat 2002) and influencing their physiology and metabolism

by limiting gaseous and moisture exchange (Lowings and Cutts 1982; Hagenmaier and Baker 1995). Coatings cannot be reliably removed from cuticle surface (Banks et al. 1993) and can reduce packaging pollution and waste (Banks et al. 1993; Sapru and Labuza 1994). The incorporation of fungicides, bio-control agents, dimethoate, glucose or calcium chloride in the wax

*Horticulture Research Centre, MARDI Headquarters, Serdang, P.O. Box 12301, 50774 Kuala Lumpur, Malaysia

**Department of Food Science, Faculty of Food Science and Technology, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia

***Corporate Affairs, Administration and Legal Services Division, MARDI Headquarters, Serdang, P.O. Box 12301, 50774 Kuala Lumpur, Malaysia

Authors' full names: Zaulia Othman, Suhaila Mohamed, Azizah Osman and Mohammed Selamat Madom

E-mail: zaulia@mardi.my

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coating significantly reduced percentage of fruit rotting, the incidence of chilling injury and larvae of fruit flies without affecting fruit quality (Potjewijd et al. 1995; Hallman and Foos 1996; Subedi et al. 1998).

There are many coating formulations commercially available which is in hydrophilic, hydrophobic or emulsion form (Sumnu and Bayindirli 1994; Bayindirli et al. 1995; McGuire and Hallman 1995; Lawes et al. 1999). Hydrophilic coatings such as dairy proteins (casein and whey) and cellulose-derived polysaccharides offer better control over film properties, high mechanical strength and ease of construction (Kester and Fennema 1986; McHugh et al. 1993; Sapru and Labuza 1994). However, it increases the gas and water vapour permeability. For example, corn-zein is an alcohol-soluble protein which has excellent film- and fibre-form properties with a good barrier to O₂, but its water vapour permeability is about 800 times higher than a typical shrink wrapping film (Park et al. 1994).

Due to these drawbacks, stable emulsions of hydrophobic coating were formulated. Most of them are single or combinations of paraffin wax and plant waxes (such as carnauba wax, candelilla, corn oil). Mineral oil, paraffin wax, plant oils (soybean, corn, peanut, linseed, cottonseed, rice bran, candelilla) and other waxes like beeswax, are successful in providing attractive gloss and preventing chilling injury, desiccation, colour changes, incidence of peel injuries, and can retain volatile flavour during storage (Nisperos-Carriedo et al. 1990; Ju et al. 2000b). According to Ju et al. (2000a), neutral lipids and phospholids inhibit scald, while α -tocopherol accelerates scald development. Pure mono-, di- and tri-acylglycerols at concentration of more than 6% are as effective as diphenylamine in controlling scald (Ju et al. 2000a). Scald control is not related to chain length of fatty acids or degree of unsaturation (Scott et al. 1995).

Paraffin (mineral petroleum) can reduce chilling injury, water loss and improve the appearance of pineapples (Paull and Rohrbach 1985), but not for apples (Scott et al. 1995). Waxes (paraffin, polyethylene wax, and, candelilla wax) with and without shellac and emulsifier is effective in increasing storage life of mango (Mitra and Baldwin 1997) and mandarin fruits (Hagenmaier 2002). Mineral oil that contains hydrocarbon, acid and alcohol, which has a high boiling temperature, is suitable as a surface coating because it does not evaporate at low storage temperatures (James and Jagannath 1983).

Waxing treatment is able to increase or retard loss of colour, firmness, total acid, soluble solid and ascorbic acid content of fruits (Singh et al. 1984; Sumnu and Bayindirli 1994). Waxing (Bayleton wax) and rewarming periodically during cold storage (6 °C, 5 weeks) can reduce chilling injury in pineapples cv. Cayene Lisa. Rewarmed, waxed pineapples have been found to ripen normally after 36 days of storage (Molina et al. 1995).

Mixture of sucrose polyester (*Semperfresh*) (Sumnu and Bayindirli 1994; Bayindirli et al. 1995), hydroxypropylcellulose (*Sta-Fresh*), carboxymethylcellulose salts and mono- and diacylglycerols (*PRO-LONG*) have been applied to delay ripening of fruits (Dhalla and Hanson 1988), reduce weight loss, delay softening (Jeong et al. 2003), prolong shelf life (Passam 1982) and inhibit pectin degradation (Schreiner et al. 2003). However, hydrophobic based coating has been proven to be most efficient for reducing weight loss, respiration and extending shelf life of fruits compared to emulsifier based coating (Sumnu and Bayindirli 1994; Bayindirli et al. 1995; McGuire and Hallman 1995; Sobac et al. 1996). However, sucrose polyester as an emulsifier tends to easily lose when the fruit is wetted as reported in many coatings (Hall 1981). Sucrose ester as a group of membrane stabilizer and glycerol

homologues alleviate chilling injury of sorghum seedlings (Wang 1990).

Internal changes in organic acids, pH and sugars during shell chlorophyll loss period are minimal by coating (Gortner et al. 1967). The effects of surface coating on different types of fruit depend on the characteristics (Banks 1985; Banks et al. 1993), cultivars and ripening stage of the fruits (Amarante et al. 2001). Inherent variability in fruit resistance characteristics has previously been suggested to be the cause of variable responses of individual fruit to coating (Banks 1985; Banks et al. 1993). There is no worldwide uniformity in the acceptance of coating components. Therefore, importing country restrictions need to be considered (Paull 1997).

Study was conducted to compare the effect of surface coating materials of different bases as follows: vegetable oil (palm oil), mineral petroleum (liquid paraffin) and sucrose polyester (*Semperfresh*) on the physico-chemical changes and physiological disorder of fresh pineapple (var. N36 and Gandul), stored at 10 ± 1 °C and 85–88% relative humidity.

Materials and methods

Fruit source

Two cultivars of fresh pineapples, Gandul (N19) and N36, were used as samples. N36 cultivar was bought from Lee Plantation at Simpang Renggam, Johor. Whereas, Gandul (N19) cultivar was obtained from MARDI, Pontian, Johor. Fruits used for the study were at the commercial maturity for export (all eyes

were green with a tinge of yellow between the eyes at the base). Fruits were harvested in the morning and sent within the same day of harvest to the laboratory at the Faculty of Food Science and Biotechnology, UPM for further treatment.

Surface coating treatment

The post-harvest coating treatments evaluated are shown in *Table 1*.

Liquid paraffin was obtained from Labchem Sdn. Bhd., Petaling Jaya, Selangor, Malaysia. Palm oil was obtained from Lam Soon (M) Bhd., Petaling Jaya, Selangor, Malaysia. Sucrose polyester used was *Semperfresh* obtained from Agricoat Industries Limited, Berkshire, England. Octave (active ingredient: prochloraze manganese chloride 50% w/w) was obtained from Schering Agrochemicals (Cambridge, England) and used as a fungicide to control storage decay caused by *Thielaviopsis paradoxa* (Tv). The emulsion was mixed thoroughly. Only the fruit body (from peduncle to base of the crown) were dipped for 30 s in the solution of surface coating materials. The fruits were air dried at room temperature for about 3 h.

Storage study

Fruits were packed in closed commercial boxes (14 x 32 x 49 cm) with 6 fruits laid on their sides in a single layer for each box. Storage study was conducted at 10 ± 1 °C, 85–88% relative humidity as recommended by Wills et al. (1985) until fruit decayed. Ten pineapples from each treatment (from different boxes and different positions of storage) were individually analysed weekly.

Table 1. Surface coating formulations

Coating based treatment	Paraffin	Palm oil	<i>Semperfresh</i>	Distilled Water	Ovelet (emulsifier)	Octave (fungicide)
Control	–	–	–	–	–	200 ppm
Paraffin	20% v/v	–	–	80% v/v	5% w/v	200 ppm
Palm oil	–	20% v/v	–	80% v/v	5% w/v	200 ppm
<i>Semperfresh</i> *	–	–	5% v/v	95% v/v	–	200 ppm

*As recommended by manufacturer

Chemical analysis

The fruits for analyses were prepared by peeling the skin and macerating the flesh in a blender (model Braun) for 3 min at a moderate speed. Analyses were carried out immediately for total soluble solids (Atago Digital Refractometer, 0–32 °Brix); ascorbic acid by Dichlorophenol Indophenol Titration (Ranganna 1977); total titratable acidity (titrating with 0.1 M NaOH using phenolphthalein as indicator) and pH (Cyberscan 1000).

Statistical analysis

Statistical analyses of the treatment responses were conducted using Analysis of Variance (ANOVA), Duncan Multiple Range Test to determine whether the comparison between different treatments and different storage duration showed significant differences ($p < 0.05$). The main effect means are presented in tables and figures. Experimental data are presented as means \pm standard deviation of the determinations for each sample. For comparison of more than two means, the mean separation was done

by Duncan Multiple Range Test (SAS Inst. 1985).

Results and discussion

Ascorbic acid

Surface treatments significantly ($p < 0.05$) affected the ascorbic acid contents of Gandul pineapple, but not the N36 pineapple (Table 2 and Figure 1). In Gandul pineapple, ascorbic acid content was significantly ($p < 0.05$) higher in paraffin treated fruit, but significantly ($p < 0.05$) lower in palm oil treated fruit as compared to control fruit.

Semperfresh reduces the ascorbic acid content of mangoes (Baldwin 1994), but increases the ascorbic acid content of 'Satsuma' mandarin and 'Ankara' pears (Sumnu and Bayindirli 1994; Bayindirli et al. 1995). Generally, fruits and vegetables stored at controlled atmosphere or modified atmosphere have better ascorbic acid retention than commodities stored in air (Eris and Turk 1996; Kader 1997; Mitra and Baldwin 1997). However in this study, hydrophobic coatings were more effective in retaining ascorbic acid compared to

Table 2. Titratable acidity (TTA), total soluble solid (TSS) and ratio of TSS:TTA of N36 and Gandul pineapples with and without surface coating treatment stored at 10 °C

	Ascorbic acid (mg/100 g)		TSS (Brix)		TSS:TA	
	N36	Gandul	N36	Gandul	N36	Gandul
Weeks						
0	15.81a	17.38a	11.21e	12.36b	13.88c	12.61ab
1	13.87b	14.39b	12.24d	11.71b	16.19b	11.04b
2	13.39b	11.19c	13.09cd	14.29a	15.33bc	13.71a
3	11.79c	10.31d	12.59d	10.85c	12.61c	10.81b
4	9.81def	7.92e	10.06cd	11.63bc	13.79bc	12.04ab
5	11.00cd	6.17f	12.74d	11.35c	13.21bc	11.75ab
6	8.96f		13.70bc		14.60bc	
7	10.37de		14.70a		16.15b	
8	9.26ef		12.65d		15.87b	
9	7.07g		14.02ab		19.23b	
Surface treatment						
Control	10.39A	11.46B	13.11AB	12.48A	13.61B	11.74AB
Liquid paraffin	12.88A	12.34A	12.78B	11.67B	17.04A	10.86B
Palm oil	11.54A	10.14C	13.33A	11.93AB	14.93B	12.42AB
<i>Semperfresh</i>	9.77A	10.96B	12.78B	12.02AB	14.76B	12.94A

Means followed by different small letters are significantly different ($p < 0.05$) between storage duration and means followed by different capital letters are significantly different ($p < 0.05$) between treatments

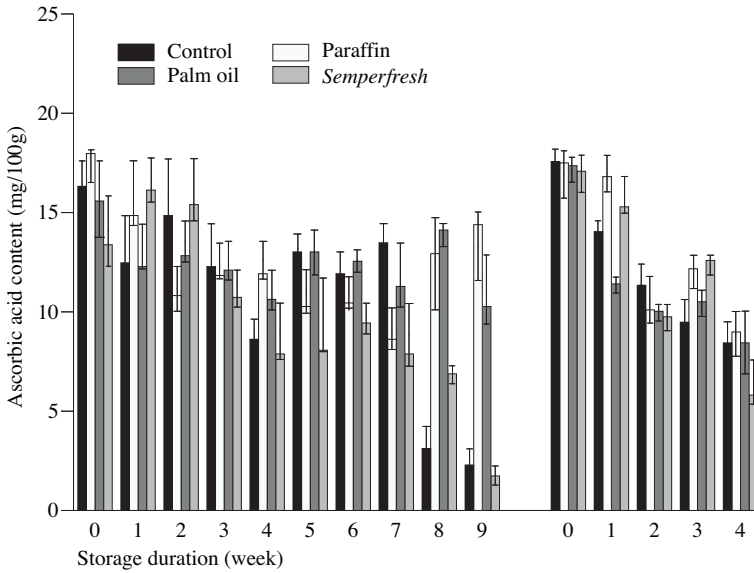


Figure 1. Effect of surface treatments on ascorbic acid content of N36 (left) and Gandul (right) pineapples

Table 3. pH values and ascorbic acid content of N36 and Gandul pineapples with and without surface coating treatment stored at 10 °C

	TTA (mg/100 g)		pH	
	N36	Gandul	N36	Gandul
Weeks				
0	0.82cd	1.04ab	3.54a	3.45a
1	0.78d	1.07a	3.47b	3.40b
2	0.83c	1.04ab	3.38de	3.44a
3	1.00a	1.01ab	3.31f	3.25d
4	0.96a	0.99b	3.44bc	3.29c
5	0.98a	0.99b	3.43cd	3.31c
6	0.98a		3.46bc	
7	0.89b		3.48b	
8	0.81cd		3.34ef	
9	0.77d		3.45bc	
Surface treatment				
Control	0.98A	1.05B	3.36B	3.40A
Liquid paraffin	0.78C	1.11A	3.58A	3.31B
Palm oil	0.89B	0.97C	3.40B	3.39A
Semperfresh	0.88B	0.98C	3.38B	3.32B

Means followed by different small letters are significantly different ($p < 0.05$) between storage duration and means followed by different capital letters are significantly different ($p < 0.05$) between treatments

hydrophilic coatings, which were similarly reported by Bayindirli et al. (1995), and Sumnu and Bayindirli (1994).

Ascorbic acid content was decreased during storage in all pineapples. This

reduction was gradual in N36 pineapple, but drastic in Gandul pineapple (Table 3). The reduced ascorbic acid in pineapple was frequently associated with increased in internal browning induced by chilling injury

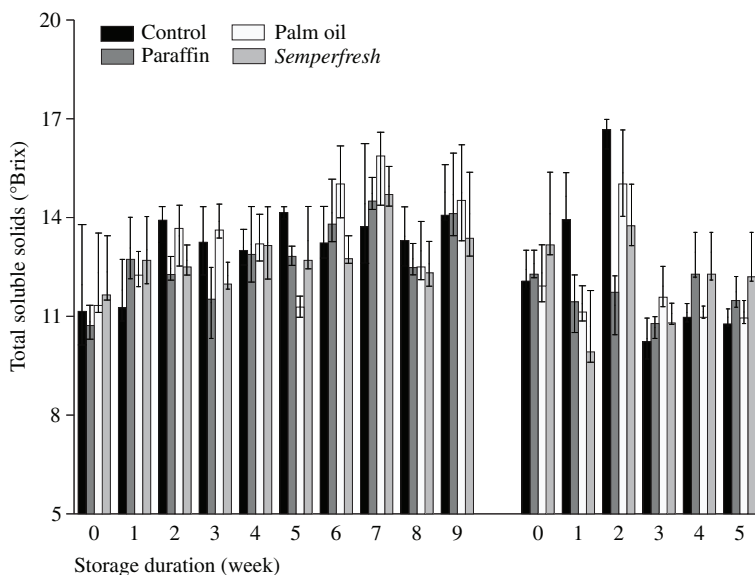


Figure 2. Effect of surface treatments on total soluble solids of N36 (left) and Gandul (right) pineapples

(Wijeratnam et al. 1996). These may suggest why N36 pineapple was more tolerant to internal browning than Gandul pineapple. The decreased ascorbic acid content during storage was similarly reported for pineapple under various other treatments (Abdullah et al. 1986) and various storage temperatures (Adisa 1986). Other fruits and vegetables also showed similar trend in the ascorbic acid content during storage (Scott and Kramer 1949; Smith and Stow 1984).

Adisa (1986) also reported that the ascorbic acid content of pineapple had decreased during the 8 weeks of storage at 0, 5, 25 and 30 °C. Storage temperature had a great effect on the content of ascorbic acid, causing a gradual decline from 0–30 °C. Adisa (1986) also investigated the effect of rot development caused by *Aspergillus aculeatus* and *Penicillium citrinum* which showed that there was a decrease in the ascorbic acid content of the infected fruits as the incubation period increased. This appearance probably explained why Gandul pineapple with rot had decayed much earlier (3–5 weeks) than N36 pineapple (8–9 weeks).

Total soluble solids (TSS)

Among the treated N36 pineapple, the TSS value of palm oil treatment was significantly ($p < 0.05$) higher than paraffin and *Semperfresh* treatments (Table 3 and Figure 2). An increase in TSS might indicate that palm oil treated pineapples showed a normal ripening as reported by Mohamed and Ahmad Khir (1993) on Mauritius pineapple and other fruits (Samson 1986). An increase of TSS by palm oil treatment can increase seal appeal for stored N36 pineapple, as reported in coated mango (Sobac et al. 1996).

In Gandul pineapple, TSS value was lowered in all surface treatments (Table 2) and the decrease was significant ($p < 0.05$) in liquid paraffin treated pineapples. The decrease in TSS by coating treatment was also reported in coated banana (Razali 1996) and guava (McGuire and Hallman 1995).

The decrease in soluble solids indicates the utilization of the soluble solids for respiration which exceeds its production and occurs during senescence. Most of surface coating treatment reduced TSS content as reported in 'Satsuma' mandarin (Bayindirli et al. 1995) and 'Ankara' pears (Sumnu and

Bayindirli 1994). This is because the surface coating had slowed down respiration and ripening of the fruits. Coatings do not affect TSS content of ‘Ida Red’, ‘McIntosh’ and ‘Golden Delicious’ apples (Chai et al. 1991).

Total titratable acidity (TTA) and pH

The decrease of pH was greater in liquid paraffin treated N36 pineapple as compared to palm oil and *Semperfresh* treated fruits (Table 3 and Figure 3). The decrease of

pH by surface coating treatment was also reported in Mauritius pineapple and banana treated with paraffin (Mohamed and Ahmad Khir 1993; Razali 1996) and mango treated with TAL Pro-long (polysaccharide based coating) (Baldwin 1994). The pH of N36 pineapples was significantly ($p < 0.05$) highest for liquid paraffin treated pineapples compared to those in control and other treated pineapples (Table 3 and Figure 3). There is strong correlation between

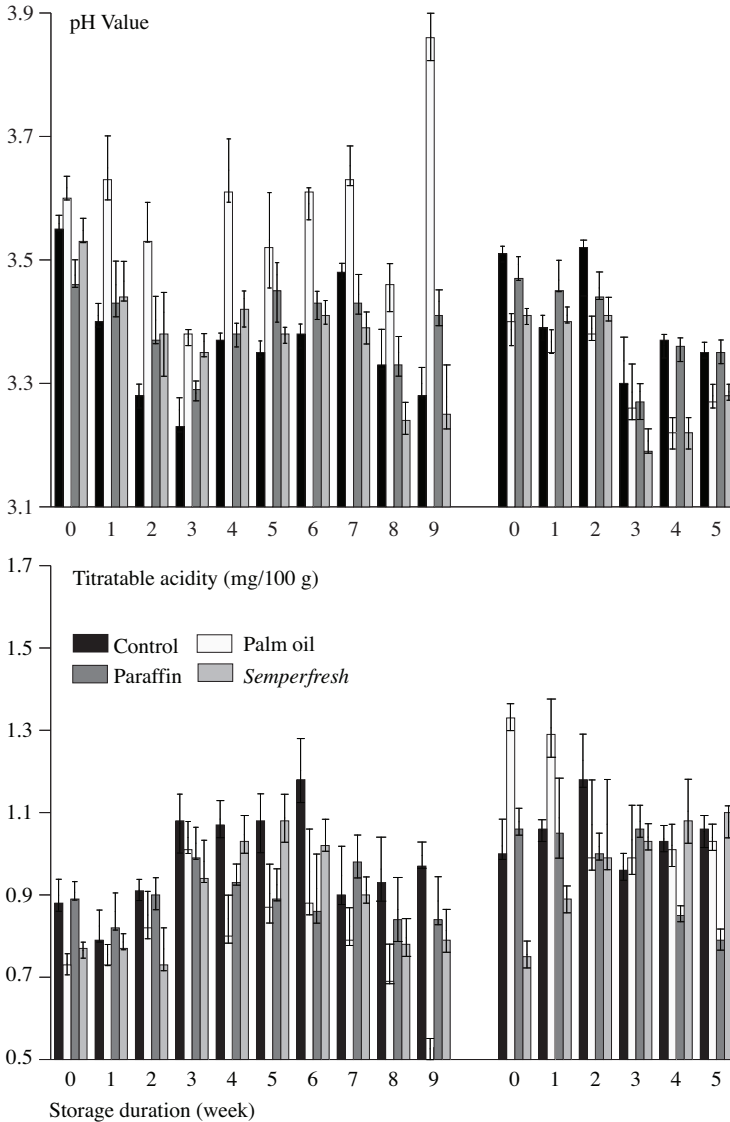


Figure 3. Effect of surface treatments on pH and titratable acidity of N36 (left) and Gandul (right) pineapples

translucency flesh development and lower acidity in liquid paraffin treated pineapples (Bowden 1969; Chen and Paull 2001). The degree of acidity developed in the fruit could be related to the availability of oxygen in the fruit (Mohamed and Ahmad Khir 1993).

Liquid paraffin was able to increase the TTA of Gandul pineapple significantly ($p < 0.05$), however, palm oil and *Semperfresh* coating had significantly ($p < 0.05$) reduced the TTA of Gandul pineapple (Table 3 and Figure 3). The pH values of *Semperfresh* and liquid paraffin treated Gandul pineapple were significantly ($p < 0.05$) lower than palm oil treated pineapples and the control pineapples.

This result showed that the changes in pH during storage and the effects of different types of surface treatment on different varieties of pineapples were varied. This may be due to the difference in the amount and kinds of organic acid present in the different varieties of pineapples which can cause different chemical metabolism in the fruit when given surface treatment. Studies on the organic acid levels in pineapples during storage at 10 °C showed that pineapple fruit are relatively low in oxalic, tartaric, malic, formic and acetic acids, but high in citric acid (Mohamed and Ahmad Khir 1993). The difference in the acidity of pineapples was related to the amount of citric acid (Bartolome et al. 1996). The main organic acids of ripe pineapples are citric and malic acids (Singleton and Gortner 1965).

According to Mohamed and Ahmad Khir (1993), pH only correlates to TA for pineapples at high temperature (20–27 °C), but not for low temperature storage (10–15 °C). At maturity, TTA increases until it reaches a peak after which it decreases during ripening (Gortner et al. 1967). It was discovered that there may be changes in the kinds of acid present (Ryall and Pentzer 1974).

Semperfresh is able to increase TTA of 'Ida Red' and 'Golden Delicious' apples (Chai et al. 1991), and mango (Sobac et al.

1996). *Semperfresh* and *Johnfresh* (carnauba wax + shellac) increase citric acid of 'Satsuma' mandarin (Bayindirli et al. 1995) and malic acid of 'Ankara' pear (Sumnu and Bayindirli 1994). Acidity is not affected by hydroxypropyl cellulose and carnauba wax coating for guava (McGuire and Hallman 1995) and *Semperfresh* for McIntosh apple (Chai et al. 1991).

Ratio of TSS:TTA

The TSS:TTA ratio was significantly ($p < 0.05$) higher in liquid paraffin treated N36 pineapple compared to control and other treatments (Table 2 and Figure 4). The TSS:TTA ratio of Gandul pineapple was significantly ($p < 0.05$) higher in *Semperfresh* treated pineapples as compared to control and other treatments. Translucency flesh developed because of chilling injury in liquid paraffin treated N36 pineapple and *Semperfresh* treated Gandul pineapple may increase sugar-acid ratio (Bowden 1969; Chen and Paull 2001). Sugar-acid ratio of 'Satsuma' mandarin can be reduced by both hydrophilic and hydrophobic coating (Bayindirli et al. 1995). Paraffin does not affect the sugar-acid ratio of banana (Razali 1996).

Sugar content

In Gandul pineapple, sucrose content in palm oil and *Semperfresh* treated pineapples was significantly ($p < 0.05$) lowered during storage. Fructose was significantly ($p < 0.05$) lowered in *Semperfresh* treated pineapples as compared to control pineapples (Table 4 and Figure 5). Glucose content was insignificantly different for all surface treatment (Figure 5). Sucrose and total sugar were significantly ($p < 0.05$) lower in palm oil and *Semperfresh* treated pineapples as compared to control and liquid paraffin treated pineapples (Table 4 and Figure 6).

The increase in sucrose content in pineapples is consistent with the breakdown of insoluble polysaccharides such as pectins and hemicellulose (Wills et al. 1981) to sugars and acids. The decrease

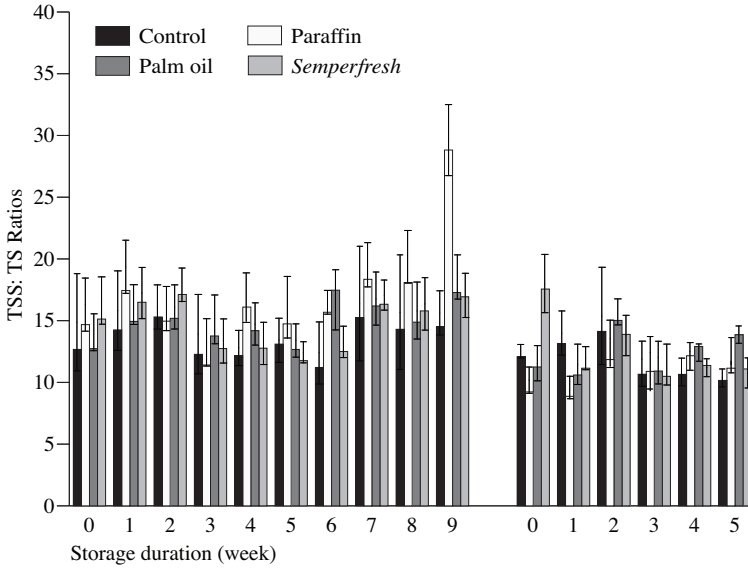


Figure 4. Effect of surface treatments on sugar acid ratio of N36 (left) and Gandul (right) pineapples

Table 4. Sugar content of N36 and Gandul pineapples with and without surface coating treatment stored at 10 °C

	Fructose		Glucose		Sucrose		Total sugars	
	N36	Gandul	N36	Gandul	N36	Gandul	N36	Gandul
Weeks								
0	1.50b	1.89b	1.52ab	1.95ab	7.05a	6.30a	10.06a	10.14ab
1	1.22b	1.43bc	1.23b	1.41b	5.66a	5.05b	8.11a	7.89c
2	1.30b	1.37c	1.37b	1.50b	6.86a	5.53ab	9.53a	8.39bc
3	1.72b	1.64bc	1.67ab	1.50b	9.94a	4.91b	13.33a	8.05c
4	1.14b	1.57bc	1.11b	1.57b	6.27a	4.57b	8.52a	7.71c
5	1.37b	2.60a	1.35b	2.41a	6.01a	5.51ab	8.73a	10.52a
6	1.88b		1.72ab		7.02a		10.62a	
7	2.20a		1.61abc		5.54a		9.36b	
8	2.30ab		2.13ab		6.43a		10.85a	
9	1.78abc		1.70ab		5.06a		8.54b	
Surface treatment								
Control	1.64A	1.93B	1.50A	1.82A	7.14A	5.81A	10.29A	9.57A
Liquid paraffin	1.64A	2.03A	1.62A	1.97A	6.59A	6.04A	9.85A	10.04A
Palm oil	1.65A	1.57BC	1.53A	1.58A	6.25A	4.75B	9.43A	7.90B
Semperfresh	1.63A	1.53C	1.51A	1.55A	6.19A	4.74B	9.33A	7.82B

Means followed by different small letters are significantly different ($p < 0.05$) between storage duration and means followed by different capital letters are significantly different ($p < 0.05$) between treatments

in sucrose content after ripening is due to the inversion of sucrose to glucose and fructose (by invertase) which may be in a more utilizable form for respiration and production of new carbohydrates (Chace and Pantastico 1975). The sugar content

of pineapple is affected by fruit variety (Hodgson and Hodgson 1993). Waxing does not appear to affect the evolution of sugars or the evolution of shell colour in pineapples (Paull and Rohrbach 1982).

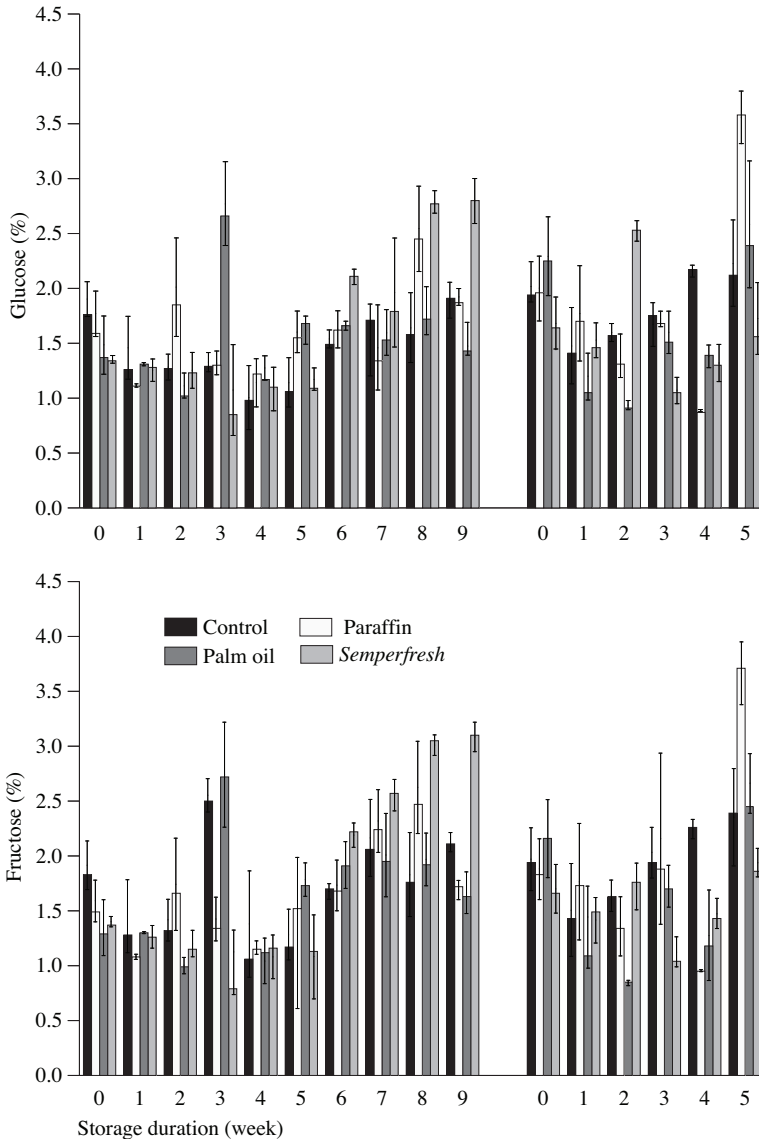


Figure 5. Effect of surface treatments on glucose and fructose contents of N36 (left) and Gandul (right) pineapples

Conclusion

Emulsion solution containing 20% palm oil was the most suitable coating for N36 pineapple. It was effective in reducing the loss in the ascorbic acid content, reducing TTA and increasing TSS and sugar-acid ratio of N36 pineapple, without chilling injury during storage.

In Gandul pineapple, paraffin was the most suitable coating treatment in maintaining fruit quality with the ability to increase the fructose content, reduce TTA and retain ascorbic content.

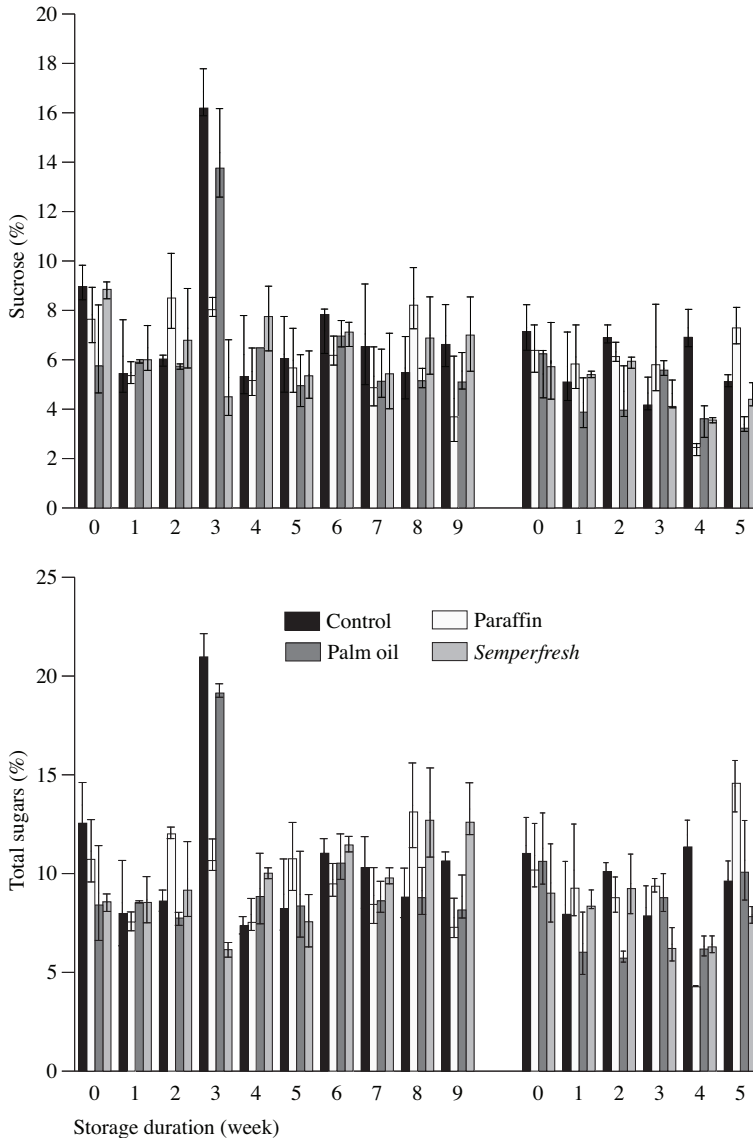


Figure 6. Effect of surface treatments on sucrose content and total sugars of N36 (left) and Gandul (right) pineapples

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Abstrak

Perubahan kimia pada nanas N36 dan Gandul yang disimpan pada suhu 10 ± 1 °C; kelembapan bandingan 85–88% dan kesan pelbagai bahan salutan permukaan (minyak kelapa sawit, parafin cair, *Semperfresh*) dikaji dengan menilai jumlah pepejal terlarut (TSS), jumlah asid tertitrat (TTA), nisbah gula-asid (TSS:TTA), pH dan gula-gula individu (glukosa, fruktosa dan sukrosa). Minyak kelapa sawit berkesan untuk mengurangkan kehilangan asid askorbik bagi nanas N36. Semua rawatan penyalutan menurunkan dengan ketara ($p < 0.05$) nilai TSS dalam semua kultivar nanas kecuali bagi nanas N36 yang dirawat dengan minyak kelapa sawit. Dalam nanas N36, minyak kelapa sawit menyebabkan meningkatnya nilai TSS dalam penyimpanan.

Nisbah gula-asid ditingkatkan dengan ketara ($p < 0.05$) oleh rawatan minyak kelapa sawit bagi semua nanas, manakala, sampel yang dirawat dengan *Semperfresh* dan parafin menyebabkan peningkatan di dalam nisbah gula-asid masing-masing pada nanas Gandul dan N36. Jumlah asid tertitrat (TTA) diturunkan dengan ketara ($p < 0.05$) oleh semua rawatan salutan permukaan pada semua nanas kecuali bagi rawatan parafin pada nanas Gandul. Rawatan parafin mengekalkan kandungan asid askorbik semua nanas semasa penyimpanan. Manakala rawatan minyak kelapa sawit hanya mengekalkan kandungan asid askorbik pada nanas N36. Salutan parafin menurunkan dengan ketara ($p < 0.05$) kandungan fruktosa dan glukosa pada nanas N36, tetapi meningkatkan dengan ketara ($p < 0.05$) kandungan fruktosa pada nanas Gandul. Rawatan minyak kelapa sawit dan *Semperfresh* menurunkan dengan ketara ($p < 0.05$) kandungan fruktosa, sukrosa dan jumlah gula pada nanas Gandul.