

Therapeutic Benefits of Avocado and Its Application in Dairy and Food Industry

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Abstract: *Persea americana*, commonly known as avocado, has recently gained substantial popularity and is often marketed as a “superfood” because of its unique nutritional composition, antioxidant content, and biochemical profile. It is the highly valued fruits consumed worldwide, and there are numerous commercially available varieties on the market. It is considered one of the main tropical fruits, as it contains fat-soluble vitamins which are less common in other fruits, besides high levels of protein, potassium and unsaturated fatty acids. Avocado pulp contains variable oil content, and is widely used in the pharmaceutical and cosmetics industry, and in the production of commercial oils like olive oil. Avocado has been recognized for its health benefits, especially due to the compounds present in the lipidic fraction, such as omega fatty acids, phytosterols, tocopherols, carotenoids, chlorophylls, phenols and squalene. This study aimed to present a literature review about nutritional importance, health benefits, application in dairy, food, pharmaceutical and cosmetic industry of avocado and its by-products.

Key words: Avocado, Nutrition composition, Health benefits, Application in dairy and food industry, Avocado seed, Avocado Peel.

I. INTRODUCTION

The name avocado originates from the Aztec word “Ahuacatl”. Ancient Aztec, Olmec and Maya cultures praised avocado as “One of the Gifts of God”. *Persea americana* (commonly known as avocado, avocado pear, or alligator pear, butter fruit). In fact, on account of its close resemblance to butter and identical lack of any taste it is so named in these parts as 'Butter Fruit'. Early Spanish explorers discovered the Aztecs enjoying avocados, but it was long considered a tasteless food.

It is native to Mexico and Central America, and a member of the flowering plant family *Lauraceae* [9]. It belongs to the kingdom *Plantae*, family: *Lauraceae*, order: *Lurales*, genus: *Persea*, and species: *P. americana*. Avocado is the most important and only edible fruit of the family *Lauraceae* and has a high commercial value. The main climatic requirements of the avocado tree are related to the temperature and rain fall, and the varieties behave differently according to their race.

The term “superfood” refers to foods that are beneficial to human health due to their high levels of nutrients and/or bioactive phytochemicals such as antioxidants. In particular, avocado has recently gained dramatic popularity and is often referred to as a “superfood” because of its unique nutritional and phytochemical composition compared to other fruits. Avocados are extensively used in food, nutraceutical, pharmaceutical, and cosmetic industries [6].

Plant Morphology of Avocado

The tree avocado is evergreen all over the year. Its height reaches about 40-80 feet from the ground and has a lot of long branches. The shape of the leaves is round oval and ovate and about length in 3-10 inches. The size of the avocado flower is small and greenish.

The shape of avocado fruit may be round, ovate or pear-shaped and the skin of the fruit is different in colour and appearance in all varieties. The skin may have more flexibility, smooth to scratchy and yellow-green, purplish-red or black in appearance.

The flesh colour of the avocado fruit is yellow-greenish to bright-yellowish and it is oily in texture when ripped, but the inner surface will be fibrous. Avocado fruit contains one large seed i.e. ovate or oval-shaped and it makes the weight of the fruit about 10 to 25 percent of the total weight. Avocados can be grown on a wide range of soils, but they are extremely sensitive to poor drainage and cannot withstand water-logging. They are intolerant to saline conditions. Optimum range of pH is from 5 to 7 [1].

Production of Avocado

Avocado production of the world was 10.27 million tonnes in 2023 with CAGR of 6.1 %. Mexico is the largest producer of Avocado in the world followed by Colombia, Dominican Republic, etc. Mexico supplies 45 percent of the international avocado market. The avocado market is still growing. The value of avocado market in India reached nearly 5000 tonnes in 2021. There are three main production region of avocado in India, the Kodaikanal area, Ooty area of Tamil Nadu, Gundlupet and Kodagu region of Karnataka and a minor area in North Eastern India. With the advent of the COVID-19 pandemic, the demand for avocado-based products has witnessed a staggering rise. Cosmetics & personal care segment is anticipated to expand at a significant value CAGR 6.3% with the rising demand for more natural products [40].

Nutritional Composition of Avocado

Avocados have been recognized for their high nutritional value and therapeutic importance for centuries. A whole avocado is reported to contain 140 to 228 kcal (~585–1000 kJ) of energy depending on the size and variety (Table 1). Fat contributes to most of the calories in an avocado. The lipid content in avocados is higher than in other fruits. Most lipids found in avocados are polar lipids (glycolipids and phospholipids), which play a fundamental role in various cellular processes such as the functioning of the cell membranes as second messengers [40].

Compared to other vegetable oils, avocado oils are high in MUFA (oleic and palmitoleic acids) and low in polyunsaturated fatty acids (linoleic acid and linolenic acid). Oleic acid is the principal fatty acid in avocado, comprising 45% of its total fatty acids, and during the ripening process, palmitic acid content decreases and oleic acid content increases (Table 2) [10]. A single serving can provide about 2 g protein and 2 g of fiber with a glycemic index of 1 ± 1. Avocado has been shown to improve the absorption of nutrients when used in combination with other foods and supplements. The absorption of provitamin A from plant sources is typically poor. Because it has a challenging matrix for the utilization of vitamin A, hindering the absorption and conversion of provitamin A to vitamin A. The consumption of lipid-rich food improves the absorption of fat-soluble vitamins, including vitamin A because it facilitates the formations of mixed micelles, which facilitate absorption [42].

Table 1: Nutritional Composition of Pulp, Seed, Peel and Leaf of Avocado

Nutritional Composition (g per 100 g)	Pulp-Value Per 100 g	Seed	Peel	Leaf
Water	72.3	52.7 - 54.1	65.7 -76.9	5.33
Energy (Kcal)	167	334	119	106
Total lipid (fat)	13.71	0.5	2.89 - 11.04	4.01 g
Carbohydrate	8.64	80		7.34
- Fiber	6.8	2.87	6.85- 56.9	38.40
- Sugars	0.3	10.83		
- Starch	0.11	27.5		
Protein	1.96	2.4 - 2.5	1.51- 6.3	25.54
Ash	1.66	1.2	0.75 -1.6	19.38

Table 2: Micronutrients and Phytochemicals of Avocado Pulp [6]

Minerals (mg /100 g)		Vitamins (mg / 100 g)		Phytochemicals (mg / 100 g)	
Potassium	507	Vitamin C	16.0	β-sitosterol	76
Phosphorus	54	Vitamin E	1.97	Campesterol	5
Magnesium	29	Niacin	1.92	Acetogenins	3.17
Calcium	13	Pantothenic acid	1.46	Stigmasterol	2
Sodium	8	Vitamin B ₆	0.29	Lutein + zeaxanthin	0.27
Zinc	0.68	Riboflavin	0.14	β-Carotene	0.063
Iron	0.61	Thiamine	0.08	α-Carotene	0.024
Copper	0.17	Vitamin B ₉	0.089		
Manganese	0.15	Vitamin K	0.012		
Selenium	0.004	Vitamin A	0.007		

Nutrients as Health Promoters

Fat: Fat contributes to most of the calories in an avocado. A 1000-kJ portion of avocado contains about 25 g of fat, most of which are healthier monounsaturated fatty acids (MUFA). The lipid content in avocados is higher than in other fruits. Most lipids found in avocados are polar lipids (glycolipids and phospholipids), which play a fundamental role in various cellular processes such as the functioning of the cell membranes as second messengers. These lipids are also used to make emulsions of water and lipids, and have a wide variety of applications in food, pharmaceuticals, and cosmetics industries. Compared to other vegetable oils, avocado oils are high in MUFA (oleic and palmitoleic acids) and low in polyunsaturated fatty acids (linoleic acid and linolenic acid). Oleic acid is the principal fatty acid in avocado, comprising 45% of its total fatty acids and during the ripening process, palmitic acid content decreases and oleic acid content increases. In terms of its total fat content and fatty acid composition, avocado oil is considered to be similar to olive oil. Avocado spread instead of other fatty alternatives such as butter, cream cheese, and mayonnaise on sandwiches can help significantly reduce the intake of calories, saturated fat, sodium, and cholesterol [10].

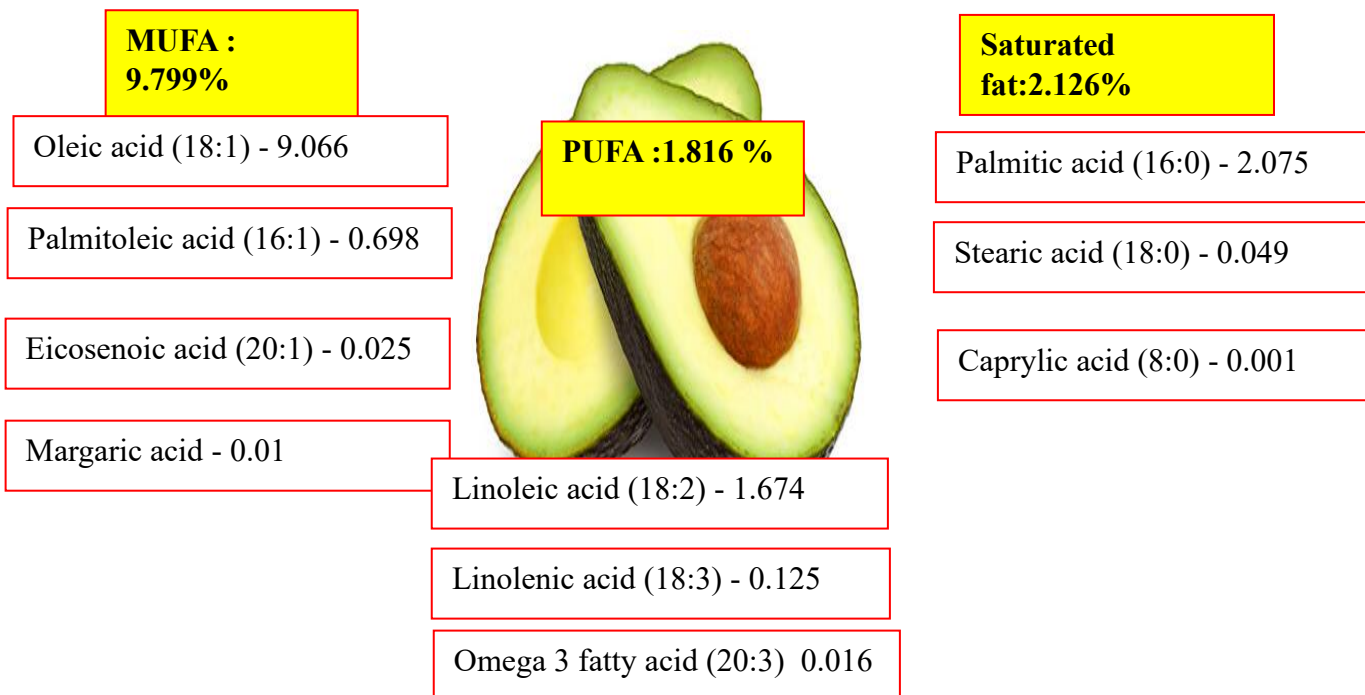


Fig 1: Lipids of Avocado Fruit Pulp (g/100 g)

Fiber: Fiber constitutes most of its carbohydrate content (75 %) (Table 1). Higher quantities of insoluble and soluble fibers (70% and 30%, respectively) are found in the pulp. Insoluble fiber prevents constipation and lowers the risk of colon cancer by improving the peristaltic movement of large intestine. Soluble fibers help lower blood cholesterol levels by trapping the bile in the small intestine in the mesh of fibers [13].

Potassium: Avocados are notable for their potassium content (507 mg/100 g of fresh weight), and it provides 60% more than an equal serving of banana (Table 2). Potassium intake helps to maintain cardiovascular health and muscle function by regulating the blood pressure through regulating high potassium and low sodium content. This balance of fluid is important for the proper functioning of the kidney that flushes out the toxins from the body. Thus, Avocados are helpful in maintaining kidney health and fight chronic kidney disorders [29].

Carotenoids: Carotenoids, including lutein, zeaxanthin, and α - and β -carotene found in the pulp of the avocado that contributed the yellow colour of fruit. The lutein content of avocado is higher than any other fruit, which comprises about 70% of its total carotenoid content (Table 2). It acts as potent free radical scavengers thus protect the skin from ultraviolet radiation-associated oxidation, inflammation. Xanthophylls suppress the damage of blood vessels by decreasing the amount of oxidized low-density lipoproteins (LDL) [12].

Phytosterols: Phytosterols contribute to 83 % of the total lipids of avocado. It include β -sitosterol (76 %), Campesterol (5 %), Stigmasterol (2 %) (Table 3). It has almost similar structure as that of cholesterol, thus mimicking the cholesterol in micelle formation. In that way it help to reduce the cholesterol content. A 17% decrease average in blood cholesterol levels was observed in a study in Mexico with 45 volunteers who consumed avocado once a day for one week. American Heart Association recommends the consumption of 2–3 g of sterols per day to promote heart health [42].

Therapeutic benefits of Avocado Fruit

Antioxidant Properties

Free radicals are atoms that have an unpaired electron. When they get into a human body, they find a suitable electron and take it from the molecule of a living cell. The molecule, which has lost the electron, starts to look for a replacement. Antioxidants are molecules with an easily detachable H atom which they donate to free radicals thereby regenerating molecule in that way inhibit the oxidation of a living cell in the body. Avocado peel and seed are a potential food-waste source of polyphenol, higher antioxidant capacity that could be used in feed, functional food, nutraceuticals, and cosmetics [42].

Table 3: Antioxidant properties of Avocado

Part Studied	Major Findings	Detection Assays	Type of Antioxidants	References
Peel, Seed, Pulp	Avocado peel shows the higher phenolic content and antioxidant capacity than seed and pulp.	DPPH, FRAP, ABTS, RPA, FICA, TAC	Pulp- Epicatechin, kaempferol, protocatechuic acid Peel- hydroxybenzoic acid.	[26]
Pulp and peel	Higher antioxidant capacity observed in pulp oil	ABTS and HPLC-PDA	α -tocopherol and β -carotene, phenolic acid, quercetin	[36]
Peel, Seed	Avocado-peel extract showed greater antioxidant effects than avocado seed	FRAP, TEAC and ORAC	Glycosylated flavonols, hydroxycinnamic acids and procyanidins	[35]
Seeds and seed coat	Significant antioxidant activity was observed in both seed and seed coat extracts. Total of 84 compounds were identified.	DPPH, TEAC, ORAC	Condensed tannins, phenolic acids, and flavonoids.	[15]

FRAP- Ferric Reducing Antioxidant Power Assay
 DPPH - 2,2'-Diphenyl-1-picrylhydrazyl Assay
 ABTS - 2,2'-Azino-bis-3-Ethylbenzothiazoline-6-Sulfonic Acid Assay
 RPA- Reducing Power Assay
 FICA - Ferrous Ion Chelating Activity Assay
 TAC-Total Antioxidant Capacity
 TEAC - Trolox Equivalent Antioxidant Capacity
 ORAC - Oxygen Radical Absorbance Capacity

Anticancer Properties

Cancer is a generic term for a large group of diseases that can affect any part of the body. Other terms used are malignant tumours and neoplasms. One defining feature of cancer is the rapid creation of abnormal cells that grow beyond their usual boundaries, and which can then invade adjoining parts of the body and spread to other organs; the latter process is referred to as metastasis. Widespread metastases are the primary cause of death from cancer. It is a leading cause of death worldwide, accounting for nearly 10 million deaths in 2020, or nearly one in six deaths. The *in vitro* cytotoxic properties of avocado against different types of cancer cell lines including breast, colon, liver, lungs, larynx, leukemia, oesophageal, oral, ovary, and prostate have been extensively reported. According to the USDA, avocados contain a significantly higher amount of glutathione per average serving compared to other fruits. Glutathione is a potent tripeptide antioxidant that plays a major role in detoxification pathways and the reduction of oxidative stress and risk of cancer [37]. Case-control study involving 243 men with prostate cancer and 273 controls in Jamaica demonstrated that MUFA from avocado may reduce the risk of prostate cancer [22]. An acetone extract of avocado containing carotenoids and tocopherols was shown to inhibit the growth of both androgen-dependent (LNCaP) and androgen-independent (PC-3) prostate cancer cell lines *in vitro*. Incubation of PC-3 cells with the avocado extract led to G2/M cell cycle arrest accompanied by an increase in p27 protein expression. Doses of avocado extract required to cause 50% reduction in the viability of PC-3 and LNCaP cells (LD50) were calculated to be 295.0 and 97.6 µg/ml, respectively. The greatest inhibition (60.8%) was observed in the LNCaP prostate cancer cell line at 100 µg/ml. The high lutein content of the avocado and the known antiproliferative and antitumor properties of this carotenoid suggested that lutein might be responsible for this effect. The effects of multiple bioactive substances in the avocado could not be reproduced by purified lutein, suggesting that multiple lipid-soluble bioactive substances may interact to produce the observed effects. Because the avocado also contains a significant amount of monounsaturated fat, these bioactive carotenoids are likely to be absorbed into the bloodstream, may contribute to the significant cancer risk reduction [37].

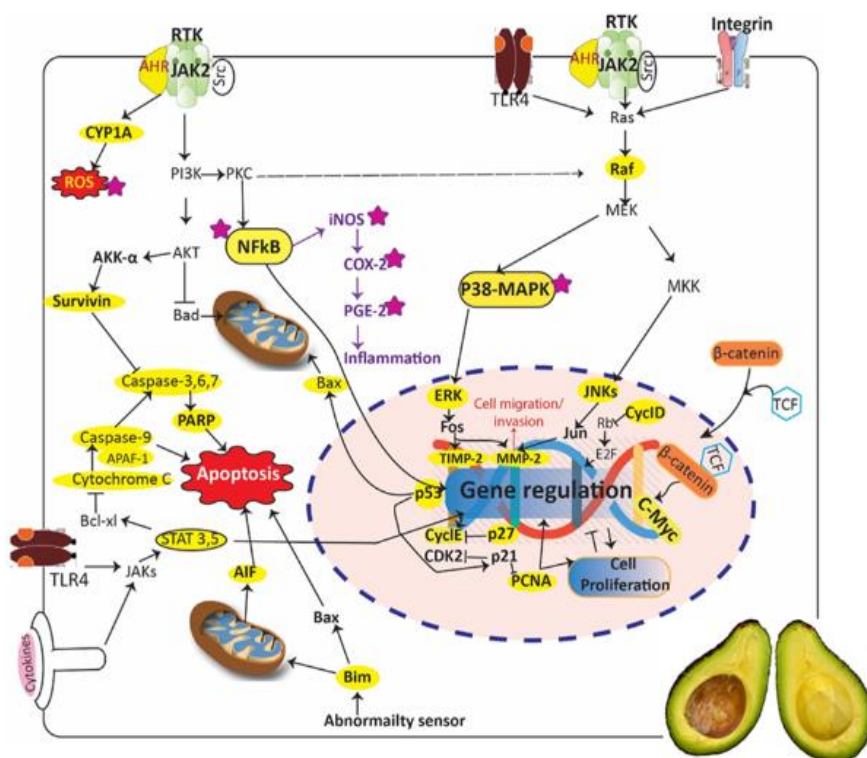


Fig 2: Effect of *Persea americana* (avocado) and its components on different cellular signal transduction pathways.

The molecular targets highlighted in yellow play key roles in the proliferation, survival, migration/invasion, and apoptosis of cancer cells. Purple stars indicate the molecular targets involved in inflammatory response.

Scopoletin, a plant coumarin and phytoalexin found in avocado, reduced the carcinogens-induced toxicity and the size of skin papilloma in vivo [28]. Further mechanistic study revealed the modulation of various key cell cycle, apoptotic and tumor invasion markers by scopoletin. Notably, the downregulation of AhR (aryl hydrocarbon receptor), CYP1A1 (cytochrome P450 1A1), PCNA (proliferating cell nuclear antigen), stat-3 (signal transducer and activator of transcription 3), survivin, MMP-2 (matrix metalloproteinase-2), cyclin D1 and c-myc (avian myelocytomatosis virus oncogene cellular homolog); and the upregulation of p53, caspase-3 and TIMP-2 (tissue inhibitor of metalloproteinases-2) by scopoletin were demonstrated. Additionally, the upregulation of TIMP-2 inhibits MMP-2 expression, which consecutively leads to the reduction of cellular migration and invasion (metastasis) [4].

Table 4: Anticancerous Properties of Avocado

Parts	Bioactive Compounds	Cancerous cells	Major Findings	References
Seeds	Triterpenoid	Breast and liver cancer	Inhibited cells with no activity against normal cells.	[2]
Root bark	4-hydroxy-5-methylene-3-undecyclidenedihydrofuran-2 (3H)- on	Breast cancer cell line	Antiproliferative activity. At the final Concentration 10 µg/mL, up to 80% of all breast cancer cells were dead.	[14]
Leaves	Persin	Breast cancer cells	Persin selectively arrested cancer cells by exerting cytotoxicity.	[8]
Pulp	Lutein, zeaxanthin, β-cryptoxanthin, α-carotene, and β-carotene, α-tocopherol and γ-tocopherol	Prostate cancer cell	Inhibited the growth of the prostate cancer cell lines.	[25]
Unripe fruit pulp	1,2,4-Trihydroxynonadecane, 1,2,4-Trihydroxyheptadec-16-ene and 1,2,4-Trihydroxyheptadec-16- yne.	Human lung, breast, colon, Kidney, pancrease, prostate cancer	All three compounds were active against six human tumor cell	[31]

Antimicrobial Properties

The increase in antimicrobial resistance, the decrease in the effectiveness of synthetic drugs, and, at the same time, their increased toxicity has led to an ever-increasing search for alternative biologically active substances. Gram-positive bacteria were more sensitive in comparison to the Gram-negative bacteria [24]. The Gram-negative bacteria have an extra protective outer membrane, which makes them more resistant to antibacterial agents compared to the Gram-positive bacteria [5].

Table 5: Antimicrobial Properties of Avocado

Parts studied	Organism inhibited	Major findings	References
Seed	<i>Listeria monocytogenes</i>	Avocado acetogenins possess antilisterial activity comparable to that of synthetic commercial antimicrobials	[36]
Peel and Seed extracts	<i>L. monocytogenes</i> , <i>S. epidermidis</i> , <i>S. aureus</i> , <i>E. coli</i>	Extracts did not have antimicrobial activity against <i>S. aureus</i> and <i>E. coli</i>	[33]
Pulp, peel and seed	<i>Bacillus cereus</i> , <i>S. aureus</i> , <i>L. monocytogenes</i> , <i>E. coli</i> , <i>Pseudomonas spp.</i>	All avocado parts had antimicrobial activities. Pulp showed the highest antimicrobial activity	[34]

Neuroprotective Effects

Parkinson's disease (PD) is a progressive neurodegenerative disorder associated with oxidative stress. Therefore, finding new antioxidant sources might be beneficial for its treatment. Polyphenols of avocado have demonstrated antioxidant properties, anti-inflammatory, and regulation of autophagy in important human neurodegenerative disorders including PD. [33] reported that peel extract can protect and/or prevent transgenic parkin *Drosophila melanogaster* fly against paraquat-induced OS, movement impairment and lipid peroxidation, Increases Life Span as model of PD.

Inhibits dengue virus replication

Dengue virus (DENV) caused millions of infections around the world annually. Dengue virus (DENV) belongs to the Flavivirus genus in the Flaviviridae family. It is divided into 4 serotypes (DENV-1–4). The symptoms of DENV-infected patients range from classic flu-like dengue fever (DF) to severe life-threatening diseases including dengue hemorrhagic fever (DHF) and dengue shock syndrome (DSS). No approved therapies are currently available for the treatment of DENV infection. Hence, novel anti-DENV agents are urgently needed for medical therapy. DENV is divided into 4 serotypes (DENV-1–4). Natural product (2R,4R)-1,2,4-trihydroxyheptadec-16-yne (THHY), extracted from unripe avocado fruit, can inhibit DENV-2 replication in a concentration dependent manner and efficiently suppresses replication of all DENV serotypes (1–4). Further reveal that the NF- κ B-mediated interferon antiviral response contributes to the inhibitory effect of THHY on DENV replication [44].

Hepatoprotective properties

Hepatotoxicity is associated with severe impairment of cell protection mechanisms with the liver, being mostly affected because it is the principal site for CCl₄ biotransformation. Aqueous leaf extract of avocado would reduce hepatic lipid accumulation in fatty liver disease and liver damage. [7] study demonstrated that pre-treatment of rats with avocado extract caused substantial decreases in alkaline phosphatase (ALP) and bilirubin levels and this decline was significant for bilirubin at extract concentration of 200 mg/kg. The mechanism by which CCl₄ causes liver damage involves the biotransformation of CCl₄ by the cytochrome P-450 enzyme system to the toxic trichloromethyl free radical (CCl₃·), and then transforming this free radical into a more reactive trichloromethyl peroxy radical (CCl₃O₂·), which causes lipid peroxidation, disrupts Ca²⁺ homeostasis, and eventually kills cells. Pre-treatment with avocado extract decreased MDA (Malondialdehyde) concentrations. It is the product of polyunsaturated fatty acids peroxidation in the cells. An increase in free radicals causes overproduction of MDA. Malondialdehyde level is commonly known as a marker of oxidative stress and the antioxidant status in cancerous patients. Thus, suggesting that the mechanism of hepatoprotection of avocado extract may be due in part to its antioxidant effect. Pre-treatment with avocado extract reduced the severity of toxic injuries caused by CCl₄ and prevent liver damage and suppress the leakage of enzymes into the blood stream by preserving hepatocyte membranes.

Weight Management

Obesity rates have been increasing worldwide for several decades, and a healthy dietary pattern is an important component of weight loss and weight management. The current prevalence of overweight and obesity is 70.7% and 37.9%, respectively, among adults. In the U.S. population, avocado consumers have lower body weight, Body Mass Index (BMI), and waist circumference compared with non-consumers [14]. Moreover, on average, avocado consumers weighed 3.4 kg less, had a mean BMI of 1 unit less, and had a waist circumference 3.0 cm smaller compared to non-consumers. A longitudinal study of ~55,400 people of mean age ~56 years, with a standard serving size 32 g/day in the U.S. in Canada found that avocado consumers gained significantly less weight over time (4–11 years follow-up) than non-consumers [18]. One possible explanation for these findings is that including avocados may increase satiety and reduced hunger when included in meals.

Osteoarthritis

Osteoarthritis is a degenerative joint condition. It causes pain, swelling and stiffness, affecting a person's ability to move freely. It affects the entire joint, including the tissues around it. It is most common in the knees, hips, spine and hands. About 73% of people living with osteoarthritis are older than 55 years, and 60% are female (WHO). ASU seems to prevent the osteoarthritic osteoblast-induced inhibition of matrix molecule production, suggesting that this compound may promote OA cartilage repair by acting on subchondral bone osteoblasts [17]. It is a mixture investigated is made up of unsaponifiable fractions of one-third avocado oil and two-third soybean oil.

Application of Avocado in Dairy and Food Industry

Avocado fruit not commonly consumed directly because of its bland taste. It is mainly converted to many values added products and used in dairy and food industry. There are many researchers conducted in this field for the incorporation of avocado into different products.

Dairy Industry**Labneh Cheese Made from Milk Fat and Avocado Paste**

Prepare a healthy Labneh cheese from fresh whole buffalo's milk and avocado paste en route to innovate a functional food. To achieve the purpose of this research, a pasteurized buffalo's milk (at 74°C for 15 sec) was cooled immediately to 40°C and divided into four equal quantities. The first quantity was manufactured as a control. The second, third, and fourth quantities were mixed with avocado paste and 0.1% disodium citrate at percentages of 5, 10 and 15%, respectively then stirred well to obtain uniform mixtures. Then a concentration of 4% fresh prepared bacterial yoghurt starter culture was added for all milk portions and incubated at 40 °C. The incubation was terminated at pH 4.8. All treatments were put into cloth bags and hung up in a refrigerator to allow whey to drain for 12 h, then 1% salt was added and filled into suitable containers. The obtained results showed that, the Labneh fortification with avocado paste up to 5% led to improve the body and the texture and did not clearly affect the appearance and the flavor. While the exceeding avocado paste addition to 15% led to a decrease in the degrees of texture, body and appearance (Mohamed, 2020).

Avocado Cream Cheese

Avocado (*Persea americana*) can be considered a crucial fruit compatible in flavour, taste and texture to cream cheese because of its mild flavour and taste with a soft creamy body and texture when the avocado is combined with cream cheese. Avocado puree concentrations (0, 10, 20, and 30% avocado puree) added to cream cheese. Chemical analysis revealed that avocado-enriched cream cheeses had more moisture, fat, and ash contents than the control sample (cream cheese without adding avocado puree) and showed softer texture with less spreadability. The cream cheese sample also had a higher syneresis and lower viscosity when combined with avocado puree.

Texture profile analysis (TPA) indicated that all avocado-enriched cream cheeses had similar adhesiveness values to each other. However, the addition of more avocado puree caused more significant colour changes and instability during storage. Also, avocado puree induced the growth of undesirable microorganisms, such as yeasts and moulds, after 3 weeks of storage of the cream cheeses fortified with relatively higher concentrations of 20 and 30% avocado puree. However, it was not detected in the control cream cheese sample without containing avocado puree and the cream cheese samples containing 10% avocado puree during the whole storage period of 4 weeks. Nevertheless, avocado-fortified cream cheese samples showed stability in their textural properties during the 4-week storage, and the sensory test showed that participants preferred a cream cheese sample added with 20% (w/w) avocado puree. Overall, the results indicate that the cream cheese products added with avocado puree had some instability due to changes in colour and flow behaviours during storage. This could be related to the chemical composition of cream cheese resulting in a decrease in protein and carbohydrate contents while an increase in moisture and fat contents by the addition of avocado puree and a combined effect of some undesired chemical reactions resulting from chlorophyll degradation and enzymatic browning [21].

Avocado Oil-Rich Cheese

Nowadays, with consumers' requirements shifting towards more natural solutions and the advent of nutraceutical-based approaches, new alternatives for obesity management are being developed. The fatty acid profile of the avocado-rich fresh probiotic cheese was mainly composed of oleic acid (C18:1; 55.35%), followed by palmitic (C16:0; 18.55%) and linoleic (C18:2 c9c12; 11.55%) acids. The results showed that oleic and palmitic acids' permeability through membrane, were capable of modulating the metabolism of adipocytes. Developed dairy matrix allowed for the delivery of bioactive fatty acids in high enough quantities to be absorbed by the intestinal wall and exert effective modulation on the obesity-related target cells. Potential of a bioactive fatty acid-rich functional dairy product as a valid food to manage obesity and offered insights into the fatty acid permeation of the intestinal wall and subsequent obesity metabolism modulation [27].

Avocado Paste as Fat Substitute in Ice Cream

Dairy products consist of high Saturated Fatty Acid (SFA) and overconsumption of SFA could lead to cardiovascular diseases. Avocado has high fat content which is a good source for substituting the milk fat in frozen dairy desserts. It contains high levels of fat dominated by Monounsaturated Fatty Acid (MUFA) and phytosterol that have the potential as a plant-based fat source to substitute dairy-fat in ice cream. Different concentrations of avocado paste ranging from 0%, 25%, 50%, 75% and 100% against dairy fat to produce non-dairy fat ice cream. The addition of 50% avocado paste was the most preferred. The addition of avocado paste lead to the increase in viscosity and hardness of the ice cream. Avocado could provide a potential substitution for dairy fat in ice cream. This substitution of dairy-fat into plant-based fat from avocado was able to lower the total fat content of the ice cream mixture and lowered the melting rate of the ice cream. This might be due to the fibre content in avocado paste that has the ability to lower the water mobility in the ice cream. Higher concentration of avocado paste in the ice cream formula provides more hydrocolloids from the dietary fibre and thus influences the viscosity properties and contributes to the stabilization of air during aeration [38].

Avocado Ice-Cream

Avocado fruit can be used as a functional ingredient in ice cream due to its flavour, natural antioxidant, fibers content in addition to its essential monounsaturated fatty acids constituents and related health promoting characteristics. This fruit pulp had unique characteristics which make it suitable to be applied in low fat ice cream making, Avocado fruit pulp improved the rheological characteristics, the antioxidant activity, overrun melting characteristics and the total acceptability of ice cream. Therefore, this fruit pulp can be used successfully in making functional low fat ice cream of acceptable sensory attributes comparable with that full fat ice cream. Avocado incorporation in ice cream at the ratio of 10- 15% can be recommended in the manufacture of low fat ice cream with enhanced acceptability comparable to full fat ice cream [23].

Avocado Oil-Functionalized Yogurt

Studies on bioactive lipids have been increasing in the last years due to their proven health benefits. Research work was to develop a yogurt with bioactive lipids with anti-obesity potential. For this purpose, yogurts were produced with avocado oil in free form or encapsulated as a bigel. The presence of avocado oil enhanced the nutritional quality of yogurts through a reduction (more than 75%) of their atherogenic and thrombogenic indexes. The high nutritional value was particularly evident in samples with bigel, as these yogurts presented eight-fold higher levels of total fatty acids than the yogurts with avocado oil in free form. In addition, yogurts with avocado bigel presented better stability throughout the gastrointestinal tract - results showed a higher recovery percentage of oleic acid (47.2%) when compared to 24% in the yogurts with avocado in free form. Moreover, the hepatic lipid accumulation in cells subjected to steatosis induced by chloroquine was reduced by 35% in cells treated with yogurt digested samples. These results showed the potential of these functional yogurts to modulate obesity-related metabolism [28].

Food Industry

Avocado Oil in Cooking

With so many choices in cooking oil, its hard to know if you're using the right thing. Most people are unaware of the dangers that come from conventional and over-processed vegetable oil. Even good olive oil isn't suitable for all cooking purposes – especially high heat cooking. Chosen Foods avocado oil is the perfect, healthy, all-purpose cooking oil, but is especially suited for higher temperatures. All cooking oils have a smoke point. That is, the temperature at which the oil begins to burn. Burnt oil doesn't taste, or smell good, so it should be avoided. When an oil heats past its smoke point, the fatty acid profile has degraded, producing toxins, free-radicals and even trans fats. When cooking at higher temperatures, you should always choose oil that has a high smoke point. Avocado oil has the highest smoke point of cooking oils, 500°F, making it by far the safest oil for high heat cooking. Due to having a high smoke point, avocado oil is great for baking, roasting, sauteing, and frying. olive oil is high in monounsaturated fat making it good for cooking with, but its smoke point lies around 350-375°F. Olive oil should not be used for deep frying, stir-frying, searing, barbecuing, or baking anything at higher temperatures than this [16].

Avocado Fruit Puree as Fat Replacer on Shortened Cakes

The avocado is known for its pleasing taste and predominance of monounsaturated fatty acids. It is also recognized as a functional food that contains health-promoting phytochemicals such as glutathione and beta-sitosterol. The purpose of this experiment was to see if avocado puree was an acceptable fat replacer in shortened cakes. Avocado puree was substituted for shortening (Control) at 50%, 75%, and 100% levels.

As percentage of avocado increased, the cake batter showed greater fluidity (increased line spread) and had increased specific gravity indicating that the more fluid batter trapped less air. Textural analysis showed firmness to increase as percent of avocado increased. Sensory analysis showed the 50% substitution to be acceptable to the consumer panellists, but acceptability decreased with 75% and 100% substitutions. In comparison to the Control, the variation with 50% avocado substitution resulted in 30% reduction in total fat, 33% reduction in saturated fat, and 13.6% reduction in calories making it an acceptable reduced fat cake. Improved nutritional content, acceptability, and low cost makes avocado puree a viable fat replacement option for use in home-baked products [30].

Avocado based products in the Market

Avocado-based products are gaining traction across the world and being used in most food and beverage products. Avocado is presumed to be a superfood that contains numerous health and nutritional benefits which has further established the proper market set up for avocado-based products. Some of the avocado-based products are avocado puree, avocado oil, and others are increasingly becoming favourable among the food & beverage manufacturers. The avocado-based products are utilized in infant food, snacks, dairy products, and others.

Table 6: Commercially available Avocado-based products.

Product name	Brand	Country	Product details
Avocado spread & jam	Phamphal	India	Prebiotic with added honey
Avocado Tzatziki Dip	Trader Joe's	U.S	Full-fat Greek yogurt with 30% avocado, garlic, cucumber, mint.
Avocado & Chips Bar	Compartes	U.S	Avocado-infused white chocolate
Avocado chocolate bar	Love Cocoa	England	Europe's 'first ever' avocado chocolate bar. 70 % organic dark chocolate + freeze dried avocado pulp powder
Avocado Oil Seaweed Snacks	gimMe	U.S	Avocado oil-infused snack. Each snack pack includes 48 seaweed snack sheets
Avocado Honey	Pirkka Parhaat	Finland	Comes from the avocado blossoms' nectar
Kiwi, Avocado & Matcha Tea Yogurt	Waitrose	UK	Product comprises kiwi, avocado and lime yogurt with added vitamin D and a hint of matcha green tea
Jelly Avocados	Waitrose	UK	Made with Belgian milk and white chocolate and avocado powder
Avocado Oil Mayonnaise	Mr. Ricco	Russia	Mayonnaise with Avocado Oil
Herbal Tea	Darusyifa Alami	Indonesia	made from the leaves of breadfruit and avocado
Avocado Cheese Potato Stick Snack	Calbee Jagariko	Japan	potato stick snack features avocado paste and cheese
Avocado Macchiato Ice Cream	Magnolia	Philippines	Avocado's high fat-content creates a base for an ice cream with a creamy, silky texture
Avocado Frozen Dessert	Cado	USA	Avocado-based frozen dessert with cacao, dark chocolate chips
Green Guacamole Cheeses	Daily Dairy's		Gouda-style green cheese is made with real avocados, lime juice, chili, tomato, onion and garlic.
Baby food	Gerber	US	Each pouch of product contain 1 cup Avocado, 1/4 Pear, 1/4 Cup Mango.
Cubed Avocado	Coop	Sweden	Ideal for a creamy guacamole or as a smoothie

II. CONCLUSION

The unique nutritional and phytochemical composition of avocados, as well as their potential for the treatment and prevention of various diseases, have been highlighted in several preclinical studies conducted in the recent years. Several studies have highlighted its significance as a source of lead compounds for drug discovery because of many unique chemical skeletons it contains. More comprehensive in vitro, in vivo, and clinical research is necessary, though, to greatly advance our knowledge of the molecular mechanisms underlying the action of its phytochemicals and assist in develop future dietary and therapeutic approaches against circumstances like diabetes, cancer, inflammation, infections, and cardiovascular disease. Studies have shown the benefits of avocado associated to a balanced diet, especially in reducing cholesterol and preventing cardiovascular diseases. Numerous studies have demonstrated the intricate synergistic relationships between various phytochemicals found in food matrices. Therefore, investigating potential synergies between avocado's bioactive compounds and those found in other fruits and vegetables can aid in the development of diet-based preventive strategies for several diseases. A few studies have suggested that avocados can increase the nutrients from other plant-based foods' bioavailability. As a result, eating avocados along with other fruits and vegetables can be good for a person's well-being.

Avocado seed and peel are the main by-products from avocado industrialisation, and account for nearly 30% of fruit weight. Their high phenolic content has been deeply associated with several nutritional and functional benefits. Fluid extract of the avocado leaves is widely used in pharmaceutical products, mainly due to the diuretic characteristic of the present compounds in plant leaves.

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