PHYSICOCHEMICAL PROPERTIES AND NUTRITIONAL VALUES OF Carissa Spinarum L. /”AGAM” FRUIT

Zinabu Hailu Siyum and Tassse Alemayehu Meresa

CONTACT Zinabu Hailu Siyum zinisheh@gmail.com College of Engineering and Technology, Chemical Engineering, Adigrat University, Ethiopia © 2021 Taylor & Francis

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*College of Engineering and Technology, Chemical Engineering, Adigrat University, Ethiopia; †College of Natural and Computational Science, Chemistry, Adigrat University, Ethiopia

ABSTRACT

Carissa spinarum L. is one of the wild plants that gives a fruit and it consumed by the peoples who are lived in the study areas without any knowledge of its nutrients. Thus, this research work was designed to explore the physicochemical properties and nutritional values of the Carissa spinarum L. fruits which were collected from two different geographical sites of Korem-Ofa wereda mainly Delesa and Maidokorem. The samples used for the study were randomly selected from the described sites, respectively, and the analysis of its physicochemical and nutritional values of the fruit was carried out using standard official methods. The result showed that, while the minerals, fat, energy, and titratable acidity contents were significantly different (p < 0.05) among the fruits collected from the two different geographical zones, the remaining compositions were not significantly different (P > 0.05). In conclusion, the plantations in different geographical locations were significantly affected some of the physicochemical, nutritional, and sensory properties of the fruit. It is, however, recommended that the effect of the geographical location on some nutritional and physicochemical properties of the fruit was significant, it can also develop Carissa spinarum L. based value-added food products.

INTRODUCTION

Wild plants grow naturally on farmland and uncultivated land which are used as a source food and for energy requirements (Kaliyamoorthy and Muthuraman, 2018). They are also relevant to household food security and nutrition in some rural areas, particularly in the drylands to supplement the essential food, fill seasonal food shortages, and as emergency food during a famine (Ambikachauhan, 2015). Carissa spinarum L. is one of the wild plants which gives fruits, and commonly consumed as fresh by the people living in tropics and subtropical countries of the world (Tamrat and Yesudas, 2018). It also has medicinal properties to prevent diseases such as asthma, skin disease, cough, cold, and tuberculosis (Tamrat and Yesudas, 2018). The physical and chemical characteristics of fruits influences, its sensory quality, shelf life and value addition potentials (Ambikachauhan, 2015; Hiregoudra, 2012).

Although worldwide research has been done on psychochemical and nutritional characteristics of Carissa spinarum L. fruit, the chemical, physical, nutritional values and sensorial characteristics of the fruit is not studied in the selected study areas, even it becomes a stable food during its production period. Therefore, this research has been done to investigate the physicochemical and nutritional constituents of the Carissa spinarum L. which could be used to develop new food products and enhance food and nutrient security.
Materials and Methods

Sample Collection and Preparation

As shown in Figure 1, the sample (Carissa spinarum L fruit) was collected in November and the end of January 2018 from Korem-Ofla, which is found at latitude and longitude of 12° 30’ N 39° 31’ E with the elevation of 2539 m above sea level (Abrha and Simhadri, 2015) and it is also 620 km away from the capital city of Ethiopia and 160 km away from Mekelle. It was harvested from two different geographical zones; Maidokorem and Delesa. The well matured fruits were harvested using hand picking, then sorting of the collected fruits was done based on its color, uniformity, and cleanness. About 2 kg of each site sorted fruits were packaged in perforated Low-Density Polyethylene, then transported to Adigrat University, Addis Pharmaceutical Industry, and Hilina Agro-industry to be analyzed for their physicochemical and nutritional contents. Each experimental and sensory measurement was carried out in triplicates per sample.

Methods of Analysis

Physical Properties

The length and width of the fruits were measured by the Vernier caliper (1/20, Germany) and their weight using digital weight balance that described in methods by (Kaliyamoorthy and Muthuraman (2018); Ambikachauhan (2015)

Titratable Acidity Determination

Titratable Acidity (TTA) was analyzed following AOAC (2002) method number 942.15 as described by Jyotimayee and Uday (2015); Zinabu (2016). About 55 g of fruits were used to extract the juice using a portable juice extractor, and about 10 g of juice was diluted to a total volume of 200 ml with boiled distilled water. An aliquot (50 ml) was mixed with 0.25 ml phenolphthalein indicator and titrated with 0.1 N NaOH to the first appearance of a pink endpoint.

The TTA was expressed as gm of ascorbic acid per 100 g fruit using the following equation:

\[
TAA(\%) = \frac{0.1 \times \text{equivalent weight of acid} \times \text{Titer}}{\text{weight of sample}} \times 100
\]

Total Soluble Solids Content (TSS)

Total Soluble Solids (TSS) was analyzed based on AOAC (2002) method number 932.12 as described by Prapasri et al. (2011) (Hiregoudra, 2012). A portable sugar refractometer was used to measure total
s oluble solids of the fruit at 20°C. The fruit was squeezed using hand and a few drops of juice placed into the reflecting mirror of an automatic refractometer and read the °Brix with an intermediate point between the light and dark color of the graded scale measuring device. AOAC method 981.12 was also used for determining the pH of the fruit (Ambikachauhan, 2015)

**Proximate Analysis Moisture Determination**

The moisture content of *Carissa spinarum* fruit was analyzed using the standard method of ISO712:1998 (Prapasri et al., 2011) with a gravimetric principle. Empty dishes made of watch glass were dried using an electro-thermostatic blast oven model of DHG-9140 oven for 20 min at 105 °C and transferred to the desiccators, was cooled for 5 min and weighed. The prepared *Carissa spinarum* fruit samples about 5 g of fresh samples were transferred to the dried and weighed dishes. The dishes and their contents were placed into the oven and were dried for 12 h at 85 °C. Then the dishes and their contents were cooled in desiccators to room temperature for 15 min and were reweighed. The amount of water present in a sample was considered to be equal to the loss of weight after drying the sample to constant weight.

\[
\%\text{Moisture} = \frac{(W3 - W2)}{(W1 - W2)} \times 100
\]

Where W2 is the weight of empty dishes, W1 weight of the sample, W3 weight of dried sample, and dishes.

**Ash Determination**

The ash content of the fruit was determined using the gravimetric principle by AOAC officialmethod 923.03 (Prapasri et al., 2011). Empty crucibles were dried in Nabertherm GMBH, Germany model of P330 MB2 muffle furnace for 15 minutes at 600°C, and transferred to desiccators to cool the crucibles for 15 min, and re-weighed. About 4.5 g of dried *Carissa spinarum* samples were transferred to the crucibles. The sample was placed in a muffle furnace for 8 h at 600°C and then removed the sample from the muffle and placed in desiccators for 15 min to cool. The weight of total ash was calculated by difference and expressed as a percentage of the fresh sample.

\[
\%\text{Ash} = \frac{W3 - W1}{W2 - W1} \times 100
\]

Where W2 is the weight of empty dishes, W1 weight of the sample, W3 weight of an ashed sample and dishes.

**Protein Content**

The protein content of the fruit was analyzed using AOAC 920.87 official method (Abrha and Simhadri, 2015). It was determined by Kjeldahl techniques and it had three major steps such as digestion, distillation, and titration. In the digestion step, about 2.5 g of samples were taken in a Tecator tube and 21 ml of 98% concentrated sulfuric acid in the fume hood for safety was added and 8.35 g of the catalyst mixture (ground 0.25 g of selenium metal with 50 g of potassium sulfate) and 0.02 g of CuSO4. The digestion was continued until a clear colorless solution was obtained or free of carbon or oxidation was completed, about 80 minutes. The tubes were cooled in the hood and 150 ml of deionized water was added and shaken to avoid precipitation of sulfate in the solution. In the distillation step, 250 ml conical-flask containing 50 ml of 4% boric acid-indictor solution with phenolphthalein indicator was placed under the condenser of the distiller for distillate receiving. The digested and diluted solution was transferred into the sample compartment of the distiller. The
tubes were rinsed with two portions of about 5 ml de-ionized water and the rinses were added into the solution. To make the solution to be distilled strongly alkali NaOH was not mixed until distillation set up was properly sited to prevent ammonia escape to the environment due to strong acids reaction. In the third titration step, the distilled solution was titrated with 0.1 N HCl.

\[
N(\text{g}%) = \frac{(\text{ml}0.1\text{NHCL}_{\text{sample}} - \text{ml}0.1\text{NHCL}_{\text{blank}}) \times 0.0014 \times \text{NHCL}}{\text{weight of sample}} \times 100
\]

Crudeprotein(%) = TotalNitrogen(%) \times 6.25N = normality of the standard hydrochloric acid; 6.25 = conversion factor from total nitrogen to the crude protein of the fruit

**Crude Fat Determination**

The crude fat content of the *Carissa spinarum* fruit was analyzed using AOAC 945.38 F; 920.39 C official methods (Prapasri et al., 2011). Approximately 2.5 g of samples were added into the extraction thimbles and then covered with about 2 cm layer of fat-free cotton. The thimbles with the sample content were placed into the Soxhlet extraction chamber. The cooling water was switched on, and 70 ml of diethyl ether was added to the extraction flask through the condenser. The extraction was conducted for about 3 h. Then the extraction flasks with their content were removed from the extraction chamber and placed in the drying oven at 80 °C for about 2 h then cooled to room temperature in the desiccators for about 15 min and re-weighed. CurdeFatContent(%) = \( \frac{W_2 - W_1}{W_d} \times 100 \)

Where; W1 = weight of extraction flask before (wt. of the flask); Wd = weight of the sample. W2 = weight of extraction flask after extraction (wt. of flask and fat);

**Crude Fiber Determination**

The crude fat content of *Carissa spinarum* fruit was analyzed using AOAC 945.38 F; 920.39C official methods (Prapasri et al., 2011). About 3.5 g of the sample was placed into a 500 ml beaker, 200 ml of 1.25% was added, and boiled gently exactly for 20 min placing a watch H2SO4 glass over the mouth of the beaker. During boiling, the level of the sample solution was kept constant with hot distilled water. After 20 min boiling, 20 ml of 28% KOH was added and boiled gently for a further 30 min, with occasional stirring. The bottom of a sintered glass crucible was covered with a 10 mm sand layer and wetted with a little distilled water. The solution was poured from a beaker into a sintered glass crucible and then the vacuum pump was turned on. The wall of the beaker was rinsed with hot distilled water several times; washing was transferred to crucible and filter. The residue in the crucible was washed with hot distilled water and filtered with 1% and 1% NaOH. The crucible with its content was dried for 2 h in a drying oven at 130°C and cooled for 30 min in the desiccators and then weighed. The crucible was transferred to a small muffle furnace and incinerated for 30 min at 500°C. The crucible was cooled in the desiccators and weighed. Then, the crude fiber content of the fruit was calculated as a residue after subtraction of the ash.

\[
\text{Curdefiber(%) = } \frac{W_1 - W_2}{W_3} \times 100
\]

Where: W1 = weight of (Crucible + sample) after drying; W2 = weight of (Crucible + Sample) after Ash; W3 = weight of the sample

**Total Carbohydrate Determination**

The total carbohydrate content of the fruit was determined by a difference, subtracting the sum of the percentages of moisture, crude protein, lipid, crude fiber and ash content from 100 (Sanjay et al., 2014).
Total carbohydrate(%) = 100 - (moisture + fat + protein + ash + fiber)

**Determination of Energy**

The energy value of the fruit was determined using the Atwater method to calculate energy from protein, fat, carbohydrate (Schakel et al., 1997)

\[
\text{Energy (Kcal)} = \frac{4 \text{Kcal}}{\text{g Carbohydrate}} \times \text{g carbohydrate} + \frac{4 \text{Kcal}}{\text{g protein}} \times \text{g protein} + \frac{9 \text{Kcal}}{\text{g fat}} \times \text{g fat}
\]

**Mineral Analysis**

Mineral analysis of the fruit was conducted using the Atomic Absorption Spectrophotometry, AS (Abrha and Simhadri, 2015). The ash was dissolved in 5 ml of 6 M HCL at 5°C on the hot plate for about 2 h then 7 ml of 3 M HCl was added and heated on the hot plate until the solution boils. The digest was cooled and filtered through a filter paper (42 mm, Whitman) into a 50 ml volumetric flask. Then 5 ml 3 M HCL was added to the dish and heated to dissolve the residues in the dishes and then transferred to the volumetric flask then the filter paper was washed thoroughly and washing was collected in the flask made to the mark. Afterward, the concentration of the minerals was determined by AAS. The calibration curve was prepared for the required metal by plotting the absorption values against the metal concentration in ppm. The mineral contents of each sample were calculated using the following formulae:

\[
\text{Metal content (mg/100g)} = \frac{(a - b) \times V}{10 \times W}
\]

Where W = weight in gm of the sample  
\( a = \) concentration in PPM of sample solution 
\( b = \) concentration in PPM of blank solution 
V = volume in ml

**Vitamin C (Ascorbic Acid) Determination**

According Titration Method of AOAC 1997, weigh 0.45 g of the sample without seed and dissolved as completely as possible in a mixture of 30 ml of water and 20 ml of 1 M of sulfuric acid and Titrate with 0.1 M ammonium cerium (IV) sulfate volumetric solution using the ferrous solution as indicator. Each ml of 0.1 M ammonium cerium (IV) sulfate volumetric solution is equivalent to 8.806 mg of C6H8O6 (Prapasri et al., 2011)

\[
\text{Vitamin C(%) = } \frac{X \text{ in mol of Titrant} \times \text{equivalent weight} \times \text{factor}}{\text{Weight of sample}} \times 100
\]

**Sensory Analysis**

The sensory evaluation was conducted with a group of professional panelists consisting of 14 people who were selected to evaluate the sensory quality attributes of the fresh *Carissa spinarum* fruit such as color, flavor, taste, firmness and overall acceptance using a 9-point hedonic scale (Ambikachauhan, 2015; Jyotimayee and Uday, 2015).
**Statistical Analysis**

The collected data were analyzed statistically and graphically, the analysis of variance (ANOVA) for the mean of physicochemical, nutritional and sensory evaluations was also carried out using Origin pro8 software.

**Results and Discussions**

**Physicochemical Analysis**

The fruits collected from Delesa had slightly good physicochemical content as compared with fruits collected from Maidokorem. The total soluble solid content of *Carissa spinarum* L. collected from Delesa and Maidokorem was 25.0°Brix and 20°Brix, respectively. The increase and decrease in TSS are directly correlated with hydrolytic changes in starch and conversion of starch to sugar being an important index of the ripening process (Ambikachauhan, 2015). The titratable acidity and pH of the fruit collected from Delesa and Maidokorem were 1.53%, 3.63, and 1.92%, 3.49, respectively (Table 1).

NB: TSS- Total Soluble Solid; TAA- Titratable Acidity

The values of physicochemical attributes of the fruit depending on its moisture content, because the fruits with high moisture content, results in a low percentage of physicochemical compositions (Kaliyamoorthy and Muthuraman, 2018). Previous research work showed results of TSS (20°Brix), TAA (1.993%) and pH (2.56) which were similar to fruits collected from Maidokorem(Abrha and Simhadri, 2015). *Carissa spinarum* L. has a width, length, weight, and seeds with different dimensions (Hiregoudra, 2012; Sanjay et al., 2014). The result of this study showed that the length, width, and weight of fruits collected from Delesa and Maidokorem were 0.42 cm, 0.76 cm, 0.42 g/seed, and 0.47 cm, 0.75 cm, and 0.47 g/seed, respectively (Table 1). The statistical result of Table 1 implies that the titratable acidity content of *Carissa spinarum* L, collected from Delesa site had significantly different than that of collected from Maidokorem at (p < 0.05) was 0.004, in the others compositions, there was not a significant difference.

**Proximate Analysis**

The proximate and mineral compositions of fruits harvested from Delesa were slightly higher than fruits collected from Maidokorem. The moisture contents of fruits collected from Maidokorem and Delesa were 62.1% and 58.62%, respectively (Table 2). Fruits with high moisture content reduce the proximate principles and thereby decreases the energy value (Debasis et al., 2014). The proximate values were obtained on a wet basis, such as protein, ash, fat, fiber, and carbohydrate (CHO). As shown in the Table 2, the proximate compositions of *Carissa spinarum* L. collected from Maidokorem and Delesa showed as protein (1.24%, 1.42%), Fat (4.94%, 5.33%), Ash (1.32%, 1.24%), Fiber (4.48%, 4.92%) and CHO (25.92%, 28.42%), respectively (Table 2).

According to the analysis result, the fruits collected from the Delesa site had higher values of carbohydrate, fiber, fat, protein, and less in ash and moisture content. Moreover, they were smaller in length and width than fruits collected from Maidokorem, this is because of less moisture content (Zinabu, 2016). Statistically, there was no significant difference in all proximate analysis parameters except for the fat content (p < 0.05) was 0.03 as shown in Table 2. The fat content of fruits depends on its moisture content, having a high amount of moisture, it would contain less amount of compositions (Debasis et al., 2014). The calculated energy value of fruits collected from Delesa and Maidokorem was 167.78Kcal and 153.1Kcal, respectively. The values are highest when compare with those reported by Mishra and Push (2005). The fruits having higher carbohydrates provide higher energy, this proves the research work, as shown in Table 3. The Vitamin C content of the fruits collected from both sites showed that 17.74 mg/100 g and 17.61 mg/100 g, respectively (Table 3). The results coincided with the studies reported by (Prapasri et al., 2011). The Iron(Fe), Calcium(Ca), Potassium(K), Phosphorus(P), Manganese(Mn) and Zinc (Zn)content of fruits collected from both sites were 1.49, 83.54, 816.69, 28.02, 0.93, 0.798 and 2.96,
118.77, 1281.68, 38.12, 0.92, 1.25 mg/100 g respectively (Table 3). The highest content of potassium was found in fruits collected from Delesa, then calcium. Overall, the fruits collected from Delesa were richer in mineral content than that of fruits collected from Maidokorem. Fruits having higher dry matter contain the high content of minerals (Prapasri et al., 2011). Besides, some research work reported as Ca (29 mg/100 g, 21 mg/100 g), Fe (3.45 mg/100 g, 39.1 mg/100 g) and P (31.9 mg/100 g, 38 mg/100 g, and 28 mg/100 g) respectively (Hiregoudra, 2012; Kaliyamoorthy and Muthuraman, 2018; Tamrat and Yesudas, 2018). The research work showed that the fruits had a significant difference in mineral contents, except Mn, and the values at (p < 0.05) were 0.00, 0.01, 0.00, 0.012, for K, Ca, Fe and Zn, respectively. As shown in Table 3. While energy content among the fruits collected from both sides had a significant difference at (p < 0.05) was 0.014 whereas, the vitamin C had not significant at (p > 0.05) was 0.76 (Table 3). However, the mineral content among the two sites varies, the Carissa spinarum fruits are richer in minerals and vitamins than the other cultivated fruits (Schakel et al., 1997).

**Sensory Analysis**

The sensory evaluation was carried out by assessing the senses of flavor, color, and firmness at the time of consuming. This sensation is important to measure the food product quality control and development (Hiregoudra, 2012). The results of sensory evaluations showed that the fruits collected from Delesa had greater overall acceptance than that of fruits collected from Maidokorem (Table 4). The skin color of the fruits collected from Delesa was preferred, this is due to the appearance of pigments such as carotenoids (Ambikachauhan, 2015). The panelists gave a high score (6.85) for color and firmness of the fruit collected from Delesa, relatively its flavor score was a low preference. Besides, the panelist’s preference in color, flavor, and firmness of fruit collected from Maidokorem was scored 6.28, but its taste was 5.85 (Table 4).

NB: “OVA” refers to Over All Acceptance Statistically, the sensory results and the overall acceptance of the parameters were significantly different in between fruits collected from Delesa and Maidokorem sites at (P < 0.05) was 0.019 as shown in Table 4.

**CONCLUSIONS**

The *Carissa Spinarum* fruit is rich in essential nutrients and chemical compositions which are very important to give health and energy. The physicochemical, nutritional and sensorial characteristics of the fruit is depending on the geographical location and environment. *Carissa spinarum* plant which grown in lowland and tropical areas gives, delicious and nutritious fruits than that of grown in highland. Besides, it has a high percentage of constituents when it compares to the cultivated fruits such as mango, banana, apple, etc. From this, it can be concluded that when the *Carissa spinarum*

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**Table 1.** Physicochemical characteristics of *Carissa spinarum* L.

| Places  | TSS (°brix) | TAA (%) | pH     | Width(cm) | Length(cm) | Weight(g) |
|---------|-------------|---------|--------|-----------|------------|-----------|
| Maidokorem | 20.0 ± 2.82 | 1.92 ± 0.02 | 3.49 ± 0.01 | 0.75 ± 0.042 | 0.47 ± 0.056 | 0.47 ± 0.028 |
| Delesa   | 25.0 ± 3.53 | 1.53 ± 0.028 | 3.63 ± 0.056 | 0.76 ± 0.001 | 0.42 ± 0.028 | 0.42 ± 0.000 |
| P < 0.05 | 0.259      | 0.004   | 0.077  | 0.782     | 0.380     | 0.130     |

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**Table 2.** Proximate Analysis Report.

| Place    | Moisture (g/100 g) | Protein (g/100 g) | Fat (g/100 g) | Ash (g/100 g) | Fiber (g/100 g) | Carbohydrate (g/100 g) |
|----------|--------------------|-------------------|--------------|--------------|----------------|------------------------|
| Maidokorem | 62.10 ± 0.084        | 1.24 ± 0.113        | 4.94 ± 0.028  | 1.32 ± 0.056  | 4.48 ± 0.141  | 25.92 ± 1.32          |
| Delesa    | 58.62 ± 1.89         | 1.42 ± 0.028        | 5.33 ± 0.014  | 1.24 ± 0.28   | 4.92 ± 0.070  | 28.42 ± 1.41          |
| P < 0.05  | 0.385                | 0.161              | 0.003         | 0.216         | 0.059         | 0.210                 |
Table 3: Mineral, energy and vitamin analysis.

| Place    | Energy | Vitamin | K     | Ca     | Fe     | Zn     | Mn     |
|----------|--------|---------|-------|--------|--------|--------|--------|
| Maidokorem mean ± sd | 153.5 ± 2.12 | 17.45 ± 1.34 | 816.5 ± 9.19 | 83.6 ± 4.9 | 1.49 ± 0.042 | 0.79 ± 0.00 | 0.925 ± 0.00 |
| Delesa  | mean ± sd | 167.5 ± 1.07 | 17.8 ± 0.56 | 1281.5 ± 2.12 | 118.0 ± 1.41 | 2.95 ± 0.14 | 1.25 ± 0.070 | 0.92 ± 0.028 |
| P < 0.05 | 0.014  | 0.767   | 0.000 | 0.011  | 0.000  | 0.012  | 0.831  |

Table 4. Sensory analysis Report.

| Place   | Color | Flavor | Taste | Firmness | OVA   |
|---------|-------|--------|-------|----------|-------|
| Maidokorem mean ± sd | 6.28 ± 0.05 | 6.28 ± 0.02 | 5.85 ± 0.07 | 6.28 ± 0.02 | 6.15 ± 0.07 |
| Delesa  | mean ± sd | 6.85 ± 0.070 | 6.0 ± 0.00 | 6.71 ± 0.12 | 6.85 ± 0.07 | 6.57 ± 0.04 |
| P < 0.05 | 0.012  | 0.005  | 0.013  | 0.009   | 0.019 |

cultivated like other cultivated fruits it can be produced a Carissa Spinuarum based on different food products which are very important in both food and nutrient security for those peoples who mainly lived in dry land rural areas.

ACKNOWLEDGMENTS

The authors express their deep gratitude to the University of Adigrat for its fundraising and Addis pharmaceutical Industry for its laboratory facilities.

Funding

This work was supported by the Adigrat University [AGU/CET/011/09].

ORCID

Zinabu Hailu Siyum (http://orcid.org/0000-0001-8601-0477)

References

Abdel, E.S., Y.K. Kawther, and A.S. Zakaria. 2013. Extraction of Pectin from Lemon and Orange Fruits Peels and Its Utilization in Jam Making. Int. J. Of Food Science and Nutrition Eng 3:5.

Abraha, M.G., and S. Simhadi. 2015. Local Climate Trends and Farmers’ Perceptions in Southern Tigray. Northern Ethiopia. American J. Of Environ Sci 11(4):15.

Ambikachauhan, B.T. 2015. Intelli Arneja. Influence of Processing on Physiochemical, Nutritional and Phytochemical Composition of Carissa Spinuarum Asian J of Pharmaceuti and Clinical Research 8(6):5.

Debasis, P., P. Satiyajit, and M. Sanada. 2014. Karonda(Carissa spp.): An underutilized Minorfruit Crop with Therapeutic and Medicinal Use. Int. J. Of Economic Plant 1(1):5.

Hiregoudra, V.S. 2012. Physico Chemical Characteristics, Value Addition and Shelf Life of Evaluation Karonda (Carissa Carandas), in Department of food science and nutrition college of rural home science. University of Agricultural Sciences Dharwad; p. 79.

Juyun, L.2011. Hedonic scaling: A review of methods and theory. Food Qual Prefer.

Jyotimayee, N., and C.B. Uday. 2015. Analysis of some nutritional properties in eight wild edible fruits of Odisha. India. Int, of Current Sci 14(1):55–62.

Kaliyamoorthy, J., and B. Muthuraman. 2018. Use and Nutrient Status of Indian Native Plant Fruit (Carissa carandas Linn.). World Scientific News. 217–224.

Mishra, R.M., and P.G. Push. 2005. Frugivory and seed dispersal of Carissa spinarum (L.) in a tropical deciduous forest of central India. Int. Society for Tropical Ecol. 46(2):6.

Prapasi, P., E. Tee, K. Julia, C. Graham, R.F. Rafael, and J. Kunchit. 2011. ASEAN Manual of Food Analysis. First ed ed. Institute of Nutrition, Mahidol University, Thailand.

Sanjay, S., A.S. Singh, P.R. Meghwal, and G.S. Swamy. 2014. Tropical and Subtropical Fruit Crops: Book Chapter. Karonda, 13.
Schakel, F.S., I.M. Buzzard, and E.S. Gebhard. 1997. Procedures for Estimating Nutrient Values for Food Composition Databases. J. Of Food Composition and Analysis 10(1):12. doi: 10.1006/jfca.1997.0527.
Tamrat, T., and D.R. Yesudas. 2018. Traditional Uses, Pharmacological Action, and Phytochemical Analysis of Carissa carandas Linn. Natural Product and Chem 6(5):1–20.
Zinabu, H. 2016. Effects of Controlled Atmosphere Storage and Temperature on Quality Attributes of Mango. J. Of Chemical Eng. & Process Tech. 7(5):6.