

Effect of hydro cooling and packaging on the shelf life of cold stored destalked litchis cultivar Taiso

R S Munbodh *

Food and Agricultural Research and Extension Institute (FAREI)

E-mail: soomunbodh@yahoo.com

Paper accepted on 22 July 2015

Abstract

Selected litchi fruits cultivar Taiso harvested at full red color stage were destalked and were (a) non-hydro cooled and (b) hydro cooled at 0 - 1°C for 12 to 15 minutes until the core pulp temperature reached 5°C and were packed in LDPE plastic packaging, clip-on barquettes, opaque plastic bags, 70 micron thick and cold stored at 5 °C. Significant difference in cumulative percentage weight loss for the treatments and over storage time was observed, non-hydro cooled fruits stored in clip-on barquettes at 30 days having a significantly higher cumulative percentage weight loss of 1.86 percent compared to hydro cooled fruits in opaque plastic bags had the least percentage weight loss of 0.83 percent ±S.E 0.06. Percentage pericarp browning in hydro cooled fruits was minimal. Hydro cooled and non-hydro cooled fruits packed in LDPE plastic 30 micron and in clip-on barquettes had a negligible percentage of fruits whose peel cover had browned by more than 25 percent. Hydro cooled fruits packed in opaque plastic 70 micron thickness had 20 percent fruits browned by more than 25 percent peel cover. No fungal growth was observed on the hydro cooled fruits irrespective of packaging. Total soluble solids and acidity values remained stable for all the treatments. It is recommended to hydro cool fresh destalked litchis in iced water (0-1 °C) until the core flesh temperature reaches 5 °C, when packed in clip-on or LDPE plastic 30 micron, pericarp browning was minimal at 3 weeks storage and no fungal growth was observed on the fruits. Key words: -post harvest, litchi, hydro cooling, packaging, shelf life.

**For correspondences and reprints*

1. INTRODUCTION

Litchi fruits are classified as drupes and have a large seed, edible aril (flesh) and thin, tough corky pericarp (skin). While the aril is succulent, sweet and juicy being translucent cream to white in color, the pericarp of the mature fruit is bright pink red in color.

These fruits have a high commercial value on the international market.(Nakasone et al., 1998) but after harvest the fruits which are very perishable, rapidly lose their bright red skin color, turning brown within 1-2 days at ambient temperature (Nip, 1988. Ray, 1998.). Emphasis is now being laid on temperature management and non chemical disease control. (Kaiser, 1994; Lichter et al., 2000) In Mauritius, 331 tons of litchis were exported for the year 2013 amounting to 53.3 million MUR. The method most commonly used to increase shelf life of litchi for export is through the fumigation of fruits using Sulphur dioxide (produced by burning Sulphur), a few hours after harvesting.

However, the use of Sulphur dioxide (SO₂) is a risk to health, especially for people suffering from allergies. To-day, SO₂ treatments have totally ceased in the U.S.A, except for treating table grapes. European legislation authorizes residue levels of 10 ppm in litchi pulp and 250 ppm in the skin. Therefore alternatives to Sulphur have to be found in order to enable exporters from Mauritius to secure international markets and to explore new ones. There is therefore the need locally to devise methods of treating litchis non chemically, such as hydro cooling so as to satisfy the demands of the GLOBALPGAP. Most fresh fruits require thorough cooling immediately after harvest in order to maintain quality and shelf life until delivery to the consumer.

Hydro cooling is the process by which harvested produce is cooled directly by chilled water. Rapid cooling of produce will lead to a reduction in the respiration rate and other metabolic processes of product tissue which lead to delaying of

decline of produce quality and lengthening of shelf life. For efficient hydro cooling, chilled water should come into contact with the product surface. The main advantage of hydro cooling is that it does not remove water from the produce and may even rehydrate slightly wilted produce.

The main objective of this study carried out was therefore to assess hydro cooling, as an alternative to Sulphur dioxide as post harvest non chemical treatment with appropriate packaging and storage at 5 °C on the quality and shelf life of fresh litchis for export.

2. MATERIALS AND METHODS

Litchi fruits cultivar Taiso were harvested at full red color stage from a commercial litchi orchard. The fruits were pruned at least 20 cm behind fruit cluster by using a sharp secateur . The fruit bunches were first placed in a plastic bag which was lowered to the ground. The harvested fruits were then transferred to clean stackable ventilated field crates and were brought to the post harvest facility at Wooton Crop Research Station within two hours under a covered transport. Fruits were destalked such that the fruit stalk was 2 mm from fruit base and selected for uniformity of shape, color and size (30 mm diameter), sweetness (brix 18) and for absence of physical damage, insect injury or fungal infection. Under sized fruits, poorly colored fruits and punctured damaged and cracked fruits with brown spots were removed. Care was taken avoid mishandling fruits during sorting operations to minimize pericarp damage and other mechanical injury. Only sound and full red destalked fruits were then subjected to the following treatments:-

- (a) Hydro cooling of selected fruits was carried out by dipping the fruits in a stainless steel water bath at 0-1 °C for 15 minutes until the core pulp temperature reached 5°C. Core pulp temperature was monitored using a digital probe thermometer. The hydro cooled fruits were then air dried using an electric fan prior to packing.

As control treatment harvested fruits at optimum maturity were not hydro cooled. Both hydro cooled and non hydro cooled selected destalked fruits were then packed in:

- (a) clip-on barquettes,
- (b) opaque plastic bags of 70 micron thickness and
- (c) LDPE bags 30 micron thick and stored at 5 °C.

The packed cold stored fruits were left undisturbed for 3 weeks to maintain the 'cold chain' under simulated export conditions after which quality assessment was carried out.

Statistical design used was randomized complete block. 15 replicates per treatment were used with each replicate containing 20 fruits.

Parameters assessed were:-

- (a) Level of pericarp browning,
- (b) Level of disease development,
- (c) Brix,
- (d) Acidity,
- (e) Percentage weight loss,
- (f) peel color, at 21 days, 26 days and 30 days of storage.

An informal sensory appraisal of the stored fruits using 8 untrained panelists at Wooton crop research station was also carried out from randomly selected packs from each treatment at 21 days, 26 days and 30 days of storage.

Parameters were assessed and recorded as follows:

(a) Percentage weight loss

Percentage weight loss was calculated by subtracting the actual weight from the initial weight of fruits per pack and dividing it by the initial weight and multiplying by 100.

(b) Pericarp browning

Level of pericarp browning was visually assessed by estimating the percentage of fruit peel browned over storage time. Degree of fruit peel browning was graded as follows: 0-5 percent, 5-10 percent, 10-25 percent & > 25 percent of fruit peel cover. The number of fruits browned and percentage browning reached were recorded. Fruit peel browned by > 25 percent was considered commercially unacceptable. After consultation of Codex Standard for litchi, Litchis of extra class must be free of defects except for very superficial defects which do not affect the general appearance of the produce and presentation in the package. These superficial defects can be equivalent to 0-5 percent browning of peel which describes slight dotted browning specs on the pericarp needles.

As Class I allows for skin defects not exceeding an area of 0.25 cm² and slight color defect being equivalent to 5-10 percent peel cover and Class II makes allowances for skin blemishes not exceeding an area of 0.5 cm² (as per Codex Alimentarius for Codex Standard for Litchi, Codex Stan 196-1995).

(c) Disease incidence

Level of disease development was measured by counting the number of fruits in the pack showing any fungal or bacterial growth and calculating the percentage number of fruits diseased over storage time in the pack. Disease and identification of pathogen was carried out by the Plant pathology division of FAREI.

(d) Peel color

Peel color acceptability index was determined by visual assessment of fruits in the pack and they were graded as per table below:

Fruit color	Grade score
Excellent	5
Good	4
Fair	3
Poor	2
Very poor	1

Excellent score index 5 was attributed to fruits having full red color, score index 4 was attributed to fruits having red color with very slight defects < 5 percent on the pericarp.

Fruit samples graded as per color peel index 3 was considered to be commercially unacceptable due to defects being accounted by >10-25 percent.

(e) Brix

Brix was determined by the mean of three values of juice readings from 5 fruits in stored pack taken by the Atago refractometer.

The fruit juice was placed on the refractometer prism and reading of degree of brix was recorded which indicates the sugar concentration present in the fruit juice.

(f) Acidity

Acidity was determined by titrating 10 ml diluted pure fruit juice against standard 0.1N Sodium Hydroxide solution. The acidity is expressed as gram of citric acid per 100 mL of fruit pulp using the equation: 1 mL of 0.1 N NaOH \equiv 0.0064g of citric acid.

3. RESULTS AND DISCUSSION

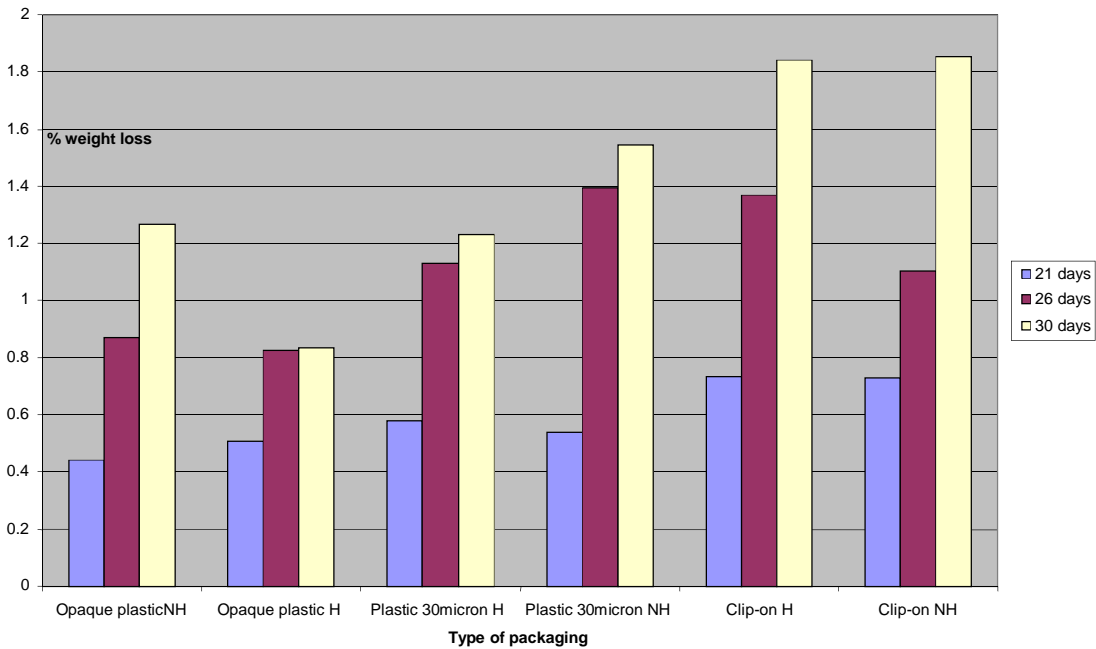
Weight loss

There was very slight significant difference in cumulative percentage weight loss over storage time for the packaging treatments for hydro cooled and non- hydro cooled fruits. Hydro cooled litchis stored in opaque plastic bags had the least

percentage cumulative weight loss (0.833 percent +- S.E 0.06) at 30 days storage compared to the other packaging treatments. There was also a significant difference over the storage time, fruits stored at 30 days having a higher cumulative percentage weight loss than those stored over 21 days irrespective of packaging treatments. Packaging and refrigeration therefore successfully slows the rate of water loss from the fruits by reducing the water holding capacity of the surrounding air, slowing the rates of diffusion and providing a physical barrier to air currents. Huang and Scott (1985) and Wong et al. (1991) reported that by packing fruit in plastic containers and overwrapping with a semi permeable membrane, reduced fruit desiccation with minimum condensation.

Type of packaging material used influenced the rate of weight loss of fruits over storage time due to their permeability properties. **Plastic** material is any of a wide range of synthetic or semi-synthetic organic solids that are moldable. Plastics are typically organic polymers of high molecular mass, but they often contain other substances. They are usually synthetic, most commonly derived from petrochemicals. Plastic bags consist mainly of polyethylene, and clip-on barquettes made up of low density poly ethylene(LDPE) both of which consists of long chains of ethylene monomers derived from natural gas and petroleum.(reported in Wikipedia 2014, Polyethylene). The polyethylene used in most plastic shopping bags is either low-density (resin identification code 4) or, more often, high-density . The thicker the plastic material polypropylene (70 micron thickness) implies the more densely packed monomers with little inter space between making the plastic material more opaque and compact and less permeable to gas exchange and water movement, compared to 30 micron thick plastic, whose less compact arrangement of monomers allows space for gas exchange and confers a more transparent crystalline look to the material. For the clip-on barquettes, more freedom of gas exchange and water vapor was allowed through the thin air space between the closed sides of the pack compared to the sealed plastic bags. This explains the significantly higher percentage cumulative weight loss of non hydro cooled litchis when stored in clip-on barquettes over storage time.

Fig 1:- Percentage cumulative weight loss of hydro cooled and non hydro cooled litchis cultivar Taiso cold stored in different packaging at 5 °C



For 21 days, both hydro cooled and non hydro cooled litchis did not lose more than one percent moisture, irrespective of packaging material. Rate of moisture loss increased thereafter except in hydro cooled litchis in opaque plastic bags which did not lose more than one percent moisture even after 30 days.

Lowering internal commodity temperature following harvest is critical in extending postharvest shelf life. A major contributing factor involved with heat and poor postharvest shelf life is respiration. Respiration is a biochemical process essential to all living tissue. Respiration also produces heat as a by-product and is temperature regulated. Increasing tissue temperature will concomitantly raise rate of respiration approximately 2 to 3 fold for every 10 °C rise reported by (Atkin and Tjoelker, 2003). Thus heat from respiration accumulates, and if not cooled, wilting and tissue decay usually results, reported by (Bourne, 1977). Besides the cooling of high surface to volume ratio vegetables, low surface to volume ratio commodities such as lychee (*Litchi chinensis* Sonn.) also benefit from heat removal.

Pericarp Browning

Hydro-cooling lychee delayed pericarp browning and improved the overall quality of fruits after storage, reported by (Kesta and Leelawatana, 1992). Lychee fruits are at a greater level of hydration after hydro-cooling and are speculated to be involved with pericarp browning (Olesen, et. al. 2003). Core temperature of 5 °C is optimal for storage and hydro-cooling is reported to hydrate the pericarp resulting in delayed browning and improved fruit quality when compared to non hydro-cooling (Olesen, et. al. 2003.). Currently, lychees produced in Hawaii are hydro cooled by the use of a hydro-cooler that would hydrate the pericarp and improve the overall quality of their product as reported by (Kesta and Leelawatana, 1992). The low surface to volume ratio of lychee fruits was easily cooled due to their relative small size. In addition to cooling of the fruit tissue, hydration of the pericarp delayed pericarp browning.

Enzymatic browning is a widespread problem in the litchis as it leads to undesirable characteristics of fruits, thereby decreasing fruit quality and value. Browning can be caused by a wide range of different stresses, such as climatic conditions prior to fruit maturation, polyphenols oxidase (PPO) reported by (Huang et al., 1990; Jiang, 2000), peroxidase (POD) (Zhanget al., 2005), fruit disease (Huang and Scott, 1985; Jiang et al., 2002), desiccation (Scott et al., 1982; Underhill and Simons, 1993; Lin et al., 2002a, 2002b), chilling (Tongdee et al., 1982), fruit senescence (Huang and Wang, 1990), decay (Huang and Scott, 1985; Johnson and Sangchote, 1994; Underhill et al., 1997), microcracks (Underhill and Critchley, 1993;

Underhill and Simons, 1993), and heat injury (Wong et al., 1991; Jiang et al., 2002). The mesocarp cells turn brown first, followed by the epicarp and endocarp (Joubert and Van Lelyveld, 1975). Mechanism of browning is mainly attributed to oxidation process of phenolics and the degradation of anthocyanin (red pigment) by the enzymes polyphenol oxidase (PPO) and peroxidase (POD), (Huang et al 1990; Zauberman et al. 1991; Underhill 1992; Zhang and Quantick 1997; Jiang et al., 2004; Jaiswal et al., 1987) and the formation of polymeric

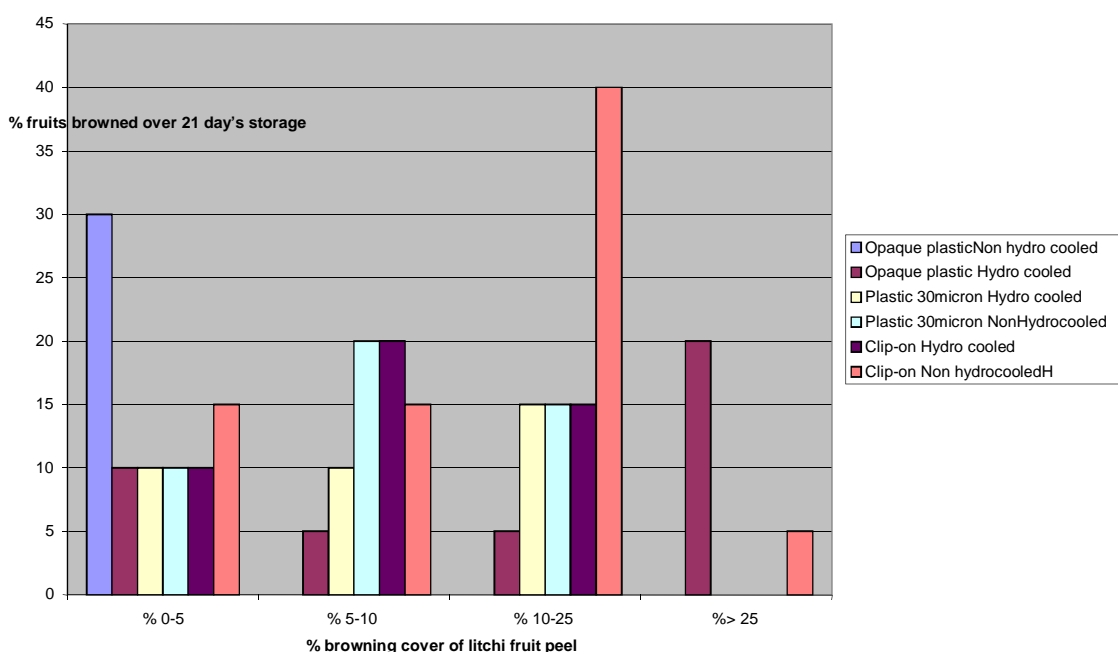
browning pigments (o-quinones). Jiang et al. (2003) also suggested that the litchi fruit can have a storage life of around 30 days at 3–5 °C. Postharvest pericarp browning and fruit quality deterioration can be effectively delayed by cold storage (Khan et al., 2012).

Pericarp browning is related to water loss or desiccation from the pericarp (Scott *et al* 1982).). Browning caused by temperature stress, decay and senescence (bagshaw et al. 1995) is evident as dark and water soaked areas on the pericarp whereas browning due to desiccation is differentiated by a pale dry appearance of the pericarp. It was observed that the percentage of pericarp browning on the fruit peel increased with storage time. At **3 weeks** storage the hydro cooled fruits packed in LDPE plastic 30 micron and in clip-on barquettes had a 0 percentage of fruits browned more than 25 percent peel cover, hydro cooled fruits packed in polypropylene opaque plastic 70 micron thickness had more than 20% fruits browned by more than 25 percent in the stored pack. Thick opaque plastic 70 micron compared to other packaging types is less permeable to gas exchange and water vapor, has accumulated excessive moisture and water condensation in stored pack generated by hydro cooled fruits which can also enhance senescence, tissue decay, browning and cellular breakdown.

For non hydro-cooled fruits, 15percent of stored fruits in clip-on barquettes and in plastic pack of 30 micron thickness, had a peel cover browning of 10-25percent , but zero percent in non hydro cooled fruits stored in 70 micron thickness no fruits had a peel cover browning percentage of 10-25 percent but 30 percent fruits had browned by 0-5 percent. This is probably due to higher permeability of packs (plastic bag 30 micron thickness and clip-on barquettes) to gas exchange and water vapor, causing desiccation and browning of pericarp whereas thick plastic 70 micron, being less permeable retained the moisture of stored litchis and browning percentage was minimized to only 0-5 percent and prevented a further increase in browning percentage of peel cover for non hydro cooled fruits. Water loss or dehydration causes rapid loss of membrane integrity, bringing the polyphenol oxidase in close contact with the substrate to initiate

browning reaction, reported by (Jiang and Fu 1999; Sun et al 2006). According to Zhang et al. (2001) the pericarp browning index increased while the anthocyanin content declined during storage. Cool temperature storage slows browning, reported by (Paul and Chen 1987), slows evaporation, respiration and tissue senescence, (Tongdee, 1998).

Fig 2:- Browning percentage cover of outer pericarp of hydro cooled and nonhydrocooled litchi fruits in various packaging and stored for 21 days at 5°C

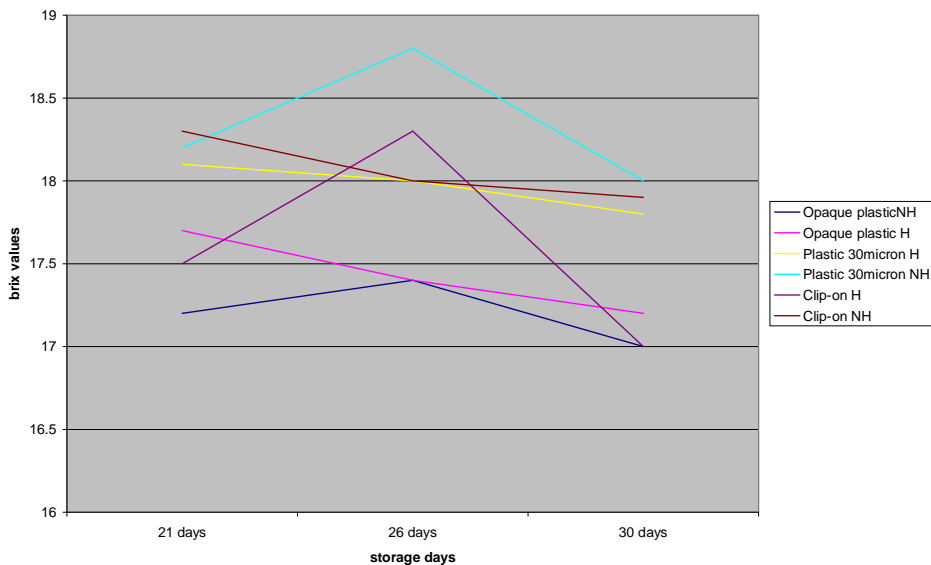


Brix and acidity

Total soluble solids, determined by degree brix value and titratable acidity are important factors in flavor and nutritive quality of litchi fruit. (Jiang and Fu, 1998) Brix(17.2-18.8) and acidity(0.26-0.34) values remained stable throughout the storage period of 3 weeks for all treatments but decreased significantly($p < 0.05$) at 30 days storage, as shown in the tables below:-

Brix			
	<i>21 days</i>	<i>26 days</i>	<i>30 days</i>
Opaque plasticNonHydrocool	17.2	17.4	17
Opaque plastic Hydro cool	17.7	17.4	17.2
Plastic 30micron Hydro cool	18.1	18	17.8
Plastic 30micron Non hydro cool	18.2	18.8	18
Clip-on Hydro cool	17.5	18.3	17
Clip-on NonHydrocool	18.3	18	17.9
S.D	0.437	0.538	0.467
S.E	0.309	0.381	0.330

Fig 3:- Brix values of litchi fruits stored at 5 °C



A rise in brix value for non hydro cooled fruits stored at 5 °C in plastic bags of 30 micron thickness can be explained by the:

- (i) biological variability of the fruits stored,
- (ii) permeability of plastic pack to moisture loss, and gases caused by respiratory activity of non hydro cooled fruits and also
- (iii) increased permeability of pericarp membrane to moisture loss causing a higher concentration of total soluble solids in stored litchi pulp.

Acidity	21 days	26 days	30 days
Opaque plastic Non Hydro cool	0.26	0.26	0.22
Opaque plastic Hydro cool	0.29	0.27	0.22
Plastic 30micron Hydro cool	0.36	0.27	0.24
Plastic 30micron Non Hydro cool	0.34	0.33	0.24
Clip-on Hydro cool	0.28	0.34	0.19
Clip-on Non Hydro cool	0.32	0.34	0.23
S.D	0.038	0.039	0.019
S.E	0.027	0.027	0.013

It was observed at storage period of 30 days the significant decrease in brix and acidity values lead to an increase in the sugar: acid ratio which influence the eating quality of the fruits. An informal taste evaluation was carried out with eight inexperienced panelists at Wooton crop research station who tasted the fruits at 21 days, 26 days and 30 days storage for all the treatments. They reported that hydro cooled fruits maintained an excellent sweet taste and were

juicy in texture at 21 days storage irrespective of packaging type. Evaluation of fruits at 30 days the panelists reported fruits to have bland taste and to be drier, less juicy in texture with increase in storage time irrespective of treatment. Decline in fruit sweetness may be attributed to a fall in sucrose content in the aril after 26 days storage due to using up food reserves for respiration and other metabolic processes reported by (Robert Paull and N.Chen, 1987).

Disease incidence

No fungal growth was observed on the hydro cooled and non hydro cooled fruits at 3 weeks storage at 5 °C in irrespective of packaging type. Proper fruit selection at harvest and careful handling of fruits during packaging and storage minimized internal damage to fruits as well as abrasions to the outer pericarp hence decreased the incidence of post harvest disease in the stored packs. Low temperature storage of 5 °C also contributed for slowing rot development.

Peel color

At 3 weeks storage excellent peel color was maintained at 5 °C for hydro cooled fruits stored in clip-on barquettes and plastic pack of 30 micron thickness plastic compared to non hydro cooled fruits where the peel color retention was graded as fair. Non hydro cooled fruits was subjected to a higher percent cumulative weight loss caused by desiccation, hence a decline in peel color index compared to hydro cooled fruits stored in the same pack. Hydro cooled and non hydro cooled fruits stored in opaque plastic 70 micron thickness retained peel color good-fair for 3 weeks after which due to low permeability of plastic material to gases and moisture, but there tends to be excessive humidity in stored pack leading to tissue expansion and fruit cracking.

Litchi micro cracking was reported by Underhill and Simons (1993) who suggested that it is caused by desiccation. Micro cracking is also one of the causes of pericarp browning (Huang et al. 2004). Micro-cracking can also be caused by poor handling processes during packing line operations, fruit dropping

during sorting at harvest also caused splitting damage in the pericarp reported by (Sivakumar and Korsten 2004).

4. CONCLUSION

It is recommended to pack hydro cooled excellent fresh destalked litchi fruits in clip-on or LDPE plastic 30 micron and store it at 5 °C as the fruits maintain their quality, peel color and market value for three weeks with a minimum cumulative weight loss percentage, low browning percentage and no disease incidence. For cold stored non-hydro cooled fruits, packaging in 70 micron plastic may be recommended for short distance markets.

Future work

Future research could be engaged in (a) evaluating a commercial hydro cooled litchis in Mauritius, for simulated controlled atmosphere sea freight export trials (b) Shelf life evaluation of hydro cooled litchis packed in bio-degradable type packaging to minimize environmental pollution and (c) to evaluate use of surface coating based on polysaccharide and sucrose ester-based coatings on cold stored litchis to minimize fruit desiccation.

Acknowledgements

Grateful to the CEO of FAREI, Mr. Ramkissoon for giving permission to present this paper, Principal Research Scientist, Fruit Division, Mrs Ramburn and staff for their help and cooperation in editing this paper.

5. REFERENCES

- BOYETTE M.D, ESTES E.A, RUBIN A.R , 1992 North Carolina A&T State University, Us Department of Agriculture - Hydro cooling.
- CHEN, W., WU, Z. and SU, M 2001. Post harvest research and handling of litchi in China- a review. *Acta Horticulturae* 558, 321-9.
- DHARINI SIVAKUMAR, LISE KORSTEN., KARIN ZEEMAM 2007. Post harvest Management on Quality Retention of Litchi during Storage.
- ENVIRONMENT.GOV.AU (2010-06-13). Plastic shopping bags in Australia. Retrieved on 2010-11-23.n of lychee (*Litchi chinensis* Sonn.) with emphasis on color retention. *Tropical Science*.28:5-11
- HOLCROFT, D.M and MITCHAM, E.J.1996. Post harvest physiology and handling of litchi, *Post harvest Biology Technology* 9:265-281
- HUANG, C.C and WANG, Y.T 1990. Effect of storage temperature on the color and quality of litchi fruit. *Acta Horticulturae* 269,307.
- JIANG, Y.M. and FU, J.R.1999. Post harvest browning of litchi fruit by water loss and its prevention by controlled atmosphere storage and high relative humidity. *Lebensmittel-Wissenschaft Technologie* **32**, 278-83
- JOHNSON, G.I. and SANCHOTE, S.1994. Control of post harvest disease of tropical fruits: Challenges for the 21st Century. *ACIAR Proceedings* 58:140-161.
- KADER, A. A. Postharvest Technology of Horticultural Crops. Univ. Calif. Agri. and Nat. Res. Pub. 3311. 2002.

- KESTA, S., and LEELAWATANA. 1992. Effect of precooling and polyethylene film liners in corrugated boxes of quality of lychee fruits. *Acta Hort.* 321: 742-746.
- KAISER., C.1994. Litchi (*Litchi chinensis* Sonn.) pericarp color retention. *Yearbook of South African Litchi growers' Association* **6**, 32-5
- NAKASONE, H.Y. and PAULL, R.E.1998. Tropical fruits. In: *Crop Production Science in Horticulture*. Series No.7 Wallingford, UK, CAB International. P.173-207
- NIP W.K. 1988. Handling and preservation of lychee with emphasis on color retention. *Tropical Science* 1988, 28, 5-11
- NIP.W 1988. Handling and preservation. *European Plastics News: Plastic T-Shirt Carrier Bag (1965)*. 26 September 2008. Retrieved 17 April 2012.
- OLESEN, T., WILTSHIRE, N., and McCONCHIE, C. 2003. Improved post-harvest handling of lychee. RIRDC Pub. 03/111, Queensland, Australia.
- PAULL, R.E., CHEN, N.J. 1987. Effect of storage temperature and wrapping on quality characteristics of litchi fruit. *Scientia Horticulturae* **33**, 223-36
- WIKIPEDIA, Oct 2014, Polyethylene.
- SAN DIEGO PLASTICS INC.sdplastics.com 2014
- UNDERHILL SJR and SIMONSDH. 1993. Lychee (*litchi chinensis* Sonn) pericarp dessication and the importance of post harvest micro cracking. *Scientia Hort.*54 287-294

UNDERHILL, S.J.R. and CRITCHLEY, C. Anthocyanin decolorisation and its role in litchi pericarp browning. *Australian journal of Experimental Agriculture*, 34, 115-122(1994).

YUEMING JIANG, LIHU YAO, AMON LICHTER and JIANRONG LI.2003. Post harvest biology and technology of litchi fruit. *Food, Agriculture & Environment* Vol (2):76-81. 2003.

J YUEMING, L. YUEBIAO and L. JIANRONG. Browning Control and Shelf life Extension of frozen Lychee fruit by diluted Hydro Chloric Acid. *Acta Horticulturae* 665, ISHS 2005

J.YUEMING *et al.* Anoxia treatment for delaying skin browning inhibiting disease development and maintaining the quality of litchi fruit. South China Institute of Botany April 2004.