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# Avocado (*Persea americana*) and Potential Anticancer Effects: Do the Effects Suppress Carcinogenesis?

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## Abstract

Avocados have become one of the most popular fruits today and contain many anticancer nutrients, such as vitamins A-C-E, polyphenols, carotenoids, glutathione, monounsaturated and polyunsaturated fatty acids, and dietary fiber. Inhibiting cancer cell proliferation, preventing metastasis, and eliminating cancer cells are important goals for cancer treatment. Because of their content, avocados can potentially stimulate apoptosis, inhibit cell differentiation, proliferation, and carcinogen absorption, and reduce reactive oxygen species and inflammatory cytokines. Limited human studies, *in vivo* studies, and *in vitro* studies that examined the effects of each type and part of avocado are included in this narrative review. Some *in vitro* studies have demonstrated the anticancer effects of avocado pulp, peel, and seeds because of their functional nutrient contents that affect apoptotic protein expression (caspase-3,-6,-7,-9), Bax, Bcl-2, and Bcl-xL trigger cell cycle arrest (cellular senescence), superoxide dismutase enzyme activity (antioxidant), and suppress proinflammatory cytokines such as tumor necrosis factor-alpha, interleukin-1 beta and 6. Consuming one-half avocado/day [~68 g (edible part)] supports beneficial nutrient intake. Although some potential anticancer effects of avocados have been demonstrated in *in vitro* studies, more *in vivo* studies are needed to increase the level of evidence.

**Keywords:** Avocado, *Persea americana*, cancer, anticancer effects, inflammation, proliferation

## INTRODUCTION

The avocado (*Persea americana*) is a tropical fruit that grows almost everywhere in the world but originated in Mexico and South America. It is from the *Lauraceae* family and is known as the "butter fruit", "alligator pear", "ahuacate", and also "avocato". There are 50 different types of avocado, and the most well-known and sold types of avocado are the "Fuerte" and "Hass". While the "Fuerte" type is bright, green, and rough, the "Hass" is purple.[1] Due to its beneficial properties and popularity, avocado has been used in both food and cosmetic industries.[2] Avocados contain many beneficial nutrients and substances, so every age group can consume this fruit. Avocado is a source of potassium, magnesium, phosphorus, non-heme iron, vitamins A, B, C, E, and K, dietary fiber (DF), and phytochemicals. Furthermore, the carbohydrate (CHO) content of this fruit is lower than that of many other fruits.[3,4] Some important studies in the current literature have demonstrated the beneficial effects of avocado on cognitive function, diabetes mellitus, cardiovascular health, and cancer.[5-8] As a potential antioxidant agent, these bioactive substances can reduce oxidative stress and inflammation.[1,4] Moreover, avocado phytochemicals have the potential to inhibit cell proliferation and stimulate apoptosis; thus, they have potential benefits against cancer development.[9] With this in mind, this study aimed to review the effects of avocados on carcinogenesis. Thus, the methodologies and results of limited human, *in vivo,* and *in vitro* studies that searched for the proapoptotic, antioxidant, anti-inflammatory, and antiproliferative effects of each type and part of avocado are included in this narrative review article.

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### Nutritional Content of Avocados

The macronutrient and micronutrient contents of avocados are related to factors such as type, growing model, consumed portion, and maturation time. Although there has been an increase in the production and sale of the "Hass" avocado in recent years, Tremocoldi et al.[10] reported that total bioactive compounds are better in the peel and seeds of the "Fuerte" type than the "Hass". The pulp of avocado has a higher water, fat, and ash content than the peel and seed. In contrast, the protein content of the seeds was better.[11] The content of the edible part of the "Hass" is 72% water, 10% fat, 7% CHOs, 2% protein, and 5% DF. Both soluble and insoluble types of DF form a significant part of the CHO content of avocados. The fat content is higher than that of the other fruits, and 71% of this content is monounsaturated fatty acids (MUFA), 13% is polyunsaturated fatty acids (PUFA), and 16% is saturated fatty acids. Although the official serving size of an avocado is 50 g, some micronutrients and nutritional substance content are present in 68 g. This fruit is a good source of fat-soluble vitamins [A (43 µg/68 g); E (1.3 mg/68 g); K (14 µg/68 g)], as well as folate (60 mg/68 g), vitamin C (6 mg/68 g), potassium (345 mg/68 g), and magnesium (19.5 mg/68 g). In addition, although avocado is not as rich in phytochemicals as red fruits and citrus, it contains some antioxidant substances. The antioxidant capacity of avocado is primarily related to its lutein and zeaxanthin (185 µg/68 g), and β (beta) carotene (43 µg/68 g) contents.[2,9,12] The nutritional content of avocados is presented as a graphic abstract in Figure 1.

### Cancer

Cancer is one of the most important causes of mortality and morbidity worldwide. The World Health Organization (WHO) reported 19.3 million cancer cases and 10 million deaths worldwide in 2020. The WHO defines cancer as uncontrolled cell growth and progression of mutated cells. The ability of mutated cells to metastasize and migrate to different tissues and organs increases the burden of cancer on patients and the healthcare system. Cancer is the second leading cause of mortality after cardiovascular diseases.[13-15] Conventional cancer therapies are based on suppressing uncontrolled cell growth, preventing metastasis, and eliminating cancerous cells. Accordingly, chemotherapy, radiotherapy, and surgical intervention are the main types of cancer treatment. Furthermore, programmed cell death is an important intracellular defense mechanism for maintaining homeostasis and suppressing carcinogenesis.[16]

Many risk factors may cause cancer development, which can be classified as modifiable or unmodifiable (gender, age, genetic factors, etc.). Factors related to lifestyle behaviors are modifiable, such as nutritional, physical, and sexual habits, alcohol consumption, and smoking.[17,18] Poor diet diversity, low food quality, and hygiene, high refined grains, alcohol consumption, fast food consumption, and low fruit, vegetable, and legume consumption are some of the nutrition-related cancer risk factors.[19] Fruits and vegetables in particular are high in DF and antioxidants, such as A-C-E vitamins, as well as phytochemicals with anticancer properties.[20] Because of the nutritional elements and bioactive nutritional components such as vitamin C, phenolic compounds, and carotenoids, the anticancer effects of avocados have been the subject of research in recent years.[9]

### Potential Anticarcinogenic Effects of Avocado

Although there are limited human studies on the effects of avocado consumption on cancer pathogenesis, some *in vitro* studies have been conducted on different cancer cell lines (Table 1).

### Potential Pro-Apoptotic Effects

While total fat, saturated fat, trans-fatty acids, and omega-6 fatty acids are associated with increased cancer risk, omega-3 and plant-based MUFAs are related to lower risk.[21] The highest fat content is found in avocados. Most of the fat content was MUFA (71%). In a case-control study involving 209 men with newly diagnosed prostate cancer and 226 healthy men, dietary MUFA intake was associated with a lower prostate cancer risk. The main dietary MUFA source was avocado.[22] Ericsson et al.[8] conducted a cohort study to evaluate the effects of avocado consumption on cancer development in the United States population.

The consumption of a weekly serving of ≥1 avocado reduced overall colorectal, lung, and bladder cancer risks in men.[8] In a randomized controlled trial, daily avocado consumption (175 g for men, 140 g for women) resulted in lower fecal bile acid concentrations, a better abundance of bacteria capable of fiber fermentation, and better fecal short-chain fatty acids, which are known as pro-apoptotic and anti-inflammatory agents in the human body.[23] Apoptosis is a cell death mechanism in the human body. This process occurs regularly to provide homeostasis between cell formation and death. Because apoptosis is a process of sequential cell death, it is also known as programmed cell death.[24] Guzmán-Rodríguez et al.[25] reported that the application of *Persea americana var drymifolia* (PaDef) extract induced apoptosis in the MCF-7 breast cancer cell line. It has been noted that the application of PaDef for 48 h increased the expression of cytochrome c, APAF 1, caspase-7, and -9, decreased the mitochondrial membrane potential, and induced apoptosis by increasing mitogen-activated protein kinase p38 phosphorylation.

### Potential Antiproliferative Effects

Cell proliferation is necessary for healthy growth and development and also for being healthy in living. However, sustaining cell proliferation signaling is a hallmark of cancer, which is known as uncontrolled cell growth.[26] In addition to apoptosis, another attractive intracellular pathway that plays an anticarcinogenic and antiproliferative role is cellular senescence. Cellular senescence, a natural process of embryogenesis, is triggered by DNA damage, exposure to oncogenic stimuli, stress, and trauma, and causes the cell cycle to arrest irreversibly in the G1 and G2 phases. The irreversible cell cycle arrest of differentiated

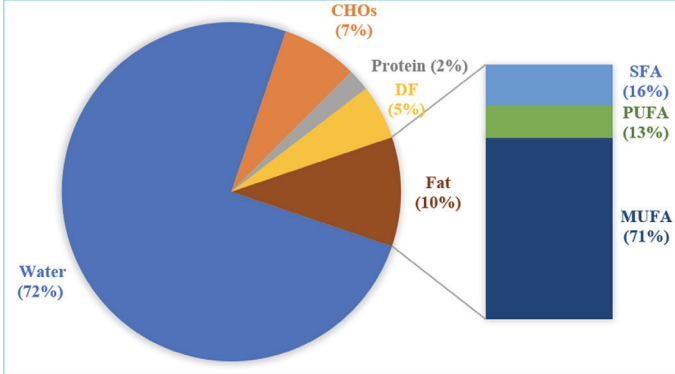


**Figure 1.** Macronutrient content of "Hass" type of avocado (prepared by the authors, based on the references in the "Nutritional content of avocado" section).

CHOs: Carbohydrates, SFA: Saturated fatty acids, DF: Dietary fiber, PUFA: Polyunsaturated fatty acids, MUFA: Monounsaturated fatty acids.

**Table 1. Literature on avocado and its anticancer effects**

**Human studies**

| Aim of the study | Material and Methods | Results | References |
|---|---|---|---|
| The effects of all fatty acids on prostate cancer development in Jamaica. | This was a case-control study. A total of 209 prostate cancer patients and 226 healthy men (40-80 years old) were included. Dietary fatty acid intake was determined using a FFQ. | Consuming avocado was found to be the main MUFA source in men from Jamaica.<br>Other fatty acids were not associated with prostate cancer, whereas higher dietary MUFA intake was associated with a lower prostate cancer risk. | 22 |
| The association between avocado consumption and cancer development in the United States. | 45,289 men in the HPFS (1986-2016) and 67,039 women in the NHS (1986-2014) participated.<br>Consumption of avocado was determined by the FFQ every four years. | While ≥1 serving/week of avocado consumption was found associated with lower risk in overall cancer types in men, this relationship was not significant in women. | 8 |

**Animal studies**

| Aim of the study | Material and Methods | Results | References |
|---|---|---|---|
| Chemopreventive mechanisms of hydroethanolic extracts from avocado pulp and seeds in rats with liver cancer. | Oral intake of 50 mg/kg hydroethanolic extract daily for 20 weeks. | The increase in lipid peroxidation was prevented. Low glutathione peroxidase, glutathione-S-transferase, and superoxide dismutase activities were improved in liver tissue (*antioxidant*).<br>COX-2 and NF-κB expression levels decreased (*anti-inflammatory*).<br>The levels of the suppressor proteins p53 and Bax increased (*proapoptotic*). | 39 |
| Evaluation of the effects of avocado oil on inflammation in male C57BL/6J mice. | Oral intake of 4 mL/kg of avocado oil was provided for 90 days. | TNF-α and IL-1β levels were decreased by avocado oil supplementation. | 37 |

***In vitro* studies**

| Cancer cell types | Materials | Results | References |
|---|---|---|---|
| Esophageal squamous cell carcinoma and colon adenocarcinoma. | Ethanol, ethyl acetate, petroleum, and chloroform extracts of avocado fruit pulp. | Twenty µg/mL ethanol extract exerted a significant inhibitory effect on cancer cell growth in related cancer cell lines. | 40 |
| Liver, breast, and colorectal cancer cells. | Acetogenin-rich extract of the avocado fruit pulp. | 8.1 µg/mL of the acetogenin-rich extract exerted anticancer effects on liver carcinoma, 52.1 µg/mL on breast cancer, and 11.3 µg/mL on colorectal cancer cells. | 41 |
| Melanoma cell line. | Nanoemulsion containing a procyanidin-rich extract of avocado peels. | The nanoemulsion increased preferential cytotoxicity and decreased migration (antimetastatic effect) in the melanoma cell line. | 42 |
| Colon and liver cancer cell lines. | The edible parts of the avocado and seed extracts. | The avocado seed extract was found to be more effective than the edible extract. Furthermore, the sterol compound was even more effective.<br>In a dose-dependent manner, both extracts exert anti-inflammatory and anticancer effects. | 4 |
| Determination of the antioxidant effect of avocado. | Avocado seed, peel, and pulp extracts (from 60 different ready-to-eat Hass varieties of avocados). | The peel extract had more phenols (gallic acid equivalents) and flavonoids (quercetin equivalents) components than the seed extracts.<br>The highest antioxidant activity was observed in the peel extract.<br>The maximum antioxidant capacity was observed at a 1 mg/mL concentration for the combination of avocado peel extract (61%) and nisin (39%). | 43 |
| Colon cancer cell line. | The lipid-rich extract of Mexican avocado. | Lipid-rich extracts at 100 and 150 µg/mL lipid-rich extract decreased cell growth.<br>Twenty eight µg/mL stimulated apoptosis via activation of caspases -8 and -9. | 44 |

**Table 1. Continued**

| | | | |
|---|---|---|---|
| Breast and liver cancer cell lines. | Triterpenoid of avocado seeds (isolated from ethanol extract). | The extracts and the isolated triterpenoid compound exhibited significant cytotoxic activity.<br>62 µg/mL triterpenoid isolate inhibited cell proliferation in the breast cancer cell line, and 12 µg/mL exerted the same effect in the liver cancer cell line. | [29] |

FFQ: Food frequency questionnaire, MUFA: Monounsaturated fatty acids, HPFS: Health professionals follow-up study, NHS: Nurses' health study, COX-2: Cyclooxygenase-2, NF-κB: Nuclear factor kappa-B, TNF-α: Tumor necrosis factor-alpha, IL-1β: Interleukin-1 beta.

cancer cells constitutes the potential tumor-suppressive property of cellular senescence.[27] Dabas et al.[28] reported that in the LNCap prostate cancer cell line, *Persea americana* seed extract suppressed the expression of cyclin-dependent kinases 1 and $E_2$, which are responsible for the regulation of the cell cycle, and showed antiproliferative effects by stopping the cell cycle in G0/G1 phase. Moreover, Abubakar et al.[29] showed that the application of 62 µg/mL and 12 µg/mL of triterpenoid extracted from *Persea americana* seed on MCF-7 (breast cancer) and HepG2 (liver cancer) cancer cell lines, respectively, had cytotoxic effects; thus, triterpenoid can suppress the proliferation of cancer cells and exert anti-cancer effects.

### Potential Anti-Oxidant Effects

It is known that reactive oxygen species (ROS) such as; superoxide radicals, hydroxyl radicals, and hydrogen peroxide, contribute to carcinogenesis by causing DNA breaks, mutations, and the proliferation of mutated cells. The intracellular antioxidant defense system plays a crucial role in preventing the damage that can be caused by ROS species. The best-known intracellular antioxidant defense mechanism is superoxide dismutase (SOD) activity. SOD catalyzes the conversion of superoxide radicals into less reactive substances such as oxygen and hydrogen peroxide. In addition to its proapoptotic and antiproliferative effects, some *in vitro* studies have reported that avocado seed extract increases SOD activity, thereby affecting the intracellular antioxidant defense system. Kupnik et al.[30] examined the antimicrobial and antioxidant effects of avocado seeds and reported that avocado seed ethanol extract has a higher antioxidant capacity, especially due to its polyphenolic content. Athaydes et al.[31] examined the protective effects of *Persea americana mill* seed extract against gastric ulcers. According to the experimental results of the study, the *Persea americana mill* seed extract has a potential protective effect against gastric mucosal injuries by increasing SOD enzyme activity as well as mucus synthesis.

Additionally, a study performed by Alkhalaf et al.[4] examined the antioxidant properties of *Persea americana* fruit and seed extract on HT 116 (colon cancer) and HepG2 (liver cancer) cancer cell lines and found that *Persea americana* had an antioxidant effect in both extracts. Moreover, although there is limited evidence in the current literature, avocation B, the odd-numbered carbon lipid of avocado, has potential anti-cancer effects as a cytotoxic agent and fatty acid oxidation inhibitor.[32]

### Potential Anti-Inflammatory Effects

The bidirectional relationship between inflammation and cancer is known. Although inflammation, especially chronic inflammation, can cause cancer, cancer cells can increase the levels of proinflammatory cytokines in the human body. Inflammation can stimulate nearly all cancer pathways.[33] There are some human studies on the effects of avocado consumption on inflammatory biomarkers. Zhang et al.[34] conducted a study with overweight and obese adults and assessed their high sensitivity to C-reactive protein (hs-CRP), interleukin-6 (IL-6), monocyte chemoattractant protein-1 (MCP-1), intracellular adhesion molecule-1 (ICAM-1), and vascular cell adhesion molecule-1 (VCAM-1) after consumption of the Hass-type avocado for 12 weeks (one avocado/day, ~168 g pulp). Although they did not observe significant changes in IL-6, MCP-1, and ICAM-1 expression, significant differences in hs-CRP and VCAM-1 expression were observed. A pilot study added a Hass type of avocado to hamburgers and compared the effects of hamburger consumption with and without avocado. This study showed that 68 g of avocado consumption preserved the nuclear factor kappa B (NF-κB) light polypeptide gene enhancer in B-cells inhibitor alpha (IκBα), thereby reducing the activation of the NF-κB pathway.[35] Another study highlighted the anti-inflammatory effects of *Persea americana* seed extracts. Lipopolysaccharide-stimulated RAW264.7 murine macrophages were treated with avocado seed extracts for 24 hours and reduction of IL-6, IL-1β, and tumor necrosis factor-alpha (TNF-α) were observed. In addition, prostaglandin $E_2$ production was inhibited by the avocado extract.[36] Additionally, avocado oil supplementation (4 mL/kg, 90 days) was found to be effective for reducing proinflammatory cytokine levels (TNF-α, and IL-1β) in male C57BL/6J mice.[37]

The human, *in vivo*, and *in vitro* studies conducted to determine the anticancer effects of avocados are summarized in Table 1. In addition, all these potential effects are illustrated in Figure 2. In addition to the pulp and peel parts of avocado, the seed is another study area. Although the literature suggests that avocado seeds may help prevent cancer and exert potent anticancer effects, the "California Avocado Commission" claims that there is insufficient data on the safety of seed consumption for human health.[38]

## CONCLUSION

An avocado, one of the most popular fruits in recent years, contains many health benefits. As the present review shows, due to the

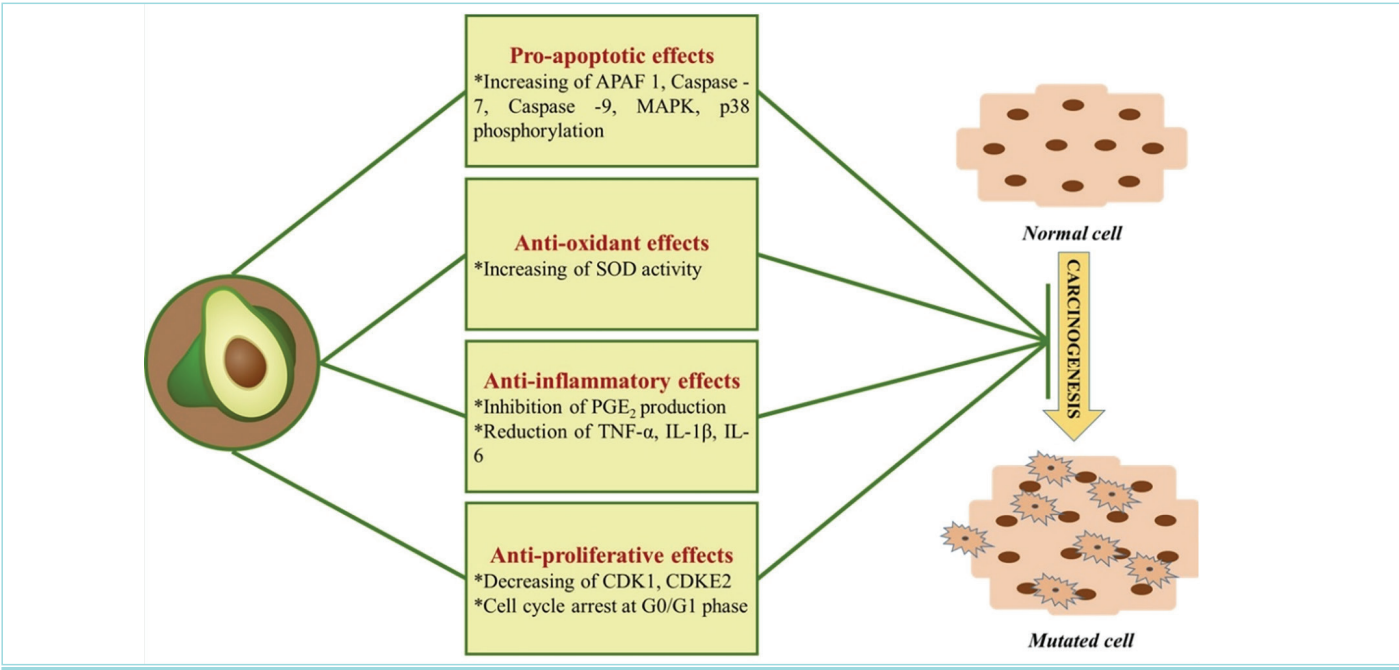


**Figure 2.** Potential cancerogenesis suppressive effects of avocado (prepared by the authors, based on the references in the "Potential anticarcinogenic effects of avocado" section and also Table 1).

APAF: Apoptotic protease activating factor, MAPK: Mitogen-activated protein kinase, SOD: Superoxide dismutase, $PGE_2$: Prostaglandin $E_2$, TNF-α: Tumor necrosis factor-alpha; IL-1β: Interleukin-1 beta, CDK: Cyclin-dependent kinases.

beneficial nutritional content of the avocado, its extracts have shown proapoptotic, antioxidant, anti-inflammatory, and antiproliferative effects in many current *in vitro* studies. The limited number of human studies showing that avocado consumption between once/day to once/a week showed anticancer effects. Thus, avocados can potentially suppress carcinogenesis. Nearly half of a portion of avocado (~68 g) can support daily DF, antioxidant vitamins, phytochemicals, MUFA, and PUFA intake. Although some important *in vitro* studies have shown that avocados have anticancer effects, the evidence remains minimal, and the number of *in vivo* studies is still limited.

Consequently, numerous *in vitro* studies on different cancer cell lines and *in vivo* studies are necessary. In particular, there is a need for studies designed to examine the pulp side (the most edible part) of avocado consumption and cancer development in humans.

## MAIN POINTS

- Avocado, which has become popular in recent years, has the potential to be effective in carcinogenesis because of its high nutritional composition and high polyphenolic content.
- *In vitro* studies have indicated that due to its rich polyphenolic content and nutritional matrix, the avocado extract may exert a proapoptotic effect by affecting caspases involved in apoptosis.
- Avocado extracts exhibited anti-inflammatory, antioxidant, and antiproliferative effects in some *in vitro* studies.
- Some human studies have shown the potential anticancer and antiinflammatory effects of avocado consumption.

## FOOTNOTES

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Concept: T.D., S.Ö., A.Y.B., Design: T.D., S.Ö., Analysis and/or Interpretation: T.D., S.Ö., Literature Search: T.D., S.Ö., A.Y.B., Writing: T.D., S.Ö., A.Y.B.

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