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Studies on physico-chemical, sensory and microbiological evaluation of carambola (*Averrhoa carambola* L.) nectar under ambient condition

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Abstract
The objective of the study was to develop fruit beverages from this highly nutritious fruit to avoid postharvest loss and extend the shelf life by ways of processing as per the FPO specification of nectar. Observations on TSS, treatable acidity, ascorbic acid, total sugar, microbial association and sensory quality were taken during storage in ambient condition at 15 days interval. Considering all the sensory and chemical factors, it was observed that carambola nectar could be stored successfully for about 45 days without using any chemical preservatives with good sensory quality and acceptability in terms of colour, aroma and taste with no development of off-flavor and minimal microbial count. Thus, this study indicated that value addition of carambola into nectar can help in reducing the wastage, increase availability, fetch better price to the growers and provide new product for good health of consumers in the future.

Keywords: Carambola, nectar, shelf life, microbial, sensory

Introduction
Carambola also commonly known as star fruit (*Averrhoa carambola* L.) is an underutilized attractive fruit of the family Oxalidaceae It is a subtropical evergreen tree, usually 6 to 9 m in height. The fruit has distinctive ridges running down its sides which in cross section appear in form of a star hence called as 'Star fruit' having light to dark yellow in colour and smooth with a waxy cuticle while the flesh is light yellow, translucent, crisp and very juicy, with or without fiber (Margen, 1992) [12]. Padun and Singh (2017) [14] also reported that Arunachal Pradesh has a rich diversity of carambola having different fruit shape, size and fruit weight ranges from 83.5g to 300 g / fruit and sweetness ranges from 5.0 to 14.9 ^{0} brix. Generally carambola has two distinct morph type viz. sour type, richly flavored, with more oxalic acid and sweet type having mild-flavored, rather bland, with less oxalic acid. Carambola is believed to be originated from Malaysia or Indonesia (Zewen and De Wet, 1982) [22] but it has also been cultivated in other Southeast Asian countries for many centuries. However, Pijpers *et al.* (1986) [17] indicated the centre of origin of Carambola as Sri Lanka or India. It is rich source of reducing sugars, ascorbic acid and minerals, such as K, Ca, Mg and P (Haick, 1952) [6]. The fruits have demand to produce a number of preserved products notably, pickles, jam, jelly, preserved, drink etc. and increased in popularity as a fresh fruit in tropical countries with large scale plantings in Malaysia as reported by Padun and Singh (2017) [14]. The leaves are antipyretic, anthelmintic and are also helpful for curing scabies, fractured bones and various types of poisoning, intermittent fevers and elimination of intestinal worms (Kirtikar *et al.* 1989) [11]. Besides, ripe fruit pulp along with little common salt is eaten against jaundice, bleeding piles and for washing utensil in Manipur (Singh *et al*. 2014) [19].
North East Region of India mainly Arunachal Pradesh, Assam, Manipur and Meghalaya has a rich source of genetic diversity of carambola having different fruit shape, size and fruit quality having sour and sweet in taste. Till now this gaining popularity underutilized fruit crop has not taken research work for the processing for this fruit crop in this region. However, Anita and Sabita (2018) [1] reported that the processed product of jam of carambola increase of storage intervals and the ranged within acceptable limits even up to storage of 60 days.

Neeta *et al*. (2015) [13] also reported that the edible coatings showed a positive effect on maintaining higher concentration of total phenolics, which decreased in control fruit due to their over-ripening and senescence processes and the use of chitosan 0.3% and gum arabic 1% coatings will maintain the carambola fruit quality and lead to better acceptance by consumers. Hare (1993) [7] reported that the storage temperature of 5°C is capable of maintaining fruit with a minimum of physiological changes for at least 6 weeks, provided moisture loss is controlled in which acidity is decline during storage, and this is often undesirable as it can be associated with blandness. However, in India there although there is lot of variability and wastages of this underutilized fruit crop due to lacking processing during its peak harvest period and supply chain of fresh fruit in North East India. Therefore, it is a need to study the process product of carambola to minimize the wastages due to limited marketability, high degree of perishability and higher moisture content which lead to the extensive postharvest losses of this medicinal value underutilized fruit crop.

Materials and methods

The study was carried out by collecting the ripe fruit of carambola from different areas of East Siang district of Arunachal Pradesh. The freshly harvested mature fruits were subjected for studies on physico-chemical, sensory and microbiological analysis of carambola nectar without chemical preservatives under the ambient room temperature.

Raw materials: Freshly harvested, mature Star fruits free from blemishes are collected and the fruits were thoroughly washed in running tap water and surface dried inside the laboratory and the juice was extracted for nectar preparation.

Preliminary Study: A preliminary test was carried out to determine the total soluble solids (TSS) and treatable acidity of the juice extracted TSS was determined using a Hand held refract meter and acidity (% of anhydrous citric acid) was measured by titrating it against 0.1N sodium hydroxide (NaOH) and Phenolphthalein as an indicator (AOAC, 2002) [2].

Preparation of Nectar: Star fruit nectar was prepared as per the FPO specification of nectar. The technological flow sheet for preparation of the nectar after calculating the ingredients is given below:

Juice extraction
↓
Preparation of syrup
(Sugar + citric acid dissolved in water and heated for 5 minutes)
↓
Filtering of Syrup through muslin cloth
↓
Addition of star fruit juice
↓
Heating at 85 ºC for 15-20 minutes
↓
Cooling for another 10 minutes
↓
Hot filling in already sterilized glass bottles & crown cork immediately
↓
Pasteurization at 80 ºC for 30 minutes
↓
Cooling of bottles
↓
Storage at laboratory in ambient condition

Observations recorded: Observations on TSS (ºBrix), titratable acidity (%), ascorbic acid (mg/100g), total sugar (%), microbes association (bacteria, yeast, moulds) and sensory attributes were recorded for the freshly prepared nectar on 0th day of storage. The same parameters were recorded at 15 days interval i.e. 15th, 30th, 45th, 60th, till the nectar was in acceptable condition. The average ambient temperature and relative humidity during the period of storage were 21.12 ºC (18.6 ºC minimum and 26.2 ºC maximum) and 64% (53% minimum and 87% maximum) respectively**.** Ascorbic acid and total sugar of the star fruit nectar were determined according to AOAC (2002) [2]. The pasteurized carambola fruit juice samples were analyzed for total viable counts by serial dilution agar plate technique. Ten (10) ml of fruit juice sample was diluted with 90ml of distilled water and plated on nutrient agar for enumeration of bacteria and potato dextrose agar (PDA) for moulds and yeast (Tournas *et al.* 2006) [20]. Inoculated plates of NA and PDA were used as control. The experiment was carried out with three replications for each of the sample. The plates were then incubated at 37 ºC and the colonies were counted after 48 hours of incubation (Gilbert *et al.* 2000) [5]. The plates with colony forming units per ml (cfu/ml), ranging from 30-300 will be considered for counting as the colonies less than 30 will be having greater statistical inaccuracy and the colonies greater than 300 will be tedious to count.

$$\text{CFU} = \frac{\text{Number of colonies x reciprocal of dilution used}}{\text{Volume of aliquot taken}}$$

Sensory quality (colour, taste, aroma, absence of off-flavour and overall acceptability) was evaluated using a 9 point hedonic scale ranging from 9 (like extremely) to 1 (Dislike extremely) following the procedure of Nirali *et al.* (2017) [15].

Statistical analysis: Quality parameters of carambola like total soluble solids (TSS), reducing sugar, total sugar, treatable acidity and vitamin C were determined with standard of A.O.A.C. (1985) and observations were analyzed in simple Completely Randomized Block Designed (CRD) as suggested by Gomez and Gomez (1983) and the statistical analysis was carried out using Web Based Agricultural Statistics Software Package (WASP).

Results and discussion

The TSS of the carambola nectar was found to slightly decrease during storage. TSS on the day of preparation was maintained at 15º Brix. However, it slightly reduced to 13º Brix on the subsequent days of storage. This may be because of the oxidation of sugars leading to formation of acids (Fennema, 1996) [4]. The acidity of the carambola nectar increased during the subsequent days of storage from 0.30% on the day of preparation to 0.38% on the 45th day of storage. This increase in acidity might also be due to the formation of acid by degradation of polysaccharides and oxidation of reducing sugars or by the breakdown of pectic substances and uronic acid (Hussain *et al*., 2008) [8]. This is in line with research carried out by Priyanthi *et al*. (2008) [18] and Kesavanath *et al.* (2015) [10] that the acidity value of RTS drink and blended cordial is increased at ambient temperature. There was significant reduction in ascorbic acid content of the nectar throughout the period of storage. On the day of nectar preparation, the ascorbic acid content was 4mg/100g and on the 30th day, it reduced to 2.66 mg/100g and 2.33 mg/100g on the 45th day of storage. As ascorbic acid is highly responsive

to the presence of oxygen in the storage environment, there is possibility of its oxidative degradation to Dehydro-ascorbic acid. Jawaheer *et al* (2003) [3] also reported that another possible cause of ascorbic acid decrease might be residual oxygen present in the head space of the container (assuming glass ware was impervious to oxygen). Moreover, it has also been reported that ascorbic acid contents of stored fruit and vegetable products generally decrease when stored at higher temperature (Watada *et al*., 1991) [21]. The total sugar of the star fruit nectar decreased significantly during consecutive days of storage at ambient condition. On the first day, total sugar of the nectar was 46.2% which reduced to 37.83% on the 15th day of storage and 26.63% on the 45th day of storage. This reduction in sugar during storage period may be due to hydrolysis of polysaccharides and oxidation of sugars. Another reason could be the polymerization of sugars at high temperature (Fennema, 1996) [4]. Similar significant reduction in total sugar throughout the storage period was also reported by Nilugin and Mahendran (2010) [14] in the RTS beverages at ambient temperature.

Yeast and moulds responsible for spoilage of fruit juices were not detected in the analyzed fruit juice samples up to 30 days of storage. This may be because of the pasteurization process which was followed during the nectar preparation which made the product safe. In our study, the association of bacteria (*Pseudomonas* species) was detected on 45th days old fruit juice and 60th days old fruit juice with log cfu/ml = 1.05 x10^3 and log cfu/ml = 2.12 x 10^3 respectively (Fig. 3). However, mould and yeast was not detected up to 45 days of the nectar without preservatives. The relatively higher bacterial count reduces the shelf life of the juice may be due to poor. Sensory attributes of star fruit nectar stored at ambient temperature changed significantly during subsequent days of storage. On the 1st day, the sensory score was as high as 9 (Like extremely) which reduced to 5.66 on the 45th day of storage. This may be due to increase in acidity and reduction in total sugar content by oxidative reactions and conversion to polymer substances (Dhaliwal *et al.* 2004) [3]. Development of off flavours, as a result of oxidation and reduction reactions in food components also slightly affect the sensory attributes of mixed cordial which makes it finally unacceptable on the 60-65th days of storage.

Considering all the quality characteristics, it was observed that star fruit nectar could be stored successfully for about 45 days without using any chemical preservatives with good sensory quality and acceptability in terms of colour, aroma and taste with no development of off-flavor and minimal microbial count. After 45 days there was rapid bacterial growth of *Pseudomonas species* in the nectar juice and started off-flavour. Lack of proper pasteurization and practices may be one of the major factors which are responsible for contamination of fruit juices nectar. Thus, this study indicated that value addition of star fruit into nectar can help in reducing the wastage, increase availability, fetch better price to the growers and provide new product for good health of consumers within 45 days with hygienic preparation from this underexploited fruit crop in the future.

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Fig 1: Highly perishable carambola fruit selling in *Ema* market, Imphal (Manipur)

Fig 2: Process product of carambola-nectar without chemical preservative

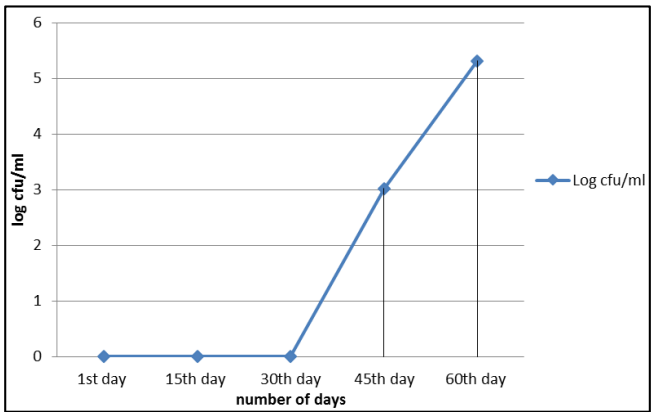

Fig 3: Rapid bacterial growth (*Pseudomonas species*) in carambola fruit juice nectar after 45 days

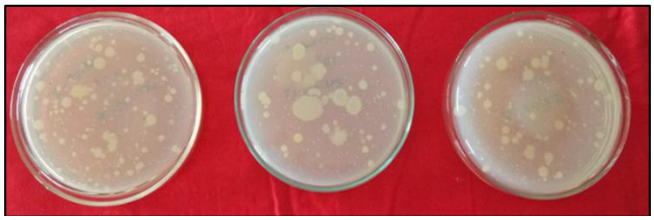

Fig 4: *Pseudomonas species* bacterial growth after 45 days in carambola nectar juice

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