Review

Bioactive compounds and medicinal properties of fruit juices

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Bioactive compounds and medicinal properties of fruit juices.

Abstract – The product. Fruit juices have attained an important place in the modern diets of people belonging to different communities and classes world over. It is the unfermented but fermentable liquid obtained from the edible part of sound, appropriately mature and fresh fruit. **Bioactive compounds**. Fruit juices contain nutrients like vitamins, minerals, trace elements, energy and phytochemicals including flavonoids, polyphenols and antioxidants that have been shown to have varied health benefits. **Medicinal properties**. The mode of action of these fruit juice compounds in most cases seems to be by modulating gene activities. Fruit juice as part of a balanced diet offers both good health and profound disease risk reduction properties. As a result, there is high demand as alternative medicine for different kinds of illnesses such as chronic inflammation, arthritis, diabetes, high blood pressure, muscle aches and pains, menstrual difficulties, headaches, heart disease, AIDS, cancers, gastric ulcers, sprains, mental depression, poor digestion, arteriosclerosis, blood vessel problems, and drug addiction. Furthermore, to identify fruit juices as non-consumable in the context of obesity and dental health would deprive the consumer of a perfectly healthy and nutritious food, and would be completely contrary to the evidence noted in the scientific community. **Discussion and conclusion.** Fruit juices are an excellent choice of drink when consumed moderately as per recommendations.

India / fruits / fruit juices / health foods / medicinal properties / antioxidants / phytochemistry / resveratrol / overweight

Composés bio-actifs et propriétés médicinales de jus de fruits.

Résumé – Le produit. Les jus de fruits ont une place importante dans les régimes modernes de personnes appartenant à différentes communautés et classes du monde entier. Ce sont les liquides non fermentés, mais fermentescibles, tirés de la partie comestible des fruits sains et suffisamment mûrs et frais. **Composés bio-actifs**. Les jus de fruits contiennent des nutriments comme les vitamines, les éléments minéraux, les oligo-éléments, de l'énergie et des composés phytochimiques, y compris des flavonoïdes, des polyphénols et des antioxydants démontrés comme présentant des avantages de santé variés. **Les propriétés médicinales**. Le mode d'action des composés bio-actifs à base de jus de fruit dans la plupart des cas semble être lié à la modulation des activités des gènes. Dans le cadre d'une alimentation équilibrée, les jus de fruit permettent à la fois d'avoir une bonne santé et de limiter sérieusement les risques de maladie ; il y a donc une forte demande par la médecine alternative pour lutter contre différents types de maladies tels que inflammations chroniques, arthrite, diabète, hypertension artérielle, douleurs musculaires, douleurs menstruelles, maux de tête, maladies cardiaques, sida, cancers, ulcères gastriques, entorses, dépression, mauvaises digestions, artériosclérose, problèmes sanguins, et toxicomanie. En outre, considérer les jus de fruits comme non-consommables dans le contexte de l'obésité et de la santé dentaire priverait le consommateur d'une denrée alimentaire parfaitement saine et nutritive, et serait tout à fait contraire aux informations données par la communauté scientifique. **Discussion et conclusion**. Les jus de fruits, consommés modérément en suivant certaines recommandations, constituent un excellent choix de boisson.

Inde / fruits / jus de fruits / aliment santé pour homme / propriété pharmacologique / antioxydant / phytochimie / resvératrol / surpoids

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1. Introduction

Fruit juices have attained an important status in the daily menu of people belonging to different ages, classes, groups and areas because of their exceptional nutritional, functional and therapeutic qualities [1]. Minerals are present in the form of electrolytes so they are easily absorbable by the human body [2, 3]. They are considered to be rich in diverse sources of vital nutrients which include vitamins like A, B, C, folate [3, 4]; minerals like iron, copper, potassium, iodine, zinc, selenium, iodine, sulfur, manganese, boron, molybdenum and magnesium [5]; dietary fiber and antioxidants, amino acids, and bioactive compounds-phytonutrients [4] which are crucial for good nutrition, disease prevention and offer great taste and health benefits [6, 7]. Pure fruit juice is an important source of fluids and a wonderful resource for enzymes (papain in papaya juice, bromelin and proteolytic enzymes in pineapple juice). As juices are consumed fresh [2, 8], they are an excellent way to retain and balance hydration levels in the body [9]. Fruit juices are readily digestible; they have no toxic effects on the body and exert a cleansing effect on the blood and digestive tract; they facilitate absorption of certain nutrients [10]. The low level of sodium in fruit juices plays an important role for people who would like to have a salt-free diet [9]. Moreover, the ailments caused by the intake of unnatural foods can be successfully treated by them as they promote detoxification in the human body [11].

Fruit juices in the daily diet have been strongly associated with reduced risk of some forms of cancer [12, 13], cardiovascular disease [14, 15], positive effect on bone health [16, 17] and skin related problems [18], allergies, gastrointestinal problems, hyperlipidemia, insulin resistance, oxidative stress, inflammation [19], dental health [20], brain health, cognition and ageing [21, 22], and other chronic diseases.

Fruit juices also prevent the formation of kidney and gall stones, due to their potassium salt richness and are recommended in acidosis, diabetes, under-nutrition, gout, and ageing tissues [11]. Antioxidant capacity varies greatly among fruit juices so it is better to consume a variety of them [23]. They reduce unwanted fat, cure ulcers, regulate digestion, have inhibitory effects against the HIV virus and promote metabolic functions [24]. Various juice blends (mixed fruit juices) fortified with calcium, folate, fiber and vitamins have been launched for improving palatability, and nutritional and medicinal quality of fruit juices on the market [8, 25]. Also worldwide, health concerns have led to the popularization of natural fruit juice as a healthy alternative to other beverages and carbonated soft drinks, which have high artificial sugar levels [26, 27]. Previously, fruits were directly consumed by health-conscious people, but in today's era of changing lifestyles, modified eating habits and in view of seasonal availability, people have shifted towards nutritious ready-to-eat or to serve products like fruit juices [5, 28].

2. General dietary recommendations for fruit juice

Considerable interest in fruit juices has been developed over the years due to their potential biological and health-promoting effects [6, 27]. According to the new USDA My Pyramid food guidance program, there are portion sizes and recommended amounts of 100 per cent fruit juices for children and adults, depending on one's age, gender, and level of physical activity [29]. The scientific findings showed that consuming a variety of fruit juices (100 mL per day or more) has the potential to decrease numerous chronic diseases like cancer, inflammation and cardiovascular diseases [30]. People with higher socio-economic status often report higher consumption of fruit juice as compared to lower ones [28, 31].

The World Health Organization (WHO) as a co-sponsor of the global 5+ a day program promotes the inclusion of at least five servings a day of fruits and vegetables as an essential element in a healthy diet [32]. Many countries have considered fruit juices as one portion of the daily fruit and vegetable intake, to be a constituent of 5+ a-day

campaigns or national dietary recommendations [33]. The UK National Diet and Nutrition Survey reported average consumption of fruit juices as 106 g per day, with men consuming slightly more than women. The American Academy of Pediatrics (AAP) suggests 100–150 mL of 100 per cent fruit juice per day for children aged 1 to 6 years, and up to 150–200 mL per day for children aged 7 to 18 years. No juices are recommended for infants less than 6 months of age [34].

Eating too much fruit juice may result in some intestinal discomfort, flatulence, obesity, diabetes mellitus and tooth decay, because fruit juice contains a small amount of sorbitol, a sugar alcohol which the body cannot process but bacteria in the digestive system can break down for energy [34].

3. Interaction mechanism of fruit juice components in the human body

Polyphenolic compounds in fruit juices are known for their antioxidant properties and play an important role in interaction of metabolic activities in the human body as therapeutic agents [35, 36]. Although here it is impossible to explain the interaction mechanisms of all fruit juice phenolic compounds, a sincere effort has been made to briefly summarize the recent information pertaining to the beneficial roles of one of the highly studied and important phenolic compounds, namely resveratrol and its interaction mechanisms in the human body with respect to its neuroprotective effect.

Research has described several beneficial properties of this compound, including anti-carcinogenic, anti-ageing, neuroprotective, analgesic, anti-diabetic and anti-obesity effects [37] and is synthesized by leaf tissues in response to fungal infection or exposure to ultraviolet light [38]. Resveratrol (trans-3, 4', 5-trihydroxystilbene) (*figure 1*) is a polyphenolic molecule found in many plant species including grapes, cranberries, bael, pomegranate, aonla and citrus fruit juices.

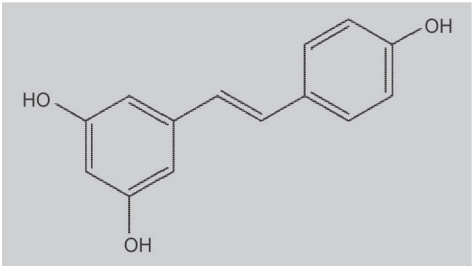

Figure 1.
Structure of resveratrol, the most important and effective bioactive compound of fruit juice on which maximum research and studies have been done.

3.1. Bioavailability and pharmacokinetics of resveratrol

A number of studies have shown that bioavailability of unconjugated resveratrol is low. At least 70% of resveratrol ingested is absorbed and readily metabolized to form mainly glucuronide and sulfate derivatives [39]. The colon microflora can produce the metabolite dihydroresveratrol. Resveratrol metabolites reach their maximum concentration in plasma approximately 30 min after intake and the half-life of total metabolites is approximately 9.2 hours [40]. Five distinct metabolites have been detected in urine after moderate consumption of red wine: resveratrol monosulfate, two isomeric forms of resveratrol monoglucuronide, dihydroresveratrol monosulfate and dihydroresveratrol [41]. It is also worth mentioning that resveratrol binds to albumin and therefore it has been suggested that albumin could be a natural polyphenol reservoir in the *in-vivo* context, where it might play a pivotal role in the distribution and bioavailability of circulating resveratrol [42].

3.2. Molecular mechanisms of the neuroprotective effects of resveratrol

A number of studies have demonstrated the beneficial effects of resveratrol through its antioxidant, anti-inflammatory and metal-chelating properties [43, 44]. However, another study has revealed that the ability of resveratrol to exert neuroprotective effects is through activation of Sirt1 [45]. Activation of Sirt1 through resveratrol induces PGC-1α activity and enhances mitochondrial function. PGC-1α [peroxisome proliferator-activated receptor γ (PPARγ)

coactivator-1] is a transcriptional coactivator and interacts with nuclear receptors and transcription factors [37, 46]. Once activated, PGC-1α performs different functions in different tissues. Another protein named peroxisome proliferator-activated receptor-γ (PPAR-γ) has been proposed as a therapeutic target for neurodegenerative diseases due to its ability to protect against mitochondrial damage through upregulation of Bcl-2, an anti-apoptotic protein [47]. There are reports which suggest that resveratrol's ability to attenuate tissue injury in the brain and restore mitochondrial function is partly attributed to its effect on Sirt1-dependent deacetylation of PGC-1α and activation of PPAR-γ [12, 48].

Activation of PPAR-γ may also target the transcription of superoxide dismutase (SOD) and catalase genes through stimulating the Nrf2/keap 1 pathway [49]. Thus, it can be hypothesized that the ability of resveratrol to increase Sirt1 and related enzyme activity could lead to changes in neuronal transcription profiles and enhanced anti-apoptotic activities [50]. A number of studies have also demonstrated the ability of resveratrol to reduce amyloid-beta (Aβ) peptide secretion [51] and suppress neuroinflammation by inhibiting NADPH oxidase and attenuating NF-κB-induced expression of iNOS, COX-2, and sPLA2 [52, 53].

Resveratrol also stimulates mitochondrial biogenesis that has been shown to be dependent on AMP-kinase (AMPK) [37, 45]. The neuronal activation of AMPK could affect neuronal energy homeostasis and contribute to the neuroprotective effects of resveratrol. The net effect of AMPK activation is to halt energy consuming (anabolic) pathways and to promote energy conserving (catabolic) cellular pathways. AMPK has, therefore, often been dubbed the 'metabolic master switch'. Increasing evidence suggests that AMPK might also function as a sensor by responding to oxidative stress. Most importantly, AMPK modulates endogenous antioxidant gene expression and/or suppress the production of oxidants. AMPK promotes cardiovascular homeostasis by ensuring an optimum redox balance on the heart and vascular tissues. Taken together, it can be concluded that besides its antioxidant and anti-inflammatory properties, resveratrol also exerts neuroprotective effects through activation of Sirt1 [54, 55].

This evidence makes resveratrol a promising therapeutic candidate for neurodegenerative disorders. Resveratrol has also been regarded as a cancer chemopreventive agent. The studies have demonstrated the antioxidant effect of resveratrol, its ability to counteract ROS production and thus to inhibit oxidative DNA damage. Evidence is growing that suggests that resveratrol may also act as a pro-oxidant and can cause induction of apoptosis of cancer cells [56].

4. Bioactive compounds of fruit juices

4.1. Nutrients

There is not much difference between fruit and fruit juice in the proximate composition and nutritional properties [2, 4]. The relevant substance groups are carbohydrates, water-soluble vitamins, minerals (potassium, calcium and magnesium), organic acids, amino acids, fibers and polyphenols like colorful anthocyanins, aroma compounds, carotenoids and other bioactive substances [26]. Fruit juices are also important sources of certain vitamins, especially vitamins A, B and C which act as antioxidants, prevent undesirable color changes and retard the development of rancidity. Vitamin A precursors like β-carotene and certain carotenoids are present in the yellow-orange fruit juices like mango, papaya, pineapple, orange, passion fruit, phalsa, tomato, raspberry and muskmelon juice [11]. Vitamin B complex and folate are present in orange, grapefruit, pineapple and other tropical fruit juices [57, 58]. Aonla, ber, noni, barbados cherry, tomato, guava, kiwifruit, orange, lemon, lime, strawberry, grape fruit, mango, pineapple, cherry and passion fruit juices contain a large amount of vitamin C [58, 59].

Fruit juices are known to store considerable amount of organic acids. Lemon and orange juice contains citric acid and ascorbic acid; apple, gooseberry and rhubarb juice contains malic acid; grape and tamarind juice contains tartaric acid; aonla juice and

ber juice contains gallic and ascorbic acid; tomato juice contains ascorbic acid, and carambola juice is rich in oxalic acid [60]. Other organic acids present in minor amounts are lactic acid, succinic acid, pyruvic acid, glyceric acid, shikimic acid, maleic acid and isocitric acid. Juices are low in compounds such as sodium and fat which are believed to have negative health impacts when ingested in large amounts [9, 57].

Many trace elements (Zn, Fe, Cu, Mn, Co, Cr, and Ni) present in fruits are also found in the corresponding fruit juices [5]. In addition, juices may serve as carriers for added nutrients such as calcium, vitamin C and phytosterols that may not be inherent in the fruit itself [2]. We discussed the proximate nutrient composition of various fruit juices (*table I*) and their positive effect on human wellness (*table II*).

Table I.
Proximate nutrient composition of various fruit juices (nutrients in 100 mL fruit juice) [58].

Fruit juice	Water (mL)	Energy (kcal)	Available carbone (g)	Beta carotene Eq (µg)	Vitamin C (mg)	Folate (µg)	Calcium (mg)	Potassium (mg)
Aonla	87.8	55.0	15.7	7.5	592.0	4.6	42.0	218.0
Apple	88.9	52.5	10.1	0	1.0	0.0	8.2	81.0
Bael	71.2	127.0	35.8	50.2	11.5	18.5	80.2	570.0
Banana	73.1	120.0	29.2	70.5	7.3	1.5	17.0	80.5
Custard apple	72.5	104.0	25.5	3.5	37.0	42.5	17.0	–
Grape	85.5	71.5	13.4	–	13.7	2.3	18.5	45.8
Grapefruit	91.4	42.5	6.0	–	61.0	5.0	12.0	100.0
Guava	87.7	57.5	18.2	3.5	212	4.9	10.5	85.6
Lemon	88.0	52.5	10.1	10.0	35.5	28.3	70.2	232.0
Lichi	87.1	61.8	15.6	0.0	31.6	5.6	8.5	150.5
Lime	86.6	55.2	10.9	15.0	65.1	27.5	90.5	160.5
Mango	86.0	85.7	20.9	2700	15.5	15.2	14.0	195.0
Orange	93.2	9.5	4.5	26.0	64.0	40.2	60.3	125.4
Papaya	90.8	32.0	7.2	660.0	55.0	23.5	17.0	60.5
Passion fruit	89.0	37.0	7.7	1968	13.0	2.5	10.0	12.5
Peach	89.0	50.2	10.5	0.0	5.0	3.0	15.0	450.5
Pear	88.0	50.5	11.9	20.5	4.5	5.3	8.5	96.8
Phalsa	84.8	70.0	15.7	410.0	22.0	7.9	120.0	345.0
Pineapple	92.5	38.4	10.3	11.5	32.3	8.0	15.3	65.0
Pomegranate	82.0	85.0	16.5	35.0	16.0	14.5	10.0	133.0
Raspberry	88.8	50.2	10.7	1240.0	30.0	37.5	40.0	–
Sapota	78.7	95.0	21.4	90.5	6.0	5.4	22.5	260.8
Strawberry	90.8	40.5	9.80	18.50	52.0	5.5	30.0	15.5
Tomato	95.0	20.0	3.6	351.0	27.0	30.0	48.0	146.0
Water melon	96.8	15.0	3.3	3.5	1.0	5.8	10.5	160.0
Wood apple	68.2	130.0	18.1	6.5	3.5	17.0	130.0	25.0
Zizyphus	85.6	78.0	22.0	21.0	76.0	15.5	4.0	25.9

Table II.
Nutrient constituents of fruit juice having positive effects on human wellness [183].

Constituent	Major sources of fruit juice	Effect on human wellness
Protein	Chilgoza, wood apple juice, currants, korukkapalli, custard apple, grape, noni and bael, etc.	Proteins are the important constituent of tissues, muscles, cells of the body and vital body fluids like blood. Proteins in the form of enzymes, hormones and antibodies are involved in metabolic processes.
Carbohydrate	Banana, bael, fresh dates, custard apple, pomegranate, ber, papaya, mango, guava, grape, orange, apple, etc.	Important sources of energy, act as fibrous component of diet, help in utilization of body fat, exert sparing effects on protein and necessary for the mechanism of digestion and elimination of waste.
Fats	Maximum fruits are fat-free. Mulberry, wood apple, guava, apple, etc.	Concentrated sources of energy, reserve food material, sources of essential fatty acids. Prevention of phrynoderma (toad skin) disease.
Energy	Fresh dates, apple, grape, chilgoza, currants, wood apple, bael, mango, orange, pomegranate, etc.	Energy is essential for rest, activity and growth of the body.
Vitamin A	Mango, papaya, orange, bael, guava, pomegranate, pineapple, etc.	Prevention of night blindness, chronic fatigue, psoriasis, heart disease, stroke, cataracts.
Vitamin B_1 (thiamine)	Chilgoza, korukkapalli, black berry, bilberry, cherry, apple, goose berry, etc.	Acts as anti beri-beri or anti-neuritic vitamin. Deficiency of thiamine causes dropsy, palpitations and heart failure.
Vitamin B_2 (riboflavin)	Bael, papaya, pineapple, black berry, bilberry, cherry, apple, goose berry, litchi, etc.	Inadequate intake of this vitamin in diet leads to soreness of tongue (glossitis), cracking at the angles of mouth, redness and burning sensation in the eyes.
Vitamin B_3 (niacin)	Litchi, chilgoza, mango, bael, grape, raspberry pear, etc.	Lack of this vitamin in the diet leads to the disease pellagra which is characterized by soreness of tongue, pigmented skin and diarrhea.
Vitamin C (ascorbic acid)	Barbadoscherry,aonla,guava,korukkapalli, musambi, orange, strawberry, lemon, lime, zizyphus, grape, pineapple, pear, etc.	Prevents scurvy, aids wound healing, healthy immune system and cardiovascular disease. Deficiency causes weakness, bleeding gums and defective bone growth.
Vitamin E (tocopherols)	Papaya, mango, kiwifruit, tomato fruit.	Heart disease, LDL-oxidation, immune system, diabetes, cancer.
Vitamin K (phylloquinone)	Kiwifruit, tomato fruit, grape, pomegranate.	Synthesis of blood procoagulant factors.
Fiber	Aonla , bael, guava, pomegranate, custard apple, wood apple, grape, mango, etc.	Lack of adequate dietary fiber in diets containing refined foods leads to constipation and colon cancer.
Calcium	Litchi, karonda, currants, wood apple, fresh dates, phalsa, pilu, pomegranate, guava, etc.	Osteoporosis, formation and maintenance of skeleton and teeth. It is required for normal contraction of muscle to make limbs move, heart for its normal function, nervous activity and blood clotting.
Iron	Karonda, fresh date, green mango, currants, watermelon, grape, pomegranate, custard apple, bael, etc.	Formation of hemoglobin of red cells of blood and plays an important role in the transport of oxygen. Required for tissue oxidation-reduction.
Magnesium	Grape, mango, plum, custard apple, phalsa, pomegranate, etc.	It is required for osteoporosis, nervous system, teeth, immune system and cellular metabolism.
Potassium	Aonla, bael, lime, loquat, phalsa, peaches, muskmelon, noni, etc.	Hypertension, stroke, arteriosclerosis. Essential to maintain osmotic balance and keep cells in proper shape.
Folic acid	Tomato fruit, pomegranate, bael, lime, loquat, phalsa, etc.	Birth defects, cancer, heart disease, nervous system.
Phosphorus	Currants, raspberry, wood apple, pomegranate, bael, lime, loquat, phalsa, etc.	Deposited as calcium phosphate in the bone and the teeth. Phosphorus is also a component of nucleic acids.
Zinc	Mango, pomegranate, custard apple, wood apple, etc.	It is a co-factor for a number of enzymes. Zinc deficiency leads to growth failure and poor development of gonadal function.
Copper	Mango, citrus, pomegranate, custard apple, wood apple, grape, etc.	It is involved in iron absorption, cross linking of connective tissues, neurotransmission and lipid metabolism.

4.2. Flavonoids and polyphenols

Flavonoids and polyphenols are the most important constituents of different fruit juices that have the ability to increase their antioxidant potential [61], affect lipid metabolism [62], and cholesterol absorption [63]. Polyphenols are mostly derivatives, and/or isomers of flavones, isoflavones, flavonols, catechins, lignins, tannins and phenolic acids [36]. Dietary polyphenols may offer indirect protection by activating endogenous defense systems and by modulating cellular signaling processes such as NF-κB activation, AP-1 DNA binding, glutathione biosynthesis, PI3-kinase/Akt pathway, MAPK proteins (ERK, JNK and P38) activation, and the translocation into the nucleus of Nrf2 [64]. They also contain phenolic constituents such as chlorogenic, arbutin, caffeic, *p*-coumaroyl quinic and *p*-coumaric acids, and a number of procyanidins and flavonol glycosides [65, 66].

Apple and cloudy apple juice contains quercetin, chlorogenic and other phenolic acids as well as dihydrochalcones like phloridzin and phloretin xyloglucoside [67], that can reduce some forms of cancer [68]. Berries (cranberry, blackberry, raspberry and strawberry) are rich in anthocyanins (cyanidin, pelargonidin), flavonoids (kaempferol and quercetin derivatives), ellagitannins and proanthocyanidins [69, 70]. Black raspberry juice has demonstrated high antioxidant capacity, which has been attributed to its high concentration of total anthocyanins and total phenolic compounds [71].

The main flavonoids found in citrus juice are limonoids, hesperidine, narirutin, naringin, flavanones, flavones, flavonols and eriocitrin [72, 73] and carotenoids such as β-carotene, α-carotene, β-cryptoxanthin, lutein, zeaxanthin, lycopene and limonoids [23, 74]. Guava fruit juice is very nutritious in respect of having ascorbic acid, pectin and antioxidants along with high amounts of flavonoids and polyphenols that serve as natural laxatives and protect the colon from carcinogenesis [11]. Grape juice is well known for the presence of resveratrol, flavonoids and anthocyanins [75–77]. They thus have beneficial effects on markers of coronary heart disease [78, 79] and exhibit many biologically significant functions, such as protection of body tissues against oxidative stress, and degenerative diseases like cancer and cardiovascular disease [61]. Red wine is a type of fermented grape juice having different types of phenolic acids like gallic acid, coumaric acid, caffeic acid and derivatives such as chlorogenic acid and flavonoids which are not essential for survival but over the long term may provide protection against a number of chronic diseases [77].

Fresh mango juice is a source of lupeol, a potential anti-carcinogenic compound against pancreatic and prostate cancers besides several other benefits in cardiovascular health, reducing risk of kidney stone formation and even reducing the rate of ageing [80]. Bael fruit juice is a very good source of marmelosin which is an age-old known remedy for dysentery, diabetes and psoralene for skin infections, and also as a heart tonic [80]. Pomegranate juice is rich in phenolic anthocyanins such as delfinidin, cyanidine, pelargonidine [81], and ellagitannins (92%) such as ellagic acid, punicalagin and punicaline [82] which help in reducing blood pressure by inhibiting ACE (angiotensin converting enzyme-1) enzyme activity, reversing damage to vessels [83], preventing prostate cancer [84], colon cancer [85] and arthritis [86], protecting phagocyte cells against auto-oxidative damage through β-carotene, maintaining blood glucose levels in the normal range [83, 87], stimulating T-cell functions, supporting formation of cytokines, and increasing the capacity of cells which naturally inhibit tumors [88].

The polysaccharide and phytochemical-rich fruit juice of *Morinda citrifolia* (noni) is used to treat hypertension, diabetes mellitus, bronchial asthma, rheumatoid arthritis, some cancers, and sexual dysfunction [89]. Tomato juice is a major source of lycopene [90] and is used to treat cancer particularly of the prostate [91], heart disease and male infertility. Cranberry juice reduces the incidence of urinary tract infections in women [92].

Much research suggests that polyphenols with other nutrients found in fruit juice help to slow the ageing process and reduce the risk of many diseases including cancer, heart

disease, stroke, high blood pressure, cataracts, urinary tract infections [93], and Alzheimer's disease [94, 95]. The intake of polyphenols in the diet should be about 1 g per day [96]. We synthesized the different bioactive compounds present in fruit juices (*table III*).

4.3. Antioxidants

Recently, there has been much interest in the natural sources of antioxidant phytochemicals of plant origin, especially fruits juices [61]. The antioxidant profile of fruit juices is complex and includes carotenoids (*e.g.*, lycopene, β-carotene), tocopherols and ascorbic acid, as well as polyphenols [97]. Vitamin C acts as a powerful antioxidant by protecting the body from oxidative stress and helps to build and repair body cells [23], along with immunity from infections and diseases. Vitamin C has been shown to reduce the levels of C-reactive protein, a marker of inflammation and provide protection against immune system malfunctioning, infection, cancer, harmful side effects of pollutants, and cardiovascular disease risk in humans [98, 99].

Consumption of fruit juices, such as cranberry, pomegranate, tomato and orange

Table III.
Bioactive compounds in fruits [183].

Constituent	Compound	Sources	Effect on human wellness
Phenolic compounds			
Proanthocyanins	Tannin, ellagic acid, ferulic acid	Apple, grape, cranberry, pomegranate, grapefruit	Cancer
Anthocyanidins	Cyaniding, malvidin, delphinidin, pelargonidin, peonidin, petunidin	Apple, black berry, blueberry, cranberry, grape, peach, plum, pomegranate, strawberry	Heart disease, cancer initiation, diabetes, cataracts, blood pressure, allergies
Flavan-3-ols	Epicatechin, epigallocatechin, catechin, gallocatechin	Apple, blackberries, plums, raspberries, strawberries	Platelet, aggregation, cancer,
Flavanones	Hesperetin, naringenin, eriodictyol	Orange, grapefruit, lemons, lime, tangerine, grape	Cancer
Flavones	Luteolin, apigenin	guava	Cancer, allergies, heart disease
Flavonols	Quercetin, kaempferol, myricetin, rutin	Cranberry	Heart disease, cancer initiation, capillary protectant
Phenolic acids	Caffeic acid, chlorogenic acid, coumaric acid, ellagic acid	Blackberry raspberry, strawberry, apple, peach, plum, cherry	Cancer, cholesterol
Carotenoides			
Lycopene	–	Tomato, watermelon, papaya, brazilian guava, red grapefruit	Cancer, heart disease, male infertility
α- carotene	–	Kiwifruit, peaches, mango, papaya	Tumor growth
ß- carotene	–	Mango, papaya	Cancer
Xanthophylls	Lutein, zeaxanthin, ß-cryptoxanthin	Citrus, pomegranate, bael	Muscular degeneration
Monoterpenes	Limonene	Orange, citrus, grapefruit, tangerine	Cancer
Sulfur compounds			
Sulfur compounds	Glucosinolates, isothiocyanates, indoles, allicin, diallyl isulphide	Apple, korukkepalli	Cancer, cholesterol, blood pressure, diabetes

tends to increase plasma levels of antioxidant vitamins [100, 101]. Each antioxidant vitamin has a unique free radical scavenging mechanism [102, 103]. Carotenoids responsible for the orange color of orange and tangerine juice are α- carotene, zeta-antheraxanthin (yellowish), violaxanthin (yellowish), β-citraurin (reddish orange), and β-cryptoxanthin (orange), the red or pink color of the pigmented grapefruit juice varieties is due to the presence of lycopene [23], and red color in orange juice is due to the presence of anthocyanins. All these compounds act as antioxidants in the human body. Citrus fruit (orange, lemon, lime and grape fruit) juices are an important source of bioactive compounds including antioxidants such as ascorbic acid, phenolic compounds and pectins that are important in human nutrition [104, 105].

Orange juice has over 170 different phytochemicals, including more than 60 flavonoids, many of which have been shown not only to have antioxidant effects but also anti-inflammatory and anti-tumor activity [72]. Pomegranate, aonla, apple, strawberry, bael and custard apple juice have moderate antioxidants with an activity of 12–64 mM FRAP (ferric reducing antioxidant potential). Antioxidants found in fruit juices are measured by ORAC score (Oxygen Radical Absorbance Capacity). The higher the ORAC score (blueberry juice, 2,400; strawberry juice, 1,540; raspberry juice, 1,220; plum juice, 949; orange juice, 750; grapes juice, 739; cherry juice, 670; kiwi fruit juice, 602), the greater its antioxidant capacity [36].

5. Medicinal properties of fruit juices

Consuming fruit juices has a natural beneficial effect on the human system by hydrating it and acting as a healthy electrolyte drink [2, 3]. The water absorbed by sick persons in this manner has an added advantage of supplying sugar and minerals at the same time [64]. These juices lower the urine density and thereby accelerate the elimination of nitrogenous wastes and chlorides by acting as a diuretic. Fruit juices have a normalizing effect and give the body a boost of energy so that it can overcome a number of health-related problems [10]. It is effective in curing dehydration, fatigue, constipation and other digestive disturbances, kidney and bladder disorders, and vision problems such as glaucoma and cataract [4]. This amazing fluid can help repair any damage to the digestive tract by relieving stomach pain and normalizing intestinal functions. More recently, the influence of vitamin C from fruit juices in gene modulation and biochemical pathways modification has been shown, particularly in blood vessel endothelium [12] and atherosclerosis [106].

Folate from citrus and pineapple juice is essential for the prevention of spina bifida [107] and premature birth [108]. It also helps in maintaining a low level of the amino acid homocysteine, a marker of inflammation that has been associated with a higher risk of heart disease, stroke, and heart failure [24]. A number of studies have shown that the phytochemicals present in fruit juices inhibit chronic inflammatory diseases like Alzheimer's disease [94, 95], insulin resistance [109, 110], diabetes, cardiovascular disease, osteoporosis, arthritis [111], cognitive functions and brain diseases [112], and some forms of cancer [113].

5.1. Glycemic index and diabetes

The worldwide burden of type-2 diabetes has increased rapidly in tandem with the increase in obesity. The number of people with diabetes was 171 million worldwide in 2000, and this number is projected to increase to at least 366 million by the year 2030 [32]. Fruit juices generally have a low glycemic index (GI) [114] and contain compounds that limit or prevent insulin resistance. Because carbohydrates in lowGI foods break down more slowly than in high GI foods, there is a more gradual rise in blood sugar levels that helps people to manage diabetes and obesity [114]. The glycemic index of a food refers to its effect on blood sugar levels. The number is a comparison with a reference food, in this case the sugar, glucose. The World Health Organization and Food and Agriculture Organization

(FAO) have recommended that people should base their diets on low GI foods in order to lessen the risk of coronary heart disease, diabetes, and obesity [115].

The GI of some common fruits and unsweetened fruit juices is: for watermelon, 72; pineapple, 46; mango, 55; orange, 52; lime, 45; unsweetened apple juice, 41; apple, 40; pear, 36; peach, 28; grapefruit, 48, and cherry, 32 [114]. A reduction in insulin resistance, oxidative stress and inflammation were reported after ingestion of several fruit juices including grapefruit juice [116], orange juice [117], cranberry juice [19] and blueberry juice [118]. Fruit juices dilate blood vessels improving blood circulation thus reducing clot formation and benefitting diabetics. Fruit juices also contain certain forms of dietary fiber and amino acids that help moderate sugar absorption and improve insulin sensitivity. Daily intake of orange juice may increase the production of somatostatin, an inhibitor of insulin secretion, and help in managing diabetes [119].

5.2. Cardiovascular health

Fruit juice keeps the cardiovascular system in good condition and helps in preventing cardiovascular disease [4], particularly atherosclerosis [111]. It acts as a cleanser inside blood vessels, scrubbing away arterial deposits that lead to heart attack and stroke [14, 15]. The principal mechanisms of action of fruit juice may include the following: increased serum antioxidant capacity, decreased plasma lipids and lipid peroxidation, decreased oxidized-LDL uptake by macrophages, decreased intima media thickness, atherosclerotic lesion areas, inflammation, angiotensin converting enzyme activity, systolic blood pressure, and enhanced biological actions of nitric oxide, thereby controlling progression of atherosclerosis and the subsequent development of coronary heart disease and stroke [120].

Fruit juices present a heart-healthy and colorful array of phytochemicals including carotenoids and polyphenols like flavonoids, resveratrol, ellagitannins, isothiocyanates and organosulfur compounds which are associated with lower risks of cardiovascular disease [121]. Fruit juices are good sources of potassium and magnesium which help in reducing high blood pressure [122]. Several fruit juices seem to be able to limit blood clot formation by preventing platelets from agglutinating in the blood vessels [78, 123, 124].

The pectin in fruit juice reduces cholesterol levels which, in turn, decrease cardiovascular risk [125]. Epidemiological studies on dietary citrus flavonoids showed a reduction in risk of coronary heart disease [126]. Fruit juices can increase the level of high density lipoproteins (HDL) and decrease the formation and oxidation of low density lipoproteins (LDL) that are deposited in the blood vessels [127]. It is known that naringin and hesperidin inhibit the first enzyme in the biosynthesis of cholesterol (HMG-Co reductase) [128]. Naringin inhibits the transcription of HMG-Co reductase, the activity of microsomal triglyceride transfer protein (MTP) and the transcription of acyl-coenzyme A: cholesterol acyltransferase 2 (ACAT2) the enzyme which in the final phase of LDL production attaches cholesterol to the lipoproteins [129]. Similarly, naringin and anthocyanins from berries have a beneficial effect on lipoprotein profiles by decreasing LDL-cholesterol and increasing HDL-cholesterol concentrations [130].

Apple juice polyphenols may act by inhibiting cholesterol ester transfer protein (CETP) [131]. A reduction of plasma cholesterol by citrus juice flavonoids is associated with a modulation of the expression of the LDL receptor (LDLR) gene [132]. The fortification of juices with calcium and phytosterol provides some supplementation for cardiovascular benefits [133].

Pomegranate juice, citrus juice, jamun juice and phalsa juice significantly reduce total cholesterol, low density lipoproteins (LDL), the LDL/HDL ratio, and the ratio of total cholesterol to HDL [134]. Consumption of pomegranate juice may modify heart disease risk factors in patients with hyperlipidemia [135]. When ingested, pomegranate juice could help patients with carotid artery stenosis, decrease carotid intima-media thickness, and their systolic blood

pressure [136]. Postprandial hyperlipidemia and oxidative stress, a well-defined risk factor for atherosclerosis, could be reduced by phenolic-rich jamun, phalsa and grape juice. Phenolic compounds of different fruit juices significantly ameliorated plasma lipid levels. After drinking 100 mL of red grape juice per day for 14 days, the concentration of cholesterol-standardized tocopherol and antioxidant capacity of plasma were significantly increased, and oxidized LDL was significantly reduced [137]. Daily intake of 100 mL of citrus fruit juice after dinner significantly reduced hyperlipidemia and oxidative stress due to the presence of citric acid, ascorbic acid and different phenolic compounds [11].

5.3. Bone health

Calcium plays a vital role in bone health and maintaining bone mineral density. A number of fruit juices are a good source of calcium, *e.g.*, orange juice (60.3 mg), bael juice (80.2 mg), lemon juice (70.2 mg), lime juice (90.5 mg), phalsa juice (120.0 mg), and wood apple juice (130.0 mg) per 100 mL fruit juice [58]. The phytochemicals present in various fruit juices help in bone mineralization, leading to better bone health and preventing diseases like arthritis [138]. Several fruit juice phytochemicals, mainly polyphenols and carotenoids- β-cryptoxanthin, β-carotene and lycopene have a positive influence on bone health by preventing destruction of osteoclasts and arthritis [139]. Citrus juice hesperidin and naringin may act through the bone morphogenetic proteins (BMPs) pathway that induces the formation of bone and cartilage [138, 140]. It should also be mentioned that citrus and pomegranate juice may have a positive effect on arthritis [16, 17].

5.4. Brain health, cognition and ageing

Compounds like flavonoids and ascorbic acid present in fruit juices have an interesting role in cognitive development of the brain by increasing its neurological activity manifold. Many research reports have shown that grape juice [141, 142], berries juice [143, 144] and citrus juice [145] play an important role in maintaining cognition, limiting brain ageing, and possibly slowing the progress of Alzheimer's disease [146]. The ability of juice compounds, particularly flavonoids, to cross the barrier protecting the brain (blood brain barrier) underlies the beneficial activity of these compounds [147].

The neuroprotective properties of dietary flavonoids are: promoting cerebral vascular blood flow, signaling neuronal cascades leading to an inhibition of cell death, and promotion neuronal differentiation thus preventing deterioration and improving cognitive performance [148]. Ascorbate from fruit juices is proposed as a neuromodulator of neurotransmitters, thus vitamin C may have potential therapeutic roles against ischemic stroke, Alzheimer's disease, Parkinson's disease, and Huntington's disease [22].

5.5. Anti-cancer and anti-inflammatory activities

Maximum fruit juices (apple, aonla, mango, bael, grapes, citrus, noni, phalsa, jamun and pomegranate) are in fashion due to their abundant nutritional richness of having vitamin C, good color and flavor, and being able to reduce the risk of certain cancers (oral, pharynx, larynx, lung, esophagus, stomach, colon, and rectum) [149]. Fruit juices are actually known for their ability to raise serum antioxidant capacity and even offset the oxidative stress and inflammation normally caused by high-fat and high-sugar meals.

Many fruit juice phytochemicals, polyphenols, carotenoids and limonoids may influence mechanisms relevant for cancer prevention that reduce DNA damage and help repair DNA, thus reducing mutations leading to cancer [12, 13]. These include antimutagenic activity, control of angiogenesis, anti-inflammatory mechanisms and modulation of signal transduction pathways. Anthocyanins from various berry juices [150, 151], grape juice [75], citrus flavonoids [73], limonoids [152] and polyphenols

in apple juice [153, 154] may also have potential anti-carcinogenic activities.

Phenolics of black grape juice prevent inflammation in hemodialysis patients and red grape juice significantly reduces plasma monocyte chemoattractant protein [32], an inflammatory factor involved with CVD risk, and showed effective power to regulate plasma lipids and oxidative stress [137]. Antioxidants and ellagic acid present in pomegranate fruit juice prevent prostate, breast, skin, colon, lung, oral, pancreas, intestine, esophagus, bladder, and leukemia cancers by acting as anti-proliferation (growth inhibition, cell cycle disruption and apoptosis), anti-angiogenesis and anti-inflammatory agents [155].

5.6. Skin health

It is a well proven fact that fruit juices are excellent sources of vitamins, minerals, trace elements, phytochemicals, a variety of enzymes and indispensable nutrients. These ingredients promote epithelial cell proliferation, prevent skin follicular keratosis, assist removal of skin pigmentation, and have the ability to maintain collagen protein, prevent decomposition of fat and melanin, and prevent skin disease activities [11, 156].

Fruit juice maintains the body's acid-base balance, adjusts the functioning of the sweat glands to reduce endocrine acidic waste preventing skin erosion, making skin white, soft, smooth, delicate, and flexible, and to delay skin ageing [11]. Citrus juices are a rich source of vitamin C and known to maintain skin collagen [157] and are used as skin tonics against acne [7]. It has a cooling effect and acts as a moisturizing agent, and is therefore used in the preparation of creams, lotions, shampoos and allied products. Fruit juice mixed with selected essential oils makes skin smoother and moisturized, acts as a sun block lotion, and is used in a wide range of beauty products.

A beneficial effect of vitamin C on skin has been found at the gene expression level [158, 159]. Fruit juice flavonoids have been shown to improve skin microcirculation [160] and collagen formation [18, 161] and carotenoids improve skin health [162].

5.7. Anemia

Anemia prevalence among children under 5 years and women is 69% and over 55%, respectively. In addition, 40.4% of children are underweight, 14.0% of the population is undernourished, and 8.5% of children die under the age of 5 years due to hunger and iron deficiency. Iron is essential for the formation of hemoglobin of red cells in blood, and plays an important role in the transport of oxygen. Tissues also require iron for various oxidation-reduction processes and other body reactions. However, if there is shortage of iron in body, this leads to anemia.

Vitamin C-rich fruit juices (orange juice, 64 mg; aonla juice, 592 mg; lime juice, 65 mg; papaya juice, 55 mg; zizyphus juice, 76 mg per 100 mL fruit juice) help in increasing non-heme iron absorption to almost double, and prevent iron deficiency anemia in the body [11, 163]. Hundred per cent juice of fruits like prune, peach, cantaloupe, dates, spinach, lemon, orange, grapefruit, tangerine, lime, mango, papaya, strawberry, kiwi, and tomato should be consumed daily for adequate supply of iron. In regional meals, the addition of citrus fruit juices increased iron availability markedly [164]. The consumption of iron-fortified orange juice is a good strategy to complement iron intake and control iron deficiency anemia [165]. It was found that the fortified juice drink was effective in reducing the prevalence of anemia and improved iron and zinc status of children [166].

5.8. Prevention of obesity

The widespread prevalence of obesity in children and the rapidity of recent increases forecast major problems for future healthcare [167]. On the contrary, it appears that people who consume fruit juice (fat free product) were found to have overall healthier diets than those who do not consume fruit juices, along with intakes of fat, saturated fat, sodium, added sugars and fats [11]. Although 100% fruit juices are not yet implicated in obesity development like other sweetened beverages, they still contain large amounts of sugar and energy. Recommended quantities of fruit juices may play

a role in the prevention of obesity [65] because they can add to dietary variety both between and within food groups; they can add palatability to the overall diet and palatability has been shown to be an important predictor of body fat [168]. Fruit juices generally have a low GI; this may help in weight management [65].

A number of research studies have evaluated the relationship between consumption of 100% fruit juice and bodyweight among children and adolescents and found that there is no systematic association between the two [169, 170]. There is no significant correlation between weight change and the consumption of 100% fruit juice and drinks in pre-school children [171]. Studies that have looked specifically at fruit juice consumption and obesity have shown mixed results [171, 172]. In fact, the relation between fruit juice consumption and weight gain is very weak because fruit juice is not energy-dense and average juice consumption per day less than 100–150 mL represents a contribution of less than 2–3% to the daily energy intake.

5.9. Dental health

Several reports have postulated that fruit juices can affect dental health, promote caries and dissolve enamel by high sugar and acid content. In spite of this, some fruit juices are rich in polyphenols, calcium, phosphorus and other minerals supporting dental health [11]. However, the detrimental effects of juice sugar and acidity can easily be eliminated by proper hygiene. Several studies on dental health have found no measurable association between intakes of 100% fruit juice with prevalence of tooth loss [173]. Concerns have been raised that the acid and sugar content of fruit juice could have a deleterious effect on dental health [174].

Recent studies have revealed that juice polyphenols have a beneficial effect on dental health [175, 176]. Furthermore, calcium added to juice can also add another beneficial effect [177]. The consumption of fruit juice as part of a balanced diet can be compatible with good dental health because of the following reasons:

– All naturally occurring sugars and fermentable carbohydrates are potentially cariogenic and a diet devoid of these nutrients would of course not be feasible. It is clear that despite the presence of sugars in the diet, dental health can be maintained if such foods are consumed appropriately as part of a healthy diet along with good oral hygiene practices.

– The main factor leading to dental erosion and caries is the frequency of consumption, rather than the absolute amount of sugars and the acidity of the product. The main preventive factor for the development of caries obviously is appropriate oral hygiene.

5.10. Antimicrobial activity

Fruit juices from the cashew apple are known to have anti-microbial, anti-inflammatory, astringent, diuretic, hypoglycemic, and other medicinal properties [178]. *Morinda citrifolia* L (noni) has been used in folk remedies by Polynesians for over 2000 years and is reported to have a broad range of therapeutic effects, including antibacterial, anti-viral, anti-fungal, anti-tumor, analgesic, hypotensive, anti-inflammatory, and immune enhancing effects. Koruk (unripe grape from *Vitis vinifera*) juice immediately decreased the initial populations of *Salmonella typhimurium* at 1–3.5 log cfu·g^{-1} [179]. Spiced extract and juice has been used for prolonging storage quality of juice and reducing spoilage [25]. The possible reason may be that spiced extracts have anti-bacterial properties which check the oxidation of juice constituents and growth of microorganisms [180].

6. Potential hazards of fruit juices

Drinking too much juice can lead to poor nutrition, diarrhea, gas, abdominal pain, bloating, and tooth decay. Children have a preference for fruit drinks as they taste good, packaging has an eye appeal, juices are inexpensive and convenient and hence

are replacing important food items in the diet. A survey of infant feeding in Asian families in England showed that, at 5 months of age, 75% of Pakistani and White mothers, 63% of Indian mothers and 61% of Bangladeshi mothers were giving fruit juices as a source of non-milk drink [177]. By replacing milk in diet, the number of children meeting recommended daily allowances (RDA) for calcium has drastically reduced to just 50% and thus it is a great health concern. The calcium in these juices is not biologically equivalent to milk calcium.

High vitamin C in fruit juices promotes iron absorption but polyphenolic compounds in certain juices inhibit iron absorption. Fruit drinks are a common cause of tooth decay and promote picky feeding [177]. Changes in bowel habits, i.e., abdominal distension, flatulence and diarrhea are frequently observed with fruit drinks [33]. A few studies have shown that intake of fruit juices in huge quantities is associated with short stature, obesity, diabetes mellitus and malnutrition [181] and cause toddler diarrhea [182]. Unpasteurized stored fruit juices can be a source of serious bacterial, fungal and yeast infections [180].

7. Conclusion

Fruit juices are excellent sources of water and natural sugar and are important principally for containing vitamins, minerals, phytochemicals, antioxidants, pigments, energy, organic acids, dietary fiber and other food components. Consumed in moderation as part of a balanced diet, fruit juices offer properties which both promote good health and reduce the risk of disease. Nevertheless, studies are still fragmentary and need to be expanded in relation to fruit juice consumption, particularly in the clinical area. It appears that juices are most effective against diseases related to chronic inflammation, cancer, heart and bone diseases, problems related to cognition and ageing, and insulin resistance. In most cases, these fruit juice compounds seem to work by modulating gene activity. Furthermore, to reject fruit juices as inadvisable in the context of obesity and dental health would deny the consumer a perfectly healthy and nutritious food, and be completely contrary to the evidence presented in the scientific community. Thus, fruit juices are an excellent choice of drink when consumed moderately as per recommendations.

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Compuestos bioactivos y propiedades medicinales de zumos de frutas.

Resumen – El producto. Los zumos de frutas ocupan un lugar importante en las dietas modernas de personas pertenecientes a diferentes comunidades y clases en el mundo entero. Se trata de líquidos no fermentados, pero fermentables, extraídos de la parte comestible de las frutas sanas y suficientemente maduras y frescas. **Compuestos bioactivos**. Los zumos de frutas contienen nutrientes como las vitaminas, los elementos minerales, los oligoelementos, energía y compuestos fitoquímicos, que incluyen flavonoides, polifenoles y antioxidantes de los que se ha demostrado que presentan una variedad de ventajas saludables. **Las propiedades medicinales**. El modo de acción de los compuestos bioactivos a base de zumo de frutas parece estar, en la mayoría de los casos, relacionado con la modulación de las actividades de los genes. En el marco de una alimentación equilibrada, los zumos de frutas permiten a la vez gozar de una buena salud y limitar seriamente los riesgos de enfermedades; existe, por lo tanto, una fuerte demanda por parte de la medicina alternativa para luchar contra diferentes tipos de enfermedades, tales como las inflamaciones crónicas, artritis, diabetes, hipertensión arterial, dolores musculares, dolores menstruales, dolores de cabeza, enfermedades cardíacas, sida, cáncer, úlceras gástricas, esguinces, depresión, malas digestiones, arterioesclerosis, problemas sanguíneos y toxicomanía. Además, considerar los zumos de frutas como no-consumibles en el contexto de la obesidad y de la salud dental privaría al consumidor de un producto alimenticio perfectamente sano y nutritivo, y sería completamente contrario a las informaciones proporcionadas por la comunidad científica. **Discusión y conclusión**. Los zumos de frutas, consumidos moderadamente siguiendo ciertas recomendaciones, constituyen una excelente elección de bebida.

India / frutas / jugo de frutas / alimentos sanos / propiedades medicinales / antioxidantes / fitoquímica / resveratrol / sobrepeso