Popoulu: A Promising Plantain Banana Could Strengthen the Banana Chips Industry in India

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ABSTRACT
Background: Nendran is the commercial variety of banana grown exclusively for preparation of chips but its yield potential is very low (10 to 12 kg/plant). Hence an attempt was made to identify suitable banana varieties for processing along with high yield.

Methods: Six banana genotypes, viz., Popoulu and Nendran (Plantain type) and NRCB-8, Monthan, Bhoodibale and Kovuur Bontha (Cooking type) were evaluated for the parameters viz., bunch weight, finger weight, finger length, finger girth, pulp recovery and crop duration apart from processing utility.

Result: ‘Popoulu’ was found to be superior for maximum pulp recovery (76.61%) along with higher chips recovery (40.45%). With respect to overall acceptability, chips processed from ‘Popoulu’ recorded higher scores (8.07) followed by Nendran (7.56). Popoulu was also found superior for finger weight, finger girth and attained maturity with lesser duration.

Key words: Banana chips, Bananas and plantains, Nendran, Popoulu, Processing, Sensory evaluation.

INTRODUCTION
Bananas and plantains are the major staple food and economic life line for many countries including India, which are grown commercially for both dessert and cooking purposes. India is the largest producer of banana in the world, contributing 26.74 % to the global production with an annual production of 30.80 million MT from an area of 8.84 lakh ha. Banana accounts for 31.64 % of total fruit production in India with a productivity 34.85 MT/ha (FAO, 2018; Anonymous, 2018). Due to huge volume of production, it is necessary to find ways to process the fruit apart from marketing for fresh consumption to avoid low returns to the growers. Various processed products like banana chips, banana flakes, banana puree, banana figs, clarified juice, banana powder, green banana flour, muffins, baby food, health drink, stem juice, pickles (flower, peel, green fruits), starch, jam, stem candy and fermented products like ethanol, wine and beer are prepared and used (Shiva et al. 2014; Soorianathasundaram et al. 2016; Kaur et al. 2018).

An advantageous way of processing bananas or plantain is for preparation of chips. Chips processed from plantains (banana slices deep-fried in coconut oil) are popular in India and abroad as these serve as intermittent snacks between meals and can be preserved long and the value addition also fetches better revenue to the processors. Besides a rich source of calorific value, deep-fried plantain and banana chips may additionally help to combat micronutrient deficiencies, by virtue of their iron, zinc and carotene contents (Adeniji et al. 2010). Recently, aspects related to postharvest utilization of banana is drawing the attention of researchers very much.

In India, Nendran (French Plantain- Musa AAB) is the commercial variety currently being grown and favored by the consumers as well as processors for preparation of chips.

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The yield potential of ‘Nendran’ is very low (about 10 to 12 kg/plant). Therefore an attempt was made to identify other suitable banana varieties for processing along with high yield as compared to Nendran. Popoulu is an exotic introduction acquired by National Bureau of Plant Genetic Resources (NBPR), New Delhi from Musa International Transit Centre (ITC), Leuven, Belgium, earlier known as International Network for Improvement of Banana and Plantain (INIBAP). The preliminary evaluation of Popoulu was done at Banana Research Station (BRS), Kannara, Kerala, indicated its potentiality in terms of yield, quality and processing attributes in India (Menon, 2000; Menon et al. 2014). Yet it’s potential for chips making and consumer acceptance in terms of sensory evaluation for its commercialization is needed. In this background the present study was taken up to screen among selected four ABB and two AAB genotypes conserved
in the field germplasm of Tamil Nadu Agricultural University, Coimbatore.

**MATERIALS AND METHODS**

**Experimental material**

For the present study, based on bunch weight and finger attributes, four cooking types (Musa ABB) viz., Boodibale, Monthan, Kovvur Bontha, NRCB-8 and two Plantain types (Musa AAB) viz., Nendran and Popoulu were selected from germplasm maintained at College orchard. The experiment was conducted during 2015 to 2016 in the Department of Fruit Crops, Horticulture College and Research Institute, Tamil Nadu Agricultural University Coimbatore. These varieties were maintained at a spacing of 1.8 m x 1.8 m in the same homogenous block in the field under drip irrigation system. Regular cultural practices and plant protection measures recommended by TNAU for cultivation of garden land bananas were followed. Bunches were harvested and fruit samples were brought to the laboratory immediately for further analysis.

**Sampling and design**

Crop duration, bunch weight, finger weight, finger length and finger girth were recorded as per the guidelines by Dadzie and Orchard (1997). From each variety three uniform bunches were selected for analysis. Hands were separated from the bunch and representative fruit samples were drawn from the second and third hand from the base.

**Pulp recovery**

It was determined by finding the proportion of difference from initial weight of green fruit (without peeling) and weight of fruit after peeling (fruit pulp). Thus pulp recovery (%) = \( \frac{[\text{pulp weight} / \text{fruit weight}] \times 100}{100} \) (Ferris et al. 1999).

**Preparation of deep fried chips**

Deep-fried chips were prepared according to the procedures as described by Adeniji (2005) and Yomeni et al. (2004). From each variety three kg of mature green fruits with three replicates were utilized for chips preparation. Fruits were washed with clean water to remove dirt and latex and then carefully hand peeled with the aid of stainless knife and pulp was immersed in water until the peeling was completed to prevent browning. The peeled fruits were sliced to 2 mm thickness disc-wise directly into a pre-heated coconut oil in fryer pan at 170°C for an average of 4 minutes. Chips were scooped into an aluminium sieve, drained properly to remove excess oil and salted as per requirement and then spread on stainless steel trays and allowed to cool at room temperature. After cooling, chips were packaged for further sensory evaluation.

**Chips recovery**

Initial weight of green fruit without peeling and weight of fried chips of same were recorded for individual genotypes. Then chips recovery percentage was calculated by weight difference as

\[
\text{Chips recovery (\%)} = \frac{\text{Weight of fried chips}}{\text{Initial weight of whole fruit}} \times 100
\]

**Sensory evaluation**

Sensory evaluations of the freshly prepared chips were done by 24 taste testing panel. Coded samples of different genotypes with a score sheet were presented to each panelist and requested to evaluate chips for appearance, color, crispiness, taste, flavor and overall acceptability using hedonic scoring scale of 1 to 9 (Molla et al. 2009).

**Statistical analysis**

The statistical parameters were computed by adopting the procedure suggested by Panse and Sukhatme (1961). Before selection of the genotypes for processing purposes, preliminary screening of their growth and yield attributes was carried out. In the field germplasm, as the varieties were maintained row wise, mean comparisons with standard error estimates were used to differentiate the performance of genotypes for growth and yield attributes and the selection for better performers was done based on mean ± standard deviation values, as well as by computing overall coefficient of variations and same was followed for sensory evaluation. Since sufficient finger samples were available from field, the processing attributes were subjected to analyses in Completely Randomized Block Design (CRBD) with samples drawn from three replicates for each of the variety studied. The mean comparisons were made for postharvest qualities by computing ANOVA and testing the significance of computed critical differences.

**RESULTS AND DISCUSSION**

**Growth and physical characteristics**

Selected banana genotypes were observed for growth and physical characteristics viz., crop duration, bunch weight, finger weight, finger girth and finger length which are presented in Table 1. Days taken from planting to harvest ranged from 306.60 to 374.00 days. Crop duration in general depends on genetic makeup of the variety and the prevailing environmental conditions during the growth period. Identifying genotypes with lesser duration is advantageous for the grower or processing industry. Among the six genotypes, early maturity was observed in Popoulu (306.60 days) and Nendran (311.40), while ‘Bhoodibale’ took longer duration (374.00 days) from planting to harvest. Longer crop duration in a way poses increased risks in crop production and also requires more inputs such as water, fertilizers or crop protection measures leading to increased cost of cultivation. Variations in crop duration among banana genotypes during evaluation have been reported by many workers (Kunchala, 2012; Menon et al. 2014).

The major economic criterion for successful cultivation of banana is bunch yield. The bunch weight among the six genotypes varied from 12.00 kg/plant to 28.50 kg/plant.
Table 1: Crop duration, bunch weight and finger attributes of selected banana genotypes.

| Genotypes            | Crop duration (days) | Bunch weight (kg/plant) | Finger weight (g) | Finger length (cm) | Finger girth (cm) |
|----------------------|----------------------|-------------------------|-------------------|-------------------|------------------|
|                      | Mean                 | SE                      | Mean              | SE                | Mean             | SE              |
| Bhoodibale (ABB)     | 374.00               | 4.16                    | 22.88             | 0.83              | 321.50           | 4.01            |
| Monthan (ABB)        | 369.80               | 4.29                    | 20.35             | 0.79              | 351.75           | 4.12            |
| Kovvur Bontha (ABB)  | 350.80               | 3.10                    | 22.75             | 0.48              | 351.00           | 4.18            |
| NRCB-8 (ABB)         | 352.80               | 4.24                    | 28.50             | 0.48              | 338.25           | 4.96            |
| Nendran (AAB)        | 311.40               | 1.94                    | 12.00             | 0.46              | 204.75           | 4.21            |
| Popoulu (AAB)        | 306.60               | 3.30                    | 21.50             | 0.54              | 417.00           | 3.85            |
| Population Mean      | 344.23               | 21.33                   | 320.71            | 22.11             | 18.61            |
| SD                   | 28.81                | 5.36                    | 70.40             | 2.22              | 2.79             |
| CV %                 | 8.37                 | 25.15                   | 21.95             | 10.05             | 14.99            |

The variety NRCB-8 recorded maximum bunch weight (28.50kg/plant), while Nendran recorded minimum bunch weight (12.00kg/plant). The varieties, Bhoodibale, Monthan, Kovvur Bontha and Popoulu recorded medium bunch weight and it ranged from 21.50 to 22.88 kg/plant. The finger weight, length and girth ranged from 204.75 to 417.00g, 19.10 to 25.03cm and 14.55 to 23.33cm respectively. Popoulu recorded higher finger weight (417.00g), finger girth (23.33cm) and lower finger length (19.10cm). While lower finger weight (204.75g), finger girth (14.55cm) and longer fingers (25.03cm) were observed in Nendran. Appearance of hands at harvest stage of selected banana genotypes are given in Fig 1. Cultivars with higher finger weight, finger girth and finger length are the main criteria for suitability to cooking and processing into chips. The low finger weights, finger length and girth are not economically suitable for processing due to the higher percentage of wastage during handling and peeling. The results obtained in the present study with respect to variation in yield, finger weight, finger length and finger girth are in similar lines with the findings of Rajmanickam and Rajmohan (2010), Menon et al. (2014) and Ssali et al. (2016) in other banana varieties.

Pulp recovery

The pulp recovery for processing into chips was ranged from 60.98 to 76.61 per cent (Table 2). Nendran, Kovvur Bontha, Bhoodibale and NRCB-8 recorded lowest pulp recovery (60.98 to 62.03%) while Popoulu registered the maximum pulp recovery of 76.61 per cent, followed by Monthan (65.60%). The higher finger weight (417.00 g) and finger girth (23.33 cm) resulted in higher pulp recovery in Popoulu. Such type of variation in pulp recovery in banana varieties was also reported by Ferris et al. (1999) and Reis et al. (2016).

Chips recovery

Chips are the most popular and commonly processed postharvest products of cooking bananas. Significant differences were observed for chips recovery among the cultivars which ranged from 28.00 to 40.45 per cent (Table 2). The cultivar ‘Popoulu’ recorded significantly higher chips recovery.
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recovery (40.45%). Popoulu produces large fruits yielded less wastage. The higher finger weight (417.00 g), finger girth (23.33 cm) resulted in higher pulp recovery and thus recorded the maximum chips recovery. Varietal variation in chips recovery was reported in the earlier studies by Dadzie and Orjeda (1998), Menon et al. (2014) and Belayneh et al. (2014).

Sensory evaluation for chips

Analysis for chips sensory evaluation using hedonic scale showed that there were a significant differences among varieties for all the sensory parameters. Appearance, colour, crispness, taste, flavour and overall acceptability were the criteria considered for sensory evaluation and the mean of the scores given for sensory parameters of chips made from selected banana varieties are presented in Table 3.

Appearance

The score for appearance ranged from 3.86 in NRCB-8 to 8.12 in Popoulu. The cultivars Popoulu and Nendran received a higher score for appearance, while the remaining genotypes were on par with population mean± SD values (5.46 ± 1.84).

Colour

The score for chips colour ranged from 3.60 in NRCB-8 to 8.25 in Popoulu. Bhoodibale, Monthan, Kovvur Bontha and NRCB-8 obtained similar colour acceptance scores (5.24 ± 2.02). Popoulu and Nendran scored higher points. The visual differences in chips colour and appearances can be observed in Fig 2.

Crispness

For chips crispness, the scores ranged from 4.89 in Monthan to 7.68 in Popoulu. Besides Popoulu, the cv. Nendran also scored higher (7.35) while in rest of the cultivars the scores were on par based on Population mean ± SD values.

Taste

The scores for taste of chips ranged from 4.41 in Monthan to 7.39 in Popoulu. Popoulu and Nendran were scored as tastier (>population mean ± SD, 6.84).

Table 2: Sensory analysis of processed chips from selected banana genotypes (9 point Hedonic scale).

| Genotypes       | Appearance | Colour | Crispness | Taste | Flavor | Overall acceptance |
|-----------------|------------|--------|-----------|-------|--------|--------------------|
|                 | Mean | SE   | Mean | SE   | Mean | SE | Mean | SE | Mean | SE | Mean | SE |
| Bhoodibale (ABB)| 4.05 | 0.40 | 3.91 | 0.34 | 5.36 | 0.38 | 5.31 | 0.37 | 5.31 | 0.33 | 5.31 | 0.25 |
| Monthan (ABB)   | 4.35 | 0.37 | 3.97 | 0.31 | 4.89 | 0.39 | 4.62 | 0.35 | 4.62 | 0.4  | 4.41 | 0.25 |
| Kovvur Bontha (ABB) | 4.83 | 0.35 | 4.35 | 0.38 | 5.50 | 0.38 | 4.85 | 0.35 | 4.81 | 0.36 | 4.72 | 0.27 |
| NRCB-8 (ABB)    | 3.86 | 0.40 | 3.60 | 0.35 | 5.25 | 0.25 | 4.41 | 0.28 | 4.45 | 0.33 | 4.52 | 0.25 |
| Nendran (AAB)   | 7.58 | 0.27 | 7.35 | 0.27 | 7.35 | 0.28 | 6.89 | 0.35 | 6.27 | 0.39 | 7.56 | 0.25 |
| Popoulu (AAB)   | 8.12 | 0.19 | 8.25 | 0.2  | 7.68 | 0.26 | 7.39 | 0.21 | 6.75 | 0.34 | 8.07 | 0.3 |
| Population Mean | 5.46 | 5.24 | 6.00 | 5.58 | 5.37 | 5.37 | 5.77 |
| SD              | 1.88 | 2.02 | 1.19 | 1.26 | 0.94 | 1.63 |
| CV (%)          | 34.43 | 38.55 | 19.83 | 22.58 | 17.60 | 28.22 |

Fig 2: Appearance of chips from selected banana genotypes.
Flavour
Scores of chips flavour ranged from 4.45 in NRCB-8 to 6.75 in Popoulu. Based on population mean ± SD values (6.31), the cultivars Popoulu and Nendran recorded higher scores of 8.07 and 7.56 respectively with respect overall acceptability, while all the four ABB cultivars scored moderate values for overall acceptability, which ranged from 4.41 to 5.31. Comparatively ‘Bhoodibale’ registered better scores than the occasionally processed cv. Monthan for chips in cooking types.

Among the six genotypes evaluated, the chips prepared from cv. Popoulu scored better than all the others cultivars for all sensory parameters including overall acceptability, while Nendran scored on par with Popoulu for most of the sensory parameters. Similar variations in sensory evaluation scores of banana chips for different varieties have been reported earlier by several research workers (Molla et al. 2009; Yan et al. 2013; Belayneh et al. 2014; Eshetu and Tola 2014).

CONCLUSION
The results indicated that among the six selected banana genotypes evaluated, Popoulu and Nendran were found suitable for processing into chips. Although, the cultivar Nendran is currently being grown extensively and favored by the processors for chips processing, the poor yield potential (12.00 kg/plant) of Nendran contributes to lower returns and makes it uneconomical for the growers. Popoulu, the newly introduced strain, performed considerably better both in terms of agronomic and processing attributes. The high bunch yield (21.50 kg/plant) and fruit weight (417.00 g), which contributed to higher yield of chips with higher sensory scores such as chips appearance, colour, crispness, taste, favour with soverall acceptability and as well as short crop duration (306.60 days), makes Popoulu as the best suitable option over Nendran for processing into chips and thus maximizing the growers returns. Therefore, Popoulu can be recommended as a potential substitute for Nendran towards commercial cultivation for processing needs and thus can strengthen the banana chips industry in Tamil Nadu, Kerala and Karnataka. It must be emphasized that the new cultivar ‘Popoulu’ should be tested in a larger area under different locations of India and other parts of the world to confirm their yield and processing attributes identified in the present study.

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