International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2024; SP-7(4): 295-301
Received: 02-01-2024
Accepted: 06-02-2024

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Sector-based value addition of grapes

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DOI: https://doi.org/10.33545/2618060X.2024.v7.i4Sd.639

Abstract
Grapes (*Vitis vinifera*) are a widely consumed fruit for the table. Consuming grape and its products regularly is linked to a decreased prevalence of degenerative illnesses including cardiovascular disease and certain malignancies. The bioactive phenolic chemicals found in grapes have garnered the most attention recently. The most significant grape polyphenols are anthocyanins, flavanols and resveratrol because they have a wide range of biological affects, including antioxidant, cardio-protective, anticancer, anti-inflammatory, anti-aging, and antibacterial capabilities. Wine, dried fruit (raisins), and fresh table grapes are the three main uses for grapes. The seeds and leaves of the grapevine are used in herbal medicine, while the fruits are utilized as a nutritional supplement. The most important use of grapes is wine production, which consumes 50-75 percent of grapes, followed by fresh fruits, dried fruits, and juice. This review includes several value-added goods, health benefits, and nutritional components of grapes.

Keywords: Grapes, anti-oxidants, wine, nutrition

Introduction
India is the seventh biggest economy in the world concerning GDP (Gross domestic product). The horticulture industry, whose goods and services are extremely popular both inside and outside of India, accounts for the majority of the GDP distribution to the agriculture sector. One of India's most important fruit crops is grapes (*Vitis vinifera*), which can be purchased commercially in subtropical and temperate regions (Shinde *et al.*, 2016) [48]. Grapes (*Vitis vinifera*), which belongs to Vitaceae family is one of the most common and popular table fruit.In India, grapes are cultivated in an area of 162 million ha in which total productions 3490 metric tons and productivity is 21.54 tons/ha (NHB, 2022). India is the 2nd largest producer of fruits which again ranks 9th in the world in the production of grapes. Maharashtra is the leading producer of grapes in India (Shinde *et al.*, 2016) [48]. With an average yield of 30 t/ha, India's grapes were the most productive of the 90 countries that grow grapes worldwide. The grape is grown on the largest area, 250 thousand ha, and in 2012 and 2013, approximately 2689 thousand tons were produced. Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu, Punjab, Haryana, western Uttar Pradesh, Rajasthan, and Madhya Pradesh are India's major grape-growing states. The significant bringing in nations of India's grapes were Bangladesh, Netherland, UAE, UK, Rassia, Saudi Arabia, Thailand, Sweeden, New Zealand, Malaysia, Australia, Sri Lanka and Nepal separately contains around 87% of India's all out product of grape. Thompson seedless is the primary assortment of table grapes being developed (Bhosale *et al.*, 2016) [7].
Grapes is known as 'Queen of Fruits' (Bhosale *et al.*, 2016) [7]. The cultivation of grapes, also known as viticulture, is widespread in India because grapes are one of the most important agricultural products. There are 10, 000 distinct grape varieties in the world. The root, stem, leaf, cane, seed, fruits, skin, and pomace all contain a variety of phytochemical compounds. Proanthocyanins, stilbenoids, aromatic acids, phenolic compounds, and flavonoids are discovered.
Sugars make up a major amount of the soluble solid in grapes. The major sugars in the juice are glucose and fructose. The sugar content of mature grape juice ranges from 150 to 250 g/L. The primary sugar in unripe berries is glucose. During the ripening stage, glucose and fructose are normally present in equal proportions (1:1). The concentration of fructose in overripe grapes surpasses that of glucose. The glucose to fructose ratio varies somewhat amongst grape varietals

when mature. The sweetness of fructose, glucose, and sucrose varies greatly. The sweetness hierarchy is as follows: fructose is sweeter than sucrose, which is sweeter than glucose (Dharmadhikari, 1994) [13].

Grapes are low in sodium, fat, and cholesterol, but they have a lot of ascorbic acid, retinol, phosphorus, and caffeic acid, which is a powerful agent that fights cancer. Resveratrol, a well-known and biologically active component of grapes that is abundant in the flesh, is renowned for its numerous medicinal properties. It has high cancer prevention agent action. Resveratrol is also said to have strong chemopreventive and antineoplastic properties. Grapes contain phytoalexin, oleanolic acid and resveratrol, all of which have been linked to positive effects on health (Hussain *et al.*, 2021) [21].

Grape products and byproducts have excellent health benefits. Even vine pruning residue may be a source of health-promoting chemicals.Anohmic extract of vine pruning with a high polyphenol content was found to have anti-colorectal cancer characteristics, including sensitization to a chemotherapeutical medication.As a result, its incorporation into functional foods or nutraceuticals should be explored, particularly in the diets of patients undergoing certain anti-colorectal cancer treatments. Grape skin extract's bioavailable components were found to be capable of influencing critical biochemical processes implicated in the pathogenesis of diabetes, such as oxidative stress, inflammation, and glucose absorption (Kandylis, 2021) [26].

Value Added Products

Raisins

The raisins are the dried grapes. The Thompson Seedless white and hypersensitive grape assortments are utilized in the creation of best quality raisins. Grape is one of the significant natural product crops in India and as of now made an extraordinary progress by delivering world's best grapes with high efficiency level than some other country (Mandal and Thakur, 2015) [30]. Due to its prolific bearing and early ripening, the cv "Parlette" occupies more than 90% of Punjab's total grape area and is commercially grown in the plains of north-west India. The second most important product made from grapes is raisins obtained through drying and processing of berries. Essentially, dried Thompson Seedless or seedless varieties with moisture content of 15% or less are referred to as raisins or Kismish, while seeded varieties are referred to as Monukkass. Every year, India produces 12, 000 tons of raisins (Chadha, 1995) [11].

Dehydration, which reduces water activity and naturally prevents the fruit from deteriorating, is the best and fastest way to preserve fresh grapes. The primary benefit of grapes is their transformation into raisins through drying, which is a common processing method in most countries that produce grapes (Adiletta *et al.*, 2016) [2]. Also, drying is viewed as the most established and best strategy for saving food, including grapes. The water content in grapes is significantly reduced during the drying process, preventing the growth of microorganisms and preserving the fruit's quality for ambient storage. Additionally, grapes become lighter and smaller, making them easier to store in bulk, making them easier to handle, generating additional income, and reducing transportation costs (Prabhakar & Mallika, 2014) [38].

Pretreatment and drying conditions control the many desirable changes in physical, chemical, and biochemical properties that occur during dehydration. Fresh grapes' concentrated carbohydrate and organic compounds are retained in the raisins during drying. Among the categories of dried fruits, raisins typically contain a significant quantity of phenolic compounds and antioxidants, both of which are necessary for enhancing human health. During drying, these compounds cause the browning reaction, which is important for raisins final appearance when certain enzymes are present. Hence, choosing appropriate pretreatment and cost-effective drying innovations during the transformation of grapes into raisins is essential (Wang *et al.,* 2014) [53].

Different drying methods for making raisins

Solar drying

The most common method of using solar energy to dry agricultural products is solar drying. The normal open sun drying comprises of spreading the grapes in direct daylight until the expected dehydration is accomplished (Prakash & Kumar, 2013) [39]. Solar drying of grapes offers simplicity, feasibility, low costs, low temperature drying, and other benefits. Solar drying can be classified as direct, indirect, or mixed in grape-drying operations. Longer infrared wavelengths from the sun are caught by the glass above the grape bunches in direct type, warming and drying the grapes (Barnwal& Tiwari, 2008) [4]. However, direct sun drying results in grapes of poor quality, such as discoloration and loss of aroma as ascorbic acid and polyphenols are sensitive to light (Gee & Webb, 1980) [3].

Shade drying

The grape bunches were shade-dried by being placed in a dark, open area away from the sun, with adequate airflow typically provided by the surrounding environment. It is an alternative indirect method of using solar energy to dry grapes without using direct sunlight. Shade drying is regarded as a natural rack dryer because the ambient air serves as the primary source of drying. India, China, and Australia all have a lot of people who like it. As grapes are not directly affected by the sun, raisins that have been shade-dried have a higher color quality than raisins that have been sun-dried. However, high labor requirement, a long drying time, and the possibility of bird, insect, and mouse attacks are the difficulties of shade drying, which are similar to those of sun drying, making the processes unprofitable.

Hot air drying

Hot air drying is otherwise called plate drying, which involves hot air as a medium to make temperature slope among grapes and air with synchronous evacuation of dampness. The drying rate and final product quality are both affected by air temperature (Adiletta *et al.,* 2016) [1]. Due to the decreased diffusivity of the grapes as a result of their decreased moisture content, hot air drying typically results in a longer drying time. During hot air drying, the dampness is by and large diffuse in fluid stage in slender vessels of shifting width. The vapor that forms on the surface of the water moves toward the fruit's surface in these capillary vessels, where it is removed by the moving air. However, the interior portion retains some moisture while the portion closest to the fruit surface dries out earlier. As a result, the drying time is increased because the thermal energy takes longer to reach that part and the vapor produced during the process also takes longer to reach the surface. Hot air drying took 180 min to eliminate 65% of dampness from grapes. Sultana grapes were dried by hot air dehydration for 72 hours, reducing to 1 kg with final moisture content of 18% dry basis (Margaris & Ghiaus, 2007) [31]. The quality attributes of grapes, such phenolic content, anthocyanins, and cancer prevention agent movement, additionally diminished during hot air drying therapy contrasted with nonconventional therapy. However, hot air drying of grapes is preferred to sun drying due to its shorter drying time and higher retention of phenolic content, anthocyanin activity, and other quality attributes (Coklar & Akbulut, 2017) [12].

Microwave drying

The electromagnetic waves are created structure magnetron and afterward gave to grapes, which brings about the vibration of water atoms, and accordingly producing nuclear power. The grapes quickly dry out as a result of this energy's assistance in evaporating the moisture that is present (Michailidis & Krokida, 2014) [33]. The study of MW drying of grapes at 350 to 1, 000 W at 2, 450 MHz frequency shows that it takes 20 minutes to remove 60% of the moisture from the grapes, compared to 180 minutes for hot air tray drying at 60 °C, which takes 180 minutes. In addition, MW drying (750 W of MW power) held most noteworthy ascorbic corrosive substance, most noteworthy rehydration proportion, and great variety properties (brilliant yellow tone) contrasted with plate drying. Higher rehydration proportion showed lower shrinkage of raisins because of the age of inner tension slope, which moves the dampness from inside to outside, hence opposing shrinkage better than hot air plate dried grapes.

Vacuum drying

The drying system, which eliminates the air encompassing the item inside a shut chamber by a vacuum siphon, and results in lower strain for misleadingly expanding the water fume pressure contrast between the item and encompassing, is called vacuum drying. Vacuum drying makes it simple to remove the heat-sensitive food product's unbound moisture (Parikh, 2015) [36]. In the processing of raisins, where the grapes are dried under pressure below that of the atmosphere, the same method has been utilized with success. Because of the vacuum, more mass is transferred between the food and the environment, resulting in lower heat requirements and higher-quality products.

Infrared drying

Using radiation, heat is transferred from a hot object to food that is at room temperature through infrared heating or drying. Infrared radiation is any electromagnetic wave with a wavelength between 0.78 and 1, 000 μm. The heating element's temperature determines these wavelengths. At the point when the infrared waves fall into the profoundly soggy food, for example, grapes, a few pieces of energy get ingested, reflected, and just a negligible part of the infrared range passes into the material (Krishnamurthy *et al.*, 2008) [28]. To begin with, the outer layer of the grape is warmed through infrared waves and afterward because of temperature distinction, the intensity is moved to the inside of the grapes (Hebbar & Rastogi, 2001).Without heating the air surrounding the grapes, the intense heating reduces the temperature gradient quickly. Grapes dried as a result of the heating, primarily due to moisture migration in the vapor phase (Sharma *et al.*, 2005) [45]. The total diffusivity values did not change as a result of the grape's decreased moisture, which decreases gradually during conventional hot air drying. According to the findings of the experiments, the most effective power for drying one grape using infrared radiation is 2.63 W. Berry skins become scorched when this power is extended (Utgikar *et al.*, 2013) [52].

Juice

Grape juice is obtained from pulverizing and mixing grapes into a fluid. It has a flavor that is both sweet and acidic. Grape juice could also be further processed, like pasteurized, to make it taste better and last longer. In addition to being produced as juice and exploited for wine production, the juice is also widely used as a natural sweetener in a number of industries, with Brazil, Spain, and the United States being the primary producers (Margraf *et al.*, 2016) [32]. The nature of grape juice to a great extent relies on sugar level, corrosive substance, and flavor constituents, for example, methyl anthranilate and different volatiles, tannins, and variety substances (Robinson *et al.*, 1949) [41]. The quality of the juice is determined by the changes that grapes undergo during growth and maturation. Normal corrosiveness, variety, and smell of new grape berries give quality in single-strength concord grape juice (Robinson *et al.*, 1949) [41]. Acidity above 0.85% brings about juice that is excessively tart. Sugar might be added for improving, yet the words sugar added should be put on the name. Anthocyanin pigments, which are found in and near the skin, account for the majority of the color in grape juice. The sorts and amounts of anthocyanin shades are different among grape species. The different types of anthocyanin help to explain why some grapes are better suited for juice processing and have better color stability than others (Ribereau-Gayon, 1959) [42]. The juice's sugar concentration is frequently reported in units of °Brix. The °Brix measurement denotes grams of sugar per 100 grams of juice (Dharmadhikari, 1994) [13].

Methods of juice extraction

Hot press

Techniques for commercial preparation of grape juice have gone through consistent change. In most business tasks, the continuous pressing strategy is utilized. To make hot-press juice, a pectolytic enzyme is added to break down the naturally occurring pectins. Paper pulp or rice hulls are used to make juice extraction easier. Compared to a cold-press juice operation, a hotpress method yields more juice with higher total solids, nonsugar solids, tannins, pigments, and other substances. In hot-pressing, grape juice can be produced with uniform color from grapes harvested throughout the season by varying the processing temperature and time. Unreasonable extraction temperatures (surpassing 65°C, or 150°F) should be kept away from to save juice quality (Sistrunk, 1976; Sistrunk and Morris, 1982; Pederson, 1971; Morris *et al.*, 1986) [49, 50, 37, 34].

Cold-press

The steps that allow for heating the crushed berries to 60-63°C (140-145°F) and holding them in tanks containing pectolytic enzymes are the only differences between this method of producing juice and the hot-press methods. The dark color from the dark-skinned grapes is not extracted without these steps, and the juice is light in color. Addition of enzymes to the cold press juice to work with the clarification and filtration process following cold adjustment (Morris *et al.*, 1998) [35].

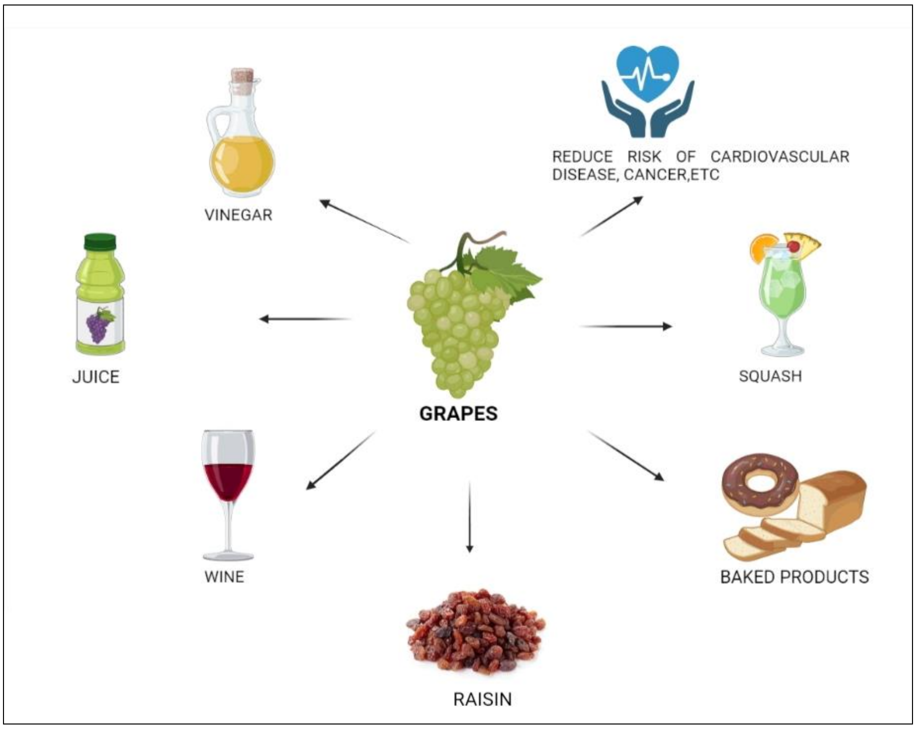

Fig 1: Value added products of grapes

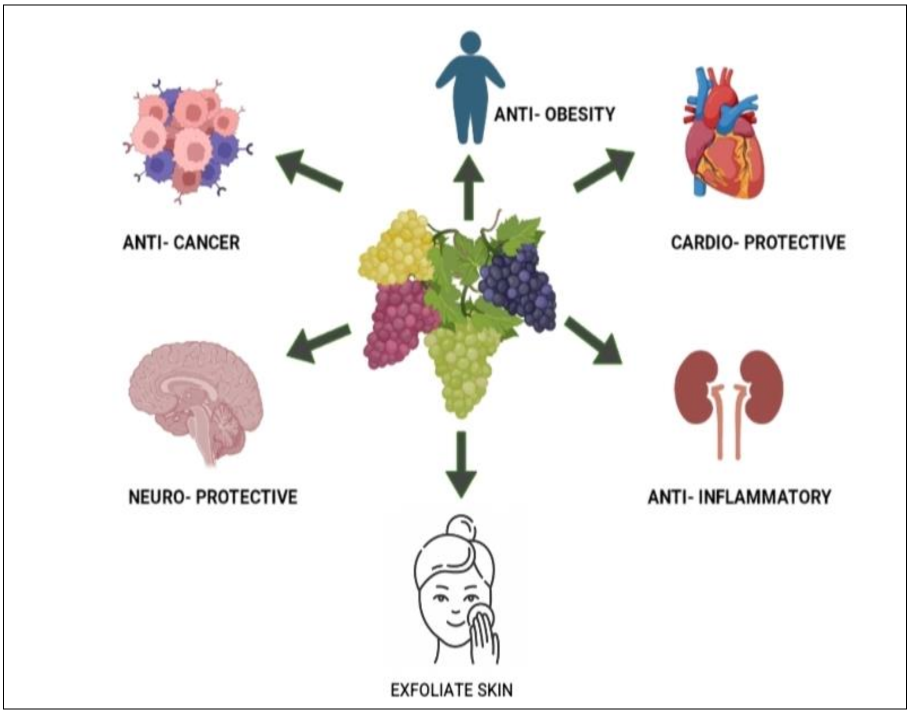

Fig 2: Grapes phytochemicals and its health benefits

Squash

Squash is a concentrated, non-alcoholic syrup with a fruity flavor that is typically made from fruit juice, water, sugar or a sugar substitute. Before drinking squash, it must be mixed with some water or carbonated water (Joseph & Shukla, 2015) [25]. The squash importance is its nutritional content and delicious flavor. The grape squash contains vitamin A, vitamin C and potassium. Wild range of juice varieties belonging to *Vitis venifera* and *Vitis labrusca* and their hybrids are available. Grapes can be utilized for preparations of squashes and they are in small scales in many parts of the country. Squash's nutritional value and delicious flavor are its main attributes. Vitamin A, vitamin C, and potassium are found in the grape squash.

The juice was extracted from fresh, fully ripe grapes. Grapes were washed completely with water. Separate weights were taken for the required sodium benzoate, sugar, and grape juice. A measuring cylinder was also used to measure water. A high-quality electric juicer was used to extract juice from grape bunches after they were weighed. The seeds were removed from the juice after it was properly strained. To make syrup, water, sugar, and citric acid were heated together. Cooled the syrup after passing it through a coarse cloth. The cool syrup was then mixed with the measured juice. After that, sodium benzoate of 2 g/l was added. After thoroughly mixing it, squash was prepared. Finally, it was poured into a sterilized bottle and sealed.

The following steps used in grapes squash are:

Collection of fruits
↓
Washing the fruits
↓
Trimming them if needed
↓
Juice extraction
↓
Straining of the juice
↓
Juice measuring
↓
Preparation of syrup {water+ sugar +citric acid (10 g per lit juice) heat to dissolve}
↓
Cool the syrup and filter it
↓
Add the syrup to fruit juice and mix
↓
Add preservative and mix well
↓
Cool it for some minutes
↓
Bottling
↓
Capping
↓
Storage

Wine

Wine is typically made from fermented grapes and is an alcoholic beverage. The red grapes used to make red wine actually have a color closer to that of black. There are numerous varieties of red wine. This is regarded as the most traditional wine in the kingdom of wines because it combines delicious red grapes with a wide range of aromas, including oak, eucalyptus, chocolate, and even hints of mint. The majority of black grapes produce a greenish-white juice; the red variety comes from anthocyanin colors present in the skin of the grape (Swami *et al.*, 2014) [51].

Natural product wines are undistilled alcoholic beverages normally produced using grapes or different organic products like peaches, plums or apricots, banana, elderberry or black current and so forth which are more nutritious, tastier, and mild stimulants. These fruits go through a fermentation and aging process. They normally have a liquor content running between 5 to 13 percent. Wines created from fruits are sometimes called after the fruits themselves. Except for water and milk, no other beverage has achieved as broad acceptance and appreciation as wine. Wine is a food that tastes like fresh fruit and can be transported and stored in the current conditions. Wine is a fermented, undistilled product based on fruits that contains the majority of the nutrients found in the original fruit juice. The nutritive worth of wine is expanded because of released of amino acids and different supplements from yeast during aging. Fruit wines have an energy value of 70 to 90 kcal per 100 mL and range in alcohol content from 8 to 11 percent to 2 to 3 percent sugar (Swami *et al.*, 2014) [51].

Ethyl alcohol, sugar, acids, higher alcohols, tannins, aldehydes, esters, amino acids, minerals, vitamins, anthocyanins, and other minor components like flavoring compounds are all found in a typical bottle of wine (Amerine *et al.*, 1980) [3]. This product, which was mentioned in the Bible and other Asian documents, is probably the oldest fermented beverage. Wines are categorized as natural wines (with 9-14% alcohol) or dessert and appetizer wines (with 15-21% alcohol) based on a variety of factors, including the cultivar, the stage of fruit ripening, the chemical composition of the juice, the addition of additives, vinification methods and aging, and the alcohol and sugar content. Sweet wine, cherries, vermouth, and port wines are considered dessert and appetizer wines, while dry wine, sweet table wine, specialty wine, champagne, muscat, and burgundy wines are considered natural wines (Amerine*et al.*, 1980) [3]. There are primarily three types of operations involved in winemaking: pre-maturation, aging and post fermentation tasks (Iland *et al*., 2000; Jackson, 2000; Ribéreau-Gayon*et al.*, 2000) [22, 24, 43]. Pre-fermentation is the process of crushing the fruit and releasing the juice in grape-based wines. White wine has its juice separated from the skin, whereas red wine does not have its skins separated from the juice. Sedimentation or centrifugation is typically used to clear juice for white wine. The clarified juice is then given yeast to start the fermentation process.

In red winemaking, the mash, skins and seeds of grapes are mixed subsequent to pounding and during all or part of the aging. The purpose of this is to extract flavor and color. Yeast is added to crush mash in red winemaking. The sugars in the juice undergo a reaction during fermentation, resulting in the production of alcohol and carbon dioxide. During the fermentation process, yeasts make use of the sugars. When yeasts don't use all of the sugar they have, the fermentation slows down or stops. This is called a stuck fermentation. Racking, filtration, and/or centrifugation are all methods of clarification. In this unconventional method of winemaking, fermentation takes place in anaerobic conditions and can be boosted with di-ammonium phosphate (DAP) to provide additional nitrogen for yeast growth. After fermentation has reached the desired stage or been completed, post-fermentation practices are carried out. Wine is racked from yeast lees here, typically in stainless steel or oak barrels. The wine can be filtered, cold stabilized, fined, or blended while it is in storage. enzymes, bentonite, diatomaceous earth, egg albumen, and other fining agents can be purchased commercially and added to wines to help clarify them. Throughout its maturation and at the appropriate stage, wine undergoes ongoing changes; the wine is separated and packaged (Swami *et al.*, 2014) [51].

Vinegar

Traditional vinegar is produced from fruit juices such as grape, apple, plum, coconut and tomato, rice, and potato. Acetic acid bacteria (AAB) are all over the environment. They may propagate in food materials which contain sugar or in the fermented products which contain alcohol. Vinegar is produced from raw materials containing starch or sugar via sequential ethanol and acetic acid fermentations and is used in a variety of food applications Grape, apple, and other fruit juices are the primary starting materials used for vinegar production although rice vinegar, malt vinegar, and beer vinegar are also produced in some countries. The production of vinegar typically involves a first fermentation where simple sugars in raw material are converted to alcohol by yeasts. The resultant alcohol is further oxidized to acetic acid by Acetic acid bacteria (AAB) during the last fermentation (Gullo and Giudici, 2008) [19].

Several methods of vinegar production exist but primarily 2 methods are used commercially. The first is a traditional method of growing AAB culture on the surface of wood shavings and providing oxygen to the surface referred to as surface method. The other method, which is to produce oxygen in the fermentation process for accelerating industrial production, is called submerged culture. (Budak *et al.*, 2014) [9]. The traditional grape wine vinegar contains a higher proportion of chlorogenic acid and syringnic acid than industrial grape wine vinegar. Industrial vinegar, on the other hand, had higher levels of catechin compared to traditional wine (Budak*et al.*, 2010) [8].

Nutracueticals

The value of grape juice is considerable, which makes it a valuable commodity. It's been widely used by consumers in the past. In Turkey, grape juice is obtained from the use of grapes for a vast majority of conventional grape products including pekmez, pestil and kofter. Lately, there has been a growing interest in grape seed. As a natural antioxidant, both juice and seeds are accepted. Grape cultivars' peel, pulp, and seed samples were often compared for total phenolic content and antioxidant activity, and comparative studies using seeds and juices of various grape cultivars appear to be quite rare (Settar *et al.*, 2022) [47]. Grape intake has been related to a reduced risk of cardiovascular disease, some forms of cancer, and other chronic disorders. Grapes have been demonstrated *in vitro* and *in vivo* to have a powerful antioxidant effect on cancer cell growth, platelet aggregation, and cholesterol levels. Grapes include antioxidants such as proanthocyanidins, anthocyanins, phenolic acids, stilbenes, and other phytochemicals.

Other inflammatory gastrointestinal illnesses are avoided by grape phytochemicals. Anti-inflammatory effects can be managed with the use of phytochemicals and vitamin D. The term "phytochemicals" refers to a set of different compounds, including terpenoids, carotenoids, and flavonoids, that are present in fruits and vegetables. Different grape varieties' skins and seeds contain a variety of phytochemicals. Grape phytochemicals, such Grape Seed Extracts (GSE), have already been utilised to regulate inflammatory reactions and lessen the expression of factors linked to inflammation, protecting health.

Byproducts of grapes

Grape byproducts can boost the nutritional content of baked goods, pastries, and pasta due to their high concentration of phenolic chemicals and dietary fibre. The viscoelastic behaviour of the combination, as well as the textural and tactile aspects of manufactured goods and pasta containing grape results, are determined by the expansion level and molecule size. As a result, the ideal quantity of finer grape byproducts flour must be identified in order to minimise negative impacts on end product quality, such as poor loaf volume and bad sensory and textural qualities. It is also desirable to increase the quantity of fibre and antioxidant substances in the product to improve its nutritional and functional value. (Iuga and Mironeasa, 2020) [23]. Grape pomace from winemaking is already being utilised on an industrial basis to extract anthocyanins. Increased efforts are now being made to obtain high-value co-products such as natural health remedies, food supplements, and novel nutrifunctional food ingredients from wine processing residues, or to use the material for enzyme production via solid state fungal fermentation (González *et al.*, 2010) [18].

Conclusion

Different research has been undertaken on the different components of grapes, and pharmaceutical and nutraceutical businesses have created this plant as a cure. Although most grapes are now processed into wine, the development of grape post-harvest technologies has focused on fresh fruit. This is because the commercial product must me*et al*l of the eating-quality requirements (appearance, texture, and taste). The quality of grapes for wine, drying, or other grape products is mostly determined by harvesting the appropriate varietals at the appropriate time and avoiding undesirable chemical changes during processing. New study has also shown that grapes can help with other chronic-degenerative diseases like cancer, Alzheimer's disease, age-related cognitive decline, and diabetes. Grapes have also been linked to improved dental health, immunological function, and antiviral activity. To make grape farming more sustainable, it is vital to reduce the resources used in cultivation and processing, as well as waste creation, and to make good use of byproducts.

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