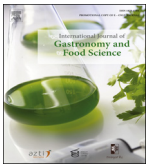

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Review Article

A review of the impact of preparation and cooking on the nutritional quality of vegetables and legumes

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Abstract

Vegetables and legumes represent one of the most important components of the human diet. Being informed about their characteristics can improve the health benefits, helping to reduce the risk of cardiovascular disease, type II diabetes and some cancers. Recent studies have demonstrated that the method of preparation and cooking can improve the nutrition quality of food. These two steps induce several changes and interactions among its constituents, in some cases positive, in others negative. Therefore, knowing the changes occurring in food from preparation to table is essential not only for scientific research, but also for the consumer, who can make decisions about how to prepare and cook a selected number of healthy legumes and vegetables. The purpose of this review was to evaluate the most recent studies and draw conclusions that will enable the consumer to make decisions about how to maximize nutrient content of plant foods and identify the critical phases during preparation and cooking, when the nutrients might be lost. For such, some nutrients of specific legumes (peas and beans) and vegetables (broccoli, potatoes and onions) were selected.

Keywords: Vegetables; Legumes; Preparation; Cooking methods; Nutritional quality

Contents

Introduction

The nutritional quality provided by vegetables and legumes consumption has been intensely reviewed (Block et al., 1992; He et al., 2007; Tiwari and Cummins, 2013). Legumes and

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vegetables are rich sources of proteins, fats, carbohydrates, minerals, antioxidants, fiber and water, as well as being excellent sources of β-carotene (provitamin A), thiamin (B1), riboflavin (B2), niacin, pyridoxine (B6), pantothenic acid, folic acid (folacin), ascorbic acid, and vitamin E and K (Karmas and Harris, 1988; Prodanov et al., 2004).

Recent studies have shown there are several ways to enhance the availability of healthy nutrients through proper selection of the method of cooking. According to these studies, the most common methods used for cooking legumes and vegetables are: steaming, roasting, boiling, frying, sautéing, *sous vide*, microwave and pressure-cooking. Besides that, the authors also considered in their researches, factors related to common domestic processing, including: washing, peeling, cutting, chopping and soaking (Tiwari and Cummins, 2013). Such information has been studied for specific vegetables such as: broccoli (Dos Reis et al., 2015; Bongoni et al., 2014; Kahlon et al., 2012; Mahn and Reyes, 2012; Martínez-Hernández et al., 2013; Miglio et al., 2008; Murador et al., 2014; Pellegrini et al., 2010; Poelman et al., 2013; Yuan et al., 2009), onion (Cavagnaro and Galmarini, 2012; Lee et al., 2008; Németh et al., 2003; Rodrigues et al., 2009; Wilson and Demmig-Adams, 2007), potato (Blessington et al., 2010; García-Segovia et al., 2008; Lachman et al., 2012, 2013; Micklander et al., 2008; Perla et al., 2012) and legumes such as beans (Ramírez-Cárdenas et al., 2010; Saikia et al., 1999; Schoeninger et al., 2014; Siqueira et al., 2013; Taiwo and Akanbi, 1997; Wang et al., 2010a) and peas (Azarnia et al., 2011; Duhan et al., 2002, 2004; Habiba, 2002; Koplík et al., 2004; Wang et al., 2008). It is known that nutrient losses occur in the preparation and cooking phases, and understanding how and why these losses occur can help the consumer, chef and food processor limit losses and enhance the nutritional quality of the food.

Many reports have found significant differences among the cooking methods. Kahlon et al. (2007) studied how cooking could influence in vitro bile acid binding by various vegetables. It has been demonstrated that bile acid binding lowers the levels of cholesterol in the blood, helping to reduce the risk of heart disease. In their first study they found that steam cooking improved bile acid binding by beets, eggplant, asparagus, carrots, green beans and cauliflower when compared to the same vegetables uncooked. In their next study, the authors obtained similar results by steaming collard greens, kale, mustard greens, broccoli, Brussel sprouts, spinach, green bell pepper and cabbage (Kahlon et al., 2008). After four years, the authors studied some of the same vegetables of the second study using other cooking methods (sautéing, boiling, steaming). They concluded that sautéing was the cooking method with the most health potential (binding bile acids) for mustard greens, kale, broccoli, cabbage and green bell pepper, with steaming the best method used for collard greens (Kahlon et al., 2012).

Changes in temperature can modify the flavor, texture and appearance of food, but this is not the only way that these modifications can occur. The processing method applied to the foods is another parameter that can modify food, and encompasses the entire spectrum from the strength of a knife to that of a processor. The cutting or processing damages the cell structure, as well as heating or freezing (America's Test Kitchen and Crosby, 2012).

As reported by Fennema (1996) without accurate information about conditions and methods of food processing, storage and handling, it is difficult to predict the influence and the retention of many vitamins, which emphasizes the great need for more research in this field.

Of the main factors that consumers consider when selecting food for cooking at home (flavor, texture, nutrition, cost, safety, convenience), flavor has been shown to be the most important (Azarnia et al., 2011; Lee et al., 2009; Van Boekel et al., 2010; Yoo et al., 2012). Enhancing the flavor of legumes and vegetables through preparation and cooking can increase the consumption of these healthy foods, especially among children (Poelman et al., 2013).

Since the early part of the twentieth century many studies have been conducted to investigate the impact of preparation and cooking methods on the stability of nutrients in food. The results of these studies vary widely leading the consumer to question the best ways of preparing and cooking foods in order to maintain the nutritional qualities, especially in legumes and vegetables. Many other researchers have shown that growth conditions of vegetables and legumes also have a significant impact on their nutrient content (Elmore et al., 2010; Kopsell et al., 2003; Lee et al., 2009; Wang et al., 2010b), but this factor will not be reviewed in this paper, which focuses on the impact of preparation and cooking on nutrient content. Therefore, the objective of this review is to evaluate the most recent studies and draw conclusions that will enable: (a) the consumer to make decisions about how to maximize nutrient content of plant foods and (b) identify the critical phases during preparation and cooking, when nutrients might be lost. For such, some nutrients of specific legumes (peas and beans) and vegetables (broccoli, potatoes and onions) were selected. The selection was based on the increased interest in these foods, according to the USDA (2010), as well as their availability in most of the world.

Vegetables and legumes: potential health benefits

The consumption of fresh food has grown considerably in recent years largely due to the fact that vegetables, legumes and fruits have been associated with many health recommendations (Hagen et al., 2009; Slavin and Lloyd, 2012; Storey and Anderson, 2014; Tiwari and Cummins, 2013). According to the Institute of Medicine, Food and Nutrition Board (IOM, 2005), dietary fiber intake could lower the risk of coronary disease and cancer. The World Health Organization (WHO/FAO, 2005) recommends a minimum of 400 g of fruit and vegetables per day (excluding potatoes and other starchy tubers) for the prevention of chronic diseases, as well as for the prevention and alleviation of several micronutrient deficiencies, especially in less developed countries. Block et al. (1992) have confirmed this fact, by evaluating 200 studies that examined the relationship between fruit and vegetable intake

and many types of cancer. The authors verified that 128 of 156 dietary studies have presented a statistically significant protective effect with vegetables and fruit intake. Epidemiologic and intervention studies have suggested that an intake of 14 g dietary fiber per 1000 kcal would promote heart health (Storey and Anderson, 2014).

Legumes are important sources of protein for the human diet. As reported by Karmas and Harris (1988), there are more than 13,000 species of legumes, but only 20 are eaten by mankind. The major legumes used as foods include peas, beans, lentils, peanuts and soybeans. The structure of peas and beans consists of a seed coat (hull), hypocotyl-radicle axis, plummule and two cotyledons. The seed coat works as a protective barrier during storage and handling. The most consumed varieties of legumes include: chick-peas (*Cicer arietinum*); peas (field or smooth pea and wrinkled pea); broad beans (*Vicia faba* or field bean); lentils (*Lens esculenta*) and beans (*Phaseolus vulgaris*, *Phaseolus lunatus*, *Phaseolus aureus* and *Phaseolus mungo*) (Karmas and Harris, 1988).

The nutritional composition of legumes can provide a high proportion of proteins, fats, carbohydrates, dietary fibers, B-group vitamins (thiamin, riboflavin, niacin), and minerals (Prodanov et al., 2004). This composition can vary according to cultivar, location of growth, climate, environmental factors, and soil type in which legumes are grown (Karmas and Harris, 1988; Bishnoi and Khetarpaul, 1993). Starch is the major constituent of available carbohydrates of peas and beans. Lipids consist primarily of triacylglycerol plus di- and monoacyglycerol, free fatty acids, sterols, sterol esters, phospholipids and glycolipids. Peas and beans are very poor sources of fat soluble vitamins and rich sources of water soluble vitamins; as well as excellent sources of minerals: calcium, phosphorus, potassium, sodium, manganese, iron, magnesium, copper, cobalt, sulfur, zinc and fluorine (Karmas and Harris, 1988). In some countries, various terms are often substituted for "legume". The term "pulse" is commonly used for legumes having a low fat content, like beans, broad beans, peas, and lentils. Soybeans and peanuts are sometimes referred to as leguminous oilseeds (Aykroyd and Doughty, 1982).

Vegetables have also been associated as part of a healthy diet, by reducing the risk of some chronic diseases. Vegetables provide vital nutrients for healthiness and maintenance of the human body, such as vitamin A, vitamin C, folate, fiber and potassium. According to the WHO (2003), the classification of vegetables can vary from country to country. The large reason for this differentiation is related to the inclusion or exclusion of starchy roots, tubers and legumes, within the vegetable groups.

Besides the related differences between vegetables and legumes, the USDA (2010) classifies all of them within one category, namely "Vegetable group". This category has been divided into five subgroups: (1) beans and peas; (2) starchy vegetables; (3) dark green vegetables; (4) red and orange vegetables and (5) other vegetables. According to this report, othe consumption of any type of bean (black, brown or white) is responsible for 89.5% of the consumption of its group, with Pinto Beans being the most consumed at 44.3%. Potatoes also have the highest consumption percentile within the Starchy vegetables subgroup (83%). Onions belong to the group "Other vegetables" and represent the second most consumed vegetable, with 19.2% of its group's consumption. Relative to the Dark green vegetables subgroup, broccoli was the most consumed (37.7%). Green peas are included into "Starchy vegetables subgroup", and not into "Beans and Peas subgroup", probably because of the high content of starch. The percentage of pea consumption is responsible for 4% of their group. The nutritional composition of these vegetables and legumes is summarized in Table 1.

The Center for Nutrition Policy and Promotion – United States Department of Agriculture – has suggested amounts of food to be consumed on a daily basis from the basic food groups, subgroups, and oils to meet recommended nutrient intakes at 12 different calorie levels. The estimated daily caloric needs can range according to the sex group/age and on the physical activity level, from sedentary to active (people who walk more than 5 km per day, accompanied of light physical activities) (USDA, 2011). The vegetable Group includes all fresh, frozen, canned, and dried vegetables and vegetable juices. According to the USDA (2011) to supply all the required needs, one person should consume, per day, one cup of raw or cooked vegetables or two cups of raw leafy greens (one cup is equivalent to $\approx$ 237 g).

Vegetables and legumes are excellent sources of several phytochemicals with proposed health-related benefits (Moreno et al., 2006). Phytochemicals are natural bioactive compounds found in vegetables and fruits used for combating free radicals and reducing the oxidative damage responsible by chronic diseases (Tiwari and Cummins, 2013). Vegetables as broccoli, provide flavonoids (Lin and Chang, 2005), polyphenols (Faller and Fialho, 2009), anthocyanin with high antioxidant activity (Monero et al., 2010) and powerful phytochemicals (glucosinates and isothiocyanates). Isothiocyanates and glucosinolates are the main biologically active compounds that are known to exhibit anti-carcinogenic activity in several in vitro and in vivo studies (Verkerk et al., 2009).

On the other hand, vegetables and legumes also have been known to contain anti-nutrients: potatoes contain alkaloid solanine, arsenic and nitrite; green leafy vegetables presents toxic oxalates and peas contain phytic acid, protease inhibitors and tannins (Karmas and Harris, 1988; Habiba, 2002). According to Habiba (2002) the reduction or elimination of these anti-nutrients is necessary to prevent poisoning and to improve the biological utilization of legumes. Most anti-nutrients can be reduced or destroyed by using the proper cooking method.

Factors that affect nutritional quality of vegetables and legumes

Preparation

Changes occasioned by food preparation can affect the flavor, texture, appearance and the nutritional quality of foods (America's Test Kitchen and Crosby, 2012). Domestic preparations of vegetables and legumes normally involve washing, peeling and

Table 1
Nutritional composition of cooked pinto beans, peas, broccolis, onions and potatoes* – value per 100 g of product**.

Nutrient	Unit	Pinto Beans	Peas	Broccoli	Onion	Potato
Proximate composition						
Water	g	62.95	77.87	89.25	87.86	77.46
Energy	kcal	143	84	35	44	86
Protein	g	9.01	5.36	2.38	1.36	1.71
Total lipid (fat)	g	0.65	0.22	0.41	0.19	0.1
Carbohydrate, by difference	g	26.22	15.63	7.18	10.15	20.01
Fiber, total dietary	g	9.0	5.5	3.3	1.4	1.8
Sugars, total	g	0.34	5.93	1.39	4.73	0.85
Minerals						
Calcium, Ca	mg	46	27	40	22	8
Iron, Fe	mg	2.09	1.54	0.67	0.24	0.31
Magnesium, Mg	mg	50	39	21	11	20
Phosphorus, P	mg	147	117	67	35	40
Potassium, K	mg	436	271	293	166	328
Sodium, Na	mg	1	3	41	3	5
Zinc, Zn	mg	0.98	1.19	0.45	0.21	0.27
Vitamins						
Vitamin C, total ascorbic acid	mg	0.8	14.2	64.9	5.2	7.4
Thiamin	mg	0.193	0.259	0.063	0.042	0.098
Riboflavin	mg	0.318	0.149	0.123	0.023	0.019
Niacin	mg	0.229	2.021	0.553	0.165	1.312
Vitamin B-6	mg	0.054	0.216	0.2	0.129	0.269
Folate, DFE	µg	172	63	108	15	9
Vitamin B-12	µg	0	0	0	0	0
Vitamin A, RAE	µg	0	40	77	0	0
Vitamin A, IU	IU	0	801	1548	2	3
Vitamin E (alpha-tocopherol)	mg	0.94	0.14	1.45	0.02	0.01
Vitamin D (D2+D3)	µg	0	0	0	0	0
Vitamin D	IU	0	0	0	0	0
Vitamin K (phylloquinone)	µg	0.35	25.9	14.1	0.5	2.1
Lipids						
Fatty acids, total saturated	g	0.136	0.039	0.079	0.031	0.026
Fatty acids, total monounsaturated	g	0.133	0.019	0.04	0.027	0.002
Fatty acids, total polyunsaturated	g	0.235	0.102	0.17	0.073	0.043
Cholesterol	mg	0	0	0	0	0

Source: USDA National Nutrient Database for Standard Reference 27 Software v.2.1.5. (2014).
**Pinto beans, mature seeds, sprouted, cooked, boiled, drained, without salt; Peas, green, cooked, boiled, drained, without salt; Broccoli, cooked, boiled, drained, without salt; Onions, cooked, boiled, drained, without salt; Potatoes, boiled, cooked without skin, flesh, without salt.

cutting (Tiwari and Cummins, 2013). The preparation methods most used are summarized in Table 2.

Modifications on texture of vegetables are strongly related to the transformations in cell wall polymers due to non-enzymatic and enzymatic reactions (Sila et al., 2008). According to the literature, the cruciferous vegetables, such as broccoli, have their flavor constituted by volatiles, sugars, acidity, as well as

Table 2
Preparation methods most applied to vegetables and legumes. *Source*: (Bartz and Brecht, 2002; Prodanov et al., 2004; America's Test Kitchen and Crosby, 2012; Smith et al., 1997).

Preparation	Description
Chop	To cut into small pieces.
Cut	To cut across the food, perpendicular to its length.
Dice	To cut into uniforms cubes.
Peeling	To remove outer skin or peel of certain vegetables.
Soaking	Consists of hydration of the seeds in water, usually until they reach maximum weight, with or without discarding of the soaking liquid; with or without salt addition. Normally used for legumes, such as beans.
Trimming	To remove all unwanted or inedible parts. Can be used to improve food appearance.
Washing	Rinsing with potable water to remove dirt, insects and small trash.

the astringency which is influenced by the phenolics' present. Pungency is increased due to an enzyme called myrosinase. This enzyme is liberated during food preparation such as chopping and trimming. When the cells are damaged, myrosinase converts glucosinolates into isothiocynates, responsible for the flavor and pungency of cruciferous vegetables (Johnson, 2002). In onions, when the *Allium* cells are damaged, the enzyme *allinase* is released and comes in contact with sulfur compounds. This factor is related to the increase of the pungency and the flavor of onions. According to Russo et al. (2013) onion flavor is closely linked to pungency and thus to the pyruvic acid content. Chopping vegetables can also alter the bioavailability of bioactive compounds such as carotenoids, polyphenols and flavonoids (Dos Reis et al., 2015).

Regarding peas and beans, many authors have cited a decrease in the cooking time by using soaking prior to cooking (Taiwo and Akanbi, 1997). During soaking, the water is dispersed into the starch granules and protein fractions of beans, which facilitate processes, such as gelatinization and protein denaturation, which soften the texture (Siddiq and Uebersax, 2012). This outcome can be improved by adding salt into soaking water. Soaking in sodium bicarbonate solution eliminates tannin contents and reduces trypsin inhibitor activity (TIA) in beans (Taiwo and Akanbi,1997). However, soaking peas in distilled water resulted in an increase in TIA (3.2–19.3%) (Wang et al., 2008). According to Taiwo and Akanbi (1997), soaking in simple water did not reduce the tannin content.

According to Schoeninger et al. (2014), a soaking time of 13.1 h with a concentration of sodium bicarbonate of 2.3 g.100 mL^{-1} followed by a drying temperature of 50 °C showed a reduction of 53% on cooking time of common beans (*P. vulgaris L.*).

Cooking method

The most common methods of cooking are sautéing, microwaving, roasting, boiling, and steaming. Other authors have studied other methods like *sous vide*, stewing and frying.

To report the changes caused by cooking methods, some key nutrients were selected for each plant food: glucosinolates and total antioxidant capacity (TAC) for broccoli; TAC and folate for potatoes; quercetin for onions; folate for peas and iron for beans. The description for each method can be seen on Table 3 and the effects of different methods of cooking on vegetables and legumes are summarized in Tables 4 and 5.

As it can be seen in Table 4, the method of preparation may greatly affect the content of nutrients and the acceptability of food. According to studies, steaming seems to be the best method to maintain the nutritional quality of broccoli (Bongoni et al., 2014; Mahn and Reyes, 2012; Stea et al., 2007; Wachtel-Galor et al., 2008). The results have showed that steaming improves the TAC, glucosinolates, carotenoids, sulphorane and, folate values. Besides, steaming broccoli presents good sensory acceptance among children. Cooking time should be 7.5 min to maintain the nutritional quality. Steamed vegetables are also more flavorsome than boiled vegetables (Poelman et al., 2013).

In potatoes, Stea et al. (2007) concluded that *sous vide* is the best method for folate retention. According to McKillop et al. (2002), few studies have examined the folate loss associated with the preparation and cooking of potatoes. The authors verified that the boiling of whole potatoes (skin and flesh) for 60 min did not result in a significant reduction in folate content (compared with raw values). Boiling was the preferred method of cooking potatoes, with 79% of the sample reporting preference for this method.

Regarding cooking effects on onions, Lombard et al. (2005) reported an increased concentration of flavonols when onions were submitted to sautéing (7%) and oven baking (25%). However, boiling decreased total flavonol concentration (18%). The authors also verified that cooking less than 5 minutes can retain over 80% of flavonols. In agreement with the USDA (2007), boiling onions retain less folate (65%), when compared to baking (85%). Zia-ur-Rehman et al., (2003) suggested that onions should be cooked, either by the ordinary method or in a microwave oven instead of a pressure-cooker, to minimize the losses of insoluble dietary fiber components.

In contrast to broccolis, boiling seems to be the best method to retain folate in peas (Table 5) (Stea et al., 2007). According to Bishnoi and Khetarpaul (1993), peas are excellent sources of dietary carbohydrates, but have relatively low starch digestibility. Pressure-cooking increases starch digestibility as well as reduces the level of anti-nutrients.

Concerned about the effect of cooking on beans, Prodanov et al. (2004) observed a marked reduction in the content of vitamins when fava beans, lentils and chickpeas were cooked. According to the USDA (2007), cooking beans for more than 2 hours, and then frying or baking them can reduce the folate retention by 50%. As reported by Léon et al. (1992), soaking beans in a salt solution, discarding the soaking solution and cooking with fresh water is the best way to improve the nutritional quality of beans. Beans contain some complex sugars of the raffinose family, and if not broken down by enzymes in the digestive system, can result in gastric issues such as gas production and flatulence. It can be solved by soaking the beans, and then cooking them, discarding the soaking liquid and cooking with fresh water. Besides, this method of cooking with salt addition can result in a tender skin due to sodium ions replacing calcium and magnesium ions bound to pectin in the cell walls (America's Test Kitchen and Crosby, 2012). In white beans, traditional cooking has a positive effect on the bioavailability of Fe. Many studies have shown that the digestibility and, therefore, absorption of Fe can be improved by heat processing (Wang et al., 2010a). Given their health and nutritional benefits, health professionals should encourage greater bean consumption (Messina, 2014).

According to the USDA (2010), cooking is the favorite way to consume potatoes, onions and broccolis, at 27.3%, 14.7% and 31%, respectively. In the United States, a survey of a thousand consumers asked how many times a week Americans were eating out: only 4% eat out more than three times a week, and 14% eat out twice, 39% once and 41% % never or rarely (Rasmussen Reports, 2013). Furthermore, there is a growing demand by consumers for food with less change or less synthetic additives during processing (Fellows, 2006).

Considering that much of the population prepares food at home, the knowledge of how these foods are prepared and how these different methods of preparation affect the nutritional quality of the food is extremely relevant for today's consumer.

Table 3
Cooking methods most applied to vegetables and legumes. *Source*: Adapted from America's Test Kitchen and Crosby (2012), Baldwin (2012), and Fellows (1996).

Method	Definition
Boil	To cook foods in boiling liquid in a pot set on a hot burner.
Fry	To cook in a hot oil in a skillet on a hot burner.
Microwave	To cook by placing the food in the path of microwaves (the induced molecular friction in water molecules will to produce heat).
Pressure-cooking	To cook food using water or other liquid in a sealed pot, normally a pressure cooker or an autoclave (Laboratory simulation).
Roast	To cook foods in a pan in a hot oven.
Sauté	To cook foods in a thin film of hot oil in a skillet set on a hot burner.
Simmer	To cook foods in liquid (below the boiling point in a pot set or hot burner).
Sous-vide	To cook in a vacuumed plastic pouches at precisely controlled temperatures.
Steam	To cook food that is suspended, generally in a basket, over simmering liquid in a covered pot set on the stovetop.
Stew	To sauté the food, and then simmer.

Table 4
Effects of cooking methods on the nutrients in vegetables*.

Cooking method	Effects	Main conclusion	Reference
Broccoli			
Basket Steaming (BS) Boiling (BL) Microwaving (MW) Oven Steaming (OS)	Fresh Broccoli: BS/OS:↑glucosinolates (37–39%) BL:↓glucosinolates (5%) MW: No differences Frozen Broccoli: All methods↓glucosinolates: BL (64%), MW(27%), BS (11%), OS (26%)	The total content of glucosinolates of fresh broccoli increased by steaming methods Steam cooking: best procedure to preserve and enhance nutritional quality of fresh broccoli	Pellegrini et al. (2010)
Boiling (BL) Frying (FR) Steaming (S)	TAC: BL↑(98%), FR↑(163%) and S↑(221%) Glucosinolates: BL ↓(71%), ↓FR (84%), and S ↑(30%)	Each vegetable should use a different cooking method. S: Best for retention of nutrients.	Miglio et al. (2008)
Boiling (BL) Microwaving (MW) *Sous vide* (SV) Steaming (S)	SV:↑TAC	All processes contributed in some way to an increased content of antioxidant compounds SV: Best for TAC retention.	Dos Reis et al. (2015)
Boiling (BL) Drying (DR) Freezing (FZ) Steaming (S)	S and DR:↑sulphorane and TAC	S and DR: have demonstrated best retention on sulphorane and TAC.	Mahn and Reyes (2012)
Boiling with a cold water start (BLC) Boiling with a hot water start (BLH) Steaming (S)	S↑glucosinates (17%) BLH↓glucosinates (41%) BLC↓glucosinates (50%) No sensorial ≠ were found ($n=99$)	S: Best cooking method for nutrient retention.	Bongoni et al. (2014)
Potato			
Boiling (BL) Microwaving (MW) Oven Baking (OB) Steaming (S)	Purple Majesty potatoes BL, MW, and S:↑Antioxidant Activity OB:↓Antioxidant Activity	BL: Seems to be the most promising method for preserving the bioactive composition.	Lemos et al. (2015)
Blanching (BLA) Boiling (BL) Microwaving (MW) Oven Baking (OB) Steaming Boling (SB) *Sous vide* (SV)	Folate retention SV (103%) > BL (72%) > OB (63%)	Folate retention: BL (59%) and OB of unpeeled potatoes (63%) caused a significant ($p < 0.05$) reduction of the folate content compared with raw potatoes on Dry Matter basis. Results indicates that the skin may give protection against folate losses.	Stea et al. (2007)
Boiling (BL)	Folate retention (82%)	BL of whole potatoes (skin and flesh) for 60 min did not result in a significant reduction in folate content. The presence or absence of potato skin had no significant impact on folate retention during boiling.	McKillop et al. (2002)
Onion			
Boiling (BL) Oven Baking (OB)	OB and SUT:↑7-25% quercetin concentration	SUT and OB:↑flavonol BL:↑5 min↓flavonol	Lombard et al. (2005)

Table 4 (*continued*)

Cooking method	Effects	Main conclusion	Reference
Sautéing (SUT)	BL: ↓18% quercetin concentration	Flavonol content more dependent on variety than cooking method.	
Boiling for 30 min (BL 30) Boiling for 60 min (BL 60) Frying (FR) Moderate Microwaving (MW) Intense Microwaving (IMW) Oven Roasting (OR)	White onion BL 30: ↓37% quercetin 3,40-diglucoside (QdG) and ↓29% quercetin 40-glucoside (QmG) BL 60: ↓53%(QdG) and ↓44% (QmG) MW did not affected flavonols content IMW: ↓16% (QdG) and↓18% (QmG)	The greatest losses of flavonoids occurred in boiled onions as a result of its migration into the cook water.	Rodrigues et al. (2009)

TAC = Total Antioxidant Capacity. *The data of this Table has been focused on broccolis, onions, potatoes, peas and beans. The references used in this table can be studied more than one nutrient; vegetable or legume.

Table 5
Effects of cooking methods on the nutrients in legumes*.

Cooking method	Effects	Main conclusion	Reference
Peas			
Sous vide (SV) Boiling (BL) Oven Baking (OB) Microwaving (MW) Steaming Boling (SB) Blanching (BLA)	Folate retention: BL 77% > MW 75% > SB 73% > BLA 71%	No method (BL, MW, SB) caused any significant ($p < 0.05$) losses of folates. Storage at various temperatures and length of times (followed by reheating) caused no further significant losses of total folate.	Stea et al. (2007)
Blanching (BLA) Freezing (FRZ)	Folate retention: 79% (BLA + FRZ)	The significant loss of folate in peas Resulting from blanching may be associated not only with the influence of heat treatment, but also with the size and degree of product fragmentation.	Czarnowska and Gujska (2012)
Beans			
Ordinary Cooking (OC) Soaking (SO)	No ≠ were found for Fe content in 7 different beans.	Concentrations of Fe were unaltered by cooking. Cooking increases soluble iron content in the cooking water.	Ferreira et al. (2014)
No Soaking (NSO) Ordinary Cooking (OC) Pressure Cooking (POC) Soaking (SO)	SO and POC↓Fe cooked grain, but↑Fe in the bean broth	Beans should be consumed in a combined form, i.e. grain with bean broth.	Carvalho et al. (2012)

* The data of this Table has been focused on broccolis, onions, potatoes, peas and beans. The references used in this table can be studied more than one nutrient; vegetable or legume.

Conclusion

This review is intended to reduce the uncertainly about how the different methods of preparation and cooking can affect the nutrient content of certain vegetables and legumes. According to this review, it is possible to conclude that:

1. Onion's pungency is increased during food preparation, such as chopping and trimming.
2. Steaming seems to be the best method to maintain the nutritional quality (TAC, carotenoids, glucosinolates, sulphorane, folate and phytochemicals).
3. Onions should be cooked or baked to improve flavonols' content.

4. *Sous vide* cooking has shown good results in cooking potatoes and should be investigated further.
5. Soaking and cooking peas and beans are effective in removing or reducing anti-nutrients such as tannins, TIA and acid phytic.
6. Boiling seems to be the best method to retain folate in peas and should be further investigated.
7. Soaking with salt, discarding water and cooking in fresh water is the best method to reduce cooking time, and to improve the protein quality, texture and appearance of beans, while reducing gastric issues.
8. The absorption of Fe can be improved by heat processing.
9. Other factors besides cooking – such as growth conditions and variety/cultivar – can affect sensory parameters.

All the steps included before vegetables and legumes consumption can affect directly their nutrition quality. Being informed about these factors might make the consumer more aware on how to optimize the nutrients obtained during a meal.

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