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Berries: The Ultimate Superfood for Human Health and Nutritional Security

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ABSTRACT
Berries have many health benefits and are a great source of antioxidants, phytochemicals, and vital nutrients. A wide range of nutrients, including sugars, essential oils, carotenoids, vitamins, minerals, and bioactive non-nutrients like flavonoids, stilbenes, lignans, and tannins, are present in berries, which is an intriguing feature. Berries have been associated with decreased inflammation, better cardiovascular health, decreased risk of chronic diseases like cancer, diabetes, and obesity, and improved cognitive performance. In addition to providing protection against oxidative stress, berries' high antioxidant content enhances general wellbeing. Berries are prized for their distinct flavor, high phenolic content, and sweet scent. Berries like blueberries, strawberries, raspberries and blackberries are excellent choices for both heart and skin as they are rich nutrient content protecting our cells, these plants compounds may reduce disease risk. Numerous studies have even demonstrated that, among frequently consumed fruits, blackberries and raspberries have the highest antioxidant activity, followed by pomegranates. In addition to highlighting the possible health advantages of berries, the review underlines their nutritional worth.
Keywords: *Antioxidants, Berries, Flavonoids, Inflammation, Phenolic acid, Phytochemicals, Stillbenes.*

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INTRODUCTION

Berries are a type of fruit that belongs to the botanical family of “simple fruits” or “accessory fruits”. They are typically small, fleshy and sweet, with a soft exterior and a juicy interior. The ovary of a flower, which houses the seeds, forms berries, which can be aggregation fruits like raspberries or single fruits like strawberries. As "juicy foods," berries are primarily composed of water and have a pleasant scent. Berries are a good source of vitamin C, a potent antioxidant. (Suvetha and Shankar; 2014) Since ancient times, berries have played a significant role in human diets by supplying antioxidants, fiber, and other necessary elements. They are also abundant in phytochemicals, which have been demonstrated to have cardioprotective, anti-inflammatory, and anti-cancer effects. Akimov *et.al*; (2021). Berries are typically eaten as fresh fruits, but there are also a broad variety of technology goods available, such as beverages and confections, which have been increasingly popular in recent years due to consumer awareness of processed "berry-loaded" foods. With over 200 species consumed worldwide, berries are one of the most varied and widely consumed fruit groupings. They come in a variety of colors, shapes, sizes, and flavors, ranging from the well-known raspberries, blueberries, and strawberries to the more unusual goji berries and acai berries. Polyphenol chemicals found in fruits, such berries, are said to have anti-inflammatory properties in people. Anthocyanins, which give berries their characteristic red, blue, and purple hues, are among the most prominent polyphenols found in berries. Berries have received a lot of attention lately because they are a nutrient-dense fruit that is not only tasty but also has a high nutritional value and possible health advantages. Ancient societies valued berries for their taste, nutritional content, and therapeutic qualities, making them a staple food in many cultures for ages. These days, berries are still prized for their distinct tastes, textures, and possible health advantages, which include lowering inflammation, enhancing cardiovascular health, and promoting mental clarity. Because of their cultural significance, rich history, and rising popularity, berries are an intriguing and delectable subject to study. Berries can be eaten fresh, frozen, dried, juiced, or made into sauces, preserves, and jams. Studies on human intervention have shown notable improvements in LDL oxidation, lipid peroxidation, total plasma antioxidant capacity, dyslipidemia, and glucose metabolism when utilizing purified anthocyanin extracts or fresh, juiced, or freeze-dried

strawberries, cranberries, blueberries, and chokeberries Basu *et.al*; (2010). They are also quite adaptable. In addition to being used in traditional medicine, cosmetics, and as natural food colorings, they are a common element in baked products, sweets, salads, smoothies, and savory foods. From the standpoint of a breeder, the availability of "highly nutritious berries" with improved health-promoting qualities would be a powerful advantage, motivating berry growers and customers both. The phenolic content of fruits together with their antioxidant efficacy has been suggested as a standardized technique for assessing fruit germplasms Labanca *et.al*; (2017). Berries have been a part of human history for thousands of years, with evidence of berry consumption dating back to ancient civilizations. Early berry intake in ancient civilizations (3000 BCE–500 CE): Berries were probably among the first fruits that early humans ate. Berries may have been consumed by ancient Middle Eastern, European, and Asian civilizations, according to archeological data. Ancient Egypt: In ancient Egypt, berries were regarded as a luxury cuisine. They were used to make jams and preserves, consumed raw, and even utilized in medicine. Ancient Greece and Rome: In ancient Greece and Rome, berries were a common meal. They were consumed raw, added to desserts, and even used as money. Middle Ages (500–1500 CE): Berries were mostly utilized for medicinal purposes at this time. They were used to cure a variety of illnesses and were thought to have therapeutic qualities. Food Preservation: Jams, preserves, and other confections were also made with berries. During the winter, these preserved berries were a great source of nourishment. Exploration Period (1500–1800 CE) New World Discoveries: New berry species were found in the new world during the period of exploration. Exotic berries including cranberries, blueberries, and strawberries were brought back by European colonists Large-scale berry production was made feasible by new farming techniques and technologies. In order to create new berry types with enhanced flavor, texture, and disease resistance, berry breeding programs were launched in the 20th century. Indigenous Peoples use about 200 varieties of berries for food and medicine, and they are one of the plant foods with the greatest nutritional and cultural value. The availability, accessibility, and consumption of berries are being progressively threatened by changes in the environment and land use (Mucioki, 2024). Global Berry Trade: Berries are now farmed and traded all over the world. Customers may now enjoy a variety of berries all year round because to the growth of foreign trade. Current Patterns: Growing Demand for Berries: Because of their versatility in baking and cooking as well as their alleged health benefits, berries have seen a rise in demand in recent years. Chemical extracts from berries preserve mitochondrial activity, proteins, and calcium homeostasis Maryam *et.al*; (2022). Sustainable Berry Production: As more farmers embrace organic and regenerative farming methods, there is a rising movement toward sustainable berry production. New berry Varieties: Breeding efforts for berries are constantly creating new berry varieties with distinctive tastes, textures, and hues. All things considered, berries have a long and intricate history that dates back thousands of years. From ancient civilizations to modern- day commercial production, berries have played an important role in human culture and cuisine.

1. Acai berry 2. Bayberry 3. Bearberry

4. Blackberry

5. Black currant

6. Black mulberry

7. Blueberry

8. Boysenberry

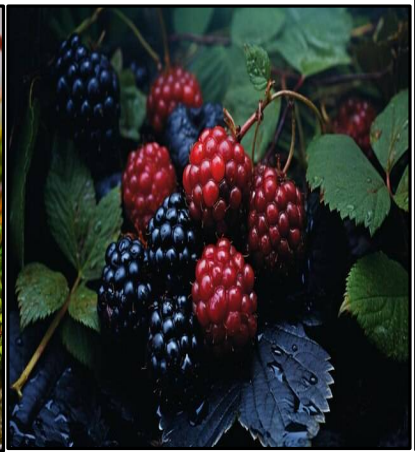
9. Caperberry

10. Chokecherry

11. Cloudberry

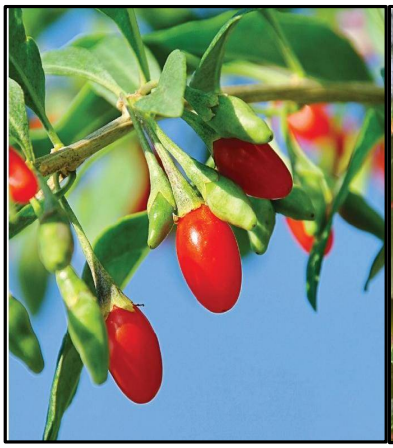
12. Cranberry

13. Crowberry



14. Dewberry

15. Elderberry



16. Goji berry/ wolf berry 17. Hardy Kiwi/Kiwi Berry 18. Huckleberry Bilberry



19. Lingonberry 20. Raspberry 21. Red currant




22. Red mulberry 23. Salmon berry 24. Red chokeberry 25. Gooseberry



26. Saskatoon berry/ Juneberry 27. Sea Buckthorn 28. Strawberry

Fig: 1Different Types of Berries

Table 1: Edible berries

S.No.	Common name	Scientific name	Center of origin
1.	Acai berry	*Euterpe oleracea*	Northern Brazil
2.	Bayberry	*Morella pensylvanica*	North America (coastal regions)
3.	Bearberry	*Arctostaphylos uva-ursi*	South-western China
4.	Blackberry	*Rubus argutus*	Armenia
5.	Blueberry	*Vaccinium corymbosum*	North America
6.	Black Currant	*Ribes nigrum*	Northern Europe
7.	Black Mulberry	*Morus nigra*	Western Asia (Iran and Afghanistan)
8.	Boysenberry	*Rubus ursinus x Rubus idaeus x Rubus fruticosus*	Anaheim, California
9.	Caperberry	*Capparis spinosa*	Native of Mediterranean from Canary Islands and Morocco to Crimea and Armenia
10.	Chokecherry	*Prunus virginiana*	North America
11.	Cloudberry	*Rubus chamaemorus*	North of Sweden
12	Cranberry	*Vaccinium subgenus oxycoccos*	North-eastern, North America
13.	Crowberry	*Empetrum nigrum*	The Arctic and subarctic regions of the Northern Hemisphere, including northern Europe, Asia and North America
14.	Dewberry	*Rubus ursinus*	North America
15.	Elderberry	*Sambucus nigra*	Europe
16.	Goji berry/Wolfberry	*Lycium barbarum*	China
17.	Gooseberry	*Ribes uva-crispa*	North-eastern and north-central United States and the adjacent regions of Canada
18.	HardyKiwi/Kiwi Berry/Siberian Gooseberry	*Actinidia arguta*	Russian Far East Native to China, Korea and Japan
19.	Huckleberry/Bilberry/ European berries	*Vaccinium membranaceum Dougl*	The Andes and other mountainous regions of South America, Eastern North America
20.	Lingonberry	*Vaccinium vitis-idaea*	Native to the Scandinavian region of Northern Europe
21.	Raspberry	*Rubus idaeus*	Turkey
22.	Red Chokeberry	*Aronia arbutifolia*	Eastern Canada and the Central and the Eastern United States
23.	Red Currant	*Ribes rubrum*	Europe and Asia
24.	Red Mulberry	*Morus rubra*	Eastern and central North America
25.	Salmonberry	*Rubus spectabilis*	North of Sweden
26.	Saskatoon Berry/Juneberry	*Amelanchier canadensis*	Western Canada
27.	Sea Buckthorn	*Hippophae rhamnoides*	Europe and Asia
28.	Strawberry	*Fragaria ✕ ananassa*	Brittany, France

Waiker and Mandave, (2023)

Classification of Berries:

S. N	Common name	Kingdom	Order	Family	Genus	Species	Chromosome no
1.	Acai berry	Plantae	Arecales	Arecaceae	Euterpe	*E.oleraca*	2n=2x=26
2.	Bayberry	Plantae	Myrtales	Myricaceae	Morella	*M.pensylvanica*	2n=2x=16
3.	Bearberry	Plantae	Ericales	Ericaceae	Arctostphylos	*A.uva-ursi*	2n=2x=26
4.	Blackberry	Plantae	Rosales	Rosaceae	Rubus	*R fruticosus*	2n=2x=14, 2n=3x=21
5.	Blueberry	Plantae	Ericales	Ericaceae	Vaccinium	*V.corymbosum*	2n=2x=24
6.	Black Currant	Plantae	Saxifragales	Grossulariaceae	Ribes	*R. nigrum*	2n=2x=16
7.	Black Mulberry	Plantae	Rosales	Moraceae	Morus	*M.nigra*	2n=2x=14

8.	Boysenberry	Plantae	Rosales	Rosaceae	Rubus	*R. urisnus x R.idaeobatus*	2n=7x=63
9.	Caperberry	Plantae	Brassicales	Capparaceae	Capparis	*C. spinosa*	2n=2x=14
10.	Chokecherry	Plantae	Rosales	Rosaceae	Aronia	*A.arbutifolia*	2n=2x=34
11.	Cloudberry	Plantae	Rosales	Rosaceae	Rubus	*R.chamaemorus*	2n=7x=63
12	Cranberry	Plantae	Ericales	Ericaceae	Vaccinium	*V.macrocarpon*	2n=2x=24
13.	Crowberry	Plantae	Rosales	Rosaceae	Rubus	*R. chmaemorus*	2n=2x=26
14.	Dewberry	Plantae	Rosales	Rosaceae	Rubus	*R. trivialis*	2n=2x=14
15.	Elderberry	Plantae	Adoxales	Adoxaceae	Sambucus	*S.nigra*	2n=2x=18
16.	Goji berry/Wolfberry	Plantae	Solanales	Solanaceae	Lycium	*L.barbarum*	2n=2x=24
17.	Gooseberry	-	-	-	-	-	-
18.	HardyKiwi/Kiwi Berry/Siberian Gooseberry	Plantae	Ericales	Actinidiaceae	Actinidia	*A.arguta*	2n=2x=58
19.	Huckleberry/Bilberry / European berries	Plantae	Ericales	Ericaceae	Vaccinium	*V.membranaceum*	2n=2x=24
20.	Lingonberry	Plantae	Ericales	Ericaceae	Vaccinium	*V.vitis-idaea*	2n=2x=24
21.	Raspberry	Plantae	Rosales	Rosaceae	Rubus	*R. idaeus*	2n=2x=14
22.	Red Chokeberry	Plantae	Rosales	Rosaceae	Aronia	*A.arbutifolia*	2n=34
23.	Red Currant	Plantae	Saxifragales	Grossulariaceae	Ribes	*R.rubrum*	2n=16
24.	Red Mulberry	Plantae	Rosales	Moraceae	Morus	*M.rubra*	2n=28
25.	Salmonberry	Plantae	Rosales	Rosaceae	Rubus	*R.spectabilis*	2n=7x=63
26.	Saskatoon Berry/Juneberry	Plantae	Rosales	Rosaceae	Amelanchier	*A.alnifolia*	2n=34
27.	Sea Buckthorn	Plantae	Rosales	Elaeagnaceae	Hippophae	*H.rhamnoides*	2n=24
28.	Strawberry	Plantae	Rosales	Rosaceae	Fragaria	*F.x ananassa*	2n=8x=56

Health Benefits of Berries:

Berries are nutritious and packed with antioxidants, vitamins and Minerals that provide numerus health benefits.

Biologically active ingredients:

1.According to the study, practically every ingredient found in fruits and berries is thought to be biologically active and energetic.

2. Tannins, polysaccharides, alkaloids, vitamins, flavonoids, and other trace elements, on the other hand, are vital bioactive substances that improve the fruit's taste, sugar, and fiber ratios both quantitatively and qualitatively Bilawal *et.al*; (2023).

3. They also have a number of biological benefits, such as anti-inflammatory, antidiabetic, antioxidant, and anti-cancer effects.

Antioxidant Properties:

1. High in Antioxidants: Antioxidants such as quercetin, ellagic acid, and anthocyanins, which help shield cells from harm and lower inflammation, are abundant in berries.

2. Cell Protection: The anti-oxidant qualities of berries protect cells from oxidative stress, which can lead to long-term conditions like cancer, heart disease, and dementia.

Heart Health:

1. Cardiovascular Health: By lowering blood pressure, cholesterol, and inflammation, berries' fiber, potassium, and antioxidants promote heart health.

2. Better Blood Lipids: The soluble fiber in berries can help raise HDL (or "good") cholesterol and decrease LDL (or "bad") cholesterol.

Anti-Inflammatory Effects:

1. Decreased Inflammation: The anti-inflammatory qualities of berries' antioxidants and polyphenols may help lessen the symptoms of inflammatory disorders like gout, arthritis, and others.

2. Better Cognitive Performance: Antioxidants and flavonoids included in berries may help lower inflammation in the brain, which could enhance cognitive performance and lower the risk of age-related cognitive decline.

Cancer Prevention:

1. Cancer Prevention: It has been demonstrated that berries' antioxidants, anthocyanins, and other phytochemicals have anti-cancer qualities, especially in lowering the incidence of oral, esophageal, and colon cancers. Vilaplana *et.al*; (2016).
2. Inhibition of Tumor Growth: Extracts from berries have been shown to stop the spread of cancer cells and cause apoptosis, or the death of cells, in a number of cancer types.
3. As a prebiotic, blackcurrant powder decreased the activity of some colon cancer markers.

Digestive Health

1.Supports Healthy Gut Bacteria: Berries are a rich source of prebiotic fiber, which helps feed the good bacteria in the gut, promoting a healthy gut microbiome.
2.Relieves Constipation: Berries fiber content can help regulate bowel movements, preventing constipation and promoting regularity.

Immune System Support

1. Boosts Immune System: Berries antioxidants and polyphenols may help support the immune system by reducing oxidative stress and inflammation.
2. Reduce Severity of Illnesses: Berries immune-boosting properties may help reduce the severity and duration of illnesses like common cold and flu.

Other Benefits

1.Supports Healthy Bones: Berries are a good source of Manganese, copper and other minerals essential for bone health.
2.May Help Manage Blood Sugar: Berries fiber and antioxidants may help regulate blood sugar levels and improve insulin sensitivity.
3.Supports Healthy skin: Berries antioxidant and Vitamins may help protect the skin from damage, promoting healthy aging and reducing the appearance of fine lines and wrinkle.

Nutritional Composition:

	Acai berry	Bayberry	Bearberry	Blackberry	Blueberry	BlackCurrant	Blackmulberry	Boysenberry	Caperberry	Chokecherry	Cloudberry	Cranberry	Crowberry	Dewberry
Energy (Kcal)	354	61	44	64	57	63	43	55	23	55	46	46	43	51
Protein (g)	4.3	0.7	1.1	1.5	0.7	1.4	1.4	1.1	2.4	1.4	1.4	0.5	1.1	1.2
Fat (g)	32.3	0.2	0.5	0.7	0.3	0.4	0.5	0.6	0.4	0.5	0.9	0.2	0.7	0.6
Carbohydrate (g)	33.5	15.3	11.5	14.7	14.5	15.4	10.9	13.3	5.4	13.3	11.3	11.9	10.3	12.2
Fiber (g)	7.1	4.3	4.8	5.3	2.4	4.8	1.7	3.1	2.2	3.1	3.6	2.3	2.5	3.2
Sugars (g)	1.3	7.3	4.6	4.9	9.6	7.3	8.1	7.4	1.2	6.2	4.8	4.3	4.2	5.1
Vitamin A (µg)	15.4													
Vitamin C (mg)	1.3	10	10	30	10	181	6.7	30	4	10	10	3.6	10	30
Vitamin E (mg)	1.4	1.2	1.2	1.2	0.8	1.1	1.1	1.2	0.9	1.2	1.1	0.5	1.1	1.2
Vitamin K	2.4µg	14.6mcg	25.6mcg	25.6mg	18.3mcg	25.6mcg	7.8mcg	20.6mcg	24.6mcg	19.8mcg	15.6mcg	5.1mcg	15.6mcg	20.6mcg
Folate (mcg)				20	6	10	6	10	13	6	10	7	6	10
Calcium (mg)	40	13	20	32	6	55	39	25	40	20	25	8	20	25
Iron (mg)	1.2	0.3	0.5	0.6	0.4	1.3	1.8	0.6	1.1	0.7	0.6	0.2	0.6	0.7
Magnesium (mg)	40	6	8	20	6	13	18	12	20	10	10	6	8	12
Potassium (mg)	450	7.3	140	162	77	322	194	162	124	142	140	25	120	150
Zinc (mg)	0.6	0.1	0.2	0.5	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.1	0.2	0.3

	Elderberry	Gojiberry	Gooseberry	Hardy Kiwi	Huckleberry	Lingonberry	Raspberry	Redchokeberry	Redcurrant	Redmulberry	Salmonberry	Sakatoonberry	Seabuckthorn	Strawberry
Energy (Kcal)	73	68	44	61	64	46	33	55	63	43	50	71	83	33
Protein (g)	0.7	3.1	0.9	1.2	1.1	0.7	1.2	1.4	1.4	1.3	1.2	1.1	1.2	0.7
Fat (g)	0.5	0.4	0.2	0.5	0.7	0.5	0.7	0.5	0.2	0.5	0.6	0.6	3.3	0.3
Carbohydrate (g)	18.4	16.4	10.2	14.7	15.7	11.5	8.4	13.3	15.4	10.2	12.2	17.7	15.4	8.1
Fiber (g)	5.2	2.4	4.3	2.5	3.6	3.5	4.8	3.1	4.3	2.2	3.8	5.9	3.9	2
Sugars (g)	4.7	8.2	6.3	8.6	8.1	5.4	4.4	6.2	7.3	7.3	6.2	6.9	6.2	5.7
Vitamin A (µg)														
Vitamin C (mg)	4.3	2.3	27	93	10	11	26	10	41	13	30	3.6	120	59
Vitamin E (mg)	1.1	1.3	0.5	1.5	1.2	1.2	1.2	1.2	0.5	0.7	1.1	1.2	3.2	0.3
Vitamin K (mcg)	6.5	13.6	11.3	40.3	18.3	15.6	12.2	14.8	11.3	7.8	15.6	15.6	25.6	2.2
Folate (mcg)	5	10	6	25	5	2	9	6	8	6	10	5	10	10
Calcium (mg)	23	28	25	34	20	15	25	20	33	20	25	39	24	16
Iron (mg)	0.4	1.3	0.3	0.5	0.6	0.3	0.7	0.7	0.6	0.7	0.6	0.8	1.2	0.4
Magnesium (mg)	11	11	16	17	8	6	22	10	11	10	12	24	37	13
Potassium (mg)	123	340	177	312	140	80	151	142	186	127	150	162	266	159
Zinc (mg)	0.2	0.4	0.2	0.3	0.3	0.2	0.5	0.3	0.2	0.2	0.3	0.4	0.6	0.2

Golovinskaia and Wang, (2021)

Processing and Products:

Since ancient times, people have loved fresh berries. Due to their low shelf-life and short seasonality, a number of artisanal techniques were developed to extend their use and consumption. Traditional methods and culinary applications eventually gave way to processing innovations and long-lasting goods. The main types of berry products and some of their commercial uses, like food items and drinks. For the long-term storage, transportation, and preservation of mature berry fruits, freezing is a crucial commercial procedure that ensures a consistent supply for both the food industry and consumers. A significant amount of water is quickly immobilized as ice by fast freezing at low temperatures, reducing cell damage and delaying the majority of harmful chemical and biological reactions. Dehydration, or the removal of water from berries, increases their shelf life but results in major structural and functional changes that severely restrict the uses of the finished dried items. Fruit bars, morning cereals, snacks, hiking foods, and sweet cakes all contain dehydrated berries. Berry powders enable clear labels by adding sweetness, appealing hues, and natural flavors to fast desserts, sauces, and liquids. Additionally, they are utilized in health supplements that are marketed as pills and capsules. Juices are beneficial substitutes that use inferior raw materials and make up for the decrease in the consumption of whole fresh fruits. Berry fruit juices are valued by consumers due to their sweetness, depth of taste, and antioxidant content (AC). (Aguilera, 2024). Popular berry products that are stable at room temperature include jams, jellies, and preserves due to their high soluble solids content, which primarily consists of added sugar. Fruit chunks or crushed fruit are commonly found in jams, fruit juice is used to make jellies, and entire berries are typically used to make preserves. Pectin (to raise the viscosity and promote gel formation) and citric acid (as a preservative) are typically added to jams, which are made by boiling fruits with sugar until the soluble solids content reaches around 65%. Berry jams, jellies, and compotes are examples of traditional and regional goods. Kissel, a traditional Northern European treat made from the sweetened juice of berries thickened or gelled with starch, is another example. Commercial dairy products that contain berry pulps and jams (such as yogurts, fermented milks, and desserts) take use of the health advantages of these fruits. The flavor, aroma, and purported medicinal properties of dried berry fruit infusions and "teas" have made them popular. Various berry fruit infusions and decoctions are recommended by traditional medicine to cure a number of illnesses, such as ocular dysfunction, diabetes, inflammation, and common colds. Berry fruit teas, which are frequently made from a blend of dried fruit, leaves, and flowers, typically contain higher levels of flavonoids and anthocyanins than herbal teas and commercial fruit teabags. Preserving these fruits and increasing their shelf life while retaining their health advantages is of interest to the scientific community. Furthermore, because the whole fruit or its natural constituents can be added to other foods to enhance their quality, the food industry is paying particular attention to the development of functional foods Barkaouis *et.al*; (2023).

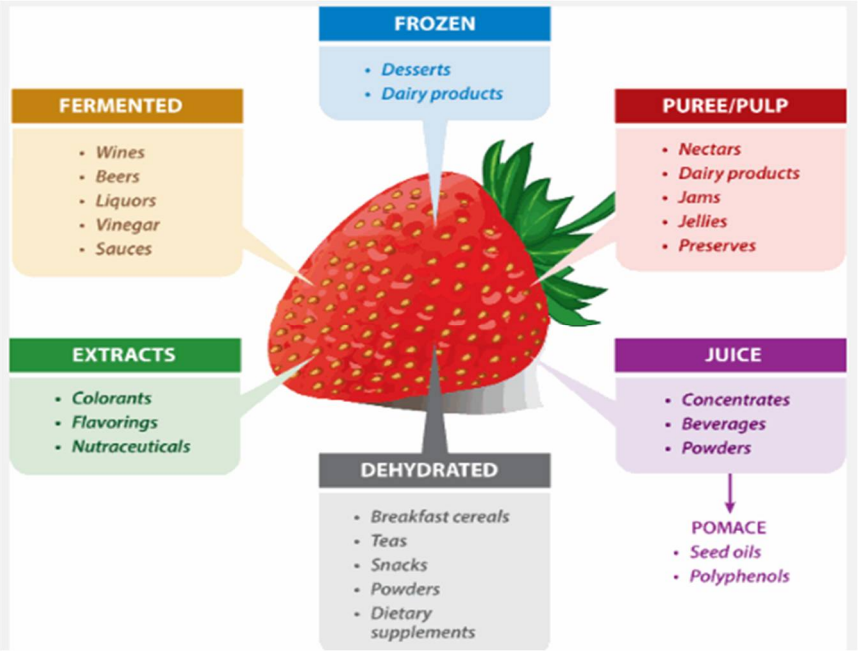


Fig 2: processed products

CONCLUSION

All things considered, berries are a tasty and nourishing supplement to a balanced diet, offering a number of health advantages that can promote general wellbeing. Because of their high antioxidant content, fiber, vitamins, and minerals, berries are a nutritional powerhouse that provide a multitude of health benefits. Berries are a tasty and adaptable complement to a balanced diet, with benefits ranging from lowering inflammation and cancer risk to promoting heart health and cognitive function. Berries' distinctive blend of flavors, textures, and colors makes them suitable for a number of applications, including baking, nibbling, and mixing into yogurt or oatmeal. There is a fruit to fit every taste, whether you like acidic and crunchy cranberries, sweet or tangy strawberries, or antioxidant-rich blueberries. Including berries in your diet on a regular basis can significantly improve your general health and wellbeing.

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