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EFFECT OF WAX-COATINGS ON THE PHYSIOLOGICAL AND BIO-CHEMICAL ASPECTS OF 'KINNOW' FRUIT*

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The effect of wax-coatings using two commercial wax emulsions, viz. Britex-561 and SB-65 (USA) on the storage behaviour of the Kinnow fruit was studied. Data on physical, physiological, biochemical and organoleptic parameters have revealed that waxing not only improves the external appearance of the fruit but also reduces weight loss, slows down the respiratory activity and ethylene production, thus extending shelf-life. The taste and flavour of waxed fruit were impaired and negative co-relation between external appearance and flavour was observed.

Key words: Waxing, Physiology , Shelflife.

INTRODUCTION

Application of wax emulsion on fruit surface adds shine, reduces water loss and rate of respiration, thus improving external appearance and extending storage life. This treatment has shown its economic value and therefore has become a commercial treatment for many fruits [1-5]. Waxes may be applied by dipping, spraying, foaming or brushing. If a thicker layer of wax is applied to the fruit surface, it will become an undesirable barrier between external and internal atmospheres and restrict exchange of respiratory gases and may cause anaerobic respiration leading to the development of off-flavour [6]. It is, therefore, necessary to tailor the thickness of wax coat according to the fruit kind, variety, storage and marketing temperatures. Since "kinnow' (a variety of mandarin) forms [1] the backbone of the citrus industry of Pakistan, the present studies were undertaken on coating the fruit with two new wax emulsions and on storage periods of waxed fruit under refrigerated and non-refrigerated conditions. The results of the experimental work are described and discussed here.

EXPERIMENTAL

Fruit. Fruits of kinnow mandarin (*Citrus reticulata* Blanco) of about 70 mm dia were harvested from trees growing in the experimental garden of the Ayub Agricultural Research Institute (4 Km distance) during the 1985-86 crop season and brought to the laboratory, and stems were cut close to the shoulder. The fruit were washed in tap water, dried on wire trays in the shade, and divided into 3 equal lots of 150 (50 x 3) each.

Treatment. Two lots of fruits were dipped in a suspension of thiabendazole (made from a commercial product Tecto-40 from M/s Merck Sharp and Dohme of Pakistan Ltd.) of 1000 ppm conc. for 2 min. while the third lot was dipped in distilled water (control). The fruit were dried again. Two wax suspensions i.e. one from Britex-561 and another from SB-65 (both commercial products of M/s. Brogdex, Winter Park, Florida, USA) were made in water (wax: H_2O = 1:0) and two separate lots of fruits were coated using hand application technique [6], one with Britex 561 and other lot with SB-65. The waxed fruits were then dried, packed separately in cardboard boxes lined with newsprint paper (0.095mm) and the fruit coated with Britex 561 was stored at room temperature (16-22^{o}). Fruit waxed with SB-65 were tested in an identical experiment under refrigerated storage (4-5^{o}). Control for each lot had neither TBZ nor wax coating.

Twenty-one (7 x 3) fruits of each lot were marked, initially weighed and reserved for weightloss study. For this study, 3 (1 x 3) fruits from each lot were selected at random, weighed initially and sealed (one fruit/jar) in a 1-litre respiration jar and stored at room temperature. After 1 hr's incubation period, 1 ml sample of the gas from each jar was taken and injected in an Infra Red Gas Analyser (IRGA) model 120 (NE1 Electronics Ltd., UK) for the estimation of CO_2 evolved by the fruit.

Ethylene production. The production of ethylene (C_2H_4) from kinnow fruit was estimated from the same samples used for respiration study. One ml sample of the gas from each jar was injected in a gas chromatograph (Carlo-Erba Fractovap Series 2150) fitted with 0.75 m x 2 stainless steel column packed with Porapak-N (80-100

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mesh) using a flame ionization detector. Details of the running conditions of the instrument have been described elsewhere [1,7].

Weight loss. Data on weight loss were collected on weekly intervals (in a study at room temperature) while on monthly intervals (in a cold storage). Percentage loss in weight was calculated on percent of initial weight losses.

Biochemical estimations. At subsequent weekly intervals 10 fruits (5 x 2) were selected at random, peeled and juice extracted using a manually operated juice extractor and duplicate samples analysed. Total titratable acidity and vitamin C contents were estimated by the method described in AOAC [8], whereas reducing and non-reducing sugars were determined spectrophotometrically using the method of Ting [9].

Organoleptic test. Waxed and unwaxed kinnows were served to a panel of 7 trained judges for consumer's acceptance using Krum's scoring method [10]. All the data were subjected to analysis of variance.

RESULTS AND DISCUSSION

Weight loss. Effect of wax-coatings on the weight loss of kinnows during refrigerated storage at 4-5^{o} is shown in Fig. 1. the coating wax of SB-65). It appears that un-waxed fruit lost significantly ($P < 0.05$) more weight than waxed kinnows during storage. The possible reason for this difference is the application of wax-coat which became a barrier

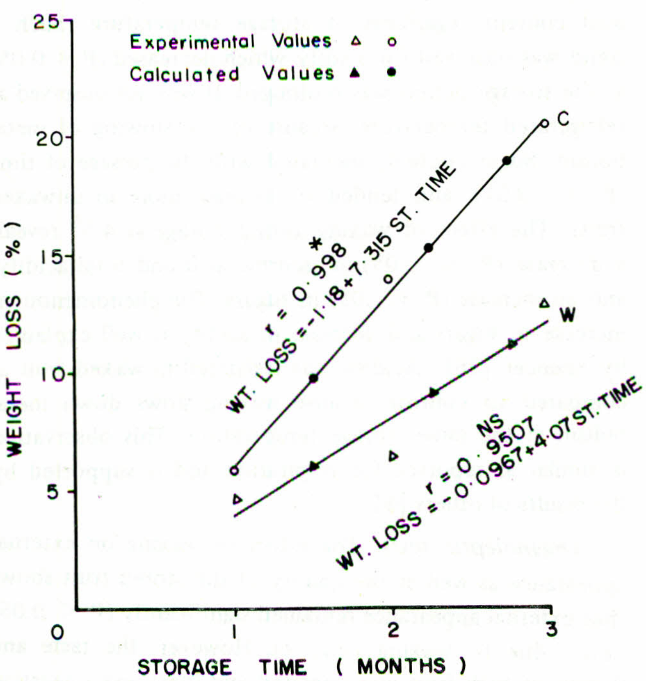


Fig. 1. Effect of waxing (Britex 561) on th weight loss of kinnow fruit during storage at room temperature, 16-22^{o}.

between the fruit and external desiccating atmosphere. These results are similar and confirm those reported by Trout, *et. al.* [2], Mack and Janer [4], Schomer and Pearson [12], Long *et. al.* [13], and Sheikh *et al.* [14].

Respiration. The effect of wax coating (with Britex 561) on the respiratory activity (CO_2 production) of kinnow mandarins during room temperature (18-22^{o}) storage shows that waxed fruit respired slowly as compared to un-waxed fruit (Fig. 2(A). Waxing provides a barrier between the external and internal atmospheres of the fruit restricting gaseous exchange, thus slowing the respiration process. Trout, *et. al.* [2] reported that wax coating of apples reduced oxygen availability to the fruit from the air and thus reduced CO_2 production. Mack and Janer [4] also reported similar results in waxed cucumbers and similar results on citrus have also been reported by Wild [15].

Ethylene production. Ethylene production was measured for the samples used for CO_2 estimation production of ethylene (C_2H_4) gas by waxed and un-waxed kinnow shows that the pattern of C_2H_4 was similar to that of CO_2 gas (Fig. 2(B), C_2H_4) production and was relatively

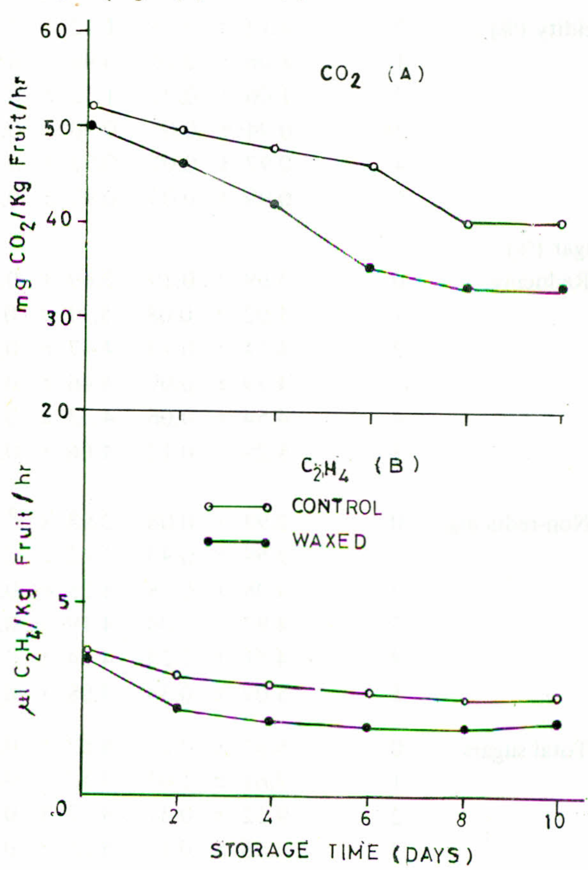


Fig. 2. Effect of waxing (Britex 561) on the evolution of CO_2 (A) and C_2H_4 (B) by kinnow fruit during storage at room temperature, 16-22^{o}.

constant during 10 days of storage; and waxed fruit produced about 1μl/kg/hr less than that of unwaxed fruit ($P < 0.05$).

Biochemical constituents. The effect of waxing of the biochemical constituents (ascorbic acid, total acidity, reducing, non-reducing and total sugars) in kinnow stored at 16-22^{0} is given in Table 1 and for those stored at 4-5^{0} in Table 2. Waxing did not significantly effect the ascorbic acid content regardless of storage temperature. Such a trend was observed for acidity which decreased ($P < 0.05$) as the storage period was prolonged. It was not observed at refrigerated temperature because of the slowing of metabolism. Sugar contents increased with the passage of time ($P < 0.01$), and tended to increase more in unwaxed fruits. The effect of waxing during storage at 4-5^{0} reveals a decrease ($P < 0.05$) in ascorbic acid and total acidity, and an increase ($P < .05$) in sugars. The phenomenon of increase in sugars and decrease in acidity is well explained by Spencer [16]. Acidity was restricted in waxed fruit as compared to control because waxing slows down metabolism at the same storage temperature. This observation is similar as reported for respiration and is supported by the results of others [4].

Table 1. Effect of waxing* on the biochemical constitutents of kinnow mandarins during storage (16-22^{0}).

Parameter	Storage time weeks	Control	Waxed
Ascorbic acid (mg/100 ml)	0	24.62 ± 0.53	24.62 ± 0.53
	1	25.35 ± 0.39	24.50 ± 0.08
	2	22.81 ± 0.43	23.68 ± 0.62
	3	25.52 ± 0.47	22.08 ± 0.49
	4	23.96 ± 0.11	22.76 ± 0.56
	5	24.26 ± 0.30	24.15 ± 0.40
Acidity (%)	0	1.12 ± 0.13	1.12 ± 0.13
	1	1.06 ± 0.14	0.96 ± 0.02
	2	1.06 ± 0.07	1.12 ± 0.06
	3	0.94 ± 0.07	0.90 ± 0.06
	4	0.97 ± 0.01	0.92 ± 0.05
	5	0.99 ± 0.03	0.97 ± 0.01
Sugar (%)			
Reducing	0	3.69 ± 0.19	3.69 ± 0.19
	1	5.02 ± 0.08	5.11 ± 0.13
	2	4.14 ± 0.13	4.47 ± 0.32
	3	4.59 ± 0.07	4.46 ± 0.39
	4	4.54 ± 0.06	4.33 ± 0.13
	5	5.29 ± 0.12	4.66 ± 0.06
Non-reducing	0	2.93 ± 0.06	2.93 ± 0.06
	1	2.59 ± 0.93	2.42 ± 0.03
	2	4.98 ± 0.18	5.25 ± 0.33
	3	4.97 ± 0.04	4.19 ± 0.04
	4	4.51 ± 0.24	4.24 ± 0.06
	5	5.07 ± 0.34	5.08 ± 0.22
Total sugars	0	6.62 ± 0.25	6.62 ± 0.25
	1	7.61 ± 1.07	7.53 ± 0.16
	2	9.12 ± 0.31	9.72 ± 0.65
	3	9.56 ± 0.11	8.65 ± 0.43
	4	9.05 ± 0.30	8.57 ± 0.19
	5	10.36 ± 0.46	9.74 ± 0.28

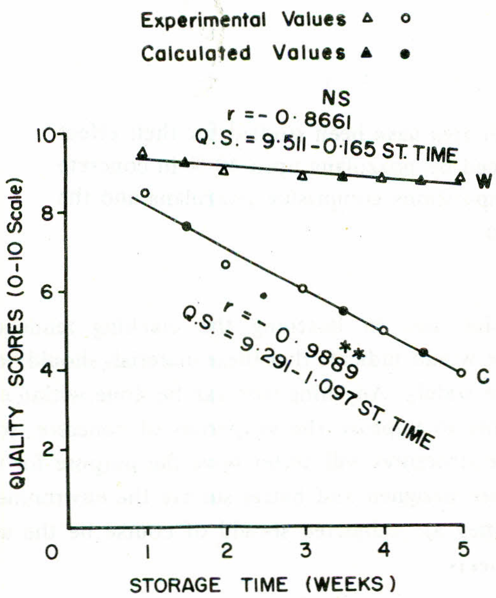
* Britex-561 (US wax emulsion).

Table 2. Effect of waxing* on the biochemical constituents of kinnow mandarins during storage (4-5^{0}).

Parameter	Storage time (months)	Control	Waxed
Ascorbic acid (mg/100 ml)	0	22.89 ± 0.48	22.89 ± 0.48
	1	20.75 ± 0.55	21.79 ± 0.98
	2	19.71 ± 0.20	20.74 ± 0.31
Acidity (%)	0	0.71 ± 0.06	0.71 ± 0.66
	1	0.55 ± 0.05	0.73 ± 0.01
	2	0.55 ± 0.07	0.70 ± 0.13
Sugar (%)			
Reducing	0	3.94 ± 0.31	3.94 ± 0.31
	1	4.20 ± 0.03	4.75 ± 0.07
	2	4.79 ± 0.03	4.81 ± 0.12
Non-reducing	0	3.25 ± 0.07	4.51 ± 0.48
	1	4.15 ± 0.16	4.91 ± 0.33
	2	4.60 ± 0.10	4.60 ± 0.17
Total sugars	0	7.19 ± 0.38	7.19 ± 0.38
	1	8.35 ± 0.19	9.66 ± 0.40
	2	9.39 ± 0.15	9.41 ± 0.29

* SB-65 (US wax emulsion).

Organoleptic tests. The effect of waxing on external appearance as well as the quality of the stored fruit shows that external appearance remained significantly ($P < 0.05$) better due to waxing (Fig. 3). However, the taste and flavour of such fruit was impaired and there was a negative correlation between appearance and flavour. Deterioration in the flavour of waxed fruit is due to restricted metabolic activity and results in fermentation (off-flavour). This suggests that the thickness of wax-coat (dilution) should be decreased and alternative storage temperatures evaluated to avoid off flavours.



CONCLUSION

Waxing of kinnow mandarins significantly improved shine, reduced weight loss and maintained the fresh look of the fruit during storage. The CO_2 and C_2H_4 production were reduced by waxing treatment, i.e. there was slower metabolic activity. There was a decrease in acidity and increase in sugar contents as the storage period was prolonged. A negative correlation between external appearance versus taste and flavour was observed in waxing treatment which suggests a careful application of this technique for shelf-life extension or the need for additional testing to refine methods of application.

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REFERENCES

1. W.A. Farooqi, Physiological, biochemical and microbiological studies on the shelf-life extension of citrus fruit, Ph. D. Dissertation, Punjab Univ. Lahore, (1986). p. 152.
2. S.A. Trout, E.G. Hall and S.M. Sykes, Aust. J. Agri. Res., **4**, 57 (1953).
3. E.G. Hall and S.A. Trout, J. Aust. Inst. Agri. Sci., **10**, 80 (1944).
4. W.B. Mack and J.R. Janer, Food Res., **7**, 38 (1944).
5. W.A. Farooqi and E.G. Hall, Aust. Hort. Res. Nelett., **29**, 29 (1970).
6. W.A. Farooqi, Biochemical and physiological basis of shelf-life extension of citrus fruit by refrigeration and controlled atmosphere storage, NIAB/PL-480 FS 2 (Final Tech. Rep.), (1983), p. 103.
7. Y. Zafar, Some studies on the diazotrophic bioconosis in Kallar grass (*Leptochloa fusca* (L) Kunth), Ph. D. Disertation, Quaid-e-Azam Univ. Islamabad (1985).
8. *AOAC, Official Methods of Analysis* (Benjamin Frankin Sta., Washington D.C. 2004, 1980), 3 ed.
9. S.V. Ting, J. Agri. Food Chem., **4**, 263 (1956).
10. J.K. Krum, Food Engr., **27**, 74 (1955).
11. W.G. Chochran and G.M. Cox, *Experimental Design*, John Wiley & Sons Inc. N.Y. (1965).
12. H.A. Schomer and C.F. Pierson, Proc. 63rd. Ann. Meet. Wash. St. Hort. Soc., (1968), p. 198.
13. J.K. Long, D. Leggo and J.A. Seberry, N.S.W. Dept. of Agri. Bull No. **168**, 36 (1965).
14. I.A. Sheikh, M.Y.I. Haq, S.M. Ali, A.F.M. Ehtesham-ud-Din and M. Aslam, Pakistan J. Sci. Ind. Res, **14**, 526 (1971).
15. B.L. Wild, Beware of the wax knobs, Rural News lett. Aust., p. 4 March (1982).
16. M. Spencer, *Fruit ripening in, Plant Biochemistry*, Academic Press. N.Y. (1965), p. 793.