DEVELOPMENT OF VALUE CHAIN OF ORGANIC PINEAPPLE (*ANANAS COMOSUS*) FROM NAGALAND

Thesis

Submitted to

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In partial fulfilments of requirements for the Degree of

Doctor of Philosophy

in

Horticulture

by

IMLIAKUM AO

Admin. No. Ph-151/13 Regn. No. 588/2014

Department of Horticulture

School of Agricultural Sciences and Rural Development,

Nagaland University, Medziphema Campus – 797 106

Nagaland

2019

Dedicated

to my

Beloved

Mother

DECLARATION

I, Imliakum Ao, hereby declare that the subject matter of this thesis is the record of work done by me, that the contents of this thesis did not form the basis of the award of any previous degree to me or to the best of my knowledge to anybody else, and that the thesis had not been submitted by me for any research degree in any other University/Institute.

This is being submitted to Nagaland University for the degree of Doctor of Philosophy in Horticulture.

Date:

Place: Medziphema **(IMLIAKUM AO)**

(AKALI SEMA)

Professor and Major Advisor

NAGALAND UNIVERSITY
Medziphema Campus
School of Agricultural Sciences and Rural Development
Medziphema – 797 106, Nagaland

Prof. Akali Sema
Professor
Department of Horticulture

CERTIFICATE – I

This is to certify that the thesis entitled **"Development of value chain of organic pineapple (*Ananas comosus*) from Nagaland"** submitted to Nagaland University in partial fulfilment of the requirements for the award of degree of Doctor of Philosophy (Agriculture) in Horticulture is the record of research work carried out by Mr. Imliakum Ao, Registration No. 588/2014 under my personal supervision and guidance.

The result of the investigation reported in the thesis has not been submitted for any other degree or diploma. The assistance of all kinds received by the student has been duly acknowledged.

Date :
Place : Medziphema

(AKALI SEMA)
Major Advisor

NAGALAND UNIVERSITY
Medziphema Campus
School of Agricultural Sciences and Rural Development
Medziphema – 797 106, Nagaland

CERTIFICATE – II

VIVA VOCE ON THESIS OF DOCTOR OF PHILOSOPHY IN HORTICULTURE

This is to certify that the thesis entitled **“Development of value chain of organic pineapple (*Ananas comosus*) from Nagaland”** submitted by Imliakum Ao, Admission No. Ph - 151/13 Registration No. 588/2014 to the NAGALAND UNIVERSITY in partial fulfillment of the requirements for the award of degree of Doctor of Philosophy (Agriculture) in Horticulture has been examined by the Advisory Board on ……………….............

The performance of the student has been found **Satisfactory/Unsatisfactory.**

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1. Prof. Akali Sema (Major Advisor & Chairman)	…………………….
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3. Prof. A.K. Makar (Dean)	....
4. Prof. C.S. Maiti	…………………….
5. Dr. A. Sarkar	…………………….
6. Dr. A.K. Singh	……………………...

Head
Department of Horticulture

Dean
School of Agricultural Sciences and Rural Development

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Date:

Place: Medziphema (IMLIAKUM AO)

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF ABBREVIATIONS

/	:	Per
%	:	per cent
&	:	and
<	:	Less than
@	:	at the rate
>	:	More than
^{o}Brix	:	Degree Brix
^{o}C	:	Degree Celsius
Anon.	:	Anonymous
ANOVA	:	Analysis of variance
Approx.	:	Approximate
BCR	:	Benefit Cost Ratio
CFB	:	Corrugated Fibre Board
cm	:	Centimeter
etc.	:	et cetera
et al.	:	and others
Fig.	:	Figure
DAH	:	Days After Harvest
G	:	Gram
H	:	Harvesting stage
ha	:	Hectare
i.e.	:	that is
Kg	:	Kilogram
IARI	:	Indian Agricultural Research Institute
ICAR	:	Indian Council of Agricultural Research
ICCOA	:	International Competence Centre for Organic Agriculture
M	:	Metre
Max	:	Maximum
Min	:	Minimum
ML	:	Millilitre
Msl	:	Mean sea level

NS	:	Non-significant
NaOH	:	Sodium Hydroxide
NGO	:	Non Governmental Organisation
SASRD	:	School of Agriculture Science and Rural Development
Nos.	:	Numbers
P	:	Packaging material
pH	:	Potential hydrogen
PLW	:	Physiological Loss in Weight
R	:	Replication
RBD	:	Randomized Block Design
SPD	:	Split plot design
T	:	Treatment
TA	:	Titratable acidity
TMNE	:	Technology Mission for North East
TSS	:	Total Soluble Solids
UV	:	Ultra Violet

CHAPTER I

INTRODUCTION

INTRODUCTION

Pineapple (*Ananas comosus* L. Merr) also known as the "Queen of the fruits" is the most important tropical fruit and a favourite of millions of people all over the world because of its beauty, delicate fragrance and excellent flavour. The original home of pineapple is believed to be Brazil from where it has spread to other parts of the world. Pineapple is the leading edible member of the family Bromeliaceae which embraces about 2000 species, mostly epiphytic and many strikingly ornamental. It is highly nutritious with exquisite flavour suited for processing into various value added products. It is herbaceous perennial monocotyledonous plant that produces a single syncarpous fruit on a terminal inflorescence.

Pineapple is a good source of carotene (Vitamin A) and ascorbic acid (Vitamin C) and is fairly rich in vitamin B and B_2 (Lal & Pruthi, 1955). It also contains phosphorous and minerals like calcium, magnesium, potassium and iron (Lodh *et al.*, 1972). Besides, it is also a source of bromelin, a digestive enzyme (Lodh *et al.*, 1973). It provides adequate roughage to prevent constipation. Its fresh juice has a cooling and refreshing effect, especially in summer. As an appetizer, the juice can be given to patients suffering from liver diseases, nephritis, stomach complaints, heart disease and general weakness. The fruit in addition to being eaten fresh can also be canned and processed in different forms. Pineapple-barn, a dried rag of pulp after juice extraction is a good source of cattle feed. A very fine fibre is extracted from its leaves for making a light but stiff fabric (Hayes, 1960) called Pina cloth.

Pineapple represents about 20% of the world production of tropical fruits and about 70% of the pineapple is consumed fresh. Brazil, Thailand, the Philippines and China produces about 50% of the world production.

However, India produces about 1,415.00 thousand tonnes of pineapple from an area of 89000 ha (Indian Horticulture Database, 2011). However, North-East India alone produces 49% of the pineapple in the country. The ‘Kew’ is the most popular cultivar amongst the growers of North-East India due to its excellent quality. The fruits are commercially harvested in two seasons, *i.e.* winter and summer. A considerable quantity of the produce is lost during handling, transportation and storage. The post harvest losses of pineapple are reported to be about 15-20% of the total production which is valued at about Rs.800 million. A substantial quantity of pineapple from Assam and other North-Eastern states is marketed in Delhi. (Deka *et al.*, 2008).

The demand for certified organic pineapple is increasing. Certified organic pineapple products, though beneficial as food and revenue sources, could also be costly to the producers in terms of resource consumption and opportunity cost of investment. The European Union (EU) represents the largest market in the world for organic pineapple with more than 2000 tonnes in 2002. The second largest market is the USA with nearly 1000 tonnes/year. Although the trade of organic pineapple in the EU goes back to the late nineties, this market is still limited and growing due to some technical limitations that restrict the supply. The main drawback in production of organic pineapple is the ban to ethylene application to induce flowering (Medina & Garcia, 2005)

The North-East region of India has fertile and organically rich soil, ample rainfall, water resources and great climatic diversity supporting diverse cropping possibilities. The progress was already made and the potentials of the region already demonstrated as a result of adopting modern technological approaches *viz.* staggering technique, high density planting (HDP), and organic cultivation. Thus the quality of the fruits is better and cultivation of pineapple in the region has good potential. The government of India, identified the potential of the North East region for horticultural crops, started a project 'Horticulture Technology Mission' in the year 2001. This resulted in 140.7% increase in the area and production of pineapple. The region produces more than 40% of the total pineapple of the country and 90-95% of the products are organic. The common cultivars grown are 'Giant Kew' and 'Queen'. Pineapple produced from this region are qualitatively different and are believed to be among the best in the world as they are very sweet (high TSS) and have less fibre. In the context of tremendous national and global market demand for organic pineapples as well as low volume of such products, this area of India is an ideal area to explore for pineapple cultivation. This area being an agrarian society with an average of 80% tribal population, this venture will result in a breakthrough of social empowerment of the tribal people of the North East states of India (Sema *et al.*, 2010).

The Agro-climatic conditions of Nagaland are highly suitable for the cultivation of pineapple in large scale. Pineapple fruits from the state are considered to be among best in the world due to its TSS content with very little or no fibre. The cultivars grown in the region at present are Giant Kew (75%), Queen (20%) and Mauritius (0.5%). With the introduction of TMNE (Technology Mission for North East) scheme in the state, the horticultural industry has drastically improved and pineapple cultivation has greatly increased with more area and production of pineapple (Saloni *et al.*, 2017).

Nagaland is producing 1,32,270 Mt of pineapples in an area of 9480 ha (Anon., 2017). The Central Institute of Horticulture and Department of Horticulture, Government of Nagaland took several initiatives to promote Nagaland pineapple especially from Molvom village. In order to have a distinct name and a symbol for better identification, a brand logo "Naga pineapple" was created which was successfully launched during North East organic fest at Delhi Haat, New Delhi on 15th December 2012. Nagaland produces the finest quality pineapples, which are in high demand all over the country. Molvom village under Dimapur district which is also known as the pineapple village of Nagaland and is now first ever Bio village in the region. The pineapple produced from this village has high demand in the market. However, the farmers are unable to reach their produce to the consumers due to various logistic problems such as lack of proper transportation, packaging and the correct time of harvest which causes huge post harvest losses.

Keeping in view on the importance of the crop in the region and considering the urgent need to develop proper post harvest management for value addition, the present research work under the title ***"Development of value chain of organic pineapple (Ananas comosus) from Nagaland"*** had been carried out with the following objectives.

OBJECTIVES:

1. To improve post harvest quality of organic pineapple by pre harvest treatments.
2. To standardize harvesting time of pineapple for distant market.
3. To standardize packaging of pineapple for distant market.
4. To assess the impact of transportation on quality and marketability of pineapple.

CHAPTER II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Studies on pineapple had been carried out by a number of researchers in different aspects; however, very little information is available on the value chain of organic pineapple. Some of the relevant literatures pertaining to the present study are highlighted in this chapter.

2.1 Pre harvest treatments to enhance post harvest life

The post harvest life of pineapple is governed to a large extent by its pre harvest history. Temperature has a strong influence on the chemical composition of many horticultural crops (Klein & Perry, 1982).

The appearance of fresh fruits and vegetables is a primary criterion in making purchasing decisions (Kays, 1991). Paull and Reyes (1996) had reported that both crown weight and fruit translucency at harvest are correlated to the monthly temperature 2 or 3 months before harvest, and there is a negative correlation between crown weight and translucency severity. They concluded that higher temperature at earlier stage of fruit development produced less translucent fruit. Product appearance is characterized by size, shape, form, colour, condition and absence of defects. Appearance is utilized throughout the production, storage, marketing and utilization chain as the primary means of judging the quality of individual units of product (Kays, 1999).

There are various methods and techniques applied in the field condition to get protection from sunburn, especially when the fruits have matured. Sunburn damage may be a response to high light/UV exposure and/or high fruit skin temperature. Key processes may include the synthesis of heat-shock proteins and UV-absorbing flavonoids, cuticular reflectance of light, epicuticular wax formation and transpiration. Some of the best known methods for sunburn in pineapple are, covering with its own leaves, covering with straws and kaolin spray (Wunsche *et al.*, 2001).

Chen and Paull (2001) stated that covering fruit with clear plastic during three weeks of fruit development decreased titratable acidity (TA) and increased translucency severity. They also reported that crown removal either at early or late stage of fruit development did not have any significant effect on fruit weight or translucency occurrence and suggested that the crown did not play a significant role in pineapple fruit development and fruit translucency occurrence.

Kaolin reduced fruit surface temperature by increasing the reflection of visible and ultra violet light (Glenn *et al.*, 2005, Wunsche *et al.*, 2004). The effectiveness of kaolin in reducing sun burn in most cultivars and regions may be more strongly ascribed to the reduction and harmful radiation reaching the fruit surface then to the reductions in surface temperature (Gindaba & Wand, 2005), although the later would lower the threshold for radiation damage.

Yazici and Kanyak (2009) did a research on the effects of kaolin and shading treatments on sunburn on fruits of Hicaznar cultivar of pomegranate. The effect of kaolin applications on sun burn were determined by applying 3% of kaolin with four applications at different periods that have been initiated at different dates within weekly intervals. They found out that applications of kaolin were the best method to prevent sunburn in fruits of the Hicaznar Pomegranate cultivar and increased soluble dry matter content and the red colour of fruits.

Abd-Allah *et al.* (2013) experimented the effect of sun-block materials on preventing sunburn injury of Keitt mango fruits. Trees were sprayed with three materials kaolin, magnesium carbonate and calamine at three concentrations 3, 4 and 5% for each to prevent the injury of sunburn on fruits which causes economic losses. All treatments were applied once during summer of two seasons in this investigation and they were compared with control (spraying water only) to study their effects on sunburn, fruit drop percentage as well as yield and fruit quality. Results showed that spraying kaolin or magnesium carbonate at 3 and 5% respectively, had a positive effect on reducing sunburned skin area and fruit drop percentage.

Abassi *et al.* (2014) reported that the highest values for reducing sugars (3.45%), non-reducing sugars (3.03%) and total sugars (7.34%) were observed in fruit covered with perforated polyethylene bags.

Chabbal *et al.* (2014) studied the effect of kaolin applications to control sunburn in 'Okitsu' mandarin. At harvest, they randomly selected 40 fruits by plot and were classified at three levels of sunburn; free of damage fruits (G.0), fruits with yellow spots up to 15 % of the shell (G.1), fruits with yellow spots more than 16 % of the shell and dark necrotic (G.2). Plots with kaolin application showed between 91.53 and 97.94% of fruits G.0, whereas control plots showed only 73.97%. Kaolin applications were effective to control sunburn on 'Okitsu' mandarin. Four applications per season at 2% applications per season at 4% of kaolin 95% allowed reaching 97% of fruits free of sunburn without affecting the internal quality.

Lopez *et al.* (2014) evaluated on the use of solar protection against sunburn and the effect of different irrigation levels on fruit quality of pineapple "Perola" at an experimental area in Janauba, M.G. They used five protections *i.e.* newspaper, brown paper bag, TNT white n^0 40, lime solution 10% and control with four replications which were evaluated for the percentage of fruits with symptoms of sunburn, pulp firmness, Total Soluble Sugar (TSS), Total Titratable Acidity (TTA), pH and TSS/TTA. The result was obtained with lower percentage of sunburn with TNT treatment.

Ennab *et al.* (2017) conducted a field experiment during 2014 and 2015 seasons at a private orchard in Motobus, Egypt to study the effect of foliar spray of 0,2,3 and 4% kaolin, twice or three times at May, June and July on sunburn percentage and fruit quality of Balady Mandarin trees. The obtained result showed that kaolin foliar applications were effective to control fruit sunburn as well as reducing severity percentage of sunburned fruits as compared to untreated trees. They also reported that kaolin foliar spray application at three times decreased leaf and fruit surface temperature specially at 3 and 4 per cent concentrations in addition, the treatments increased yield and improved fruit quality in terms of fruit size, diameter, weight, peel thickness and Vitamin C. Kaolin foliar spray raised the fruit values of SSC %, acidity and SSC/Acid ratio compared to control trees with no significant variation among kaolin concentrations on this variables. They concluded that spraying Kaolin at 3 or 4 per cent three times in summer months had a positive effect on preventing fruit sunburn damage and improve yield and fruit quality of Balady Mandarin trees.

Lal and Sahu (2017) explained that sunburn injury is common on fruits due to high solar radiation levels and air temperatures, low relative humidity, and high elevations. The incidence and severity of sunburn depends upon climatic factor, cultivars, hormonal, nutritional and soil moisture. Fruit production losses due to sunburn may be 6 to 30 per cent depending on seasons and the type of fruit. They suggested that the growers must follow best management practices to minimise sunburn and grow tolerant cultivars, efficient irrigation, appropriate canopy management, cover or intercropping, over tree sprinkler, shade netting, fruit bagging, suppressants (Kaolin or calcium carbonate) and chemical protectants.

Silva *et al.* (2017) commented that high temperature and solar radiation of the tropical regions can burn and reduce the fruit size of the pineapple. An alternative to the farmers of this crop is the shading of the plants, providing the climatic condition. With an objective to evaluate the different shade conditions in the chlorophyll content and morpho-anatomy of pineapple leaves on fruit production, they carried out a field experiment with five treatments comprising 0% shading (pineapples grown in sunlight), 45% shading (provided by adjacent cassava plants), 48.3% shading (provided by adjacent jack bean plants) and 30 and 50% shading (provided by shade netting). They found out that pineapples grown under cassava or jack bean showed phenotypic plasticity with the 'D' leaves presenting trichomes of reduced length and vessel elements of smaller diameter in comparison with plants cultivated under sunlight, while pineapple plants exposed to jack bean have shown reduction in the thickness of the chlorophyll parenchyma, mesophyll and leaf blade. They observed that shadding with net prevented the loss of fruit by sunburn.

Prabha *et al.* (2018) carried out a study on the effect of fruit bagging on physic-chemical properties of pineapple cv. Mauritius during the year 2016 at Horticultural farm of Palli Siksha Bhavana, Sriniketan, West Bengal with five treatments *i.e*. Jute bag, Paper bag, transparent polythene bag, black polythene and control in four replications. Their result showed that the fruit length with crown was found maximum (25.43 cm) in paper bag and minimum (22.33 cm) was observed in transparent polythene bag, fruit length with crown was recorded maximum (18.24 cm) in black polythene and minimum result was found in control (15.80 cm). Highest (677.89 g) fruit weight without crown was obtained in paper bag whereas lowest (462.03 g) was reported in transparent polythene bag, they also reported that the maximum total sugar (8.69 %), TSS (14.22 ^{o}Brix) was found in paper bag and minimum (5.29%) and 12.35 ^{o}Brix respectively was observed in control. They concluded that paper bag was better option for fruit bagging of pineapple cv. Mauritius for prominence effect on yield and quality.

Rahman *et al*. (2018), studied on the effect of pre harvest fruit bagging on post harvest quality of guava cv. Swarupkathi using RBD with three replications in the germplasm centre, Bangladesh Agricultural University during March to July 2016 by using four types of bagging *viz*. brown paper bag, white paper bag, white polythene bag, black polythene bag and uncovered fruit as control. Fruit bagging treatment showed significant effect on different parameters such as fruit size, fruit weight, Vit. C concentration and moisture content. They found out that fruits gained maximum size (6.59 cm length, 5.86 cm Diameter) and weight (164.26 g) under white paper bag followed by white polythene bag (131.3 g) .TSS of the fruit was found maximum (12.33 ^{o}Brix) in brown paper bag while maximum Vit. C (162.14 mg/100g) was recorded under white paper bag. Among the various fruit covering materials, white paper bag was found to be the best for overall improvement of physical and chemical quality of guava cv. Swarupkathi.

2.2. Impact of harvesting stages and packaging on quality of pineapple at distant market

2.2.1. Impact of harvesting time on quality of pineapple at distant market

Pineapple fruits harvested at different maturity stages are not of uniform quality and they show significant variations in the shelf life and physicochemical changes during storage (Ahmed & Bora, 1989).

The aroma of pineapple is a blend of a number of important aromatic compounds and nearly 200 volatile compounds have been reported (Umano *et al*., 1992).

Juiciness and flavour intensity were found to be the most important traits for the acceptability of dry- cured ham (Ruiz *et al*., 2002).

Pineapple fruits must be well ripened, have proper humidity, good formation, well developed eyes, free of decomposition, scalds caused by the sun, free of injuries, burns, illness, insects or mechanical injuries. The base should be well cut. The leaves should be of the same colour, well stuck to the fruit, and should not be more than five per each crown. The longitude of the leaves should not be less than 10cm or more than double the size of the fruit. The pineapple is initially assessed by the external appearance, should be fresh, clear and shiny. When it is completely ripe, the leaves of the crown must be green colour and well developed. (Anon., 2004).

Changes in maturation stage are evident when peel colour turns from green to yellow at the base of the fruit. A minimal content of soluble solids of 12% and a maximal acidity of 1% insure a minimal level of consumer acceptance along with size and texture uniformity, absence of rotting, sun burn cracks, bruises, internal break down endogenous brown spot, gummosis or damage by insects. Crown leaves should be green, medium length and erected. Soluble solids must fall between 11 and 18 %, titratable acidity from 0.5 to 1.6%, Ascorbic Acid should fall between 20 and 65 mg/100g of fresh weight depending on the cultivar and stage of maturity (Medina & Garcia, 2005).

Sairi *et al.* (2004) carried out an organization of sensory evaluation test with 10 trained members panel to evaluate the quality of fresh processed pineapple juice. They were asked to taste one sample at a time and record their responses by using an evaluation form with 1 to 5 structured scale for sweetness, tartness or sourness, colour and overall acceptability of pineapple juice while 1 to 3 structured scale was used for odour. This result showed a considerable increased in sweetness and reduction in the tartness of deacidified pineapple juice. They observed no significant changes in odour and colour.

Schulbach *et al.* (2007) carried out an evaluation of overall acceptability of fresh pineapple using the regression tree approach from five different countries and six different producers using eight descriptive terms:

sweetness, sourness, pineapple flavour intensity, firmness, juiciness, off-flavour, banana character and coconut character along with a rating for overall acceptability by a panel of 15 students and staff from the University of Florida Fruit Science and Human Nutrition Department. Their study revealed that the attributes sweetness, pineapple flavour intensity and off-flavour were the most important factors in determining acceptability. However, the regression tree analysis showed that an increasing concentration of aroma volatiles (as measured pineapple flavour intensity) is probably causing the increased sweetness readings and concluded that by increasing the aroma volatiles in pineapple will not only result in a pineapple with higher flavour intensity, but one with higher apparent sweetness and higher overall acceptability.

The stage of maturity at which pineapple should be harvested depends largely on its ultimate destination or use. The extend of maturity of ripening could be determined by the appearance of eyes and the fruit colour. When immature, the eyes are grey or almost white giving the fruit a greyish appearance. As fruit matures, the space between the eyes fills out and the colour gradually changes from light to dark green as the fruit ripens, the eyes change from pointed to flat condition with slight hollowness at the centre, the fruit becomes enlarged, less firmed and more aromatic (Ranganna, 2008).

During the harvesting season, major bulk of fruits is harvested and creates a glut in the market. As a result a sufficient amount of pineapple fruit gets spoiled due to Lack of proper marketing, storage and processing facilities due to highly perishable in nature, the fruits undergo serious losses after harvest (Kabir *et al*., 2010).

Gupta and Jawandha (2010) reported that there was an increase in the physiological loss in weight, TSS: acid ratio with the advancement of maturity and storage period in peach fruits. In contrast, Vitamin A content followed a linear decline with storage and advancement of maturity stages. There was a gradual decrease in reducing sugars of the fruits picked after optimum maturity with increase in storage period.

Kabir *et al.* (2010) conducted a study to find out the appropriate stages of maturity, the effect of different post harvest treatment on the shelf life of pineapple and select suitable storage method to extend the shelf life in the laboratory of the department of horticulture and bio chemistry, Bangladesh Agricultural University during the period of June to September 2007. Fruits of two maturity stages *i.e*. pre mature (10 days before optimum maturity) and optimum maturity were harvested and places\d in the laboratory room which were given six post harvest treatments *viz*. control, fruit treated with GA_3 100,200 and 300 ppm, 50 ppm GA_3 + 50 ppm NAA and covered with straw. The two factor experiment was laid out in a completely Randomized design (CRD) with three replications. The result revealed a significant variation between the pre matured fruits with longer shelf life (24.27 days) and the optimum matured fruits (21.27 days). Among the treatments GA_3 200 and 300 ppm extended the shelf life of pineapple by 15 and 19.5 days respectively under normal condition. Optimum mature fruits showed higher dry matter content (21.79%), edible portion (66.57%) and total sugar (14.24%) than the pre mature fruit. They also reported that premature fruits showed higher weight loss (15.70%) and Ascorbic Acid (21.05%) during entire period of storage.

Kamol *et al.* (2014) studied the effect of different maturity stages and postharvest treatments on the storage behaviour of Pineapple fruits. They found out that on the 18th day of storage, premature fruits contained the maximum shelf-life (19.33 days), total weight loss (16.00%), moisture content (92.66%), total titratable acidity (0.77%), ascorbic acid content (17.49 mg/100g fruit) while the minimum (14.5 days), (14.67%), (90.66%), (0.68%), (9.75 mg/100g fruit) in optimum mature fruits, respectively. On the other hand, optimum mature fruits had higher dry matter content (14.78%), edible portion (67.77%), TSS (16.03%), pulp to peel ratio (2.56), total sugar content (13.5%) while these were minimum (12.57%), (65.16%), (14.43%), (2.37), (10.56%) in pre mature fruits, respectively. Among the treatments maximum shelf life (22.83 days) was observed in fruits treated with 100 ppm NAA and minimum shelf life (12.66 days) was recorded in control. They also stated that covering materials prolong the shelf life probably due to the reduction of various gases (O_2, CO_2) exchange from the inner and outer atmosphere as well as slowing down the hydrolyses process.

In fruits and vegetables processing, the maturity of raw materials has great effect to the change of their properties, nutritional values and sensory characteristics of final product. Their result showed that, properties of materials were significantly changed corresponding to different maturity levels. When ripening, a decrease of moisture content, Vitamin C content, acid content, and hardness of raw materials and an increase of sugar content and yellowness . (Truc *et al.*, 2008).

Mandal *et al*. (2015), carried out an investigation at research laboratory, Department of Horticulture, Aromatic and Medicinal plants, Mizoram University, Aizwal, on the effect of nine- post harvest treatments *viz*. fruit dipping in NAA at 100 mg L^{-1}, Gibberellic Acid at 100mg L^{-1}, salicic acid at 5mg L^{-1}, covering the fruit with perforated polythene and newspaper bag, fruit coating with wax at 60g L^{-1} , fruit dipping in maleic hydrazide at 500mg L^{-1}, covering fruit with dry straw and control on fruit physic chemical qualities and shelf life of pineapple cv. Giant Kew. Their study revealed that fruits treated with GA at 100mg L^{-1}, showed delayed response of ripening and high shelf life (19.05 days) during storage.

2.2.2. Impact of packaging on quality of pineapple at distant market

Amerine *et al.* (1965) concluded that, as every shopper knew, the appearance was often the only attribute on which they could base a decision to purchase or consume. Hence, they became adept at making wide and risky inferences from small clues, and test subjects did the same in the booth. It followed that the sensory analyst must pay meticulous attention to every aspect of the appearance of test samples and must often attempt to obliterate or mask much of it with colored lights, opaque containers, etc.

In most countries, pineapple harvested from the field for local and overseas markets are normally heaped into lorries without using any containers. On arrival in whole sale markets, the fruits are transferred into bamboo or rattan baskets, stackable plastic containers or corrugated fibre board (CFB) boxes. Despite the packaging measures for the pineapple are not standardized, they are guided by the international packing norms for agricultural products according to the size. The average minimum loss reported is 21% and occasional instance estimates of 40 to 50% and above (Salunkhe & Desai, 1984).

Shaikh *et al.* (2003), presented and discussed the details of the laboratory and the mill trials, simulated and actual packaging and transportation trials with oranges. Results indicated that good quality kraft paper suitable for manufacture of CFB (corrugated fibreboard) boxes can be prepared from cotton plant stalks. The techno-economic feasibility worked out by conducting large scale trial in a mill indicates that the box prepared from cotton plant stalk kraft would be cheaper than that of commercially available box. Results of the simulated and actual packaging and transportation trials demonstrate suitability of corrugated fibre boxes for packaging, transportation and storage of Nagpur mandarin oranges.

Singh and Thakur (2003), researched on packaging boxes from bamboo for horticultural produce. Bamboo boxes made from four bamboo species (*Bambusa polymorpha, B. Nutans, B. Arundinacea* and *Dendrocalamus strictus*) were fabricated and tested for packaging 20 kg kinnow fruit. The boxes made from bamboo were found to have a better capacity to withstand flat drop compared to conventional wooden boxes and their capacity to withstand top to bottom compression was comparable to the conventional wooden boxes. It was also found that the weight of the bamboo boxes was about half of the conventional wooden boxes. Furthermore, the bamboo boxes were cheaper by approximately 16% and their transportation costs were reduces by approximately 10% compared to the wooden conventional boxes.

Medina and Garcia (2005), described that the preferred method of packaging was to place the fruit vertically on the base, and then to place dividers between the fruits to prevent rubbing and movement. With come cartons, this was not possible and fruits were laid horizontally in alternating directions, where two layers of fruits were packed, a layer of card was required between the layers. Fruits were normally packed to a net weight of 10 to 15 kg (22 to 33lb) depending on the carton and the market. High value small pineapples may be shipped in some instances at 6 kg (13 lb), whereas the large fruit in some cases maybe packed upto 20 kg (45 lb.). A full telescopic two piece fibreboard carton with internal dividers between the fruits bursting strength 275 lb/in2. Top and bottom ventilation, in addition to side vents were required, particularly where sea-shipments in break bulk were used. Where staples were used in carton construction, care was taken to ensure complete staples closure to prevent fruit damage.

Deka *et al.* (2008), researched on developing a packaging system for distant transportation of ‘Kew’ pineapple (*Ananas comosus*). Different packaging systems (3 corrugated fibre board boxes and one each of bamboo and wooden box) were designed and developed and their suitability was assessed for distant transportation of pineapple by truck. Corrugated fibre board boxes type II were found better over other packaging systems as not a single corrugated fibre board boxes were damaged during transportation. The highest postharvest loss of 14.05% (bruising + decay) during transportation was observed in bamboo boxes while the lowest (4.16%) was recorded in CFB type II boxes.

Packaging is defined as a techno-economic means for minimizing cost of delivery and maximizing the sales. In other words it is a means of ensuring safe delivery to the consumers in sound condition and at an affordable cost. Packaging has gained importance only in recent years. Packaging industry has made excellent strides to develop more and more varieties of packaging material and packaging machinery. This is mainly due to growth of consumer awareness and willingness to pay for value and hygienic product, growth of export market and innovations in processed foods. Packaging has great role and contribution in right quantity with a right quality. Packaging material can affect the quality of fruit and vegetable product. Hence, suitable packaging material should be selected which would not react or undergo chemical reaction with the processed product. It should protect the flavour and taste and provide protection from environmental hazards (Singh, 2009).

Fresh fruit generally acts as a major source of health regulating nutrients, however, perishable natured fruits have to be maintained for quality with the combined efforts of growers, purchasers, storage authorities and retailers. Rough handlings, lack of sorting and grading, inappropriate packaging, poor pre cooling and inadequate temperature regulation are still common causes of post-harvest loss of fruits and vegetables in developing countries. Pineapple fruits are to be harvested with care to avoid any mechanical injuries. In general, fruits are packed in baskets with bamboo strips or in plastic crates. While packing pineapple fruits, they are arranged in an upside down position, so that the crowns act as cushioning material preventing injuries or bruises. Storage life of fruits can be improved by proper post-harvest handling, removal of damaged parts during sorting and effective temperature modification which can help to maintain quality of produce and minimize storage loss. Apart, another practice of post-harvest loss minimization is conversion of fruits in various edible and marketable processed products (Mirza *et al.*, 2016).

Fruits were packed in baskets woven with bamboo strips. For local markets the fruits were arranged in baskets (each weighing 20 to 25 kg) lined with paddy straw to stand on their stumps. The second layer of the fruits were arranged on top of the crown of the first layer of fruits. For distant markets, fruits were wrapped individually with paddy straw and then packed. For export purpose the pineapples were packed into fibre board or wooden containers. The fruits were placed vertically or horizontally in the containers. The inner space present between the fruits was filled with straw and the inner lining of container had a layer of straw. For long distance transportation, fruits were held at 7°C for 10-20 days (Saloni *et al*., 2017).

2.2.3. Impact of transportation on quality and marketability of pineapple

Harvested fruits are placed in trucks or wagons crown side down and up to 3 layers high. It is important to avoid fruit over heating either in the field as well as during transport and handling. Road transport by truck/ lorries is the most popular mode of transport due to easy approach from orchard to the market.

Fruits produced in an organic system usually have higher value in large markets, attending commercial niches that pay more depending on the quality of the product. To serve these markets, after harvest fruits should be packed into cardboard boxes that increase protection and reduce the risk of fruit losses during transport from the production area to the consumer centre ensuring adequate fruit quality (Anon., 2016).

Hossain (2016) studied on transport of pineapples for export. He concluded that product stacking will depend on the type and size of container and must be carefully planned to minimize physical damage. Fruits with crown were kept without damage for 10-15 days after harvesting. When fruits are transported for long distances or for a period of several days, refrigerated transport is required to slow down the ripening process. Pineapples can be stored well for a period of 20 days when refrigerated at 10-13 °C. The best storage is at 7.20 °C and 80 or 90% relative humidity.

The growers usually dispose off their produce at the farm gate to the middle man. Majority of the cultivators sell their crop either through trade agents at village level or commission agents at the market (Saloni *et al*., 2017).

CHAPTER III

MATERIALS AND METHODS

MATERIALS AND METHODS

The present investigation entitled "**Development of value chain of organic pineapple (*Ananas comosus*) from Nagaland"** was carried out at Molvom village also known as "Pineapple village" under Medziphema block, Dimapur district. Methodologies followed and materials used in the present study are summarized below.

3.1. General information:

3.1.1: Location

The experimental site is located at Molvom village, Medziphema under Dimapur district. The geo-coordinates of Molvom village is $20^0$45'45''N latitude and $93^0$53'04'' E longitude at an elevation of 360 meters above mean sea level (msl).

3.1.2: Climatic condition

The experimental farm lies in humid sub-tropical zone having an annual rainfall ranging from 2000 to 2500 mm per annum. The mean temperature ranges from 21° to 32° C in summer and 8° to 21°C in winter. However, the temperature fluctuates during the night time (Table 1).

3.2. Pre harvest treatments to enhance post harvest life

The experiment was conducted in an established pineapple field at Molvom village about 5 km away from Medziphema. The study site was selected after a thorough inspection where a block of 30 x 20m^2 consisting of healthy pineapples to carry out the experiment. The block was thoroughly cleaned and hand weeding was done before setting out the experiment. Twenty (20) fruits were selected for each replication.

Table 1: Meteorological observations during the period of investigation (March to September 2014 and March to September 2016) at Molvom village, Nagaland

Month	2014					2016				
	Temperature (°C)		Relative Humidity (%)		Rainfall (cm)	Temperature (°C)		Relative Humidity (%)		Rainfall (cm)
	Maximum	Minimum	Maximum	Minimum		Maximum	Minimum	Maximum	Minimum	
March	29.90	14.00	77.00	17.00	33.90	31.30	14.40	89.00	44.00	34.00
April	32.50	18.20	72.00	23.00	41.20	32.60	20.00	84.00	51.00	108.50
May	32.40	22.00	76.00	41.00	137.60	31.60	21.30	90.00	63.00	214.80
June	33.00	24.80	81.00	55.00	114.50	33.50	24.80	89.00	68.00	203.00
July	32.00	25.40	83.00	62.00	311.50	32.30	24.60	92.00	72.00	264.20
August	31.10	25.20	83.00	63.00	269.90	34.00	24.40	92.00	69.00	398.90
September	30.80	24.10	85.00	60.00	149.50	32.50	23.90	94.00	73.00	283.70

Source**:** ICAR meteorological observatory, Nagaland centre, Jharnapani

Plate 1: Experimental plot at Molvom village

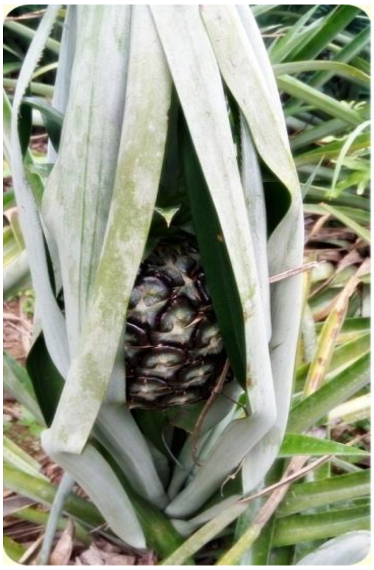
3.2.1. Technical details:

Various pre harvest treatments were employed where, the pineapple fruits were covered with its own leaves, paddy straws, nets, clothes and kaolin spray @ 24 kg/acre as a means of sunburn protection. Twenty fruits were selected for each replication, thereby a total of one hundred fruits per treatment were taken for experiment.

Experimental design	RBD (Randomised Block Design)
Number of treatments	6
Number of replications	5

Treatment details:

T_1 (Covering with own leaves):	The leaves from the base of the plant were raised and were firmly tied covering the top of fruit with the help of a plastic rope.
T_2 (Covering with straw):	Paddy straws were collected and were gently placed around the fruits.
T_3 (Coating with Kaolin):	Kaolin 5% with some detergent (as a source of adherent) was sprayed on the fruits with the help of a knapsack sprayer.
T_4 (Covering with net):	Green color nets were used to cover the top of marked plot.
T_5 (Covering with cloths):	Used cloths were placed above the pineapple plants in the marked plot.
T_6 (Open Condition):	The fruits were not given any protection.



T_1: Covering with own leaves

T_4: Covering with net

T_2: Covering with straw

T_5: Covering with cloth

T_3: Coating with kaolin (5%)

T_6: Open condition

Plate 2: Pre harvest treatments for sunburn protection

Treatment randomization:

Treatments	R_1	R_2	R_3	R_4	R_5
T_1= Covering with own leaves	T_1R_1	T_1R_2	T_1R_3	T_1R_4	T_1R_5
T_2= Covering with straw	T_2R_1	T_2R_2	T_2R_3	T_2R_4	T_2R_5
T_3= Coating with kaolin (5%)	T_3R_1	T_3R_2	T_3R_3	T_3R_4	T_3R_5
T_4= Covering with net	T_4R_1	T_4R_2	T_4R_3	T_4R_4	T_4R_5
T_5= Covering with cloths	T_5R_1	T_5R_2	T_5R_3	T_5R_4	T_5R_5
T_6= Open condition	T_6R_1	T_6R_2	T_6R_3	T_6R_4	T_6R_5

3.2.2: Physico-chemical parameters of fruits:

3.2.2.1. Size of fruit

The length and breadth of the fruits were measured using a vernier caliper and expressed in cm.

3.2.2.2. Weight of fruit with crown

The weight of individual fruit was measured with crown and with the help of a digital weighing balance (Sumo Model, ED) and expressed in kilograms.

3.2.2.3. Weight of fruit without crown

The crown of the fruit was removed and weight of fruit was measured with the help of a digital weighing balance (Sumo Model, ED) and expressed in kilograms.

3.2.2.4. Volume of fruit

The volume of the fruits were determined by water displacement method and expressed in cm^3.

3.2.2.5. Peel, flesh and core weight

The weight of peel, flesh and core of individual fruit was measured with the help of a digital weighing balance (Sumo Model, ED), and was recorded in terms of gram.

3.2.2.6. Physiological Loss in Weight (PLW)

The weight of the fruits was measured on each date of observation (*i.e.* 4, 8 and 12 DAH) using a digital weighing balance and the weight was expressed in terms of grams. The PLW of the fruits were estimated by subtracting the weight of the fruits on different dates of observation from the initial weight of the fruits and expressed in percentage using this formula,

$$PLW\ (\%) = \frac{Initial\ weight - final\ weight}{Initial\ weight}\ x\ 100$$

3.2.2.7. Juice content

100 g of fruit pulp was taken and the juice was extracted using a muslin cloth. The juice was then measured in a graduated measuring cylinder and represented in percentage (%).

3.2.2.8. TSS (Total Soluble Solids)

The TSS content of the juice was determined with the help of ERMA Hand Refractometer, calibrated at 20 ^{o}C temperature, and the results were represented as ^{o}Brix.

3.2.2.9. Total and reducing sugar

Total and reducing sugar of fruits was estimated by titrating the juice against Fehling A and Fehling B reagents using Methylene blue as an indicator following the method of Lane and Enyon, (Ranganna, 2008). The results obtained were presented in terms of percentage.

3.2.2.10. Non-reducing sugar

The non-reducing sugar content of fruits were calculated by using the following formula and represented as percentage:

Non-reducing sugar (%) = (Total sugar-Reducing sugar) x 0.95

3.2.2.11. Titratable Acidity

Titratable acidity was determined by titrating the dilute fruit juice against 0.1 N NaOH solution using Phenolpthalein as indicator and the result was expressed in percentage.

3.2.2.12. Ascorbic acid content

Ascorbic acid content was estimated by using 2, 6 dichlorophenol indophenol dye by titration method as suggested by Sadasivan and Manikam (1992). The results thus obtained were represented as mg/100g of pulp.

3.2.3. Sun burn

The number of fruits that had been sunburned were counted and was estimated by using the formula,

$$\text{Sun burn (\%)} = \frac{Number\ of\ sunburned\ fruits}{Total\ number\ of\ fruits}\ x\ 100$$

3.3: Impact of harvesting stages and packaging on quality of pineapple for distant market

The fruits were harvested at four different harvesting stages from the farm located at Molvom village, Nagaland. Five fruits per treatment per replications were taken to the SASRD laboratory for further analysis *i.e.* before transport.

Another eight fruits per treatment (different harvesting stages) per replication were packed in four different types of packaging boxes *i.e.* wooden boxes, bamboo boxes, CFB boxes and used carton boxes. These boxes were then transported to Dimapur railway station via local transportation (Tata mobile vehicle). Later it was transported to New Delhi by rail (cargo carrier), which reached Delhi after four days of transit. Then the samples were taken to IARI for physico-chemical analysis (through auto carrier). On reaching the destination, the damaged or decaying fruit from different packaging were collected and taken into account for working out the Post Harvest Loss. The physico-chemical analysis was carried out the next day (5 DAH) and then further analysis was done at 5 days interval (10 DAH). For organoleptic test, the fruit samples were taken to the consumer through an NGO who works in marketing of organic products at Delhi.

3.3.1: Experimental design

The pineapple fruits were harvested at different harvesting stages and packed in different packaging boxes.

Design of experiment	Split plot design
Number of treatments	16
Number of replications	3

3.3.2: Treatment details:

Factor 1: Harvesting Stages: (Observed by visual observation)

H_1: Fully matured but no color development.

H_2: 1/8th color development.

H_3: 1/4th color development.

H_4: ½ color development.

Factor 2: Methods of packaging: (Size- Length=1.5ft, Width= 1ft, Height= 1ft)

P_1: Wooden box.

P_2: Bamboo box.

P_3: CFB (corrugated fibre board box).

P_4: Used carton box.

H_1: Fully matured but no colour development

H_2: 1/8 colour development

H_3: 1/4 colour development

H_4: 1/2 colour development

Plate 3: Different harvesting stages of pineapple

Harvesting at Molvom village

SASRD laboratory

Organoleptic test at SASRD

Plate 4: Analysis at SASRD before transport

P_1: Wooden boxes

P_2: Bamboo boxes

P_3: CFB boxes

P_4: Used carton boxes

Plate 5: Different methods of packaging of pineapple

Plate 6: Harvesting and packaging at Molvom field

Molvom field (loading and packaging)

Dimaur Railway Station

Delhi Railway Station

IARI (Analysis) Lab

Plate 7: Process of transporting fruits from field to New Delhi

3.3.3: Treatment Randomization:

R_1	R_2	R_3
H_1P_1	H_1P_1	H_1P_1
H_1P_2	H_1P_2	H_1P_2
H_1P_3	H_1P_3	H_1P_3
H_1P_4	H_1P_4	H_1P_4
H_2P_1	H_2P_1	H_2P_1
H_2P_2	H_2P_2	H_2P_2
H_2P_3	H_2P_3	H_2P_3
H_2P_4	H_2P_4	H_2P_4
H_3P_1	H_3P_1	H_3P_1
H_3P_2	H_3P_2	H_3P_2
H_3P_3	H_3P_3	H_3P_3
H_3P_4	H_3P_4	H_3P_4
H_4P_1	H_4P_1	H_4P_1
H_4P_2	H_4P_2	H_4P_2
H_4P_3	H_4P_3	H_4P_3
H_4P_4	H_4P_4	H_4P_4

3.3.4. Physico-chemical parameters of fruits:

The physico-chemical analysis such as, Physiological Loss in Weight, juice content, TSS, Total sugar, Reducing sugar, Non-reducing sugar, Titratable Acidity and Ascorbic acid content were carried out following the same procedure as mentioned above in experiment-1.

3.3.5. Organoleptic test

Various parameters like, appearance, aroma, sweetness and fibre content of the fruits were estimated by five different panels. This method was laid out using a five level Hedonic Scale developed by Amarine *et al.* 1965. The test was done at SASRD NU Medziphema before transport and at NGO office at New Delhi after transport. The level of appearance, aroma, sweetness and fibre content were rated at five different levels as mentioned below;

1- Bad, 2- Satisfactory, 3- Good, 4- very good and 5- Excellent.

3.3.6. Shelf life

To study the shelf life of pineapple, three fruits each per treatment per replication were kept at room temperature till the fruit start spoilage, and was expressed in terms of number of days.

3.3.7. Post Harvest Loss

The post harvest loss was estimated by counting the numbers of marketable fruits from each treatment and each replication after the transit. And the numbers of lost or deteriorated fruits were calculated in terms of percentage.

3.3.8. BCR (Benefit Cost Ratio)

BCR, was calculated taking into consideration all the cost incurred for the fruits, packaging, transportation (railway and local), labour etc (as landing cost), on the basis of the number of fruits that were marketable at Delhi after transport and the selling price at Delhi.

Stage of fruits at room temperature to study shelf life

Pineapple fruit at New Delhi after transit

Plate 8: Study of Shelf life and Post Harvest Loss

Organoleptic test at NGO office, New Delhi

Plate 9: Organoleptic test by different panels at New Delhi

3.4. Statistical analysis

The data recorded were subjected to one way analysis of variance (ANOVA) by Randomized Block Design (RBD) in case of experiment-1 while experiment-II was subjected to two way analysis of variance (ANOVA) by Split plot Design (SPD) following the procedure outlined by Gomez and Gomez (1984). Fisher Shedecor 'F' test was used to determine the significance and non-significance of the variance due to different treatments at 5% level of significance.

CHAPTER IV

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

The The results obtained during the course of present investigation on **"Development of value chain of organic pineapple (*Ananas comosus*) from Nagaland"** are presented and discussed with the relevant works of other researchers in this chapter under the following heads.

4.1. Effect of pre-harvest treatments on physico-chemical parameters

Under this experiment, a study was carried out during the year 2014 to 2016 in an established pineapple field at Molvom village that was being grown organically to study the effect of pre harvest treatments to improve the post harvest quality of the fruit. Six pre harvest treatments such as covering with own leaves (T_1), covering with straw (T_2), coating with Kaolin (T_3), covering with net (T_4), covering with cloth (T_5) and open condition (T_6) *i.e.* without any protection were given at the time of fruit maturity to see their effect on the physico-chemical parameters of the fruits. The findings of the present observation are described below and the data recorded are presented from Table 2 to 6 and Fig. 1 to Fig. 6.

4.1.1. *Size of fruit (cm^2)*

The results obtained on fruit size as depicted in Table 2 and Fig. 1 revealed that there was a significant difference among the treatments. The maximum fruit size was found under T_2 (Covering with straw) recording 145.88 and 141.60 cm^2 followed by the treatment with Kaolin (T_3) that recorded 138.50 and 137.90 cm^2 in both the years of observation with a mean of 143.74 cm^2 and 138.20 cm^2 , respectively. The minimum fruit size was recorded under Open condition (T_6) with 128.12 and 123.86 cm^2 during 2014 and 2016, respectively as a value mean of 125.99 cm^2. Ortiz and Barrows (2005) stated that there was an overall shift from smaller size fruit to larger size fruit through the use of surround and reducing fruit waste. Mupambi *et al*. (2018) from the experiment on apple, expressed that in some regions where trees or plants regularly experience abiotic stress due to excessive solar radiation, netting may have a positive effect on fruit size by maintaining higher photosynthetic rates especially when compared to trees or plants in full sun that may be experiencing photoinhibition. Yang and Huang (2009) reported that bagging promoted longan fruit development resulting in larger sized fruit with good circumference.

4.1.2. *Weight of fruit with crown (kg)*

The data pertaining to the weight of fruit with crown is represented in Table 2, which indicated that there was no significant difference among various treatments. However, the weight of fruit with crown was maximum under T_3 (Kaolin coating) with 1.34 and 1.37 kg during 2014 and 2016, respectively with mean value of 1.36 kg followed by T_2 treatment with 1.33 and 1.35kg during 2014 and 2016, respectively. The minimum value was recorded in the treatment T_6 (Open condition) with 1.17 and 1.16 kg during 2014 and 2016, respectively with mean value of 1.17 kg. Prabha *et al*. (2018) from their experiment on pineapple reported that fruit length with crown was found maximum (24.43 cm) in T_2 (Paper bag) and minimum (15.80 cm) in control. They opined that paper bag, straw and hay are thermo insulators which provide better environment as they resist heat, lowers the temperature than the outer environment that stimulates better development and growth which might have increased the weight of the fruit.

4.1.3. *Weight of fruit without crown (kg)*

The data recorded in the present investigation indicated that there was no significant difference in the weight of fruit without crown among various treatments (Table 2). However, the weight of fruit without crown was recorded maximum under T_3 (Kaolin coating) *i.e*. 1.12 and 1.18 kg during 2014 and 2016 respectively with mean as 1.15 kg. This was followed by T_2 with 1.11 and 1.08 during 2014 and 2016, respectively whereas, the weight of

Table 2: Effect of various treatments on fruit size, weight of fruit with crown and weight of fruit without crown of organic pineapple

Treatments	Size of fruit (cm^2)			Weight of fruit with crown (kg)			Weight of fruit without crown (kg)		
	2014	**2016**	**Pooled**	**2014**	**2016**	**Pooled**	**2014**	**2016**	**Pooled**
Covering with own leaves: (T_1)	136.16	137.28	136.72	1.24	1.30	1.27	1.00	1.02	1.01
Covering with straw: (T_2)	145.88	141.60	143.74	1.33	1.35	1.34	1.11	1.08	1.10
Coating with kaolin: (T_3)	138.50	137.90	138.20	1.34	1.37	1.36	1.12	1.18	1.15
Covering with net : (T_4)	134.16	133.23	133.70	1.23	1.25	1.24	0.99	0.93	0.96
Covering with cloth: (T_5)	130.76	126.96	128.86	1.19	1.20	1.20	0.94	0.92	0.93
Open condition: (T_6)	128.12	123.86	125.99	1.17	1.16	1.17	0.97	0.91	0.94
Sem±	2.95	2.92	2.08	0.08	0.07	0.05	0.08	0.07	0.05
CD (P= 0.05)	8.71	8.62	5.94	NS	NS	NS	NS	NS	NS

Note: **NS = Non significant at 5% level of significance**

fruits without crown was recorded minimum *i.e*. 0.97 and 0.91 kg during 2014 and 2016 respectively with mean as 0.94 kg under treatment T_6 (Open condition). Prabha *et al*. (2018) observed from the experiment on pineapple cv. Mauritius that the highest (677.89 g) fruit weight without crown was recorded in paper bag whereas lowest (462.03g) was recorded in transparent polythene bag.

4.1.4. *Volume of fruit (cm^3)*

The results obtained on the volume of fruit revealed that there was a non-significant difference among the treatments (Table 3). However, the maximum volume of fruit (852.00 and 855.00 cm^3) was recorded under T_3 (Kaolin coating) during 2014 and 2016 respectively with mean of 853.50 cm^3 followed by 830.00 and 827.00 cm^3 under T_2 treatment respectively during 2014 and 2016. The minimum volume of fruit *i.e*. 765.00 and 734.40 cm^3 was recorded under treatment T_6 (Open condition) in both the years of observation with mean as 738.70 cm^3. Prabha *et al.* (2018) found out that the maximum fruit circumference was found in paper bag treatment which was at par with black polythene bag and minimum fruit circumference was observed in control. They expressed that paper bag are thermo insulator thus it resist the heat and maintain the microclimate in which transverse division take place.

4.1.5. *Weight of peel (g)*

The data pertaining to the weight of peel represented in Table 3, showed no significant difference among the various treatments. The weight of peel was recorded maximum *i.e*. 274.40 and 272.00 g under T_2 (Covering with straw) during 2014 and 2016 respectively with mean as 273.20 g followed by T_3 with 265.20 and 262.80 g during 2014 and 2016, whereas, the minimum weight of peel *i.e.* 212.40 and 218.80g was recorded in the treatment T_6 (Open condition) during 2014 and 2016 respectively with mean as 215.60 g. These results are in conformity with the result obtained by Ennab *et al.* (2017), where spraying kaolin at 4% in balady mandarine gave the highest value of fruit peel thickness.

4.1.6. *Weight of Flesh (g)*

The results obtained on the flesh weight of fruit revealed that there was no significant difference among the treatments (Table 3). The maximum weight of flesh *i.e*. 725.20 and 789.80 g was found under T_3 (Kaolin coating) during 2014 and 2016 respectively with mean as 757.50 g followed by T_2 (Covering with straw) with 707.40 and 678.20 during 201 and 2017 respectively. Among the treatments, minimum flesh weight of fruit *i.e*. 593.00 was found under T_5 (Covering with cloth) during 2014 and 523.60 g was recorded under treatment T_6 (Open condition) during 2016.

4.1.7. *Weight of Core (g)*

Core weight of fruit did not show any significant difference among the treatments (Table 3). However, the maximum weight of core *i.e*. 130.60 and 129.60 g was recorded under T_2 (Covering with straw) during 2014 and 2016 respectively with mean as 130.10 g followed by T_3 with 126.80 and 128.00 during 2014 and 2016 respectively. The minimum weight of core *i.e*. 117.20 and 115.40 g was recorded in the treatment T_6 (Open condition) during 2014 and 2016 respectively with mean value of 121.30 g.

4.1.8. *Physiological Loss in Weight (PLW)*

From the data depicted in Table 4, Fig. 2, it was evident that the PLW was significantly influenced by different treatments on all dates of observation *i.e*. 4^{th}, 8^{th} and 12 DAH in both the years. It was evident that the highest PLW (8.65%) was recorded in T_6 (Open condition) and lowest (5.87%) in T_2 (Covering with straw) in both the years throughout the different dates of observation. Further scanning of the data showed that the increase in PLW was maximum on 8^{th} DAH. Bhushan *et al.* (2015), from their experiment on mango cv. Amrapali using different treatments recorded highest PLW in control (water spray) and lowest PLW with black LDPE mulching, which is in conformity with the present finding. They opined that the PLW of ripe fruits

Table 3: Effect of various treatments on volume of fruit, weight of peel, flesh weight of fruit and core weight of fruit of organic pineapple

Treatments	Volume of fruit (cm^3)			Weight of peel (g)			Weight of flesh (g)			Weight of core (g)		
	2014	**2016**	**Pooled**	**2014**	**2016**	**Pooled**	**2014**	**2016**	**Pooled**	**2014**	**2016**	**Pooled**
Covering with own leaves: (T_1)	820.00	822.00	821.00	264.40	262.60	263.50	608.20	624.60	616.40	126.60	127.80	127.20
Covering with straw: (T_2)	830.00	827.00	828.50	274.40	272.00	273.20	707.40	678.20	692.80	130.60	129.60	130.10
Coating with kaolin: (T_3)	852.00	855.00	853.50	265.20	262.80	264.00	725.20	789.80	757.50	126.80	128.00	127.40
Covering with net : (T_4)	782.00	780.00	781.00	240.40	238.00	239.20	628.40	567.40	597.90	125.40	125.00	125.20
Covering with cloth: (T_5)	765.00	762.00	763.50	227.20	225.20	226.20	593.00	554.40	573.70	121.60	121.00	121.30
Open condition: (T_6)	743.00	734.40	738.70	212.40	218.80	215.60	593.80	523.60	558.70	117.20	115.40	116.30
Sem±	68.49	47.14	41.57	18.44	18.51	13.06	76.16	71.67	52.29	6.90	6.48	4.73
CD (P= 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: **NS = Non significant at 5% level of significance**

Table 4: Effect of various treatments on Physiological Loss in Weight of organic pineapple

Treatments	Physiological Loss in Weight (%)								
	4 DAH			8 DAH			12 DAH		
	2014	**2016**	**Pooled**	**2014**	**2016**	**Pooled**	**2014**	**2016**	**Pooled**
Covering with own leaves: (T_1)	2.51	2.41	2.46	5.20	4.71	4.95	7.87	6.65	7.26
Covering with straw: (T_2)	2.16	2.35	2.25	4.31	4.54	4.43	6.93	4.80	5.87
Coating with kaolin: (T_3)	2.90	2.10	2.50	6.64	4.33	5.48	9.79	7.18	8.49
Covering with net : (T_4)	3.27	2.00	2.64	5.57	4.69	5.13	7.88	6.19	7.03
Covering with cloth: (T_5)	2.59	2.20	2.39	5.29	3.88	4.58	7.51	5.56	6.54
Open condition: (T_6)	2.96	2.51	2.74	6.83	4.84	5.84	9.95	7.34	8.65
Sem±	0.23	0.11	0.13	0.24	0.20	0.15	0.48	0.44	0.33
CD (P= 0.05)	0.69	0.33	0.37	0.70	0.58	0.44	1.42	1.31	0.94

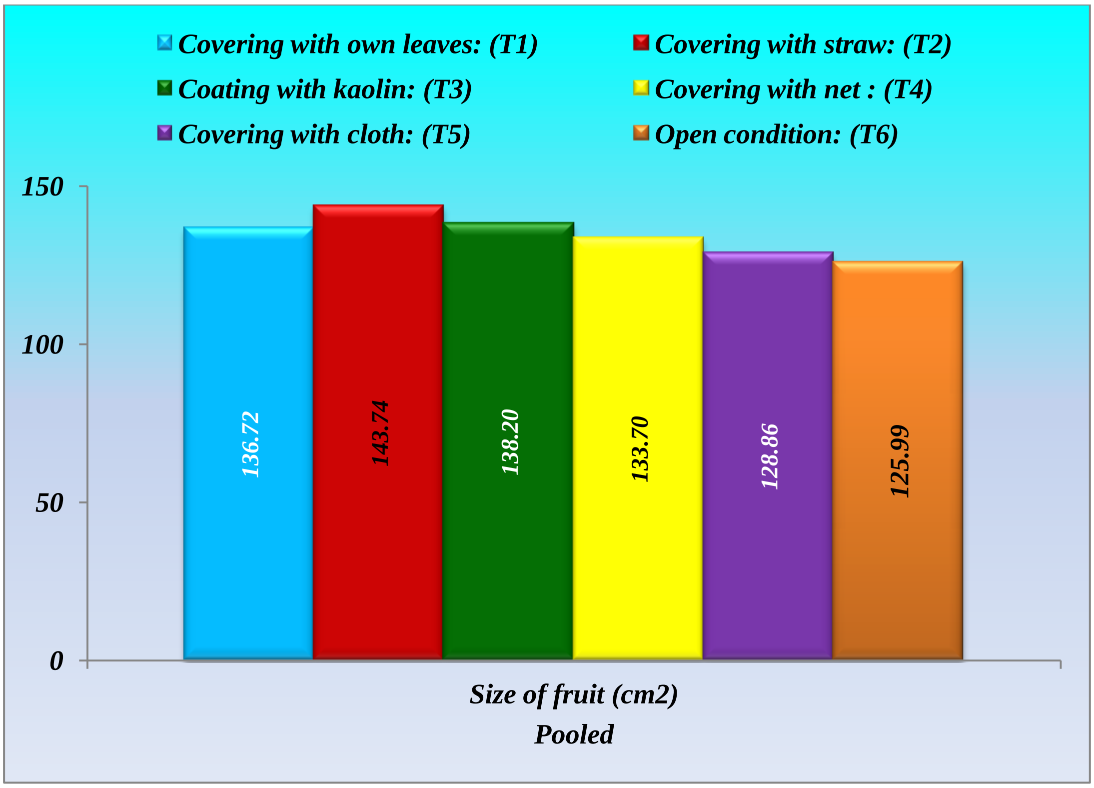


Figure 1: Effect of various treatments on fruit size of organic pineapple

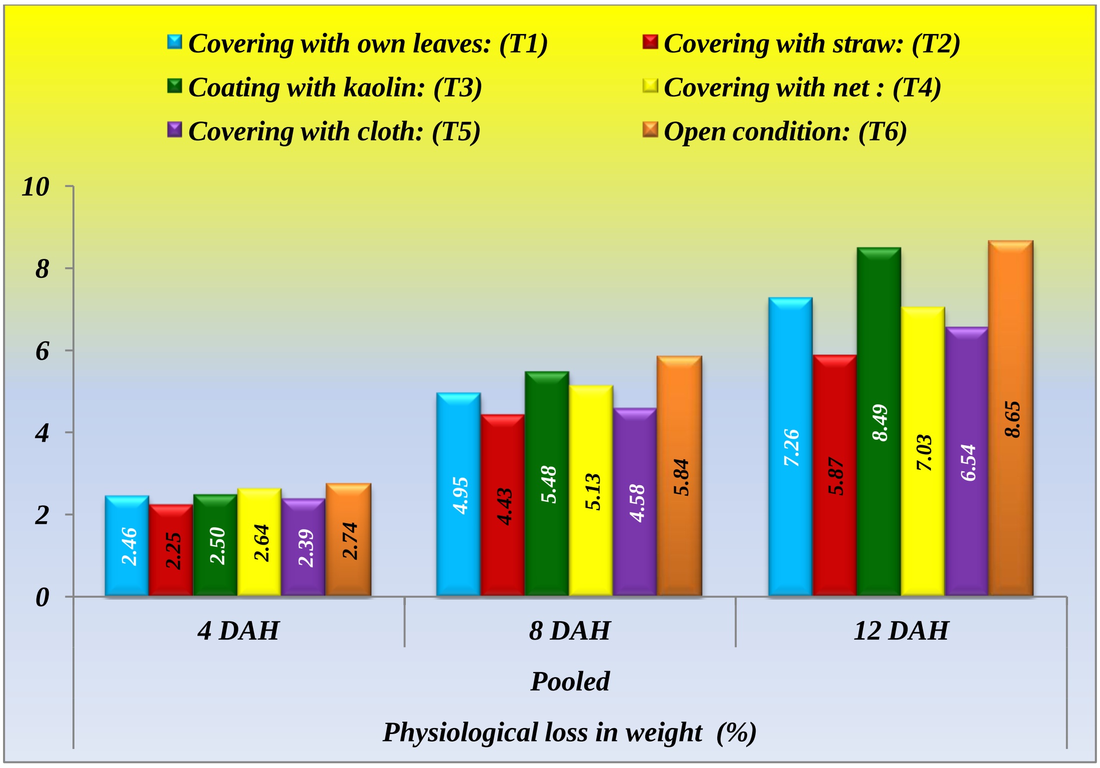


Figure 2: Effect of various treatments on Physiological Loss in Weight of organic pineapple

represents its freshness and quality thus influencing its marketability.

4.1.9. ***Juice content (%)***

The results obtained from Table 5, Fig. 3 revealed that there was a significant difference among the treatments in juice content. It was apparent from the data that the maximum juice content were recorded in T_2 (Covering with straw) and T_3 (Kaolin coating) with 67.20 and 69.00 % during 2014 and 2016 with the mean value of 67.40 and 66.50 ml respectively. Minimum juice content *i.e.* 50.60 and 53.80% was recorded under T_6 (Open condition) treatment during 2014 and 2016 respectively with mean value of 52.20%. Enabb *et al.* (2017) also recorded lower juice content in control (spray with tap water only) and highest juice content was observed in T_7 (spraying kaolin @ 4%) in mandarin fruit which was similar to the present findings.

4.1.10. ***Total Soluble Solids (^{o}Brix)***

The data represented in Table 5, Fig. 4 in terms of TSS content revealed that there was a significant difference among the treatments. The maximum TSS *i.e.* 16.60 and 17.20 ^{o}Brix was found under T_2 (Covering with straw) during 2014 and 2016 respectively with mean as 16.90 ^{o}Brix which was followed by T_3 (16.00 and 15.50) during 2014 and 2016 respectively with a mean value of 15.75, while the minimum was recorded under the treatment T_6 (open condition) with 12.60 and 13.20 ^{o}Brix during 2014 and 2016 respectively. Similar results were also obtained by Chen and Paull (2001) in pineapple, where maximum TSS (13.2 ^{o}Brix) was observed in shaded fruit and minimum (11.9 ^{o}Brix) in exposed fruit.

4.1.11. ***Total sugar (%)***

The experimental results pertaining to total sugar percentage showed that there was a significant difference among the treatments (Table 5). The maximum Total sugar percentage *i.e.* 8.46 and 9.96% was found under T_2 (Covering with straw) during 2014 and 2016 respectively with a mean value of 9.21%, which was followed by T_3 (Kaolin spray) (6.81 and 8.10%) during

2014 and 2016 respectively, and the minimum Total sugar percentage of 6.16 and 6.72% was recorded under treatment T_6 (Open condition) during 2014 and 2016 respectively with mean of 6.44%. Singh *et al.* (2007) also reported from the experiment in guava that total sugar increased after bagging. Prabha *et al.* (2018) reported similar findings in pineapple cv. Mauritius where in they observed lowest total sugar in control and highest in paper bag. Providing a cover can affect many properties which enhances the quality as it creates a microclimate in which temperature raise but not so simultaneously as it ensures the temperature raising slowly which effect the fruit in a beneficial way by improving the aroma and total sugar. This can be justified by several research (Zhou & Guo, 2005, Meena & Maji 2016, Watanawan *et al*., 2008) in grapes, guava and mango.

4.1.12. *Reducing sugar (%)*

The data indicated that there was a significant difference on the reducing sugar percentage among various treatments (Table 5). The maximum reducing sugar percentage was recorded in T_2 (Covering with straw) and T_5 (Covering with cloth) with 4.21 and 4.15% during 2014 and 2016 respectively with a mean value of 4.16% in both the treatments. Minimum reducing sugar percentage was found in T_6 (Open condition) with 3.23 and 3.17% during 2014 and 2016 respectively with the mean value of 3.20%. Dutta and Majumdar (2012) reported similar findings where reducing sugar was maximum when mango fruits were bagged rather than exposed. Temperature and solar radiation are the environmental variables which mainly give variation in sugar accumulations. It also effects the rate of respiration and helps in steady control, (Prabha *et al*., 2018). Zhou and Gou, (2005) found increase in soluble sugar in grapes after bagging. Meena and Maji (2016) also revealed the same result after bagging of guava.

Table 5: Effect of various treatments on Juice content, Total Soluble Solid, Total sugar and Reducing sugar of organic pineapple

Treatments	Juice content (ml)			Total Soluble Solids (^{o}Brix)			Total sugar (%)			Reducing sugar (%)		
	2014	**2016**	**Pooled**	**2014**	**2016**	**Pooled**	**2014**	**2016**	**Pooled**	**2014**	**2016**	**Pooled**
Covering with own leaves: (T_1)	54.20	55.40	54.80	13.40	15.20	14.30	6.78	8.10	7.44	3.90	4.03	3.97
Covering with straw: (T_2)	67.20	67.60	67.40	16.60	17.20	16.90	8.46	9.96	9.21	4.21	4.10	4.16
Coating with kaolin: (T_3)	64.00	69.00	66.50	16.00	15.50	15.75	6.81	8.10	7.46	3.78	3.67	3.73
Covering with net: (T_4)	61.20	64.00	62.60	13.40	15.00	14.20	6.33	7.79	7.06	3.41	3.45	3.43
Covering with cloth: (T_5)	56.60	60.40	58.50	13.00	13.60	13.30	6.27	7.48	6.88	4.18	4.15	4.16
Open condition: (T_6)	50.60	53.80	52.20	12.60	13.20	12.90	6.16	6.72	6.44	3.23	3.17	3.20
Sem±	2.14	2.80	1.76	0.87	0.70	0.56	0.46	0.47	0.33	0.18	0.16	0.12
CD (P= 0.05)	6.30	8.26	5.03	2.56	2.05	1.59	1.37	1.38	0.94	0.54	0.48	0.35

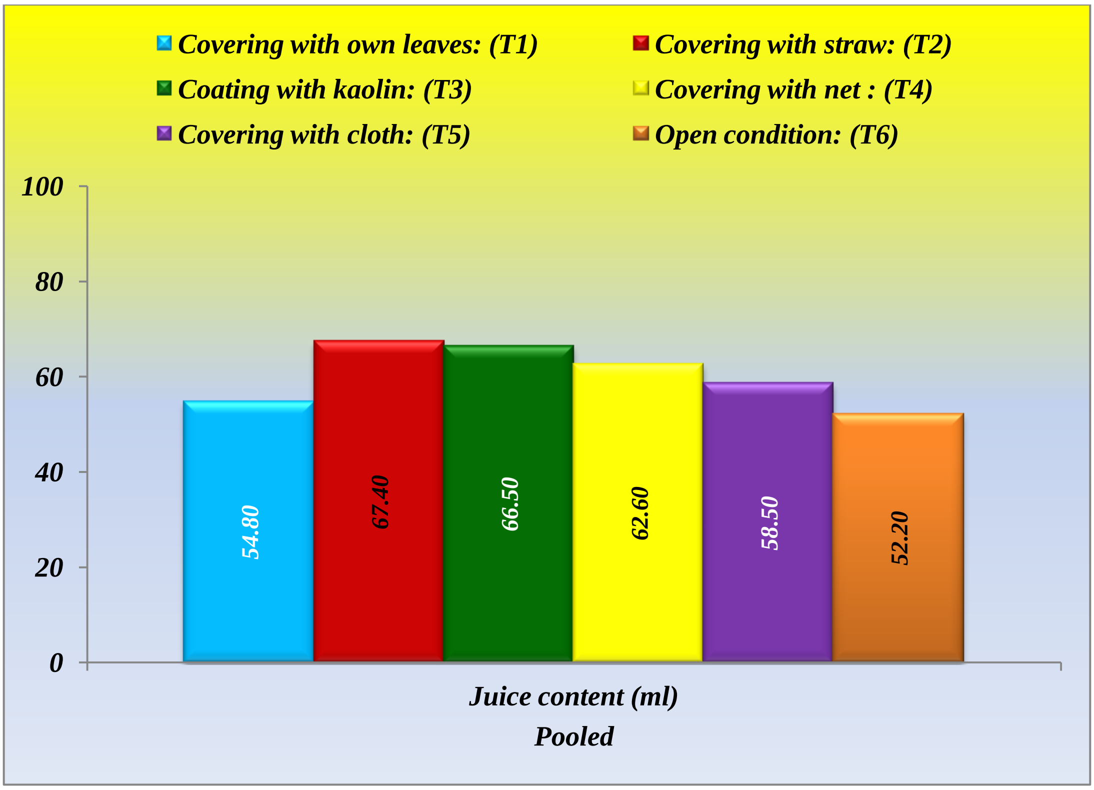


Figure 3: Effect of various treatments on juice content of organic pineapple

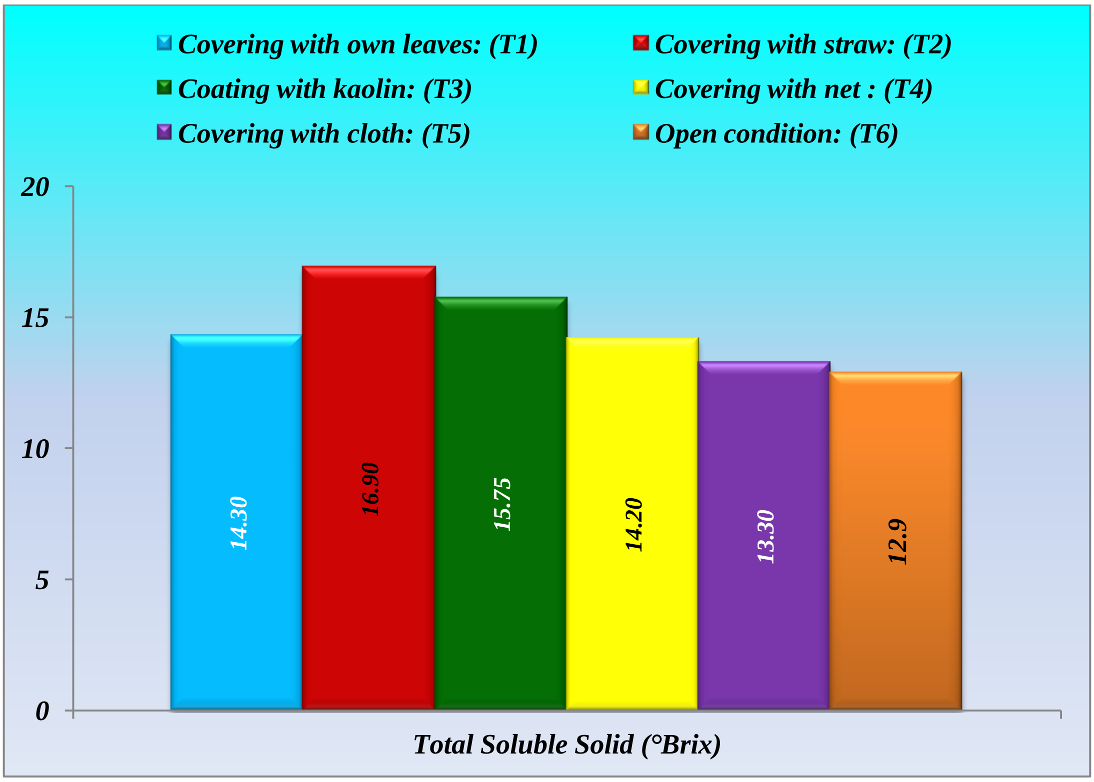


Figure 4: Effect of various treatments on Total Soluble Solid of organic pineapple

4.1.13. ***Non-reducing sugar (%)***

Data from Table 6 showed that the non-reducing sugar percentage was significantly different among various treatments. Non-reducing sugar percentage was recorded maximum *i.e.* 4.25 and 5.87% in T_2 (Covering with straw) during 2014 and 2016 respectively with mean as 5.06% followed by T_3 (3.03 and 4.43%) during 2014 and 2016 respectively. Minimum non-reducing sugar percentage (2.09 and 3.33%) was found in T_5 (Covering with cloth) during 2014 and 2016 respectively with the mean as 2.71%. Abassi *et al.* (2014) reported highest non reducing sugars (3.03%) in fruit covered with perforated polyethylene bags in guava. Effects of bagging in various research works carried out by Zhou and Guo, (2005); Meena and Maji (2016); Watanawan *et al.* (2008) in grapes, guava and mango were similar to the present findings. There is improvement of non reducing sugar after bagging because it might control the temperature and the light with various wavelength which is one of the environmental factor of ripening and maturation, (Prabha *et al*., 2018).

4.1.14. ***Titratable acidity (%)***

The result obtained on titratable acidity percentage revealed that there was a significant difference among the treatments (Table 6 & Fig. 5). Maximum (0.50 and 0.52%) titratable acidity was found in T_1 (Covering with own leaves) during 2014 and 2016 respectively with mean of 0.51%. Among the treatments, minimum titratable acidity percentage of 0.30 and 0.32% were recorded in treatment T_5 (Covering with cloth) during 2014 and 2016 respectively with mean value as 0.31%. Higher titratable acidity was recorded under shaded fruits as compared to the exposed ones (Chen & Paull, 2001). Prabha *et al.* (2018) also reported that acidity was maximum in control and minimum in covered fruits. In many other researches also, it was reported that acidity is affected by bagging. Singh *et al.* (2007) reported higher acidity in unbagged fruits and attributed to the fact that bagging delays the ripening

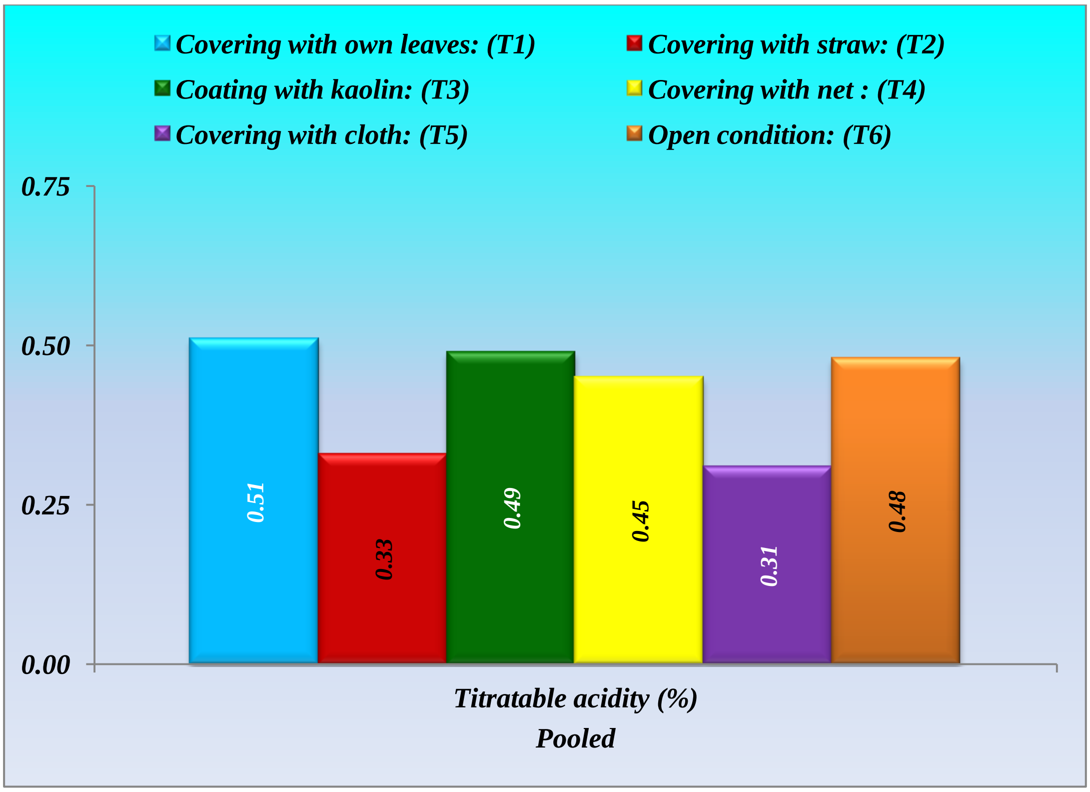


Figure 5: Effect of various treatments on titratable acidity of organic pineapple

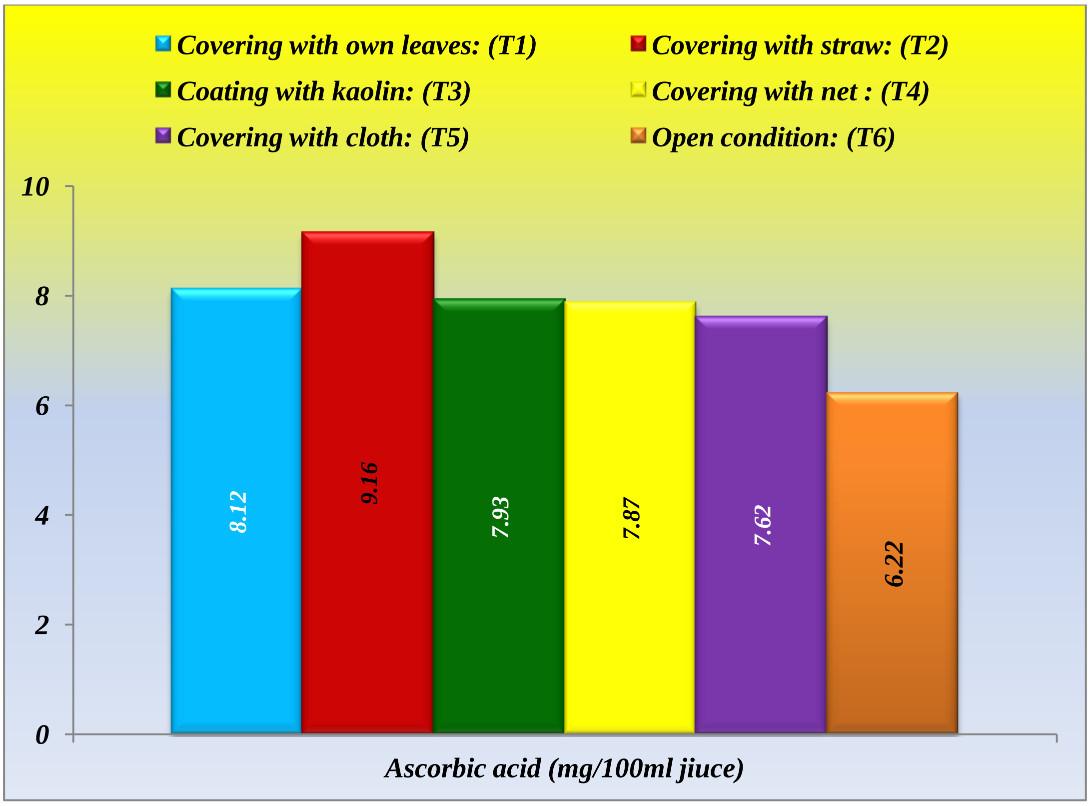


Figure 6: Effect of various treatments on ascorbic acid of organic pineapple

process and transpiration features thus resulting in fruit producing less titratable acid.

4.1.15. *Ascorbic Acid (mg/100ml juice)*

Data from Table 6 and Fig. 6 showed that Ascorbic Acid content was significantly different among various treatments during 2014 and 2016 with a maximum of 9.84 and 8.47 mg/100ml juice in T_2 (Covering with straw) followed by T_1 (Covering with own leaves) with 9.05% during 2014 and T_3 (Kaolin spray) with 8.47% during 2016. Minimum (5.62 and 6.82 mg/100ml) value was recorded in T_6 (Open condition) with a mean of 6.22 mg/100ml. Ennab *et al.* (2017) observed that acidity was slightly increased by kaolin treatments without significant differences among them as compared to control in both seasons. Spraying kaolin at different concentrations significantly increase vitamin C comparing with the control in both seasons. Similar results were obtained by Gindaba and Wand (2007) and Chabbal *et al.* (2014). Vitamin C of fruits were significantly improved under all types of bagging (Lal & Sahu, 2017).

4.1.16. Sun burn (%)

The data in Table 6 and Fig. 7, pertaining to sun burn percentage was found to be significantly different among various treatments during 2014 and 2016 with a maximum of 20.00 and 28.00 % under T_6 (Open condition) with mean of 24.00%. While, minimum was observed in treatment T_2 (Covering with straw) with 4.00 and 4.00% during 2014 and 2016 respectively with mean of 4.00 % which was followed by T_1 (Covering with own leaves) and T_5 (Covering with cloth) with 8.00% and 12.00% during 2014 and 2016 respectively. According to Ennab *et al.* (2017) spraying kaolin at 3 and 4 % three times in summer months had a positive effect on preventing fruit sun burn damage and improved yield and fruit quality of Balady mandarin trees.

Therefore, it was apparent from the present findings that covering with straw (T_2) during the maturity of the fruit can be the best option as pre harvest

Table 6: Effect of various treatments on Non reducing sugar, Titratable acidity, Ascorbic acid and Sun burn of organic pineapple

Treatments	Non reducing sugar (%)			Titratable acidity (%)			Ascorbic acid (mg/100ml juice)			Sun burn (%)		
	2014	**2016**	**Pooled**	**2014**	**2016**	**Pooled**	**2014**	**2016**	**Pooled**	**2014**	**2016**	**Pooled**
Covering with own leaves: (T_1)	2.88	4.07	3.48	0.50	0.52	0.51	9.05	7.19	8.12	8.00	12.00	10.00
Covering with straw: (T_2)	4.25	5.87	5.06	0.31	0.35	0.33	9.84	8.47	9.16	4.00	4.00	4.00
Coating with kaolin: (T_3)	3.03	4.43	3.73	0.47	0.50	0.49	7.40	8.47	7.93	16.00	20.00	18.00
Covering with net: (T_4)	2.92	4.34	3.63	0.44	0.47	0.45	8.20	7.54	7.87	12.00	12.00	12.00
Covering with cloth: (T_5)	2.09	3.33	2.71	0.30	0.32	0.31	7.81	7.42	7.62	8.00	8.00	8.00
Open condition: (T_6)	2.93	3.55	3.24	0.46	0.51	0.48	5.62	6.82	6.22	20.00	28.00	24.00
Sem±	0.41	0.50	0.32	0.05	0.04	0.03	0.50	0.62	0.40	1.22	1.08	0.81
CD (P= 0.05)	1.21	1.48	0.93	0.13	0.13	0.09	1.47	1.84	1.14	3.59	3.20	2.33

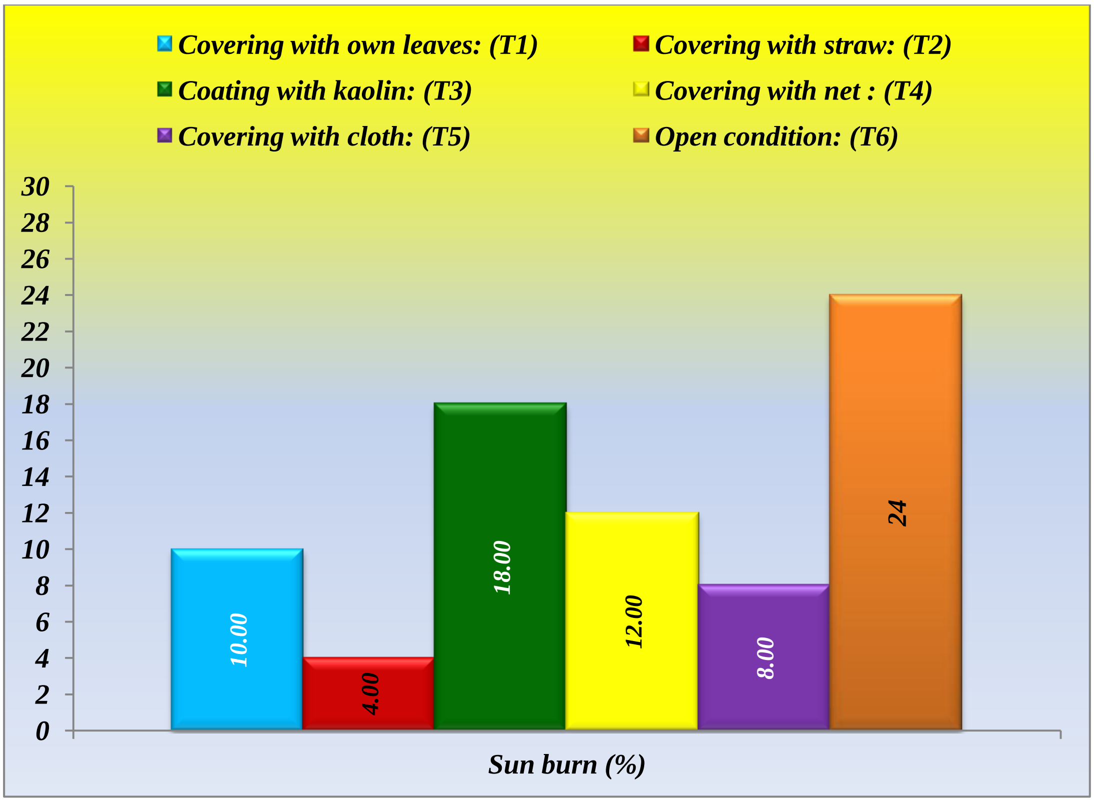


Figure 7: Effect of various treatments on Sun burn of organic pineapple

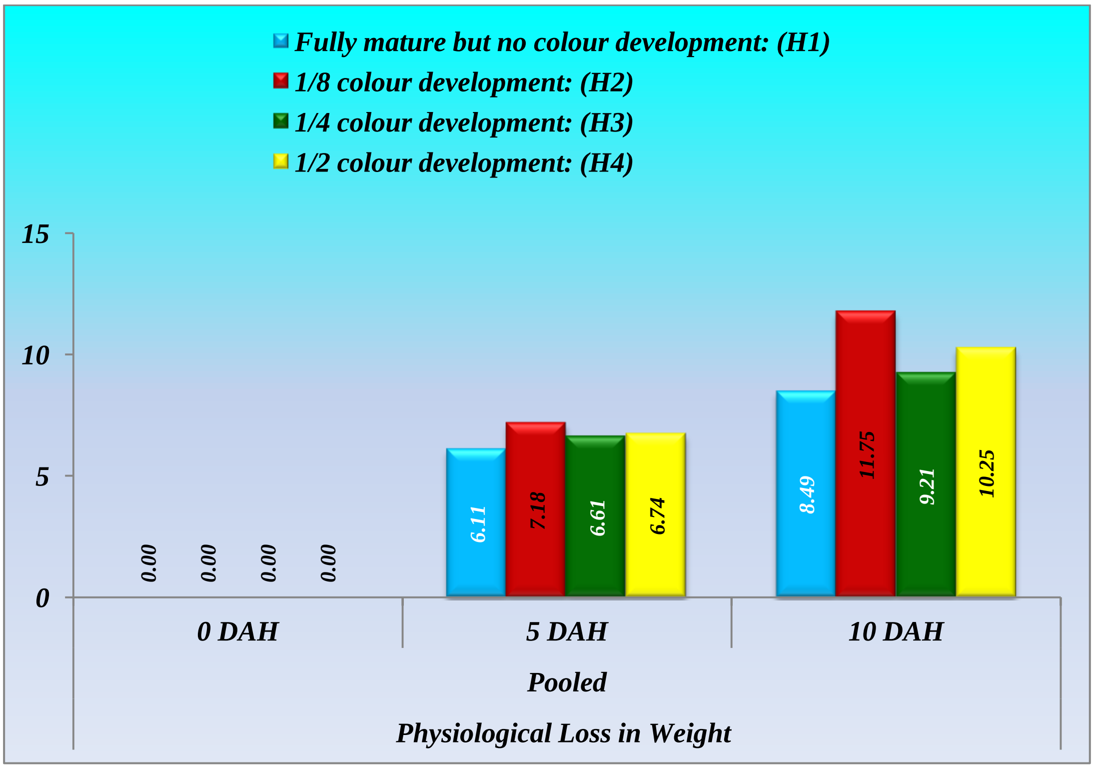


Figure 8: Effect of various harvesting stages on Physiological loss in Weight of organic pineapple before transport

treatment in reducing sun burn in pineapple which is cost effective and easily available for the growers. The present finding is supported by Wunsche *et al*., (2001) who also stated that some of the best known methods for sun burn in pineapple are, covering with its own leaves, covering with straw and kaolin spray. Suryawanshi and Gupta (2015) also suggested that sun exposed portion of the fruit can be covered with dry straw or grass or with any other locally available materials. Grower must follow best management practices to minimise sun burn and grow tolerant cultivars, efficient irrigation, appropriate canopy management, cover or inter cropping, over tree sprinklers, shade netting, fruit bagging, suppressants (Kaolin or calcium carbonate) and chemical protectants (Lal & Sahu, 2017).

Sun burn is a major problem of pineapple and it results when plant leans or falls over to one side, thus exposing one side of the fruit to direct sunlight. Covering of the fruits by own leaves, straw, suppressants, net shade and cloth, are generally used for its protection purpose, which also enhances the colour and aroma. It mainly controls the temperature around the fruit and form favourable micro-climate which help in maturation by synthesis of proper enzymes.

A key issue concerning the cultivation of pineapple in regions with high level of solar radiation can burn the fruit, giving rise to a loss in yield or an increase in production cost (by up to 11.79 %) if the crop has to be protected through the provision of artificial shade (Anon., 2012). However, the use of natural shade provided by a mix culture system represents an accessible and low cost alternative to net shading (Silva *et al*., 2017).

4.2. Impact of harvesting time and packaging on quality of pineapple for distant market

Under this experiment, pineapples were harvested at 4 different stages of maturity during third week of July in the year 2014 and 2016. After harvest, the fruits were brought to the Horticultural laboratory, School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema Campus where physicochemical analysis was carried out at different interval. Another 8 fruits per replication per treatment from four different harvesting stages were kept in four different packaging boxes and transported to IARI, New Delhi by train. After transportation, physico-chemical analyses were carried out in the division of Pomology, IARI. Organoleptic test, Shelf life, Post Harvest Loss (PHL) and Benefit Cost Ratio (BCR) were also studied. The data, thus recorded are presented in Table 7 to 28.

4.2.1. Physico-chemical analysis at SASRD (before transport)

4.2.1.1. *Physiological Loss in Weight (%)*

From the data depicted in Table 7 and Fig. 8, it was evident that the PLW was significantly influenced by different treatments on all dates of observation *i.e.* 5^{th}, and 10 DAH in both the years. Highest PLW (11.75%) was recorded in H_2 (1/8 colour development) and lowest (8.49%) in H_1 (fully matured but no colour development) in both the years throughout the period of observation. Further scanning of the data showed that the increase in PLW was maximum on 5^{th} DAH. Kabir *et al.* (2010) found that the higher weight loss was observed in premature fruits than the optimum mature fruits during the storage period of pineapple.

4.2.1.2. *Juice content (%)*

According to Table 8 and Fig. 9, the maximum juice percentage was obtained in treatment H_4 (1/2 colour development) on all 3 different dates of observation *i.e.* 70.00%, 76.00% and 79.50% respectively. There was a significant increasing trend of juice content with the storage periods. However, on 5^{th} DAH, the increase of juice content was positively significant in all the treatments where, maximum value (9.00) was recorded under H_1 followed by H_2 (8.50) and minimum (4.00) was found under H_3. On the 10^{th} DAH, maximum (13.50 and 13.00) was recorded under the treatments H_2 and

Table 7: Effect of various harvesting stages on Physiological Loss in Weight of organic pineapple before transport

Harvesting stages	Physiological Loss in Weight (%)						
	0 DAH	5 DAH			10 DAH		
		2014	2016	Pooled	2014	2016	Pooled
Fully mature but no colour development: (H_1)	0.00	5.45	6.76	6.11	6.93	10.05	8.49
1/8 colour development: (H_2)	0.00	5.88	8.49	7.18	8.73	14.76	11.75
1/4 colour development: (H_3)	0.00	5.19	8.04	6.61	7.87	10.54	9.21
1/2 colour development: (H_4)	0.00	5.66	7.81	6.74	7.76	12.75	10.25
Sem±	-	0.40	0.27	0.24	0.34	1.40	0.72
CD (P= 0.05)	-	1.78	1.24	0.83	1.54	6.28	2.49

Table 8: Effect of various harvesting stages on juice content of organic pineapple before transport

Harvesting stages	Juice content (ml)								
	0 DAH			5 DAH			10 DAH		
	2014	**2016**	**Pooled**	**2014**	**2016**	**Pooled**	**2014**	**2016**	**Pooled**
Fully mature but no colour development: (H_1)	58.00	56.00	57.00	67.00	65.00	66.00 (9.00)	70.00	70.00	70.00 (13.00)
1/8 colour development: (H_2)	62.00	58.00	60.00	70.00	67.00	68.50 (8.50)	75.00	72.00	73.50 (13.50)
1/4 colour development: (H_3)	68.00	67.00	67.50	73.00	70.00	71.50 (4.00)	77.00	77.00	77.00 (9.50)
1/2 colour development: (H_4)	70.00	70.00	70.00	77.00	75.00	76.00 (6.00)	79.00	80.00	79.50 (9.50)
Sem±	1.71	2.01	1.32	1.11	1.52	0.94	1.26	1.04	0.82
CD (P= 0.05)	5.91	6.94	4.06	3.83	5.25	2.89	4.35	3.60	2.52

Note: **Figures in the table are mean values and those in parenthesis are mean differences**

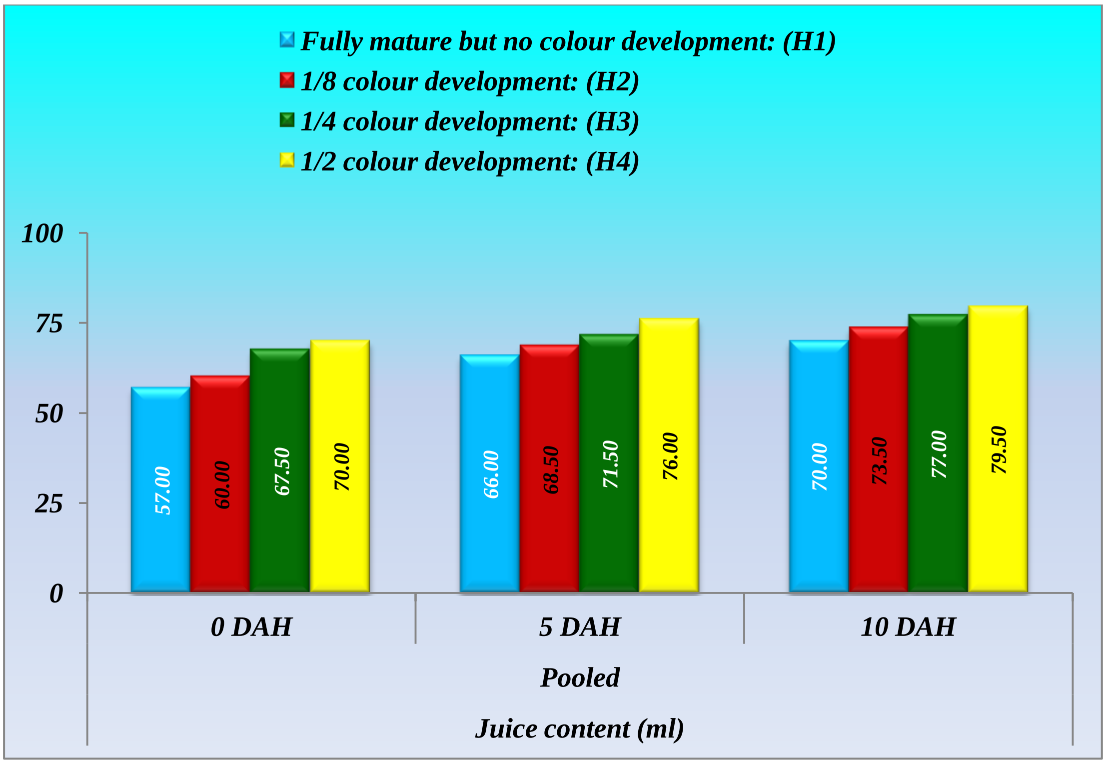


Figure 9: Effect of various harvesting stages on juice content of organic pineapple before transport

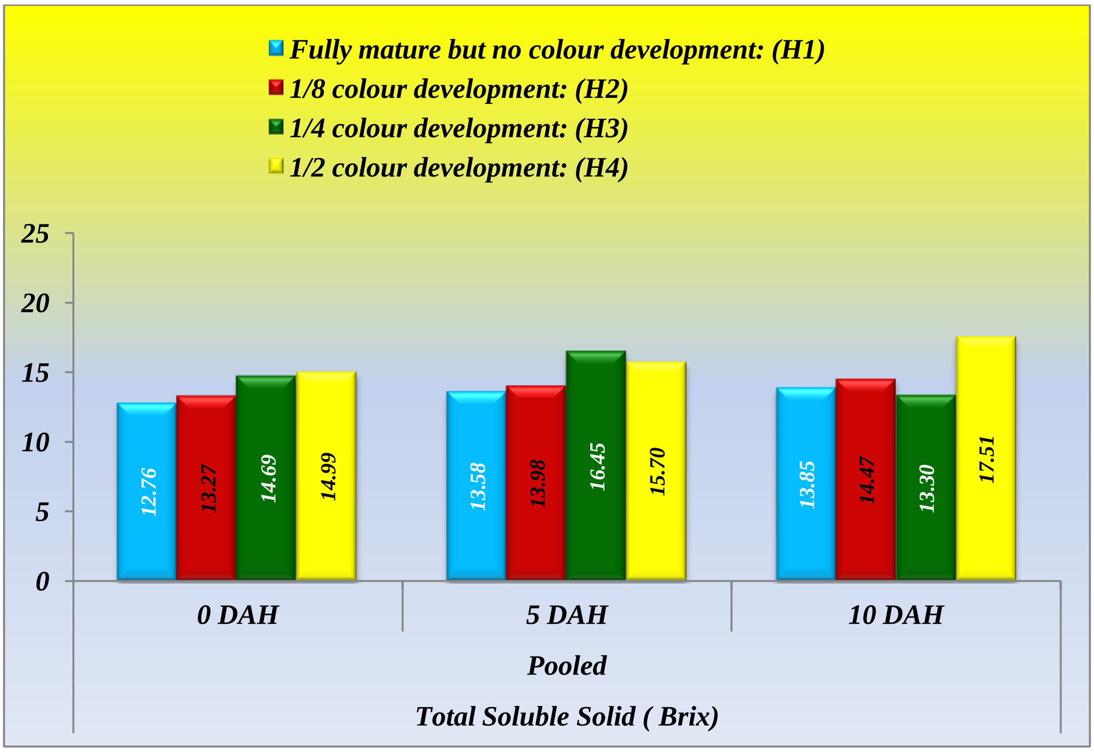


Figure 10: Effect of various harvesting stages on Total Soluble Solid of organic pineapple before transport

H_1 respectively and minimum (9.50 and 9.50) was found under H_3 and H_4 respectively. Dhar *et al.* (2008) also reported that freshly harvested pineapple fruits contained 61.04%, 63.65% and 64.65% juice respectively in three stages of maturity *i.e*. stage 1 (14 days before optimum mature stage), stage 2 (7 days before mature stage) and stage 3 (optimum mature stage) that increased with increased period of storage which was in agreement with the present findings.

4.2.1.3. *Total Soluble Solid (^{o}Brix)*

It was apparent from Table 9 and Fig. 10 that TSS was significantly different among various harvesting stages and there was an increased trend with the storage period. On the day of the harvest, maximum ^{o}Brix of 14.99 was obtained from the treatment H_4 (1/2 colour development) followed by H_3 (1/4 colour development) with 14.69 ^{o}Brix. Minimum TSS (12.76 ^{o}Brix) was obtained from the treatment H_1 (fully matured but no colour development). On 5th DAH, the maximum TSS (16.45 ^{o}Brix) was found under the treatment H_3 (1/4 colour development), and the minimum of 13.58 ^{o}Brix was recorded in H_1 (fully matured but no colour development). As per the parenthesis, there was a significant increase of TSS values and the maximum (1.76) was recorded in H_3 (1/4 colour development) followed by H_1 (fully matured but no colour development) with 0.82 and the minimum (0.71) was found in H_2 (1/8 colour development) and H_4 (1/2 colour development). On the 10th DAH, highest TSS (17.51 ^{o}Brix) was observed in treatment H_4 followed by H_2 (1/8 colour development) with 14.47 ^{o}Brix and the lowest (13.30 ^{o}Brix) was recorded in H_3 (1/4 colour development). Similarly, there was a significant difference between different dates of harvest and the maximum TSS (2.52) was exerted by treatment H_4 followed by H_2 (1.20), while the minimum (-1.39) was noted under treatment H_3. The present finding was in conformity with those of Kabir *et al*. (2010), who reported highest TSS in optimum matured fruits at 8th day of storage in pineapple.

Table 9: Effect of various harvesting stages on Total Soluble Solid of organic pineapple before transport

Harvesting stages	Total Soluble Solid (^{o}Brix)								
	0 DAH			5 DAH			10 DAH		
	2014	2016	Pooled	2014	2016	Pooled	2014	2016	Pooled
Fully mature but no colour development: (H_1)	12.80	12.72	12.76	13.42	13.75	13.58 (0.82)	14.33	13.36	13.85 (1.09)
1/8 colour development: (H_2)	13.29	13.25	13.27	14.30	13.67	13.98 (0.71)	14.50	14.44	14.47 (1.20)
1/4 colour development: (H_3)	14.57	14.80	14.69	16.45	16.45	16.45 (1.76)	12.17	14.42	13.30 (-1.39)
1/2 colour development: (H_4)	14.86	15.12	14.99	15.70	15.70	15.70 (0.71)	17.48	17.53	17.51 (2.52)
Sem±	0.13	0.14	0.10	0.32	0.36	0.24	0.11	0.10	0.07
CD (P= 0.05)	0.46	0.49	0.30	1.11	1.25	0.74	0.37	0.33	0.22

Note: **Figures in the table are mean values and those in parenthesis are mean differences**

4.2.1.4. *Total Sugar (%)*

Data for Table 10 showed that there was a significant difference of total sugar percentage between various harvesting stages (Table 10). On the day of the harvest, the highest percentage (6.87%) was recorded under the treatment H_4 (1/2 colour development) and the minimum (6.10%) under treatment H_1 (fully matured but no colour development). On the 5th and 10th DAH, the highest (9.41% and 12.20%) was observed under the treatment H_4 (1/2 colour development), while the lowest (7.11% and 9.18%) was observed under the treatment H_1 (fully matured but no colour development). In the same way, the highest value (2.54 and 5.33) in the parenthesis was observed under treatment H_4, this was followed by H_3 with 1.66 and 4.38 and the lowest (1.01 and 3.08) under the treatment H_1. Similar result was reported by Dhar *et al.* (2008) who also recorded maximum total sugar in full matured pineapple fruits while minimum was recorded in pre matured fruits at initial stage and stated that there was an increasing trend of total sugar with the progress of storage period till 12th day of storage and decreased thereafter. The increase in total sugar associated with the advancement of storage period is usually due to break of polysaccharides and conversion of starch into sugar (Wills *et al.*, 1989).

4.2.1.5. *Reducing Sugar (%)*

From Table 11, it was observed that there was an increasing trend of reducing sugar % during the storage period. On the day of the harvest, the reducing sugar % was found to be highest (2.10%) in H_2 (1/8 colour development) followed by H_1 (fully matured but no colour development) with 2.04% and lowest (1.23%) in H_4 (1/2 colour development). On 5th DAH, the reducing sugar was found to be the highest (3.08%) under H_4 (1/2 colour development) followed by H_2 (1/8 colour development) with 2.89% and lowest (2.40% and 2.45%) under H_1 and H_3 respectively. Similarly, the values in the parenthesis also showed the highest value (1.85) in H_4 followed by H_3 (1.14) and lowest (0.36) in H_1 (fully matured but no colour development). On

Table 10: Effect of various harvesting stages on total sugar of organic pineapple before transport

Harvesting stages	Total sugar (%)								
	0 DAH			5 DAH			10 DAH		
	2014	2016	Pooled	2014	2016	Pooled	2014	2016	Pooled
Fully mature but no colour development: (H_1)	6.06	6.15	6.10	7.02	7.20	7.11 (1.01)	9.10	9.25	9.18 (3.08)
1/8 colour development: (H_2)	6.15	6.52	6.34	7.69	7.85	7.77 (1.43)	9.30	9.52	9.41 (3.07)
1/4 colour development: (H_3)	6.45	6.90	6.68	8.52	8.16	8.34 (1.66)	11.12	11.00	11.06 (4.38)
1/2 colour development: (H_4)	7.02	6.72	6.87	9.30	9.52	9.41 (2.54)	12.15	12.25	12.20 (5.33)
Sem±	0.17	0.12	0.11	0.36	0.30	0.23	0.38	0.34	0.25
CD (P= 0.05)	0.60	0.42	0.33	1.24	1.05	0.72	1.30	1.18	0.78

***Note:* Figures in the table are mean values and those in parenthesis are mean differences**

Table 11: Effect of various harvesting stages on reducing sugar of organic pineapple before transport

Harvesting stages	Reducing sugar (%)								
	0 DAH			5 DAH			10 DAH		
	2014	2016	Pooled	2014	2016	Pooled	2014	2016	Pooled
Fully mature but no colour development: (H_1)	1.94	2.15	2.04	2.19	2.60	2.40 (0.36)	3.30	3.63	3.46 (1.42)
1/8 colour development: (H_2)	1.93	2.27	2.10	2.77	3.00	2.89 (0.79)	3.04	3.04	3.04 (0.94)
1/4 colour development: (H_3)	1.19	1.44	1.31	2.72	2.18	2.45 (1.14)	4.38	4.15	4.27 (2.96)
1/2 colour development: (H_4)	1.13	1.32	1.23	3.05	3.11	3.08 (1.85)	4.79	4.83	4.81 (3.58)
Sem±	0.01	0.01	0.01	0.49	0.40	0.32	0.23	0.24	0.17
CD (P= 0.05)	0.03	0.05	0.03	1.69	1.38	0.97	0.79	0.83	0.51

Note: **Figures in the table are mean values and those in parenthesis are mean differences**

10^{th} DAH, the reducing sugar was found to be highest (4.81%) in H_4 (1/2 colour development) followed by H_3 (1/4 colour development) with 4.27% and lowest (3.04%) under H_2 (1/8 colour development). In the parenthesis, the highest value (3.58) was recorded under the treatment H_4 (1/2 colour development) followed by H_3 (2.96) and the lowest (0.94) under H_2 (1/8 colour development). Dhar *et al.* (2008) also reported that on the 8^{th} DAH, the reducing sugar percentage was 4.14%, which was in conformity with the present findings.

4.2.1.6. *Non- Reducing Sugar (%)*

There was a significant difference among all the treatments on all the dates of observation, and it was observed that there was an increasing trend of NRS with the storage period (Table 12). On 0 DAH, it was found that the highest (5.36%) and lowest (3.86%) percentage of Non- reducing sugar was exhibited by H_4 (1/2 colour development) and H_1 (fully matured but no colour development) respectively. At 5^{th} DAH, the highest (6.33%) and the lowest (4.71%) content of Non- reducing sugar was exhibited by H_4 (1/2 colour development) and H_1 (fully matured but no colour development) respectively. However, the values in the parenthesis showed maximum increase in H_4 (0.97) followed by H_1 (0.88) and minimum in H_3 (1/4 colour development) with 0.79%. Similarly, on 10^{th} DAH, the highest (7.39%) and the lowest (5.71%) was exhibited by H_4 (1/2 colour development) and H_1 (fully matured but no colour development) respectively. The values calculated in the parenthesis was maximum (2.34) under H_2 followed by H_4 (2.03) and minimum under the treatments H_3 (1.69). Dhar *et al*. (2008), observed similar results in pineapple where reducing sugar were recorded maximum at optimum maturity stage and minimum in fruits during initial stage, it was because the initial stage was taken as 14 days before optimum matured stage.

Table 12: Effect of various harvesting stages on Non reducing sugar of organic pineapple before transport

Harvesting stages	Non reducing sugar (%)								
	0 DAH			5 DAH			10 DAH		
	2014	2016	Pooled	2014	2016	Pooled	2014	2016	Pooled
Fully mature but no colour development: (H_1)	3.91	3.80	3.86	4.82	4.60	4.71 (0.88)	5.80	5.62	5.71 (1.85)
1/8 colour development: (H_2)	4.02	4.04	4.03	4.92	4.85	4.89 (0.86)	6.26	6.48	6.37 (2.34)
1/4 colour development: (H_3)	5.00	5.19	5.10	5.80	5.97	5.89 (0.79)	6.74	6.85	6.79 (1.69)
1/2 colour development: (H_4)	5.59	5.12	5.36	6.25	6.42	6.33 (0.97)	7.36	7.42	7.39 (2.03)
Sem±	0.02	0.02	0.02	0.15	0.25	0.15	0.18	0.20	0.13
CD (P= 0.05)	0.07	0.08	0.05	0.50	0.88	0.45	0.62	0.70	0.42

Note: **Figures in the table are mean values and those in parenthesis are mean differences**

4.2.1.7. ***Titratable Acidity (%)***

There were significant differences among all the treatments on all dates of observation, (Table 13 & Fig. 11). It was observed that there was a decreasing trend of acidity content with the storage period. On the day of harvest, the highest (0.63%) and the lowest (0.37%) percentage of titratable acidity was found in H_1 (fully matured but no colour development) and H_3 (1/4 colour development) respectively. At 5^{th} DAH, data showed that the highest percentage of titratable acidity was shown in H_1 (fully matured but no colour development) (0.57%) and lowest (0.25%) in H_4 (1/2 colour development). According to the values in the parenthesis, maximum decrease in titratable acid value (-0.12) was observed under H_4 followed by H_3 (-0.09) and the lowest decrease of titratable acid was found under H_1 (-0.03). Highest titratable acidity (0.42%) on 10^{th} DAH, was in H_1 (fully matured but no colour development) and lowest (0.21%) in H_4 (1/2 colour development). Parenthesis indicated that maximum decrease value (-0.16) was in H_4 and minimum decrease (-0.24) in H_2 (1/8 colour development). Similar results were reported by Dhar *et al.* (2008) and Kamol *et al.* (2014) in pineapple. In most climacteric fruits, acidity declines as ripening advances (Wills *et al*., 1989). The decrease in titratable acidity during storage may be attributed to the utilization of organic acids in respiratory process and other bio degradable reactions (Kamol *et al*., 2014).

4.2.1.8. ***Ascorbic Acid (mg/100ml juice)***

Ascorbic acid content in organic pineapples were found to be highest (9.69 mg/100ml juice) in H_1 (fully matured but no colour development) and lowest (5.46 mg/100ml juice) in H_4 (1/2 colour development) on the day of the harvest. However data from Table 14, Fig. 12 indicated that there was a significant decline during the storage period. On 5^{th} DAH, the highest (8.02 mg/100ml juice) was recorded in H_1 (fully matured but no colour development) and lowest (4.20 mg/100ml juice) in H_4 (1/2 colour

Table 13: Effect of various harvesting stages on Titratable acidity of organic pineapple before transport

Harvesting stages	Titratable acidity (%)								
	0 DAH			5 DAH			10 DAH		
	2014	2016	Pooled	2014	2016	Pooled	2014	2016	Pooled
Fully mature but no colour development: (H_1)	0.62	0.64	0.63	0.51	0.62	0.57 (-0.06)	0.38	0.46	0.42 (-0.21)
1/8 colour development: (H_2)	0.57	0.55	0.56	0.44	0.51	0.48 (-0.08)	0.25	0.38	0.32 (-0.24)
1/4 colour development: (H_3)	0.42	0.44	0.43	0.32	0.32	0.32 (-0.11)	0.24	0.25	0.25 (-0.18)
1/2 colour development: (H_4)	0.38	0.35	0.37	0.25	0.25	0.25 (-0.12)	0.19	0.22	0.21 (-0.16)
Sem±	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CD (P= 0.05)	0.01	0.03	0.01	0.04	0.04	0.03	0.04	0.05	0.03

***Note:* Figures in the table are mean values and those in parenthesis are mean differences**

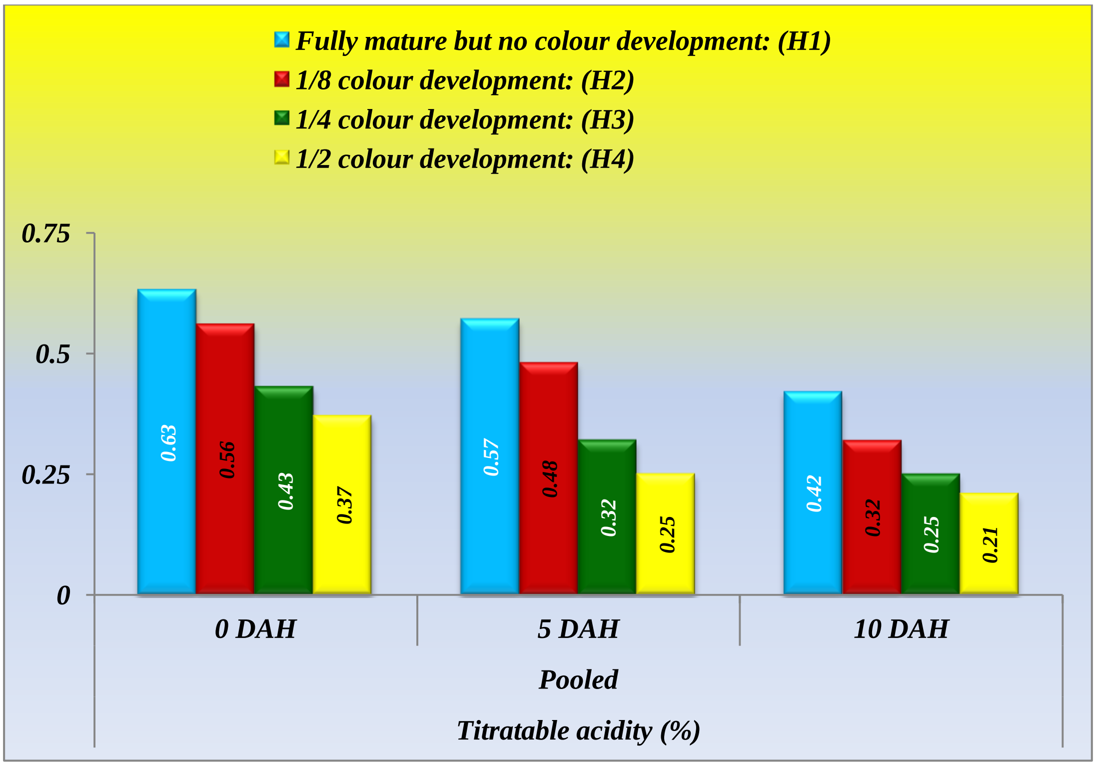


Figure 11: Effect of various harvesting stages on titratable acidity of organic pineapple before transport

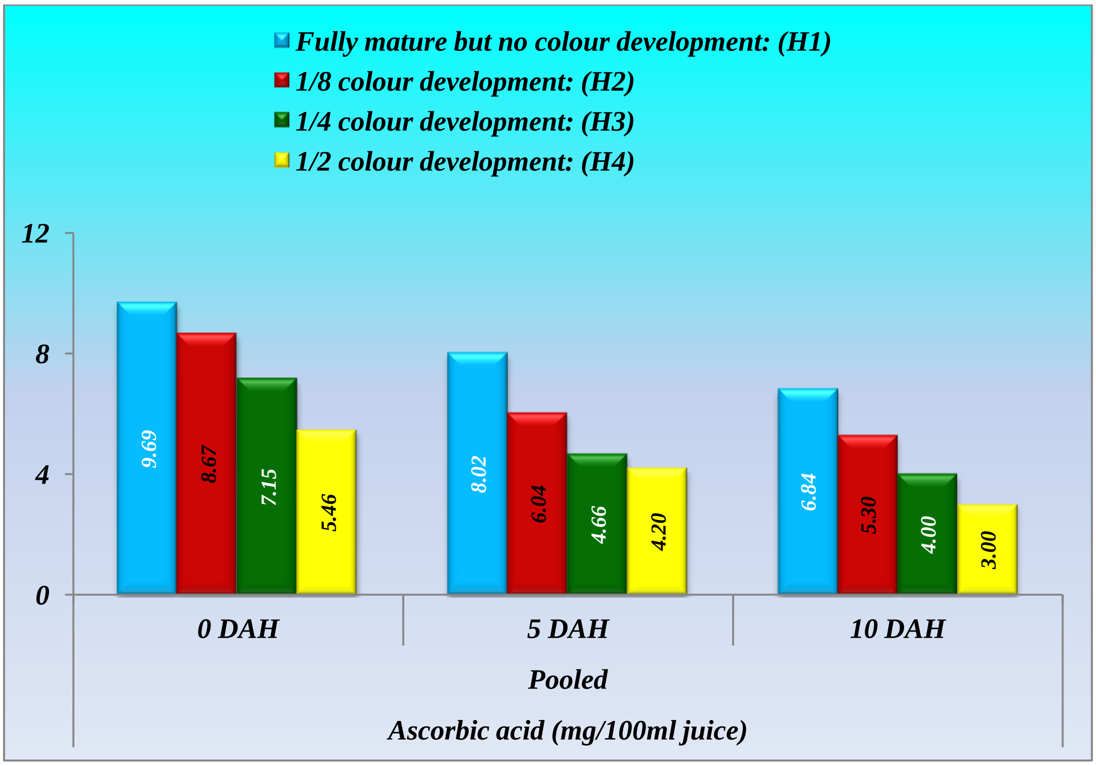


Figure 12: Effect of various harvesting stages on ascorbic acid of organic pineapple before transport

Table 14: Effect of various harvesting stages on Ascorbic acid of organic pineapple before transport

Harvesting stages	Ascorbic acid (mg/100ml juice)								
	0 DAH			5 DAH			10 DAH		
	2014	2016	Pooled	2014	2016	Pooled	2014	2016	Pooled
Fully mature but no colour development: (H_1)	9.82	9.56	9.69	7.84	8.20	8.02 (-1.67)	6.17	7.52	6.84 (-2.85)
1/8 colour development: (H_2)	8.52	8.82	8.67	5.60	6.48	6.04 (-2.63)	5.03	5.56	5.30 (-3.37)
1/4 colour development: (H_3)	7.05	7.25	7.15	4.20	5.12	4.66 (-2.49)	3.80	4.20	4.00 (-3.15)
1/2 colour development: (H_4)	5.60	5.32	5.46	3.92	4.48	4.20 (-1.26)	2.80	3.20	3.00 (-2.46)
Sem±	0.02	0.01	0.01	0.21	0.28	0.18	0.26	0.23	0.18
CD (P= 0.05)	0.05	0.03	0.03	0.74	0.96	0.54	0.91	0.80	0.54

Note: **Figures in the table are mean values and those in parenthesis are mean differences**

development) with the maximum decrease (in the parenthesis) found in treatment H_2 (-2.63) and the minimum in H_4 (-1.26). Comparably at 10th DAH, the highest (6.84 mg/100ml juice) was recorded in H_1 and lowest (3.00 mg/100ml juice) in H_4 (fully matured but no colour development). However, the maximum decrease in the parenthesis was found under the treatment H_2 (-3.37) and the lowest in H_4 (1/2 colour development) with -2.46. The present result was an agreement with the findings of Adisa (1986), Kabir *et al*. (2010) and Kamol *et al*. (2014) who also reported that the ascorbic acid content of pineapple gradually decreased with the increase in storage period. The decrease in ascorbic acid content of fruit juice with advancement of ripening stage of fruits in storage period was due to the conversion of the acid to sugar with the activity of ascorbic acid dehydrogenase (Rahman *et al*., 1979).

4.2.1. 9. Organoleptic test before transport (Table 15 & Fig. 13)

4.2.1.9.1. Appearance

The maximum rating for appearance was recorded under the treatment H_2 (1/8 colour development) of 3.60 and 3.00 with their mean as 3.30 during 2014 and 2016 respectively and the minimum rating was recorded in treatment H_1 (fully matured but no colour development) with 2.20 and 2.10 and mean as 2.15 during 2014 and 2016 respectively.

4.2.1.9.2. Aroma

The ratings recorded for aroma evaluation was found to have been significantly influence by the harvesting stages of pineapple. The maximum was recorded in the treatment H_3 (1/4 colour development) with 3.40 and 3.50 during 2014 and 2016 respectively and a mean value of 3.45. However, the minimum rating recorded in treatment H_1 (fully matured but no colour development) with 2.80 and 2.50 and a mean of 2.65 during 2014 and 2016 respectively.

Table 15: Effect of various treatments on organoleptic parameters of organic pineapple fruit before transport

Treatments	Appearance			Aroma			Sweetness			Fibre content			Overall acceptability		
	2014	2016	Pooled	2014	2016	Pooled	2014	2016	Pooled	2014	2016	Pooled	2014	2016	Pooled
Fully mature but no colour development: (H_1)	2.20	2.10	2.15	2.80	2.50	2.65	2.70	2.60	2.65	2.30	2.20	2.25	2.50	2.35	2.43
1/8 colour development: (H_2)	3.60	3.00	3.30	3.20	3.30	3.25	3.10	3.00	3.05	2.40	2.30	2.35	3.00	2.73	2.86
1/4 colour development: (H_3)	3.50	2.40	2.95	3.40	3.50	3.45	3.10	3.00	3.05	2.30	2.50	2.40	3.20	3.10	3.15
1/2 colour development: (H_4)	3.30	2.30	2.80	3.30	3.10	3.20	3.50	3.40	3.45	2.10	2.20	2.15	3.00	2.68	2.84
Sem±	0.22	0.18	0.14	0.14	0.15	0.10	0.16	0.17	0.12	0.12	0.17	0.11	0.25	0.21	0.16
CD (P= 0.05)	0.67	0.56	0.42	0.43	0.46	0.30	0.49	0.51	0.34	NS	NS	NS	NS	NS	NS

***Note:* NS = Non Significant at 5% level of significance**

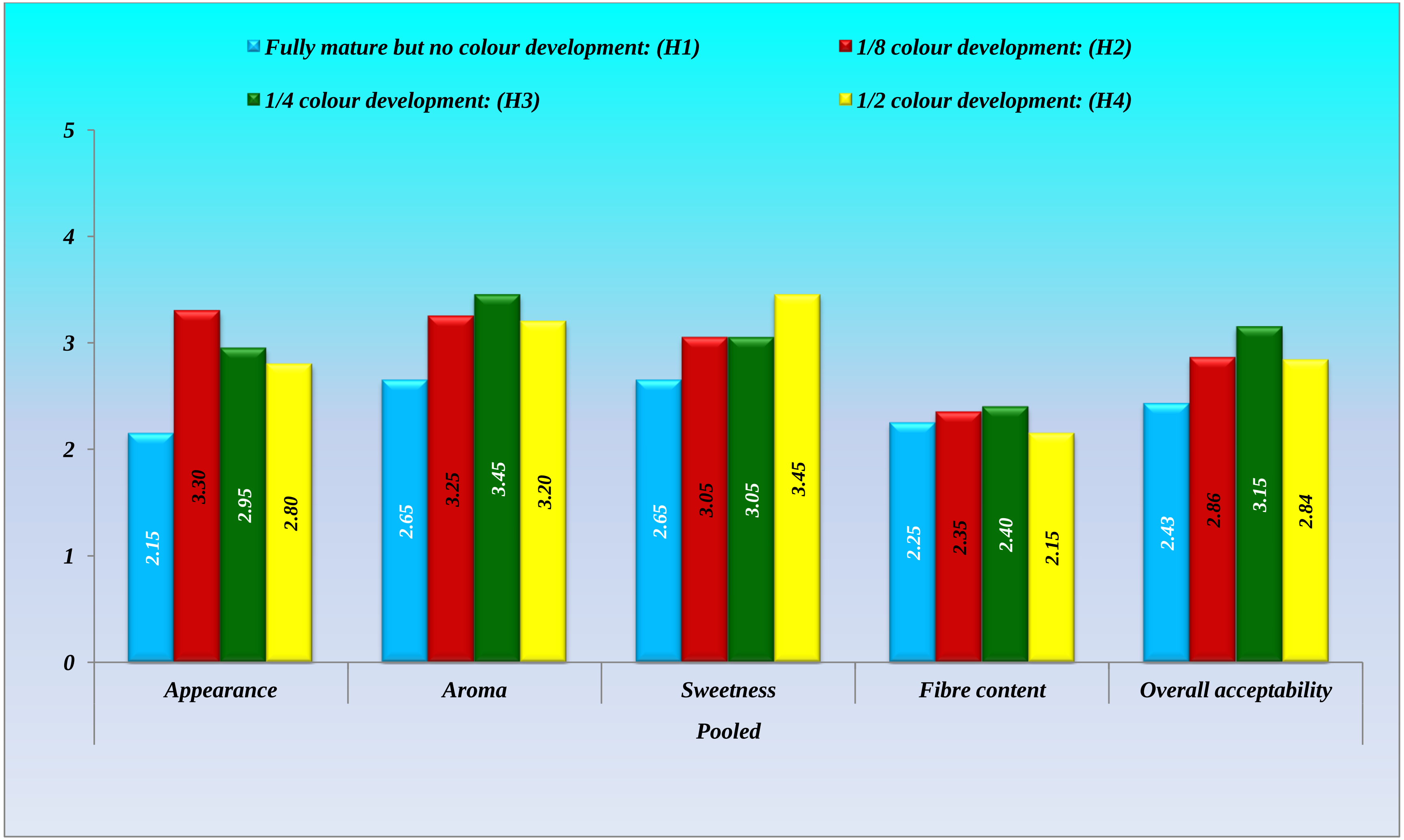


Figure 13: Effect of various treatments on organoleptic parameters of organic pineapple fruit before transport

4.2.1.9.3. Sweetness

The sweetness levels of the fruits were significantly affected by the different harvesting stages. The maximum rating of sweetness level was recorded under the treatment H_4 (1/2 colour development) with 3.50 and 3.40 and a mean of 3.45 during 2014 and 2016 respectively. The minimum was found under the treatment H_1 (fully matured but no colour development) with 2.70 and 2.60 and a mean value of 2.65 during 2014 and 2016 respectively.

4.2.1.9.4. Fibre content

The fibre content of the fruits did not show any significant difference among different harvesting stages. However, H_3 (1/4 colour development) showed maximum fibre content while H_4 (1/2 colour development) showed minimum fibre content.

4.2.1.9.5. Overall acceptability

It was apparent from the data depicted in Table15. Fig. 13 that overall acceptability was not significantly influenced by various treatments. However, H_3 (1/4 colour development) gave the maximum (3.15) rating which was followed by H_2 (1/8 colour development) with 2.86 and the minimum was recorded in H_1 (fully matured but no colour development) with 2.43.

Schulbach *et al.* (2007) found in their study that a regression tree model relating acceptability to the other sensory attributes showed that sweetness, pineapple flavour intensity and off- flavour were the most important factors in determining acceptability. The aroma of pineapple is a blend of a number of important aromatic compounds and nearly 200 volatile compounds had been reported (Umano *et al*., 1992).

4.2.2. Physico-chemical analysis at Delhi (after transport)

4.2.2.1. *Physiological Loss in Weight (%)*

The results obtained on Physiological Loss in Weight (PLW) revealed that there was a significant difference among the various harvesting stages

Table 16: Effect of various harvesting stages and packaging on Physiological Loss in Weight of organic pineapple after transport

Treatments	Physiological Loss in Weight (%)						
	0 DAH	5 DAH			10 DAH		
		2014	2016	Pooled	2014	2016	Pooled
Harvesting stages							
Fully mature but no colour development: (H_1)	0.00	6.26	6.50	6.38	9.82	10.29	10.06
1/8 colour development: (H_2)	0.00	6.72	7.00	6.86	10.20	10.64	10.42
1/4 colour development: (H_3)	0.00	6.86	7.12	6.99	12.14	12.67	12.40
1/2 colour development: (H_4)	0.00	7.68	7.90	7.79	13.92	14.22	14.07
Sem±	-	0.04	0.03	0.02	0.12	0.15	0.10
CD (P= 0.05)	-	0.12	0.09	0.07	0.42	0.51	0.30
Packaging materials							
Wooden boxes: (P_1)	0.00	7.48	7.72	7.60	12.24	12.67	12.46
Bamboo boxes: (P_2)	0.00	6.90	7.18	7.04	11.80	12.25	12.03
CFB boxes: (P_3)	0.00	6.44	6.70	6.57	10.77	11.18	10.97
Used carton boxes: (P_4)	0.00	6.70	6.92	6.81	11.26	11.73	11.49
Sem±	-	0.05	0.04	0.03	0.11	0.11	0.08
CD (P= 0.05)	-	0.15	0.12	0.09	0.31	0.33	0.22

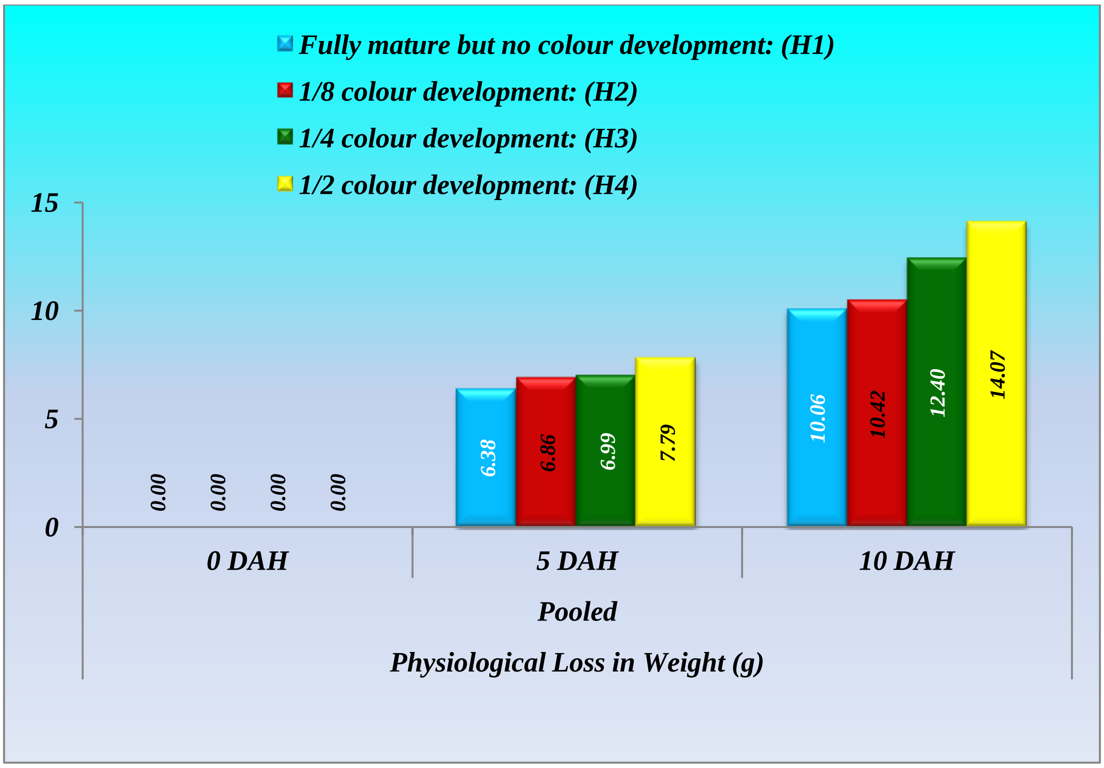


Figure 14: Effect of various harvesting stages on Physiological Loss in Weight of organic pineapple after transport

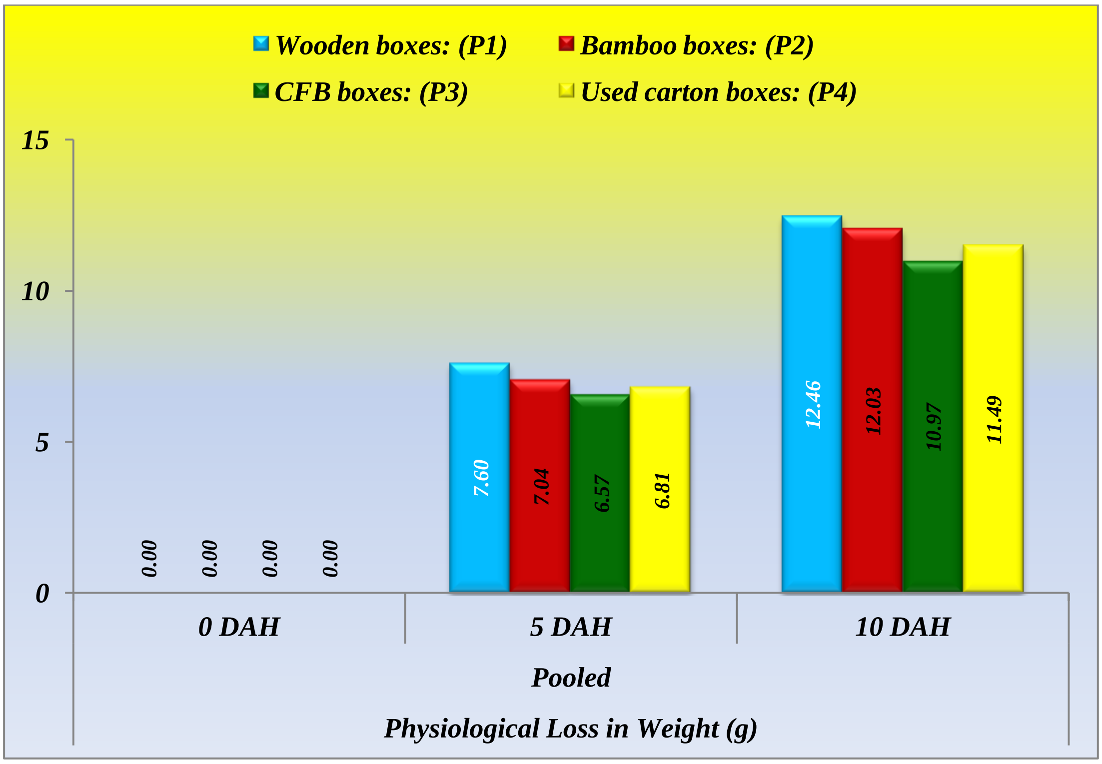


Figure 15: Effect of various packaging on Physiological Loss in Weight of organic pineapple after transport

Table 17: Interaction effect of various harvesting stages and packaging on Physiological Loss in Weight of organic pineapple after transport

Treatments	Physiological Loss in Weight (%)						
	0 DAH	5 DAH			10 DAH		
		2014	2016	Pooled	2014	2016	Pooled
H_1P_1	0.00	6.58	6.78	6.68	10.37	10.82	10.59
H_1P_2	0.00	6.30	6.60	6.45	9.95	10.42	10.18
H_1P_3	0.00	6.00	6.22	6.11	9.16	9.64	9.40
H_1P_4	0.00	6.17	6.40	6.28	9.80	10.30	10.05
H_2P_1	0.00	7.52	7.78	7.65	10.68	11.10	10.89
H_2P_2	0.00	6.70	7.04	6.87	10.38	10.85	10.62
H_2P_3	0.00	6.25	6.52	6.38	9.57	9.99	9.78
H_2P_4	0.00	6.42	6.65	6.53	10.18	10.62	10.40
H_3P_1	0.00	7.70	7.95	7.83	12.72	13.22	12.97
H_3P_2	0.00	6.82	7.07	6.95	12.40	12.92	12.66
H_3P_3	0.00	6.28	6.54	6.41	11.49	12.03	11.76
H_3P_4	0.00	6.65	6.90	6.78	11.94	12.52	12.23
H_4P_1	0.00	8.12	8.35	8.23	15.20	15.55	15.38
H_4P_2	0.00	7.78	8.02	7.90	14.47	14.82	14.64
H_4P_3	0.00	7.25	7.52	7.38	12.87	13.05	12.96
H_4P_4	0.00	7.55	7.73	7.64	13.13	13.47	13.30
Sem±	-	0.10	0.08	0.07	0.21	0.23	0.15
CD (P= 0.05)	-	0.30	0.25	0.19	0.61	0.66	0.44

(Table 16 & Fig. 14) and the PLW percentage increased with storage period. On the 5 DAH, it was apparent from the data that the maximum (7.79%) PLW was shown in H_4 (1/2 colour development) while, the minimum (6.38%) was recorded in the treatment H_1 (Fully mature but no colour development). On the 10^{th} day, it was apparent from the data that the maximum (14.07%) PLW was found in H_4 (1/2 colour development) while, the minimum was recorded under H_1 (fully matured but no colour development) treatment with 10.06%. Sabahel Kheir *et al.* (2010), stated that physical, chemical and sensorial characters of pineapple showed significant difference during several maturation stages.

Fruit maturation as characterized by changes in physiological, bio chemical and morphological traits of sour cherry, which determine the qualitative characteristics of any cultivar and finally its depreciation during senescence (Milosevic and Milosevic, 2012). Fruit growth and development in pineapple involves many changes that include its morphology, anatomy, physiology and bio chemistry (Hajar *et al.*, 2012).

Similarly, (Table 16 & Fig. 15) packaging also showed a significant influence on PLW during the storage period. The maximum (7.60%) PLW at 5 DAH was recorded under the treatment P_1 (wooden boxes) and minimum of 6.57% was recorded under the treatment P_3 (CFB boxes). The data pertaining to 10^{th} day, showed a significant result with maximum weight loss (12.46%) in P_1 (wooden boxes) treatment and minimum (10.97%) weight loss under P_3 (CFB boxes) treatment. Sindumathi *et al.* (2017) studied different packaging materials (Arecanut sheath, aluminium foil and polypropylene container) treated with nisin and found out that for all the packaging materials polypropylene containers gave the minimum PLW since they can extend the lag-period and reduce the growth rate of microorganism to prolong shelf life, which is in conformity with the present finding since the CFB boxes are more enclosed as compared to other packaging methods.

The interaction effect of harvesting stages and packaging on Physiological Loss in Weight was significant (Table 17). The highest value on 5 DAH was recorded under H_4P_1 (8.23%) followed by H_4P_2 (7.90%) and minimum was observed under the treatment H_1P_3 (6.11%). Likewise, on the 10^{th} day, maximum weight loss was recorded in treatment H_4P_1 (15.38%) followed by H_4P_2 (14.64%) and minimum was observed under the treatment H_1P_3 (9.40%).

4.2.2.2. *Juice content (%)*

The experimental results pertaining to juice content (Table 18 & Fig. 16) showed that there was a significant influence of harvesting stages and showed a decline at the 5^{th} DAH but increased on the 10^{th} DAH except for one treatment (H_4). At 0DAH, highest juice content (69.48 %) was exerted by treatment H_4 followed by H_3 (67.65 %) and minimum in H_1 (57.40 %). At 5 DAH, maximum (66.58 %) was found under treatment H_3 ($1/4^{th}$ colour development) followed by H_4 (64.65 %) and the minimum was recorded under treatment H_1 (Fully matured but no colour development) of 53.63%. However, the mean difference showed a significant decline on the 5^{th} DAH, where maximum decreased value (-4.07) was recorded under H_4 followed by H_1 (-2.85) and minimum decreased value under H_2 (-0.56). Similarly, on the 10 DAH, the maximum mean value (68.31 %) was found under H_3 ($1/4^{th}$ colour development) followed by H_4 (68.29%) and minimum (60.92%) under treatment H_1 (Fully matured but no colour development). As per the parenthesis, the highest increase was observed in H_2 (4.47) and the minimum increase (-1.19) was recorded under H_4. Dhar *et al.* (2008) also opined that the moisture content of pineapple gradually decreased with the progress of storage period.

Likewise, the packaging also had a significant effect on the juice content of the fruit which declined on the 5^{th} DAH and gradually increased at the 10^{th} DAH (Table 18 & Fig. 17). At the day of the harvest, the highest

Table 18: Effect of various harvesting stages and packaging on Juice Content (%) of organic pineapple after transport

Treatments	Juice Content (%)								
	0 DAH			5 DAH			10 DAH		
	2014	2016	Pooled	2014	2016	Pooled	2014	2016	Pooled
Harvesting stages									
Fully mature but no colour development: (H_1)	58.38	56.42	57.40	54.09	55.01	54.55 (-2.85)	60.54	61.29	60.92 (3.52)
1/8 colour development: (H_2)	62.42	58.25	60.33	59.46	60.08	59.77 (-0.56)	64.25	65.35	64.80 (4.47)
1/4 colour development: (H_3)	68.29	67.00	67.65	65.44	68.33	66.89 (-0.76)	68.96	67.67	68.31 (0.66)
1/2 colour development: (H_4)	70.42	68.54	69.48	64.08	66.73	65.41 (-4.07)	67.92	68.67	68.29 (-1.19)
Sem±	0.95	0.92	0.66	1.18	1.09	0.80	1.04	1.08	0.75
CD (P= 0.05)	3.30	3.19	2.04	4.07	3.77	2.47	3.59	3.73	2.31
Packaging materials									
Wooden boxes: (P_1)	61.17	58.75	59.96	56.50	60.27	58.38 (-1.58)	65.96	66.42	62.98 (3.02)
Bamboo boxes: (P_2)	63.67	61.08	62.38	58.89	61.32	60.11 (-2.27)	64.08	63.77	63.93 (1.55)
CFB boxes: (P_3)	69.50	66.83	68.17	66.56	67.62	67.09 (-1.08)	69.50	68.96	69.23 (1.06)
Used carton boxes: (P_4)	65.17	63.54	64.35	61.13	60.95	61.04 (-3.31)	62.13	63.83	66.19 (1.84)
Sem±	0.65	0.52	0.42	1.01	0.75	0.63	1.07	1.05	0.75
CD (P= 0.05)	1.91	1.53	1.19	2.96	2.18	1.79	3.13	3.06	2.13

Note: **Figures in the table are mean values and those in parenthesis are mean differences**

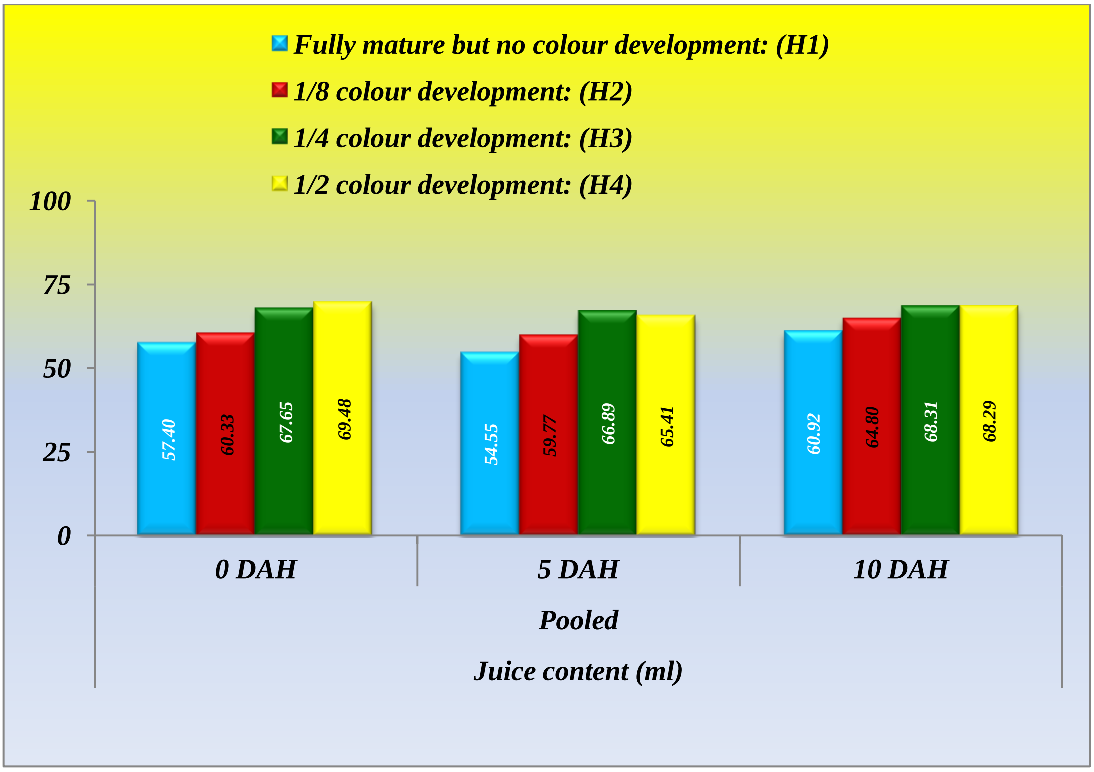


Figure 16: Effect of various harvesting stages on Juice Content of organic pineapple after transport

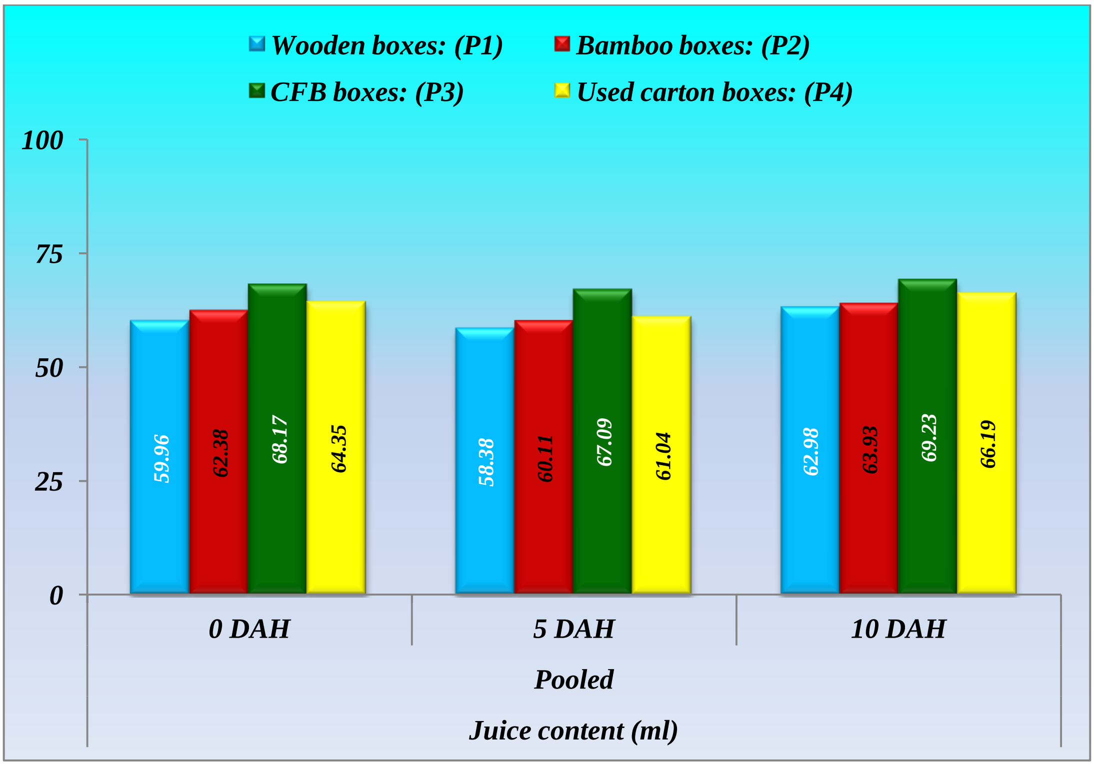


Figure 17: Effect of various packaging on Juice Content of organic pineapple after transport

Table 19: Interaction effect of various harvesting stages and packaging on Juice Content (%) of organic pineapple at Delhi

Treatments	Juice Content (%)								
	0 DAH			5 DAH			10 DAH		
	2014	2016	Pooled	2014	2016	Pooled	2014	2016	Pooled
H_1P_1	54.17	52.00	53.08	48.74	51.07	49.90	61.17	62.00	61.58
H_1P_2	58.00	56.00	57.00	52.07	53.12	52.60	60.00	61.17	60.58
H_1P_3	62.00	60.33	61.17	64.88	64.22	64.55	70.00	69.33	69.67
H_1P_4	59.33	57.33	58.33	50.67	51.65	51.16	51.00	52.67	51.83
H_2P_1	57.00	53.33	55.17	56.33	56.33	56.33	66.33	67.33	66.83
H_2P_2	59.33	55.33	57.33	54.00	55.50	54.75	62.50	64.07	63.28
H_2P_3	69.33	63.67	66.50	66.33	68.17	67.25	68.00	69.50	68.75
H_2P_4	64.00	60.67	62.33	61.17	60.33	60.75	60.17	60.50	60.33
H_3P_1	67.83	66.33	67.08	63.48	66.33	64.91	68.33	67.00	67.67
H_3P_2	67.67	65.00	66.33	68.33	67.50	67.92	69.50	64.33	66.92
H_3P_3	71.33	70.00	70.67	66.80	70.33	68.57	72.00	69.67	70.83
H_3P_4	66.33	66.67	66.50	63.17	69.17	66.17	66.00	69.67	67.83
H_4P_1	65.67	63.33	64.50	57.44	67.33	62.39	68.00	69.33	68.67
H_4P_2	69.67	68.00	68.83	61.17	69.17	65.17	64.33	65.50	64.92
H_4P_3	75.33	73.33	74.33	68.22	67.77	67.99	68.00	67.33	67.67
H_4P_4	71.00	69.50	70.25	69.50	62.67	66.08	71.33	72.50	71.92
Sem±	1.31	1.05	0.84	2.02	1.50	1.26	2.15	2.10	1.50
CD (P= 0.05)	3.81	3.06	2.38	5.91	4.37	3.58	6.27	6.12	4.27

(68.17%) was obtained from P_3 (CFB boxes) followed by P_4 (used carton box) (64.35%) and recorded minimum (59.96%) under P_1 (wooden box). During the 5 DAH, the maximum (67.09%) was recorded under P_3 (CFB box) followed by P_4 (used carton box) with 61.04% and the minimum (58.38%) in P_1. However, the data in the parenthesis showed a significant decline on 5 DAH, where maximum decrease (-3.31) was obtained from P_4 followed by P_2 (-2.27) and minimum decrease in P_3 (-1.08). On the 10 DAH, the maximum juice content (69.23%) was recorded under the treatment P_3 (CFB boxes) followed by P_4 (used carton boxes) with 66.19% and the minimum (62.98%) was found under P_1 (wooden box). The maximum increased value during 10th DAH was obtained under P_1 (3.02) followed by P_4 (1.84) and the minimum under P_3 (1.06).

The interaction between the harvesting stages and packaging on juice content significantly influenced the juice content (Table 19). On 0 DAH, the maximum value was recorded under H_4P_3 (74.33%) followed by H_3P_3 (70.67%) and the minimum was recorded under H_1P_1 (53.08%). On the 5th DAH, the maximum interaction effect on juice content was recorded under treatment H_3P_3 (68.57%) followed by H_4P_3 (67.99%) and minimum under H_1P_1 (49.90%). On the 10th day after harvest, the highest (71.92%) was recorded under H_4P_4 followed by H_3P_3 (70.83) and the minimum (51.83%) in H_1P_4.

4.2.2.3. *Total Soluble Solids (^{o}Brix)*

The experimental results pertaining to Total Soluble Solids showed that there was a significant difference among the treatments and was apparent from the data that there was an increasing trend along with the storage period (Table 20 & Fig. 18). The maximum Total Soluble Solids on harvesting stages at 0 DAH was found under treatment H_4 (1/2 colour development) with 14.99 ^{o}Brix followed by H_3 (1/4 colour development) with 14.69 ^{o}Brix and the minimum (12.76 ^{o}Brix) was recorded under treatment H_1 (Fully matured but no colour development). Similarly, at 5 DAH, the maximum (17.21 ^{o}Brix) was recorded under treatment H_4 followed by H_3 (15.98 ^{o}Brix) and minimum (13.30 ^{o}Brix) in H_1. The mean differences in the parenthesis also showed maximum (2.22) increase in H_4 followed by H_2 (1.71) and the minimum (0.54) in H_1. Furthermore, even in 10 DAH, the maximum (18.34 ^{o}Brix) was recorded under treatment H_4 followed by H_3 (16.74 ^{o}Brix) and minimum (13.84 ^{o}Brix) in H_1. The results in the parenthesis further showed maximum values (3.35) in H_4 followed by H_2 (2.31) and minimum in H_1 (1.08). Deka *et al.* (2005) also reported that pineapple fruit harvested during 146-150 days after flowering (1/2 colour development stage) had the highest TSS (18-19 ^{o}Brix) content.

Regarding the influence of packaging on TSS, (Table 20, Fig. 19) at 0 DAH, the treatments influence were found significant. At 5 DAH, the maximum was recorded under treatment P_3 (CFB boxes) with 15.58 ^{o}Brix followed by P_4 (used carton boxes) with 15.56 ^{o}Brix and the minimum was recorded under treatment P_1 (Wooden boxes) with 14.89 ^{o}Brix. Even though the highest mean value was obtained from P_3 (CFB boxes), the maximum mean differences (1.84) in the parenthesis was recorded under P_2 followed by P_4 (1.63) and minimum (0.96) under $P_{1.}$ However, on the 10^{th} DAH, the maximum TSS (16.93 ^{o}Brix) was exerted by P_3 followed by P_4 (16.39 °Brix) and minimum (15.33 ^{o}Brix) in P_1. The values in the parenthesis also gave highest (2.70) in P_3 followed by P_4 (2.46) treatment and the minimum (1.40) in P_1 treatment. Latifah *et al.* (1999) studied in minimally processed pineapple using two packing systems and recorded that there was a steady decreasing trend in the TSS value of fruit shown in both packaging systems during the 3 weeks of storage at 2°C. The TSS content which is an approximate measurement of the sugar content of a fruit is a good indicator of fruit sweetness. Besides that, the value can also indicate the available energy remaining in the fruit to carry on respiration and other metabolic functions

Table 20: Effect of various harvesting stages and packaging on Total Soluble Solid of organic pineapple after transport

Treatments	Total Soluble Solid (°Brix)								
	0 DAH			5 DAH			10 DAH		
	2014	2016	Pooled	2014	2016	Pooled	2014	2016	Pooled
Harvesting stages									
Fully mature but no colour development: (H_1)	12.80	12.72	12.76	13.48	13.13	13.30 (0.54)	13.88	13.81	13.84 (1.08)
1/8 colour development: (H_2)	13.29	13.25	13.27	14.75	15.21	14.98 (1.71)	15.46	15.71	15.58 (2.31)
1/4 colour development: (H_3)	14.57	14.80	14.69	16.13	15.83	15.98 (1.29)	16.90	16.58	16.74 (2.05)
1/2 colour development: (H_4)	14.86	15.12	14.99	17.25	17.17	17.21 (2.22)	18.31	18.38	18.34 (3.35)
Sem±	0.24	0.14	0.14	0.31	0.15	0.17	0.18	0.29	0.17
CD (P= 0.05)	0.84	0.47	0.43	1.08	0.53	0.54	0.62	1.01	0.53
Packaging materials									
Wooden boxes: (P_1)	13.80	14.06	13.93	14.98	14.79	14.89 (0.96)	15.21	15.46	15.33 (1.40)
Bamboo boxes: (P_2)	13.58	13.63	13.61	15.29	15.58	15.44 (1.84)	15.81	15.92	15.86 (2.26)
CFB boxes: (P_3)	14.27	14.20	14.23	15.75	15.42	15.58 (1.35)	16.98	16.88	16.93 (2.70)
Used carton boxes: (P_4)	13.85	14.00	13.93	15.58	15.54	15.56 (1.63)	16.54	16.23	16.39 (2.46)
Sem±	0.11	0.13	0.09	0.17	0.14	0.11	0.19	0.15	0.12
CD (P= 0.05)	0.33	0.39	0.25	0.50	0.42	0.32	0.55	0.43	0.34

Note: **Figures in the table are mean values and those in parenthesis are mean differences**

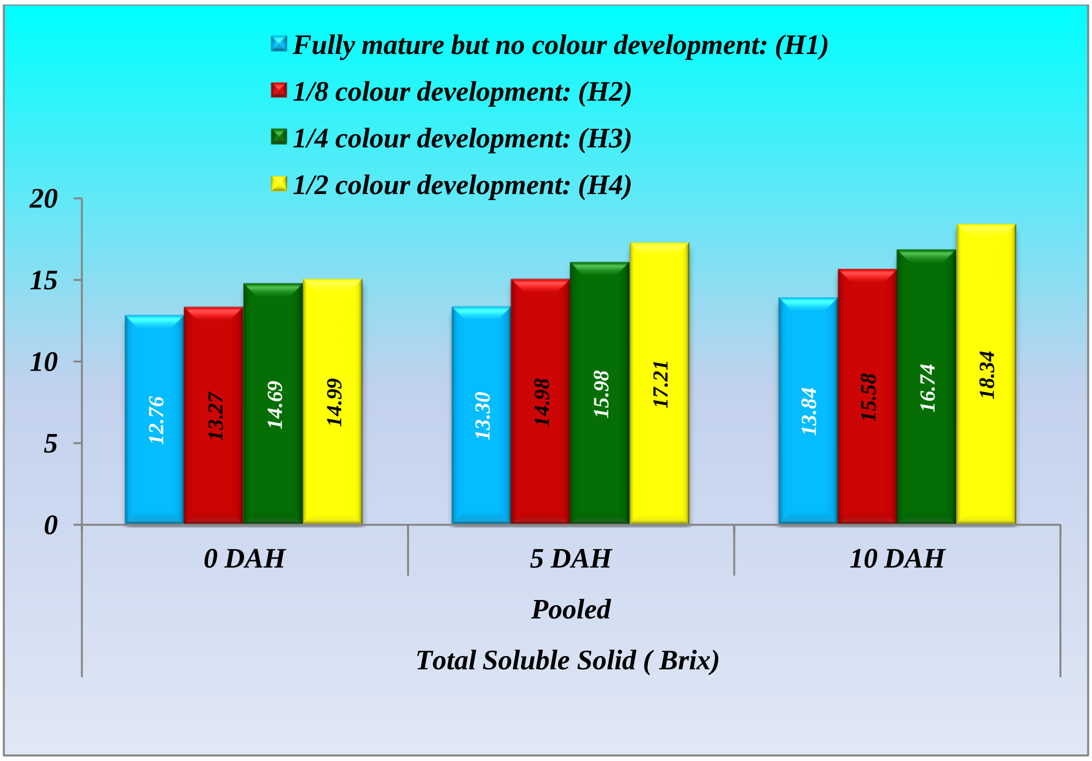


Figure 18: Effect of various harvesting stages on Total Soluble Solid of organic pineapple after transport

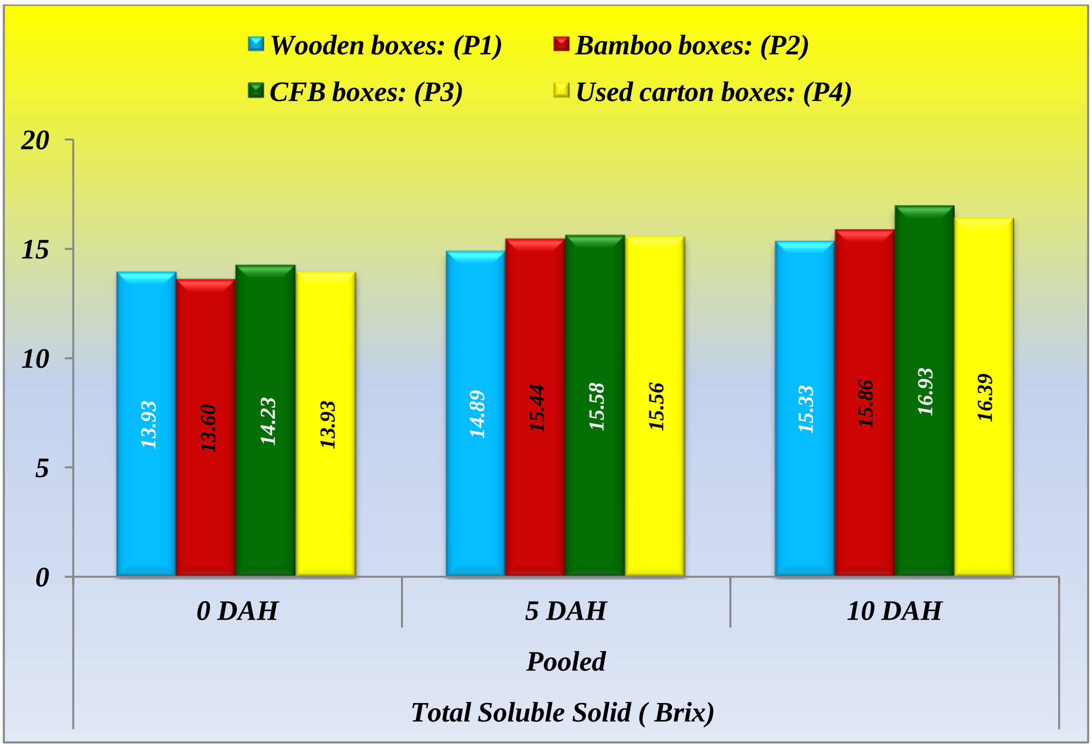


Figure 19: Effect of various packaging on Total Soluble Solid of organic pineapple after transport

Table 21: Interaction effect of various harvesting stages and packaging on Total Soluble Solid of organic pineapple after transport

Treatments	Total Soluble Solid (°Brix)								
	0 DAH			5 DAH			10 DAH		
	2014	2016	Pooled	2014	2016	Pooled	2014	2016	Pooled
H_1P_1	12.23	12.87	12.55	12.92	12.33	12.63	12.67	13.00	12.83
H_1P_2	13.17	12.87	13.02	13.67	13.50	13.58	13.67	14.00	13.83
H_1P_3	12.87	12.23	12.55	13.83	13.50	13.67	15.00	14.67	14.83
H_1P_4	12.92	12.92	12.92	13.50	13.17	13.33	14.17	13.58	13.88
H_2P_1	13.98	13.07	13.53	14.33	14.83	14.58	14.67	14.67	14.67
H_2P_2	12.83	12.67	12.75	15.33	15.33	15.33	15.50	16.00	15.75
H_2P_3	13.17	13.73	13.45	15.00	15.50	15.25	16.00	16.50	16.25
H_2P_4	13.17	13.53	13.35	14.33	15.17	14.75	15.67	15.67	15.67
H_3P_1	14.33	14.60	14.47	15.67	15.00	15.33	15.83	17.00	16.42
H_3P_2	14.17	13.98	14.08	15.50	15.67	15.58	17.25	16.00	16.63
H_3P_3	15.50	15.50	15.50	17.00	16.17	16.58	17.33	17.00	17.17
H_3P_4	14.27	15.13	14.70	16.33	16.50	16.42	17.17	16.33	16.75
H_4P_1	14.67	15.72	15.19	17.00	17.00	17.00	17.67	17.17	17.42
H_4P_2	14.17	14.98	14.58	16.67	17.83	17.25	16.83	17.67	17.25
H_4P_3	15.53	15.33	15.43	17.17	16.50	16.83	19.58	19.33	19.46
H_4P_4	15.07	14.43	14.75	18.17	17.33	17.75	19.17	19.33	19.25
Sem±	0.22	0.27	0.18	0.35	0.29	0.22	0.37	0.30	0.24
CD (P= 0.05)	0.66	0.78	0.50	1.01	0.83	0.64	1.09	0.87	0.68

(Latifah *et al*., 1999).

The interaction effect (Table 21) of various harvesting stages and packaging on Total Soluble Solids of pineapple at 0 DAH were found maximum under the treatments H_3P_3 (15.50 ^oBrix) followed by H_4P_3 (15.43 ^oBrix) and minimum was recorded under H_1P_1 and H_1P_3 (12.55 ^oBrix) each. At 5 DAH, the maximum (17.75 ^oBrix) interaction effect was recorded under H_4P_4 followed by H_4P_3 (17.25 ^oBrix) whereas the minimum was recorded under treatment H_1P_1 (12.63 ^oBrix). On the 10^{th} DAH the maximum (19.46 ^oBrix) was obtained from the treatment combination of H_4P_3 followed by H_3P_4 (19.25 ^oBrix) and the minimum was observed under H_1P_1 (12.83 ^oBrix).

4.2.2.4. *Total sugar (%)*

The results obtained on total sugar (%) revealed that there was a significant difference among the various harvesting stages and also showed an increasing trend along with the storage period (Table 22). On 0 DAH, it was apparent from the mean value data that the maximum (6.87%) total sugar was recorded in H_4 (1/2 colour development) followed by H_3 (1/4 colour development) with 6.68% and the minimum (6.10%) was recorded under the treatment H_1 (Fully matured but no colour development). On the 5^{th} DAH, the maximum mean value (9.41%) was recorded under the treatment H_3 followed by H_4 and the minimum was apparently recorded under the treatment H_1 with 7.16%. Furthermore, the mean differences in the parenthesis showed that H_3 gave the maximum of 2.73 followed by H_4 (2.38) and minimum (1.06) in H_1. However, on 10^{th} DAH, H_4 and H_3 gave the maximum mean value percentage of 11.09% and 11.00% respectively followed by H_2 (9.34%) and minimum was recorded in H_1 with 8.50%. In the parenthesis, H_3 gave the maximum (4.32) followed by H_2 (3.00) and minimum under H_1 (2.40) treatment. Kabir *et al*. (2010) observed that there was an increasing trend of total sugar in pineapple with the progress of storage period and was found maximum in optimum matured fruits as compared to those in premature fruits, which was in conformity with the present findings.

Total sugar content showed a significant increase as influenced by packaging (Table 22). At 0 DAH, the maximum (6.71%) total sugar (%) was obtained under the treatment P_3 (CFB boxes) followed by P_4 (used carton boxes) (6.61%) while the minimum (6.15%) was recorded under the treatment P_1 (wooden boxes). However, on 5^{th} DAH, the maximum (8.83%) was obtained under the treatment P_1 followed by P_4 and P_2 (8.32% and 8.29%) while the minimum was recorded under the treatment P_3 with 7.97%. The data in the parenthesis showed that P_1 gave the maximum (2.68) followed by P_2 (1.78) and minimum under P_3 (1.26). On the 10^{th} DAH, the maximum (10.85%) was recorded under P_1 followed by P_3 (9.85%) and the minimum was recorded under P_4 (9.59%). In the parenthesis, maximum (4.70) was recorded under P_1 followed by P_3 (3.14) and minimum under P_4 (2.98). The reason why the percentage of total sugar decreased on the 5^{th} and 10^{th} DAH in P_3 (CFB boxes) and P_4 (used carton boxes) as compared to other methods of packaging may be because it was more confined to an enclosed space and thus the breakdown of polysaccharides were slower, however, the increase of total sugar in P_1 (wooden boxes) and P_2 (bamboo boxes) at 5^{th} and 10^{th} DAH was due to more exposure of fruits in the open condition and hence the breakdown of polysaccharides and conversion of starch into sugar was rapidly taking place. This was supported by Wills *et al*. (1989) as they concluded that the increase in total sugar associated with the advancement of storage period was usually due to break down of polysaccharides and conversion of starch into sugar.

The interaction effect (Table 23) of various harvesting stages and packaging on total sugar (%) of pineapple at 0 DAH were found maximum under the treatments H_4P_3 (7.08%) followed by H_4P_2 and H_4P_4 (6.93%) each and the minimum under H_1P_1 (5.68%). At 5 DAH, the maximum (10.15%) was recorded under H_3P_4 followed by H_4P_1 (9.72%) and minimum under the

Table 22: Effect of various harvesting stages and packaging on Total sugar of organic pineapple after transport

Treatments	Total sugar (%)								
	0 DAH			5 DAH			10 DAH		
	2014	2016	Pooled	2014	2016	Pooled	2014	2016	Pooled
Harvesting stages									
Fully mature but no colour development: (H_1)	6.06	6.15	6.10	7.09	7.24	7.16 (1.06)	8.47	8.54	8.50 (2.40)
1/8 colour development: (H_2)	6.15	6.52	6.34	7.48	7.71	7.60 (1.26)	9.38	9.30	9.34 (3.00)
1/4 colour development: (H_3)	6.45	6.90	6.68	9.19	9.63	9.41 (2.73)	11.02	10.97	11.00 (4.32)
1/2 colour development: (H_4)	7.02	6.72	6.87	9.26	9.23	9.25 (2.38)	11.18	11.00	11.09 (4.22)
Sem±	0.17	0.12	0.11	0.18	0.17	0.13	0.45	0.40	0.30
CD (P= 0.05)	0.60	0.42	0.33	0.62	0.60	0.39	1.56	1.37	0.92
Packaging materials									
Wooden boxes: (P_1)	6.03	6.27	6.15	8.97	8.69	8.83 (2.68)	10.88	10.81	10.85 (4.70)
Bamboo boxes: (P_2)	6.45	6.58	6.51	8.11	8.48	8.29 (1.78)	9.63	9.63	9.63 (3.12)
CFB boxes: (P_3)	6.65	6.77	6.71	7.75	8.19	7.97 (1.26)	9.92	9.79	9.85 (3.14)
Used carton boxes: (P_4)	6.55	6.66	6.61	8.19	8.45	8.32 (1.71)	9.61	9.57	9.59 (2.98)
Sem±	0.03	0.02	0.02	0.18	0.16	0.12	0.20	0.23	0.15
CD (P= 0.05)	0.09	0.07	0.06	0.53	NS	0.34	0.60	0.66	0.43

Note: **NS = Non Significant**

Figures in the table are mean values and those in parenthesis are mean differences

Table 23: Interaction effect of various harvesting stages and packaging on Total sugar of organic pineapple after transport

Treatments	Total sugar (%)								
	0 DAH			5 DAH			10 DAH		
	2014	2016	Pooled	2014	2016	Pooled	2014	2016	Pooled
H_1P_1	5.63	5.72	5.68	7.76	8.12	7.94	9.65	9.80	9.72
H_1P_2	6.03	6.14	6.09	6.82	7.27	7.04	7.61	7.45	7.53
H_1P_3	6.31	6.41	6.36	7.10	6.56	6.83	8.43	8.57	8.50
H_1P_4	6.25	6.35	6.30	6.67	7.00	6.83	8.17	8.33	8.25
H_2P_1	5.72	6.34	6.03	8.34	9.02	8.68	10.64	10.50	10.57
H_2P_2	6.14	6.56	6.35	7.02	7.34	7.18	8.31	8.19	8.25
H_2P_3	6.41	6.67	6.54	7.23	7.88	7.56	9.67	9.80	9.74
H_2P_4	6.35	6.50	6.43	7.32	6.61	6.97	8.87	8.70	8.79
H_3P_1	6.27	6.50	6.38	9.52	8.41	8.96	11.17	11.08	11.13
H_3P_2	6.52	6.86	6.69	8.65	9.94	9.29	10.77	10.91	10.84
H_3P_3	6.57	7.15	6.86	8.74	9.72	9.23	11.21	10.80	11.00
H_3P_4	6.45	7.09	6.77	9.87	10.43	10.15	10.93	11.10	11.01
H_4P_1	6.50	6.54	6.52	10.24	9.20	9.72	12.07	11.86	11.97
H_4P_2	7.10	6.76	6.93	9.94	9.37	9.66	11.83	12.00	11.91
H_4P_3	7.30	6.87	7.08	7.95	8.61	8.28	10.35	10.00	10.17
H_4P_4	7.17	6.70	6.93	8.91	9.74	9.33	10.45	10.15	10.30
Sem±	0.06	0.05	0.04	0.36	0.31	0.24	0.41	0.45	0.30
CD (P= 0.05)	0.19	0.14	0.11	1.06	0.91	0.68	1.19	1.31	0.87

treatments H_1P_3 and H_1P_4 (6.83%) each. On the 10^{th} DAH, the maximum (11.97 and 11.91%) was recorded under the treatments H_4P_1 and H_4P_2 respectively, followed by H_3P_1 (11.13%) and minimum was recorded under treatment H_1P_2 of 7.53%.

4.2.2.5. *Reducing sugar (%)*

With regard to harvesting stages, it was recorded from the experiment that the reducing sugar (%) had a significant effect on all the dates of observation and showed an increasing trend with the progress of storage period (Table 24). On 0 DAH, the maximum mean value of 2.10% was recorded under the treatment H_2 followed by H_1 (2.04%) while the minimum was recorded under H_4 (1.23%). The maximum mean value on 5^{th} DAH was recorded under H_4 (3.51%) followed by H_3 (3.30%), and minimum under H_1 (2.90%). The values in the parenthesis on 5 DAH, showed a maximum (2.28) in H_4 followed by H_3 (1.99) and lowest (0.86) in H_1. Similarly, on the 10 DAH, the pertaining data of reducing sugar (%) was found maximum (3.89%) under the treatment H_4 followed by H_3 (3.60%) and minimum (3.23%) under $H_{1,}$ on 10 DAH maximum (2.66) was in H_4 followed by H_3 (2.19) and lowest under H_1 and H_2 (1.19) each. Gupta and Jawandha (2010), opined that there was a progressive increase in reducing sugar content of peach fruits picked at pre-optimum and optimum stages with the increase in storage period, which supports the present findings.

Packaging also showed a significant difference with an increasing trend as storage period progressed (Table 24). The maximum (1.80%) reducing sugar (%) at 0 DAH was recorded under the treatment P_3 (CFB boxes) followed by P_4 (used carton boxes) with 1.70% while the minimum was recorded under the treatment P_1 (Wooden boxes) with 1.55%. At 5 DAH, maximum reducing sugar was recorded under the treatment P_4 (used carton boxes) followed by P_3 (CFB boxes) with 3.27% and minimum (2.83%) under P_1 (Wooden boxes). Data pertaining to mean differences in 5 DAH registered

Table 24: Effect of various harvesting stages and packaging on Reducing sugar of organic pineapple after transport

Treatments	Reducing sugar (%)								
	0 DAH			5 DAH			10 DAH		
	2014	2016	Pooled	2014	2016	Pooled	2014	2016	Pooled
Harvesting stages									
Fully mature but no colour development: (H_1)	1.94	2.15	2.04	2.70	3.10	2.90 (0.86)	2.99	3.47	3.23 (1.19)
1/8 colour development: (H_2)	1.93	2.27	2.10	2.80	3.21	3.01 (0.91)	3.08	3.49	3.29 (1.19)
1/4 colour development: (H_3)	1.19	1.44	1.31	3.32	3.27	3.30 (1.99)	3.60	3.60	3.60 (2.29)
1/2 colour development: (H_4)	1.13	1.32	1.23	3.35	3.68	3.51 (2.28)	3.65	4.13	3.89 (2.66)
Sem±	0.01	0.01	0.01	0.07	0.09	0.06	0.09	0.08	0.06
CD (P= 0.05)	0.03	0.05	0.03	0.25	0.30	0.18	0.32	0.27	0.18
Packaging materials									
Wooden boxes: (P_1)	1.44	1.67	1.55	2.65	3.01	2.83 (1.28)	2.91	3.39	3.15 (1.60)
Bamboo boxes: (P_2)	1.51	1.75	1.63	3.04	3.17	3.10 (1.47)	3.32	3.50	3.41 (1.78)
CFB boxes: (P_3)	1.66	1.94	1.80	3.17	3.37	3.27 (1.47)	3.48	3.76	3.62 (1.82)
Used carton boxes: (P_4)	1.57	1.82	1.70	3.32	3.71	3.51 (1.81)	3.61	4.05	3.83 (2.13)
Sem±	0.01	0.01	0.01	0.06	0.07	0.04	0.06	0.07	0.04
CD (P= 0.05)	0.02	0.03	0.02	0.16	0.19	0.12	0.18	0.19	0.13

Note: **Figures in the table are mean values and those in parenthesis are mean differences**

Table 25: Interaction effect of various harvesting stages and packaging on Reducing sugar of organic pineapple after transport

Treatments	Reducing sugar (%)								
	0 DAH			5 DAH			10 DAH		
	2014	**2016**	**Pooled**	**2014**	**2016**	**Pooled**	**2014**	**2016**	**Pooled**
H_1P_1	1.77	1.97	1.87	2.53	2.93	2.73	2.80	3.35	3.07
H_1P_2	1.87	2.08	1.98	2.60	3.00	2.80	2.91	3.38	3.14
H_1P_3	2.12	2.36	2.24	2.66	3.04	2.85	2.87	3.41	3.14
H_1P_4	1.98	2.20	2.09	3.01	3.42	3.22	3.37	3.74	3.56
H_2P_1	1.76	2.10	1.93	2.21	3.13	2.67	2.45	3.38	2.92
H_2P_2	1.85	2.20	2.02	2.95	3.14	3.05	3.17	3.45	3.31
H_2P_3	2.10	2.47	2.29	3.01	3.25	3.13	3.34	3.42	3.38
H_2P_4	2.00	2.29	2.15	3.03	3.32	3.18	3.37	3.71	3.54
H_3P_1	1.15	1.37	1.26	3.08	2.96	3.02	3.02	3.35	3.18
H_3P_2	1.17	1.42	1.30	3.16	3.10	3.13	3.77	3.32	3.55
H_3P_3	1.24	1.52	1.38	3.50	3.17	3.33	3.85	3.49	3.67
H_3P_4	1.18	1.44	1.31	3.56	3.86	3.71	3.78	4.22	4.00
H_4P_1	1.10	1.22	1.16	2.77	3.02	2.89	3.39	3.47	3.43
H_4P_2	1.14	1.30	1.22	3.45	3.44	3.44	3.42	3.83	3.63
H_4P_3	1.17	1.42	1.30	3.52	4.02	3.77	3.87	4.70	4.28
H_4P_4	1.12	1.35	1.24	3.66	4.22	3.94	3.92	4.52	4.22
Sem±	0.02	0.02	0.01	0.11	0.13	0.09	0.12	0.13	0.09
CD (P= 0.05)	0.04	0.05	0.03	0.32	0.38	0.24	0.36	0.38	0.26

maximum under P_2 and P_3 (1.47) each and the minimum in P_4 (1.18). At 10 DAH, the maximum (3.83%) was exerted by P_4 followed by P_3 (3.62%) and minimum was found under P_1 (3.15%), the values in the parenthesis also gave the highest (2.13) in P_4 followed by P_3 (1.82) and minimum under P_1 (1.60). Kumar *et al.* (2007) from their experiment with guava in different packing materials concluded that reducing sugar increased during storage period when stored in different packaging materials, which supports the present finding.

The interaction effect between harvesting stages and packaging (Table 25) on reducing sugar at 0 DAH was found maximum under the treatment H_2P_3 with 2.29% followed by H_2P_4 (2.15%) and minimum under H_4P_1 (1.16%). During 5^{th} DAH, the maximum of 3.94% was recorded under H_4P_4 followed by H_4P_3 (3.77%) and the minimum was observed under H_1P_1 (2.73%). However at 10 DAH, the maximum (4.28%) value was recorded under the treatment H_4P_3 which was then followed by H_4P_4 (4.22%) and H_1P_1 gave the minimum value of 3.07%.

4.2.2.6. *Non reducing sugar (%)*

The experimental results pertaining to non reducing sugar showed that there was a significant difference among the treatments and also revealed an increasing trend with the progress of storage period (Table 26). The maximum non reducing sugar at 0 DAH was found in treatment H_4 (1/2 colour development) with 5.36% followed by H_3 (1/4 colour development) and minimum under H_1 (fully mature but no colour development) with 3.86%. H_3 (1/4 colour development) exhibited the highest (5.81%) during 5^{th} DAH which was followed by H_4 (1/2 colour development) (5.45%) while the minimum was recorded under H_1 (Fully matured but no colour development) with 4.05%. Parenthesis value also revealed the highest value in H_3 (0.71) followed by H_2 (0.33) while the minimum was recorded under the treatment H_4 (0.09). At 10 DAH, maximum value (7.03%) was recorded in treatment H_3 followed by H_4 (6.84%) and minimum under H_1 (5.01%), mean differences in the

Table 26: Effect of various harvesting stages and packaging on Non reducing sugar of organic pineapple after transport

Treatments	Non reducing sugar (%)								
	0 DAH			5 DAH			10 DAH		
	2014	2016	Pooled	2014	2016	Pooled	2014	2016	Pooled
Harvesting stages									
Fully mature but no colour development: (H_1)	3.91	3.80	3.86	4.17	3.93	4.05 (0.19)	5.21	4.81	5.01 (1.15)
1/8 colour development: (H_2)	4.02	4.04	4.03	4.44	4.28	4.36 (0.33)	5.98	5.51	5.75 (1.72)
1/4 colour development: (H_3)	5.00	5.19	5.10	5.58	6.03	5.81 (0.71)	7.05	7.01	7.03 (1.93)
1/2 colour development: (H_4)	5.59	5.12	5.36	5.62	5.28	5.45 (0.09)	7.15	6.53	6.84 (1.48)
Sem±	0.02	0.02	0.02	0.19	0.15	0.12	0.39	0.40	0.28
CD (P= 0.05)	0.07	0.08	0.05	0.64	0.52	0.37	1.35	1.40	0.86
Packaging materials									
Wooden boxes: (P_1)	4.36	4.38	4.37	6.00	5.39	5.70 (1.33)	7.57	7.05	7.31(2.94)
Bamboo boxes: (P_2)	4.69	4.59	4.64	4.81	5.04	4.93 (0.29)	6.00	5.83	5.92 (1.28)
CFB boxes: (P_3)	4.74	4.59	4.66	4.35	4.58	4.47 (-0.19)	6.11	5.74	5.92 (1.26)
Used carton boxes: (P_4)	4.73	4.60	4.67	4.64	4.50	4.57 (-0.10)	5.70	5.25	5.47 (0.80)
Sem±	0.03	0.02	0.02	0.17	0.15	0.11	0.19	0.21	0.14
CD (P= 0.05)	0.08	0.07	0.05	0.48	0.43	0.31	0.55	0.61	0.40

Note: **Figures in the table are mean values and those in parenthesis are mean differences**

Table 27: Interaction effect of various harvesting stages and packaging on Non reducing sugar of organic pineapple after transport

Treatments	Non reducing Sugar (%)								
	0 DAH			5 DAH			10 DAH		
	2014	2016	Pooled	2014	2016	Pooled	2014	2016	Pooled
H_1P_1	3.67	3.57	3.62	4.97	4.93	4.95	6.51	6.13	6.32
H_1P_2	3.95	3.85	3.90	4.01	4.05	4.03	4.47	3.86	4.17
H_1P_3	3.97	3.85	3.91	4.21	3.34	3.78	5.28	4.91	5.09
H_1P_4	4.05	3.95	4.00	3.48	3.39	3.44	4.56	4.36	4.46
H_2P_1	3.77	4.03	3.90	5.83	5.59	5.71	7.78	6.76	7.27
H_2P_2	4.08	4.14	4.11	3.86	3.98	3.92	4.88	4.50	4.69
H_2P_3	4.09	3.98	4.04	4.01	4.40	4.21	6.02	6.06	6.04
H_2P_4	4.13	4.00	4.07	4.08	3.13	3.60	5.23	4.74	4.98
H_3P_1	4.86	4.87	4.86	6.11	5.17	5.64	7.75	7.35	7.55
H_3P_2	5.08	5.16	5.12	5.22	6.49	5.86	6.65	7.20	6.93
H_3P_3	5.07	5.35	5.21	4.98	6.23	5.60	6.99	6.94	6.97
H_3P_4	5.00	5.37	5.19	5.99	6.24	6.12	6.79	6.53	6.66
H_4P_1	5.13	5.05	5.09	7.10	5.87	6.49	8.25	7.97	8.11
H_4P_2	5.66	5.19	5.42	6.17	5.64	5.90	7.99	7.76	7.87
H_4P_3	5.83	5.17	5.50	4.21	4.35	4.28	6.16	5.04	5.60
H_4P_4	5.74	5.09	5.41	4.99	5.24	5.12	6.21	5.35	5.78
Sem±	0.06	0.05	0.04	0.33	0.29	0.22	0.38	0.41	0.28
CD (P= 0.05)	0.17	0.14	0.11	0.96	0.86	0.63	1.11	1.21	0.80

parenthesis was maximum (1.93) in H_3 followed by H_2 (1.72) and minimum was recorded in H_1 (1.15). Dhar *et al.* (2008) opined that the highest non reducing sugar was recorded in stage III pineapple fruits while it was found minimum in stage I (initial stage). Singleton and Gortner, (1965) observed similar results in developing pineapple fruits.

Data pertaining to non reducing sugar showed a significant difference among various methods of packaging (Table 26), and was apparent from the data that on 0 DAH, the maximum (4.67%) results were shown under the treatment P_4 (used carton boxes) followed by P_3 (CFB boxes) with 4.66% while the minimum was recorded under P_3 with 4.37%. On the 5^{th} DAH, highest (5.70%) was calculated in P_1 (wooden boxes) followed by P_2 (bamboo boxes) with 4.93% and minimum under P_3 (4.47%). However, the mean differences in the parenthesis was recorded to be highest in P_1 (1.33) followed by P_2 (0.29) and the minimum in P_4 (-0.10). On the 10 DAH, the data pertaining to non reducing sugar showed the maximum value under the treatment P_1 (Wooden boxes) of 7.31% followed by P_2 and P_3 with 5.92% each and the minimum was recorded under P_4 with 5.47%. Parenthesis results revealed that the highest value was recorded in P_1 with 2.94 followed by P_2 (1.28) and lowest under P_4 (0.80).

The interaction data obtained from non reducing sugar (Table 27) between harvesting and packaging at 0 DAH was maximum in treatments H_4P_3 (5.50%) followed by H_4P_2 (5.42%) while the minimum value was recorded in H_1P_1 (3.62%). On 5^{th} DAH, H_4P_1 gave the highest (6.49%) non-reducing sugar content followed by H_3P_4 with 6.12% and lowest was in H_1P_4 (3.44%). However, at the 10 DAH the maximum level of non reducing sugar was recorded under the treatment H_4P_1 (8.11%) followed by H_4P_2 (7.87%) and the minimum was observed under the treatment H_1P_2 (4.71).

4.2.2.7. *Titratable acidity (%)*

The experimental results pertaining to Titratable acidity showed that there was a significant difference among the treatments and with the progress storage period, the acidity percentage decreased (Table 28 & Fig. 20). The maximum (0.63%) Titratable acidity on harvesting stages at 0 DAH was found under treatment H_1 (Fully mature but no colour development) which was followed by H_2 (1/8 colour development) with 0.56% and the minimum was recorded under treatment H_4 (1/2 colour development) with 0.35%. Similarly, on the 5^{th} DAH, maximum (0.44%) was found under treatment H_1 (Fully mature but no colour development) which was followed by H_2 (1/8 colour development) with 0.43% and the minimum was recorded under treatment H_4 (1/2 colour development) with 0.35%. According to the data in the parenthesis, H_4 gave the least decreased value (-0.02) and H_1 had the most decreased value (-0.19). Likewise, at 10 DAH, the maximum Titratable acidity on harvesting stages was also found under treatment H_1 (Fully mature but no colour development) with 0.36 % followed by H_2 (1/8 colour development) (0.35%) and the minimum was recorded under treatment H_4 (1/2 colour development) with 0.26%, mean difference values showed that H_4 gave the least (-0.11) decreased value and H_2 gave the highest decreased value (-0.27). A decrease in acidity during pineapple fruit ripening might due to rapid utilization of acids as substrate during respiration where it has been converted to sugars as found in Mauritius pineapple fruit (Fernando & Silva, 2000).

The packaging also showed a significant difference with a decreasing trend during the storage period (Table 28 & Fig. 21). The maximum acidity content (0.57) at 0 DAH was recorded under the treatment P_1 (wooden boxes) followed by P_2 (bamboo boxes) with 0.52% and minimum (0.42%) was recorded under P_3 (CFB boxes). During the 5^{th} day of analysis, the highest mean value was recorded under P_2 (bamboo boxes) with 0.43% followed by P_1 (wooden boxes) with 0.42% and minimum (0.38) under P_3 (CFB boxes).

Table 28: Effect of various harvesting stages and packaging on Titratable acidity of organic pineapple after transport

Treatments	Titratable acidity (%)								
	0 DAH			5 DAH			10 DAH		
	2014	2016	Pooled	2014	2016	Pooled	2014	2016	Pooled
Harvesting stages									
Fully mature but no colour development: (H_1)	0.62	0.64	0.63	0.43	0.45	0.44 (-0.19)	0.35	0.36	0.36 (-0.27)
1/8 colour development: (H_2)	0.57	0.55	0.56	0.42	0.44	0.43 (-0.13)	0.34	0.36	0.35 (-0.21)
1/4 colour development: (H_3)	0.42	0.44	0.43	0.38	0.42	0.40 (-0.03)	0.29	0.33	0.31 (-0.12)
1/2 colour development: (H_4)	0.38	0.35	0.37	0.35	0.35	0.35 (-0.02)	0.26	0.27	0.26 (-0.11)
Sem±	0.003	0.007	0.004	0.006	0.006	0.004	0.005	0.006	0.004
CD (P= 0.05)	0.010	0.025	0.012	0.022	0.021	0.014	0.017	0.020	0.011
Packaging materials									
Wooden boxes: (P_1)	0.57	0.58	0.57	0.41	0.43	0.42 (-0.15)	0.32	0.35	0.33 (-0.24)
Bamboo boxes: (P_2)	0.52	0.52	0.52	0.42	0.44	0.43 (-0.09)	0.32	0.34	0.33 (-0.19)
CFB boxes: (P_3)	0.42	0.41	0.42	0.37	0.39	0.38 (-0.04)	0.29	0.31	0.30 (-0.12)
Used carton boxes: (P_4)	0.48	0.47	0.47	0.39	0.40	0.39 (-0.08)	0.30	0.32	0.31 (-0.16)
Sem±	0.005	0.005	0.004	0.010	0.008	0.006	0.009	0.008	0.006
CD (P= 0.05)	0.015	0.014	0.010	0.029	0.023	0.018	0.026	0.023	0.017

Note: **Figures in the table are mean values and those in parenthesis are mean differences**

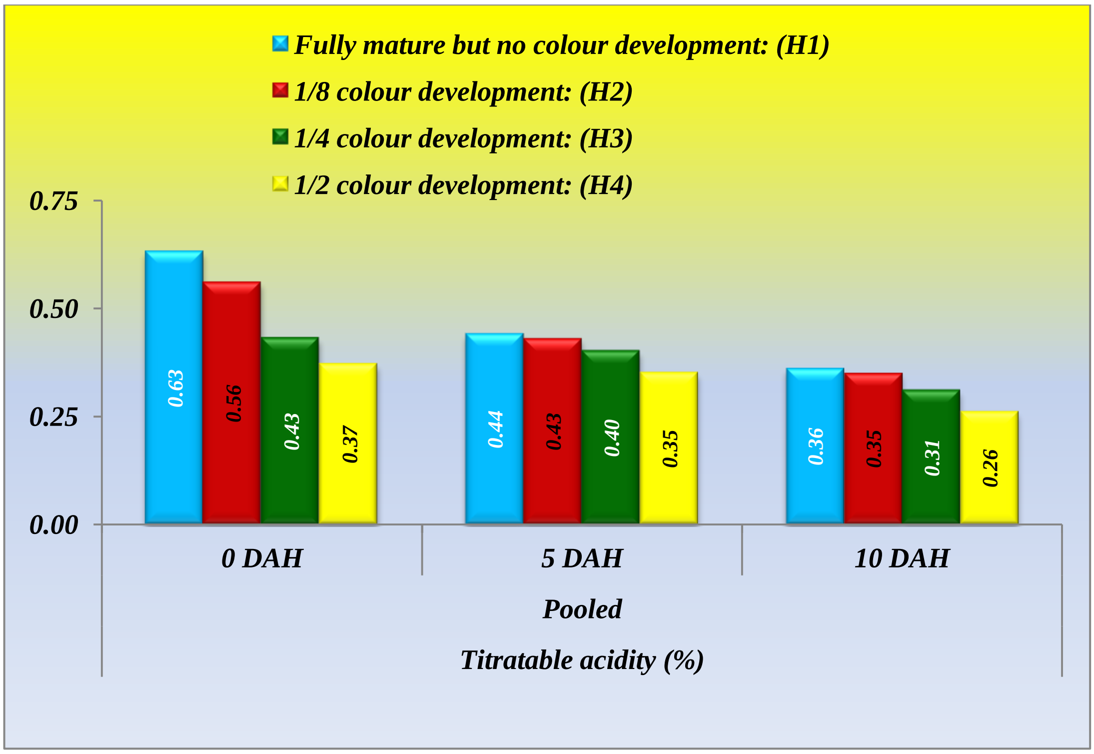


Figure 20: Effect of various harvesting stages on Titratable Acidity of organic pineapple after transport

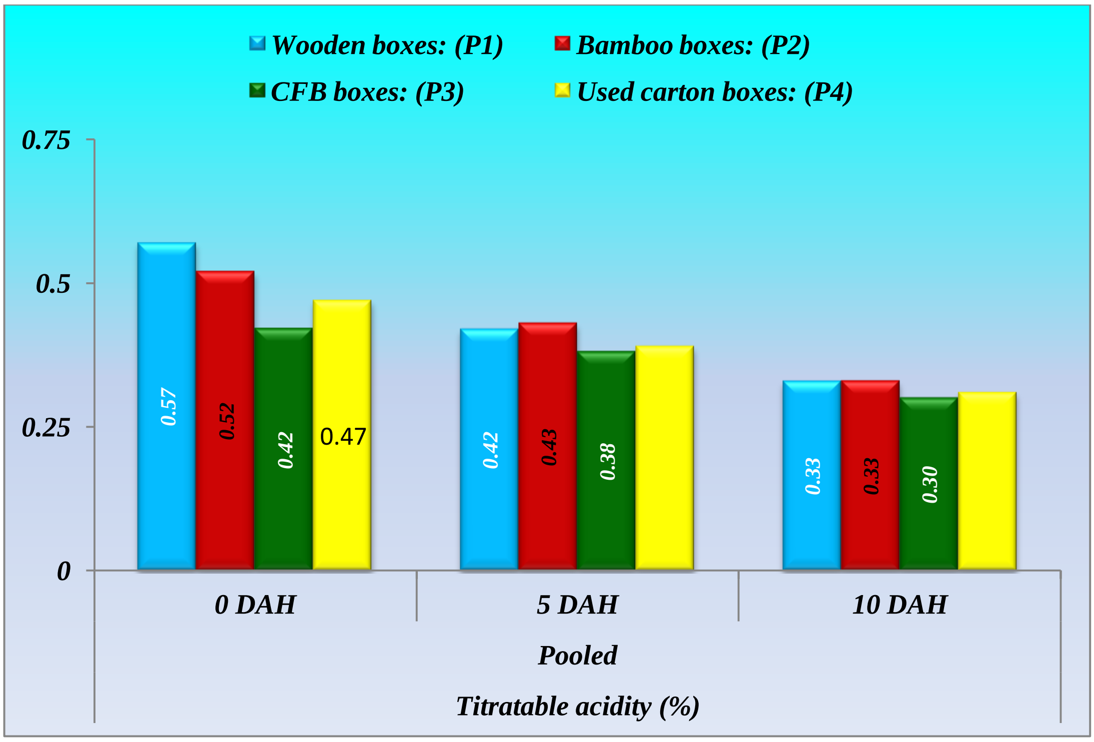


Figure 21: Effect of various packaging on Titratable Acidity of organic pineapple after transport

Table 29: Interaction effect of various harvesting stages and packaging on Titratable acidity of organic pineapple after transport

Treatments	Titratable acidity (%)								
	0 DAH			5 DAH			10 DAH		
	2014	2016	Pooled	2014	2016	Pooled	2014	2016	Pooled
H_1P_1	0.68	0.72	0.70	0.45	0.46	0.46	0.37	0.39	0.38
H_1P_2	0.65	0.67	0.66	0.37	0.36	0.36	0.27	0.26	0.26
H_1P_3	0.56	0.56	0.56	0.44	0.47	0.46	0.36	0.39	0.38
H_1P_4	0.60	0.62	0.61	0.48	0.50	0.49	0.40	0.42	0.41
H_2P_1	0.62	0.61	0.62	0.44	0.46	0.45	0.36	0.38	0.37
H_2P_2	0.60	0.58	0.59	0.52	0.54	0.53	0.42	0.44	0.43
H_2P_3	0.50	0.48	0.49	0.35	0.38	0.37	0.27	0.30	0.29
H_2P_4	0.55	0.52	0.54	0.37	0.39	0.38	0.29	0.31	0.30
H_3P_1	0.52	0.55	0.54	0.33	0.42	0.38	0.23	0.34	0.29
H_3P_2	0.42	0.44	0.43	0.43	0.44	0.44	0.33	0.34	0.34
H_3P_3	0.34	0.36	0.35	0.38	0.40	0.39	0.30	0.32	0.31
H_3P_4	0.40	0.42	0.41	0.39	0.41	0.40	0.31	0.33	0.32
H_4P_1	0.45	0.42	0.43	0.43	0.36	0.39	0.33	0.28	0.30
H_4P_2	0.42	0.40	0.41	0.37	0.43	0.40	0.27	0.33	0.30
H_4P_3	0.30	0.26	0.28	0.29	0.32	0.31	0.22	0.24	0.23
H_4P_4	0.36	0.32	0.34	0.30	0.30	0.30	0.21	0.22	0.22
Sem±	0.010	0.010	0.007	0.020	0.015	0.013	0.018	0.016	0.012
CD (P= 0.05)	0.030	0.028	0.020	0.058	0.045	0.036	0.052	0.045	0.034

Highest decreased value was in P_1 (-0.15) and lowest decreased value was under P_3 (-0.04). And at 10th DAH, the maximum was recorded under the treatment P_1 and P_2 with 0.33% each while the minimum was recorded under P_3 (0.30%). As per the parenthesis data, the highest decreased value was recorded under P_1 (-0.24) followed by P_2 (-0.19) and lowest decreased value under P_3 (-0.12). Burton (1982) opined that the TTA (total titratable acidity) value which is a quantitative measure of the organic acid, decreases with senescence process, this is in conformity with the present findings, where titratable acidity decrease with maturity stage. Latifah *et al.* (1999) experimented on two packaging systems in minimally processed pineapple and found the overall total titratable acidity value increased after 2 weeks but decreased with prolonged storage, which is in conformity with the present finding.

The interaction effect of various harvesting stages and packaging on Titratable acidity of pineapple (Table 29) at 0 DAH were found maximum under the treatments H_1P_1 (0.70%) followed by H_1P_2 (0.66%) and minimum was in H_4P_3 (0.28%). At 5th DAH, the maximum value was under H_2P_2 (0.53%) followed by H_1P_4 (0.49%) and minimum under H_4P_4 (0.30%). At 10 DAH, maximum Titratable acidity (%) were recorded under H_2P_2 (0.43%) followed by H_1P_4 (0.41%) and minimum in H_4P_4 (0.22).

4.2.2.8. ***Ascorbic Acid (mg/100ml juice)***

The results obtained from ascorbic acid (Table 30 & Fig. 22) showed a significant difference among various harvesting stages and had an increasing trend on the 5th DAH but gradually declined on the 10th DAH. At 0 DAH, the highest ascorbic acid content (9.69) was observed from H_1 (Fully mature but no colour development) followed by H_2 (1/8 colour development) with 8.67 and the minimum was recorded under the treatment H_4 (1/2 colour development) (5.46). On 5 DAH, there was a significant increase in ascorbic acid content with the highest value in H_1 (9.97) followed by H_2 (9.02) and lowest in H_4 (6.16). Mean difference was highest in H_4 (0.70) followed by H_3 (0.42) and lowest in H_1 (0.28). At 10 DAH, the given ascorbic acid content was found to have maximum in treatment H_1 with 8.76 mg/100ml followed by H_2 (7.38) and minimum in H_4 (5.76). Data indicated in the parenthesis revealed that there was a decreasing trend on the 10^{th} day of analysis, where the maximum (0.30) was found in H_4 followed by H_1 (-0.93) and minimum in H_2 (-0.29). This finding was in line with the finding of Belitz and Grosch (1992), where they observed that vitamin C content of fruits decreased remarkably during maturation stage due to oxidation.

The data pertaining to Ascorbic acid as influences by packaging showed a significant difference among treatments on all dates of observations except on 10 DAH there was a decreasing trend during the storage period (Table 30 & Fig. 23). On 0 DAH, the maximum (7.96) ascorbic acid content was found under the treatment P_3 (CFB boxes) followed by P_4 (used carton boxes) and the minimum was observed under treatment P_2 (bamboo boxes) with 7.49. On the 5^{th} DAH, P_1 gave the highest ascorbic content (8.62) followed by P_2 (8.44) and the minimum was recorded under P_3 (7.82). The data in the parenthesis showed the highest in P_2 (0.95) followed by P_1 (0.92) and lowest in P_3 (-0.14). However, it was non significant. Latifah *et al.* (1999) also observed a decreasing trend of the ascorbic acid during storage of minimally processed pineapple though no significant difference was observed between the two packing systems at weekly intervals.

The interaction effect of harvesting stages and packaging showed a significant result on ascorbic acid content (Table 31). As per the result obtained, the maximum ascorbic acid content at 0 DAH was recorded under the treatments H_1P_3 (9.88 mg/100ml juice) followed by H_1P_4 (9.75 mg/100ml juice) and the minimum were recorded under treatment H_4P_2 (5.19 mg/100ml juice). On the 5^{th} DAH, H_1P_1 exhibited the maximum (10.18 mg/100ml juice) followed by H_1P_4 (10.14 mg/100ml juice) and minimum under H_4P_3 (5.63

Table 30: Effect of various harvesting stages and packaging on Ascorbic acid of organic pineapple after transport

Treatments	Ascorbic acid (mg/100ml juice)								
	0 DAH			5 DAH			10 DAH		
	2014	2016	Pooled	2014	2016	Pooled	2014	2016	Pooled
Harvesting stages									
Fully mature but no colour development: (H_1)	9.82	9.56	9.69	10.03	9.90	9.97 (0.28)	8.64	8.87	8.76 (-0.93)
1/8 colour development: (H_2)	8.52	8.82	8.67	8.93	9.12	9.02 (0.35)	7.31	7.45	7.38 (-1.29)
1/4 colour development: (H_3)	7.05	7.25	7.15	7.37	7.76	7.57 (0.42)	5.97	5.88	5.92 (-1.23)
1/2 colour development: (H_4)	5.60	5.32	5.46	6.31	6.01	6.16 (0.70)	5.71	5.82	5.76 (0.30)
Sem±	0.02	0.01	0.01	0.09	0.10	0.07	0.22	0.19	0.15
CD (P= 0.05)	0.05	0.03	0.03	0.31	0.33	0.20	0.76	0.67	0.45
Packaging materials									
Wooden boxes: (P_1)	7.70	7.71	7.70	8.52	8.72	8.62 (0.92)	7.09	7.28	7.19 (-0.51)
Bamboo boxes: (P_2)	7.49	7.50	7.49	8.40	8.48	8.44 (0.95)	6.99	7.03	7.01 (-0.48)
CFB boxes: (P_3)	7.97	7.95	7.96	7.88	7.77	7.82 (-0.14)	6.77	6.82	6.79 (-1.17)
Used carton boxes: (P_4)	7.82	7.79	7.81	7.84	7.82	7.83 (0.02)	6.79	6.88	6.84 (-0.97)
Sem±	0.02	0.01	0.01	0.13	0.12	0.09	0.14	0.13	0.10
CD (P= 0.05)	0.04	0.02	0.02	0.38	0.34	0.25	NS	NS	NS

Note: **NS = Non Significant**

Figures in the table are mean values and those in parenthesis are mean differences

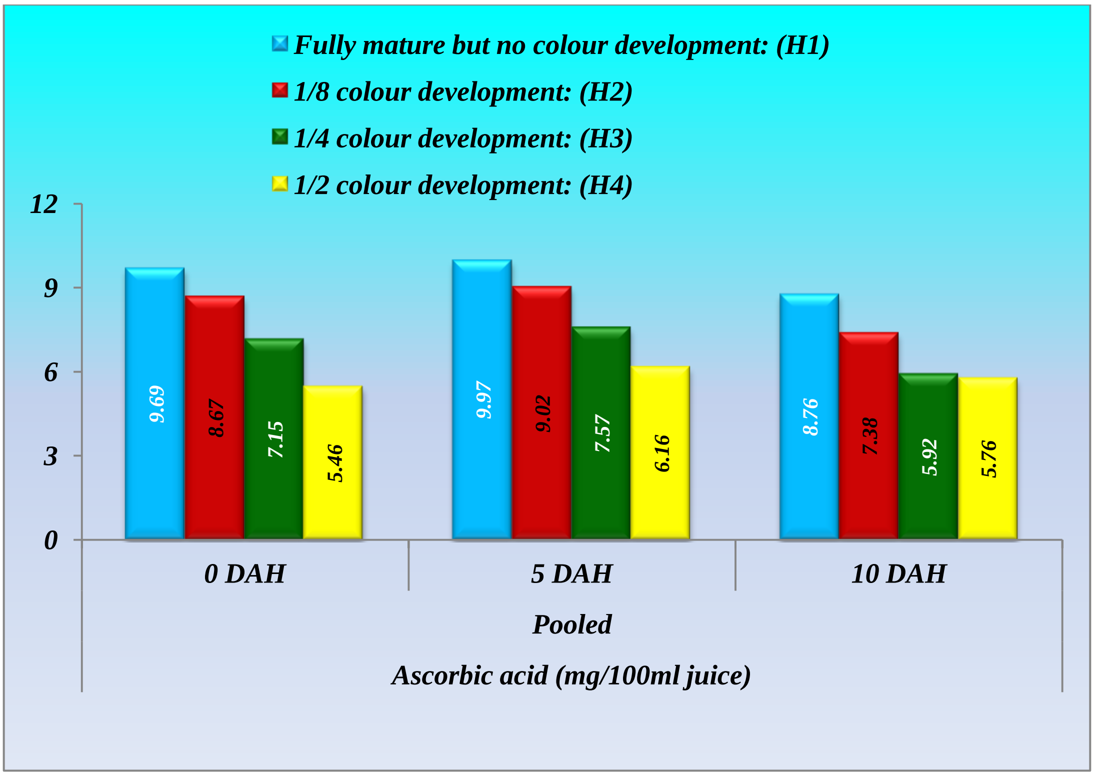


Figure 22: Effect of various harvesting stages on Ascorbic Acid of organic pineapple after transport

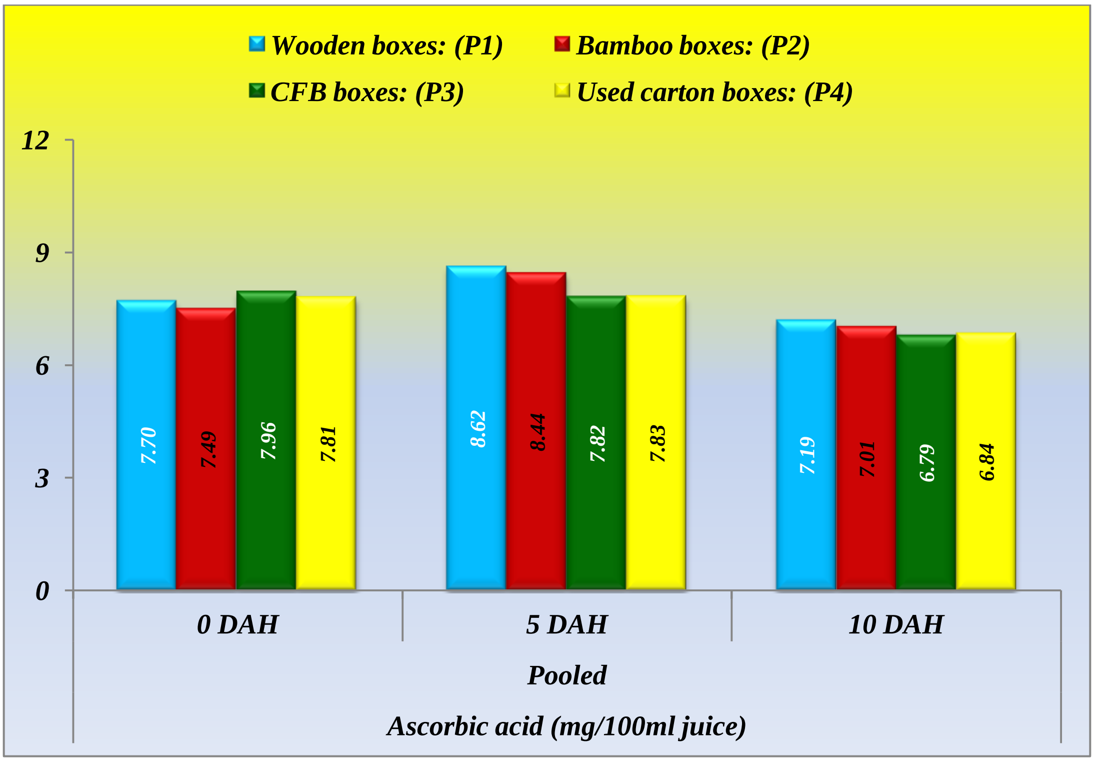


Figure 23: Effect of various packaging on Ascorbic Acid of organic pineapple after transport

Table 31: Interaction effect of various harvesting stages and packaging on Ascorbic acid of organic pineapple after transport

Treatments	Ascorbic acid (mg/100ml juice)								
	0 DAH			5 DAH			10 DAH		
	2014	2016	Pooled	2014	2016	Pooled	2014	2016	Pooled
H_1P_1	9.80	9.52	9.66	10.20	10.17	10.18	8.57	8.98	8.78
H_1P_2	9.60	9.35	9.48	9.80	9.68	9.74	8.32	8.67	8.49
H_1P_3	10.00	9.76	9.88	9.83	9.77	9.80	8.30	8.72	8.51
H_1P_4	9.87	9.62	9.75	10.30	9.98	10.14	9.38	9.12	9.25
H_2P_1	8.50	8.82	8.66	9.57	10.12	9.85	7.53	7.86	7.70
H_2P_2	8.30	8.58	8.44	9.32	10.04	9.68	7.21	7.15	7.18
H_2P_3	8.70	9.03	8.87	8.90	8.56	8.73	7.92	8.02	7.97
H_2P_4	8.57	8.85	8.71	7.92	7.76	7.84	6.58	6.76	6.67
H_3P_1	6.98	7.22	7.10	7.54	8.10	7.82	5.93	6.05	5.99
H_3P_2	6.76	6.98	6.87	7.80	8.22	8.01	6.21	6.14	6.18
H_3P_3	7.32	7.48	7.40	6.93	7.32	7.13	5.74	5.23	5.49
H_3P_4	7.15	7.32	7.24	7.20	7.41	7.30	5.98	6.10	6.04
H_4P_1	5.52	5.27	5.40	6.78	6.48	6.63	6.32	6.24	6.28
H_4P_2	5.30	5.08	5.19	6.69	5.98	6.34	6.21	6.17	6.19
H_4P_3	5.87	5.54	5.71	5.83	5.42	5.63	5.12	5.30	5.21
H_4P_4	5.70	5.38	5.54	5.92	6.13	6.03	5.20	5.56	5.38
Sem±	0.03	0.01	0.02	0.26	0.23	0.18	0.28	0.27	0.20
CD (P= 0.05)	0.09	0.04	0.05	0.77	0.68	0.50	0.83	0.78	0.56

mg/100ml juice). At 10 DAH, the maximum ascorbic acid content on harvesting stages and packaging materials were recorded under H_1P_4 (9.25 mg/100ml juice) followed by H_1P_1 (8.78 mg/100ml juice) and minimum under H_4P_3 (5.21mg/100ml juice).

4.2.2.9. Organoleptic test after transport (New Delhi)

4.2.2.9.1. Appearance

From the data in Table 32, Fig. 24, the maximum rating for appearance was recorded under the treatment H_3 (1/4th colour development) with 3.03 and 3.90 with their mean value as 3.46 during 2014 and 2016 respectively and the minimum was rated under the treatment H_1 (fully matured but no colour development) with 1.90 and 2.70 and their mean as 2.30 during 2014 and 2016 respectively.

In case of packaging **(**Table 32, Fig. 25), the maximum appearance rating was found in P_3 (CFB boxes) and P_1 (wooden boxes) with 2.88 and 3.60 during the year 2014 and 2016 respectively while, the minimum was found in P_2 (bamboo boxes) and P_3 (CFB boxes) during 2014 and 2016.

The interaction between harvesting stages and packaging on appearance **(**Table 33**)** was found significant and the maximum was recorded under the treatments H_3P_1 and H_3P_4 with 3.60 and 4.10 during 2014 and 2016. The minimum was found under the treatments H_1P_4 with 1.50 during 2014 and 2.60 each in H_1P_2 and H_1P_4 in 2016.

4.2.2.9.2. Aroma

The ratings recorded for aroma evaluation **(**Table 32, Fig. 24**)** was found to have a significant effect on the harvesting stages of pineapple. The maximum value was recorded under the treatment H_4 (1/2 colour development) and H_3 (1/4 colour development) with 3.65 and 3.53 during 2014 and 2016 respectively. However, the minimum was rated under the treatment H_1 (fully matured but no colour development) with 2.18 and 2.60 and a mean of 2.39 during 2014 and 2016 respectively.

Packaging also showed a significant difference with respect to aroma ratings (Table 32, Fig. 25). The maximum was recorded under the treatment P_3 (CFB boxes) and P_1 (wooden boxes) with 3.15 and 3.50 respectively during 2014 and 2016 while, the minimum was recorded under the treatments P_1 (wooden boxes) and P_4 (2^{nd} hand carton boxes) of 2.95 and 2.95 respectively during 2014 and 2016.

The pertaining data as influence of interaction between harvesting stages and packaging (Table 33) on the aroma ratings, showed significant impact. The maximum was recorded under the treatments H_4P_4 and H_2P_2 with 4.00 and 4.00 each during 2014 and 2016 respectively. And the minimum was found under the treatments H_1P_1 and H_1P_4 with 2.00 and 2.10 during 2014 and 2016 respectively.

4.2.2.9.3. Sweetness

The sweetness level of the fruits showed a significant effect by different harvesting stages (Table 32, Fig. 24). The maximum were recorded under the treatments H_4 (1/2 colour development) and H_2 (1/8 colour development) with 3.80 and 3.63 during 2014 and 2016 respectively. However, the minimum rating was recorded in treatment H_1 (fully matured but no colour development) with 1.68 and 2.30 and a mean of 1.99 during 2014 and 2016 respectively.

The sweetness level of the fruits as influenced by packaging was significant during 2014 and non-significant (NS) during 2016 (Table 32, Fig. 25). Maximum value during 2014 was found in treatment P_3 (CFB boxes) with 3.10 and the minimum was recorded in P_1 (wooden boxes) of 2.68.

The interaction between harvesting stages and packaging (Table 33) was found to significantly influence level of sweetness of fruits. During 2014, the maximum value was found in treatment H_4P_4 with 4.20 and during 2016, the maximum was found under treatments H_2P_2 which was at par with H_3P_3 and H_4P_3 having 3.90 value each. While the minimum level during 2014 was found under the treatment H_1P_3 that was at par with H_1P_4 with 1.50 and during 2016, the minimum was recorded under the treatment H_1P_1 with 2.10.

4.2.2.9.4. Fibre content

The fibre content in the fruits showed significant difference with respect to harvesting stages in both the years **(**Table 32, Fig. 24**)**. The maximum rating was recorded under the treatment H_4 (1/2 colour development) with 3.63 and 3.30 and mean of 3.46 during 2014 and 2016 respectively and the minimum was recorded under H_1 (fully matured but no colour development) with 1.85 and 2.45 and mean of 2.15 respectively during 2014 and 2016.

The packaging showed significant influence on fibre content during 2014 but was non-significant (NS) during 2016 **(**Table 32, Fig. 25**)**. The maximum rating was recorded under P_4 (2^{nd} hand carton boxes) with 3.20 and the minimum was found in treatments P_1 (wooden boxes) and P_2 (bamboo boxes) with 2.88 rating each.

Harvesting stages and packaging interaction showed a significant influence on the fibre content of the fruits (Table 33). The maximum rating was recorded under the treatment H_4P_1 with 3.90 and 3.70 and means of 3.80 during 2014 and 2016 respectively. However, the minimum was found under H_1P_1 with 1.70 and 2.00 and their mean of 1.85 during 2014 and 2016 respectively.

4.2.2.9.5. Overall acceptability

The overall acceptability of the fruits showed a significant difference as influenced by different harvesting stages **(**Table 32, Fig. 24**)**. The maximum (3.48) was recorded in the treatments H_4 (1/2 colour development) followed by H_3 (1/4 colour development) with 3.39 and the minimum rating was recorded rated under the treatment H_1 (fully matured but no colour development) with 2.21.

Table 32: Effect of various treatments on organoleptic parameters of organic pineapple fruit after transport

Treatments	Appearance			Aroma			Sweetness			Fibre content			Overall acceptability		
	2014	2016	Pooled	2014	2016	Pooled	2014	2016	Pooled	2014	2016	Pooled	2014	2016	Pooled
Harvesting stages															
Fully mature but no colour development: (H_1)	1.90	2.70	2.30	2.18	2.60	2.39	1.68	2.30	1.99	1.85	2.45	2.15	1.90	2.51	2.21
1/8 colour development: (H_2)	2.60	3.55	3.08	3.25	3.45	3.35	2.93	3.63	3.28	3.08	3.13	3.10	2.96	3.44	3.20
1/4 colour development: (H_3)	3.03	3.90	3.46	3.35	3.53	3.44	3.28	3.48	3.38	3.45	3.13	3.29	3.28	3.51	3.39
1/2 colour development: (H_4)	2.93	3.65	3.29	3.65	3.43	3.54	3.80	3.43	3.61	3.63	3.30	3.46	3.50	3.45	3.48
Sem±	0.12	0.05	0.06	0.08	0.18	0.10	0.14	0.04	0.07	0.06	0.03	0.03	0.10	0.07	0.06
CD (P= 0.05)	0.41	0.18	0.20	0.28	0.63	0.31	0.48	0.14	0.22	0.20	0.11	0.10	0.33	0.23	0.19
Packaging materials															
Wooden boxes: (P_1)	2.70	3.60	3.15	2.95	3.50	3.23	2.68	3.20	2.94	2.88	3.03	2.95	2.80	3.33	3.07
Bamboo boxes: (P_2)	2.30	3.35	2.83	3.23	3.43	3.33	2.93	3.03	2.98	2.88	2.90	2.89	2.83	3.18	3.00
CFB boxes: (P_3)	2.88	3.28	3.08	3.15	3.13	3.14	3.10	3.30	3.20	3.05	3.13	3.09	3.04	3.21	3.13
Used carton boxes: (P_4)	2.58	3.58	3.08	3.10	2.95	3.03	2.98	3.30	3.14	3.20	2.95	3.08	2.96	3.19	3.08
Sem±	0.07	0.07	0.05	0.06	0.10	0.06	0.10	0.13	0.08	0.07	0.09	0.06	0.08	0.08	0.05
CD (P= 0.05)	0.20	0.21	0.14	0.18	0.29	0.16	0.28	NS	NS	0.21	NS	0.17	1.90	NS	2.21

Note: **NS = Non Significant**

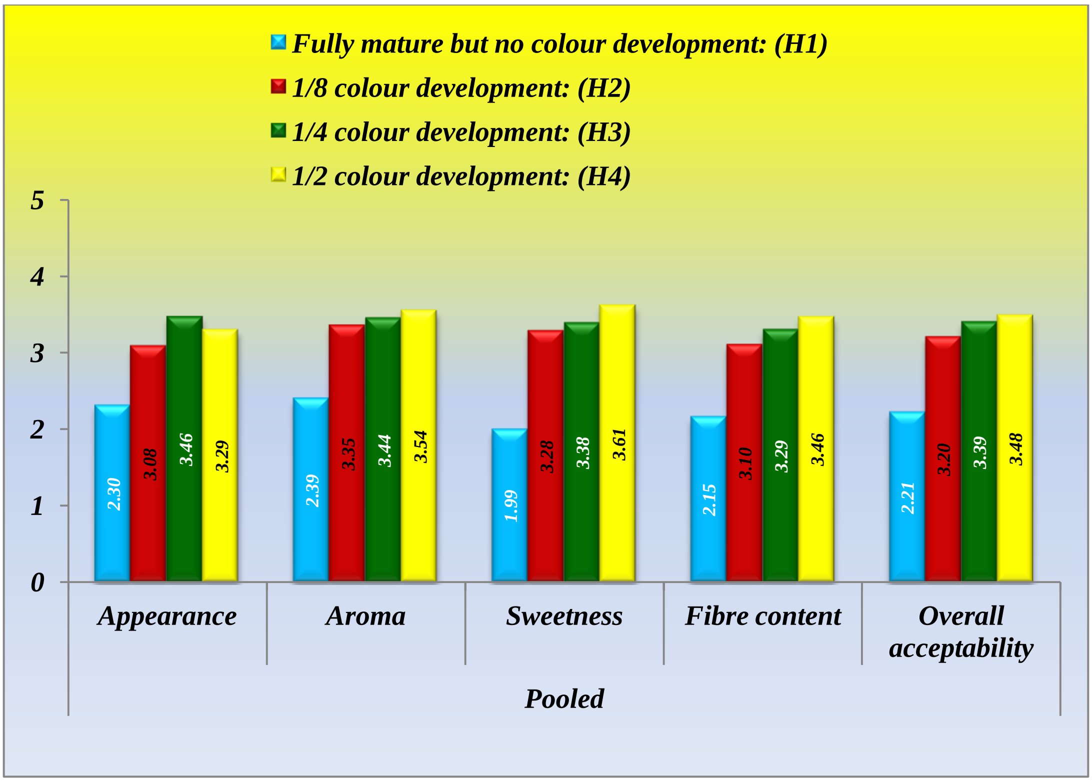


Figure 24: Effect of various harvesting stages on organoleptic parameters of organic pineapple fruit after transport

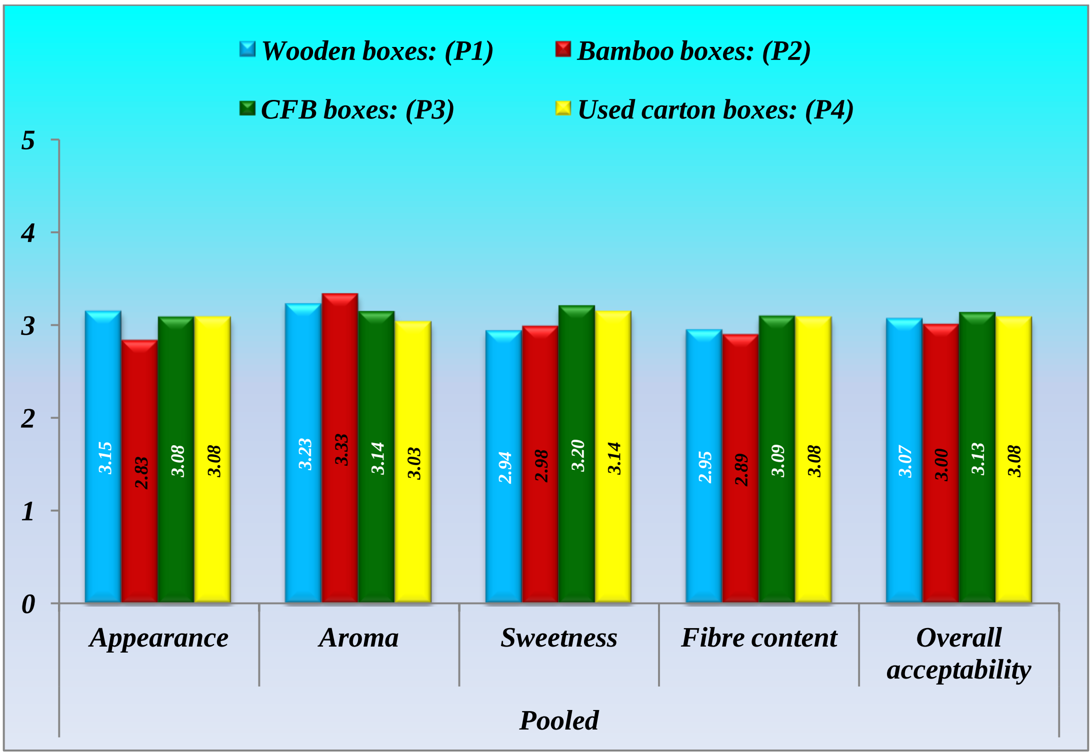


Figure 25: Effect of various packaging on organoleptic parameters of organic pineapple after transport

Table 33: Interaction effect of various treatments on organoleptic parameters of organic pineapple fruit after transport

Treatments	Appearance			Aroma			Sweetness			Fibre content			Overall acceptability		
	2014	**2016**	**Pooled**	**2014**	**2016**	**Pooled**	**2014**	**2016**	**Pooled**	**2014**	**2016**	**Pooled**	**2014**	**2016**	**Pooled**
H_1P_1	1.80	2.70	2.25	2.00	2.80	2.40	1.80	2.10	1.95	1.70	2.00	1.85	1.83	2.40	2.11
H_1P_2	1.80	2.60	2.20	2.10	2.70	2.40	1.90	2.20	2.05	2.10	2.70	2.40	1.98	2.55	2.26
H_1P_3	2.50	2.90	2.70	2.30	2.80	2.55	1.50	2.60	2.05	1.80	2.60	2.20	2.03	2.73	2.38
H_1P_4	1.50	2.60	2.05	2.30	2.10	2.20	1.50	2.30	1.90	1.80	2.50	2.15	1.78	2.38	2.08
H_2P_1	2.30	3.90	3.10	2.70	3.60	3.15	2.60	3.80	3.20	2.90	3.00	2.95	2.63	3.58	3.10
H_2P_2	2.40	3.20	2.80	3.70	4.00	3.85	2.90	3.90	3.40	2.70	3.10	2.90	2.93	3.55	3.24
H_2P_3	2.80	3.30	3.05	3.30	2.90	3.10	3.10	3.10	3.10	3.30	3.40	3.35	3.13	3.18	3.15
H_2P_4	2.90	3.80	3.35	3.30	3.30	3.30	3.10	3.70	3.40	3.40	3.00	3.20	3.18	3.45	3.31
H_3P_1	3.60	3.90	3.75	3.20	3.80	3.50	2.70	3.60	3.15	3.00	3.40	3.20	3.13	3.68	3.40
H_3P_2	2.70	4.00	3.35	3.80	3.80	3.80	3.40	2.80	3.10	3.60	2.90	3.25	3.38	3.38	3.38
H_3P_3	3.00	3.60	3.30	3.60	3.20	3.40	3.90	3.60	3.75	3.50	3.10	3.30	3.50	3.38	3.44
H_3P_4	2.80	4.10	3.45	2.80	3.30	3.05	3.10	3.90	3.50	3.70	3.10	3.40	3.10	3.60	3.35
H_4P_1	3.10	3.90	3.50	3.90	3.80	3.85	3.60	3.30	3.45	3.90	3.70	3.80	3.63	3.68	3.65
H_4P_2	2.30	3.60	2.95	3.30	3.20	3.25	3.50	3.20	3.35	3.10	2.90	3.00	3.05	3.23	3.14
H_4P_3	3.20	3.30	3.25	3.40	3.60	3.50	3.90	3.90	3.90	3.60	3.40	3.50	3.53	3.55	3.54
H_4P_4	3.10	3.80	3.45	4.00	3.10	3.55	4.20	3.30	3.75	3.90	3.20	3.55	3.80	3.35	3.58
Sem±	0.14	0.14	0.10	0.12	0.20	0.12	0.20	0.25	0.16	0.14	0.19	0.12	0.08	0.12	0.07
CD (P=0.05)	0.40	0.42	0.28	0.36	0.57	0.33	0.57	0.73	0.45	0.41	0.54	0.33	0.23	0.35	0.20

However, the overall acceptability of the fruits was not significantly influenced by packaging in both the years. **(**Table 32, Fig. 25**)**

The interaction between harvesting stages and packaging **(**Table 33**)** was found to have significant impact on the overall acceptability of the fruits. The maximum was found in the treatment H_4P_1 with 3.65 followed by H_4P_4 with 3.58 as the minimum level was in treatment H_1P_4 with 2.08.

Huang and Hseieh (2005) showed that consumer liking of pear fruit leather could be increased by using the level of fruit aroma, sweetness, tartness and shininess. Sindumathi *et al.* (2017) worked with the quality attributes like appearance, flavour, taste and over all acceptability values of pineapple and concluded that maximum score for fresh cut pineapple was found in those that were treated with nisin and decreasing trend was observed in control samples at the end of storage. They opined that effects of packaging material slightly affected the organoleptic characteristics of fresh cut pineapple. Water loss from the minimally processed fruits and vegetables via evaporation reduces sensory quality as it causes wilting and turgor loss (Wills *et al.*, 1989)

4.2.2.10. Shelf life (Days)

Harvesting stages impact on shelf life was significant as apparent from Table 34 and Fig 26. H_1 (fully matured but no colour development) showed the highest value of 11.17 and 10.83 during 2014 an 2016 with a pooled result of 11.00 days. The lowest pooled result of 9.38 days was recorded under the treatment H_4 (1/2 colour development). Different researchers had also reported similar findings in reference to the present work. (Kabir *et al.*, 2010, Kamol *et al.*, 2014). Dhar *et al.* (2008) observed maximum shelf life in fruits harvested at 14 days before optimum mature stage and concluded that for immediate consumption as fresh fruit, the optimum mature stage appeared to be the best while earlier harvesting might be appropriate for canning and long distance transport.

Packaging also had a significant impact on shelf life (Table 34, Fig 27). The maximum shelf life was observed under the treatment P_3 (CFB Boxes) with a pooled result of 10.33 days. However, the minimum pooled result (9.67 days) of shelf life was taken from the treatment P_4 (used carton boxes). The fruit packed in bamboo or wooden boxes is more prone to physical injuries due to sharp edge of bamboo and nails present in wooden boxes. To minimise the physiological weight loss, fruit should be bagged in corrugated fibre boxes. (Singh, 2009), thus increasing shelf life which was in conformity with the present finding.

The interaction between harvesting stages and packaging was found to significantly influence shelf life (Table 35). During 2014, the maximum was found under the treatment H_1P_3 with 12.67 and during 2016, the maximum was found under treatments H_1P_2 and H_3P_1 with 12.00 each. . While the minimum level (8.00 days) during 2014 was found under the treatment H_4P_2 and during 2016, the minimum (9.00 days) was recorded under the treatment H_2P_4.

4.2.2.11. Post Harvest Loss % (PHL)

It is apparent from Table 34 and Fig 26 that harvesting stages had a significant influence on PHL of the fruits. The maximum (15.63 and 20.83%) PHL was observed under the treatment H_4 (1/2 colour development) during 2014 and 2016 respectively with a mean of 18.23%. While, the minimum of 3.13 and 12.50% of PHL was observed under the treatment H_1 (fully matured but no colour development) during 2014 and 2016 respectively with a mean of 7.81%.

Packaging also had a significant effect on the PHL of fruits (Table 34, Fig 27). P_2 (Bamboo boxes) gave the maximum PHL of 16.67 and 25.00% during 2014 and 2016 respectively with a mean of 20.83%. And the minimum was observed under the treatment P_3 (CFB Boxes) of 4.17 and 7.29 with a mean of 5.73% during 2014 and 2016 respectively. Similarly, Deka *et al.*

Table 34: Effect of various harvesting stages and packaging on shelf life and post harvest loss of organic pineapple fruit after transport

Treatments	Shelf life (Days)			Post Harvest Loss (%)		
	2014	2016	Pooled	2014	2016	Pooled
Harvesting stages						
Fully mature but no colour development: (H_1)	11.17	10.83	11.00	3.13	12.50	7.81
1/8 colour development: (H_2)	10.42	9.92	10.17	6.25	17.71	11.98
1/4 colour development: (H_3)	9.50	10.42	9.96	15.63	17.71	16.67
1/2 colour development: (H_4)	8.58	10.17	9.38	15.63	20.83	18.23
Sem±	0.08	0.12	0.07	2.80	1.56	1.61
CD (P= 0.05)	0.28	0.41	0.22	9.71	5.41	4.95
Packaging materials						
Wooden boxes: (P_1)	9.42	11.17	10.29	15.63	25.00	20.31
Bamboo boxes: (P_2)	9.42	11.00	10.21	16.67	25.00	20.83
CFB boxes: (P_3)	11.00	9.67	10.33	4.17	7.29	5.73
2^{nd} hand carton boxes: (P_4)	9.83	9.50	9.67	4.17	11.46	7.81
Sem±	0.13	0.14	0.10	1.80	2.41	1.50
CD (P= 0.05)	0.38	0.40	0.27	5.27	7.02	4.28

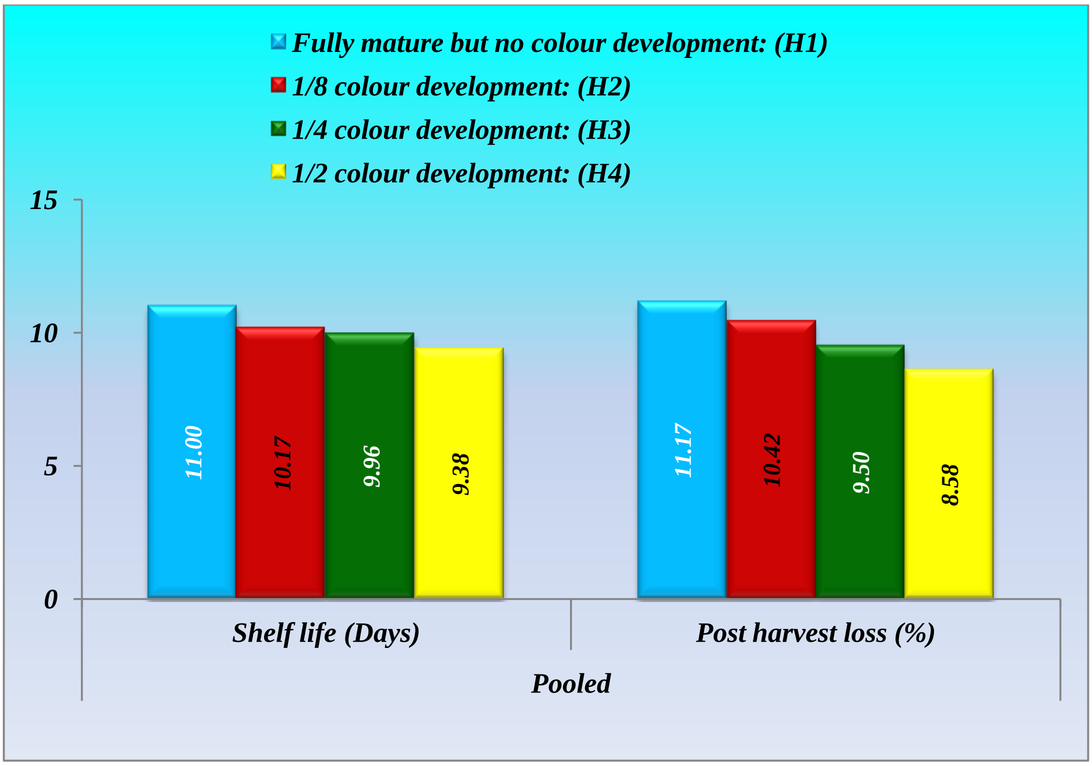


Figure 26: Effect of various harvesting stages on shelf life and post harvest loss of organic pineapple fruit after transport

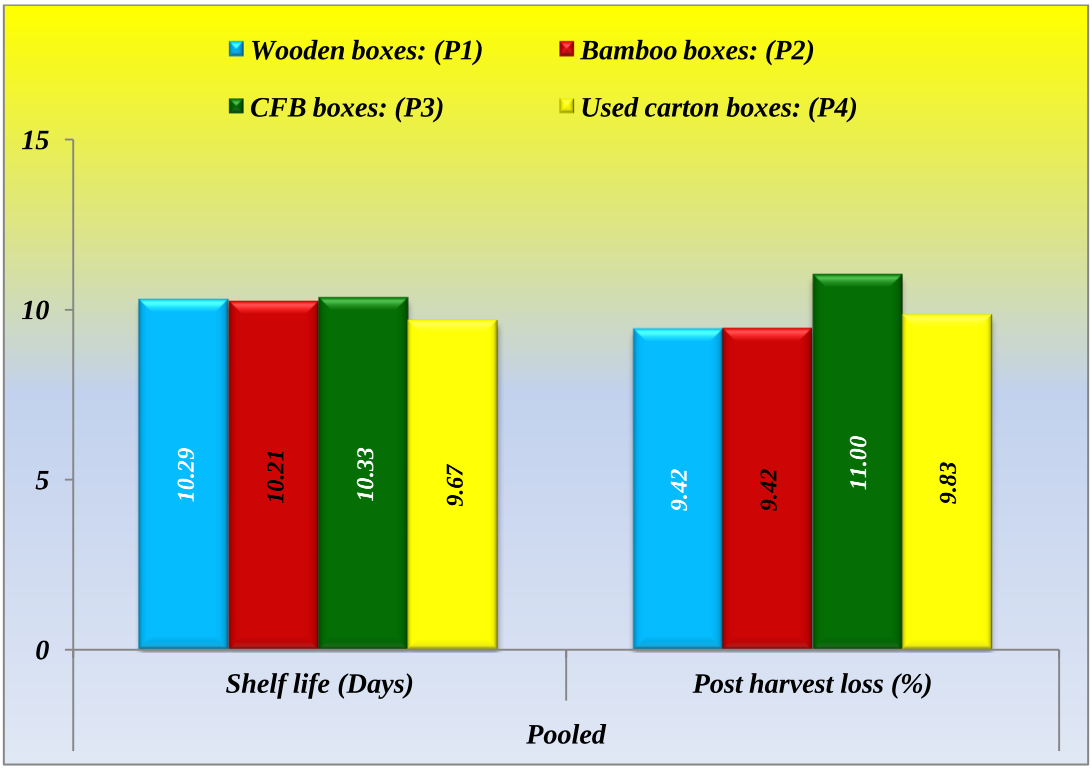


Figure 27: Effect of various packaging on shelf life and post harvest loss of organic pineapple fruit after transport

Table 35: Interaction effect of harvesting stages and packaging on shelf life and post harvest loss of organic pineapple fruit after transport

Treatments	Shelf life (Days)			Post Harvest Loss (%)		
	2014	**2016**	**Pooled**	**2014**	**2016**	**Pooled**
H_1P_1	10.67	11.67	11.17	4.17	20.83	12.50
H_1P_2	10.33	12.00	11.17	8.33	25.00	16.67
H_1P_3	12.67	10.00	11.33	0.00	0.00	0.00
H_1P_4	11.00	9.67	10.33	0.00	4.17	2.08
H_2P_1	9.67	10.33	10.00	8.33	29.17	18.75
H_2P_2	10.00	11.00	10.50	12.50	25.00	18.75
H_2P_3	11.67	9.33	10.50	0.00	8.33	4.17
H_2P_4	10.33	9.00	9.67	4.17	8.33	6.25
H_3P_1	9.00	12.00	10.50	20.83	25.00	22.92
H_3P_2	9.33	10.67	10.00	29.17	20.83	25.00
H_3P_3	10.67	9.67	10.17	8.33	8.33	8.33
H_3P_4	9.00	9.33	9.17	4.17	16.67	10.42
H_4P_1	8.33	10.67	9.50	29.17	25.00	27.08
H_4P_2	8.00	10.33	9.17	16.67	29.17	22.92
H_4P_3	9.00	9.67	9.33	8.33	12.50	10.42
H_4P_4	9.00	10.00	9.50	8.33	16.67	12.50
Sem±	0.26	0.28	0.19	3.61	4.81	3.01
CD (P=0.05)	0.77	0.81	0.54	10.53	14.04	8.55

(2004) reported that highest post harvest loss during transportation was observed in bamboo boxes. Anon. (2002), reported that carton with at least 275 lb/in^2 bursting strength should be used to avoid damage to the product during transport and handling. Commonly used package in the international trade of pineapples is a full-telescopic two-piece corrugated fibre board carton. Chonhenchob *et al.* (2007) studied different methods of packaging and concluded that the corrugated containers showed the best protective performance for pineapples. According to them, the corrugated containers with paperboard partitions showed the lowest damage levels as compared to other packaging methods, which is in conformity with the present findings. Deka *et al.* (2008) found out that CFB type II were better over packaging systems such as bamboo and wooden boxes as not a single CFB boxes were damaged during transportation which support the present findings.

The pooled data of the interaction between harvesting stages and packaging (Table 35) with regard to PHL revealed that the maximum of 27.08% PHL was observed under the treatment H_4P_1 whereas, during 2014, the minimum (0.00%) was observed under the treatments H_1P_3, H_1P_4 and H_2P_3. While in 2016, the minimum (0.00%) was found under the treatment H_1P_3. Minimum pooled data was found in the treatment H_1P_3.

4.2.2.11. Benefit Cost Ratio (BCR)

It was apparent from the Table 36 and 37 that during 2014, the Benefit Cost Ratio was highest in treatment H_1P_4 (1.49) followed by H_2P_4 and H_3P_4 with 1.43 each. While, the lowest was observed in treatment H_4P_1 with 0.90. Similarly, during 2016, the highest BCR was recorded in treatment H_1P_4 (1.53) followed by H_2P_4 and H_3P_4 with (1.40) each and the minimum was observed under the treatment H_4P_1 (1.06). Shaikh *et al.* (2003) indicated that good quality kraft paper suitable for manufacture of CFB boxes can be prepared from cotton plant stalks. The techno- economic feasibility worked out for conducting large scale trial in a mill indicated that the box prepared from cotton plant stalk kraft would be cheaper than that of commercially available box. On the other hand Singh and Thakur (2003) expressed that bamboo boxes were cheaper by approximately 16% and their transportation cost were reduced by approximately 10% compared to the wooden conventional boxes in transporting kinnow fruits.

Table 36: BCR (Benefit Cost Ratio) of transport of organic pineapple from Molvom to New Delhi (2014)

	1	2	3	4	5	6	7	8
Treatments	**Cost of Packing / treatment (3 boxes)**	**Railway transport cost/ treatment (3 boxes)**	**Total cost till Delhi (Col. 1+2+CC)**	**Landed cost per fruit (Col.3/ 24)**	**No. of marketable fruits**	**PHL of fruits (Nos)**	**Sale proceeds at Delhi (Col. 5 x selling price)**	**BCR (Col.7/ col.3)**
H_1P_1	180	329.85	1224.10	51.00	23	1	1495	1.22
H_1P_2	150	329.85	1194.10	49.75	22	2	1430	1.20
H_1P_3	270	285.87	1270.12	52.92	24	0	1560	1.23
H_1P_4	45	285.87	1045.12	43.55	24	0	1560	1.49
H_2P_1	180	329.85	1224.10	51.00	22	2	1430	1.17
H_2P_2	150	329.85	1194.10	49.75	21	3	1365	1.14
H_2P_3	270	285.87	1270.12	52.92	24	0	1560	1.23
H_2P_4	45	285.87	1045.12	43.55	23	1	1495	1.43
H_3P_1	180	329.85	1224.10	51.00	19	5	1235	1.01
H_3P_2	150	329.85	1194.10	49.75	15	9	975	0.82
H_3P_3	270	285.87	1270.12	52.92	22	2	1430	1.13
H_3P_4	45	285.87	1045.12	43.55	23	1	1495	1.43
H_4P_1	180	329.85	1224.10	51.00	17	7	1105	0.90
H_4P_2	150	329.85	1194.10	49.75	19	5	1235	1.03
H_4P_3	270	285.87	1270.12	52.92	22	2	1430	1.13
H_4P_4	45	285.87	1045.12	43.55	22	2	1430	1.37

Table 37: BCR (Benefit Cost Ratio) of transport of organic pineapple from Molvom to New Delhi (2016)

Treatments	1 Cost of Packing / treatment (3 boxes)	2 Railway transport cost/ treatment (3 boxes)	3 Total cost till Delhi (Col. 1+2+CC)	4 Landed cost per fruit (Col.3/ 24)	5 No. of marketable fruits	6 PHL of fruits (Nos)	7 Sale proceeds at Delhi (Col. 5 x selling price)	8 BCR (Col.7/ col.3)
H_1P_1	180	419.85	1522.27	63.43	21	3	1785	1.17
H_1P_2	150	419.85	1492.27	62.18	20	4	1700	1.14
H_1P_3	270	363.87	1556.29	64.85	24	0	2040	1.31
H_1P_4	45	363.87	1331.29	55.47	24	0	2040	1.53
H_2P_1	180	419.85	1522.27	63.43	21	3	1785	1.17
H_2P_2	150	419.85	1492.27	62.18	21	3	1785	1.20
H_2P_3	270	363.87	1556.29	64.85	24	0	2040	1.31
H_2P_4	45	363.87	1331.29	55.47	22	2	1870	1.40
H_3P_1	180	419.85	1522.27	63.43	20	4	1700	1.12
H_3P_2	150	419.85	1492.27	62.18	19	5	1615	1.08
H_3P_3	270	363.87	1556.29	64.85	21	3	1785	1.15
H_3P_4	45	363.87	1331.29	55.47	22	2	1870	1.40
H_4P_1	180	419.85	1522.27	63.43	19	5	1615	1.06
H_4P_2	150	419.85	1492.27	62.18	20	4	1700	1.14
H_4P_3	270	363.87	1556.29	64.85	22	2	1870	1.20
H_4P_4	45	363.87	1331.29	55.47	21	3	1785	1.34

CHAPTER V

SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSIONS

The present investigation entitled "***Development of value chain of organic pineapple (Ananas comosus) from Nagaland***" was carried out in Molvom village under Dimapur district and fruits were analysed in the laboratory of Department of Horticulture NU: SASRD, Medziphema campus, Nagaland University, and IARI New Delhi during the year, 2014 and 2016. Two experiments were conducted in the present investigation, where first experiment was carried out to study the effect of pre harvest treatments to improve the post harvest quality of organic pineapple. And the second experiment was conducted to study the Standardization of harvesting time, packaging of pineapple and impact of transportation on quality and marketability for distant market.

The salient findings thus obtained from the study are summarized below:

Experiment I: **Pre harvest treatments to improve post harvest quality of organic pineapple**.

Various physico-chemical parameters and sun burn percentage were taken in order to compare between various pre harvest treatments.

1. Size of fruits was significantly higher in T_2 (Covering with straw) and minimum in open condition (T_6) in both the years.
2. Parameters like weight of fruits with crown, weight of fruits without crown, volume of fruits, peel weight, flesh weight and core weight were not significantly influenced by various treatments in both the years of observation. However, T_2 (covering with straw) and T_3 (coating with kaolin) showed higher values, while T_6 (open condition) showed lower values in all these parameters.

3. Physiological Loss in Weight (%) significantly increased with the advancement in maturity stage, and was higher in T_6 (open condition) and lowest in T_2 (covering with straw) on all dates of observations in both the years.
4. Juice content, TSS, total sugar and reducing sugar significantly recorded higher values in T_2 (covering with straw) followed by T_3 (coating with kaolin) in most parameters while the lower value was recorded in T_6 (open condition) in both the years.
5. Non reducing sugar recorded significantly highest value in treatment T_2 (covering with straw) and minimum in T_5 (covering with cloth) in both the years.
6. Titratable acidity was significantly higher in T_1 (covering with own leaves) and minimum in treatment T_5 (covering with cloth) in both the years.
7. Significantly higher ascorbic acid content was found under the treatment T_2 (covering with straw) followed by T_1 (covering with own leaves) and minimum in T_6 (open condition) treatment in both the years.
8. Significantly lowest sun burn was recorded in T_2 (covering with straw) and highest in T_6 (open condition) treatment in both the years.

Experiment II: **Impact of harvesting stages and packaging on quality of pineapple for distant market.**

I. Physico chemical analysis at SASRD (before transport)

1. PLW increased significantly during storage with the highest value recorded in H_2 (1/8 colour development) and lowest in H_1 (Fully mature but no colour development) treatment in both the years.
2. Juice content significantly increased during the period of storage wherein H_4 (1/2 colour development) recorded highest value and H_1

(fully mature but no colour development) recorded lowest value on all dates of observation in both the years.

3. TSS was significantly influenced by harvesting stages and showed gradual increase during storage period in both the years. Highest TSS was recorded in H_4 (1/2 colour development) and lowest in H_1 (fully mature but no colour development) treatment with some exceptions.
4. Total sugar significantly differed between treatments and recorded maximum value in H_4 (1/2 colour development) and minimum in H_1 (fully mature but no colour development). It showed an increasing trend during storage in both the years of observation.
5. Reducing sugar increased with period of storage and significantly influenced by different harvesting stages. The highest value was recorded in H_4 (1/2 colour development) treatment while the lowest was recorded in H_2 (1/8 colour development) and H_1 (fully mature but no colour development) treatments in both the years of observation.
6. Non reducing sugar was significantly influenced by different treatments and it increased gradually with increasing number of days after harvest in both the years. The highest value of non reducing sugar was noted in H_4 (1/2 colour development) treatment while the lowest was recorded in H_1 (fully mature but no colour development) treatment on all dates of observation with few exceptions.
7. Titratable acidity decreased with period of storage and was significantly influenced by different treatments with the highest value recorded in H_4 (1/2 colour development) treatment and lowest in H_1 (fully mature but no colour development) treatment in both the years of observation.
8. Ascorbic acid was significantly influenced by harvesting stages and showed a gradual decrease with number of days after harvest. The highest value was recorded in H_4 (1/2 colour development) treatment

while the lowest was recorded in H_1 (fully mature but no colour development) treatment in both the years.

9. Organoleptic test was significantly influenced by different treatments where H_1 (fully mature but no colour development) registered lowest rating in all parameters while H_3 (1/4 colour development) registered highest rating in aroma, fibre content and overall acceptability and second highest in appearance and sweetness in both the years of observation.

II. Physico chemical analysis at Delhi (after transport)

1. PLW was significantly influenced by harvesting stages, packaging and their interaction on all dates of observation and in both the years. There was a significant increase in PLW with increasing number of days of the harvest irrespective of treatments. The lowest PLW was recorded in H_1 (fully mature but no colour development) and P_3 (CFB box) while the highest was recorded in H_4 (1/2 colour development) and P_1 (wooden box).
2. Juice content increased gradually with increasing number of days after harvest in all the treatments in both the years of experiment. Harvesting stages, packaging as well as their interaction significantly influenced the juice content in both the years of observation. H_3 (1/4 colour development) and P_3 (CFB box) recorded highest juice content while H_1 (fully mature but no colour development) and P_1 (wooden box) recorded the lowest juice content.
3. TSS was significantly influenced by harvesting stages, packaging as well as their interaction on all dates of observation except the influence of packaging on 0 DAH which was non significant. Highest value was recorded in H_4 (1/2 colour development) P_3 (CFB box) while the lowest was recorded in H_1 (fully matured but no colour development) and P_1 (wooden box) in both the years.

4. Total sugar significantly increased during the period of storage irrespective of treatments and in both the years of observation. Harvesting stages, packaging as well as their interaction significantly affected the total sugar content in both the years. Highest value of total sugar was recorded in H_4 and H_3 amongst the harvesting stages and P_3 (CFB box) amongst the packaging, while lowest value was recorded in H_1 and P_1.
5. Reducing sugar registered significant difference among the treatments (harvesting stages, packaging and their interaction). There was a decreasing trend of reducing sugar throughout the period of storage irrespective of treatments and years of observation. H_4 (1/2 colour development) and P_4 (used carton box) recorded highest reducing sugar content while H_1 (fully mature but no colour development) and P_1 (wooden box) recorded the lowest value in both the years.
6. Non reducing sugar showed an increasing trend during the storage period in all the treatments in both the years. It was significantly influenced by harvesting stages, packaging and their interaction. The highest value was recorded in H_3 (1/4 colour development and P_4 (used carton boxes) while lower values were recorded in H_1 (fully mature but no colour development) and P_1 (wooden box).
7. Titratable acidity was significantly different between the treatments of (harvesting stages, packaging and their interaction) in both the years of observation. A decreasing trend in titratable acidity was noted in all the treatments with lowest value registered in H_4 (1/2 colour development) and P_3(CFB boxes) while the highest value was recorded in H_1 (fully mature but no colour development) and P_1 (wooden box) with some exceptions.
8. Ascorbic acid decreased with increasing number of days after harvest. Harvesting stages, packaging and their interaction significantly impacted the ascorbic acid content with an exception of influence of

packaging on the 10^{th} DAH which was non-significant. Highest ascorbic acid content was noted in H_1 (fully mature but no colour development) and P_1 (wooden box) while the lowest was recorded in H_4 (1/2 colour development) and P_3 (CFB boxes) in both the years.

9. Organoleptic parameters were found to be significantly influenced by harvesting stages and the interaction between harvesting stages and packaging while the influence of packaging was only significant in appearance and aroma ratings in both the years. Among the harvesting stages, H_4 (1/2 colour development) gave better ratings in aroma, fibre content and overall acceptability while H_3 (1/4 colour development) rated better in appearance and sweetness. The lowest rating in all organoleptic parameters was noted in H_1 (fully mature but no colour development) treatment. Among the packaging P_3 (CFB box) registered better rating in sweetness, Fibre content and Overall acceptability, while P_2 (bamboo box) recorded lower rating in almost all organoleptic parameters.
10. Shelf life was significantly influenced by harvesting stages, packaging and their interaction with the highest value recorded in H_1 (fully mature but no colour development) and P_3 (CFB box) treatment and lowest value in H_4 (1/2 colour development) and P_4 (used carton box) treatments in both the years.
11. Post Harvest Loss was also significantly influenced by harvesting stages, packaging and their interaction in both the years of observation. H_1 (fully mature but no colour development) and P_3 (CFB box) gave the lowest PHL, while H_4 (1/2 colour development) and P_2 (bamboo carton box) registered maximum PHL.
12. Benefit Cost Ratio was highest in H_1P_4 and lowest in H_3P_2 in both the years of observation.

Conclusion:

1. Pre harvest treatments *i.e.* T_1 (Covering with own leaves), T_2 (Covering with straw), T_3 (Coating with kaolin), T_4 (Covering with net) and T_5 (Covering with cloth) significantly improved the post harvest qualities while control (T_6 – open condition) registered the lowest value in all quality parameters. Among the treatments, T_2 (covering with straw) was found to be the best with lowest sun burn, lowest PLW and highest fruit size, fruit weight, TSS, sugar and ascorbic acid content.
2. H_4 (1/2 colour development) gave better qualitative parameters like TSS, total sugar, titratable acidity and organoleptic test while H_1 (fully mature but no colour development) gave higher values in terms of PLW, ascorbic acid, shelf life, PHL and BCR however, H_3 (1/4 colour development) recorded better result in almost all the parameters. Hence, in general among the harvesting stages, H_3 (1/4 colour development) may be considered the best time for harvesting. However, for distant market, H_1 (fully mature but no colour development) can be considered as best.
3. Among the packaging treatments, P_3 (CFB box) showed much better results in almost all parameters which was closely followed by P_4 (used carton box) treatment. So P_3 (CFB box) may be considered as the best treatment however, P_4 (used carton box) can also be considered a better option for distant market with higher BCR.
4. Transportation of fruits to Delhi resulted in higher PLW especially on the 10^{th} DAH. It also resulted in higher PHL in H_4 (1/2 colour development) and P_2 (bamboo box) treatments while the minimum loss was recorded in H_1 (fully mature but no colour development) and P_3 (CFB box) treatment. Hence, to reduce the impact of transportation, the fruits may be harvested at fully mature but no colour development stage (H_1) and packed in CFB boxes (P_3) for lower PHL and PLW.

CHAPTER VI

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APPENDICES

ANOVA I

ANOVA 1: Effect of various treatments on fruit size of fruit of organic during 2014 and 2016 (Pooled)

Source of Variance	***Degree of Freedom***	***Sum of Square***	***Mean Sum of Square***	***F Cal***	***F Tab at 5%***	***S/NS***
Years	1	67.73	67.73	1.57	4.08	NS
Replication	8	636.34	79.54	1.84	2.18	NS
Treatment	10	2088.67	417.73	9.69	2.45	Significant
Year x Treatment	10	65.73	13.146	0.30	2.45	NS
Error	40	1725.19	43.13			
Total	59	4583.66				

ANOVA 2: Effect of various treatments on Physiological Loss in Weight at 4 days after harvest (DAH) of organic pineapple during 2014 and 2016 (Pooled)

Source of Variance	***Degree of Freedom***	***Sum of Square***	***Mean Sum of Square***	***F Cal***	***F Tab at 5%***	***S/NS***
Years	1	3.29	3.29	19.65	4.08	Significant
Replication	8	1.00	0.12	0.74	2.18	NS
Treatment	10	1.48	0.30	1.77	2.45	NS
Year x Treatment	10	3.33	0.666	3.97	2.45	Significant
Error	40	6.71	0.17			
Total	59	15.81				

ANOVA 3: Effect of various treatments on Physiological Loss in Weight at 8 days after harvest (DAH) of organic pineapple during 2014 and 2016 (Pooled)

Source of Variance	***Degree of Freedom***	***Sum of Square***	***Mean Sum of Square***	***F Cal***	***F Tab at 5%***	***S/NS***
Years	1	19.41	19.41	81.69	4.08	Significant
Replication	8	2.05	0.26	1.08	2.18	NS
Treatment	10	14.31	2.86	12.05	2.45	Significant
Year x Treatment	10	11.33	2.266	9.54	2.45	Significant
Error	40	9.50	0.24			
Total	59	56.59				

ANOVA 4: Effect of various treatments on Physiological Loss in Weight at 12 days after harvest (DAH) of organic pineapple during 2014 and 2016 (Pooled)

Source of Variance	***Degree of Freedom***	***Sum of Square***	***Mean Sum of Square***	***F Cal***	***F Tab at 5%***	***S/NS***
Years	1	62.07	62.07	57.95	4.08	Significant
Replication	8	11.75	1.47	1.37	2.18	NS
Treatment	10	59.36	11.87	11.08	2.45	Significant
Year x Treatment	10	3.62	0.725	0.68	2.45	NS
Error	40	42.84	1.07			
Total	59	179.63				

ANOVA 5: Effect of various treatments on juice content of organic pineapple during 2014 and 2016 (Pooled)

Source of Variance	*Degree of Freedom*	*Sum of Square*	*Mean Sum of Square*	*F Cal*	*F Tab at 5%*	*S/NS*
Years	1	112.07	112.07	3.61	4.08	NS
Replication	8	362.93	45.37	1.46	2.18	NS
Treatment	10	1932.33	386.47	12.46	2.45	Significant
Year x Treatment	10	35.73	7.147	0.23	2.45	NS
Error	40	1240.27	31.01			
Total	59	3683.33				

ANOVA 6: Effect of various treatments on Total Soluble Solid of organic pineapple during 2014 and 2016 (Pooled)

Source of Variance	*Degree of Freedom*	*Sum of Square*	*Mean Sum of Square*	*F Cal*	*F Tab at 5%*	*S/NS*
Years	1	9.20	9.20	2.97	4.08	NS
Replication	8	30.38	3.80	1.23	2.18	NS
Treatment	10	114.32	22.86	7.39	2.45	Significant
Year x Treatment	10	8.62	1.724	0.56	2.45	NS
Error	40	123.78	3.09			
Total	59	286.31				

ANOVA 7: Effect of various treatments on Titratable acidity of organic pineapple during 2014 and 2016 (Pooled)

Source of Variance	*Degree of Freedom*	*Sum of Square*	*Mean Sum of Square*	*F Cal*	*F Tab at 5%*	*S/NS*
Years	1	0.01	0.01	1.34	4.08	NS
Replication	8	0.09	0.01	1.14	2.18	NS
Treatment	10	0.38	0.08	7.72	2.45	Significant
Year x Treatment	10	0.00	0.0003	0.03	2.45	NS
Error	40	0.39	0.01			
Total	59	0.87				

ANOVA 8: Effect of various treatments on Ascorbic Acid of organic pineapple during 2014 and 2016 (Pooled)

Source of Variance	*Degree of Freedom*	*Sum of Square*	*Mean Sum of Square*	*F Cal*	*F Tab at 5%*	*S/NS*
Years	1	1.70	1.70	1.06	4.08	NS
Replication	8	11.21	1.40	0.88	2.18	NS
Treatment	10	44.93	8.99	5.63	2.45	Significant
Year x Treatment	10	19.61	3.922	2.46	2.45	Significant
Error	40	63.89	1.60			
Total	59	141.34				

ANOVA 9: Effect of various treatments on Sun burn of organic pineapple during 2014 and 2016 (Pooled)

Source of Variance	*Degree of Freedom*	*Sum of Square*	*Mean Sum of Square*	*F Cal*	*F Tab at 5%*	*S/NS*
Years	1	106.67	106.67	16.06	4.08	Significant
Replication	8	68.33	8.54	1.29	2.18	NS
Treatment	10	2613.33	522.67	78.70	2.45	Significant
Year x Treatment	10	133.33	26.667	4.02	2.45	Significant
Error	40	265.67	6.64			
Total	59	3187.33				

ANOVA II

ANOVA 1: Effect of various treatments on appearance of organic pineapple fruit before transport during 2014 and 2016 (Pooled)

Source of Variance	*Degree of Freedom*	*Sum of Square*	*Mean Sum of Square*	*F Cal*	*F Tab at 5%*	*S/NS*
Years	1	4.90	4.90	24.12	4.26	Significant
Replication	8	5.13	0.64	3.15	2.36	Significant
Treatment	6	6.95	1.16	5.70	2.51	Significant
Year x Treatment	6	203.15	33.858	166.69	2.51	Significant
Error	24	4.88	0.20			
Total	39	225.00				

ANOVA 2: Effect of various treatments on aroma of organic pineapple fruit before transport during 2014 and 2016 (Pooled)

Source of Variance	*Degree of Freedom*	*Sum of Square*	*Mean Sum of Square*	*F Cal*	*F Tab at 5%*	*S/NS*
Years	1	0.06	0.06	0.55	4.26	NS
Replication	8	2.63	0.33	3.18	2.36	Significant
Treatment	6	3.52	0.59	5.69	2.51	Significant
Year x Treatment	6	268.58	44.763	434.06	2.51	Significant
Error	24	2.47	0.10			
Total	39	277.25				

ANOVA 3: Effect of various treatments on sweetness of organic pineapple fruit before transport during 2014 and 2016 (Pooled)

Source of Variance	*Degree of Freedom*	*Sum of Square*	*Mean Sum of Square*	*F Cal*	*F Tab at 5%*	*S/NS*
Years	1	0.10	0.10	0.76	4.26	NS
Replication	8	5.93	0.74	5.60	2.36	Significant
Treatment	6	3.20	0.53	4.03	2.51	Significant
Year x Treatment	6	250.10	41.683	315.09	2.51	Significant
Error	24	3.17	0.13			
Total	39	262.50				

ANOVA 4: Effect of various treatments on fibre content of organic pineapple fruit before transport during 2014 and 2016 (Pooled)

Source of Variance	*Degree of Freedom*	*Sum of Square*	*Mean Sum of Square*	*F Cal*	*F Tab at 5%*	*S/NS*
Years	1	0.01	0.01	0.06	4.26	NS
Replication	8	3.25	0.41	3.68	2.36	Significant
Treatment	6	0.37	0.06	0.56	2.51	NS
Year x Treatment	6	117.98	19.663	178.08	2.51	Significant
Error	24	2.65	0.11			
Total	39	124.25				

ANOVA 5: Effect of various treatments on overall acceptability of organic pineapple fruit before transport during 2014 and 2016 (Pooled)

Source of Variance	*Degree of Freedom*	*Sum of Square*	*Mean Sum of Square*	*F Cal*	*F Tab at 5%*	*S/NS*
Years	1	0.60	0.60	8.36	4.26	Significant
Replication	8	9.17	1.15	15.96	2.36	Significant
Treatment	6	1.71	0.29	3.98	2.51	Significant
Year x Treatment	6	173.83	28.972	403.55	2.51	Significant
Error	24	1.72	0.07			
Total	39	187.03				

ANOVA III

ANOVA 1: Effect of harvesting stages and packaging on Physiological Loss in Weight at 5 days after harvest of organic pineapple after transport during 2014 and 2016 (Pooled)

Source of Variance	*Degree of Freedom*	*Sum of Square*	*Mean Sum of Square*	*F Cal*	*F Tab at 5%*	*S/NS*
Years	1	1.49	1.49	0.36	5.99	NS
Replication	4	0.12	0.03	2.62	3.26	NS
Harvesting (H)	6	24.63	4.11	344.62	3.00	Significant
Error I	12	0.14	0.01			
Pakaging (P)	6	13.92	2.32	87.37	2.29	Significant
H x P interaction	18	1.79	0.10	3.75	1.82	Significant
Error II	48	1.28	0.03			
Total	95	43.38				

ANOVA 2: Effect of harvesting stages and packaging on Physiological Loss in Weight at 10 days after harvest of organic pineapple after transport during 2014 and 2016 (Pooled)

Source of Variance	*Degree of Freedom*	*Sum of Square*	*Mean Sum of Square*	*F Cal*	*F Tab at 5%*	*S/NS*
Years	1	4.59	4.59	0.11	5.99	NS
Replication	4	1.65	0.41	1.87	3.26	NS
Harvesting (H)	6	250.68	41.78	189.53	3.00	Significant
Error I	12	2.65	0.22			
Pakaging (P)	6	29.79	4.97	34.62	2.29	Significant
H x P interaction	18	6.80	0.38	2.63	1.82	Significant
Error II	48	6.89	0.14			
Total	95	303.04				

ANOVA 3: Effect of harvesting stages and packaging on Juice content at 0 days after harvest of organic pineapple after transport during 2014 and 2016 (Pooled)

Source of Variance	***Degree of Freedom***	***Sum of Square***	***Mean Sum of Square***	***F Cal***	***F Tab at 5%***	***S/NS***
Years	1	129.50	129.50	0.32	5.99	NS
Replication	4	6.10	1.52	0.14	3.26	NS
Harvesting (H)	6	2429.85	404.97	38.35	3.00	Significant
Error I	12	126.71	10.56			
Pakaging (P)	6	871.31	145.22	34.46	2.29	Significant
H x P interaction	18	181.71	10.10	2.40	1.82	Significant
Error II	48	202.28	4.21			
Total	95	3947.45				

ANOVA 4: Effect of harvesting stages and packaging on Juice content at 5 days after harvest of organic pineapple after transport during 2014 and 2016 (Pooled)

Source of Variance	***Degree of Freedom***	***Sum of Square***	***Mean Sum of Square***	***F Cal***	***F Tab at 5%***	***S/NS***
Years	1	91.07	91.07	0.13	5.99	NS
Replication	4	185.54	46.39	2.83	3.26	NS
Harvesting (H)	6	4103.27	683.88	41.74	3.00	Significant
Error I	12	196.63	16.39			
Pakaging (P)	6	376.43	62.74	7.14	2.29	Significant
H x P interaction	18	626.76	34.82	3.97	1.82	Significant
Error II	48	421.50	8.78			
Total	95	6001.18				

ANOVA 5: Effect of harvesting stages and packaging on Juice content at 10 days after harvest of organic pineapple after transport during 2014 and 2016 (Pooled)

Source of Variance	*Degree of Freedom*	*Sum of Square*	*Mean Sum of Square*	*F Cal*	*F Tab at 5%*	*S/NS*
Years	1	2.57	2.57	0.02	5.99	NS
Replication	4	21.62	5.41	0.40	3.26	NS
Harvesting (H)	6	913.65	152.27	11.33	3.00	Significant
Error I	12	161.34	13.45			
Pakaging (P)	6	575.10	95.85	7.10	2.29	Significant
H x P interaction	18	909.73	50.54	3.74	1.82	Significant
Error II	48	648.36	13.51			
Total	95	3232.37				

ANOVA 6: Effect of harvesting stages and packaging on Total Soluble Solid at 0 days after harvest of organic pineapple after transport during 2014 and 2016 (Pooled)

Source of Variance	*Degree of Freedom*	*Sum of Square*	*Mean Sum of Square*	*F Cal*	*F Tab at 5%*	*S/NS*
Years	1	0.22	0.22	0.02	5.99	NS
Replication	4	2.40	0.60	1.29	3.26	NS
Harvesting (H)	6	84.43	14.07	30.22	3.00	Significant
Error I	12	5.59	0.47			
Pakaging (P)	6	5.10	0.85	4.62	2.29	Significant
H x P interaction	18	14.68	0.82	4.43	1.82	Significant
Error II	48	8.83	0.18			
Total	95	121.26				

ANOVA 7: Effect of harvesting stages and packaging on Total Soluble Solid at 5 days after harvest of organic pineapple after transport during 2014 and 2016 (Pooled)

Source of Variance	***Degree of Freedom***	***Sum of Square***	***Mean Sum of Square***	***F Cal***	***F Tab at 5%***	***S/NS***
Years	1	0.11	0.11	0.003	5.99	NS
Replication	4	2.04	0.51	0.70	3.26	NS
Harvesting (H)	6	198.76	33.13	45.61	3.00	Significant
Error I	12	8.72	0.73			
Pakaging (P)	6	9.01	1.50	4.99	2.29	Significant
H x P interaction	18	12.77	0.71	2.36	1.82	Significant
Error II	48	14.45	0.30			
Total	95	245.87				

ANOVA 8: Effect of harvesting stages and packaging on Total Soluble Solid at 10 days after harvest of organic pineapple after transport during 2014 and 2016 (Pooled)

Source of Variance	***Degree of Freedom***	***Sum of Square***	***Mean Sum of Square***	***F Cal***	***F Tab at 5%***	***S/NS***
Years	1	0.24	0.24	0.01	5.99	NS
Replication	4	2.90	0.72	1.09	3.26	NS
Harvesting (H)	6	243.11	40.52	61.02	3.00	Significant
Error I	12	7.97	0.66			
Pakaging (P)	6	34.95	5.82	16.85	2.29	Significant
H x P interaction	18	15.73	0.87	2.53	1.82	Significant
Error II	48	16.59	0.35			
Total	95	321.48				

ANOVA 9: Effect of harvesting stages and packaging on Titratable acidity at 0 days after harvest of organic pineapple after transport during 2014 and 2016 (Pooled)

Source of Variance	*Degree of Freedom*	*Sum of Square*	*Mean Sum of Square*	*F Cal*	*F Tab at 5%*	*S/NS*
Years	1	0.00003	0.00003	0.0001	5.99	NS
Replication	4	0.0008	0.0002	0.54	3.26	NS
Harvesting (H)	6	1.05	0.18	492.93	3.00	Significant
Error I	12	0.004	0.0004			
Pakaging (P)	6	0.31	0.05	171.54	2.29	Significant
H x P interaction	18	0.02	0.001	3.27	1.82	Significant
Error II	48	0.01	0.0003			
Total	95	1.40				

ANOVA 10: Effect of harvesting stages and packaging on Titratable acidity at 5 days after harvest of organic pineapple after transport during 2014 and 2016 (Pooled)

Source of Variance	*Degree of Freedom*	*Sum of Square*	*Mean Sum of Square*	*F Cal*	*F Tab at 5%*	*S/NS*
Years	1	0.01	0.01	0.45	5.99	NS
Replication	4	0.01	0.001	3.07	3.26	NS
Harvesting (H)	6	0.12	0.02	42.45	3.00	Significant
Error I	12	0.01	0.0005			
Pakaging (P)	6	0.04	0.01	7.45	2.29	Significant
H x P interaction	18	0.20	0.01	11.56	1.82	Significant
Error II	48	0.05	0.00			
Total	95	0.43				

ANOVA 11: Effect of harvesting stages and packaging on Titratable acidity at 10 days after harvest of organic pineapple after transport during 2014 and 2016 (Pooled)

Source of Variance	*Degree of Freedom*	*Sum of Square*	*Mean Sum of Square*	*F Cal*	*F Tab at 5%*	*S/NS*
Years	1	0.01	0.01	0.57	5.99	NS
Replication	4	0.004	0.001	2.72	3.26	NS
Harvesting (H)	6	0.13	0.02	64.46	3.00	Significant
Error I	12	0.004	0.0003			
Pakaging (P)	6	0.02	0.003	3.98	2.29	Significant
H x P interaction	18	0.20	0.01	13.32	1.82	Significant
Error II	48	0.04	0.001			
Total	95	0.41				

ANOVA 12: Effect of harvesting stages and packaging on Ascorbic acid at 0 days after harvest of organic pineapple after transport during 2014 and 2016 (Pooled)

Source of Variance	*Degree of Freedom*	*Sum of Square*	*Mean Sum of Square*	*F Cal*	*F Tab at 5%*	*S/NS*
Years	1	0.002	0.002	0.00004	5.99	NS
Replication	4	0.01	0.002	1.05	3.26	NS
Harvesting (H)	6	246.91	41.15	23580.70	3.00	Significant
Error I	12	0.02	0.002			
Pakaging (P)	6	2.80	0.47	287.77	2.29	Significant
H x P interaction	18	0.07	0.004	2.44	1.82	Significant
Error II	48	0.08	0.002			
Total	95	249.89				

ANOVA 13: Effect of harvesting stages and packaging on Ascorbic acid at 5 days after harvest of organic pineapple after transport during 2014 and 2016 (Pooled)

Source of Variance	*Degree of Freedom*	*Sum of Square*	*Mean Sum of Square*	*F Cal*	*F Tab at 5%*	*S/NS*
Years	1	0.03	0.03	0.001	5.99	NS
Replication	4	3.06	0.77	7.39	3.26	Significant
Harvesting (H)	6	202.81	33.80	326.34	3.00	Significant
Error I	12	1.24	0.10			
Pakaging (P)	6	12.66	2.11	11.44	2.29	Significant
H x P interaction	18	12.34	0.69	3.72	1.82	Significant
Error II	48	8.85	0.18			
Total	95	241.00				

ANOVA 14: Effect of harvesting stages and packaging on Ascorbic acid at 10 days after harvest of organic pineapple after transport during 2014 and 2016 (Pooled)

Source of Variance	*Degree of Freedom*	*Sum of Square*	*Mean Sum of Square*	*F Cal*	*F Tab at 5%*	*S/NS*
Years	1	0.22	0.22	0.01	5.99	NS
Replication	4	1.06	0.26	0.52	3.26	NS
Harvesting (H)	6	142.27	23.71	46.27	3.00	Significant
Error I	12	6.15	0.51			
Pakaging (P)	6	2.41	0.40	1.75	2.29	NS
H x P interaction	18	14.03	0.78	3.39	1.82	Significant
Error II	48	11.02	0.23			
Total	95	177.15				

ANOVA IV

ANOVA 1: Effect of harvesting stages harvesting stages and packaging on appearance of organic pineapple fruit after harvest during 2014 and 2016 (Pooled)

Source of Variance	*Degree of Freedom*	*Sum of Square*	*Mean Sum of Square*	*F Cal*	*F Tab at 5%*	*S/NS*
Years	1	16.83	16.83	5.29	5.99	NS
Replication	4	0.13	0.03	0.31	3.26	NS
Harvesting (H)	6	19.09	3.18	31.42	3.00	Significant
Error I	12	1.21	0.10			
Pakaging (P)	6	3.05	0.51	8.54	2.29	Significant
H x P interaction	18	4.73	0.26	4.41	1.82	Significant
Error II	48	2.86	0.06			
Total	95	47.91				

ANOVA 2: Effect of harvesting stages harvesting stages and packaging on aroma of organic pineapple fruit after harvest during 2014 and 2016 (Pooled)

Source of Variance	*Degree of Freedom*	*Sum of Square*	*Mean Sum of Square*	*F Cal*	*F Tab at 5%*	*S/NS*
Years	1	0.50	0.50	0.14	5.99	NS
Replication	4	0.65	0.16	0.69	3.26	NS
Harvesting (H)	6	21.74	3.62	15.29	3.00	Significant
Error I	12	2.84	0.24			
Pakaging (P)	6	2.87	0.48	5.97	2.29	Significant
H x P interaction	18	6.62	0.37	4.59	1.82	Significant
Error II	48	3.84	0.08			
Total	95	0.50	0.50	0.14		

ANOVA 3: Effect of harvesting stages harvesting stages and packaging on sweetness of organic pineapple fruit after harvest during 2014 and 2016 (Pooled)

Source of Variance	*Degree of Freedom*	*Sum of Square*	*Mean Sum of Square*	*F Cal*	*F Tab at 5%*	*S/NS*
Years	1	1.98	1.98	0.28	5.99	NS
Replication	4	2.07	0.52	4.21	3.26	Significant
Harvesting (H)	6	42.81	7.13	57.94	3.00	Significant
Error I	12	1.48	0.12			
Pakaging (P)	6	1.75	0.29	1.93	2.29	NS
H x P interaction	18	6.84	0.38	2.52	1.82	Significant
Error II	48	7.25	0.15			
Total	95	64.18				

ANOVA 4: Effect of harvesting stages harvesting stages and packaging on fibre content of organic pineapple fruit after harvest during 2014 and 2016 (Pooled)

Source of Variance	*Degree of Freedom*	*Sum of Square*	*Mean Sum of Square*	*F Cal*	*F Tab at 5%*	*S/NS*
Years	1	0.0000	0.0000	0.0000	5.99	NS
Replication	4	0.07	0.02	0.62	3.26	NS
Harvesting (H)	6	28.14	4.69	178.67	3.00	Significant
Error I	12	0.31	0.03			
Pakaging (P)	6	1.23	0.20	2.52	2.29	Significant
H x P interaction	18	4.77	0.27	3.26	1.82	Significant
Error II	48	3.90	0.08			
Total	95	38.42				

ANOVA 5: Effect of harvesting stages harvesting stages and packaging on overall acceptability of organic pineapple fruit after harvest during 2014 and 2016 (Pooled)

Source of Variance	*Degree of Freedom*	*Sum of Square*	*Mean Sum of Square*	*F Cal*	*F Tab at 5%*	*S/NS*
Years	1	2.4146	2.4146	0.5521	5.99	NS
Replication	4	0.27	0.07	2.97	3.26	NS
Harvesting (H)	6	26.24	4.37	193.09	3.00	Significant
Error I	12	0.27	0.02			
Pakaging (P)	6	0.65	0.11	3.60	2.29	Significant
H x P interaction	18	2.42	0.13	4.48	1.82	Significant
Error II	48	1.44	0.03			
Total	95	33.71				

ANOVA V

ANOVA 1: Effect of harvesting stages harvesting stages and packaging on shelf life of organic pineapple fruit after harvest during 2014 and 2016 (Pooled)

Source of Variance	*Degree of Freedom*	*Sum of Square*	*Mean Sum of Square*	*F Cal*	*F Tab at 5%*	*S/NS*
Years	1	4.17	4.17	0.49	5.99	NS
Replication	4	0.71	0.18	1.46	3.26	NS
Harvesting (H)	6	50.67	8.44	69.49	3.00	Significant
Error I	12	1.46	0.12			
Pakaging (P)	6	47.50	7.92	36.19	2.29	Significant
H x P interaction	18	11.50	0.64	2.92	1.82	Significant
Error II	48	10.50	0.22			
Total	95	126.50				

ANOVA 2: Effect of harvesting stages harvesting stages and packaging on post harvest loss of organic pineapple fruit after harvest during 2014 and 2016 (Pooled)

Source of Variance	*Degree of Freedom*	*Sum of Square*	*Mean Sum of Square*	*F Cal*	*F Tab at 5%*	*S/NS*
Years	1	1186.52	1186.52	3.70	5.99	NS
Replication	4	509.41	127.35	4.60	3.26	Significant
Harvesting (H)	6	1923.83	320.64	11.59	3.00	Significant
Error I	12	332.09	27.67			
Pakaging (P)	6	4762.37	793.73	31.33	2.29	Significant
H x P interaction	18	1110.03	61.67	2.43	1.82	Significant
Error II	48	1216.17	25.34			
Total	95	11040.41				

ANOVA VI

DETAILS OF COSTING FOR BCR CALCULATION:

1. **Cost of packaging :** Wooden box (P_1) - Rs. 60/box
   Bamboo box (P_2) - Rs. 50/box
   CFB box (P_3) - Rs. 90/box
   Used carton box (P_4) - Rs. 15/box
2. **Railway transport cost:** Rs.7.33 /kg (2014) & Rs. 9.33/ kg (2016)
   Wt. of fruit = 1.5 Kg (*i.e.* 12Kg per box appox.)
   Wt. of box = Wooden (P_1) - 3 kg
   Bamboo (P_2) - 3kg
   CFB (P_3) - 1kg
   Used carton (P_4) - 1kg
3. **Common cost (CC)/treatment**

Particulars	2014 (Rs)	2016 (Rs)
Local transportation (Farm to Railway station, Dimapur & Railway station, Delhi to IARI)	420/-	480/-
Labour Charge/box (at Farm and railway station)	6.25/-	10.42/-
Cost of fruit at farm (Rs. 12 for 2014 & Rs. 18 for 2016)	288/-	432/-
Total	714.25/-	922.42/-

Note:-

No. of fruit /box = 8

No. of box/treatment = 3

Total fruits/treatment = 24

4. **Selling price at Delhi/fruit** = Rs. 65 (2014) & Rs.85 (2016)