

Impact of Pre-harvest Treatments on Physico-chemical Attributes of Organic Pineapple (*Ananas comosus* L. Merr) in Nagaland, India

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ABSTRACT

The experiment aimed to study the influence of covering materials as pre-harvest treatment so as to improve the post harvest quality of the organic pineapple in Nagaland. The treatments, T₁ (Covering with own leaves), T₂ (Covering with straw), T₃ (Coating with kaolin), T₄ (Covering with net), T₅ (Covering with cloth) and T₆ (Open condition) were applied to enhance post harvest life using Randomized Block Design (RBD) with 3 replications. Among the various

pre-harvest treatments, T₂ was found to be the best with lowest sunburn, lowest PLW (Physiological loss in weight) and highest fruit size, juice content, TSS, sugar and ascorbic acid content. The treatment T₁ showed the highest titratable acidity percentage and the data pertaining to volume of fruit, weight of flesh and weight of core did not show any significant difference. Considering the minimal occurrence of sunburn, reduced physiological weight loss and enhanced post-harvest characteristics observed in organic pineapples, it is reasonable and logical to suggest that utilizing straw coverings after fruit maturation may represent an economical and superior choice.

Keywords Organic, Pineapple, Sun-burn, Pre-harvest treatment, Post-harvest quality.

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INTRODUCTION

Pineapple, scientifically known as *Ananas comosus* L. Merr, is a significant tropical fruit that is highly preferred by customers worldwide due to its attractive appearance, subtle aroma, and exceptional taste. The plant is a monocotyledonous, herbaceous, perennial plant that produces a single syncarpous fruit on a terminal inflorescence. In India, pineapple is grown in an area of 106 thousand hectares with total production of 1799 thousand metric tonnes (Anonymous 2021). Northeast region is one of the major pineapple growing areas of India, with Nagaland occupying 9000 ha area with a total production of 142.5000 tonnes/

annum (Anonymous 2019).

The cultivar 'Kew' is most popular amongst the growers of North-East India due to its excellent quality. The North-East Region of India has abundant rainfall, fertile and organically rich soil and exceptional climatic diversity supporting various cropping feasibilities. Moreover, pineapple requires slightly acidic to neutral soil with a pH ranging from 4.5–6.5 (Hossain 2016) which makes it congenial for the North East Region. Thus, the quality of the fruit is better and cultivation of pineapple in the region has good potential. The region bring about more than 40% of the overall pineapple production of the country and 90–95% of the products are organic because of less use of pesticides. The agro-climatic condition of Nagaland is found to be ideal for growing quality pineapple, producing fruits with high TSS and meagre fiber content. In this region, cultivars grown are Giant Kew (75%), Queen (20%) and Mauritius (0.50%) (Saloni *et al.* 2017). Therefore, it is imperative to state that the pineapple grown in Nagaland has better quality in terms of taste and flavor. Considering the prospects of this crop, several initiatives were taken by Central Institute of Horticulture (CIH) and Department of Horticulture, Government of Nagaland to promote Nagaland pineapple. One such effort was recognizing Molvom Village under Dimapur District as "The Pineapple Village" to commercialise its production. As the demand for pineapple from Molvom Village increased, the area under its cultivation also grew, however, practical approaches to sustain quality post harvest life of the perishable crop seems to be meagre which could not assure neither quality supply to the long distance consumers nor sustainable income for the farmers. In addition, this study aims to identify effective pre-harvest treatments using various covering materials to improve the quality and yield of pineapple fruit. The importance of this research resides in its capacity to enhance fruit quality, promote sustainable agricultural practices, and offer cost-effective solutions for farmers, ultimately contributing to improved economic and environmental outcomes. The selection of covering materials for the study was based on their availability, cost-effectiveness, and potential benefits to the quality and yield of pineapple fruit. Keeping in view about the need to bridge the gap for supply of quality produce between

producers and consumers and to mitigate losses, this study on improving post harvest quality of pineapple by pre-harvest treatments was considered.

MATERIALS AND METHODS

The research was conducted on a well-established organic pineapple plantation located in Molvom Village, approximately 5 kilometers from Medziphe-ma, between 2014 and 2016. The study site was selected after a thorough inspection where a block of 30×20 m² 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, thereby a total of one hundred (100) fruits per treatment were taken for experiment. The experiment was conducted using a Randomized Block Design (RBD) with six treatments and five replications. The treatment details were as follows T₁ (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, T₂ (Covering with straw): Paddy straws were collected and were gently placed around the fruits, T₃ (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, T₄ (Covering with net): Green color nets were used to cover the top of marked plot, T₅ (Covering with cloths): Used cloths were placed above the pineapple plants in the marked plot and T₆ (Open condition (control)): The fruits were not given any protection. The physico-chemical fruit parameters were analyzed using the following methods- The dimensions of the fruit were determined by measuring its length and width using a vernier calliper, and the measurements were recorded in centimeters. The fruit volume was determined using the water displacement method and reported in cubic centimeters (cm³). The weight of the flesh and core of each fruit was measured using a computerized weighing balance (Sumo Model, ED) and recorded in grams. The juice content was determined by extracting the juice from 100 g of fruit pulp using a muslin cloth. The juice was subsequently quantified using a graduated measuring cylinder and expressed as a percentage. The weight of the fruits was measured on three distinct observation days: 4,

8 and 12 Days after harvest (DAH), using a digital weighing scale. The weight was measured in grams. The percentage weight loss (PLW) of the fruits was calculated by subtracting the weight of the fruits on different observation dates from the original fruit weight. This calculation was done using the formula recommended by Srivastava and Tandon (1968).

$$\text{PLW (\%)} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

The ERMA Hand Refractometer was utilized to assess the Total Soluble Solids (TSS) concentration in the juice. The total and reducing sugar content of the fruit was measured using the Lane and Enyon method (Ranganna 2008). The non-reducing sugar content of fruits was determined by applying the subsequent formula and expressed as a percentage:

$$\text{Non-reducing sugar (\%)} = (\text{Total sugar} - \text{Reducing sugar}) \times 0.95$$

Titration of the dilute fruit juice with 0.1 N NaOH solutions and using Phenolphthalein as the indicator, the titratable acidity was analyzed. Titration method suggested by Sadasivan and Manikam (1992) was used for determining the ascorbic acid content. The results thus obtained were represented as mg/100 g of pulp. The number of fruits that had been sunburned were counted and was estimated by using the formula,

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

The recorded data were evaluated using a one-way analysis of variance (ANOVA) with a Randomized Block Design (RBD), following the approach described by Gomez and Gomez (1984). The Fisher-Shedecor 'F' test was employed at a significance level of 5% to ascertain the significance or non-significant of the variance resulting from different treatments.

RESULTS AND DISCUSSION

Size of fruit (cm³): The findings on fruit size (Table 1) revealed significant variability among the treatments. The maximum fruit size was found under T₂ (Covering with straw) recording 145.88 and 141.60

cm² during the two years of observation. The minimum fruit size was noted under open condition (T₆) with 128.12 and 123.86 cm² during 2014 and 2016, respectively. The increase in size may stem from reduced solar stress leading to decline in photosynthetic activity induced by light. In their study, Mupambi *et al.* (2018) found that using netting to protect apple trees from excessive solar radiation had a positive impact on fruit size. This was attributed to the net's ability to maintain higher photosynthetic rates. However, it was observed that trees or plants exposed to full sun exhibited lower quality, possibly due to photo inhibition.

Volume of fruit (cm³): The findings on the fruit volume indicated that there was no statistically significant distinction between the treatments (Table 1). Though, the maximum volume of fruit (852.00 and 855.00 cm³) was recorded under T₃ (Kaolin coating) during 2014 and 2016 respectively with mean of 853.50 cm³ followed by 830.00 and 827.00 cm³ under treatment T₂ during 2014 and 2016, respectively. The cm³ was recorded under treatment T₆ (Open condition) in both the years of observation with mean as 738.70 cm³.

Weight of flesh (g): From the obtained results of Table 1, regarding the weight of the fruit's flesh the results indicated that there were no notable distinctions observed across the various treatments. The highest weight of flesh, specifically 725.20 and 789.80 g, was seen under T₃ (Kaolin coating) in 2014 and 2016, respectively. Among the treatments, minimum flesh weight of fruit i.e., 593.00 g was found under T₅ (Covering with cloth) during 2014 and 523.60 g was recorded under treatment T₆ (Open condition) during 2016.

Weight of core (g): There was no significant variation in the core weight of the fruit among the different treatments (Table 1). The weight of core was recorded maximum i.e., 130.60 and 129.60 g under T₂ (Covering with straw) during 2014 and 2016 respectively with mean as 130.10 g followed by T₃ with 126.80 and 128.00 g during 2014 and 2016 respectively. The minimum weight of core i.e., 117.20 and 115.40 g was recorded in the treatment T₆ (Open condition) during 2014 and 2016.

Table 1. Effect of various treatments on fruit size, volume of fruit, flesh weight of fruit and core weight of fruit of organic pineapple. Note : NS = Non significant at 5% level of significance.

Treatments	Size of fruit (cm ²)		Volume of fruit (cm ³)		Weight of flesh (g)		Weight of core (g)	
	2014	2016	2014	2016	2014	2016	2014	2016
Covering with own leaves: (T ₁)	136.16	137.28	820.00	822.00	608.20	624.60	126.60	127.80
Covering with straw: (T ₂)	145.88	141.60	830.00	827.00	707.40	678.20	130.60	129.60
Coating with kaolin: (T ₃)	138.50	137.90	852.00	855.00	725.20	789.80	126.80	128.00
Covering with net: (T ₄)	134.16	133.23	782.00	780.00	628.40	567.40	125.40	125.00
Covering with cloth: (T ₅)	130.76	126.96	765.00	762.00	593.00	554.40	121.60	121.00
Open condition: (T ₆)	128.12	123.86	743.00	734.40	593.80	523.60	117.20	115.40
SEm±	2.95	2.92	68.49	47.14	76.16	71.67	6.90	6.48
SD	4.17	4.13	96.86	66.67	107.71	101.36	9.76	9.16
CD (p= 0.05)	8.71	8.62	NS	NS	NS	NS	NS	NS

The current study suggests that the improved physical characteristics of pineapple, such as fruit volume, flesh weight, and core weight, may be attributed to the use of kaolin as an anti-transpirant. Kaolin reduces the thickness of the fruit skin and non-edible parts, leading to enhancements in fruit weight, size, total soluble solids, grain and juice percentage, anthocyanin content in the juice, moisture content in the peel and seeds, volatile compounds, as well as weight and size of the arils. Additionally, it enhanced the relative rigidity of the leaves. The results are in close conformity with several studies of fruit crops. Hamdy *et al.* (2022) found with relation to fruit quality and yield, and the highest values were achieved when 6% of kaolin was sprayed. In conclusion, Keitt mango trees can produce more fruit and

have higher-quality fruit if kaolin is applied. Similar results of increase in fruit weight after application of kaolin was recorded in pomegranate (Ghanbarpour *et al.* 2019, Al-saif *et al.* 2022).

Physiological loss in weight (PLW): The data on effect of various treatments on physiological loss in weight is presented in Table 2. PLW findings showed that the PLW was significantly influenced by various treatments on all dates of observation i.e., 4th, 8th and 12th DAH in both the years. The highest PLW (8.65%) was recorded in T₆ (Open condition) and lowest (5.87%) in T₂ (Covering with straw) in both the years throughout the different dates of observation. Furthermore, scanning of the data showed that the increase in PLW was maximum on 8th DAH. The decrease in

Table 2. 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	2014	2016	2014	2016
Covering with own leaves: (T ₁)	2.51	2.41	5.20	4.71	7.87	6.65
Covering with straw: (T ₂)	2.16	2.35	4.31	4.54	6.93	4.80
Coating with kaolin: (T ₃)	2.90	2.10	6.64	4.33	9.79	7.18
Covering with net: (T ₄)	3.27	2.00	5.57	4.69	7.88	6.19
Covering with cloth: (T ₅)	2.59	2.20	5.29	3.88	7.51	5.56
Open condition: (T ₆)	2.96	2.51	6.83	4.84	9.95	7.34
SEm±	0.23	0.11	0.24	0.20	0.48	0.44
SD	0.33	0.16	0.34	0.28	0.68	0.62
CD (p= 0.05)	0.69	0.33	0.70	0.58	1.42	1.31

Table 3. Effect of various treatments on juice content, total soluble solids, total sugar and reducing sugar of organic pineapple.

Treatments	Juice content (%)		Total soluble solids (°Brix)		Total sugar (%)		Reducing sugar (%)	
	2014	2016	2014	2016	2014	2016	2014	2016
Covering with own leaves: (T ₁)	54.20	55.40	13.40	15.20	6.78	8.10	3.90	4.03
Covering with straw: (T ₂)	67.20	67.60	16.60	17.20	8.46	9.96	4.21	4.10
Coating with kaolin: (T ₃)	64.00	69.00	16.00	15.50	6.81	8.10	3.78	3.67
Covering with net: (T ₄)	61.20	64.00	13.40	15.00	6.33	7.79	3.41	3.45
Covering with cloth: (T ₅)	56.60	60.40	13.00	13.60	6.27	7.48	4.18	4.15
Open condition: (T ₆)	50.60	53.80	12.60	13.20	6.16	6.72	3.23	3.17
SEm±	2.14	2.80	0.87	0.70	0.46	0.47	0.18	0.16
SD	3.03	3.96	1.23	0.99	0.65	0.66	0.25	0.23
CD (p= 0.05)	6.30	8.26	2.56	2.05	1.37	1.38	0.54	0.48

the PLW may be due to reduction in respiration and transpiration rates thus, protecting the fruit from environmental stress, physical damage and maintaining hydration levels. 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 line with the current results. They opined that the PLW of ripe fruits represents its freshness and quality thus influencing its marketability.

Juice content (%): The findings indicated a notable disparity in juice content among the various treatments (Table 3). The maximum juice content were recorded in T₂ (Covering with straw) and T₃ (Kaolin coating) with 67.20 and 69.00% during 2014 and 2016 with the mean of 67.40 and 66.50%, respectively. Minimum juice content i.e., 50.60 and 53.80% was recorded under T₆ (Open condition) treatment during 2014 and 2016 respectively with mean of 52.20%. Pineapples are sensitive to sunburn and excessive heat therefore increase in juice content might result from the various pre-harvest treatments provided to the fruit which resulted in protection from the direct sunlight, reduced heat stress and modification of microclimate. Ennab *et al.* (2017) also recorded lower juice content in control (spray with tap water only) and highest juice content was observed in T₇ (Spraying kaolin @ 4%) in mandarin fruit which was

similar to the present findings.

Total soluble solids (°Brix): The data represented in terms of TSS content revealed differences which were significant in all treatments studied (Table 3). TSS was recorded highest i.e., 16.60 and 17.20 °Brix under T₂ (Covering with straw) during 2014 and 2016 respectively, while the minimum was recorded under the treatment T₆ (Open condition) with 12.60 and 13.20 °Brix during 2014 and 2016 respectively. The rise in TSS may due to the controlled micro-environment around the fruit which helps to maintain optimal temperature and humidity levels that are conducive to the biochemical processes involved in sugar synthesis and accumulation. Similar results were also obtained by Singh *et al.* (2020) in strawberry, where TSS was improved in covered fruit compared to the exposed one.

Total sugar (%): The trial results on the total sugar percentage indicated (Table 3) a notable variation among the treatments. The highest total sugar percentage, namely 8.46 and 9.96%, was observed in T₂ (Covering with straw) in 2014 and 2016 respectively, with an average of 9.21%. The lowest total sugar percentage, namely 6.16 and 6.72%, was recorded in treatment T₆ (Open condition) in 2014 and 2016, respectively. Prabha *et al.* (2018) reported similar findings in pineapple cv Mauritius where in they

Table 4. 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/100 ml juice)		Sun burn (%)	
	2014	2016	2014	2016	2014	2016	2014	2016
Covering with own leaves: (T ₁)	2.88	4.07	0.50	0.52	9.05	7.19	8.00	12.00
Covering with straw: (T ₂)	4.25	5.87	0.31	0.35	9.84	8.47	4.00	4.00
Coating with kaolin: (T ₃)	3.03	4.43	0.47	0.50	7.40	8.47	16.00	20.00
Covering with net: (T ₄)	2.92	4.34	0.44	0.47	8.20	7.54	12.00	12.00
Covering with cloth: (T ₅)	2.09	3.33	0.30	0.32	7.81	7.42	8.00	8.00
Open condition: (T ₆)	2.93	3.55	0.46	0.51	5.62	6.82	20.00	28.00
SEm±	0.41	0.50	0.05	0.04	0.50	0.62	1.22	1.08
SD	0.58	0.71	0.07	0.06	0.71	0.88	1.73	1.53
CD (p= 0.05)	1.21	1.48	0.13	0.13	1.47	1.84	3.59	3.20

observed lowest total sugar in control and highest in paper bag. It maybe concluded that providing a cover over the developing fruit can enhance the fruit quality as it creates a microclimate around the fruit with gradual increase in temperature which eventually enhances the aroma and total sugar content. This result is in close conformity with findings from Meena *et al.* (2016) in guava.

Reducing sugar (%): The data pertaining to reducing sugar is presented in the Table 3. It indicated significant difference on the reducing sugar percentage among various treatments. The highest percentage of reducing sugar was observed in treatment T₂ (Covering with straw) and T₅ (Covering with cloth) with values of 4.21 and 4.15% in the years 2014 and 2016, respectively. The average percentage of reducing sugar in both treatments was 4.16%. The enhancement in reducing sugar could be due to the covering of pineapple that helps to promote more uniform and controlled ripening by shielding the fruit from fluctuating external conditions. Uniform ripening allows for consistent enzymatic activity that breaks down complex sugars into simpler reducing sugars, thus enhancing the sweetness of the fruit. Several studies confirmed that bagging influenced the environmental variables such as solar radiation and temperature which play a pivotal role in accumulation of sugar, rate of respiration and also increase in soluble sugar

in guava (Meena *et al.* 2016, Prabha *et al.* 2018).

Non-reducing sugar (%): The percentage of non-reducing sugar varied significantly among the different treatments (Table 4). Non-reducing sugar percentage was recorded highest i.e., 4.25 and 5.87% in T₂ (Covering with straw) during 2014 and 2016 respectively, with mean of 5.06%. Minimum non-reducing sugar percentage (2.09 and 3.33%) was found in T₅ (Covering with cloth) during 2014 and 2016 respectively. Bhelawe *et al.* (2024) reported highest non reducing sugars (3.90%) in fruit covered with butter paper bags in sweet orange. The result is in close conformity to research works done in guava, grapes and mango by Meena *et al.* (2016). Studies by Prabha *et al.* (2018) reported that bagging improved then on reducing sugar content which could be due to control of temperature and various light wave length which is involved in ripening and maturation.

Titratable acidity (%): The maximum titratable acidity (0.50 and 0.52%) was found in T₁ (Covering with own leaves) during 2014 and 2016 respectively with mean of 0.51% (Table 4). Among the treatments, minimum titratable acidity percentage of 0.30 and 0.32% were recorded in treatment T₅ (Covering with cloth) during 2014 and 2016, respectively. The practice of covering or bagging pineapples before harvest tends to decrease titratable acidity by creating

favorable conditions for sugar accumulation and acid metabolism. According to Prabha *et al.* (2018) acidity levels were highest in the control group and lowest in the group of fruits that were covered. Subsequent research has consistently found that bagging has an impact on acidity.

Ascorbic acid (mg/100 ml juice): The levels of ascorbic acid varied significantly among different treatments in 2014 and 2016 as shown in Table 4. The highest concentration of ascorbic acid, 9.84 mg/100 ml juice, was found in T₂ (Covering with straw) in 2014, followed by T₁ (Covering with own leaves) with a concentration of 9.05 mg/100 ml. In 2016, T₃ (Kaolin spray) had the highest concentration of ascorbic acid at 8.47 mg/100 ml. The minimum ascorbic acid was recorded in T₆ (Open condition) with 5.62 and 6.82 mg/100 ml during 2014 and 2016 respectively. The impact of covering the fruit on ascorbic acid can vary depending on the types of material that is being used and also the time and duration of covering. Excessive exposure to sunlight, particularly UV light, can degrade ascorbic acid. By covering the fruit, the amount of UV light reaching the pineapple is reduced, thereby preserving its ascorbic acid content. Ennab *et al.* (2017) observed that in comparison to control, treatment using kaolin resulted in slight increase in acidity and significant increase in Vitamin C content in both growing seasons. Vitamin C of fruits was significantly improved under all types of bagging (Lal and Sahu 2017).

Sun burn (%): The sun burn percentage presented in Table 4 was found to be significantly different among various treatments during 2014 and 2016 with a maximum of 20.00 and 28.00% under T₆ (Open condition). While, the minimum was observed in treatment T₂ (Covering with straw) with 4.00 and 4.00% during 2014 and 2016 respectively, which was followed by T₁ (Covering with own leaves) and T₅ (Covering with cloth) with 8.00 and 12.00% during 2014 and 2016 respectively. Therefore, it was apparent from the present findings that covering with straw (T₂) during the maturity of the fruit can be the best option as pre-harvest treatment in reducing sun burn in pineapple which is cost effective and easily available for the growers. Suryawanshi and Gupta (2015) suggested that sun exposed portion of the

fruit can be covered with dry straw or grass or with any other locally available materials. Growers must implement best management practices to minimize sun burn and follow appropriate canopy management, grow tolerant cultivars, fruit bagging, cover or inter cropping, efficient irrigation, shade netting, over-tree sprinklers, suppressants such as kaolin or calcium carbonate, as well as chemical protectants were used (Lal and Sahu 2017). According to Ennab *et al.* (2017) in their studies on Balady mandarin trees reported positive effect on preventing fruit sun burn damage by following three kaolin sprays @ 3 and 4% during summer season. This also improved yield and fruit quality. Mechanical pre-harvest treatment with black shade net, fruit wrap and fruit cap also showed just 0–15% sunburn incident rate (Shafawi *et al.* 2020). Ogiela (2020) documented that the application of kaolin had positive effects on the nutritional status of persimmons. It also helped to reduce sunburn damage to the fruit and enhance fruit quality and productivity.

One of the major plights in pineapple cultivation is sunburn which occurs when plant lodges and exposes the fruit to direct sunlight; as a result it raises reduction in yield or an increase in cost of the production if the crop has to be protected by providing shade artificially. Nonetheless, using a mix culture system to apply natural shade offers a practical and affordable substitute for net shading (Silva *et al.* 2017).

CONCLUSION

On the basis of the results recorded, it was concluded that using different covering materials as pre-harvest treatments i.e., T₁ (Covering with own leaves), T₂ (Covering with straw), T₃ (Coating with kaolin), T₄ (Covering with net) and T₅ (Covering with cloth) significantly improved the post harvest qualities while control (T₆– Open condition) registered the lowest value in all quality parameters. T₂ (Covering with straw) was found to be pre-eminent from the rest of the treatments with highest fruit size, fruit weight, sugar, ascorbic acid content, lowest sun burn and lowest physiological loss in weight. The study found that there were no significant differences in the volume of fruit, weight of flesh, and weight of core when various treatments were applied. Thus, taking into account the minimal sunburn, minimal physiological

weight loss, and the enhanced post-harvest qualities of organic pineapple, it is reasonable and logical to conclude that using straw to cover the pineapple after it has ripened can be regarded as a superior choice.

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