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Review Article

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Analytical Method, Chemistry and Properties of Fructose, Sucrose and Ascorbic Acid in Pear Fruit Juice

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ABSTRACT

Pear is a gently sweet fruit, arich source of several nutrientsincludingfiber, sugar, vitamin C molecules, and potassium. This article reports the history, consumption, Types, health benefits, and diseases of various fruit juices. Carbohydrates, Fructose, sucrose, vitamin C, fibers, vitamins, and minerals are prime constituents present in almost all juices. The nutrition composition, manufacturing technique, processing steps, specification, stability data, contamination, and related details of pear juice are discussed in this review. The pharmacological and functional applications of pear juice like Anti-diabetic, Anti-hyperlipidemic, Anti-inflammatory, and Cardio-protective, etc. are covered with their mechanism of action. The marketed preparation and patents are also highlighted. Moreover, the analytical estimation of active constituents by spectroscopy and chromatography [like UV, HPLC, UPLC, and mass spectroscopy] isexplained in this article. The physic-chemical properties, synthesis, chemistry, biological study, pharmacokinetics, and pharmacodynamics of fructose, sucrose, and ascorbic acid, which are chief phytoconstituents in pear juice, are explained in the present article. This review suggests therapeutic pharmacological andanalytical techniques available for estimating sucrose, fructose, and ascorbic acid analytically and bioanalytically. This will contribute in creating a straightforward and verified procedure that complies with green chemistry.

Key words: *Analytical methods, Chemistry, Biosynthesis, Fructose, Sucrose, Ascorbic acid (Vitamin C)*

INTRODUCTION

In the United States, laws governing fruit and vegetable juice have existed since the late 19th and early 20th centuries [1, 2]. The word "juice" originates from Old French and dates back to before 1300 [3, 4]. Old French terms "jus, juis, jouis," which denote "liquid generated by boiling plants," are where it originated. Juice is a beverage made from fruits and vegetables that have had their natural liquid extracted [5, 6]. Fruit juice, which is prepared from fresh fruit flesh or even the entire fruit, is an entirely natural product [7]. Juices are available in a variety of flavors that nature offers and contains voluminous nutrients that support a healthy life. People frequently drink juice as a beverage, utilize it as a flavoring element in food, and use it forsmoothies [8].

Worldwide consumption of juice

Market research shows that the average European consumed 32 ml of fruit juice per day in 2018, or 11.5 liters. Juices will bring approximately US$103.50 billion in revenue in 2022. The market is expected to grow by 6.97% annually (CAGR 2022-2026). United States revenue is the highest when compared globally ($23,670.00mm in 2022) [9]. Based on population statistics, per-person sales of US$ 13.60 are generated in

2022. In the juices market, out-of-home consumption will represent 38% of spending and 11% of volume by 2026. (e.g., in bars and restaurants). Juice sales volume is predicted to reach 37,748 ML by 2026. Juices are anticipated to see a volume increase of6.4percentage in 2023. Juice consumption per person is anticipated to reach a volume of 4.42L in 2022 [10].

Types of juices [11]

According to the product composition

- Fruit Juice from Concentrated: Concentrated Fruit Juice:
- Water Extracted Fruit Juice: Dehydrated/Powdered Fruit Juice: Freshly Extracted Fruit/ Vegetable Juices.

According to thepreservation method

- Freshly Squeezed juice
- Chilled Juice
- Frozen Juice
- Pasteurized Juice
- Concentrated Juice

Health benefits of juice

The World Health Organization'srecommendationsarethe basis of the UK's 5 A Days initiative (WHO). A healthy diet must include the fruit and vegetable consumption advised by the WHO [12]. Drinks with added sugar and 100% pure fruit juice consumption have a detrimental effect on diet quality and body weight control. Concerning the WHO's effort to minimize the intake of free sugar, an analysis of a nationally representative survey was done. Fruit juice and sweetened beverage consumption weremore frequently correlated with age and gender than weight [13-16].

- *Fructose*

Fructose is a type of sugar found in both fruits and vegetables. Fructose is used as a sweetenerandcarries a lower glycemic index load and lipogenesis. The total consumption of fructose in women is 133g/day and in men 136g/day [12].

- *Sucrose*

Sucrose is adisaccharide sugar molecule; it provides energy benefits for performing physical and mental functions. Sucrose aids in lipid metabolism and insulin sensitivity. The American Heart Association suggested capping the daily intake of sucrose calories at 100kcal for women and 140kacl for men [17].

- *Vitamin C*

Ascorbic acid, also known as vitamin C, is the most abundant source of nutrients in fruit juice. Vitamin C functions as an antioxidant agentandwound healing agent to maintain bone, skin, and blood vessels. For women, the daily-recommended intake of vitamin C is 75 mg, while for men it is 90 mg [18].

- *Fiber*

Fiber is an indigestible carbohydrate. Blood sugar management is greatly aided by fiber. A fiber-balanced diet is important for preventing cardiovascular disease, diabetes anddisambiguations. In Europe, the total intake of fiber is 25-32g/day for women and 30-35g/day for men [12].

- *Folate (Folic acid)*

Vitamin B9 in its natural form is called folate, which is naturally in a variety of fruitsand vegetable sources. Folate helps in protein metabolism repair blood vessels and cell growth. Recommended Dietary Allowances (RDAs) for Folate, 400mcg DFE supplements for adults, and 600mcg DFE in pregnancy [19].

- *Potassium*

Potassium is an important mineral in fruit and vegetables. Potassium works as an electrolyteandplays vital role conduction and maintenance of normal heart rhythm. It helps reduce blood pressure, and water retention, and prevent osteoporosis and kidney stone. The American Dietary Guidelines 2010 according to the total intake of potassium in adultsis4700mg/day [20].

- *Immune function*

Fruit juices are microelements and bioactive phytonutrients. It plays an important role in cell-mediated immune reactions. It provides a defense host against viruses, bacteria, and terms that can cause some kind of diseases [21].

- *Antioxidants*

Fruit juice such as citrus fruit contains carotenoids, vitamin C, and folate, antioxidants that can protect against skin damage, various diseases and enhance the immune system [10, 22].

Pear juice

The pear is among the oldest and most well liked fruits in the world. It is believed that pears were first grown in Europe around 1000 B.C [23]. The pear is a genuinely amazing fruit that is hardy and commonly cultivated in temperate regions of the world. Its size, shape, texture, and flavor are all different [24].

Pears are a juicy, mildly sweet fruit with a buttery texture. In terms of nutrients among cultivated fruits, it comes in second place after apples. The genus Pyrus contains dicotyledonous plant species, including the pear (family Rosaceae). It is referred to as "Amritphale" in Sanskrit. Its different variantsinclude "stiff" types (Nashpati) and (Babbu- ghose). Based on their origin and commercial production, pears can be divided into three groups: European pears (Pyrus communist L.), Japanese pears (P. Pyrofolia Burn.), and Chinese pears (P. brestchneideri Re-hd. and P. ussuriensis maxim). There are at least 22 different species of pears, with more than 5000 different subspecies. The pear tree is nutritious and has a variety of therapeutic benefits [25]. The taxonomical Classification of Pear is listed in **Table 1**.

Table 1. Taxonomical Classification of Pear [25]

S. No.	Kingdom	Plantae
1.	Division	Magnoliophyta
2.	Class	Mangnoliopside
3.	Order	Rosales
4.	Family	Rosacease
5.	Subfamily	Amygdaloideae
6.	Tribe	Maleae
7.	Sub-Tribe	Malinae
8.	Genus	*Pyrus L.*
9.	Species	*Communis Linn*

Components of pears juice

Pears'nutritional profile includes a variety of elements like fiber, vitamin C, and potassium. It has fructose and sorbitol, two ingredients associated with childhood diarrhea. Compared to other fruits, pears are notably high in fructose and sorbitol. Pears include 4.5% fructose, 4.2% glucose, 2.5 % sucrose, and 2.5% sorbitol. A great source of vitamin C is pearsbecause they contain roughly 7mg of the vitamin [26].

- *Carbohydrates*

Most of the energy used by humans comes from carbohydrates. The carbonyl group on carbohydrates, which may be an aldehyde or a keto group, is potentially active. Based on the carbon atoms that they contain; carbohydrates can be categorized. Monosaccharides, disaccharides, oligosaccharides, and polysaccharides are the four types of carbohydrates. Disaccharides hydrolyze to two monosaccharides whereas monosaccharides themselves cannot be hydrolyzed [27]. In 1993, the Food and Drug Administration (FDA) declared thatmonosaccharide and disaccharide sugar analysis is essential for the whole food business [28].

- *Fructose*

Many plants contain fructose, often known as fruit sugar, which is a ketonic simple sugar that is frequently joined with glucose to produce the disaccharide sucrose. Along with glucose and galactose, it is one of the three dietary monosaccharides that are directly absorbed into the blood following digestion [29].

- *Sucrose*

Sucrose, a disaccharide, and the primary component of white sugar, is a natural sugar generated by plants that is made up of the subunits of glucose and fructose. Bacteria can only produce this clingy polysaccharide using this one type of sugar [30].

- *Vitamins*

Vitamins are chemical compounds that are present in food and are just marginally necessary for the body to operate normally. Thirteen vitamins that are known to exist in human nutrition are grouped into two groups

based on how soluble they, the water-soluble vitamin is composed of the areB group vitamins and vitamin C [31]. Vitamin C is also known as ascorbic acid, crucial for both human and animal survival. Vitamin C helps in the production of collagen, the healing of wounds, the prevention of scurvy and cancer, and the common cold [32].

- *Arbutin*

Arbutin is a hydroquinone-D-glucopyranoside glycoside. Arbutin decomposition results in the formation of hydroquinone. Antibiotics and skin-whitening agents are known to exist in it. Arbutin is administered topically, utilized in cosmetic products to inhibit tyrosinase and fragrances, and used to stop the production of melanin. Pear peel contained 1.20 milligrams of arbutin per gram of fresh weight overall [33].

- *Flavonides*

A secondary polyphenolic metabolite is flavonoids. The total flavonoid content of Korean pears ranges from 182.5 to 368.1 mg per 100g of fresh weight. Flavonoids are utilized medicinally for their antioxidant, anti-inflammatory, antiviral, and potentially harmful drug effects [33].

- *Phenolic acid*

A phenolic ester of 5-O-caffeoylquinic acid is chlorogenic acid. Particularly, unripe Korean pears have 106.7–247.5mg/100g of chlorogenic acid. Chlorogenic acid has pharmacological qualities that include hypoglycemia, hypolipidemic, anti-inflammatory, antioxidant, and others. It effectively prevents the onset of type 2 diabetes by preventing the growth of liver steatosis [33, 34]. Turkish pears have lower concentrations of caffeine acid (3,4-dihydroxy cinnamic acid), a phenolic substance is present in the meat and peel (56.2 vs. 73.5mg/kg).in the flesh and peel (56.2 vs. 73.5mg/kg. The antioxidant properties of caffeine have a positive impact on health. Inflammation, cancer, toxicity, diabetes, and weariness from exercise are all prevented by it [33, 35].

- *Triterpenoids*

Triterpenoids, which are metabolites of isopentenyl pyrophosphate oligomers, have been discovered in cultivars of European pears (P. communis), with peel content exceeding flesh content by more than 17-fold (3460.51255.9 vs. 201.477./g). Triterpenoids aid in hepatic steatosis reduction, obesity reduction, improved glucose tolerance, and aromatase suppression [33].

Common or usual name of pear fruit

Pear is one of the most typical fruits of temperate climates. The scientific name of the pear fruit is *pyrusPyrifolia.* Pear fruit is called other names such aspearsincludingnasi, Asian, Chinese, Korean, Japanese, Twanese, and sand pears. Pear fruit in other contraries: Pear (Dutch), Birnen(German), Pera (Spanish and Italian), Nashpati (India) [36]. The synonyms of pear are listed in **Table 2**.

Table 2. The common names, synonyms, and scientific names of the pear species [33]

S. No.	Scientific Name	Synonyms	Common Name
1.	*Pyrusanatalica*	*Pyrusanatalica*	Turkey Pear
2.	*Pyrusbretschneideri*	-	Chinese white Pear
3.	*Pyruscalleryana var. fauriei*	*PyrusfaurieC.K.Schneider*	Korean Sun pear
4.	*Pyrusmalus var.*	*M. domestica(Suckow)*	Ussurian Pear, Manchurian
5.	*P. pyrifolia*	*Pyrusserotina*	Asian Pear
6.	*PyrusSinkiangensis*	-	Xinjang pear

Production /manufacturing process of pear juice

Pear fruit juice and pear juice concentrated are manufactured under conditions of cGMP and PC regulation below are 7 subparts that go over important topics related to a thorough food safety program. The production process takes place in a production facility that is FSSC (Food Safety System Certification Scheme) certified and meets appropriate hygiene requirements [37, 38].

Starting material

The starting raw material used to make the product is the fruit of *Pyruscommunis*a European pear and *Pyruspyrofolia*a Japanese pear produced from pear plants, trees grown in Europe and Japan [39].

Processing steps

The first step in making any beverage made with pears is to remove the fruit juice or pulp. The essential production phases are as follows:

- Choosing a fresh pear and getting the raw materials ready. For all the Pear fruit
- Fully Cleaning squeezes this juice with a spiral juice extractor and juice extraction.
- Uses the plate and frame filter press filtration after handling 2 hours under 45-50ºC, remove pomace. Obtain the clear pear juice with the diatomite filter filtration.
- Pear juice high-temperature instantaneous sterilization 5 seconds under, 95-100ºC of the condition, cooled at 35ºC rapidly, sterile filling, the finished product pear juice.
- The expressed fruit juice's freshness quality is essential to the end product's quality [40].

Processing aids

Processingaidsincludeflocculating agents, antifoaming agents, clarifying agents, packing gas, and enzymes used in the making of clear or cloudy fruit juice and concentrated juice of pear products [41, 42]. The minimum level of use for processing AIDS is listed in **Table 3**.

Table 3. Maximum Level of Use for Processing AIDS in Compliance with Good Manufacturing Practices [41]

Function	Substance
Foam-Reducing Agent	Polydimethylsiloxane, Adsorbent resin, cellulose
Clarifying Agents	Ion exchange resin(cation and anion)
Filtration Aids	Isinglass
Flocculating Agents	Kolin, perlite
formulated enzymes	Pectinases (for breakdown of pectin) Proteinases (for protein degradation)
Packing Gas	Nitrogen, Carbon dioxide

Stability data

Pear fruit juice and pear concentrated fruit juice isaliquid product intended to be added to foods or intake as such, with or without water. The product is (pear fruit juice and pear concentrated) 275-gallon bag-in-bin authorized, sanitized food grade tanker, 52-gallon net fill food grade epoxy lined, open top, sanitized steel drum, and two 4-mil poly bag liners. The products are pasteurizedandmaintained pH to ensure microbiological stability and storage is at frozen condition [43].

Storage and shelf life

The testing of pear fruit juice and fruit juice concentrate at 3 storage conditions and the Shelf life of pears depends on the method of storage and how early they were picked [43, 44].

After opening, pear fruit juice that has been kept continually chilled often lasts for 5 to 7 days. Under the recommended processing and storage conditions, the proposed shelf life is one year. Additionally, the pH of pear fruit juice ranges from 3.5 to 4.6 [45], which is known to be below which disease-causing bacteria cannot grow.

Pear juice's pharmacological and functional applications

- *Anti-diabetic effects*

The lowering of hypoglycemia is a benefit of pears. Hyperglycemia is mediated by alpha-amylase and alpha-glucosidase, two enzymes that aid in digestion, absorption, and metabolism. Pear, acai, cherry, and combined apple fruit suppressed diabetes indicators as well. Consuming apples and pears, for instance, fell by 18% (95% confidence interval: 0.75 to 0.88), the incidence of Type 2 diabetic mellitus (T2DM) [46].

- *Anti-hyperlipidemic effects*

Pears' anti-hyperlipidemic properties are particularly noticeable in hyperglycemic states; diabetes patients frequently have hyperlipidemia. Due to their increased risk of CVDs, diabetic individuals should place even greater emphasis on maintaining healthy lipid levels. Catechin, a component of pear peels, has more powerful lipid-lowering capabilities than pear pulp, with reductions in triglyceride levels of 14.6%, total cholesterol levels of 19.4%, and low-density lipoprotein cholesterol (LDL-C) of 33.3% when compared to the control [47].

- *Anti-inflammatory effects*

In a food-based investigation, consuming pears, apples, Strawberries, red wine, and inflammation scores (IS) all found unfavorable correlations: In a cohort of US adults, higher dietary anthocyanin and flavonol intake

showeda robust correlation with anti-inflammatory benefits [48].

- *Cardio-protective effects*

There are cardio-protective properties in pears. When it comes to the active ingredients in pears, chlorogenic acid has been shown to enhance ex-vivo vascular function and shield endothelial cells from HOCl-induced oxidative damage through enhanced nitric oxide generation and activation of Hmox-1 [49].

- *Skin whitening effects*

Arbutin is a substance that is naturally abundant in pears. Tyrosinase, a skin-lightening enzyme, plays a key role in the production of dark pigments, particularly melanin [50]. The other pharmaceutical properties are anti-mutagenic, anti-carcinogenic, Respiratory protective effects, alcohol detoxification, hepato-protection, etc. Some of the patents and marketed products of pear juice is listed in **Table 4**.

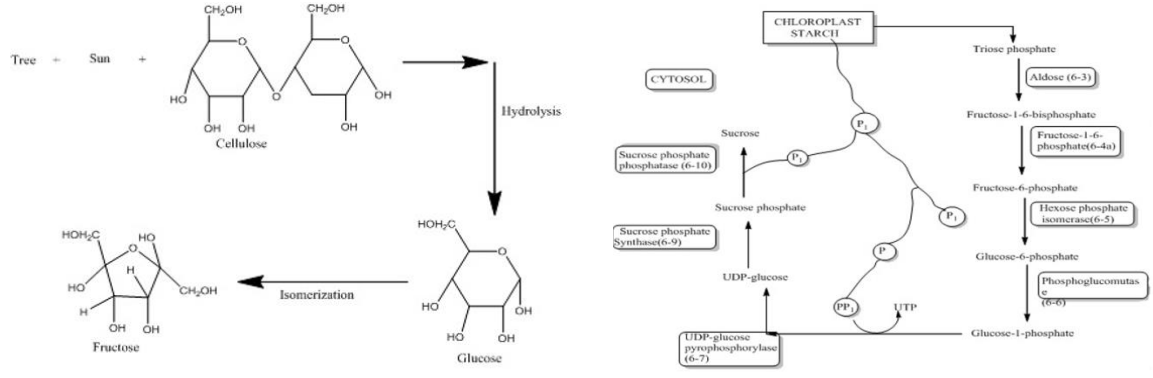
Table 4. Patents of Pear Fruit juice [51]

S. no.	Title	Publication No.	Publication date
1.	Preparation method of clear juice	CN104223238A	24-12-2014
2.	Novel rock sugar-snow pear beverage and preparation method thereof	CN1041723665A	12-03-2014
3.	Method for making concentrated pear juice	CN101874644B	28-08-2013
4.	Method for preparing concentrated cloudy pear juice	CN103404925A	27-11-2013
5.	The manufacturing method for fermented drinks using Korean pear	KR101042576B1	20-06-2011
6.	Refreshing Anli Pear juice Beverages	CN2009101435921A	05-06-2009
7.	Anli pear juice beverage	CNA20081017219XA	14-11-2008
8.	Pear juice and processing method	CN1775112A	24-05-2006

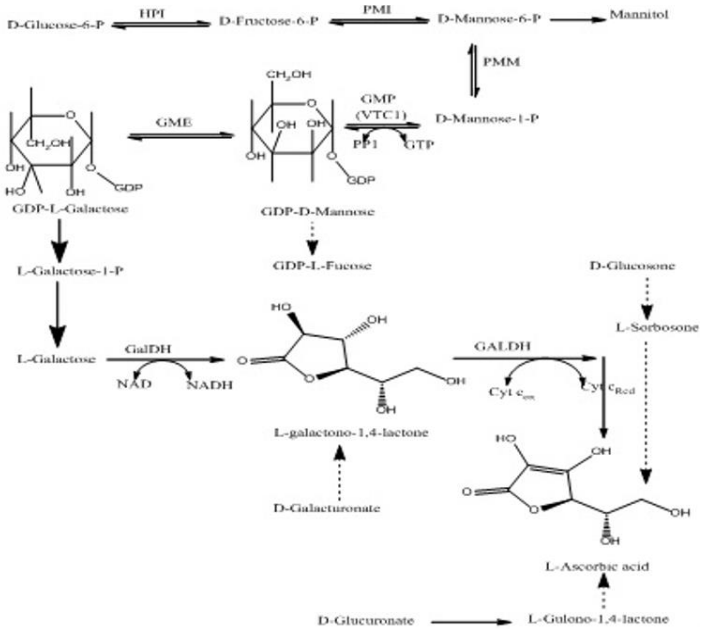
Analytical study

Spectrophotometric method

Spectrophotometry is a popular and affordable technique for figuring out how many different chemicals are present in a solution or how much light is absorbed. When light of a specific wavelength is sent through the sample using a light beam, each substance in the solution either absorbs or transmits the light of that wavelength. Falguera *et al*. developed a technique that investigated the impact of UV-Vis photochemical processing on pear juice from six different varieties. Depending on the characteristics of each variety, polyphenol oxidase was inactivated at various rates. Additionally, the absorbance spectrum often decreased with increasing irradiation time, suggesting that some of the pigments in the juice may have been harmed. The reduction was particularly noticeable between 400 and 450 nm. The use of CIELab parameters allowed for the observation of these changes as well. During treatment, vitamin C also decreased. There were no noticeable changes in the pH, soluble solids, or sugar levels [52]. Jiang *et al*. With the production of juice concentrate from Asian pears, changes in total phenolic acid, flavonoid content, and antioxidant activities were developed (PyruspyrifoliaNakai). Additionally, Niitaka and Wasn pear press cake waste (skin and seeds) had higher antioxidant activity than fresh pears [53]. The biosynthesis of fructose, sucrose, and ascorbic acid is shown in **Figure 1**.



a) b)



c)

Figure 1. Biosynthesis of fructose (a), sucrose (b) and ascorbic acid(c)

Chemical, biological and analytical study

- *Fructose*

A significant dietary monosaccharide, fructose was first separated from cane sugar in 1847 [54]. As a bulk sweetener, fructose is frequently employed since it is sweeter than glucose or sucrose [55].

Chemistry

Because of its chemical makeup and long-lasting internal hydrogen bonds, fructose is a 6-carbon polyhydroxy ketone with a six-membered structure known as -D -fructopyranose. In solutions, D-fructopyranose, D-fructopyranose, D-fructopyranose, and keto-D-fructose produce an equilibrium mixture from which fructose emerges (the non-cyclic form) [19]. Since it is water soluble, fructose is a white, crystalline solid. The **Table 5** lists the physiochemical characteristics of fructose [56, 57].

Table 5. Physiochemical properties of fructose, sucrose, and ascorbic acid.

Parameters	Fructose	Sucrose	Ascorbic acid
IUPAC Name	(3S,4R,5R)-1,3,4,5,6-Pentahydroxyhexan-2-one	β-D-fructofuranosyl α-D-glucopyranoside	
Others Name	Fruitsugar,Levulose,D-fructo-furanose,D-fructose, D-arabino-hexos-2-lose	(2R,3R,4S,5S,6R)-2-{[(2S,3S,4S,5R)-3,4-Dihydroxy-2,5-bis(hydroxymethyl)oxol-an-2-oxy]-oxy}-6-(hydroxymethyl)-oxan-3,4,5-triol	L-threo-Hex-2-enono-1,4-lactone or (R)-3,4-dihydroxy-5-[(S)-1,2-di-hydroxy-ethyl)-furan-2-(5H)-one
Chemical Formula	$C_6H_{12}O_6$	$C_{12}H_{22}O_{11}$	$C_6H_8O_6$
Molar mass	180.156g.mol^{-1}	342.30g/mol	176.124g/mol
Density	1.694g/cm^3	1.587g/cm^3(0.0573Ib/cu in), solid	1.694g/cm^3
Melting Point	103^{0}C(217^{0}F;376K)	Decomposes at 186^{0}C(376^{0}F,459K)	190^{0}C-192^{0}C(374^{0}F-378^{0}F)
Solubility in water	~4000g/L(25^{0}C)	~200g/dl(25^{0}C,77^{0}F)	Water(330g/L), ethanol(20g/L)
Appearance	White color	Monoclinic	White or light-yellow solid
pKa	12.08(18^{0}C)	-3.76	4.17-11.6

Synthesis

- *Synthesis in plants*

The carbon ingested during photosynthesis is the source of the fructose found in plants. The Calvin cycle converts CO_2 into tied triose phosphate in the chloroplasts during photosynthesis (triose-P). Tries-P is exported to the cytosol, where it is joined with two other triose-P molecules to form a single fructose 1,6-bisphosohate

molecule (F1,6BP). It is possible to create nucleotide sugars like UDP-glucose using F1,6BP (UDP-G). In a process mediated by sucrose phosphate synthase Together, UDP-G and F6P create sucrose-6-phosphate (sucrose-6P). Sucrose, a nonreducing glucose and fructose disaccharide, is produced via the dephosphorylation of sucrose-6P. The cleavage starts the sink tissue's utilization of sucrose for metabolism. Sucrose is broken down by either invertase (INV), which creates glucose and fructose, or sucrose synthase (SUS), which breaks down sucrose and produces UDP-G and fructose [58].

- *Synthesis in mammals and yeast*

Bacteria, plants, and yeast can produce fructose by isomerizing other polyols that are present in humans and most other mammals. To generate fructose, the polyol pathway's aldose reductase (AKR1B1) and sorbitol dehydrogenase (SORD) transfer glucose and sorbitol across cell membranes. Fructose is subsequently converted into fructose-1-phosphate by ketone hexokinase (KHK). The pathogenesis of renal disease and the metabolic syndrome are both influenced by the metabolism of fructose, which can also be turned back into glucose and promotes the accumulation of triglycerides and uric acid [59-61].

Mechanism of action

The gut immediately absorbs free fructose. The process by which fructose is absorbed in the small intestine remains unknown. Some evidence suggests active transport because fructose uptake has been shown to proceed against a concentration gradient [62]. GLUT5 movement on the mucosal barrier, protein makes fructose absorption easier. Fructose can travel down a concentration gradient into the electrolytes with the aid of transport proteins since its concentrations are higher in the lumen. Fructose may be moved out from the enterocytes and through the basolateral membrane by either GLUT2 or GLUT5. The GLUT2 transporter, which has a better capacity for doing so, may transport fructose out of the enterocyte in the majority [63, 64].

Pharmacological properties

Fructose is also included in high fructose corn syrup (HFSC), a synthetic sweetener created by converting glucose to fructose in corn syrup using enzymes. The fructose content of HFCS is indicated by the popular designations HFCS-42 and HFCS-5S. Although both HFCS and HFCS-42 are used to sweeten soft drinks, HFCS is more commonly found in processed foods, breakfast cereals, baked products, and some soft drinks [65].

Pharmacokinetics

The description of the absorption, distribution, metabolism, and excretion of fructose is discussed below.

Absorption

When consumed as part of the disaccharide sucrose, fructose has a substantially higher absorption capacity due to its 1:1 ratio with glucose. Less than 5g to 50g of fructose per individual meal can be absorbed through monosaccharides. At low concentrations, the GLUT5 transfer rate can be saturated, and simultaneous absorption with glucose seems to enhance absorption. The number of transport proteins in the lumen is increased by fructose [66, 67]. High-fructose meals (>2.4g/kg body weight) increase the transport of proteins three days after consumption [68].

Distribution

Since fructose cannot be absorbed in the small intestine, the colonic flora there ferments it. Hydrogen is produced by the portal vein. This hydrogen can be measured using the hydrogen breath test once it has reached the lungs and been exchanged there. When there is unabsorbed fructose present, colonic fibers also produce short-chain fatty acids, organic acids, and trace gases, in addition to creating gastrointestinal symptoms such as bloating, diarrhea, flatulence, and pain [69, 70]. Exercisingsoon after eating can worsen these systems since it shortens the small intestine transit time [71].

Metabolism

The GLUT2 transporter carries the dietary monosaccharide fructose into the liver. In the liver, galactose, and glucose are phosphorylated by galactokinase (Km=0.8mM) and fructose (Km=0.5mM). Normally, glucose is digested everywhere in the body after going through the liver (Km of hepatic glucokinase=10mM). The fructose transporter GLUT5 is active and insulin controls fructose absorption in skeletal muscle cells [72]. According to isotopic tracer studies in humans, the oxidation rates of dietary fructose were 45.0%10.7(mean±SD) in non-

exercising subjects within 3-6 hours and 45.8%7.3(mean±SD) in exercising people within 2-3 hours. When ingested with glucose, fructose (1%) appeared to be directly converted to plasma TG and reached 41%10.5(mean ±SD) in 3-6 hours. However, a quarter of the fructose you eat can turn into lactate very fast because ofthe effects of hyperlipidemia [73].

Excretion

Both the baseline condition and a 135-minute infusion of fructose at a rate of 2 mmol/min were observed in healthy subjects. After 45 minutes of fructose infusion, somatostatin (9 g/min) was given for 60 minutes to cause hypo-glucagonemia. A-RV= -0.17 mmol/L, as opposed to 0 mmol/L in the baseline condition, P=0.02, and the infusion of fructose, resulted in a 35% increase in the kidney's net production of glucose. Net glucose release from the kidney may account for 55% of the net renal absorption of fructose.

- *Sucrose*

The most readily available of all low molecular weight carbohydrates is sucrose, a natural di-saccharide. The English scientist William Miller first used the word sucrose in his writings in 1857. On a large scale, it is made from sugar cane or sugar beet [74, 75].

Chemistry

In contrast to sucrose, a white, crystalline solid that is highly soluble in water, methanol is only slightly soluble in ethanol. In sucrose, the monomers glucose and fructose are joined via an ether bond formed by C1 on the glucosyl subunit and C2 on the fructosyl unit. The bond is referred to as a glycosidic linkage. There are only two types of sucrose: and -D-fructo-furanose [76].

Synthesis

Biosynthesis of sucrose

In the cytosol, sucrose is biosynthesized. The enzyme sucrose 6-phosphate synthase catalyzes the process of turning sucrose 6-phosphate into sucrose, while sucrose 6-phosphate phosphatase catalyzes the process of turning sucrose 6-phosphate into sucrose. The cleavage of uridine diphosphate provides the reaction with the energy needed (UDP) [77]. Plants, algae, and cyanobacteria are the only organisms that can produce sucrose.

Chemical synthesis

The synthesis of -D FDIC to furan oxides is provided based on the idea of locking the anomeric CH_2OH group to the -side through an internal bridge to the 4-hydroxyl group.

Mechanism of sucrose

The enzyme binds to the substrate, sucrose, which is made up of glucose and fructose joined together. This complex is known as an enzyme substrate. Stress is put on the glucose and fructose link due to the binding of the substrate and enzyme. Glycosidic linkages are broken during hydrolysis, transforming sucrose to glucose and fructose. However, because hydrolysis proceeds so slowly, a solution of sucrose can remain unchanged for a whole year.

Pharmacological properties

Oral sucrose is routinely given to newborns to reduce procedural pain because of its effects on behavioral and physiological pain scores. Oral sucrose delivery with and without non-nutritive sucking is the most often studied non-pharmacological method for procedural pain relief in infants [4, 5].

Pharmacokinetic

The following description of sucrose's absorption, distribution, metabolism, and excretion is based in part on pharmacokinetics.

Absorption

In the intestinal mucosa, sucrose, a disaccharide, is efficiently digested (by sucrose) byits monosaccharides. It is known that fructose absorption is stimulated by glucose in a dose-dependent way [6]. With the aid of intricate transport molecules, the human body can absorb glucose and fructose after sucrose has been broken down into

its component sugars. The small bowel's lining cells must be crossed before the glucose and fructose in food can enter the bloodstream. Fructose is needed for fructose to be transported into the lining of the colon. The resultant glucose and fructose molecules enter the bloodstream quickly.

Distribution

Only when salt is present does SGLUT1, which comes after absorption, transport glucose. Then, GLUT2 transporters deliver glucose and fructose into the bloodstream. Blood acts as a conduit for nutrients to move between organs, much like a freeway [7]. When consumed, sucrose causes a swift spike in blood sugar levels and offers instant energy. Sucrose is a readily absorbed mononutrient. The energy value of sucrose, a pure carbohydrate, is 3.94 kcal per gram, or 17kJ/g.

Metabolism

The metabolism of glucose and fructose differs significantly in key aspects. The preferred energy source is glucose. The insulin hormone sends a signal to the cell to pick it up as it enters the bloodstream and blood levels rise. While glucose causes a glycemic and insulinemic response that promotes its absorption into cells, fructose largely undergoes processing in the liver via an insulin-independent mechanism unrelated to energy supply. There, it could be converted into trioses used in the de novo production of triglycerides and cholesterol (TG) [7].

Excretion

The amount of sugar excreted through the urine in healthy subjects following a typical diet. In the basal and low sucrose diets, the average urine excretion of sucrose during the sample time was strongly linked (P0.01, r=0.7) with the food consumption of sucrose on the collection day. A multiple regression model that determines two distinct regression lines for the excretion data obtained during basal and low sucrose diets.

- *Ascorbic acid (Vitamin C)*

Ascorbic acid (AA), which is naturally present in several fruits and vegetables, is one of the water-soluble vitamins in the human diet. A vital antioxidant fights heart disease, stress, and cancer. It is a part of the cellular chemistry responsible for sperm production, energy production, and the production of collagen protein, which is essential for the development and health of cartilage, joints, skin, blood vessels, and other tissues.

Chemistry

In impure samples, ascorbic acid appears as a solid that can be either white or light yellow. An organic substance called vitamin C is made up of carbon, hydrogen, and oxygen. Ascorbic acid's L-enantiomer and its oxidized forms, such as dehydro-ascorbic acid, are both referred to as "vitamin C" in all instances (DHA). L-ascorbic acid and L-ascorbate are stated in turn.

Synthesis

Biosynthesis in plants

Ascorbic acid, also known as vitamin C, is frequently prevalent in plants. It reaches a concentration of more than 20 mM in chloroplasts. They control cell growth and are an enzyme cofactor in photosynthesis. The enzymes L-galactose dehydrogenase (GDH), hexose phosphate isomerase (HPI), phosphor-mannose isomerase (PMI), phospho-mannose mutase (PMM), GDP-mannose pyro phosphorylase (GMP), GDP-mannose-3,5-epimerase (GME), and L-galactose dehydrogenase (GALDH) are While GALD is located outside of the inner mitochondrial membrane, the other enzymes are likely found in the cytoplasm. The enzymes that release L-galactose from GDP-L galactose are still a subject of research. Intermediates of the GDP-sugar pathway are precursors for the synthesis of protein glycosylation and cell wall polysaccharides. The primary outcomeofMannitol is a product of mannose metabolism; additional possible ascorbate precursors are indicated by the italicized terms; the addition of glucuronic and D-galacturonic acids. The "inversion" of the carbon skeleton would be necessary to incorporate ionic acids into ascorbate, although this process could only produce a small amount of ascorbate.

Chemical synthesis

In the industrial manufacturing of ascorbic acid, D-sorbitol is transformed into L-ascorbic acid through a fermentation step (Bioconversion of D-sorbitol to L-sorbose by Gluconobacteroxydans and various chemical

procedures) (from L-sorbose to L-ascorbic acid). Chinese producers typically use a two-step fermentation process to create ascorbic acid due to the high and low product quality. Contrary to the typical method, the two-step fermentation method converts L-sorbose into the intermediary 2-keto-L-gulonic acid through a mixed fermentation of the keto-gulonicigenium vulgate and Bacillus spp (2-KGL).

Mechanism of action

Ascorbic acid is absorbed via simple diffusion and active transport, a two-mechanism, energy-dependent process. Transporters for hexose and sodium-dependent vitamin C transporters, or SVCTs, are also involved [2]. Reduced vitamin C is delivered as ascorbic acid (AA), which is taken up by the sodium-ascorbate co-transporter into cells. (SVCT1 and SVCT2). Through the facilitative glucose transporters, it has dehydroascorbic acid (DHA), which is trapped intercellularly and stored as AA, but also plays a crucial function in creating placental tissue that is required to maintain pregnancy [72, 73]. In human cells, gluts carry hexose and the oxidized form of vitamin C, dehydro-ascorbic acid (DHA), across membranes [10].

Pharmacological properties

Oral consumption of food or supplements is the primary method of delivering vitamin C. Vitamin C is abundant in nature; in particular, fruits and vegetables contain large amounts of ascorbate [74]. The medicine may be injected subcutaneously, intravenously, or both. IM injection is the preferred parenteral method since it appears to improve vitamin consumption when administered parenterally. Adults should consume 70–150 mg of vitamin C every day on average to safeguard their bodies.

Pharmacokinetics

The components of pharmacokinetics describe how drugs are absorbed, distributed, metabolized, and excreted. It is discussed below.

Absorption

From the American National Institutes of Health (In Human) "Around 70 to 90% of vitamin C is absorbed with a modest consumption of 30 to 180 mg per day. However, at doses larger than 1000 mg per day, absorption falls to less than 50%. Large levels of sugar in the colon can prevent absorption because both glucose-sensitive and glucose-insensitive cells transport it there [75, 76]. Vitamin C's bioavailability is dose-dependent 200-400 mg per day in humans. The absorption rate for a 500 mg dosage is about 70% [77].

Distribution

Almost every tissue in the body has vitamin C. Adrenal glands, pituitary glands, and retina has large concentrations of it. In the kidneys and muscles, its level declines [69]. The primary mechanisms for vitamin C absorption by tissues are sodium-dependent vitamin C transporters (SVCTs). Distribution from the blood stream to the various tissues is primarily regulated by the slightly larger SVCT2, which is a low-capacity/high-affinity transporter. Distribution from the blood stream to the various tissues is mediated by the high capacity/low-affinity SVCT1, which mediates epithelial ASC uptake and reuptake (Vmax of about 15 pmol/min/cell and Km of about 62-252 M). Maybe with some assistance from the introduction of DHA, which soon changes into ASC [70].

Metabolism

Typically, ascorbic acid performs redox reactions via a method reliant on free-radical activities. Glutathione metabolism and ascorbate metabolism are related. Ascorbic acid is also necessary for animals with a mutation in the L-gluconolactoneoxidase gene or a deficiency in that gene. When ascorbic acid is absent, monooxygenase and dioxygenase activation are reduced. Based on several factors, the statistics indicate that adults should consume up to 75-90 mg of ascorbic acid every day [65].

Excretion

The kidneys can get rid of ascorbic acid through urine. In humans, the kidney reabsorbs vitamin C rather than excreting it when food intake is low. Only until plasma concentrations are 1.4 mg/DL or higher do extra doses easily pass into the urine and reabsorption begins to diminish. This salvage procedure postpones the onset of a deficit [63]. Over 50% of the absorbed dosage is not digested and is eliminated in the urine. Only 50% of a 1250 mg dosage is eliminated in the body. Since vitamin C is not protein-bound, it is removed throughout 10 to 12

hours. Plasma vitamin C values in western people range from 54 to 91 mol-1 [56].

Spectrophotometric method for analysis of ascorbic acid

Numerous commercial fruit juices frequently include ascorbic acid in addition to sugars including sucrose, glucose, and fructose. Using a spectrophotometer, the sugar and vitamin C levels of pear juice were determined. Llamas *et al*. created a flow-injection spectrophotometric method with on-line photodegradation for measuring ascorbic acid and total sugars. The flow-injection system includes a straightforward UV photoreactor for on-line photodegradation. The process consists of three stages: determination, UV exposure, and total sugar measurement at 268 nm. The suggested technique was used to calculate the ascorbic acid and total sugars in samples of manufactured and natural fruit juice. The procedure was applied and validated to spike samples with recoveries for ascorbic acid between 96.4 and 108.3% and for total sugars between 91.0 and 113.2% [63].

Chromatographic techniques

Hyphenated approaches and high-performance liquid chromatography

By measuring the organic acids, sugars, phenolic contents, and antioxidant potential of orange juice and orange wine, the first method—developed by Kelebek *et al*. reports on the measurement. Using HPLC methods, these compounds were located and measured. For the measurement of sugar, they employed a UV/vis detector (SPD-20A) monitored at 210 nm, a constructed HPLC with a pump system, and a refractive index detector (RID-10A). Analyses of sugar and organic acids were carried out simultaneously on a Bio-Rad AminexHPX-87H column (300 x 7.8 nm) that was kept at a temperature of 55 °C. The following analytical circumstances were used: a flow rate of 0.3 mL per minute, an NH_2SO_4 concentration of 0.045, and a fluency of 6% acetonitrile. The mobile phase was composed of two solvents, solvent A (acetonitrile/solvent A, 60:40, v/v) and solvent B (water/formic acid, 95:5, v/v). Phenolic chemicals were eluted under the following circumstances: 1 mL per minute [65].

Li *et al*. developed the RID-PAD-HPLC method, which was used to compare the sugar and organic acid profiles of various fruit juices. The soluble sugar in HPLCusing a 1525 binary HPLC system connected to a RI 2414 refractive index detector in fruit juices (Waters Crop., Wilford, MA, USA). A Waters Sugar-Pak I column (6.5300nm) was used to separate the soluble sugars at 80°C while using Ca-EDTA solution (50mg/L) as the elution solvent. A 0.5 ml/min injection volume was used. The soluble sugars in fruit juice were identified and quantified using standards such as sucrose, glucose, fructose, and sorbitol. Goji Berry sugar analysis using the HPLC-ELSD Montesano *et al.* developed method. The HPLC analysis was performed using an ELSD (Sedex-55, S.E.D.E.R.E., France) and LC-10ADvd pump (Shimadzu crop, Kyoto, Japan) running at 60°C and 230Kpa of nitrogen pressure. Maintaining isocratic elution using the mixture ASN: H_2O (80:20, v/v) at a flow rate of 1.2mL min-1 for 20 minutes on a platinum amino column (5, 250mm4.6mm Id.; Grace, Lokeren Belgium) [59].

HPLC analysis and measurement of saccharides in certain fruit and vegetable juices were developed by Rokai *et al*. The micro filter ProFill-25 HPLC syringe filter nylon (PA), the ultrasonic bath type UC 002BM, the column Nucleolar 100-5 NH_2-RP (2504) (Phenomenex NH_2 column), and acetonitrile were used in an HPLC-RI method to determine saccharides (glucose, fructose, and sucrose). Water serves as the mobile phase (75:25 v/v). Analysis was performed in isocratic mode using a flow rate of 1 ml/min, temperature maintenance of 40 °C, and a 5 L injection volume [51, 78].

Reuter and co. created a technique for the HPLC-UV detection of organic acids in fruit juice. The HPLC system with an A-10 UV detector was employed. Validated Aqueous C18, 5 mm, 4.6 mm, 250 mm column, and mobile phase; Isocratic, 25 mm K-phosphate buffer, modify pH 2.4, Analysis time 8.0 min; wash/ equilibrium time = 6.0 min; 1.5 mL/min (3000 psi; 200 bar) flow rate, 210 nm wavelength, 20 l injection volume, and 5 pt/sec sampling rate [50]. The analytical study for fructose, sucrose, and ascorbic acid is enlisted in **Table 6**.

Table 6. Various Analytical Methodsfor Fructose

Various Analytical Methods for Fructose								
S. No.	**Techniques**	**Matrix**	**Mobile Phase**	**Flow Rate**	**Detector**	**Wavelength**	**LOD**	**LOQ**	**Ref**

1.	HPLC	Orange juice and orange wine	0.49N H_2SO_4 with 6% acetonitrile	0.3mL/min	Refractive Index Detector (RID-10A)	210nm	-	-	[68]
2.	HPLC	Juice	Single solution of sulfuric acid 0.008mol^{-1}	0.6mL/min	Refractive Index (RI) for sugar	-	0.0062g.100mL^{-1}	0.0189g.100mL^{-1}	[69]
3.	HPLC	Fruit juice	At 80°C with Ca-EDTA	0.5mL/min	Refractive Index RI 2414	210nm	-	-	[70]
4.	UPLC-MS/MS	Fruit juice	Mixture A 10:90 Acetonitrile: 0.1% ammonium hydroxide in water. Mixture B 90:10 acetonitrile: 0.1% ammonium hydroxide in water	0.3mL/min 0.2mL/min	MS Detector LC-MS/MS	-	-	-	[71]
5.	HPLC	Fruit juice	1:50 water/acetone mixture	-	ELSD Detector	-	-	-	[72]
6.	HPLC	Goji Berry	ACN:H_2SO_4(80:20 v/v)	1.2 mL/min	ELSD Detector	-	1.2µg	3.6µg	[73]
7.	HPLC	Fruit and vegetable	Acetonitrile water(75:25v/v)	1ml/min	RI Detector	-	-	-	[10]
			Various Analytical Method For Sucrose						
8.	HPLC	Orange juice and orange wine	0.45N H_2SO_4 with 6% acetonitrile(v/v)	0.3mL/min	Refractive Index (RID-10A)	210nm	-	-	[68]
9.	HPLC	Juice	Single solution of sulfuric acid 0.008$molL^{-1}$	0.6mL/min	Refractive Index (RI) for sugar	-	0.0139g.100mL^{-1}	0.443g.100mL^{-1}	[69]
10.	HPLC	Fruit juice	At 80ºC with Ca-EDTA	1.0mL/min	Refractive Index RI 2414	-	-	-	[70]
11.	UPLC-MS/MS	Fruit juice	Mixture A: 10:90 acetonitrile 0.1% ammonium hydroxide in water. Mixture B: 90:10 acetonitrile 0.1% ammonium hydroxide in water	0.3mL/min	MS Detector LC-MS/MS	-	-	-	[71]

12.	HPLC	Fruit juice	1:50 water/acetone mixture	-	ELSD Detector	-	-	-	[72]
13.	HPLC	Goji Berry	ACN:H_2SO_4	1.2mL/min	ELSD Detector	-	1.0µg	3.0µg	[73]
14.	HPLC	Fruit and vegetable oil	Acetonitrile: Water (75:25v/v)	1mL/min	RI Detector	-	-	-	[10]
Various Analytical Methods for Ascorbic Acid (Vitamin C)									
15.	HPLC	Orange juice and orange wine	0.45N H_2SO_4 with 6% acetonitrile (v/v)	0.3mL/min	UV/Vis Detector (SPD-20A)	210 nm	-	-	[68, 77]
16.	HPLC	Juice	Single solution of sulfuric acid 0.008molL^{-1}	0.6mL/min	DAD	-	0.0020g.100mL	0.039g.100 mL	[72]
17.	HPLC	Fruit Juice	Diammonium hydrogen phosphate solution (0.02 mol/L adjusted to pH 2.4 with sulfuric acid)	1.0mL/min	Photodiode array Detector	210 nm	-	-	[70]
18.	HPLC-UV	Fruit Juice	Isocratic 25 mM K-phosphate buffer	1.5mL/min (~3000 psi, 200 bar)	UV Detector	210 nm	-	-	[10]
19.	RP-HPLC	Packed Juice	Methanol: Buffer (20:80)	-	UV-Visible Detector	240 nm	-	-	[74]
20.	HPLC-EC-RI	Plasma	Methanol: Water (25:75)	0.8mL/min	UV Detector	245 nm	-	-	[74]
21.	RP-HPLC	Various Fruits	Sulfuric acid	0.4mL/min	UV Detector	254 nm	-	-	[76]

Analytical cognizance with green chemistry

The literature review of analytical and bioanalytical methods for the drugs fructose, sucrose, and ascorbic acid shown in the above table indicates that buffers or acetonitrile is typically used for method development and method validation; consequently, it is essential to find an alternative method that is uncomplicated, dependable, accurate, precise, specific, and affordable while also adhering to green chemistry [71].

CONCLUSION

Pears are a fruit having a variety of applications, including those in food, cosmetics, and medicine. Fructose is a dietary monosaccharide and a ketonic simple sugar. Sucrose is a disaccharide or sugar that contains both glucose and fructose subunits. Vitamin C, also known as ascorbic acid, is one of the essential vitamins and is required

for both human and animal life. A simple HPLC method can be used to quantify fructose, sucrose, and vitamin C utilizing a variety of detector types. The outcomes are exceedingly consistent, exact, and precise. The problem is in the solvent, which is commonly buffer or acetonitrile. These mobile phases are incompatible with green chemistry and hurt the environment.

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