VOL 5(1), 46-57
Copyright © Madda Walabu University
ISSN: 2523-1901 (Online)
URL: http://jessd.mwu.edu.et/
Email: JESSDeditorials@mwu.edu.et
JESSD
Journal of Equity in Sciences & Sustainable Development
DOI: https:// doi.org/10.20372/mwu.jessd.2022.1530

Full Length Research Paper

Estimation of Citric Acid and Sugar Content and Its Nutritional Values of Selected Acidic Fruits, Available in Local Market, Robe Town, Ethiopia

Yohannes Shuka Jara* and Mekonnen Abera Anbese
Madda Walabu University, College of Natural and Computational Sciences, Department of Chemistry, Bale Robe, Ethiopia

Article Info

Article History
Received: 25 Nov 2021
Accepted: 10 Jan. 2022

Keywords:
Acid content, diseases, fruits, nutritionals value, sugar content, % juice content

Abstract

The study was conducted to address the nutritional analysis of juice and citric acid content, total soluble solids, and sugar concentration among the selected acidic and sub acidic citrus fruits, which are available locally in Robe Town, South Eastern Ethiopia. Four acidic and sub acidic citrus fruit samples including Sweet lemon; Lime, Pineapple, and Mango were collected and analyzed through different analytical methods on the same day. The obtained results indicated that the % of juice content high in sweet lemon than other fruits, being an acidic fruit lime contained the highest concentration of citric acid as compared to other fruits. But the contents of Mango and Sweet lime were found to be highly rich in total soluble solids and sugar content than other fruits. On the other hand, Sweet lemon and Pineapple have possessed sugar concentration. Hence, the present study concluded based on observations, each fruit has specific characteristics having high nutritional value and the daily intake of fruits enhances the immunity system to defend against many diseases.

* *Corresponding Email: johnaxis2021@gmail.com*

1. Introduction

Healthy life and Nutrition are two inseparable things. Proper nutrition serves as a major preventative agent to many ailments (Seaton *et al.,* 1994). Natural antioxidants have the potential to reduce the risk of cancer and many other disorders. Plant species including many fruits has been studied for their antioxidant, therapeutic, and pharmaceutical activities (Majhenic *et al.,* 2007). Fruits are rich sources of fibers, vitamins, minerals, antioxidants, water, and vitamin C at a remarkable content (Usha, 2010). They are considered good food supplements since they contain carbohydrates, sugars, water, different vitamins which include A, C, D, B1, and B2 as well as minerals like Potassium, Sodium, Calcium, Magnesium, and Iron. The use of fruits positively affects human health in reducing the risk of cancer, cardiovascular diseases, cataracts, and other diseases (Usha, 2010). Nutritional and pharmaceutical benefits Citrus fruits have received the attention of many scholars (Campbell *et al.,* 1999). Citrus fruits contain citric acid and are categorized as acid fruits, which include orange, lemon, sweet lime, grapefruit, strawberry, and sub-acid fruits include mango, apricot, peach, grapes, apple, pineapple, pear, and also sweet fruits include papaya and banana (ECAMA, 2012).

Lime (*Citrus aurantifolia)* & Sweet lemon *(Citrus limetta)* are species of citrus. Both limes and sweet lemon are popular citrus fruits consumed in many ways around the world, whether in garnishes, savory dishes, desserts, or drinks. They're very closely related and have a lot of overlap in nutritional values. India was the original home of lime in ancient times. They are also found in green color and are cultivated in California and Italy. The most essential citrus family fruits (lemon & lime) that thrive in the Southern Ethiopia. The fruit's hardiness makes it a suitable candidate for cultivating in the wild or even dry areas. At full maturity, it appears like a cross between a green orange and a mature lemon. The variety from Ethiopia features a dark green color and measures around 6 cm across its berry. Its taste is like that of the lemon but has more juice than its famous cousin (GFAMP, 2021).

The chemical composition of sweet lemon depends on the area where it grows. Sweet lemons are used for many purposes, for example, it is suitable for eating and contain the amount of oil includes peel oil as well as juice oil and they are volatile. It contains a high amount of ascorbic acid (Sandhu and Minhas, 2006). Anwar *et al*. (2007) studied the performance of twenty sweet lime varieties under the soil and climatic conditions of the agricultural Research Institute, Tarnab, and Peshawar during 2002 and 2003 data were recorded on Physico-chemical properties of fruits. *Musambi* (sweet lime) contains the highest non-reducing sugar (6.4%), reducing sugar (6.47%), and total sugar (13.21%). Sweet Lemon juice and lime juice are rich sources of citric acid, containing 1.44 and 1.38 g/oz, respectively. Lemon and lime juice concentrates contain 1.10 and 1.06 g/oz, respectively (Stephen, 2008).

Pineapple (*Ananas comosus***)** which is also called the king of fruits grows in over 2.1 million acres in 82 countries. In countries like Hawaii, Philippines, Australia, South Africa, Puerto Rico, Kenya, Mexico, Cuba, and Formosa smooth Cayenne cultivar is extensively cultivated (de Azevedo *et al*., 2007). Thailand is the largest producer of pineapple followed by Brazil and Costa Rica (Baruwa, 2013). In Africa, Nigeria is the leading producer and 7th in the world (FAO, 2011). In Ethiopia, the major pineapple production sites are located in the Southern and South Western part of the country. The farms are owned by private farmers and the state (Edossa, 1998). According to CSA data 2016/17 in Ethiopia, the pineapple was planted by 70,584 farmers on more than 645.2ha. Farmers produce Pineapples on a small scale on fragments of land, whereas the state farms produce pineapple along with their main plantation (coffee or maize) (Edossa, 1998). Smallholder farmers are accustomed to working with pineapples as a cash crop in a mixed farming system for decades. Substantial pineapple cultivation is mainly practiced in the Southern parts of Ethiopia (Sidama and Gamo) areas (Shamil et al., 2019).In General, the consumption pattern of the Ethiopian population encourages the production of the pineapple mainly for regional markets (close to Ethiopia) and in the Arabic peninsular markets for fresh fruits and processing purposes (SNV BOAM 2, 2010- 2011).

Pineapple has long been one of the most popular of the non-citrus tropical and sub-tropical fruits, largely because of its attractive flavour and refreshing sugar-acid balance. It is available fresh and canned (Arthey, 1995). 100g pineapple contain 47-52 calories, 85.3-87.0g water, 0.4-0.7g protein, 0.2-0.3g fat, 11.6-13.7g total carbohydrate, 0.4-0.5g fiber, 0.3-0.4g ash, 17-18mg calcium, 8-12mg phosphorus, 0.4mg iron, 1-2mg sodium and 125-146mg potassium (Bartolome, 1995).Pineapple also contains 12-15% sugars of which two-thirds are in the form of sucrose and the rest are glucose and fructose.0.6-1.2% of pineapple is acid of which 87% is citric acid and 13% is malic acid. The pH of pineapple is acidic, which is 3.71 and the acidity percentage is 53.5%. The composition of the juice varies with geographical, cultural, and seasonal harvesting and processing (Adhikary, 1987).

Mango (*Mangiferaindica L.***)** is a tropical evergreen fruit tree commercially grown in many countries and popular both in fresh and processed forms (Mitra, 1997). It is one of the most popular fruits of the world, because of its attractive color, delicious taste, and excellent nutritional properties. In Ethiopia, mango is produced mainly in the west and east of Oromia, SNNPR, Benshangul, and Amhara (Edossa *et al.,* 2006); Seid Hussen and Zeru Yimer (2013). In 2008, the total area of production under smallholders and production was estimated at 6.1 thousand hectares and 0.44 million metric tons, respectively (CAS, 2008).

Chatterjee *et al*. (2007) determined the physico–chemical characters of 13 mango hybrids grown in the agro-climatic condition of Sabour, Bhagalpur, Bhiar and India. The highest stone/pulp ratio (4.63) was observed in langra. The highest (25.00%) total soluble solid (TSS) was recorded in Amrapali and the lowest (18.43%) in Neelgoa. The maximum acidity (0.265%) was obtained in Neelashan and the minimum (0.170%) in prabhashakra. The highest ascorbic acid (42.82g/100g) was recorded in Langra and the Lowest (19.13g/100g) in Alfah. Reducing sugar was highest (6.77%) in sunder lanra and the lowest (4.15%) in Mahmud Bahar. Amarpali was superior to all hybrids than the control in terms of non-reducing sugar (13.99%). The highest total sugar content (19.86%) was recorded in Amarpali and the lowest (13.93%) in Mahmud Bahar.

The citric acid ($C_6H_8O_7$) is the primary acid present in many fruits that gives them a sour taste. Due to its excellent acidulant, flavorant, and preservative properties, citric acid is found in a large number of natural and processed foods and beverages, such as fruit juice, soft drinks, beer, milk, bread, candies and dairy, and also meat products (Mollering, 1986). The quality of fresh fruits depends on their external (color and firmness) and internal characters viz; Total soluble solids (TSS) or Brix, total acidity, total soluble solids/acid ratio, juice content, and other characteristics (Purvis, 1983).

In general, the present study aims at the assessment of citric acid and sugar content and its nutritional value of some acidic and sub acidic citrus fruits (Sweet lemon, Lime, Pineapple, and Mango), which is available locally in Robe Town market of Bale Zone, South Eastern Ethiopia. All the above-mentioned fruits were cultivated in South and West Ethiopia and are available in the local market of this town. Currently, there has been no report regarding the citric acid and sugar content and the nutritive values of the above fruits. So, the researchers paid small attention to assessing the nutritional values of some acidic and sub acidic fruits, available local market of Robe Town.

2. Materials and Methods

2.1. Apparatus and Instruments

Analytical balance accurate to 0.01mg, Laboratory tissue paper, Four 50ml Beaker, Erlenmeyer flask, Aluminum foil, 50 mL burette with Burette stand and clamp, 10 mL pipette and pump, 100 mL conical flask, Filter Paper, Blender, 1L volumetric flask, Plastic knife, Juice extractor from Kenstar-model2007, India and Handheld Refractometer was purchased from Atago.

2.2. Chemicals and Reagents

0.1N Sodium hydroxide (NaOH), 1% Phenolphthalein indicator and prepared fresh juice samples were used for the determination of acidity. Methylene blue, Copper sulphate, Sodium hydroxide, and Sodium potassium tartarate (Rochelle salt) were used for the preparation of standardized Fehling solution '*A*' and Fehling solution '*B*' whereas standard glucose solution was used for the determination of sugar. Stock standard solutions of analytes were prepared by dissolving each compound in water (100 mg/mL) and storing them at 25°. Distilled water was used for the preparation of standards. All chemicals and reagents were used in this study are analytical grade chemicals and distilled water was produced with a LASANY LPH-4 Water Distillation Unit.

2.3. Collection, Sampling and Estimation of fruits

2.3.1.Sample preparation

The selected acidic and sub acidic citrus fruits (Sweet lemon, Lime, Pineapple, and Mango) from the Robe market were collected and transported to the main laboratory of the Chemistry Department, Madda Walabu University. To begin up, the fruit samples were washed with tap water and with double distilled water to eliminate adsorbed dust and particulate matter and blotting dry using laboratory tissue paper. Secondly, the fruit samples were weighed and the mass was noted. Lastly, the fruit samples were chopped into small pieces using a plastic knife to facilitate extraction and transferred to a juice extractor (Kenstar, model2007, India). The extracted juice was collected in beakers separately and used for the following analysis.

2.3.2. Determination of Juice contents

The test to determine the 'Percent Juice Content' is important to determine the quality of the fruit. The juice contents were weighed and recorded in grams (Lacey, 2020). The percent juice contents were calculated by using the following formula;

$$\textbf{\% Juice contents} = \frac{Juice\ weight}{Fruit\ weight} \times 100$$

2.3.3. Determination of acidity

Acid (titratable acidity) is a measure of the total acid present in a juice. The predominant acid naturally occurring in some acidic and sub acidic citrus fruits (Sweet lemon, Lime, Pineapple, and Mango) juice is citric acid. The amount of acid present in the juice is reported as percent citric acid. It needs to be noted that the total acid cannot be measured by 'pH' because the acids concerned are "weak acids" and not completely ionized. The acid content must be measured using titration with sodium hydroxide. The acidity of the juices was determined (in triplicate) by acid-base titration (Lacey, 2020).

Percentage acid $= \frac{Titer \times Acid\ factor \times 10}{10ml\ of\ Juice}$, Acid factor for citric acid is 0.064 (citrus fruit)
Where; Titer = Consumed volume of Sodium hydroxide by the juice.

2.3.4. Determination of Total soluble Solids (TSS)

Brix (total soluble solids) is a measure of the total soluble solids in the juice. These soluble solids are primarily sugars; sucrose, fructose, and glucose. Citric acid and minerals in the juice also contribute to the soluble solids. The refractometer, which optically measures the refractive index of juice, is the standard method used to measure solid soluble concentration (SSC) or TSS of fruit and vegetables. TSS value or ºBrix represents the percentage by mass of total soluble solids of a pure aqueous primarily sugars; sucrose, fructose, and glucose solution (Pereira *et al.*, 2013). Brix is expressed as "degrees Brix" and is equivalent to percentage. For example, a juice which is 12 degrees Brix has 12% total soluble solids. The percentage sugar, measured in degrees Brix (ºBrix), indicates the sweetness of the fruit by measuring the number of soluble solids in the juice. Total soluble solids of the fruit juice were determined (in triplicate) as °Brix by using Atago Hand Refractometer (Lacey, 2020).

2.3.5. Estimation of the TSS to Acid Ratio

The sugar-acid ratio contributes to the unique flavour of citrus. At the beginning of the ripening process, the sugar-acid ratio is low, because of low sugar content and high fruit acid content—this makes the fruit taste sour. During the ripening process, the fruit acids are degraded, the sugar content increases and the sugar-acid ratio achieves a higher value. The total soluble solid to Acidity ratio (TSS/acidity) was calculated by dividing the total soluble solids by percent acid (Lacey, 2020).

TSS: Acid =°Brix value/Percentage acid

2.3.6 Determination of Sugars

Sugar Analysis is a quantification of mono- and disaccharides in a wide range of citrus fruits sample. Two methods are in common use for the estimation of sugars. The first is the chemical method, depending upon the reducing properties of certain sugars. The second is a polarimetric method, depending upon the optical activity of the sugars concerned. The second method is the most accurate and rapid method and is of considerable technical importance. The chemical method, although less accurate than the polarimetric method, is of great value for the estimation of sugars in biological fluids and citrus fruits juice, as well as less economical cost and simplicity. In the present study the chemical method was selected and the reducing sugar (glucose) was estimated quantitatively by using oxidizing agent Fehling's solution.

Glucose also reduces Fehling's solution quickly; the latter is obtained by mixing an aqueous solution of copper sulphate with an alkaline solution of sodium-potassium tartarate (Rochelle salt). The latter prevents the precipitation of cupric hydroxide by forming a complex. A freshly prepared Fehling's solution is first standardized by titration against a standard glucose solution. The standardized Fehling solution is then used to determine the amount of glucose in citrus fruit samples. The sugars were estimated (in triplicate) by using the chemical estimation method (Sethi, 2010).

Strength of unknown glucose solution $= \frac{4 \times W \times V1}{V}$ **gm/litter**

Where;

W=Weight of glucose in 250 ml standard solution

V_1= Volume of standard glucose solution used for 25 ml of Fehling's solution

V=Volume of unknown glucose solution used for 25 ml Fehling's solution

3. Result and Discussion

In the present study, the results showed significant variations in % of juice content, citric acid content, total soluble solids, and sugar concentration among the selected acidic and sub acidic citrus fruits (shown in Table 1).

Table 1: % of juice content, citric acid content, total soluble solids and sugar concentration of some fruits available in local market of Robe Town, Ethiopia

S.N	Name of the fruit sample	Juice content (%)	Citric Acid content (g/ml)	TSS values (%) °Brix	TSS/Acid Ratio	Sugar Conc. (g/ml)	Minimum juice content (%v/v)[1]	Minimum level TSS values % (°Brix)[1]	Sugar Conc. (g/ml)[2]
1.	Mango	29.67	0.64	31.20	487.5	2.5	25.0	13.5	1.8
2.	Sweet lemon	52.70	1.28	29.47	230.2	13.33	50.0	11.2-11.8	12.1
3.	Lime	30.35	3.2	27.96	87.37	2.1	(*)[3]	8	1.2
4.	Pine apple	46.10	1.41	30.19	214.4	9.3	40.0	12.8	8.0

Data source**;** [1]Joint FAO/WHO Codex Stan 247/2005 [2]AUSNUT, 2013 (FSANZ) [3]No Data currently available

Citrus fruit is one of the most important fruits all over the world, due to health-related elements and valuable components which involve vitamins C, carotenoids, flavonoids, pectin, calcium, and potassium. Of course, the nutritional and phytochemical contents of citrus vary widely depending upon growing conditions, the variety of fruit, maturity, storage conditions, and processing (Turner and Burri, 2013). According to Joint FAO/WHO Codex Stan 247 (2005), General Standard for Fruit Juices and Nectars the minimum level standard requirement for acidic and acidic citrus fruit juice is shown in the above Table 1. In the present study, a higher concentration of juice content, TSS/Brix value, and sugar concentration were observed in selected acidic and sub acidic citrus fruits and which is in the range of standard value of the joint FAO/WHO Codex. Juice content, Brix value, and sugar content of all fruits were low ranging from 29.76-52.7% v/v, 27.96-31.20%, and 2.1-13.33g/ml respectively for the fruits assessed. This value is greater than that of the required Codex Stan 247/2005 minimum standard level. FSANZ (2013) determined a sugar concentration of 1.8 g/ml for Mango, 12.1g/ml for Sweet lemon, 1.2g/ml for Lime, and 8.0g/ml for Pineapple as shown in Table 1. The carbohydrate content of citrus fruits (which is predominantly sugars) ranges from 2.1-13.33g/ml for the fruits assessed. The maximum sugar concentration was obtained in assessed citrus fruits compared with FSANZ. It was also indicated that selected citrus fruits were grown in a suitable agro-climatic condition of cultivated area and also the effectiveness of the analysis method.

According to Table 1, it was observed that the juice content of Sweet lemon (52.70%) was greater in percentage while it was lower in the Pineapple, Lime, and Mango were 46.1%, 30.35%, and 29.67% respectively. The juice content of Sweet lemon was greater in percentage while it was in the mango comparatively. So it was evaluated that Sweet lemon contains a higher amount of juice content because rich in vitamin C and flavonoids than other citrus fruits. In addition, Sweet lemon pulp covers 95% of the whole portion but, Mango pulp covers 50% of the whole portion approximately. Citrus fruit is a rich resource of flavonoids with many physiological properties involved in controlling antiviral activity and anti-microbial activity. They are present in the form of the glycoside or aglycone, especially in citrus juices as glycosyl derivatives (flavonoid glycosides, FGs) which showed potential health benefits for the human body (Waleed, 2020). Regular consumption of Sweet lemon juice can improve the functioning of the heart. It boosts the proper circulation of blood which in turn leads to a healthy immunity system. Sweet Lemon is rich in vitamin C thus reducing the possibility of scurvy. As it is already known that 100 grams of sweet lemon constitute 50 mg of vitamin C, which amounts to nearly 60% of the vitamin C which is recommended daily intake (Firdous, 2020). Percent of juice content obtained in the samples Sweet lemon > Pineapple > Lime > Mango.

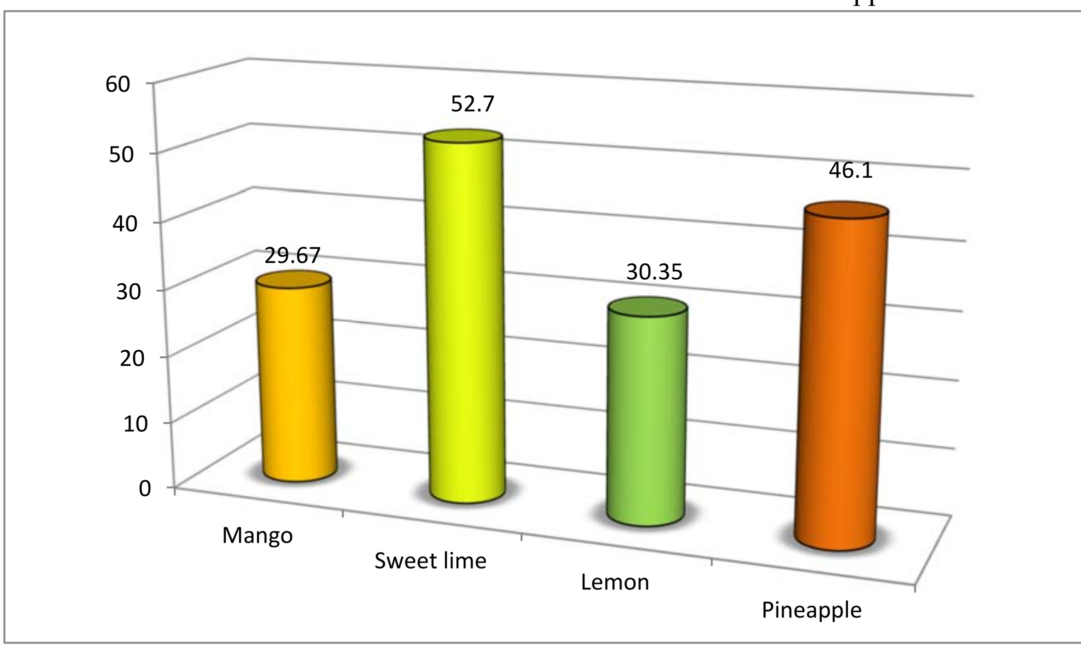

Fig1.The Total juice content in all samples

TSS value or °Brix represents the percentage by mass of total soluble solids of a pure aqueous sucrose, glucose, and fructose solution (Pereira *et al*., 2013). The obtained TSS values or °Brix of the different fruit juice are given in Table 1. TSS value in Mango juice is higher than in Pineapple, Sweet lemon, and Lime. TSS values in the Mango, Pineapple juice, Sweet lemon, and Lime were 31.20%, 30.19%, 29.47%, and 27.96% respectively.

Mango is the richest citrus fruit with Carotenoids, which are fat-soluble pigments that create different fruit colors, such as yellow, orange, and red. Mango contains a variety of macro-and micronutrients. In terms of macronutrients, the mango pulp contains carbohydrates (16–18%), proteins, amino acids, lipids, organic acids, as well as dietary fiber. The mango pulp juice is also a good source of micronutrients, including trace elements such as calcium, phosphorus, iron, and vitamins (vitamins C and A). Consumption of mango pulp juice provides high energy: 60–190 Kcal from 100g of fresh pulp (Lebaka *et al*., 2021). Many functions and health benefits of carotenoids have been described: they are antioxidants, have positive effects on the immune system, promote bone formation and health, stimulate gap junction communication between cells, promote eye health, and lower the risk of cancer (Turner and Burri, 2013). From this study, it was found that Mango can provide four times more sugar content than Sweet lemon and limes, so it helps to control a disease that is caused by a deficiency of Carotenoids more rapidly as compared to the other three fruits. TSS value obtained in the samples Mango > Pine apple > Sweet lemon > Lime.

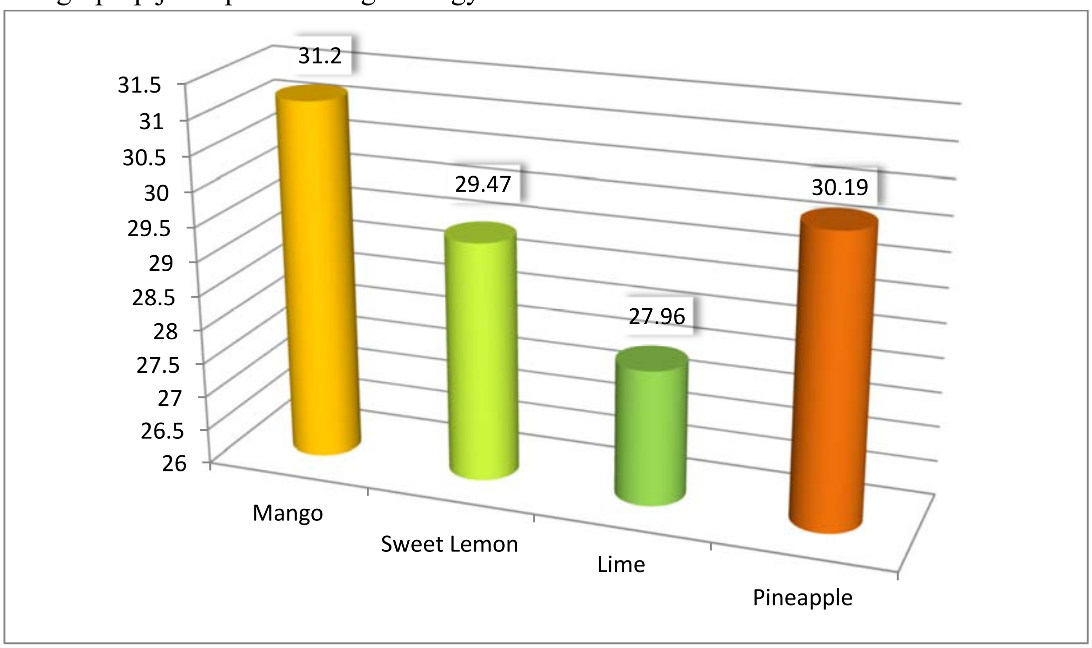

Fig 2.Total Soluble Solids (TSS) in all samples

Total acidity is expressed as anhydrous citric acid. Titration results showed that Lime contains the highest amount of citric acid content which was 3.2 g/ml and is in the range of standard value of citric acid content (3.82 g/ml) also evaluated by Penniston *et al*, (2009). While Mangoes contain a small amount of citric acid content equal to 0.64 g/ml. The titrableacidity varies from the values in previous works where the value ranges from 3.33-5.55 g/ml. The Sweet lemon contains 1.28 g/ml of citric acid concentration and these results are in line with Penniston.

Regarding citric acid content in the samples, it was concluded that Lime is useful for the protection of kidney stones and it also maintains the pH of urine. A kidney stone is a crystal structure formed by excessive salts in the urine. The most common type of stone is calcium stone. A stone will increase in size until it is not passable and becomes lodged in the ureter. Some people prone to stones have been found with insufficient levels of citrate in their urine (Economos and Clay, 1999). Citrate consumption can increase urine pH, and also increase citrate concentration in the urine. Citrate also decreases SSCaOx due to its capacity to form a complex with calcium. It has been suggested that eating citrus fruits and drinking orange juice may help prevent kidney stones by increasing urinary citrate (Han, 2015). More research is needed in this area, but increasing fruit consumption is a nutritionally sound recommendation that may prove to be very beneficial for individuals at risk of certain kinds of kidney stones. Percent of citric acid content obtained in the samples Lime > Pineapple > Sweet lemon > Mango.

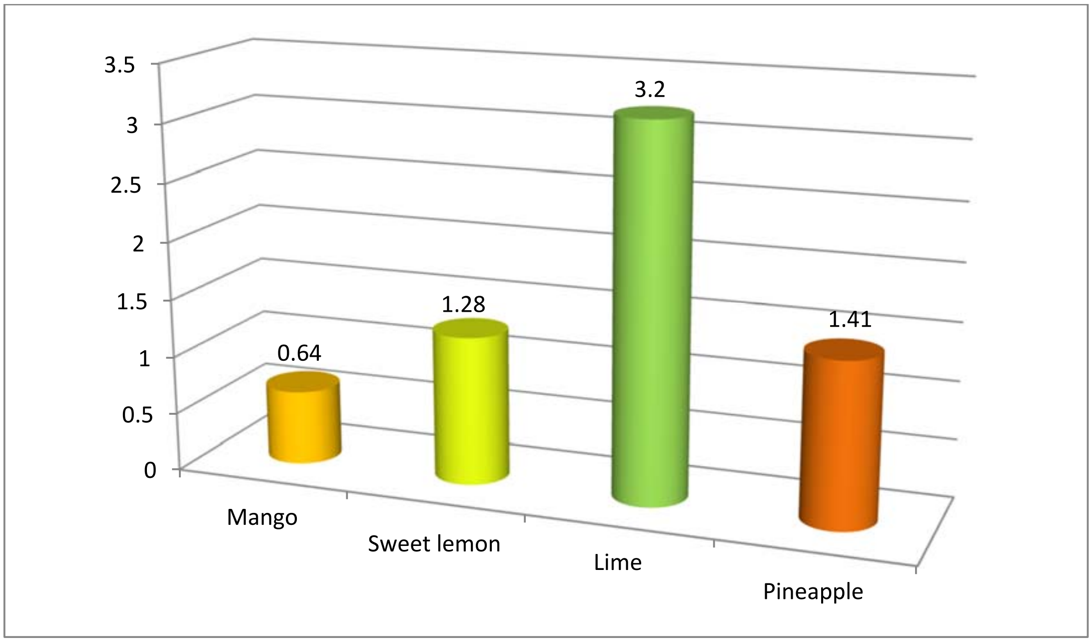

Fig.3.Citric acid content in all samples

Several classes of phytochemicals, including monoterpenes, limonoids (triterpenes), flavanoids, carotenoids, and hydroxycinnamic acid, have been isolated from citrus (see Figure 1). The possible anticarcinogenic mechanisms of phytochemicals include their antioxidant capabilities, their effects on cell differentiation, increased activity of the enzymes that detoxify carcinogens, an altered colonic milieu, and the blocking of nitrosamines (Katrine 2003). The regular intake of a varied mix of phytochemicals is only possible through the consumption of plant-based foods, such as citrus, as part of the normal diet.

4. Conclusion and Recommendations

This study is likely to represent the data on the juice contents, TSS/ºBrix, total acidity, and sugar concentration in Sweet lemon, Lime, Pineapple, and Mangoes available in the local market of Robe Town and its nutritional values. A higher concentration of juice content was obtained in Sweet lemon (52.70%) while it was lower in the Pineapple, Lime, and Mango were 46.1%, 30.35%, and 29.67% respectively. Regular consumption of sweet lemon juice can improve the functioning of the heart. It boosts the proper circulation of blood which in turn leads to a healthy immunity system. Citric acid content was found larger in Lime while TSS is in

Mangoes. Regarding citric acid content in the samples, it was concluded that Lime is useful for the protection of kidney stones and it also maintains the pH of urine. TSS value in Mango juice is higher than in Pineapple, Sweet lemon, and Lime. TSS values in the Mango, Pineapple juice, Sweet lemon, and Lime were 31.20%, 30.19%, 29.47%, and 27.96% respectively. From this study, it was found that Mango can provide four times more sugar content than Sweet lemon and limes, so it helps to control a disease that is caused by a deficiency of carotenoids more rapidly as compared to the other three fruits. From all obtained results; the Lime juice is concentrated with more citric acid while the Mangoes juice the more sugar content. But Pineapple has exceptional juiciness with an attractive flavour and refreshing sugar-acid balance. It is recommended that each fruit have specific nutritional value should be used widely to meet the nutritional demand of the local communities. The regular intake of a varied mix of phytochemicals is only possible through the consumption of plant-based foods, such as citrus, as part of the normal diet. The same methods can be repeated with other citrus and non-citrus fruits. Numerous parameters could be checked such as the color of the fruit, temperature of storage, the effect of chemicals, and age of fruits.

Acknowledgments

The authors are thankful to Chairman, Department of Chemistry, Madda Walabu University for providing laboratory facilities.

Conflict of Interest

There is no conflict of interest regarding this paper.

References

Abobatta, W.F. (2020). Nutritional Benefits of Citrus Fruits. *Am J Biomed Sci & Res*, 3(4). AJBSR.MS.ID.000681. Doi: 10.34297/AJBSR.2019.03.000681.

Adhikary, S.K., Harkare, W.P., Govindan, K.P., Chikkappaji, K.C., Sareja, S. and Anjundaswamy, A. M. (1987). Deacidification of Fruit Juices by Electrodialysis-Part II. Indian Journal of Technology, 25, 24-27.

Alo, S., Gezahegn, A., Geremew, D., and Getachew, W. (2019). Evaluation of Pineapple (*Ananascomosus L.*) Varieties at Teppi, South Western Ethiopia. *Greener Journal of Agricultural Sciences.*

Anwar, F., Latif, S., Przybylski, R., Sultana, B., and Ashraf. M. (2007). Chemical composition and antioxidant activity of seeds of different cultivars of mungbean. *Journal of Food Science*, 72(7): 503-510.

Arthey, D. (1995). *Food Industries Manual in Fruit and Vegetable Product*. London.151.

Baghurst, K. (2003). The Health Benefits of Citrus Fruits. *CSIRO Health Sciences & Nutrition*. Horticultural Australia Ltd.

Bartolome, A., Ruperez, P. and Foster, C. (1995). Pineapple Fruit, Morphological characterstics, Chemical Composition and Sensory Analysis of Red Spanish and Smooth Cayenne Cultivars. *Food Chemistry*, 53, 75-79.

Baruwa, O.I. (2013). Profitability and constraints of pineapple production in Osun State, Nigeria. *Journal of Horticultural Research*, 21(2):59-64.

Campbell, M. K., Wahnefried, M., Symons, W. D., Kalsbeek, J., Dodds, A., Cowan, B., Mcclelland, J.W. (1999). Fruit and vegetable consumption and preventation of cancer, the black churches united for better health project. *American J. Public Health*; 89, 1390-1396.

CAS. (2008). Statistical bulletin of agricultural sample survey Report on area and production of crops.

Chatterjee, D., Maurya, K. R, and Mandal, M.P. (2007). Flowering and fruiting behavior of some Hybrids of mango (Mangiferaindica Linn.). *Journal of Interacademicia*, 11, 283-287.

DeAzevedo, P.V., De Souza, C.B., Da Silva, B.B., da Silva, V.P. (2007). Water requirements of pineapple crop grown in a tropical environment, Brazil. *Agricultural Water Management,* 88(1-3):201-208.

Economos and Clay. (1999). Nutritional and health benefits of citrus fruits. Nutrition Programmes Service, Food and Nutrition Division, FAO, Rome.

Edossa, E., Lemma, A. and Dereje, T. (2006). Review on the status of some tropical fruits in Ethiopia. *Proceedings of the Inagural and Frist Ethiopian Horticultural Science Society Conference*, 39-44.

Firdous, D. (2020). Health Benefits of Sweet Lime (Mosambi Fruit) and It's Side Effects. Available at; www.lybrate.com Accessed 4 Jan 2022.

Food and Agriculture Organization (2011). Corporate Statistical Database (FAOSTAT) Available at http://www.fao.org accessed on 22 Dec 2021.

Food Standard Australia New Zealand. (2013). Australian food, supplement and nutrient database (AUSNUT). Available at www.foodstandards.gov.au accessed 3 Jan 2022.

Global Food and Agriculture Marketplace (GFAMP). (2022). Ethiopia Lime. Available at https://www.selinawamucii.com/ viewed on the 12 Nov 2022.

Haewook, H., Adam, M., Segal, J., Seifter, L. and Dwyer, J.T. (2015). Nutritional Management of Kidney Stones (Nephrolithiasis). *Clinical Nutrition Research,* 4 (3): 137-152. doi:10.7762/cnr.2015.4.3.137.

Hussen, S. and Yimer, Z. (2013). Assessment of Production Potentials and Constraints of Mango (Mangiferaindica) at Bati, Oromiya Zone, Ethiopia. *International Journal of Sciences, Basic and Applied Research (IJSBAR).*

Joint FAO/WHO Codex Alimentarius Commission. (2005). General Standard for Fruit Juices and Nectars. (CODEX STAN 247-2005).

Lacey K. (2020). Measuring internal maturity of citrus. Department of Agriculture. *Food farm note*, 1-4.

Majhenic L., Skerget, M. and Knez, Z. (2007). Antioxidant and antimicrobialactivity of guarana seed extracts. *Food chem,* 104, 1258-1268.

Mitra, S.K. and Baldwin, E.A. (1997). *Mango, in postharvest physiology and storage of tropical and subtropical fruits*. CAB International, Wallingford, UK; 85-122.

Mollering, H. (1986). *Citrate, in methods of enzymatic analysis* (*Bergmeger.H.U.Ed)* (3rd ed.). VGH publishers (UK), VII, 2-122.

Penniston, K. L., Nakada, S.Y., Holmes, R.P., and Assimos, D.G. (2009). Quantitative assessment of lemon juice, lime juice and commercially available fruit juice products. *NIHPA author manuscript*, 22 (3), 567-570.

Pereira, F.M.V., de Souza Carvalho, A.,

Cabec, L.F., Colnago, L.A. (2013). Classification of intact fresh plums according to sweetness using time-domain nuclear magnetic resonance and chemometrics. *Microchem. J,* 108, 14–17.

Purvis, A. C. (1983). Effect of film thickness and storage temperature on water loss and internal quality of seal packaged grapefruit. *American J. Soc. Hort. Sci;* 108,562-566.

Reddy, L.V., Wee, Y-J., Weibing, Y. and Korivi, M. (2021). Nutritional Composition and Bioactive Compounds in Three Different Parts of Mango Fruit. *Int. J. Environ. Res. Public Health,* 18 (741).

Sandhu, K. S. and Minhas, K.S. (2006). Oranges and Citrus juices. *Handbook of fruits and fruit processing.*

Seaton, A., Godden, D.J. and Brown, K. (1994). Increase in asthma a more toxic environment or a more susceptible population. *Thorax,* 49; 171-174.

Sethi, A. (2010). *Systematic laboratory experiments in organic chemistry* (7th ed.). New age international Pvt. Ltd: 978-8122428285.

Soyer, Y., Koca, N., and Karadeinz, F. (2003). Organic acid profile in Tikish while grapes and grapes juices. *Journal of food composition and analysis,* 16, 629-636.

Stephen, K., Nakada, Y., Ross, P., Dean, G., Assimos, P., (2008). Quantitative Assessment of citric Acid in Lemon Juice, Lime Juice, and Commercially-available Fruit Juice Products. *J Endourol*, 22(3), 567-570.

Turner, T., and Burri, B.J. (2013). Potential Nutritional Benefits of Current Citrus Consumption. *Agriculture,* 3, 170-187. Doi: 10.3390/agriculture3010170.