

NUTRITIONAL VALUE, FUNCTIONAL PROPERTIES AND INDUSTRIAL APPLICATIONS OF FRUIT JUICE

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Summary

Considerable interest in fruit juices has been developed over the years due to their potential biological and health promoting effects. Consumption of fresh fruit is often replaced by the intake of fruit juices, due to their easily, conveniently and readily consumable nature which is the need of today's fast and busy life. It is the unfermented but fermentable liquid obtained from the edible part of sound, appropriately mature and fresh fruit. 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. The mode of action of these fruit juice compounds in most cases seems to be by modulating gene activities. The fruit juice as part of a balanced diet, offer both: good health and profoundly disease risk reduction properties so have high demand in 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 be completely contrary to the evidence noted in the scientific community.

This chapter will introduce the reader to role of fruit juices in health security. After a brief introduction, categories and products of fruit juices, phytonutrients present in fruit juices, proximate composition, nutritional and functional properties of fruit juices will be discussed along with interaction mechanism of fruit juice components in human body. Special emphasis is placed on recent developments and findings as well as on representative examples to provide more concrete illustrations of these far-ranging topics like industrial applications of fruit juices and future prospects of fruit juice industry, storage potential, general dietary recommendations and therapeutic role in various diseases. At the end of the chapter a conclusion and perspective section will summarize the subject.

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 and functional value. They are considered to be rich and diverse source of vital phytonutrients which include carbohydrates, vitamins like A, C, B, folate; minerals like iron, calcium, copper, potassium, iodine, and magnesium; dietary fibre; organic acids, amino acids, antioxidants and polyphenols like colourful anthocyanins, aroma compounds, carotenoids and other bioactive compounds, which are crucial to nutrition and health of human beings. Juices are low in compounds such as sodium and fat which are believed to have negative health impacts when ingested in large amounts. 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.

Pure fruit juice is an important source of fluids and enzymes. As juices are consumed fresh, it is an excellent way to retain and balance the moisture level of body. They are readily digestible and exercise a cleansing effect on the blood and digestive tract by eliminating biochemical toxins from body.

Moreover, the ailments caused by the intake of unnatural foods can be successfully treated by them as they promote detoxification in the human body. Fruit juices in the daily diet have been strongly associated with reduced risk of some forms of cancer, cardiovascular disease, bone and skin related problems, allergies, gastrointestinal problems, hyperlipidemia and other chronic diseases. Antioxidant capacity varies greatly among fruit juices so it is better to consume a variety of them. They reduce unwanted fat, cure ulcers, regulate digestion, have inhibitory effects against the HIV virus and promote metabolic functions.

Various juice blends (mixed fruit juices) fortified with calcium, folate, fibre and vitamins have been launched for improving palatability, nutritional and medicinal quality of fruit juices in the market. Also worldwide health concern has led to the popularization of natural fruit juice as a healthy alternative to other beverages and carbonated soft drinks, which have high artificial sugar level.

2. Role of Fruit Juices in Therapeutic Nutritional Security: A Concept

Earlier fruits were directly consumed by the health conscious people, but in today's era the changing lifestyle, modified eating habits and due to seasonal availability, people got shifted towards nutritious ready-to-eat/ serve products like fruit juices. Fruit juices play an important part in therapeutic nutritional security and they are prescribed in various diseased conditions. Therapeutic nutritional value of some important fruit juices is discussed below.

Constituent	Major sources	Effect on human wellness
Protein	Chilgoza juice, wood apple juice, currants juice, korukkapalli juice, custard apple juice, grape juice, noni juice and bael juice etc.	Proteins are the important constituent of tissues, muscles, cells of body and vital body fluids like blood. Proteins in the form of enzymes, hormone and antibodies are concerned with metabolic process.
Carbohydrate	Banana juice, bael juice, fresh dates juice, custard apple juice, pomegranate juice, ber juice, papaya juice, mango juice, guava juice, grape juice, orange juice, apple juice etc.	Important source of energy, act as fibrous component of diet, help in utilization of body fat, exert sparing effect on protein and necessary for the mechanism of digestion and elimination of waste.
Fats	Maximum fruit juices are fat free. Mulberry juice, wood apple juice, guava juice, apple juice etc.	Concentrated source of energy, reserve food material, source of essential fatty acids. Prevention of phrynoderma (toad skin) disease.
Energy	Fresh dates juice, apple juice, grape juice, chilgoza juice, currants juice, wood apple juice, bael juice, mango juice, orange juice, pomegranate juice etc.	Energy is essential for rest, activity and growth of body.
Vitamin A	Mango juice, papaya juice, orange juice, bael juice, guava juice, pomegranate juice, pineapple juice etc.	Prevention of night blindness, chronic fatigue, psoriasis, heart disease, stroke, cataracts
Vitamin B ₁ (Thiamine)	Chilgoza juice, korukkapalli juice, black berry juice, bilberry juice, cherry juice, apple juice, goose berry juice etc.	It acts as anti beri-beri or anti-neuritic vitamin. Deficiency of thiamine causes dropsy, palpitation and heart failure.

Vitamin B ₂ (Riboflavin)	Bael juice, papaya juice, pineapple juice, black berry juice, bilberry juice, cherry juice, apple juice, goose berry juice, litchi juice etc.	Inadequate intake of this vitamin in diet leads to soreness of tongue (glossitis), cracking at the angles of mouth, redness and burningsensation in the eyes.
Vitamin B ₃ (Niacin)	Litchi juice, chilgoza juice, mango juice, bael juice, grape juice, raspberry juice pear juice etc.	Lack of this vitamin in the diet leads to the disease pellagra which is characterized by soreness of tongue, pigmented skin and diarrhoea.
Vitamin C (ascorbic acid)	Barbados cherry juice, <i>aonla</i> juice, guava juice, korukkapalli juice, <i>musambi</i> juice, orange juice, strawberry juice, lemon juice, lime juice, zizyphus juice, grape juice, pineapple juice, pear juice 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 juice, mango juice, kiwifruit juice, tomato fruit juice	Heart disease, LDL- oxidation, immune- system, diabetes, cancer
Vitamin K (phylloquinone)	Kiwifruit juice, tomato fruit juice, grape juice, pomegranate juice	Synthesis of blood procoagulant factors
Fibre	<i>Aonla</i> juice, bael juice, guava juice, pomegranate juice, custard apple juice, wood apple juice, grape juice, mango juice etc.	Lack of adequate dietary fibre in diets containing refined foods leads to constipation and colon cancer.
Calcium	Litchi juice, karonda juice, currants juice, wood apple juice, fresh dates juice, phalsa juice, pilu juice, pomegranate juice, guava juice 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 juice, fresh date juice, green mango juice, currants juice, watermelon juice, grape juice, pomegranate juice, custard apple juice, bael juice, etc.	Formation of haemoglobin of red cells of blood and plays an important role in the transport of oxygen. Required for tissues oxidation-reduction.

Magnesium	Grape juice, mango juice, plum juice, custard apple juice, phalsa juice, pomegranate juice etc.	It is required for osteoporosis, nervous system, teeth, immune system and cellular metabolism.
Potassium	<i>Aonla</i> juice, bael juice, lime juice, loquat juice, phalsa juice, peaches juice, muskmelon juice, noni juice etc.	Hypertension, stroke arteriosclerosis. Essential to maintain osmotic balance and keep cells in proper shape.
Folic acid	Tomato fruit juice, pomegranate juice, bael juice, lime juice, loquat juice, phalsa juice, etc.	Birth defects, cancer, heart disease, nervous system
Phosphorus	Currants juice, raspberry juice, wood apple juice, pomegranate juice, bael juice, lime juice, loquat juice, phalsa juice etc.	Deposited as calcium phosphate in the bone and teeth. Phosphorus is also a component of nucleic acids.
Zinc	Mango juice, pomegranate juice, custard apple juice, wood apple juice 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 juice, citrus juice, pomegranate juice, custard apple juice, wood apple juice, grape juice etc.	It is involved in iron absorption, cross linking of connective tissues, neurotransmission and lipid metabolism

Table 1. Nutrient constituents of fruit juices having positive effect on human wellness

- Apple juice contains a high percentage of sugars and organic acids which help in normalizing the metabolism and restoring an organism after physical activity. It is rich in iron, manganese, vitamins A, B₁, B₂, C and E which are very effective in intestinal infections, kidney diseases, anemia, atherosclerosis, obesity, gall bladder diseases and gout. An optimal proportion of potassium, sodium and calcium in apple juice help to strengthen the cardiovascular system.
- *Aonla* juice is rich in vitamins C, B₁, B₂, carotene, polyphenols, potassium, iron, organic acids, pectin, tannins and sugars. It has a healing effect on stomach ulcers, atherosclerosis, kidney diseases, metabolic dysfunctions and anemia. It is also effective in intestinal diseases and boosts the immune system.
- Blackberry juice contains vitamins A, B, C, E, calcium and potassium. Due to the presence of powerful natural antioxidants, blackberry juice is effective in fighting free radicals, which are molecules that destroy cells and tissues in the body and are linked to cancer and heart disease. It has anti-ageing properties also and helpful in controlling diabetes.
- Bilberry juice surpasses all other berries, fruit and vegetable juices in the amount of manganese. It has vitamins C, B₁, B₂, carotene, tannins, pectin and sugars along with

- malic, quinic, succinic and lactic acids. Its juice is used to treat diseases of digestive system, intestinal infections, hepatitis, anemia, gout, rheumatism, kidney stones and skin disorders. It also improves sight and reduces the blood sugar level. Phyto-elements contained in bilberry juice can cure dysentery, diphtheria and typhoid fever.
- Cherry juice contains glucose, fructose, vitamins B₁, C, carotene, polyphenols, folic acid, organic acids, copper, potassium, magnesium, iron and pectin. It has a positive effect in anemia, lung and kidney diseases, atherosclerosis and constipation. It works destructively against infections caused by *Staphylococcus* and *Streptococcus*.
 - Cranberry juice helps preventing or even treats bladder infections due to presence of a substance which prevents bacteria from binding to the bladder. It has been recommended for the treatment of urinary tract infection.
 - Citrus juices contain vitamin C, thiamine, biologically active compounds, antioxidants and flavonoids which help in preventing unwanted damage to cell membrane by neutralizing free radicals and possess antitumor activity. Vitamin C, the most important natural antioxidant in citrus fruit juices protects the organism from oxidative stress and cancer.
 - Gooseberry juice improves the metabolism, helps in curing iron deficiency anemia and is a good laxative and diuretic. It contains vitamin B complex, C, P and carotene, copper, iron, phosphorus, sugars, organic acids, pectin and tannins.
 - Grape juice is rich in carbohydrates and organic acids and also contains potassium, calcium, magnesium, manganese, vitamins C, P, B₁, B₆, B₁₂, polyphenols, folic acid and carotene. It is a good energy source due to more glucose content. It possesses anti-bacterial, diuretic, laxative, sweat-inducing and expectorate properties. It decreases hypertension and hypercholesterolemia and is recommended in fatigue or even exhaustion due to its wonderful role in functioning of nervous system. It is also useful in common cold, relaxing body and brain muscles, stomach problems, cough, kidney and urinary bladder pain, liver and lung disorders, dog bite, skin problems and exerts cooling effects on body.
 - Grapefruit juice possesses valuable dietary and healing properties. It improves digestion, normalizes liver functioning and restores strength. Juice with pulp is very helpful for those having loss of appetite and indigestion.
 - Guava juice is rich in vitamins A and C, folic acid, dietary fibre, minerals (potassium, copper, manganese), antioxidant pigments like carotenoids and polyphenols. It is effective in digestive problems, anorexia, cerebral ailments, childbirth, epilepsy, nephritis and jaundice. It has potent anti-diarrheal, antihypertensive, hepatoprotective, antimicrobial, hypoglycemic and anti-mutagenic activities.
 - Kiwi fruit juice contains more of vitamin C, calcium, iron, phosphorous and potassium, it is effective in treating anorexia, anaemia and helps to flush cholesterol from the blood. It also contains proteolytic enzyme and therefore helps in digestion.
 - Mango juice is high in antioxidant, provitamin A, β -carotene, α -carotene, β -cryptoxanthin, vitamin C, vitamin B₆, folate, other B vitamins, prebiotic dietary fibre, diverse polyphenols (quercetin and kaempferol), gallic acid, caffeic acid, catechins, tannins, and the unique mango xanthonoid, mangiferin, essential minerals such as potassium, copper, omega 3 and 6 polyunsaturated fatty acids. It is very essential for vision, protects against cancers, important component of cell and body fluids

controlling heart rate and blood pressure, helps body develop resistance against infections.

- Orange juice is rich in vitamin C, folic acid, potassium and is an excellent source of bioavailable phytochemicals, antioxidant and significantly improves blood lipid profiles in people affected with hypercholesterolemia. It is a great immune system booster and is therefore effective in preventing colds and other infections. It is also a good cleanser of the intestinal system and calms the nervous system, making it effective in treating nervousness, anxiety and insomnia.
- Papaya juice is rich in carotene, sugars, vitamin C, polyphenols, folic acid, iron and fibre. It helps in constipation, atherosclerosis, hemorrhoids and blood, kidney and cardiovascular diseases.
- Pineapple juice is very good source of vitamins B, C, calcium, copper, magnesium, manganese and potassium. It is very effective in digestion and also helps in blood disorders, sore throats and common cold problems. It is well known for its anti-inflammatory properties due to high levels of the enzyme bromelain and can treat gout, arthritis and rheumatism.
- Pomegranate juice is an excellent cooling beverage and allays thirst, it improves digestion and assists assimilation of food and has a positive effect in pancreatic diseases. It is very useful in digestive tract problems, infectious diseases and surgeries as a general strength booster. It is a tonic for heart patients, highly effective in inflammation of the stomach and heart pain. It acts as an effective medicine for diarrhea, dysentery and many other ailments such as colitis, anemia, jaundice, high blood pressure, piles and arthritis.
- Peach juice contains vitamins A, C and B₁, sugar, fibre, calcium, iron, magnesium, manganese, sulphur, zinc and organic acids. It is good in heart problems, anemia, constipation, indigestion and digestive problems caused by anxiety and stress, kidney stones and urinary infections.
- Pear juice contains vitamins A, B, C, calcium, iron, magnesium, manganese, sulphur and zinc in sufficient quantities. It is an excellent treatment for arthritis, rheumatism and gout, due to its ability to dissolve uric acid crystals. It calms the nervous system, lowers high blood pressure, treats bladder problems such as cystitis and helps in prostate problems and asthma.
- Plum juice contains sugars, pectin, potassium, carotene, organic acids, vitamins C, B₁ and polyphenols. It is used for cholecystitis, liver, kidney and heart diseases.
- Prune juice is rich in vitamins, minerals and polyphenols which associate with digestive health benefit.
- Pulu (*Salvadora persica* L.) juice is very good source of different polyphenols, useful in rheumatism and scurvy and acts as antidote to poison. It is also useful in biliousness, asthma, cough, tumour and pile.
- Raspberry juice has iron, copper, potassium, pectin, fibre, tannins, organic acids, sugars, vitamins C, B₁, B₁₂, polyphenols and folic acid. It's most common use is to control cold and fever. It is also very useful in anemia, atherosclerosis, gastric and kidney diseases.
- Strawberry juice is a well-known food with many healing properties. It contains sugars, vitamin C, B complex, folic acid, carotene, fibre, pectin, cobalt, iron, calcium, phosphorus, manganese and organic acids such as citric, malic and salicylic acid. It is a successful fighter of eczemas and normalizes metabolism, helps in curing

heart, kidney and gastro-enteric diseases. It also brings positive effect in treatment of stomach ulcers, cholecystitis, gall bladder stones, intestinal infections, anemia and goitre.

- Tomato fruit juice stimulates food metabolism and reduces the risk of cancers. Its excellent nutritional composition is best for pregnant and lactating mothers.
- Watermelon juice contains vitamins C, B₁, B₂, carotene, folic acid, polyphenols, fibre, pectin, carbohydrates and potassium salts. It has beneficial effect on cardiovascular system, kidney pain, jaundice, clears urinary bladder and stomach, increases immunity and facial beauty. Its fibre content improves peristalsis and accelerates removal of excessive cholesterol. It is a perfect food for patients with gout, arthritis and diabetes and increases the sexual power.

3. Categories and Products of Fruit Juices

Juice is prepared by mechanically squeezing fresh fruits or is extracted with water. According to the CODEX general standard for fruit juices and nectars “fruit juices have the essential physical, chemical, organoleptic and nutritional characteristics of the fruit(s) from which it comes”. Properly extracted juices are very similar to the fruit as they contain most substances which are found in the original ripe and sound fruit from which the juice is made. Fruit juice is free of chemical preservatives and other additives except few like ascorbic acid is added in cloudy apple juice for preventing its browning. So, it is the major task of modern food technology to transfer the valuable fruit components into the juice and to produce stable products by physical means. Fruit juice is always 100 per cent pulp extracted from fruit and should not be confused with soft drinks or other refreshing drinks. Processing industry has brought revolution by producing varied fruit juices and their products for catering the ever demanding needs of the consumers.

3.1. Fruit Juice

Fruit juice is the extracted juice of fruit, which has not been concentrated. It is the liquid that is naturally contained in fruit tissue and is commonly consumed as a beverage or used as an ingredient or flavoring in foods. Juice is prepared by mechanically squeezing or macerating fruit pulp without the application of heat or any other artificial flavours, colours or additives except carbon dioxide and acidifying agents.

3.2. Fruit Nectar

Fruit nectars are the products obtained by adding water and sugar and/or honey to fruit juice. This type of fruit beverage contains at least 20 per cent fruit juice / pulp and 15 per cent total soluble solids (TSS) and also about 0.3 per cent acid (as per FSSAI specifications). Fruit nectar may be prepared by concentrated fruit juice, dehydrated/powdered fruit juice, fruit puree or a mixture of these products also.

3.3. Juice Drink

A blend of fruit juice(s) with other ingredients, such as high-fructose corn syrup and other nutritive bio-product with the objective to enhance taste, flavour, nutritive value and other organoleptic characters in the product is called a juice cocktail or juice drink.

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R.L.Bhardwaj is Assistant Professor- Horticulture at Krishi Vigyan Kendra- Sirohi, Maharana Pratap University of Agriculture and Technology-Udaipur, Rajasthan, India. He completed his Post Graduation in 2001 from Rajasthan College of Agriculture, Udaipur (MPUAT-Udaipur), Doctoral degree in Horticulture in 2005 from SKN College of Agriculture, Jobner (RAU- Bikaner) and successfully attained degree of MBA in Human Resource Development in 2009 from IGNOU-New Delhi. The author qualified National Eligibility Test (NET) in fruit science (Horticulture) subsequently in 2001 and 2003. The author joined Punjab National Bank (Farmers Training Centre- Neemrana, Alwar) as a Lecturer (Training Associate) on 14 Feb., 2005. He has more than 7 years of teaching, training, extension and research work experience in horticulture field. He has active participation in paper presentations at seminars and given several radio talks on horticultural aspects. His research interest is fruit juice blending for better nutritional and therapeutic properties in which he is working for last 8 years. The author has authored/ written research paper (published-16, under publication-7), abstract (2), review articles (published-3, under publication-1), booklets (5), book chapter (under publication-3), compendium (12), books (3) besides contributing over 125 articles to professional journals and magazines of horticulture, agriculture and management. His areas of interests are hi-tech horticulture, post harvest management of fruits and vegetables, natural resource management and human resource management in rural areas. He is also engaged in writing a book on agro-processing and post harvest management of fruits and vegetables. The author can be contacted at rajubhardwaj3@gmail.com.

Urvashi Nandal is a young and dynamic writer. She is achiever in life by excelling both in academics as well as extracurricular activities with varied interests and expert communication skills. She has done her Master of Science in Foods and Nutrition from Indira Chakravarty College of Home Science, CCS Haryana Agricultural University, Hisar in 2004. She has been a meritorious scholar and prolific writer endowed with good oratorical skills. She has been bestowed with two university gold medals and university merit scholarship throughout study period and remained topper throughout academics period.

Presently she is working as Assistant professor-Foods and Nutrition at Krishi Vigyan Kendra, Rajsamand, Maharana Pratap University of Agriculture and Technology, Udaipur where she has been awarded appreciation certificate for her outstanding contribution in women empowerment at district and university level. Her interaction with students, faculties and scientists coupled with radio talks and exchange with media gradually developed in her an interest for good and popular writing on current and scientific issues. Her flair of wide ranging reading and research resulted in her contributing many articles to newspapers, magazines, seminars and conferences; book chapters in edited books; various training manuals, compendiums, books, booklets and folders. She is working on nutritional and therapeutic uses of fruits and vegetables for improving the nutritional status of tribal and rural people since past 7 years aiming for nutritional and health security. Her areas of research interest are- therapeutic nutrition through fruits and vegetables, post harvest processing of fruits and vegetables and livelihood security of rural and tribals. The author can be contacted at nandalu@rediffmail.com.