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An apple a day keeps the doctor away? - a review of health benefits of apples

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Abstract:**Introduction and purpose:**

Apples are a widely consumed fruit globally and are known to be a great source of nutrition. Studies have shown that apples contain high levels of antioxidants, dietary fiber, and vitamins that contribute to numerous health benefits. This paper aims to provide a comprehensive review of the impact of apples on human health.

State of knowledge:

The paper reviews the current literature on the health benefits of apples, focusing on their impact on various health conditions such as cancer, cardiovascular diseases, diabetes, and obesity. Additionally, it examines the role of apples in improving intestinal, immune, and cognitive function. The paper also discusses the potential mechanisms by which apples exert their health benefits, such as high levels of flavonoids, polyphenols, and dietary fiber.

Summary:

In conclusion, the vast body of evidence reviewed in this paper supports the notion that consuming apples regularly can contribute to better health outcomes. They may help reduce the risk of chronic diseases, such as cancer, cardiovascular diseases, and diabetes, as well as promote healthy gut microbiota and immune function. Despite the controversy surrounding the use of pesticides in apple cultivation, the benefits of consuming apples outweigh the risks. Therefore, it is highly recommended to include apples as part of a balanced and nutritious diet to promote optimal health and wellbeing. As the saying goes, "An apple a day keeps the doctor away".

KEYWORDS: apple, health, diet, chronic disease

INTRODUCTION

Apples are one of the most commonly produced fruits in the world [1]. Not only are they good in taste, but also packed with nutrients that can benefit health in numerous ways. From improving heart condition to preventing cancer, apples have been linked to a wide range of health benefits. Apples contain a number of vitamins, flavonoids, carotenoids, microelements and fiber [2], which are involved in many biochemical processes that ensure proper functioning. The content of substances from various groups that have a pleiotropic effect on the body also causes disease prevention.

In accordance with the study performed so far, apples can: reduce cardiovascular risk [3], lower glycemia [4], are hepatoprotective [5], anticancer [6], and support peristalsis [7]. Apples are low in calories and high in fiber, making them an ideal food for weight management.

In this article, we will explore the many health benefits of apples and the science behind their effects on the body. We will look at the different nutrients found in apples, how they impact our health, and the research that supports their health benefits. Taking into consideration all the above, it has been commonly used the saying "An apple a day keeps the doctor away". We will try to prove the validity of the title proverb.

DESCRIPTION OF THE STATE OF KNOWLEDGE

Nutrients in apples

When it comes to apple composition, there are several key elements to consider. Apples are primarily made up of water, with an average water content of around 86%. Therefore, it is a good low-calorie product for obese people [34]. They also contain a variety of vitamins and minerals, including vitamin C, potassium, and fiber [2]. In addition, apples are a good source of antioxidants, such as flavonoids and phenolic acids, which help to protect the body against cellular damage caused by free radicals [5]. These antioxidants are mostly found in the skin of the apple [2], so it's important to eat the skin in order to reap the full benefits. In the table below we present the biochemical composition of apples along with their content.

Components	Value per 100 g	Guideline Daily Amounts [%]
Energy [kcal]	52	2.6
Water [g]	85.56	-
Total carbohydrates [g]	13.81	5.31
Total dietary fiber [g]	2.21	-
Total sugar [g]	10.39	11.54
Fructose [g]	5.9	-
Glucose [g]	2.43	-
Protein [g]	0.26	0.52
Total lipid [g]	0.17	0.24
Vitamin C [mg]	4.6	5.75
Thiamin [mg]	0.017	1.55

Riboflavin [mg]	0.026	1.86
Niacin [mg]	0.091	0.57
Vitamin B ₆ [mg]	0.041	2.93
Folate, DFE [g]	3	1.5
Vitamin A, RAE [g]	3	0.38
Vitamin A [IU]	54	-
Vitamin E [mg]	0.18	1.5
Vitamin K [g]	2.2	2.93
Calcium [mg]	6	0.75
Iron [mg]	0.12	0.86
Magnesium [mg]	5	1.33
Phosphorus [mg]	11	2
Potassium [mg]	107	5.35
Sodium [mg]	1	0.04
Zinc [mg]	0.04	0.4
Total polyphenols [mg]	110.20	-
Flavanols [mg]	96.33	-
Hydroxycinnamates [mg]	14.21	-
Flavonols [mg]	5.66	-
Dihydrochalcones [mg]	4.17	-
Anthocyanins [mg]	1.62	-

Table 1. The content of ingredients in 100 g of apples, and Guideline Daily Amounts [20,41]

Comparison of varieties of apples

Reading publications, we learn that the content of nutrients, including polyphenols, varies depending on the variety and growing conditions. By reviewing the reports, it can be inferred that the Fuji variety and Red Delicious are the leaders in terms of flavonoid and polyphenol content [2]. It is also interesting to note that scientists have found that most antioxidants and polyphenols are found in by-products after juice production (including peels) [8].

According to research presented by Hodgson et al., regular apple consumption reduces the risk of death from any cause by about 14% [9].

Looking more closely, scientists have shown that incorporating apples into a daily diet reduces the risk of death from the most common diseases of affluence [10]. Below is presented extensive information according to different target points.

1. Cardiovascular system

Several studies have investigated the effects of apple consumption on cardiovascular health, and the results have been promising. Even small consumption significantly reduces the risk of premature death from cardiovascular diseases [2]. Here are some ways in which apples may influence the cardiovascular system:

1.1. Lower Blood Pressure

High blood pressure is a major risk factor for cardiovascular disease. Several studies have found that apple consumption may help lower blood pressure. From studies published in the journal *Free Radical Biology and Medicine*, consuming whole apples resulted in a reduction of systolic blood pressure (SBP) by 3.3 mmHg and a reduction of pulse pressure (PP) by 1.9 mmHg [11]. Apples are rich in potassium too, a mineral that can help to lower blood pressure. Studies have shown that a diet rich in potassium can help to reduce the risk of hypertension [12]. Additionally, the fiber in apples may also help reduce the absorption of sodium from the diet, which may contribute to lowering blood pressure [13]. Quercetin is an interesting discovery of recent years. It is a flavonoid found in the skin of apples, and is particularly beneficial for cardiovascular health. It helps to reduce blood pressure and improve vascular function [14].

1.2. Lower Cholesterol Levels

Cholesterol levels, especially low-density lipoprotein (LDL), strongly correlate with cardiovascular risk. Thankfully it is a modifiable parameter. For example, a diet high in saturated and trans fats can increase LDL cholesterol, while regular exercise and a diet rich in fruits, vegetables, and

whole grains can help lower LDL cholesterol and increase high-density lipoprotein (HDL) levels. In the research group of an experiment conducted in 2007, two apples of the Annurca variety were administered. Compared to the control group, a decrease in total cholesterol (TC) by 8.4%, LDL by 14.5%, and an increase in HDL by 15.2% were observed [15]. Apples are high in fiber, which can help to lower cholesterol levels. The soluble fiber in apples binds to cholesterol in the digestive tract and helps to remove it from the body [16].

1.3. Reduce Risk of Heart Disease

Apples are rich in antioxidants, which can help to reduce the risk of heart disease. The antioxidants in apples can help to prevent the oxidation of LDL cholesterol, which is a key step in the development of heart disease. Additionally, the flavonoids in apples have been shown to reduce inflammation in the body, which can also contribute to a lower risk of heart disease. Research conducted in the USA shows that regular consumption of apples significantly reduces C-reactive protein (CRP) levels [15].

1.4. Improve Endothelial Function

Endothelial dysfunction is a key contributor to the development of heart disease. Apples contain a variety of nutrients that can help to improve endothelial function, including quercetin, a flavonoid that has been shown to improve endothelial function in people with heart disease. Studies on rabbits have shown a positive effect on the regression of atherosclerotic lesions and the improvement of endothelial function [17]. An increase in nitric oxide (NO) has been observed [17], which plays a role in vasodilation [18].

1.5. Stroke

Apples are believed to have a positive impact on stroke prevention. A study published in 2007 found that people who ate apples on a regular basis had a lower risk of stroke compared to those who did not [19]. The high levels of antioxidants, fiber, and other nutrients found in apples may help to reduce the risk of stroke by improving cardiovascular health and reducing inflammation. Additionally, apples are low in sodium and high in potassium [20], which can help to regulate blood pressure, another important factor in stroke prevention [21]. Therefore, incorporating apples into a balanced and healthy diet may be beneficial for reducing the risk of strokes.

2. Cancer prevention

Apples contain a variety of substances that have anti-inflammatory and antioxidant properties, including flavonoids, catechin, triterpenoids and Polyphenols. It is they that determine the anticancer effect of apples. Antioxidants can help to neutralize harmful free radicals in the body, which can damage cells and contribute to the development of cancer [2,23]. Studies on the role of fisetin, which, according to reports, can inhibit the cell cycle of cancer and induce apoptosis, look promising [24]. Another interesting compound is phloretin, which has pleiotropic health-promoting and anti-cancer effects. It is a good antioxidant and immunomodulator. Scientists also emphasize its anti-proliferative and pro-apoptotic effects on cancer cells [25]. Polyphenols and triterpenoids have been shown to inhibit the growth of cancer cells [26,27], while pectin may help to prevent the spread of cancer cells [28]. Research suggests that eating apples may help reduce the risk of several types of cancer.

2.1. Colon cancer

Studies show that eating apples may reduce the risk of colon cancer. One study found that consuming apples on a regular basis was associated with a reduced risk of colon cancer. Another study found that the flavonoids found in apples may help inhibit the growth of colon cancer cells [26]. Apples are also a good source of dietary fiber, which has been shown to have a protective effect against colon cancer. Fiber helps keep the gastrointestinal system healthy and can help reduce inflammation in the colon, which may contribute to the development of cancer [28,29].

2.2. Breast cancer

Several studies have suggested that eating apples may help reduce the risk of breast cancer. Another study found that the polyphenols found in apples may help inhibit the growth of breast cancer cells. Apples are also a good source of dietary fiber [20], which has been shown to have a protective effect against breast cancer. Fiber helps keep the digestive system healthy and can help reduce levels of estrogen in the body, which may contribute to the development of breast cancer [30].

2.3. Other cancer

Some studies have suggested that eating apples may help reduce the risk of lung cancer, pancreatic cancer, oesophageal cancer, oral cavity cancer, bladder cancer and prostate cancer also [31].

3. Gastrointestinal system

Apples are particularly high in a type of fiber called pectin, which can help to promote gastrointestinal health in a number of ways [20]. Pectin can help to bind to toxins and cholesterol in the gut, which can prevent them from being absorbed into the body. It can also help to regulate the movement of food through the digestive system [13]. Improvement of gut microbiota: studies suggest that fiber can help improve gut microbiota, which may contribute to reducing the risk of cardiovascular diseases and hypertension [20]. Apples contain polyphenols, which are compounds that have been shown to have anti-inflammatory effects. Inflammation can contribute to digestive problems such as inflammatory bowel disease, and polyphenols may help to reduce this inflammation [17]. Eating apples also can help regulate digestion and prevent constipation because they contain fiber, which promotes intestinal peristalsis and facilitates bowel movements [13].

3.1. Gastric and duodenal ulcers

Studies have shown that eating apples may help reduce the risk of ulcer diseases because they contain antioxidants that protect the mucous membrane of the stomach and duodenum from damage [32].

3.2. Colitis Ulcerosa

Due to their anti-inflammatory and antioxidant properties, apples may be beneficial for people with colitis ulcerosa (CU), helping to rebuild the normal bacterial flora and reduce inflammation [33].

3.3. Glycemic Index

Apples have a low glycemic index [34], which means that they do not cause a rapid spike in blood sugar levels. This can be helpful for people with diabetes who need to manage their blood sugar levels [35]. It can also help to prevent cravings and promote satiety, which can support weight loss efforts. Apples also have phlorizin [20], which has been shown to inhibit the activity of the sodium/glucose cotransporter 1 (SGLT1) protein [36]. By inhibiting SGLT1, phlorizin reduces glucose absorption and may help to improve glucose metabolism and insulin sensitivity [36]. This mechanism of action makes phlorizin a potential therapeutic target for the treatment of diabetes and other metabolic disorders.

4. Respiratory system

Apples have been found to have a positive impact on respiratory health and may help reduce the risk of certain respiratory diseases. This is due in part to the high levels of antioxidants found in apples, including quercetin and flavonoids, which have anti-inflammatory properties [2]. One study found

that regular consumption of apples was associated with a lower risk of asthma and improved lung function in adults [37]. Another study showed that the antioxidants found in apples may help protect against the oxidative stress that can lead to chronic obstructive pulmonary disease (COPD) [38]. In addition to their antioxidant properties, apples are a good source of vitamin C [2], which has been shown to have a positive impact on respiratory health. Vitamin C helps support the immune system and may help reduce the severity and duration of respiratory infections [39].

5. Baldness

There are reports that the Annurca variety, known for its high content of polyphenols, has a beneficial effect on hair growth. According to a randomized study, supplementation with Annurca extract causes an increase in the amount of hair on the bald scalp by > 5% after 30 days and > 10% after 60 days. In addition, an increase in hair weight and keratin content was demonstrated [40].

SUMMARY

Analyzing many scientific studies, including meta-analyses and clinical trials, it is highly probable that introducing apples into a balanced diet increases its health-promoting properties. As a team, we made a thorough analysis of several scientific reports available in databases. We have prepared a review by selecting the most valuable, especially multicenter meta-analyses and studies that do not raise any substantive doubts. Apples are a source of at least a dozen valuable substances that improve the functioning of the body and have anti-disease and even anti-cancer properties. These activities are pleiotropic in nature. Additionally, eating apples may have a positive effect on the digestive and nervous systems.

The proverb "An apple a day keeps the doctor away" should be taken figuratively, but like any ancient motto, it has a grain of truth in it. The importance of apples in the daily diet for health has been emphasized for centuries. While eating an apple alone may not be enough to prevent disease, it can certainly contribute to your overall health and well-being.

It is worth noting that the health benefits of apples may depend on various factors: the variety of apples, the method of their preparation and individual differences in the absorption and metabolism of nutrients. Finally, we would like to indicate directions for further scientific considerations. In recent years, there has been more and more talk about the need to change the diet from fruit to vegetables due to, among other things, the glycemic index. We believe that there should be more meta-analyses comparing the effects of apples and vegetables. Nowadays, the effectiveness of supplements containing apple extracts should be compared with that of natural fruit. Additionally, research on the absorption of substances contained in fruit in combination with other foods would be important.

Author's contribution:

Conceptualization: P.B., M.R.,; methodology: P.B., M.R. software: P.B., M.R., P.R., J.R.; formal analysis: P.B., M.R., P.R., J.R.; investigation: P.B., M.R., P.R., J.R., J.R., B.M., K.M, M.G-S., A.G., W.R.; resources: P.B., M.R., P.R., J.R.; data curation: P.B., M.R., P.R., J.R., J.R., B.M., K.M, M.G-S., A.G., W.R.; writing - rough preparation: P.B., M.R., P.R., J.R., J.R., B.M., K.M, M.G-S., A.G., W.R.; writing - review and editing: P.B., M.R., P.R., J.R., J.R., B.M., K.M, M.G-S., A.G., W.R. ; visualization: P.B., M.R.; supervision: P.B., M.R. project administration: P.B., M.R.

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