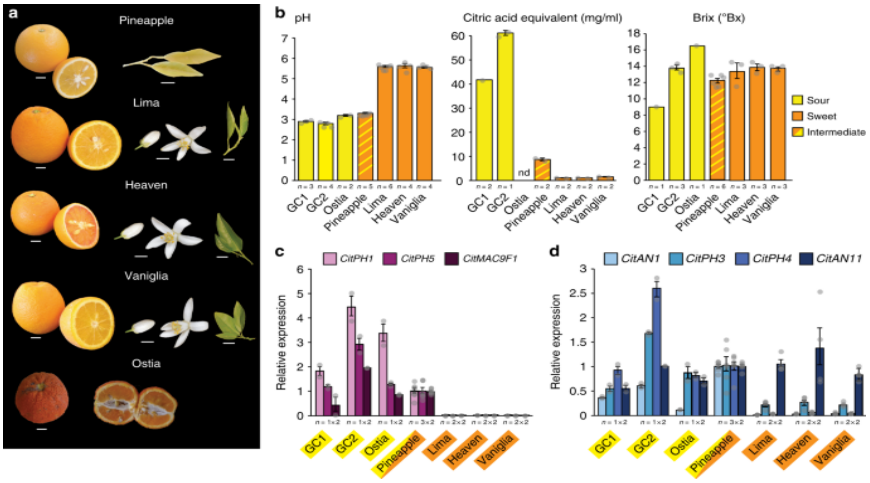
GOVERNMENT DEGREE COLLEGE,SIDDIPET

(AUTONOMOUS)

CHEMISTRY

PROJECT ON

CITRIC ACID IN FRUIT JUICES



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CITRIC ACID IN FRUIT JUICES

ABSTRACT

Background and Purpose

Knowledge of the citric acid content of beverages may be useful in nutrition therapy for calcium urolithiasis, especially among patients with hypo citraturia. Citrate is a naturally-occurring inhibitor of urinary crystallization; achieving therapeutic urinary citrate concentration is one clinical target in the medical management of calcium urolithiasis. When provided as fluids, beverages containing citric acid add to the total volume of urine, reducing its saturation of calcium and other crystals, and may enhance urinary citrate excretion. Information on the citric acid content of fruit juices and commercially-available formulations is not widely known. We evaluated the citric acid concentration of various fruit juices.

Materials and Methods

The citric acid content of 21 commercially-available juices and juice concentrates and the juice of three types of fruits was analyzed using ion chromatography.

Results

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. The citric acid content of commercially available lemonade and other juice products varies widely, ranging from 0.03 to 0.22 g/oz

Conclusions

Lemon and lime juice, both from the fresh fruit and from juice concentrates, provide more citric acid per liter than ready-to-consume grapefruit juice, ready-to-consume orange juice, and orange juice squeezed from the fruit. Ready-to-consume lemonade formulations and those requiring mixing with water contain ≤6 times the citric acid, on an ounce-for-ounce basis, of lemon and lime juice.

INTRODUCTION

Citric acid (2-hydroxy-1,2,3-propanetricar-boxylic acid) is a weak tricarboxylic acid that is naturally concentrated in citrus fruits. At physiologic blood pH, and to a lesser extent in urine, it exists mainly as the trivalent anion. Citric acid is frequently used as a food additive to provide acidity and sour taste to foods and beverages. Citrate salts of various metals are used to deliver minerals in biologically-available forms; examples include dietary supplements and medications. Among fruits, citric acid is most concentrated in lemons and limes,[1] comprising as much as 8% of the dry fruit weight. A major source of citric acid *in vivo* results from endogenous metabolism in the mitochondria via the production of ATP in the citric acid cycle. Gastrointestinal absorption of citric acid from dietary sources has been associated with a modest increase in urinary citrate excretion.[2–4]

Urinary citrate is a potent, naturally-occurring inhibitor of urinary crystallization. Citrate is freely filtered in the proximal tubule of the kidney. Approximately 10% to 35% of urinary citrate is excreted; the remainder is absorbed in various ways, depending on urine pH and other intra-renal factors. Citrate is the most abundant organic ion found in urine. Hypocitraturia, defined as <320 mg (1.67 mmol) urinary citrate/day,[5] is a major risk factor for calcium urolithiasis. The activity of citrate is thought to be related to its concentration in urine, where it exhibits a dual action, opposing crystal formation by both thermodynamic and kinetic mechanisms. Citrate retards stone formation by inhibiting the calcium oxalate nucleation process and the growth of both calcium oxalate and calcium phosphate stones, largely by its ability to bind with urinary calcium and reduce the free calcium concentration, thereby reducing the supersaturation of urine. Citrate binds to the calcium oxalate crystal surface, inhibiting crystal growth and aggregation.[6] There is also evidence that citrate blocks the adhesion of calcium oxalate monohydrate crystals to renal epithelial cells.[7] Medical interventions to increase urinary citrate are a primary focus in the medical management of urolithiasis.[8]

MATERIALS AND METHODS

Materials

All products were obtained from local supermarkets in Madison, Wisconsin and Winston-Salem, North Carolina, and included fresh fruits, ready-to-consume fruit juices, lemon and lime juice concentrates, and crystallized lemonade formulations. The products purchased are listed in Table .

Table

Citric Acid Content, in Descending Order, of Various Fruit Juices and Commercially-Available Juice Formulations (Grams per Liter)

			Total citric acid	
Product	**Type of product**	***n***	**Mean**	**SD**
Lemon juice	fresh, from fruit	2	48.0	3.82
Lime juice	fresh, from fruit	2	45.8	6.86

Lime juice, ReaLime 100%	juice concentrate	1	35.4	
Lemon juice, ReaLemon 100%	juice concentrate	1	34.1	
Orange juice, Tropicana Pure Premium	ready-to-consume	1	16.9	
Orange juice, Tropicana Light 'n Healthy	ready-to-consume	1	16.7	
Orange juice	fresh, from fruit	2	9.10	1.98
Lemonade, Minute Maid Light	ready-to-consume	1	5.20	
Raspberry lemonade, Minute Maid	ready-to-consume	1	5.00	
Lemonade, Tropicana	ready-to-consume	4	4.83	0.61
Pink lemonade, Minute Maid	ready-to-consume	1	4.80	
Lemonade, Tropicana Sugar-Free	ready-to-consume	3	4.60	0.44
Lemonade, Minute Maid	ready-to-consume	1	4.40	

Sample preparation

Samples of the ready-to-consume beverages and juice concentrates were taken directly from their packages. Crystallized lemonade formulations were mixed with water according to package directions. From the fresh fruits, juice was extracted manually. Samples were diluted 1/5000 in water for analysis.

Equipment

Ion chromatography analyses were performed on a system consisting of a Dionex ED50 conductivity detector, a Dionex AS11-HC 2 × 250-mm ion exchange column with a guard column at a controlled temperature of 30°C, and a Dionex ASRS-ULTRA 2-mm suppressor (Dionex Corporation, Sunnyvale, CA).

Chromatographic conditions

A gradient of 20 to 35 mM sodium hydroxide over 10 minutes was used; citrate eluted at 7.6 minutes. Peak areas were related to those of a standard curve for quantifying citric acid concentration.

Statistical methods

We compared the citric acid concentrations of groups of juices and juice products with an analysis of variance (ANOVA). Pair-wise comparisons were made using Fisher's protected least significant difference tests. *P*-values <0.05 were considered as significant. All analyses were performed using SAS statistical software (SAS Institute Inc., Cary, NC).

RESULTS and Conclutions

The citric acid content of various fruit juices and fruit beverages are listed in Table 1. Comparisons of the citric acid content of the juices and beverages, by group, are shown in Figure 1. The juice of lemons and limes squeezed from the fruits contained the most citric acid (48 and 46 g/L, respectively). There was no difference between the juice of lemons and limes for citric acid content (P =0.35). Lemon and lime juice from concentrate were similar for citric acid content (34–39 g/L). Grapefruit juice and orange juice from ready-to-consume, 100% juice formulations contained 25 and 17 g/L, respectively. There was no difference between the regular orange juice formulation and its "light" counterpart. Orange juice squeezed directly from oranges had a lower citric acid content than ready-to-consume orange juice (P =0.003). Of the commercially-available lemonade and limeade formulations, which are generally formulated to contain 15% real juice or less, those that are ready-to-consume contained more citric acid than the powdered mixes that were prepared by mixing with water according to package instructions (P =0.03). There was no difference between the light and sugar-free ready-to-consume lemonades and their regular counterparts (P =0.76) and no difference between the light and sugar-free lemonades and the crystallized, powdered lemonade mixes (P =0.21).

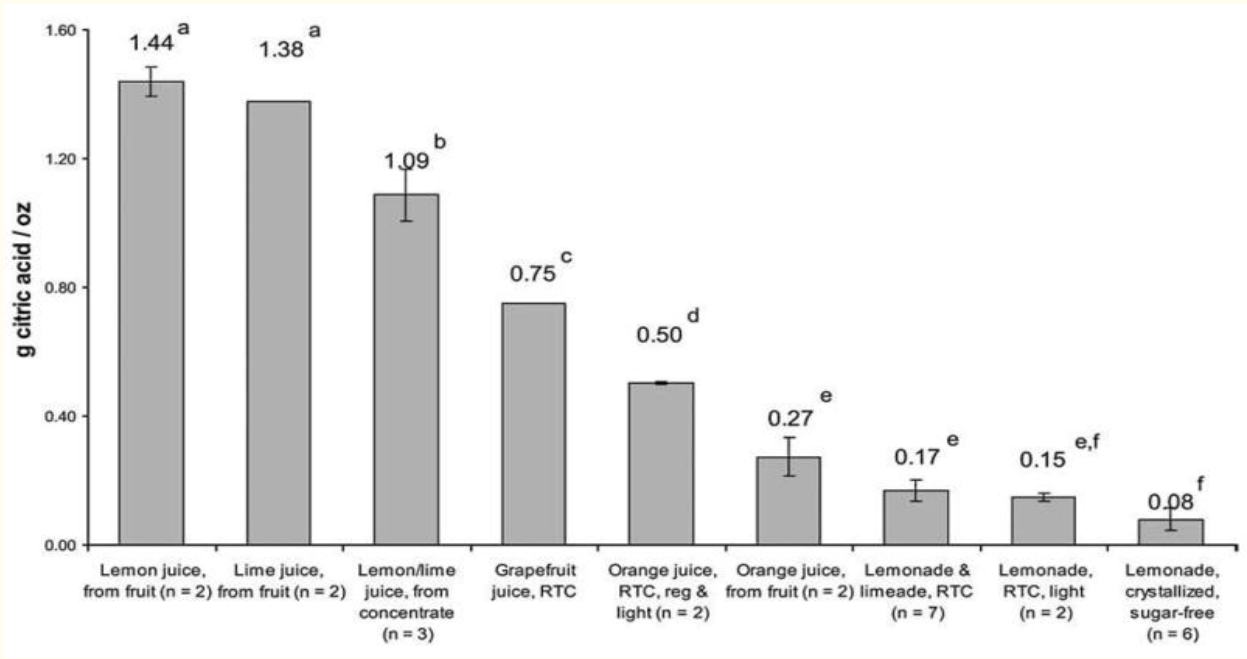

FIG. 1
Comparison of citric acid concentrations (g/oz.) of juices and juice products by group. Bars, where shown, represent SD for each group. Values above each bar are the mean citric acid content (g/oz.) per group. Groups with same letters are similar (p >0.03). RTC, ready to consume; reg, regular.

Citric Acid Formula: Structure, Properties, Uses

Citric acid occurs in citrus fruits that include lemons, oranges, pomelo, etc. Citric acid is a weak organic acid with having a chemical formula $C_6H_8O_7C_6H_8O_7$. IUPAC name of citric acid is 22-hydroxypropane-1,2,31,2,3-tricarboxylic acid. The sour taste of citrus fruits such as lemon and orange is due to the presence of citric acid by 8%8% of its total dry weight. Citric acid is completely soluble in water due to its polarity.

Though we know that citric acid is present in nature, there are various ways by which citric acid can be synthesized to meet industrial demands. One of the most widespread methods is the fermentation of fungi such as *Aspergillus niger* or *Candida* species from various sources of carbohydrates, such as molasses and starch. Citric acid is very beneficial to our health as it acts as an antioxidant. Thus, it is used in many beverages, medicines, skincare products, as well as disinfectants. In this article, let's learn everything about citric acid chemical formula and its uses.

Uses of Citric Acid

1. Citric acid is mostly used in foods and beverages such as soft drinks, juices, etc. It gives them a tangy, citrus taste. Thus, it is widely used as a flavouring agent.
2. It acts as food preservatives because its acidic pH inhibits the growth of many bacteria on food, thus preventing them from getting spoiled. In frozen foods, citric acid is lowering the pH making oxidative enzymes inactive.
3. Citric acid is used in soaps and detergents to soften their basic pH.
4. It is also used in many cosmetic products as a preservative to maintain acid-base pH balance.
5. In pharmaceuticals, citric acid is also used as an acidulant to control pH and acts as an anticoagulant by chelating calcium in the blood.
6. In diseases like osteoporosis, lemon peels, as a source of citric acid, are used to improve bone health as they contain a high amount of calcium and vitamin C, which assist in the maintenance of bones.

Side Effects of Citric Acid

1. Overexposure to citric acid can erode tooth enamel, which may lead to tooth decay. Mostly, this does not happen due to an overdose of citrus fruits. But, over intake of beverages containing citric acid can lead to such conditions.
2. Sometimes, if many citrus fruits are taken, it may cause acidity in the stomach and stomach ache.
3. Serious side effects of citric acid include numbness or tingly feeling, muscle twitching or cramps, rapid weight gain or swelling in the body, fast or slow heart rate, sudden mood changes, diarrhoea, convulsions, etc.

Summary

The chemical formula of citric acid is C6H8O7C6H8O7 and its IUPAC name is 22-hydroxypropane – 1,2,31,2,3-tricarboxylic acid. Due to the presence of

three carboxylic acid groups, it is a weak tribasic acid. It exists as an optically inactive compound. Citric acid is found naturally in citrus fruits that include lemons, oranges, pomelo, etc. It is widely used in the food industry as it acts as an acidifier, a flavouring, and a chelating agent that make them useful food preservatives.
Citric acid is a non-toxic compound as it is biodegradable. Thus, it can be thoroughly used in pharmaceutical industries to make medicines. Citric acid is produced by fermentation of *Aspergillus niger* in large quantities in bioreactors. Citric acid is soluble in water due to the presence of three carboxylic acid groups. Citric acid can be chemically synthesized from glycerol through a series of reaction steps. This process gives a good yield of citric acid.

Though citric acid has immense benefits, it also has few side effects, including tooth decay, nausea, vomiting, etc.

In biochemistry, it acts as an intermediate in the citric acid cycle, which is a metabolic process in aerobic organisms to produce a high amount of energy that is derived from the breakdown of carbon compounds in the body. Thus, it can be concluded that citric acid is a very important organic acid used in a wide range of applications.

Juices That Contain Citric Acid

Pucker Up

Citric acid is the culprit causing your lips to pucker up when taking a bite of a lemon or tasting unsweetened lemon juice. That sour taste comes from the citric acid in the fruit. Citric fruits like lemons, limes, oranges and grapefruit have the highest concentration of citric acid, giving juices made from these fruits their tart, tangy flavor. Citric acid added to commercially prepared juice drinks increases the tangy flavor and preserves the color of the juice.

Natural Citri c Acid

The highest concentration of citric acid occurs in lemon juice with 1.44 grams per ounce of juice. Lime juice comes in second with 1.38 grams per ounce, according to Dr. Kristina L. Penniston of the University of Wisconsin School of Medicine. Fresh orange juice or orange juice made from concentrate contains about 0.25 grams of citric acid per ounce. Grapefruit juice contains 0.0068 grams per ounce.

Citric Acid Additives

The citric acid content of commercially prepared juice drinks varies, depending on the manufacturer, but can range from 0.03 grams per ounce to 0.22 grams per ounce. Some artificially flavored and sweetened juices that actually contain no fruit can have more citric acid than the naturally occurring citrate in citrus fruit.

Energy Boost

The citric acid in juice has no nutritional value, but it is necessary to your metabolism. According to Reginald H. Garrett and Charles M. Grisham, authors of the book "Biochemistry," citric acid is critical in providing energy to your cells by converting carbohydrates, proteins and fatty acids into water and carbon dioxide. This process is known as the citric acid cycle.

Drink in Moderation

When drinking juices that contain citric acid, moderation is the key. Too much citric acid can cause tooth enamel erosion because of its low pH. Lemon and lime juice have a pH of less than 2, which is similar to the corrosive qualities of battery acid, according to an article in "Tufts Dental Medicine" magazine. If you are susceptible to canker sores, drinking too much juice containing citric acid could cause outbreaks.

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