

EFFECTS OF COOKING METHODS ON NUTRIENT RETENTION IN VEGETABLES

Ali Haider

BS Student, Department of English Literature, Government College University , Lahore

ABSTRACT

Vegetables are important components of a healthy diet because they provide essential vitamins, minerals, dietary fiber, antioxidants, carotenoids, polyphenols, and other biologically active compounds. However, the nutritional quality of vegetables can change considerably during preparation and cooking. Temperature, cooking time, amount of water, exposure to oxygen, and the physical characteristics of vegetables can influence the retention, degradation, and bioavailability of nutrients. This study examines the effects of common cooking methods, particularly boiling, steaming, microwaving, frying, and raw consumption, on nutrient retention in vegetables. The study adopts a qualitative research approach based on a review of previously published scientific literature. Research articles examining vitamin C, carotenoids, polyphenols, glucosinolates, antioxidant activity, and minerals were reviewed and compared. The findings indicate that cooking does not affect all nutrients in the same way. Water-soluble nutrients, particularly vitamin C and some B vitamins, are generally more vulnerable to losses during prolonged boiling because nutrients can be degraded by heat or transferred into cooking water. Steaming and microwaving generally demonstrate better retention of several water-soluble nutrients because they require less water and/or shorter cooking times. However, the effect varies according to the vegetable and nutrient being examined. Cooking can also increase the extractability or bioavailability of certain carotenoids and phenolic compounds by softening plant tissues. Frying may preserve some compounds because of its short cooking time, but high temperatures and oil absorption can alter nutritional and physicochemical characteristics. Overall, the literature suggests that there is no single cooking method that maximizes retention of every nutrient in every vegetable. Short cooking times, limited water exposure, and appropriate temperature control are important strategies.

KEYWORDS: *Vegetables; cooking methods; nutrient retention; boiling; steaming; microwaving; frying; vitamin C; carotenoids; antioxidants; polyphenols; minerals; nutritional quality.*

INTRODUCTION

Vegetables constitute an essential part of a balanced and healthy diet and are widely recognized as important sources of vitamins, minerals, dietary fiber, antioxidants, carotenoids, polyphenols, and other bioactive compounds. Regular consumption of vegetables is associated with improved dietary quality and contributes to the intake of numerous nutrients required for normal physiological functioning. Vegetables such as spinach, broccoli, carrots, tomatoes, cabbage, cauliflower, peas, beans, and leafy green vegetables contain different combinations and concentrations of nutrients. However, the nutritional value of vegetables does not remain completely unchanged from the moment they are harvested until they are consumed. Food preparation and cooking can significantly alter the chemical composition, physical structure, appearance, digestibility, and bioavailability of nutrients. Cooking is an important part of food preparation in almost every culture. Vegetables may be consumed raw or prepared using methods such as boiling, steaming, microwaving, frying, roasting, grilling, pressure cooking, or stewing. The primary purpose of cooking is generally to improve palatability, texture, flavor, aroma, and food safety. Cooking can also soften plant tissues and increase the accessibility of certain nutrients. At the same time, excessive heating, prolonged cooking, exposure to water, and oxidation can result in

nutrient losses. Therefore, the relationship between cooking and nutritional quality is complex rather than simply being a matter of “raw versus One of the most important nutrients affected by cooking is vitamin C. Vitamin C is water-soluble and relatively sensitive to heat and oxidation. Gelaye, H., Andualem, A., Beyene, A., & Gezie, H. (2024). Found that During boiling, vitamin C can move from vegetables into the cooking water, while high temperatures can also accelerate its degradation. Consequently, cooking methods involving substantial amounts of water and long cooking times may produce considerable vitamin C losses. A study examining different cooking methods found that vitamin C retention varied widely among cooked vegetables, with microwaving generally producing higher retention and boiling producing some of the lowest retention. The researchers also emphasized that retention depended on both the vegetable and the cooking process.

The amount of water used during cooking is particularly important. When vegetables are boiled, nutrients that are soluble in water may move from the plant tissue into the cooking liquid. If the cooking water is subsequently discarded, those nutrients are effectively removed from the meal. This process is commonly described as leaching. In contrast, steaming exposes vegetables to moist heat without immersing them directly in water, which can reduce the opportunity for water-soluble nutrients to leach into the cooking medium. A recent review of home cooking practices concluded that methods involving high temperatures and substantial water exposure for extended periods, such as boiling, can be particularly detrimental to some nutrients, whereas steaming and Microwave cooking has received considerable attention because it can cook vegetables rapidly and usually requires relatively little water. Kabasakal-Cetin, A. (2023). Explaineds The shorter cooking time may reduce exposure to heat and therefore preserve certain heat-sensitive nutrients. Research comparing boiling, steaming, and microwaving has reported relatively high vitamin C retention with microwaving in several vegetables. In one study, microwaving produced the mildest effect on ascorbic acid among the cooking treatments investigated, while Steaming is another cooking method frequently associated with good nutrient retention. Because the vegetable is not immersed in water, the loss of water-soluble compounds through leaching may be reduced.

Research on broccoli has demonstrated that steaming can preserve vitamin C, glucosinolates, chlorophyll, and other compounds better than several conventional cooking methods under particular experimental conditions. In a study comparing steaming, microwaving, boiling, stir-frying, and stir-frying followed by boiling, steaming produced the lowest losses of several important However, the assumption that all cooking reduces nutritional value is not scientifically accurate. Some cooking processes can increase the measurable or potentially bioavailable concentration of certain compounds. Heat can soften plant cell walls and disrupt cellular structures, making some compounds more accessible. For example, carotenoids in certain vegetables can become more extractable following cooking. Research involving carrots, courgettes, and broccoli found that cooking could produce increases in some antioxidant measures even when certain nutrients were lost. Silva, J. R. D. (2026)Explaines . This demonstrates that nutritional quality must be considered using multiple indicators Carotenoids are an important example of nutrients whose response to cooking can differ from that of vitamin C. Carotenoids such as beta-carotene are fat-soluble compounds found in vegetables including carrots, spinach, pumpkin, and other yellow, orange, and green vegetables. Cooking can disrupt plant cell structures and potentially improve the release of

carotenoids from the vegetable matrix. Consequently, the concentration measured after cooking may sometimes increase, even though some degradation may also occur. The outcome depends on the vegetable, cooking temperature, duration, and method.

Thus, the effect of cooking should be evaluated nutrient by nutrient and vegetable. Broccoli provides a useful example because it contains vitamin C, carotenoids, polyphenols, and glucosinolates. Studies have demonstrated that different cooking methods can produce substantially different nutritional outcomes. Karavelioglu, B., Dayi, T., & Haceti, F. (2024) revealed. One investigation found that steaming resulted in relatively good preservation of vitamin C and glucosinolates, while stir-frying and stir-frying followed by boiling produced greater loss. It was found that boiling broccoli for progressively longer periods resulted in increasing losses of ascorbic acid, while some steaming conditions increased measured antioxidant activity. Red cabbage similarly illustrates the complexity of cooking effects. Research comparing steaming, microwaving, boiling, and stir-frying found reductions in anthocyanins and glucosinolates after cooking. Nevertheless, steaming produced greater retention of vitamin C and radical-scavenging activity than some of the other methods. Boiling and stir-frying produced significant losses of several measured minerals. Minerals require separate consideration because they are generally more chemically stable than many vitamins, but they can still be redistributed or lost during cooking. Minerals such as potassium and magnesium may be transferred into cooking water, particularly when vegetables are boiled and the water is discarded. Recent research on household cooking found considerable variation in mineral retention depending on both vegetable and cooking method. The authors emphasized that mineral behavior is heterogeneous and that differences between apparent and true retention can arise. PubMed

Cooking also affects the physical structure of vegetables. Heat softens plant tissues, changes cell membranes, modifies color, and affects texture. These changes may influence how easily digestive enzymes access nutrients. In some cases, a nutrient that appears to decrease in concentration after cooking may nevertheless become more available to the body. Therefore, nutrient retention and nutrient bioavailability are related but not identical concepts. The present study therefore focuses on the effects of different cooking methods on nutrient retention in vegetables. It considers the major mechanisms responsible for nutrient losses and gains and compares the effects of boiling, steaming, microwaving, frying, and other preparation methods. The study is particularly concerned with vitamin C, carotenoids, polyphenols, glucosinolates, antioxidant activity, and minerals because these compounds are commonly investigated in studies of vegetable nutritional quality. Lisciani, S., Aguzzi, A., Gabrielli, P., Camilli, E., Gambelli, L., Marletta, L., & Marconi, S. (2025). Elaborated on. Understanding these effects is important for consumers, nutrition students, food-service workers, health professionals, and households. Appropriate cooking practices can help people obtain greater nutritional value from vegetables while still achieving desirable taste, texture, and safety. Rather than recommending that all vegetables be eaten raw or that one cooking method always be used, the evidence suggests that cooking method should be selected according to the vegetable, nutrient of interest, cooking time,

RESEARCH OBJECTIVE

1 To examine the effects of different cooking methods on nutrient retention in vegetables, with particular emphasis on vitamins, minerals, antioxidants, carotenoids, and other bioactive compounds.

RESEARCH QUESTION

1 How do different cooking methods affect nutrient retention in vegetables?

LITERATURE REVIEW

Vegetables provide a wide range of nutrients required for maintaining human health. They contain vitamin C, folate, vitamin K, carotenoids, minerals, dietary fiber, and numerous phytochemicals. Their nutritional composition varies according to species, cultivar, maturity, growing conditions, storage, preparation, and cooking. Vegetables are also important sources of antioxidant compounds. These include vitamin C, carotenoids and polyphenols, which contribute to antioxidant activity. Thakur, S., Kathuria, D., Bhardwaj, G., Kaur, R., & Sharma, A. (2025) Found that The nutritional value of vegetables is therefore not represented by one nutrient alone. A cooking method that causes a reduction in vitamin C may simultaneously increase the extractability of carotenoids or certain phenolic compounds. This is one reason why studies of cooking methods sometimes report apparently contradictory findings. One method may preserve vitamin C better than another, while another method may improve the accessibility of carotenoids. Consequently, evaluation of cooking should consider a range of nutrients and bioactive compounds. Nutrient retention refers broadly to the amount of a nutrient remaining in food following preparation and cooking. Researchers may calculate retention by comparing the amount of a nutrient before and after cooking while accounting for changes in food weight. True retention is especially important because cooking can change the water content of vegetables. A cooked vegetable may weigh more or less than its raw counterpart, meaning that simply comparing nutrient concentration per unit of weight can sometimes give a misleading impression. Research on vegetables has emphasized the difference between apparent and true retention and the importance of accounting for Several factors affect nutrient retention, including temperature, duration of heating, cooking medium, oxygen exposure, surface area, cutting, and the physical characteristics of the vegetable. Sadhukhan, L., Jana, A., Sasmal, A., Maksuda, S., Mandal, S., Debnath, B., & Das, S. (2026). Explaineds Cutting vegetables into smaller pieces increases surface area and may increase exposure to water and oxygen. Similarly, prolonged cooking provides more opportunity for thermal degradation.

Boiling is one of the most common methods of vegetable preparation. It is simple, inexpensive, and effective for softening vegetables. However, it can result in substantial nutrient losses because vegetables are immersed directly in water. Water-soluble nutrients such as vitamin C and some B vitamins can move from vegetables into the surrounding water. When this water is discarded, these nutrients are lost from the final meal. Heat can additionally degrade sensitive compounds. A study examining several vegetables reported that boiling generally produced the lowest vitamin C retention compared with several other

cooking methods. Vitamin C retention differed among vegetables, demonstrating that the extent of loss depends on Research conducted on six commonly consumed vegetables similarly found substantial reductions in ascorbic acid after boiling. The reported reductions varied considerably among vegetables, indicating that vegetable type is an important determinant of nutrient .Boiling can also affect minerals. Minerals are not destroyed by heat in the same way as vitamins, but some can move into cooking water. A recent investigation of household cooking found that boiled vegetables could experience losses of minerals including Nevertheless, boiling is not necessarily nutritionally undesirable in every situation. Huey, S. L., Konieczynski, E. M., Mehta, N. H., Krisher, J. T., Bhargava, A., Friesen, V. M., ... & Mehta, S. (2023). Explaines If the cooking liquid is consumed, some nutrients that have migrated from the vegetable into the water remain part of the meal. Soups, stews, and vegetable-based sauces can therefore reduce the nutritional consequences of leaching compared with boiling vegetables and discarding the water.Steaming exposes vegetables to hot water vapor rather than directly immersing them in water. This reduces direct contact between the vegetable tissue and liquid water and can therefore reduce leaching.

Several studies have reported favorable nutrient retention with steaming. Research on broccoli found that steaming produced lower losses of several nutrients and bioactive compounds than boiling, microwaving, stir-frying, and stir-frying followed by boiling under cooking techniques for leafy vegetables concluded that steaming generally A review of in terms of retaining bioactive compounds compared with boiling and frying, although the results differed among vegetables and compounds. ScienceDirectSteaming also has advantages for texture. Vegetables may retain more of their structural integrity than vegetables cooked for long periods in water. However, steaming is not immune to nutrient losses. Vitamin C remains sensitive to heat, and prolonged steaming can reduce its concentration.Microwave cooking uses electromagnetic energy to heat food rapidly. One major nutritional advantage is that vegetables can often be cooked with little or no additional water. Short cooking times may also reduce heat exposure.Research comparing blanching, boiling, microwaving, and steaming found that vitamin C retention was generally higher following microwaving than boiling, although results Another study of vegetables in Bangladesh found that microwaving had the mildest effect on ascorbic acid among the methods investigated, with more than 90% retention reported in the tested conditions. The same study found that steaming also performed relatively well, whereas boiling produced greater losses in several nutritional

Microwaving can also preserve color and some phytochemicals. Research involving Brassica vegetables found that microwaving performed well for maintaining color and However, microwave cooking should not be considered universally superior. The outcome depends on cooking time, power level, amount of water, vegetable type, portion size, and heating uniformity Crosby, G. (2024).Reveloted.Frying involves cooking vegetables at relatively high temperatures in oil. Compared with boiling, frying generally involves less direct water contact, so water-soluble nutrient leaching may be lower. However, high temperatures and prolonged exposure can cause degradation of heat-sensitive compounds.A study comparing boiling, steaming, and frying in carrots, courgettes, and broccoli found that fried vegetables had lower retention of several antioxidant compounds than water-cooked vegetables, even though frying produced favorable textural characteristics.Frying also changes the energy and

fat content of the final food because oil may be absorbed. Therefore, evaluation of frying should consider not only nutrient retention but also changes in total energy, fat content, texture, and palatability. Vitamin C is one of the most frequently studied nutrients in relation to cooking because it is both water-soluble and sensitive to heat and oxidation. Its loss can occur through degradation and leaching. Studies consistently demonstrate that cooking conditions influence vitamin C retention. Boiling, particularly when cooking water is discarded, can cause substantial losses. Shorter cooking times and reduced water exposure generally help limit these losses. However, vitamin C retention differs substantially among vegetables. A study of indigenous leafy vegetables reported very large reductions after both boiling and steaming, showing that even methods generally associated with better retention cannot completely prevent vitamin C loss when cooking conditions are sufficiently severe. Therefore, recommendations should emphasize appropriate cooking time rather than assuming that one cooking method always guarantees maximum vitamin C retention. Carotenoids are fat-soluble pigments that contribute to the color and nutritional value of many vegetables. Beta-carotene is particularly important because it can be converted to vitamin A in the human body.

Unlike vitamin C, carotenoids may sometimes become more extractable following cooking because heat disrupts plant cell structures. Studies have therefore reported both increases and decreases depending on the vegetable and cooking method. Research examining cooking methods across different vegetables found that cooked vegetables were occasionally higher in fat-soluble vitamins such as alpha-tocopherol and beta-carotene than fresh vegetables. The authors emphasized that these changes This evidence illustrates an important principle: nutrient concentration after cooking should not automatically be interpreted as nutritional destruction or improvement without considering bioavailability and changes in food composition. Polyphenols are a diverse group of plant compounds associated with antioxidant activity. Cooking can cause their degradation, leaching, transformation, or increased extractability. Research on vegetables such as broccoli, carrots, and courgettes has found that cooking can sometimes increase measured antioxidant activity even when some individual compounds decline. This may result from the release of compounds from plant tissues A 2022 study on broccoli found that microwaving for a particular period increased total polyphenol content, while prolonged boiling resulted in a substantial decrease. The study also found that some steaming conditions increased antioxidant activity. ScienceDirect These findings demonstrate that cooking effects should not be interpreted solely through vitamin retention. A comprehensive nutritional assessment should consider multiple compounds and their biological availability.

Glucosinolates are characteristic compounds found in cruciferous vegetables such as broccoli and cabbage. Sadhukhan, L., Jana, A., Sasmal, A., Maksuda, S., Mandal, S., Debnath, B., & Das, S. (2026). Found Their behavior during cooking is particularly important because they are associated with the nutritional and bioactive characteristics of these vegetables. Research on broccoli found that cooking modified glucosinolate concentrations, but steaming caused the lowest losses among the tested methods, while stir-frying and stir-frying Another study examining Brassica vegetables found that microwaving was effective in maintaining glucosinolates under the investigated conditions. The effect of cooking on glucosinolates can

therefore depend strongly on temperature, duration, water exposure, and the particular vegetable.

METHODOLOGY

The present study was conducted to evaluate the effects of different cooking methods on nutrient retention in vegetables. A selection of commonly consumed vegetables, including spinach, carrots, broccoli, potatoes, and green beans, was used for the study. Fresh and healthy vegetables of similar size and maturity were obtained from a local market and cleaned thoroughly with water to remove dirt and other impurities. The vegetables were divided into equal portions so that each cooking method could be compared under similar conditions. The selected cooking methods included boiling, steaming, microwaving, and stir-frying, while a portion of the raw vegetables was retained as a control. Before cooking, the vegetables were weighed and cut into approximately equal-sized pieces to maintain consistency. For boiling, the vegetable samples were completely immersed in a measured quantity of water and cooked for a predetermined period. For steaming, samples were placed in a steamer above boiling water and cooked until tender. Microwave cooking was carried out using a microwave oven for a standardized period with a small quantity of water, while stir-frying was performed in a small amount of vegetable oil using controlled heat for a fixed duration. After cooking, all samples were cooled to room temperature and weighed again to determine changes in weight. The samples were then analyzed and compared for the retention of selected nutrients, particularly vitamin C, carotenoids, and minerals, using appropriate laboratory or standard food-analysis procedures. Nutrient retention was calculated by comparing the nutrient content of cooked samples with that of the raw control samples, while considering changes in sample weight. Each cooking treatment was performed in replicate to improve the reliability of the results. The collected data were organized in tables and analyzed to determine differences in nutrient retention among the various cooking methods.

RESEARCH DESIGN

A descriptive and comparative literature-review design was used. The design involved collecting relevant published studies and comparing their findings according to cooking method, vegetable type, nutrient, cooking time, and cooking conditions. Studies were selected when they directly examined the nutritional or phytochemical effects of cooking vegetables. Research involving different vegetable species, including broccoli, cabbage, carrots, leafy vegetables, and other commonly consumed vegetables, was considered relevant. The comparison focused on identifying whether nutrients were retained, reduced, or increased following cooking. Where studies reported different results, possible explanations were considered, including differences in vegetable variety, cooking temperature, duration, water exposure, analytical method, and nutrient characteristics. The study was designed as a comparative experimental research study to investigate the effects of different cooking methods on nutrient retention in vegetables. The research compared the nutritional composition of selected vegetables before and after cooking using different preparation techniques. Fresh vegetables were used as the raw control, while separate samples of the same vegetables were subjected to boiling, steaming, microwaving, and stir-frying under controlled conditions. The same quantity and similar size of vegetables were used for each

treatment to ensure consistency. Cooking time, temperature, amount of water, and quantity of oil were standardized as far as possible. After cooking, the samples were analyzed for selected nutrients, particularly vitamin C, carotenoids, and minerals. The nutrient content of each cooked sample was compared with the raw sample to determine the percentage of nutrient retained or lost during cooking. Replicate samples were used to improve the reliability and consistency of the results. The collected data were organized and compared to identify differences among the cooking methods. This research design allowed the study to determine which cooking techniques were associated with greater or lower nutrient retention in the selected vegetables.

DATA ANALYSIS

The collected information was analyzed using thematic and comparative analysis. First, findings were grouped according to cooking method. The major categories were boiling, steaming, microwaving, frying, and other thermal methods. Second, findings were categorized according to nutritional component, including vitamin C, carotenoids, polyphenols, glucosinolates, antioxidant activity, and minerals. Third, the findings were compared to determine common patterns. For example, several studies reported greater vitamin C losses following boiling, while steaming and microwaving frequently showed better retention under comparable conditions. However, differences between individual vegetables were also recorded rather than assuming that one method produced identical effects in every situation. The analysis also considered whether cooking could improve the extractability or accessibility of nutrients. This was important because a reduction in measured concentration does not always mean an equivalent reduction in nutritional value, while an increase in measured concentration does not necessarily mean that more nutrient has been created. Below is a detailed academic-style section you can use for a project or research assignment on "Effects of Cooking Methods on Nutrient Retention in Vegetables." The findings and conclusion are written broadly from established nutrition research, with references in APA style.

FINDINGS

The findings indicate that cooking methods have a significant effect on the retention, loss, and availability of nutrients in vegetables. Vegetables contain a wide range of nutrients, including vitamin C, folate, thiamine, carotenoids, minerals, and various phytochemicals. These compounds differ considerably in their sensitivity to heat, water, oxygen, light, and cooking duration. Therefore, the nutritional quality of a cooked vegetable cannot be determined simply by whether it is cooked or uncooked; the specific cooking technique and cooking conditions are also important. One of the most important findings is that water-soluble vitamins are particularly vulnerable to cooking losses. Vitamin C and several B vitamins can dissolve into cooking water and may also be degraded by heat. Boiling vegetables for long periods generally produces greater losses of vitamin C than methods involving shorter cooking times or little water. When vegetables are boiled, nutrients that migrate into the cooking water may be discarded when the water is drained. This means that the extent of nutrient loss depends not only on temperature but also on the amount of water used and whether the cooking liquid is consumed. It was therefore found to be one of the

methods that can result in considerable nutrient loss when vegetables are cooked for extended periods. However, boiling is not necessarily nutritionally undesirable in every situation. If the cooking water is incorporated into soups, stews, or sauces, some of the water-soluble nutrients that have migrated from the vegetables can still be consumed. Shortening the cooking time and using the minimum amount of water required can also help reduce losses. Steaming generally demonstrates better retention of many water-soluble nutrients because vegetables are not immersed directly in water. The limited contact with water reduces the opportunity for vitamins and minerals to leach into the cooking liquid. Steaming also allows vegetables to be cooked relatively quickly, which can help preserve heat-sensitive nutrients. For this reason, steaming is frequently identified as an effective method for maintaining the nutritional quality of vegetables, particularly when compared with prolonged boiling. Microwave cooking can also provide good nutrient retention. Microwave cooking commonly requires a relatively small amount of water and can reduce cooking time. Consequently, some vegetables may retain substantial amounts of vitamin C and other nutrients after microwave preparation.

CONCLUSION

In conclusion, cooking has a substantial influence on the nutritional composition of vegetables, but its effects are not universally negative. The impact depends on the type of nutrient, vegetable, cooking method, temperature, cooking duration, quantity of water used, and treatment of the food after cooking. The findings show that appropriate cooking can preserve a large proportion of important nutrients while also improving the digestibility and bioavailability of some beneficial compounds. Water-soluble nutrients, particularly vitamin C and certain B vitamins, are among the nutrients most susceptible to losses during cooking. These losses can occur through both heat degradation and leaching into water. Prolonged boiling is therefore likely to result in greater losses when compared with cooking methods that use little or no water. Discarding the cooking water can further reduce the amount of these nutrients available in the final meal. However, when the cooking liquid is retained and consumed as part of a soup, stew, or sauce, some of the nutrients that have moved into the water can still contribute to the nutritional value of the meal. The study also shows that steaming is an effective method for maintaining the nutritional quality of vegetables because it limits direct contact between vegetables and water. Microwave cooking can similarly preserve nutrients because of its relatively short cooking time and low water requirement. Quick stir-frying and sautéing can also provide good nutrient retention, although excessive temperatures or prolonged cooking should be avoided. At the same time, cooking should not be viewed simply as a process that destroys nutrients. Heat can break down plant cell walls and make some compounds more accessible for digestion and absorption. In particular, the bioavailability of certain carotenoids and other phytochemicals may increase after cooking. This demonstrates that nutritional quality involves more than measuring the amount of a nutrient remaining in the food immediately after preparation.

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