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# Studies on physico-chemical characteristics of unripe fruits of local mango (*Mangifera indica* L.) cv. Heinou Khongnembi fruit of Manipur

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**Abstract**
The experiment entitled "Studies on Physico-chemical characteristics of unripe fruits of Local Mango (*Mangifera indica* L.) cv. Heinou Khongnembi Fruit of Manipur" was undertaken during the period May 2021 to July 2021 at Laboratory of Department of Horticulture, College of Agriculture, Central Agricultural University, Iroisemba, Imphal, Manipur. The experiments under study was carried out in (CRD) Completely Randomized Design with eight treatments of different growth stages of local mango fruit of Manipur $T_1$ (20g fruit weight), $T_2$ (40g fruit weight), $T_3$ (60g fruit weight), $T_4$ (80g fruit weight), $T_5$ (100g fruit weight), $T_6$ (120g fruit weight), $T_7$ (140g fruit weight) and $T_8$ (160g fruit weight). Treatment $T_8$ (160g fruit weight) was found to be good with respect to TSS, total sugars and lowest moisture content. Treatment $T_1$ (20g fruit weight) performed well with respect to titratable acidity and minimum pH.

**Keywords:** Fruits, moisture, physiological, postharvest and tropical

## Introduction
Mango (*Mangifera indica* L.) is an important tropical fruit, belonging to the family Anacardiaceae and genus Mangifera. The genus has 69 species, out of which only a few have edible fruits. In India only 3 species are found *i.e. Mangifera indica*, *Mangifera sylvatica* and *Mangifera coloneura*. The species *Mangifera indica* bears edible fruits. Mangifera sylvatica is a wild species, grown in north eastern parts of India and fruit is not edible. The mango is Asia's most valuable fruit, ranking fifth in total production among major fruit crops after bananas, oranges, grapes, and apples worldwide (FAO Production year book, 1993). Mango is known as the "King of Tropical Fruits" because of its high palatability, excellent taste and exemplary nutritive value. Annual production of mango in India is 21.822 million tonnes from 2.25 million ha area with productivity of 9.7 MT/ha. India contribute about 64% of the world mango production. In India, mango occupies the top position with an annual production of about 10 million tones, which accounts for about 65% of the total world production *i.e.*, 14.63 million Tones. In India, mango occupies 38.28 percent of the total area under fruits comprising of 1.60 million hectares with a total production of 10.78 million tones. The main mango growing States in India are Uttar Pradesh, Andhra Pradesh, Bihar, West Bengal, Kerala, Karnataka, Maharashtra, Orissa, Tamil Nadu, Punjab, Haryana, Himachal Pradesh, and Jammu & Kashmir. Flowering in mango is preceded by the differentiation of the flower bud in the shoots. Period of differentiation is reported to be October-December depending upon the climatic conditions. In Baramasi strain of mango, the critical time of differentiation is twice in a year *i.e.*, May-June and September-October. Apart from the inherent character of the variety, the time of flowering in different regions is mainly governed by the local climate, for example the time of flowering in South India is December but in North India it is February-March. Mangoes are eaten as a fresh fruit. It's a fruit with a lot of nutritional value. It's high in vitamins A, B, and C, as well as minerals. Water (75-82%), sugar (13.7%), dietary fiber (1.6g), protein (0.82g), vitamin C (36.4 mg), and energy (250 kJ) are the key components of mango. It also has a carbohydrate content of approximately 17%. Mangoes are a good source of dietary fiber, energy, and nutrients, so they're linked to a lower risk of cancer, as well as heart disease and cholesterol buildup. (Anonymous, 2015) [1]. Nanda *et al*. (2012) [11] revealed that 5.8-18.1% of fruits were lost during harvesting, postharvest activities, handling and storage.

Tight fruit packaging, improper transportation, and insufficient field handling are all common causes of quality loss. Fruit losses can vary drastically depending on postharvest handling and export conditions, particularly in terms of decay, pests, and physiological breakdown. Despite a wide range of uses, post-harvest processing of mango crops is limited, and the processed product is scarce in some parts of North East India, particularly in Manipur.

## Materials and Methods

The experiment entitled "Studies on Physico-chemical characteristics of unripe fruits of Local Mango (*Mangifera indica* L.) cv. Heinou Khongnembi Fruit of Manipur" was undertaken during the period. May 2021 to July 2021 at Laboratory, College of Agriculture, Central Agricultural University, Iroisemba, Imphal, Manipur.

**Physico-chemical characteristics of unripe mango fruits are**

1. **Fruit weight (g):** The weight of ten mango fruits selected at random was taken on a digital weighing machine individually and expressed as an average fruit weight (g/ fruit).
2. **Fruit length and breadth (cm):** The fruit size of mango was determined with the help of a Vernier calliper by measuring the length and breadth of ten fruits selected at random. The average fruit size was to be calculated and expressed in centimetres.
3. **Specific gravity (g/cm3):** Firstly, the weight of selected fruits was taken and then their volume was recorded. Weight divided by volume of fruit gave a specific gravity of fruit.

$$\text{Specific gravity (g/cm3)} = \frac{\text{Weight of the fruit (g)}}{\text{Volume of water displeased (cm}^3\text{)}}$$

4. **Peel + Flesh content and Stone content (%):** The peel, flesh (edible portion) and stone of mango fruits was removed and weighed separately on a digital weighing machine and expressed as percent of fruit weight.
5. **Total soluble solids (ºBrix):** Total soluble solids (T.S.S.) were determined with the help of hand refractometer (Erma Japan, 0 to 32 ºBrix) and value was corrected at room temperature and expressed in ºBrix.
6. **PH:** The pH of the mango fruit was determined with the help of pH meter. Standard solutions of pH 4.0 and 7.0 were used as reference to calibrate. The sample was prepared by grinding the mango pieces into mixer. 10gm of prepared sample was taken into a beaker and 25 ml water was added, into it. The sample was mixed thoroughly and the pH was recorded.
7. **Titratable acidity (%):** Titratable acidity was determined according to the method given by (Ranganna, 2007) [18].

**Reagents**

a) 0.1 N sodium hydroxide (NaOH): 4 g NaOH was dissolved in distilled water and make volume to one litre. b) Phenolphthalein indicator (1%).

**Extraction**

Five grams of sample was macerated in distilled water and volume was made to 25 ml. It was kept on boiling water bath for one hour. After cooling, filtration, volume was made to 100 ml.

**Estimation**

Ten ml of aliquot was pipetted in a 50 ml conical flask. 1-2 drops of the phenolphthalein indicator were added. Titrated against 0.1% NaOH untill finally one drop of NaOH gave pink colour lasting for a minute or longer. From the volume of alkali used, acidity was calculated and results were expressed in percent acidity in terms citric acid.

$$\text{Acidity (\%)} = \frac{\text{TItre value} \times \text{Normality of NaoH} \times \text{Vol. made up} \times \text{Eq. weight of acid} \times 100}{\text{Volume of sample taken for estimation} \times \text{Wt. or Vol. of sample taken} \times 1000}$$

**Total sugars**

Total sugar was determined the method of Yemm and Willis (1954).

**Reagents:** a) Anthrone reagent (0.2%): It was prepared in 70% H2SO4 freshly every time and allowed to stand for 30 to 40 minutes before use under low temperature (4-5 °C) in a refrigerator. b) Standard sugar solution: 25 ml glucose was dissolved in water and made to 100 ml. This solution contained 25 µg glucose per ml. for obtaining a standard curve, 0.1 ml to 0.1 ml of this solution was used.

**Estimation**

Five ml of anthrone reagent was pipetted into test tubes and chilled in ice cold eater. 0.2 ml of aliquot was layered on the anthrone reagent, cooled for 3-5 minutes and then thoroughly mixed while still immersed in ice cool water. The tubes were then heated in boiling water bath for 10 minutes and then immediately cooled in ice water. A blank was run simultaneously. The absorbance of green color developed was read at 625 nm in spectrophotometer (Spekol 1100, Analytic Jena GmbH, Germany). The amount of sugar was calculated from the standard curve prepared using glucose.

**Moisture (%)**

Moisture content was determined by the method of A.O.A.C. (1990) [2]. The fruits were cut into small pieces with a sharp knife and 10 g of the sample was dried at 60 ± 5 ºC to constant weight. The samples were cooled in a dessicator and weighed. Moisture content was expressed in percentage and worked out by the following formula:

$$\text{Moisture (\%)} = \frac{\text{Loss of weight (g)}}{\text{Weight of the sample}} \times 100$$

**Chlorophyll**

The chlorophyll content is determined using the method as described by Sadasivam and Manickam (1991) [20]. 100 mg of sample was extracted with 80% of acetone and centrifuged at 5000rpm for 5 minutes. The supernatant was then collected. The absorbance of the green coloured solution was read at 645 and 663 nm. The chlorophyll a, chlorophyll b, and total chlorophyll were calculated using the formula given below and expressed in mg of pigments per gram of fresh weight as per Sadasivam and Manickam (1991) [20].

Total chlorophyll = 20.2(OD at 645) + 8.01(OD at 663) × V/W × 100 mg/g

## Results and Discussion

### 1. Fruit weight (g)

The fruit weight of mango is shown in Table 1. It is important to note that the fruit weight of local mango fruit increased significantly during different growth stages, minimum fruit weight was recorded in $T_1$ with a value of 20.66 g (4.60 g) and attained maximum fruit weight was in $T_8$ with a value of 160 g (12.68 g). Fruit weight followed a linear sigmoid pattern in the current studies, which agrees with the findings of Wongmetha *et al.* (2015) [24] who observed the increase in fruit weight (0.022-1.025 kg) throughout the growth. Fleancu (2007) [3], growth is a quantitative process which results in an increase of fruit weight and volume. Fruit weight increases as a result of changes in fruit length, breadth, thickness, seed weight, and composition during fruit growth and development. Similar findings have been reported by Wongmetha *et al.* (2015) [24] Mango fruit weight, width and length of mango cv. Jinhwang significantly increased during growth.

### 2. Fruit length and breadth (cm)

The cumulative fruit growth in term of fruit length and breadth in different growth stages of local mango fruit increased significantly is presented in Table 1. Minimum fruit length and breadth was noted in $T_1$ with a value of (4.33 cm & 3.03 cm) and Maximum fruit length and breadth was observed in $T_8$ with a value of (9.10 cm & 6.76 cm). Fruit length and breadth were found to increase as fruit maturity progressed in this study. Similar findings have been reported by Sastry *et al.* (1975) [21] where the fruit length was 11.52 cm with the Amlet variety of mango and the breadth was 8.93 cm. They also found that the early stage of maturity of 8 to 9 weeks growth was the optimum stage of maturity for picking when the fruit attained almost the maximum fruit length and breadth. Fruit length and breadth in different growth stages of mango fruit increased significantly. Increasment in fruit length and breadth is a result of cell division.

### 3. Specific gravity (g/cm$^3$)

Changes in specific gravity of different growth stages of local mango fruit are presented in Table 1 and specific gravity significantly increased. The values were ranged from 0.83 to 1.04. The minimum specific gravity was recorded at stage $T_1$ with a value of (0.83) and maximum specific gravity was recorded at stage $T_8$ with a value of (1.04). The present results are in agreement with the studies of Rajput and Pandey (1998) in two mango cultivars *viz*. Langra and Sunderja and two hybrids namely Mallika and Amrapalli. Specific gravity of the fruits showed a decreasing trend up to 45 days after fruit set and a linear increase in specific gravity was observed up to maturity of fruits in all cultivars. Specific gravity of different growth stages of mango fruit significantly increased. Increasment in specific gravity is a result of increased fruit volume and fruit weight. Fruit volume is directly related to fruit size, weight and specific gravity of fruit. Tandon and Kalra (1983) [23], as well as Verma *et al.* (1986) [6], observed similar results.

### 4. Fruit peel and flesh content (%)

The peel and flesh content of different growth stages of local mango fruit are presented in Table 1 and peel and flesh content of fruit was found to be 84.57% to 87.62% among different fruit growth stages of local mango fruit. Maximum peel and flesh content was recorded in $T_8$ with a value of (87.62%) and minimum peel and flesh content was recorded in $T_1$ with a value of (84.57%). The peel and flesh content of fruit continuously increase in $T_1$ with a value of (84.57%) to $T_8$ (87.62%). Peel and flesh content of mango fruit was low during $T_1$, while it increased from $T_1$ to $T_8$. It was increase significantly with fruit growth. Increased peel and flesh content from $T_1$ to $T_8$ may be due to increased cell division and enlargement in the interior (Mesocarp) and exocarp (Peel). The thinness or thickness of the peel and flesh, on the other hand, is a varietal feature. The findings of Rajput and Pandey (1997) [15] and Mitra and Mitra (2001) [10] are consistent with the findings of this study.

### 5. Stone content (g)

The stone content of different growth stages of local mango fruit are presented in Table 1 and the average stone content of fruit was found to range from 3.18 g to 19.80 g among different fruit growth stages of local mango fruit. Maximum stone content was recorded in $T_8$ with a value of 19.80 g and minimum stone content was recorded in $T_1$ with a value of 3.18 g. The stone content of fruit was found to continuously increase from $T_1$ with a value of 3.18 g to $T_8$ with a value of 19.80 g. It has been observed that the percentage of stone content in the fruit gradually decrease from T1 (15.43%) to T8 (12.38%) with the increase in maturity of the fruit. The stone content of different growth stages of local mango fruit was increased from $T_1$ to$T_8$. Stone content was minimum at $T_1$. Massive increase in growth rate during this periodis directly associated with the period of maximum activity of auxin and gibberellin like substance in the stone. An increase in stone content from $T_1$ to $T_8$ as observed in mango fruits were also reported by Pandey *et al*. (1974) [13] and Padhiar *et al*. (2011) [12].

### 6. TSS (ºBrix)

TSS content of different growth stages of local mango fruit improved gradually and significantly Table 1. Minimum total soluble solids was recorded in $T_1$ with a value of (6.43°B), and maximum total soluble solids was recorded in $T_8$ with a value of (9.41°B). Values were increased continuously from $T_1$ with a value of (6.43°B) to $T_8$ with a value of (9.41°B). According to the findings of the current studies, an increase in TSS was observed as the fruit reached physiological maturity. Kudachikar *et al.* (2003) reported increase in TSS continuously during growth and maturity of mango cultivars. At maturity, maximum TSS was recorded in Langra. They have concluded that increase in TSS might be due to metabolic transformations in soluble compounds mainly sugars. The accumulated starch in the fruit is hydrolyzed into sugars as the fruit matures, and sugars are the primary constituent of TSS. As a result, in the current study, the impact of native TSS present in fruits of various growth stages. The TSS are increase with growth stage of fruit. Tandon and Kalra (1983) [23] and Gowda and Ramanjaneya (1994) [4] and Parekh *et al*. (2015) [14] found similar results in mango cultivars, supporting the current findings.

### 7. Titratable acidity (%)

The titratable acidity of different growth stages of local mango fruit are presented in Table 1 and the titratable acidity of mango fruit differs significantly with respect to different treatments of growth stages of fruits. Titratable acidity of fruit

was found to be 2.56% to 2.76% percent among different fruit growth stages of local mango fruit. Maximum titratable acidity was recorded in $T_1$ with a value of (2.76%) and minimum titratable acidity was recorded in $T_8$ with a value of (2.56%). The titratable acidity of fruit was continuously decrease from $T_1$ with a value of (2.76%) to $T_8$ with a value of (2.56%). Rajput and Pandey (1998) [16] reported that the titratable acidity in mango increased after fruit set and fruit development. The acidity increased up to 45 days after fruit set in Amrapali, 70 days in Sunderja and Langra while up to 75 days in Mallika. Thereafter, it decreased in all the cultivars. Titratable acidity of fruits decreases during different ripening periods, while their pH and TSS increase (Jiménez *et al*., 2011) [5]. Rooban *et al*. (2016) [19] worked on ripening behavior of mango at immature, mature, ripen and over ripen stages, and observed that high acidity was found at immature stage whereas low at over ripe stage. The decrease in mango fruit acids from $T_1$ to $T_8$ could be attributed to the conversion of organic acids into sugar and their derivatives, or to their utilisation in respiration. These findings are consistent with the findings of Krishnamorthy *et al*. (1960) [7], who discovered that the titratable acidity of mango fruits decreases during ripening and Mandal *et al*. (1993) [9] discovered that acidity decreased throughout the various stages of mango fruit growth and development.

**8. pH**

The pH of different growth stages of local mango fruit are presented in Table 1 and the pH of mango fruit differs significantly with respect to different treatments of growth stages of fruits. pH of fruit was found to range between 3.92 to 3.33 among different fruit growth stages of local mango fruit. Maximum pH was recorded in $T_8$ (3.92) and minimum pH was recorded in $T_1$ (3.33). The pH of fruit was continuously increase from $T_1$ with a value of (3.33) to $T_8$ with a value of (3.92). The mango pH value (from 3.3 to 7.9) and cashew apple pH value (from 4.4 to 8.8). As compared to untreated controls during ripening this is closely associated with the report of (Ranganna, 1977) [17]. Moreover, Titratable acidity of fruits decreases during different ripening periods, while their pH and TSS increase (Jiménez *et al*., 2011) [5]. The increase in pH of mango fruit with increasing fruit development stage may be attributable to a similar decrease in acidity of mango fruit. Similar findings were observed Rooban *et al*. (2016) [19].

**9. Total sugars (%)**

Total sugar content of different growth stages of local mango fruit improved gradually and significantly Table 1. Minimum total sugars was recorded in $T_1$ with a value of (5.11%), and maximum total sugars was recorded in T8 with a value of (6.20%). Values were increased continuously from $T_1$ with a value of (5.11%) to $T_8$ with a value of (6.20%). According to the findings of the current studies, an increase in TSS was observed as the fruit reached physiological maturity. The physicochemical change occurring during the growth and development was studied by Rajput and Pandey (1998) [16] in two mango cultivars *viz*. Langra and Sunderja and two hybrids namely Mallika and Amrapalli. TSS and total sugar content of the fruits were increased after fruit set to maturity and highest in Langra and Sunderja, respectively. The accumulated starch in the fruit is hydrolyzed into sugars as the fruit matures. As a result, in the current study, the impact of native total sugars present in fruits of various growth stages. The total sugar are increase with growth stage of fruit.

**10. Moisture (%)**

Total moisture content of different growth stages of local mango fruit decrease gradually and significantly Table 1. Moisture content of fruit was found to be (87.08%) to (84.32%) among different fruit growth stages of local mango fruit. Maximum moisture content was recorded in $T_1$ with a value of (87.08%) and minimum moisture content was recorded in $T_8$ with a value of (84.32%). Moisture content of different, different growth stage of mango significantly decrease. Ueda *et al.* (2000) [25] also observed almost similar finding. They harvested mango fruits 10, 13, 16, and 19 weeks after blooming and found moisture levels of greater than 80% in all phases of fruit development. However, the fruits picked 10 weeks after flowering had the highest moisture content of 88.6 percent.

**11. Chlorophyll (mg/g)**

The chlorophyll content of different growth stages of local mango fruit decrease gradually and significantly Table 1. Chlorophyll content of fruit was found to be (2.55 mg/g) to (1.40 mg/g) among different fruit growth stages of local mango fruit. Maximum chlorophyll content was recorded in $T_1$ with a value of (2.55 mg/g) and minimum chlorophyll content was recorded in $T_8$ with a value of (1.40 mg/g). Rooban *et al*. (2016) [19] observed that among the pigment change during different stages of fruit ripening of Mango and Cashew apple in the chlorophyll content was high at immature stage and low in over ripen stage. Chlorophyll content of mango fruit was high during $T_1$, while it decreased from $T_1$ to $T_8$. It was decrease significantly with fruit growth. Chlorophyll content decreases due to chlorophyll degradation as a result of fruit maturity. The degradation of chlorophyll is a regulated process, with multiple enzymes (Chlorophyllase, Mg-dechelatase) catalysing the various reactions (Takamiya *et al*., 2000) [22].

**Table 1:** Physico-chemical characteristics of unripe mango fruits

| Treatments (Growth stages of fruits) | Fruit weight (g) | Fruit length (cm) | Fruit breadth (cm) | Specific gravity ($g/cm^3$) | Peel+Flesh content (%) | Stone content gram (%) | TSS (°Brix) | Total sugars (%) | Titratable acidity (%) | Chlorophyll (mg/g) | pH | Moisture (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $T_1$ (20g fruit weight) | 20.66(4.60) | 4.33 | 3.03 | 0.83 | 84.57 | 3.18(15.43) | 6.43 | 5.11 | 2.76 | 2.55 | 3.33 | 87.08 |
| $T_2$ (40g fruit weight) | 42.66(6.57) | 5.56 | 4.03 | 0.92 | 85.67 | 6.11(14.33) | 7.28 | 5.17 | 2.70 | 2.54 | 3.36 | 86.43 |
| $T_3$ (60g fruit weight) | 60.33(7.80) | 6.30 | 5.13 | 0.99 | 85.72 | 8.61(14.28) | 7.43 | 5.24 | 2.69 | 2.48 | 3.41 | 86.21 |
| $T_4$ (80g fruit weight) | 82.33(9.10) | 7.50 | 5.46 | 1.00 | 86.18 | 11.37(13.82) | 8.14 | 5.35 | 2.67 | 2.14 | 3.51 | 86.09 |
| $T_5$ (100g fruit weight) | 104.0(10.12) | 7.70 | 5.76 | 1.01 | 86.80 | 13.72(13.20) | 8.46 | 5.44 | 2.66 | 2.10 | 3.52 | 86.08 |
| $T_6$ (120g fruit weight) | 120.0(11.00) | 8.13 | 6.13 | 1.02 | 87.02 | 15.57(12.98) | 8.72 | 5.56 | 2.65 | 1.90 | 3.67 | 85.63 |
| $T_7$ (140g fruit weight) | 140.0(11.86) | 8.56 | 6.46 | 1.03 | 87.20 | 17.92(12.80) | 9.35 | 6.11 | 2.63 | 1.60 | 3.75 | 85.33 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $T_8$ (160g fruit weight) | 160.0(12.68) | 9.10 | 6.76 | 1.04 | 87.62 | 19.80(12.38) | 9.41 | 6.20 | 2.56 | 1.40 | 3.92 | 84.32 |
| Mean | 91.25(9.22) | 7.15 | 5.35 | 0.98 | 86.35 | 12.03(13.65) | 8.15 | 5.52 | 2.67 | 2.09 | 3.56 | 85.90 |
| S.Em± | 0.474(0.032) | 0.062 | 0.039 | 0.005 | 0.268 | 0.107(0.222) | 0.022 | 0.005 | 0.007 | 0.010 | 0.026 | 0.344 |
| C.D. at 5% | 1.413(0.096) | 0.187 | 0.117 | 0.016 | 0.804 | 0.322(0.666) | 0.067 | 0.014 | 0.023 | 0.031 | 0.079 | 1.032 |

**Note:** The fruit weight value that presented under bracket is the (SQRT) value and Stone content value presented under bracket in the (%).

## Conclusion

Despite its abundance during the peak season in Manipur, most local varieties have a tendency to become infested with insects and fail to completely ripen. As a consequence, it is important to conserve the immature mango by processing and value addition in order to reduce and mitigate the loss. Fruit weight, fruit length & breadth, fruit peel & flesh content, specific gravity, stone content were found to be increased during different growth stages. The TSS, total sugars and pH were found to be increased whereas titratable acidity, chlorophyll and moisture content decreased during different growth stages.

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