



# Better *Latte* Than Never: Should Coffee Consumption be Encouraged in Public Health Guidelines?

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**Abstract:** Coffee is part of the daily habits of millions of people globally. Given this significant consumption, it is important that the dietary guidelines reflect what effects this consumption may have on people's health. This review aims to examine the latest evidence regarding coffee consumption, consumers' perception of possible coffee health benefits, and the current recommendations given in Food-Based Dietary Guidelines (FBDG) to assess whether these are up to date and therefore, if coffee consumption should be encouraged in public health guidelines. Studies were obtained through the search in different databases. Selection criteria were broad for the introductory studies but stricter for those referring to health impact, concretely to a 5 year prior to the writing of this script and mainly selected meta-analyses, reviews, and systematic reviews and, where sensible, cohort studies. Coffee is a culturally ingrained drink with potential health benefits but is, generally, negatively viewed in FBDG. Recent research on coffee has not translated into new FBDG recommendations for the general population. A better understanding of the long-term effects of coffee, the consumers' behavior or the cultural impact of coffee could be useful to further support in favor or against a future update of public health dietary guidelines.

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**Resum:** Prendre cafè forma part dels hàbits diaris de milions de persones arreu del món. Tenint en compte la rellevància d'aquest consum, és important que les guies alimentàries reflecteixin quins efectes pot tenir aquest consum en la salut de les persones. Aquesta revisió té com a objectiu examinar les últimes evidències sobre el consum de cafè, la percepció dels consumidors sobre possibles beneficis derivats del consum de cafè i les recomanacions actuals en les guies alimentàries per avaluar si aquestes estan actualitzades i, per tant, esbrinar si s'hauria de promoure el consum de cafè a través de guies de salut pública. Els estudis obtinguts es van trobar mitjançant la cerca en diferents bases de dades. Els criteris de selecció van ser amplis per als estudis introductoris, però més estrictes per a aquells que es referien a l'impacte en la salut, concretament a cinc anys abans de l'escriptura d'aquest treball i, principalment, es van seleccionar meta-anàlisis, revisions i revisions sistemàtiques i, en casos determinats, estudis de cohorts. El cafè és una beguda arrelada culturalment amb possibles beneficis per a la salut, però, en general, les guies alimentàries mostren una visió més aviat negativa sobre el seu consum. L'evidència científica més recent sobre el cafè no s'ha traduït en noves recomanacions per a la població general. Una millor comprensió dels efectes a llarg termini del consum de cafè, del comportament dels consumidors o de l'impacte cultural del cafè pot ser útil per donar encara més suport, a favor o en contra, d'una futura actualització de les guies alimentàries.

Review

# Better *Latte* Than Never: Should Coffee Consumption be Encouraged in Public Health Guidelines?

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**Abstract:** Coffee is part of the daily habits of millions of people globally. Given this significant consumption, it is important that the dietary guidelines reflect what effects this consumption may have on people's health. This review aims to examine the latest evidence regarding coffee consumption, consumers' perception of possible coffee health benefits, and the current recommendations given in Food-Based Dietary Guidelines (FBDG) to assess whether these are up to date and therefore, if coffee consumption should be encouraged in public health guidelines. Studies were obtained through the search in different databases. Selection criteria were broad for the introductory studies but stricter for those referring to health impact, concretely to a 5 year prior to the writing of this script and mainly selected meta-analyses, reviews, and systematic reviews and, where sensible, cohort studies. Coffee is a culturally ingrained drink with potential health benefits but is, generally, negatively viewed in FBDG. Recent research on coffee has not translated into new FBDG recommendations for the general population. A better understanding of the long-term effects of coffee, the consumers' behavior or the cultural impact of coffee could be useful to further support in favor or against a future update of public health dietary guidelines.

**Keywords:** coffee, caffeine, food-based dietary guidelines, nutrition policy, consumers' behavior

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## 1. Introduction

Coffee is one of the most popular and consumed beverages around the world. Data from the International Coffee Organization show that global coffee consumption has increased each year since 2008, reaching a record of 168.1 million coffee bags (60kg each) in year 2018. This increase in popularity is a global phenomenon as growth has been recorded in America, Africa, Europe, Asia, and Oceania when averaging over the last 5 years [1].

Given this significant consumption in the general population, it is important that the dietary guidelines reflect what effects this consumption may have on people's health. This bibliographical review aims to examine the latest evidence regarding coffee consumption, the consumers' perception of possible coffee health benefits, and the current recommendations given in Food-Based Dietary Guidelines (FBDG) to assess whether these are up to date and therefore, if coffee consumption should be encouraged in public health guidelines.

In order to answer this question, this review starts by giving a general background on coffee consumption, a description of coffee nutritional facts and its main compounds, as well as detailing concepts that might be pertinent to recommendation guidelines, such as brewing methods or decaffeination process. Then, an analysis of the current health evidence on coffee has been included. After that, current FBDG concerning coffee consumption are reviewed as well as a brief analysis of the consumers' perception of possible health benefits from coffee consumption has been described.

Finally, the positive and negative aspects of coffee consumption are evaluated and discussed. The paper concludes with recommendations for future research.

## 2. Materials and Methods

In order to write this bibliographic review different studies were obtained through the search of different concepts in PubMed and Google Scholar databases. General background information and studies related to the cultural and social aspects have been researched with a larger scope. The information related to the FBDC was obtained through various government or institutions official websites. In order to better understand consumers' perception of health benefits of coffee two searches were performed in the PubMed Database using the Mesh terms "Coffee" and, respectively, "Health Knowledge, Attitudes, Practice", and "Consumer Behavior". Finally, in order to find the latest evidence on the relationship between coffee and health benefits searches were performed by using "Coffee [MAJR]" and different concepts such as "neoplasms" or "Diabetes Mellitus, Type 2". Other suggested articles or Mesh Terms from the articles previously obtained were also useful to gather more information such as "Coffee/adverse effects"[MAJR]. Selection criteria was restricted to a 5 years window prior to the writing of this script and selected were meta-analyses, reviews and systematic reviews as primary sources, as those are regarded more favorably in the evidence-based pyramid, in some cases, cohort studies were used.

## 3. General Background on Coffee and Coffee Consumption

Coffee is defined as "a beverage prepared by percolation, infusion or decoction from roasted and grounded beans of coffee plant" [2]. Genus *Coffea* belongs to Family *Rubiaceae* and comprises 103 species from Latin America, Africa, and Asia, but only two species of *Coffea* genus are widely cultivated, *Coffea arabica* and *Coffea canephora*, which account for, approximately, 65% and 35% of world coffee production, respectively [3]. *Coffea liberica* (also referred as *C. excelsa*) production is also worth mentioning [4].

Coffee is a well-known source of a very large and complex number of chemical compounds. Several factors might affect its composition, such as coffee species, processing (e.g. higher roasting can decrease polyphenol content [5,6]), altitude where it is produced (e.g. higher amounts of nicotinic acid have been found when coffee was grown in higher altitudes [7]), post-harvest processing methods [8] or other factors, such as shade [9].

Although it might be difficult to determine the exact chemical composition of coffee, green beans were described to contain carbohydrates (59–61%), lipids (10–16%), proteins (10%), and chlorogenic acids (7–10%), containing lower amounts of minerals (4%), aliphatic acids (2%), caffeine (1–2%), trigonelline (1%), and free amino acids (<1%). Upon roasting, a decrease is observed in carbohydrates (38–42%), proteins (8%) and especially chlorogenic acids (3–4%). The other components retain their relative content. Formation of melanoidins must be noted, as they will make up about 25% of the dry weight of roasted coffee beans [10] and those might be important when referring to possible coffee health benefits.

Presence of micronutrients has also been described in the coffee brew, such as potassium and magnesium (especially in espresso methods), vitamin E, and vitamin B3 (a coffee cup can amount up to 6–18% of the recommended dietary allowance for adult men). The dietary fiber content of coffee brews ranges from 0.14 to 0.65g, which could be relevant when referring to the possible prebiotic effect of coffee [11].

Concerning the potential health benefits of coffee, it may not be the most numerous compounds that draw attention to researchers, but rather a large number of bioactive compounds often found in lesser amounts. Furthermore, it is possible that the exact physiological effects of coffee are not due to a concrete compound but rather to their different interactions.

Compound	Type of chemical compound	Amount in coffee	Potential health effects
<b>Chlorogenic acids (CGA)</b>	Monophenol	24-423mg per espresso, probably s the main source of CGA in the diet  Roasting and storage may cause important loses [12]	<ul style="list-style-type: none"> <li>• Gene modulation of phase II metabolism</li> <li>• Anticarcinogenic activity (e.g. inhibition of DNA methyltransferase)</li> <li>• Antithrombotic agents (platelet activity inhibition)</li> <li>• <i>In vitro</i> inhibition of <i>Listeria Monocytogenes</i></li> <li>• Anti-adhesive properties against <i>S.mutans</i>, (major causative agent of dental caries in humans)</li> </ul>
<b>Caffeine</b>	Alkaloid	50-100mg ( <i>C.Robusta</i> > <i>C.Arabica</i> , and higher in more roasted coffee) [13]	<ul style="list-style-type: none"> <li>• Stimulatory effects (enhanced perception, reduced fatigue, increased capacity to remain awake and enhancing of memory consolidation; improves cognition) [14]</li> <li>• Reduction of symptoms of Parkinson disease</li> <li>• Increased metabolic rate, energy expenditure, lipid oxidation and lipolytic and thermogenic activities</li> <li>• Beneficial for athletic performance across endurance-based situations, and short-term, supramaximal and/or repeated sprint tasks [15]</li> </ul>
<b>Trigonelline</b>	Alkaloid	40-110mg per serving ( <i>C.Arabica</i> > <i>C.Robusta</i> )  Substantially degraded to nicotinic acid in roasting (B3)	<ul style="list-style-type: none"> <li>• Therapeutic potential as hypoglycemic, neuroprotective, antiinvasive, estrogenic and antibacterial activities found in rats and/or mice or <i>in vitro</i> studies</li> <li>• Potential agent against <i>Salmonella enterica</i></li> </ul>
<b>Kahweol and cafestol</b>	Diterpenes	< 0.6 – 12mg (boiled > espresso >>> filtered methods or soluble coffee)	<ul style="list-style-type: none"> <li>• Serum LDL rising in humans due to LDLr reduction and CETP and PLTP increase (especially cafestol) [16]</li> <li>• Potential anti-inflammatory, anticarcinogenic, antidiabetic and anti-osteoclastogenesis activities [16]</li> </ul>
<b>Melanoidins</b>	Polymers - Roasting products derived from Maillard reaction	0.5 to 2.0 g/day for moderate and heavy consumers [17].  Coffee is one of the main sources of melanoidins in the diet	<ul style="list-style-type: none"> <li>• Dietary fiber <i>in vivo</i> and potential prebiotic activity. Being largely indigestible by humans, it is and fermented in the gut (0.5-2g reaches the gut in moderate to heavy coffee drinkers).</li> <li>• Potential biological activities as antioxidant, metal chelating activity, anticarcinogenic and ability to modulate microflora</li> </ul>

**Table 1.** Summarized table on the most studied coffee compounds.

Note: All results come from the summary of Ludwig et al. [11]. Extra information has been added from other studies, properly cited [12-17]

When reviewing the latest evidence on these compounds, it is important to avoid translating overblown claims about potential healthy metabolites into coffee health benefits. Potential healthy metabolites should be consumed, absorbed, and metabolized in a consistent amount in order to have an impact on human health. Some of the most studied and known compounds in coffee are described were described by 2014 by Ludwig et al. [11] and are summarized in Table 1 [12-17].

### 3.1. Brewing Methods

Brewing methods can differ due to individual and cultural preferences, and it has been shown that coffee brewing technique has a significant effect on both the antioxidant potential of the beverage and the levels of specific minerals [18].

Certain methods may be recommended to individuals with certain pathologies. For example, filter methods are recommended for people with cardiovascular risk, as it lowers the amount of cafestol present in the brew [19]. As a relevant example for the general population, the usage of coffee capsules, an increasingly popular method in the last years, has shown lower values of antioxidant capacity (chlorogenic acid and melanoidins) and total phenolic content when compared with traditional coffeemakers [20].

Therefore, studies comparing coffee brewing methods might be important to give accurate recommendations both for certain pathologies and to the general population, but also to collaborate with the food industry to assure that the antioxidant potential of coffee does not diminish from plant to cup.

Numerous brewing methods and *recipes* to prepare coffee are popular among coffee enthusiasts, but for the purposes of this review, focus is placed on the most important: filter, espresso and infusion methods, along with soluble instant coffee; these are summarized in Table 2.

Coffee brewing method	Preparation	Examples
<b>Filter methods</b>	Pouring hot water over freshly grinded coffee beans that sit on a metal or paper filter	Drip Coffee, Pour over, Hario V60, Kalita, Chemex, AeroPress, etc.
<b>Espresso methods</b>	Pouring pressured steamed hot water over grinded coffee beans	Espresso, K-Cup® (or equivalent coffee capsules), moka pot
<b>Infusion methods</b>	Infusing coffee for a period of time in which extraction is done. In some methods, coffee is later filtered	French Press, Turkish, Cold Brew
<b>Soluble instant coffee</b>	Probably cannot be considered a <i>method</i> as a preparation only consist of mixing the soluble coffee with a liquid (such as milk, non-dairy equivalent or water).  Instant coffee is prepared from green beans, which are roasted, granulated, extracted, and then, concentrated and dried by atomization or freeze drying [21].	

**Table 2.** Classification of the most important methods of coffee brewing

Diverse brewing methods will produce different volumes of coffee but typically the amount of coffee grounds per cup does not widely vary, as only the extraction is found to be more diluted in some preparations. In any case, this ought to be considered when using “cup” as a unit size to give recommendations, as preparations will likely differ between countries.

As an example of these observable differences, in a metabolomic study of biomarkers of habitual coffee intake, from four European countries, the type of coffee most often consumed differed (espresso in France, drip-filter coffee in Germany, Greek coffee in Greece, and moka espresso in Italy) as well as average volume of a cup, which varied widely between the four countries, from 55 mL (Italy) to 209 mL (Germany) [22].

### 3.2. Decaffeinated Coffee

As the presence of caffeine may be considered undesirable for certain population groups, decaffeinated (popularly abbreviated as *decaf*) coffee is an available option frequently found in supermarkets, bars, and restaurants. In order to obtain this almost-free caffeine product, various processes can be used, and include using an organic solvent, using the Swiss Water® process or using supercritical carbon dioxide, along with other methods [23,24]. These processes allow people to reduce their caffeine intake without the need to give up coffee. Later on, this review will deep into the health effects of decaffeinated coffee.

## 4. Current Scientific Evidence on the Effects of Coffee Consumption on Human Health

Before discussing whether updating FB DG recommendations on coffee consumption may be required, it is relevant to review the latest evidence regarding coffee consumption and its health benefits.

This review will focus on the effects on most common non-communicable diseases as well as pathologies that seem to be affected from the consumption of coffee. This review does not pretend to systematically review all studies published until this date, but to evaluate whether current evidence is pushing towards giving more or fewer recommendations on FB DG. The literature search was conducted in the PubMed Database. Only meta-analysis, reviews, and systematic reviews published 5 years prior to the writing of this script were included.

After the review of diverse literature, Table 3 presents a summary of the effects of coffee consumption on selected pathologies, with a description of the possible underlying mechanisms of action.

It must be noted that, with the exception of one study [36], all of studies mentioned refer to the relation between coffee and certain diseases; rather than talking about the health effects of one single coffee compound, such as caffeine. Therefore, it might be more difficult to elucidate the underlying mechanisms behind coffee health effects, as coffee is a big source of diverse metabolites which might have different mechanisms of action.



Pathology	Study Type	Conclusions	Possible mechanisms of action
<b>Diabetes Mellitus Type II (T2D)</b>	Review [25]	Consumption in moderation is safe and beneficial both for healthy people and those with T2D	Different possible mechanisms of action proposed in [26]: <ul style="list-style-type: none"> <li>• Possible thermogenic, antioxidative, and anti-inflammatory effects</li> <li>• Modulation of adenosine receptor signaling</li> <li>• Impact on microbiome content and diversity</li> </ul>
	Systematic review and meta-analysis [26]	Coffee consumption is inversely associated with risk of T2D. The risk of T2D decreased by 6% for each cup-per-day increase in coffee consumption	
	Review of meta-analysis [27]	Coffee consumption was consistently associated with a lower risk of type 2 diabetes for high versus low consumption, similar comparisons with decaffeinated	
<b>Cardiovascular diseases (CVD)</b>	Meta-analysis of observational studies [28]	An inverse association was found between coffee consumption and CVD	Coffee consumption be a source of CGA which could: <ul style="list-style-type: none"> <li>• Activation of the AMPK pathway</li> <li>• Inhibition of NADP(H) activity</li> <li>• Scavenge free radicals</li> <li>• Promote NO production</li> <li>• Inhibit the angiotensin-converting enzyme in plasma [30]</li> </ul>
	Meta-analysis of prospective cohort studies [29]	Coffee consumption is associated with decreased risk of mortality from CVD	
	Review of meta-analysis [27]	Coffee consumption was consistently associated with a lower risk of mortality from all causes of cardiovascular disease, coronary heart disease, and stroke in a non-linear relation, with summary estimates indicating largest reduction in relative risk at three cups a day	

Pathology	Study Type	Conclusions	Possible mechanisms of action
<b>Cancer</b>	Review of observational and experimental studies [31]	In 2016, the International Agency for Research on Cancer (IARC), revised its classification of coffee from Group 2B (“possibly carcinogenic to humans” to Group 3: ‘Not classifiable as to carcinogenicity’ after a re-evaluation with a database of more than 1000 observational and experimental studies	[33] collected different possible mechanisms of action behind the possible benefits of coffee, although warning that many controversies exist. Also, different mechanisms might be involved in different types of cancer:
	Review of meta-analysis [32]	Inverse associations with liver and endometrial cancer supported by highly suggestive evidence. An inversely related risk of endometrial and liver cancer, melanoma, oral and oral/pharyngeal cancer was also found	<ul style="list-style-type: none"> <li>• Prevention of oxidative DNA damage, modification of the apoptotic response and reversal of the cell cycle checkpoint function by caffeine</li> <li>• Suppression of the progression of hepatocellular carcinoma through the Akt signaling pathway by caffeine</li> <li>• Anticarcinogenic properties of cafestol and kahweol</li> <li>• CGA clearance of reactive oxygen species and anti-tumoral effect</li> <li>• Caffeine and other compounds increased the clearance of estradiol and inhibited estradiol-mediated carcinogenesis in endometrial cells</li> <li>• Decreased exposure of epithelial cells to carcinogens in the colon by increasing colonic motility</li> <li>• Reduction of the synthesis and secretion of bile acids</li> </ul>
	Review of meta-analysis [27]	At the same time, an increased risk for acute lymphocytic leukemia, leukemia, bladder, and lung cancer was found	
	A meta-analysis of prospective observational studies [33]	A meta-analysis of 40 cohort studies showed a lower incidence of cancer for high versus low coffee consumption, any versus no consumption, and one extra cup a day	
		Supports an inverse association between coffee intake and oral, pharynx cancer, liver cancer, colon cancer, prostate cancer, endometrial cancer and melanoma and increased association for lung cancer	

Pathology	Study Type	Conclusions	Possible mechanisms of action	
Degenerative Cognitive Diseases	Dementia	Meta-analysis of prospective studies [34]	Did not find an association between coffee consumption and an increased risk of overall dementia	No effects
	Alzheimer Disease (AD)	Meta-analysis of prospective studies [34]	Did not find an association between coffee consumption and increased risk of Alzheimer's Disease	Potential mechanisms could involve [35]: <ul style="list-style-type: none"> <li>• Blockade adenosine receptor antagonism, which may attenuate damage caused by b-amyloid</li> <li>• Caffeine intake of 500 mg caffeine or 5 cups/d of coffee could protect against or treat AD in an AD mouse model</li> <li>• Higher insulin sensitivity, diabetes risk reduction, a strong risk factor for cognitive decline</li> </ul>
		Meta-analysis of cohorts [35]	Another 2016 meta-analysis of cohorts found suggested a significant inverse association between highest coffee consumption and the risk for Alzheimer Disease	
	Parkinson's Disease	Meta-analysis of cohorts [36]	Caffeine consumption modified disease risk and progression in Parkinson's Disease, among both healthy individuals and those with Parkinson's Disease	Additional studies required
		Systematic review of meta-analysis and primary studies (case-control, cohort, and cross-sectional) [37]	Coffee consumption was consistently found to be negatively associated with the onset of PD	

Pathology	Study Type	Conclusions	Possible mechanisms of action
Liver diseases	Meta-analysis of epidemiological studies [38]	When comparing patients that drank coffee daily vs. those who did not, 23% decreased risk of non-alcoholic fatty liver disease (NAFLD) and a 32% decreased risk of liver fibrosis development in already diagnosed NAFLD patients was found	Among other mechanisms provided by different coffee compounds: <ul style="list-style-type: none"> <li>• Decreased oxidative stress and inflammation</li> <li>• Decrease of leptin levels</li> <li>• Anti-fibrotic properties</li> <li>• Decreased lipid accumulation in hepatocytes</li> </ul>
	Systematic review and meta-analysis of prospective studies [39]	An inverse relation between coffee consumption and the risk of hepatocellular carcinoma (HCC) and even stronger negative association with chronic liver disease	Concretely, for Hepatocellular carcinoma [40]: <ul style="list-style-type: none"> <li>• Caffeine reduces HCC cell proliferation.</li> <li>• Cafestol and kahweol increase activity of phase 2 liver enzymes</li> <li>• Polyphenols may ameliorate oxidative DNA damage</li> </ul>

**Table 3.** Summary of the effects of coffee consumption on selected pathologies

## 5. Current Food-Based Dietary Guidelines Recommendations on Coffee Consumption

Food-Based Dietary Guidelines are defined as a set of guidelines or qualitative statements that will help a person or a population lead a healthy life, maintain optimum weight, and reduce the risk of chronic diseases. These often help to translate vast evidence into culturally appropriate and actionable recommendations that can inform and influence consumer behavior [41,42].

Before assessing whether current FBDG should be updated to include more or fewer recommendations regarding coffee consumption, it is important to review the latest statements provided by the government of various countries or its health institutions. Various FBDG were analyzed in this review, including the US [43], Canada [44], several European countries, New Zealand [45], Australia [46,47] and Mexico [48].

All the information and FBDG were researched and extracted from original and official sources, from each country, respectively. The information about European countries was extracted from a summary of “*Food-Based Dietary Guidelines recommendations for water for the EU, Iceland, Norway, Switzerland and United Kingdom*” [49] provided by EU Science Hub from European Commission, which used the respective FBDG from each country. 32 European countries were included (30 countries plus Belgium, which provided information about the Flanders and Wallonia regions). In total, 37 countries were included. The results are summarized in table 4.

As most FBDG give qualitative recommendations, and food groupings and parameters differ across individual FBDG, it is difficult to construct a table summarizing and classifying preferred choices of food using the same parameters. Therefore, Table 4 attempts to summarize by including concrete citations and general ideas.

In this analysis, although limited and with risk of bias, as it only includes self-selected (but numerous) countries, a similar trend regarding recommendations can be found:

- First, water is found to be the preferred and most important source of liquid intake which should be prioritized over other options.
- Second, coffee is mentioned often but not always in the different FBDG, and in those that it is included, it is generally done under the beverage section, as a beverage that can help to contribute to liquid intake.
- Third, FBDG seem to be more focused on giving proper caffeine consumption recommendations, with or without intake limits, rather than recommendations on coffee or other caffeine-containing foods or beverages, as coffee or tea.
- Fourth, most of the outlined benefits in FBDG are found on health-care professionals’ versions not generally destined to the general population, such as the Australian FBDG. Therefore, it is possible the statements included in those guidelines might not be translated into proper recommendations to the general population.

Similarly, in 2018, Reyes and Cornelis aimed to provide a summary of FBDG on dietary caffeine consumption. Their research provides a solid analysis of FBDG, but it is more focused on caffeine consumption rather than coffee, which is the goal of this review. Some of their conclusions overlap with our conclusions, especially the idea that FBDG has a marked focus on caffeine-intake upper limits and the notion of caffeine-containing beverages as possible sources of calories. Although this review focused only on coffee, it came to a similar conclusion: FBDG provide an unfavorable view of caffeine-containing beverages and few guidelines balance their recommendations with messages about evidence-based benefits.

In conclusion, from the selected FBDG in this review, our analysis supports the idea that few FBDG encourage coffee consumption or suggest that its consumption might be beneficial. On the contrary, FBDG seem more focused on warning about its consumption due to its caffeine content or as a possible source of calories if sugar, milk, cream, or other products are added. Although guidelines should outline both positive and negatives, currently their focus seems slanted towards the latter.

Source	Coffee references and recommendations on Food-Based Dietary Guidelines (DG)
<p><b>Dietary Guidelines for Americans (2015-2020) by the Department of Agriculture of the U.S (U.S.; 2015 [43])</b></p>	<ul style="list-style-type: none"> <li>- Moderate consumption ((...) up to 400 mg/day of caffeine) can be incorporated into healthy eating patterns</li> <li>- Moderate consumption unassociated with an increased risk of major chronic diseases (e.g., cancer) or premature death, especially from CVD</li> <li>- Individuals who do not consume (...) caffeinated beverages are not encouraged to incorporate them into their eating pattern.</li> <li>- Coffee beverages often contain added calories (...) and added sugars, which should be limited</li> </ul>
<p><b>Canada's Dietary Guidelines for Health Professionals and Policy Makers (Canada; 2019 [44])</b></p>	<ul style="list-style-type: none"> <li>- No references to coffee itself or coffee health benefits</li> <li>- 3 references under "Foods and beverages that undermine healthy eating" section, mostly referring about beverages that can contribute to the consumption of excess free sugars (e.g. [Sugary drinks] include (...) other sweetened hot or cold beverages, such as iced tea, cold coffee beverages")</li> </ul>
<p><b>Food Based Dietary Guidelines recommendations for water for the EU, Iceland, Norway, Switzerland, and United Kingdom)</b></p> <p><b>(countries detailed on the paper; 2002-2018 [49])</b></p>	<p>Countries mentioning coffee consumption (n=12):</p> <ul style="list-style-type: none"> <li>- 9 countries include it in the preferred choices of beverage, recommend coffee consumption as contributor to liquid intake or remain neutral</li> <li>- 2 countries include limits on coffee consumption for those who drink it</li> <li>- 1 mentions that excessive consumption can cause insomnia and irritability and along with the warning that tea and coffee contain energy if milk, cream, or sugar is added</li> </ul> <p>Countries mentioning caffeine consumption (n=4)</p> <ul style="list-style-type: none"> <li>- 2 recommend caffeine up to 300mg/day</li> <li>- 1 recommends up to 400mg/day (excluding pregnant woman)</li> <li>- 1 mention "moderate consumption of drinks with calories and sugars or pharmacologically-active substances (e.g. caffeine)"</li> </ul>
<p><b>Eating and Activity Guidelines for New Zealand Adults (New Zealand; 2015 – Upd. 2020 [45])</b></p>	<ul style="list-style-type: none"> <li>- "There is some evidence that (...) can provide benefits for health such as antioxidative properties"</li> <li>- Moderate amounts recommended because of caffeine and tannins content, which can lower the amount of iron absorbed in the gut</li> </ul>

Source	Coffee references and recommendations on Food-Based Dietary Guidelines (DG)
<p><b>Eat for Health Australian Dietary Guidelines [summary version included] (Australia; 2013 [46,47])</b></p>	<p>Summarized version:</p> <ul style="list-style-type: none"> <li>- “Tea and coffee provide water, although they are unsuitable for young children and large quantities can have unwanted stimulant effects in some people.”</li> </ul> <p>Extended version for professionals:</p> <ul style="list-style-type: none"> <li>- Mentioned up to 23 times, mostly in tables in to provide evidence about coffee health benefits or association with diseases (e.g. Consumption of coffee of four or more cups per day is associated with reduced risk of type 2 diabetes, with grade B (probable association))</li> <li>- Caffeine intake is advised to be restricted to a maximum of 300 mg of caffeine per day for the pregnant and breastfeeding woman. Energy drinks may also be high in caffeine and are unsuitable for children</li> </ul>
<p><b>Guías alimentarias y de actividad física en contexto de sobrepeso y obesidad en la población mexicana (México; 2015 [48])</b></p>	<ul style="list-style-type: none"> <li>- Coffee is ranked level 3 (along with tea and sugar-free fruity water) in a classification made by an expert committee convened by the Ministry of Health according to energy content, nutritional value and health risks, ranking from most (level 1) to least (level 5) healthy</li> </ul>

**Table 4.** Summarized Food Based Dietary Guidelines (FBDG) recommendations on coffee consumption from various countries

## 6. Consumers' perception of possible health benefits from coffee consumption

For the purposes of this review, consumers' perception of possible health benefits from coffee consumption was regarded as a relevant factor. Both public health interventions and FBDG could benefit from a better understanding of the consumers' perception, as it could help to customize future recommendations and public health campaigns.

Two searches were performed in the PubMed Database using the Mesh terms "Coffee" and, respectively, "Health Knowledge, Attitudes, Practice", and "Consumer Behavior". Twelve studies were initially found, but only two were found to be relevant to this topic discussion, elaborated by Samoggia and Riedel [50,51].

In 2018, the authors analyzed in a systematic review the motives and characteristics driving coffee-consumers [50]. Their results suggest that the leading drivers to coffee consumption are sensory qualities, the stimulating function, habits, and socialization. The barriers, instead, are most importantly the dislike in the taste and beliefs about negative health effects. The authors described that the relationship between consumption and consumers' perception of the health aspect had not been explored systematically, leading to a subsequent paper authored by them.

In 2019, face-to-face interviews were used by Samoggia and Riedel to obtain 250 questionnaires for analyzing consumers' perceptions of coffee health benefits [51]. Even though consumers seem to recognize a healthy range of consumption, only 25% thought that drinking coffee could have positive benefits. Interestingly, the consumers who drank one-to-two cups a day had a more positive view (32.5%) than those that drank three-to-four (21.3%). 80% of consumers thought that decaffeinated can have a similar impact (when comparing with caffeinated coffee) on human health.

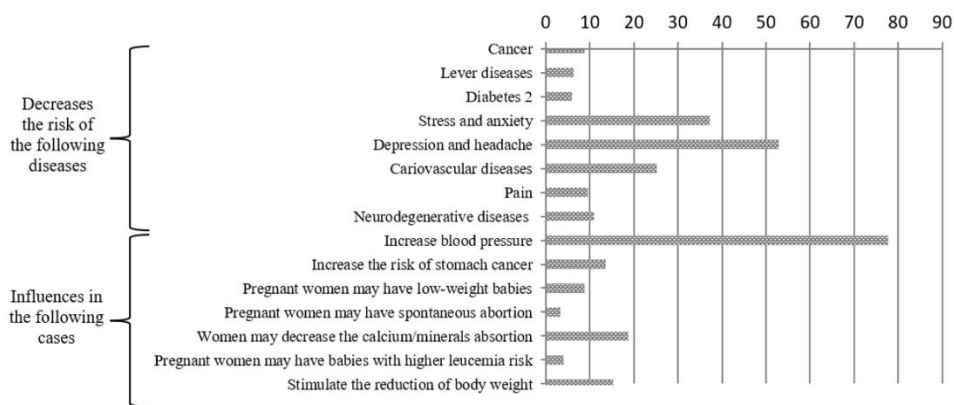
Consumers do recognize a limited number of benefits or effects (e.g. 25% thought it decreases risk of cardiovascular diseases) but do not acknowledge the effects on other diseases such as liver disease, diabetes, cancer or neurodegenerative diseases, on which there are evidence-based benefits [Figure 1]. The authors concluded that drinking coffee is already acknowledged as pleasurable but there is space to improve perceptions of scientifically based health benefits, marketing coffee as pleasant and healthy at the same time.

These studies provide a first snapshot on the issue, yet there is a need for more studies in different populations, as well as understanding of the perceptions of those who do *not* consume, to better understand the barriers that might cause them to avoid consumption. Also, a better comprehension of certain audiences who might have more misconceptions about coffee or that might benefit more from its consumption, such as people with TD2, might be of interest.

Some examples of questions that need to be resolved are: "Do consumers know how many cups a day they can consume while maintaining a healthy range of caffeine consumption?", "Do consumers consider decaffeinated as a pleasurable healthy alternative?", "Are non-consumers knowledgeable on coffee benefits?"

The answers to these and other questions might translate into different approaches on how FBDG should encourage coffee consumption. As an example, encouraging coffee consumption is not the same as emphasizing its benefits, something better suited if consumers already drink enough coffee but do not know about its benefits. If the latter was true, another question might come up is whether FBDG would be the best place to do so. Other strategies, such as the introduction of health claims, funding higher quality coffee, or lowering taxes could be a better alternative.





**Figure 1.** Consumers’ perception of health effect of coffee consumption (%). Note: Consumers’ response options were “yes”/“no” for each item. From Sammogia and Riedel [51].

### 7. Historical, Cultural, and Social Impact of Coffee

The following paragraphs contain a further discussion on the historical, cultural, and social impact of coffee to analyze whether those can contribute to already mentioned coffee health benefits.

Historically speaking, several legends surround the discovery of coffee, but most seem to refer to Ethiopia as its birthplace as early as the 9th century. The first credible evidence appears in the late 15th century, by Sufi Imam Muhammad Ibn Said Al Dhabhani who is known to have imported goods from Ethiopia to Yemen [52]. Coffee became popular among bourgeoisie and intellectuals in Europe after the opening of coffeehouses in the late 17th century.

Therefore, we can see how coffee has remained long enough in our society to leave a mark on different cultures around the world. As an example, coffee can even get immersed into the lexicon of a language. As an example, *Fika* is a Swedish word used as early as 1910 to describe a traditional coffee break in Sweden [53], where people come together for a coffee and pastry. This concept has been recently popularized and even books with this topic have been written [54]. A similar concept exists in German, called “Kaffeepause” [55].

Another, maybe more relevant mark, of this cultural expression are “*coffee rituals*” and recipes. Traditional recipes, such as an Irish coffee, a *café de olla* in Mexico, or a *cortado* serve as examples of recipes. “*Coffee rituals*” such as the moka pot frequently used in Italy, Turkish coffee or Ethiopian coffee ceremonies are cultural expressions of not only coffee brewing but a reason to pause and bring people together. These emphasize another social aspect of coffee: slowing down.

Even though recently coffee has been marketed as a symbol for a hectic, rushed, on-the-go life, preparing coffee can be seen as an excuse to have a talk with someone and slow down. Most *coffee rituals* cannot be done in a rushed manner, require technique and some patience, so it can actually be seen as an invitation to decelerate. Also, most brewing techniques often produce coffee for more than one person. We could even ask ourselves if the rise of capsule coffee, which prepares individual and quicker coffee, reflects how we have evolved socially and culturally.

#### 7.1. Third-places: a new and relevant concept

As mentioned before, coffee helped the rise of coffeehouses around Europe, spaces to debate and socialize along with some cup of coffee. Even though perhaps not with the same elegance as the 17th century bourgeoisie, lots of people regularly enjoy coffee on several widespread locations. To end this brief analysis of the social impact of coffee, it seems relevant to introduce the third-place concept.

Third places are “physical locations outside of the home (first place) or workplace (second place) that facilitate social interaction, community building, and social support. Public facilities and institutions, including libraries and parks, constitute third places; but so, do commercial businesses (...) such as coffee shops and cafes (...)” [56]

These spaces seem to be crucial in enabling socialization between people in different communities, but this topic seems to be still under-researched to draw any conclusions. A 2020 study found that for seniors familiar with the concept of third places, the more often they go to third places (such as markets, coffee shops or a friend's house), the higher happiness they achieve [57].

The aforementioned study also highlighted that the disappearance of such places could have devastating public health consequences and called on researchers to investigate what the consequences of the disappearance of these third places could be.

Estimating the mental health impact of the disappearance of third-places is difficult, as it is something deeply ingrained in our culture. Perhaps, special circumstances that cause complete disengagement from third-places (such as the lockdown resulting from the SarS-Cov-2 pandemic) could serve as a guideline to compare the effects of a lack of a space that invites socialization, such as bars or restaurants. Until the cultural and social impact is not properly researched, we should not underestimate the importance of these places, so deeply ingrained in our culture.

The aim of this section was to note that some of the benefits perceived from people who regularly consume coffee could go further than the beverage itself and be related to cultural and social aspects, especially when coffee serves both as an excuse and a place for people to gather together.

A lot of the arguments presented in this section could be flagged as anecdotal rather than evidence-based, but they should be noted nonetheless as – potentially under-researched – critical aspects. Coffee not only is a beverage with health impact on the population, but also has a historical background, cultural roots that persist until today, and last but not least, is a drink which serves an opportunity to come together.

## 8. Possible Limitations to Encouraging Coffee Consumption in Food Guidelines

To recap, until this point in the review, it has been shown that coffee is a widely consumed beverage with an important health impact, especially for certain pathologies. At the same time, it is evident that FBDG have an unfavorable view of caffeine-containing beverages and that consumers do not fully perceive the potential benefits of coffee. Therefore, the question that follows is understanding the underlying reasons for this negative vision in FBDG and the barriers that might be in the way of a more balanced view of coffee consumption. This discussion section aims to draw some hypotheses and starting points that might be useful for future research.

### 8.1. Caffeine

FBDG have demonstrated to have a greater focus on caffeine consumption rather than coffee, which, from a public health perspective, is understandable. Some population groups should avoid the consumption of large doses of caffeine and should be definitely mindful of its effects, but this should not become the general reason to refuse coffee, especially in a healthy population.

First and foremost, it must be stated that caffeine is safe for consumption in a healthy range. Up to 400mg/day in healthy adults has not been associated with overt, adverse cardiovascular effects, behavioral effects, reproductive and developmental effects, acute effects, or bone status. For children and adolescents, 2.5mg/kg bodyweight/day seems to be an appropriate recommendation [58], although significantly lower than in healthy adults, hence the general recommendation for minors to avoid drinking coffee.

There are several reasons why even though caffeine can be regarded as safe it might have adverse effects on some people. Variables, such as polymorphisms, age, life stages, medications or certain pathologies might alter the half-life of caffeine in the body and therefore, it can have a more prolonged impact on the consumer. Table 5 recaps four of the most common cases in which caffeine consumption might be not recommended (citations also found on the table [27,58-67]).

Case	Evidence and/or recommendations on the different cases
<b>Sleep deprivation</b>	<ul style="list-style-type: none"> <li>• Sleep deprivation is one form of sleep disruption, which can have several short- and long-term consequences [59]. Sleep quality was found to be altered by caffeine even in expected consumptions in society, but that the magnitude of its effects was modulated by individual differences in a 2018 systematic review [60]</li> <li>• A 2015 study summarized key findings on sleep hygiene in which avoidance of caffeine was recommended, but the effects of morning and afternoon caffeine use was less clear. They noted that harmful effects of caffeine on sleep could be limited to caffeine sensitive individuals [61]. People that suffer sleep deprivation should take into account that caffeine taken 6 hours before bedtime can have important disruptive effects on sleep [62]</li> </ul>
<b>Pregnancy</b>	<ul style="list-style-type: none"> <li>• Half-life of caffeine is known to double during pregnancy and is also known to easily cross the placenta. At the same time, activity of the caffeine metabolizing enzyme, CYP1A2, is low in the fetus, resulting in prolonged fetal exposure to caffeine [27]</li> <li>• Coffee consumption seems to be associated to low birth weight, preterm birth, and pregnancy loss [27]. In another systematic review, consumption of 300 mg of caffeine/day in healthy pregnant women was generally not associated with adverse reproductive and developmental effects [58]</li> </ul>
<b>Hypertension</b>	<ul style="list-style-type: none"> <li>• Caffeine intake of 200 to 300 mg can produce an important increase in blood pressure (BP), which can be observed 60 min after intake, and can persist up to 180 min afterward [63].</li> <li>• Although people with high BP should avoid large doses in a short period of time, there might be no reason to prohibit consumption. No significant estimates of risk at any level of consumption in a non-linear dose-response analysis were found for hypertension [64]. In a more recent meta-analysis published in Nature, consumption of coffee was inversely associated with the risk of hypertension in a dose–response manner. The risk of hypertension was reduced by 2% with each one cup/day increment of coffee consumption [61].</li> </ul>
<b>Anxiety-related disorders</b>	<ul style="list-style-type: none"> <li>• Caffeine can be considered anxiogenic [65]. In people experiencing non-pathologic levels of anxiety, low doses of caffeine could reduce anxiety but increase anxiety, nervousness, and jitteriness at high doses. In some individuals, anxiety can be considerably reduced by giving up coffee [66].</li> <li>• Variability in the anxiogenic response can have a genetic basis. A 2018 review analyzed impact of genetic variability on physiological responses to caffeine. Single-nucleotide polymorphisms have been found to be associated in the anxiogenic effects of coffee, but the authors concluded that habitual use may cause tolerance to the anxiogenic consequences of caffeine regardless of select genetic variations [67].</li> </ul>

**Table 5.** Common cases in which caffeine consumption might be not recommended.

Caffeine content in coffee may be a strong enough reason for some individuals to avoid coffee completely and can be a logical argument for recommending moderate consumption to the general population, but it probably does not justify a complete negative view of coffee, especially when it is one of the most important sources of polyphenols in the diet.

Of course, coffee is not essential for life or human health, but there is no reason not to both include caffeine warnings as well as evidence-based statements on coffee benefits in FBDG, especially if decaffeinated coffee is a feasible alternative. Nowadays coffee industry technology allows for organoleptically adequate decaffeinated coffee, which seems to have similar health benefits as regular coffee. No harmful associations between decaffeinated coffee and any health outcome were found in a before mentioned meta-analysis [27].

To end, FBDG need to be understandably cautious, but, based on this review's findings, they should refrain from advising against coffee consumption merely for its caffeine content, and should not single out coffee as the single culprit in this regard. Other drinks, such as tea and soda, have been found to be relevant contributors [68], and in some countries those can make up a relevant amount of the percentage of caffeine-containing beverage volume sales. [69]. Also, energy drinks should be included in this discussion as a high contributor of caffeine (up to 207mg per 8oz) [70].

### *8.2. Obtention of Reliable Studies*

Most of the evidence in favor of coffee in this review has been obtained through large meta-analysis of cohorts and observational studies. There is a need for long-term large randomized controlled trials (RCTs) to confirm these findings, but methodological difficulties may exist, such as the obtention of a group sample that complies with the avoidance of coffee consumption for a long time if it is assigned to the control group or the problem to standardize consumption of coffee as coffee blends, roasting, storage or preparation methods can affect the final result and make it more difficult to create same conditions for all participants.

While this goal is pursued, another line of research could be working towards a better understanding of the mechanisms of action underlying coffee health benefits. Future research might be able to compare the effects of certain coffee metabolites, such as chlorogenic acid, by comparing coffee-enriched blends with higher amounts of some metabolite with a regular coffee control blend one, by creating a double-blind placebo trial.

### *8.3. Lack of comprehension of consumers' consumption and behavior*

There are very few studies that have analyzed the behavior of consumers regarding coffee consumption. As stated in section 6, there is a need to understand how coffee is perceived by consumers which might translate in more tailored recommendations and future public health strategies.

### *8.4. Conflicts of Interest*

Finally, it should not be underestimated how the coffee industry might be one of the biggest beneficiaries from new emerging coffee claims and recommendations in FBDG. Institutions and food regulators should watch out for direct and indirect lobby pressures and conflicts of interest that might affect their final decisions.

## **9. Discussion and conclusions**

As coffee consumption is growing worldwide and it is nowadays part of the daily nutritional intake of millions of people around the globe, it seemed important to review if the current dietary guidelines reflected the effects that consumption has on people's health. This review aimed to analyze the latest evidence regarding coffee consumption and related health benefits, the perception of consumers' health benefits on coffee, and the current recommendations given in Food-Based Dietary Guidelines to assess whether these are up to date and, therefore, if coffee consumption should be encouraged in public health guidelines.

Recent research has served to change how coffee is regarded from unhealthy to neutral to potentially healthy. The International Agency for Research on Cancer (IARC) recent classification

change serves a relevant example of this. New evidence supports that, in moderate doses, coffee is safe for consumption and its consumption might be beneficial for prevention or treatment of different metabolic diseases. The upper limits of such moderation are likely to be determined by caffeine intake (as higher consumption than recommended limits could be detrimental) and decaffeinated coffee does not seem to be associated with harmful outcomes. The question that follows is whether there is enough long-term evidence to support an encouragement in FBDG. The reviewed literature suggests that there might not be enough long-term studies to yet encourage coffee in public health guidelines, especially if governments prefer to be cautious.

That being said, it is evident that, in their current iteration, FBDG have a negative view on coffee and other caffeine-containing beverages. Caffeine seems to be an important barrier to update guidelines, and from a public health point view, this could be seen as understandable, as high levels of caffeine consumption can be a public health problem, especially in certain population groups, but such a restrictive approach is problematic for various reasons. First, certain groups of populations, such as children or pregnant woman are already targeted to avoid high consumption and even some countries have legislated in that sense (e.g. in 2018, UK proposed banning the sale of energy drinks in England to anyone under the age 18 amid growing fears about their effects on children's health – [71]). Second, FBDG should recognize that naturally containing sources of caffeine, such as tea or coffee, have other potential benefits by themselves that can balance in favor of a recommendation. At the same time, they probably should be classified differently from artificial sources of caffeine, such as sugar carbonated or energy drinks, which tend to be important sources of calories and added sugar which do not provide any further benefits. Third, as long as consumers receive easy-to-understand recommendations on limits of caffeine consumption (e.g. two cups of coffee a day), there is no reason why its consumption should be discouraged, again, because caffeine seems to be the only culprit. And fourth, even if the detrimental effects of caffeine outweighed the benefits of coffee, there would be, until this point, no evidence to warn against decaffeinated coffee consumption. In fact, evidence seems to point to the opposite to be true.

It is possible that the current recommendations are affecting the perception of the general population. Research has recently changed how coffee is regarded, and consumers' perception of its health benefits may simply be lagging. There is a shortage of studies on the consumers' perception of coffee (e.g. health benefits or limits of consumption) that could be useful to narrow down how future recommendations or even public health campaigns could be done. This is among other obstacles that might work against an encouragement of coffee consumption in FBDG, along with other aspects mentioned in section 8.

This research added another argument in favor of updating FBDG. Coffee is a culturally ingrained beverage, with an historic background and social impact still not fully researched, so unlike new health-marketed products, coffee is not a simple healthy "fad", but it is here to stay. Thus, if coffee ends up being more positively regarded by the end consumer, this point might serve as leverage in favor of strategies or public health campaigns, such as the substitution of sugary carbonated drinks for low or non-calorie coffee.

Therefore, all data from this review will support the need of FBDG to revise their position regarding coffee to give recommendations on coffee in accordance with of the scientific current evidence. We even hypothesize that if coffee consumption continues its uplifting trend, an encouragement for consumption might not be needed but a change of perception by the consumer could be possible and positive. A clear message that coffee consumption is not only not harmful but can be beneficial in the face of certain pathologies would be important and positive to change the social perception that is sometimes had of coffee consumption.

On a similar note, although the energetic aspect of coffee seems to be a driving factor for consumption, we hypothesize that the decaffeinated market has a lot of ground to cover, and might be able to target potential customers that have previously refused consumption due to the adverse effects of caffeine. The food industry should as well be interested in - and in cooperation with scientific research - the production of higher quality coffee, not only in its organoleptic features, but

also in its health properties, like better preservation or cultivation methods that produce coffee higher in antioxidants.

As far as we know, this is first review suggesting that FBDG guidelines should be updated to reflect recent evidence in favor of coffee consumption. This study presents limitations on the number of FBDG reviewed and does not encompass a comprehensive analysis of all the health benefits related to coffee consumption, although this was not the primary goal of this work. Despite these limitations, this review serves as a relevant starting point for future research on how coffee consumption should be reflected in public health guidelines.

In summary, recent research on coffee and coffee consumption has not translated into FBDG concrete recommendations for the general population and is still takes a negative/neutral stance on the subject. Several factors might be involved in this, most of which future research is likely to address. At the same time that more epidemiological studies come to light, other related topics, such as consumers' behavior or the cultural impact of coffee should be studied thoroughly to further support in favor or against a future update of public health dietary guidelines.

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